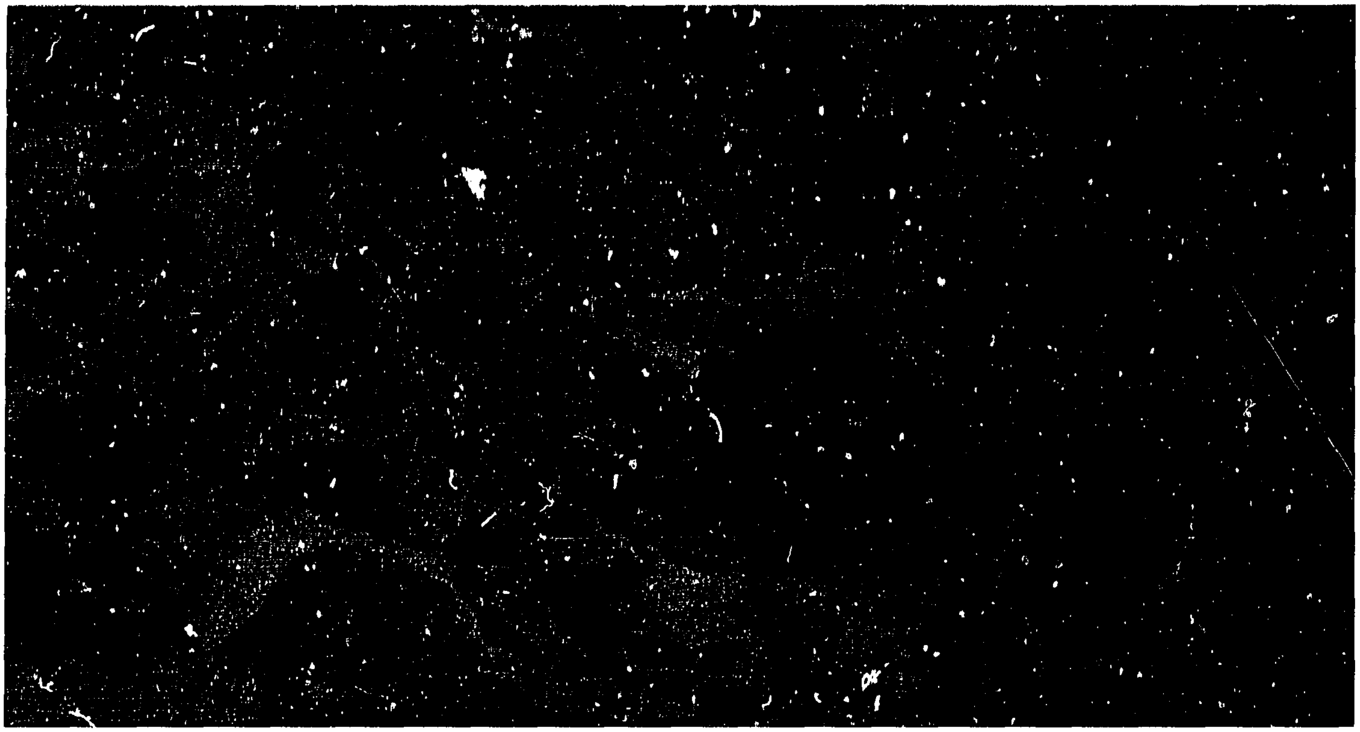
Papua New Guinea Conservation Needs Assessment

Volume 1



Government of Papua New Guinea
Department of Environment
and Conservation

Papua New Guinea
Conservation Needs Assessment
Volume 1

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Edited by Janis B. Alcorn

Biodiversity Support Program
A USAID-funded Consortium of
World Wildlife Fund,
The Nature Conservancy, and
World Resources Institute
Washington, D.C.

Government of Papua New Guinea
Department of Environment and Conservation
Boroko, Papua New Guinea

Papua New Guinea Conservation Needs Assessment, Volume 1

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Foreword

Conservation Needs Assessment for Papua New Guinea

The Honorable Meg Taylor[1]

The Five Directive Principles of Papua New Guinea's Constitution provide the vision and tools to enable our society to achieve the concept of sustainable development/sustainable living in the 21st century.

Many of our village societies continue to live sustainably as our people have for hundreds of years, living a life balanced and in harmony with the environment.

The past 17 years since independence have been a challenging time for our country. The path for economic growth has been to short-term benefits, not long-term sustainable growth. Short-term economic growth, I believe, challenges much of the fundamental values of Melanesian society, such values as community responsibility and environmental responsibility.

It is now apparent that Papua New Guinea's (PNG's) major asset is its wealth of environmental resources. The forests, the mangroves, the reef, and the ocean are abundant with a richness that is desired by peoples and corporations for their monetary value. For PNG these resources are a life source for current and future generations. Managing our resources in this century, when many of our people want the benefits of a modern economy, is an even greater challenge. Leaders in PNG have a grave responsibility in meeting the needs of our communities and taking PNG into a modern life with the benefits of good health facilities, education, and economic opportunities.

In the desire to progress we endanger the very sources of our physical and spiritual existence. We have been endowed greatly by the Creator with the richness of our islands. Our country is indeed bountiful. Yet now our environment is threatened. Greed has motivated the exploitation of our resources. Once our environment is gone, there is nothing, absolutely nothing, left for us as a people. We will be scavengers. I do not want to be responsible for that loss. Many men and women in PNG do not want to be responsible either.

[1] Ambassador to the United States from Papua New Guinea.

Therefore, in this time of choice and decision, the challenge is to ensure that every effort that is humanly possible is made to direct the development of our country on a sustainable pathway.

I have read the Constitution often, yet I must now admit that 17 years hence I have finally come to understand and draw guidance in my work from the Five Directive Principles.

1. **Integral Human Development**
   Every person should be dynamically involved in the process of freeing himself or herself from every form of domination or oppression so that each man and woman will have the opportunity to develop as a whole person in relation with others.

2. **Equality and Participation**
   All citizens should have an equal opportunity to participate in and benefit from the development of our country.

3. **National Sovereignty and Self-Reliance**
   Papua New Guinea should be politically and economically independent and our economy should be basically self-reliant.

4. **Natural Resources and Environment**
   Papua New Guinea's natural resources and environment should be conserved and used for the collective benefit of all and should be replenished for future generations.

5. **Papua New Guinea Ways**
   Papua New Guinea should achieve development primarily through the use of Papua New Guinea forms of social, political and economic organizations.

It could not be clearer that our Constitution embodies man/woman, development, equality, nationhood, environment and our traditional structures for consultation to enhance and give substance to our way of life.

As we address the issues that are now critical for our future, the future of generations to come, for our country, we will enter into dialogue with each other and friends from other nations to find ways to sustain life for all peoples. It is an enormous but achievable task. The Conservation Needs Assessment (CNA) is one such task.

CNA was implemented through a process that stimulated collaboration between non-governmental organizations (NGOs), government, Landowners and scientists.

Throughout the CNA, process was as important as product. And the CNA itself was the first step in a process. Now a national discussion is needed in order to use the CNA information to empower people to weigh their choices and to initiate awareness of decisions being made/open to be made. This will enable PNG to develop a national consensus on appropriate development projects as well as to develop local consensus about land/resource-use options open to communities.

The CNA maps are "works in progress." The mapping process does not end with the publication of these maps; instead, the maps should be used as starting points for further research.

The maps should also be used, with the other CNA information, to begin and expand participatory approaches to conservation. The social legend presented on each of the CNA maps underscores the point that conservation in Papua New Guinea cannot be separated from the needs and priorities of the local people.

The CNA maps are intended to be distributed not only to scientists and government planners, but also to NGOs and local resource owner groups ("Landowners") through the proposed Natural Resources Options Centre and existing channels. It is hoped that these maps can serve as tools for more participatory decisions about conservation and development in Papua New Guinea.

The fact that areas do not fall within the circles on the CNA maps does not mean that they do not contain valuable biodiversity. Nor does it mean that environmental impact assessments should not be done on development projects or extractive enterprises proposed in those areas outside the circles. Local biodiversity is always important locally, and local assessment of biodiversity importance should have precedence.

This document, then, is a tool that will assist PNG in the critical choices for our future.

Executive Summary

J. Fred Swartzendruber[1]

The Conservation Needs Assessment (CNA) for Papua New Guinea was requested by the government of Papua New Guinea, and funded by the U.S. Agency for International Development (USAID). The CNA was implemented by the Biodiversity Support Program, a USAID-funded consortium of World Wildlife Fund, World Resources Institute, and The Nature Conservancy, in collaboration with local and international non-governmental organizations (NGOs), museums, and academic institutions.

The assessment compiled an extensive body of the available scientific literature on the biological diversity (biodiversity) of Papua New Guinea, and assessed the present state of knowledge, conditions, trends, and environmental threats. Special maps were produced identifying sites of particularly high endemism, high species richness, and unusual ecosystems and habitats.

A CNA Workshop was conducted in Madang, Papua New Guinea, in April 1992, to discuss the findings of the scientific assessments, to finalize the maps of terrestrial and marine biodiversity, and to consider a range of recommendations for conservation initiatives. Workshop participants included representatives of the government of Papua New Guinea, USAID, numerous scientific and research institutions and museums, social scientists and legal scholars, NGOs, and local Landowners' groups.

The Workshop developed a process for information sharing and consensus decision-making, and resolved that this model should be used in future development planning and conservation initiatives in Papua New Guinea. The loss of biological resources in Papua New Guinea, as elsewhere, is driven primarily by non-biological factors, and conservation actions must take account of social and political realities. The CNA process emphasizes such issues as communication, rights adjudication, modes of conflict resolution, and attitudes toward biodiversity. The process is intended to be a starting point for participatory approaches to conservation.

There is an urgent need to begin building stronger relationships between Papua New Guinean Landowners and others who are involved in natural resource use and management, conservation, and research, including government, NGOs, the private sector, and scientists. In addition, social scientists should be fully involved in analyzing, designing, monitoring, and implementing conservation activities in Papua New Guinea.

[1] Biodiversity Support Program, c/o WWF, Washington, D.C., U.S.A.

Key recommendations from the CNA include:

- Establish a Natural Resources Option Centre;
- Implement the National Environment and Conservation Plan;
- Strengthen government capacity for environmental monitoring, impact assessment, and enforcement;
- Distribute the CNA Biodiversity Maps as widely as possible to scientists, conservation groups, NGOs, and local Landowners' groups;
- Reform existing legislation to strengthen environmental management and customary tenure systems;
- Develop participatory conservation and development models appropriate to Papua New Guinean culture and conditions;
- Support research focused on priority sites within Papua New Guinea, in collaboration with local scientists and Landowners;
- Provide training in environmental planning, monitoring, and management for government and NGOs, and local resource users;
- Strengthen relationships between government, NGOs, and local Landowners in Papua New Guinea;
- Consider establishing an independent environmental trust fund to support and fund conservation activity in Papua New Guinea;
- A social legend should be placed on the CNA biodiversity map so all potential users recognize the need to consult landowning clans before taking action based on the map's information.

The Conservation Needs Assessment points the way forward for those concerned with environmental conservation and sustainable development in Papua New Guinea. The report's recommendations should be seen as guidelines for designing, funding, and implementing activities which affect the country's rich natural resources. Some of these guidelines are directed toward government, others to NGOs, scientists, the private sector, and foreign donors and investors. In turn, it is important that all of these groups work more closely with Papua New Guinean resource owners, or "Landowners."

The common theme underlying the set of CNA recommendations is the urgency of building stronger relationships between Papua New Guinean Landowners and those who are, in various ways, responsible for changing their natural environment and, therefore, their traditional ways of life. The need to work more closely with local groups applies not only to those who extract natural resources for commercial gain but also to those who initiate activities intended to protect the environment and to bring about economic development and even to researchers.

Papua New Guinea represents an unusual combination of circumstances making it a globally important site for conservation efforts. As the CNA Report makes clear, Papua New Guinea is one of the world's most significant centers of biodiversity, with many unique ecosystems and species. Although much of the landscape has thus far escaped serious degradation, many of the country's terrestrial and marine ecosystems face growing threats, and urgent preventive action is needed.

At the same time, Papua New Guinea represents a unique opportunity for supporting conservation initiatives which build upon a rich base of indigenous knowledge and participatory models of decision-making. Melanesian land and resource tenure traditions, which have evolved over thousands of years, are explicitly recognized by the modern legal framework of the state. This situation, which is rare in global terms, provides an unusual opportunity for conservation action. By building upon this heritage and strengthening it where appropriate, Papua New Guinea can begin to retain responsibility for the long-term health of the environment, and join Landowners in a partnership for making economic development more sustainable.

The people of Papua New Guinea will ultimately decide the outcome of conservation initiatives in their country. Their genuine participation in the processes that affect them is not only desirable, but essential to the conservation of one of the world's great remaining centers of biological and cultural diversity.

Background and Guide to the CNA Report

Background

Papua New Guinea's tropical forests and freshwater wetlands are equal in biological importance to the Amazon and Congo Basins. The coastal and marine areas surrounding Papua New Guinea are among the most diverse aquatic systems in the world. Yet PNG's rich biodiversity is under immediate threat from unmanaged development and nonsustainable resource extraction activities.

Papua New Guineans are proud of their rich biological heritage. The fourth goal of Papua New Guinea's Constitution states:

> "We declare our fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and be replenished for the benefit of future generations.
>
> We accordingly call for:
>
> 1) Wise use to be made of our natural resources and the environment in and on the land or seabed, in the sea, under the land, and in the air, in the interest of our development and in trust for future generations;
>
> 2) The conservation and replenishment, for the benefit of ourselves and prosperity, of the environment and its sacred, scenic, and historical qualities; and
>
> 3) All necessary steps to be taken to give adequate protection to our valued birds, animals, fishes, insects, plants, and trees."

In September 1991, the Government of Papua New Guinea requested that the United States Agency for International Development (USAID) fund a "Stage One Conservation Needs Assessment" (CNA) as technical assistance to the Department of Environment and Conservation (DEC) under the National Forestry and Conservation Action Plan (NFCAP).

The CNA was implemented by the Biodiversity Support Program (a USAID-funded consortium of World Wildlife Fund, The Nature Conservancy, and the World Resources Institute) in collaboration with NGOs, museums, and academic institutions. Collaborating NGOs included: World Wildlife Fund, Worldwide Fund for Nature, World Resources Institute, Wildlife Conservation International, Conservation International, National Alliance of Non-governmental Organisations of PNG (NANGO/PNG), Greenpeace, International Institute for Environment and Development (IIED), Experiment in International Living, CARE, and The Keystone Center. Collaborating institutions included: USAID, Bishop Museum, Royal Botanic Gardens at Kew, University of Western Sydney, Smithsonian Institution, University of Papua New Guinea, the Papua New Guinea University of Technology, Christensen Research Institute, PNG National Museum, and Wau Ecology Institute. The CNA was a unique, collaborative effort to which the organizations listed above generously contributed their expertise for minimal remuneration (not high consultant fees). They participated because they have a commitment to join the global and national community in assisting the Government of Papua New Guinea to assess national conservation needs. The PNG Department of Environment and Conservation, under the direction of Secretary Iamo Ila, coordinated participation by other PNG government agencies including the departments of Forests, Agriculture and Livestock, Fisheries and Marine Resources, Finance, and the Department of the Prime Minister.

The CNA Process

The 15 month CNA process used an innovative approach for determining national priorities for conservation action. CNA was innovative because it focused on both the social dimensions of conservation and the geographic dimensions of biodiversity, and because in-depth preparation prior to a workshop and inclusion of a broad range of participants enabled the workshop to produce significant, new products. The CNA process was as important as the CNA products; the process became one of the products. A social scientists' team, a legal team, an information management team, and an NGO/Landowner team gathered and analyzed information relevant to conservation implementation. Teams of internationally-recognized experts in Papua New Guinean biodiversity compiled and analyzed existing information on Papua New Guinea's biodiversity. The CNA Workshop brought together a wide range of "stakeholders" with an interest in conservation in Papua New Guinea, including representatives of government, representatives from PNG NGOs, Landowners, biological scientists, social scientists, lawyers, resource managers, conservation planners, and donors. The CNA Workshop stimulated dialogue among the major stakeholders, enabled biologists to reach consensus on the biologically important areas of PNG, and produced a set of recommendations.

Guide to the CNA Report

The CNA Report is divided into two volumes. Each volume opens with an introduction that highlights the main points of each chapter in that volume. Volume 1 contains reports on conservation issues and opportunities in Papua New Guinea, as well as information from the CNA Workshop including the consensus maps of biologically important areas, points of agreement among participants, issues that remain to be resolved, and recommendations. Volume 2 contains a biodiversity analysis including taxonomic reviews of PNG's flora, warm-blooded vertebrates, cold-blooded vertebrates, and invertebrates; and ecological analyses of PNG's freshwater wetlands, marine environments, and forests. Extensive bibliographies are also provided in Volume 2.

A CNA Synopsis Report and a full-color CNA wall map have been produced as companions to the full CNA Report. The CNA Report, the CNA Synopsis Report, and the full-color CNA wall map are available in Papua New Guinea from the Department of Environment and Conservation, and the National Alliance of NGOs (NANGO). These documents are also available from the Biodiversity Support Program, c/o World Wildlife Fund, 1250 24th St., NW, Washington, D.C. 20037 U.S.A. (fax 1-202-861-8324).

Acknowledgments

Secretary Iamo Ila, Department of Environment and Conservation (DEC), requested the Conservation Needs Assessment under the National Forestry and Conservation Action Plan (NFCAP), through the Government of Papua New Guinea Office of International Development Assistance. Secretary Ila provided much appreciated, unstinting support throughout all phases of the CNA. First Assistant Secretary Guy Kula and his staff at DEC, especially Lester Seri, William Asigau, Mick Raga, and John Wilmot, participated actively throughout the CNA. John Douglas and First Assistant Secretary Kembi Watoka of DEC also provided much appreciated help. Bruce Jefferies, Basil Peutalo, and David Howlett of the Technical Advisory Team of the NFCAP also provided support and critical input to the CNA. The cooperation of the PNG Departments of Forests, Agriculture and Livestock, Fisheries and Marine Resources, Finance, and the Department of the Prime Minister is also gratefully acknowledged.

Funding for the CNA was provided by the U.S. Agency for International Development (USAID). Louis Kuhn, Assistant Director of USAID/South Pacific; Jim Osborn, former Assistant Director of USAID/South Pacific based in Suva; Molly Kux, Environmental Coordinator for AID/Washington's ASIA Bureau; and Sy Sohmer, AID's Senior Biodiversity Advisor, contributed to the development of the Conservation Needs Assessment concept and supported the CNA process at every step. Jim Rieger and Caroly Shumway, AAAS Fellows at AID, contributed their expertise at the CNA Workshop in Madang. AID/Washington's Center for Development Information and Evaluation contributed the services of information management specialist Peter Hobby.

The CNA was implemented by the Biodiversity Support Program, a USAID-funded consortium of World Wildlife Fund, The Nature Conservancy, and World Resources Institute. Janis B. Alcorn, BSP Program Manager for Asia and the Pacific, served as the CNA director. Kathryn Saterson, BSP Director, and Bruce Leighty, BSP Program Manager for Finance, provided much-appreciated guidance. BSP logistical, contracting, accounting, and general support was provided by Margaret Bjerklie and Richard Richina. Norma Blum of Travel Resources did a remarkable job of handling arrangements for the workshop in Madang. BSP's Margaret Bjerklie also prepared the CNA Report, Synopsis Report and publication brief in computerized format for reproduction. BSP Program Officer Stacy Roberts provided advice at critical points in the publication process. Mimi Hutchins at the World Wildlife Fund did the final formatting and created the CNA covers. J. Fred Swartzendruber synthesized the information from the lengthy CNA reports into a succinct executive summary. Susanne and Hartmut Holzknecht translated the CNA Synopsis Report into Tok Pisin.

Organizations and institutions that collaborated with BSP and provided in-kind contributions to carry out the CNA include: World Wildlife Fund, Worldwide Fund for Nature, World Resources Institute, Wildlife Conservation International, Conservation International, Greenpeace, Institute for Environment and Development (IIED), Experiment in

International Living, CARE, National Alliance of Non-governmental Organisations/PNG (NANGO/PNG), Keystone Center, USAID, Bishop Museum, Royal Botanic Gardens at Kew, University of Western Sydney, Smithsonian Institution, University of Papua New Guinea, Papua New Guinea University of Technology, Christensen Research Institute, PNG National Museum, and Wau Ecology Institute.

The CNA was a collaborative effort of many individuals, all of whose contributions are appreciated. Among those meriting special recognition for their contributions at critical moments include: The Honorable Meg Taylor, PNG Ambassador to the U.S.A.; Andrew Ariako, Premier, Madang Provincial Government; Peter Hunnam, Worldwide Fund for Nature's South Pacific Program Director; Vincent Manukayasi, Secretary of the National Alliance of NGOs; Lafcadio Cortesi, Pacific Program Director for Greenpeace; John Burrows of the World Bank; Don Henry, World Wildlife Fund-U.S.'s Pacific Program Director; Gail Bingham, Director of WWF's RESOLVE program; Hartmut Holzknecht, Anthropology Department, Australian National University; Lance Hill, Biology Department, University of Papua New Guinea; Chris Mercer, University of Technology at Lae; Scholla Warai, PNG Catholic Women's Federation; Natsuki Hirasuka, UNDP; and Sally Townley, University of New England.

The CNA is the product of the dedicated efforts of those who served on the CNA teams. It is the team members' commitment and work which forms the heart of the reports and maps. Bruce Beehler served tirelessly as the biologists' team leader, and his dedication to the cause of conservation in Papua New Guinea was appreciated by all the CNA teams. Vincent Manukayasi led the NANGO assessment of conservation concerns among PNG NGOs and Landowners. Michael Brown served as social scientists' teamleader, and Owen J. Lynch led the legal assessment.

Biologist topic leaders and correspondent team members contributed their scientific expertise and field experience to assist the Government of Papua New Guinea to assess the existing knowledge of PNG's biodiversity and to determine geographic patterns of biodiversity distribution within PNG. Topic leaders and correspondent members included: Tundi Agardy, Gerald Allen, Allen Allison, William Asigau, Bruce M. Beehler, Ilaiah Bigilale, David Coates, Barry Conn, Robert Cowie, Jared M. Diamond, Lucius Eldredge, Tim Flannery, John Genolagani, Jeremy Holloway, Helen F. Hopkins, Michael Huber, Matthew Jebb, Robert Johns, Karol Kisokau, Samson Laup, Greg Leach, James I. Menzies, Christopher Mercer, Scott Miller, Patrick Osborne, Larry Orsak, John Pernetta, Dan Polhemus, Monika Rau, Simon Saulei, Richard Schodde, Lester Seri, Charles Tenakenai, Richard Vane-Wright, John Wilmot, George Zug, and Richard Zweifel.

Michael Brown, Hartmut Holzknecht and Vincent Warakai participated on the social scientists' CNA team. Owen Lynch, Jim Fingleton and Allan Marat worked together on the assessment of legal issues. Joash Yambut served as NANGO's Conservation Networking Officer dedicated to work on CNA. Member organizations of NANGO which worked closely with him on the CNA included Village Development Trust, PNG Trust, East Sepik Womens' Council, PANGO, Melanesian Environment Foundation, and other NANGO member NGOs. BSP thanks all those who provided assistance and answered the CNA

teams' questions in Port Moresby, Lae, Madang, Gahavisuka, Josephstaal, the Huon peninsula, and Canberra. The assistance of Michael Kanako of Melanesian Solidarity was especially helpful during the visit to Josephstaal. The BSP social scientists' team acknowledges the hospitality of Pr. Janadabing Apo and his family in Busong.

The Christensen Research Institute (CRI) and Jais Aben Resort in Madang provided excellent facilities for the CNA Workshop. Leisurely dinner conversations over the delicious meals prepared by the Jais Aben staff provided opportunities for informal discussion of the issues raised in formal sessions. BSP thanks Matthew Jebb, Director of CRI, for hosting the CNA Workshop and arranging local logistics. BSP thanks Charles Burg, Smithsonian Institution, for his assistance with management of the workshop. The workshop was professionally facilitated by John Huyler of The Keystone Center of Colorado, U.S.A., who worked tirelessly day and night, despite the loss of his luggage in the U.S. en route.

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Janis Alcorn and Bruce Beehler thank everyone who authored chapters of the CNA Report and everyone who participated in, funded, or otherwise supported the Papua New Guinea Conservation Needs Assessment. The CNA participants in turn acknowledge those who read and make use of the CNA Report -- for it is the readers' use of this report that will determine whether the CNA contributes to the process of linking conservation and development in Papua New Guinea.

Contributors

JANIS B. ALCORN has more than 20 years experience in the field of environment and development, and has authored books and articles on ethnobiology, international development and conservation of biodiversity. She has served as a AAAS Fellow advisor in natural resources to USAID and faculty member in the Biology Department at Tulane University. She is currently the Program Manager for Asia and the Pacific at the Biodiversity Support Program, housed at World Wildlife Fund in Washington, D.C.

M. TUNDI AGARDY is a marine biologist with expertise on sea turtles and marine ecosystem processes. She is a senior scientist in the Conservation Science Program of the World Wildlife Fund in Washington, D.C., and Vice-Chair of the I.U.C.N. Commission of Ecology.

ALLEN ALLISON is a vertebrate ecologist specializing in herpetology, small mammal faunas, and biodiversity of Melanesian rain forests. He is chairman of the Zoology Department and Assistant Director for Research at the Bernice P. Bishop Museum, Honolulu.

BRUCE M. BEEHLER is an ornithologist and tropical ecologist with expertise on the ecology and biogeography of birds of New Guinea and India. He is associate research zoologist for Wildlife Conservation International and Conservation International in Washington, D.C.

MICHAEL BROWN is an anthropologist with more than 15 years experience in development and conservation activities in Africa, the Caribbean, the Middle East, Asia, and the South Pacific. For the past three years, Brown has directed the PVO-NGO/NRMS Project, which strengthens the technical and institutional capacities of nongovernmental organizations (NGOs) in a full spectrum of natural resource management activities in sub-Saharan Africa. PVO-NGO/NRMS is a USAID-funded project implemented by a consortium of EIL, CARE, and WWF, and housed at WWF in Washington, D.C.

JAMES STREET FINGLETON is a Barrister, Supreme Court of New South Wales, and Barrister and Solicitor, National Court of Papua New Guinea. Fingleton is Managing Director of Palata Pty Limited in Canberra, NSW, Australia. He has acted as consultant on land tenure and forestry law reform in many countries in Asia and Oceania, including Papua New Guinea, Nepal, the Solomon Islands, and Vietnam. He holds a PhD from Australian National University.

HARTMUT HOLZKNECHT is a social anthropologist and a Papua New Guinea citizen. He has been active in human and natural resource development activities (both in academic and development consultancy work) in Papua New Guinea for the last 20 years. He is director of H S M Associates Pty Ltd consultant service in Canberra, NSW, Australia.

SUSANNE HOLZKNECHT is a linguist, particularly of Austronesian languages in the Melanesian region. She is a communications specialist focusing especially on the teaching and use of English as a second language and English for special purposes.

PETER HOBBY is an information specialist who, at the time of the CNA, was working for USAID, Center for Development Information and Evaluation in Washington, D.C.

ROBERT J. JOHNS is a botanist with more than 20 years of field and teaching experience in Papua New Guinea. He is currently a staff scientist at the Royal Botanic Garden, Kew.

JOSEPH KAU is a journalist and long-time volunteer with the Melanesian Environment Foundation in Port Moresby, Papua New Guinea.

OWEN J. LYNCH is an associate in the Asia Program at the World Resources Institute Center for International Environment and Development in Washington, D.C., and a lecturer at Johns Hopkins University School of Advanced International Studies. He has been researching and writing about community-based management of tropical forests in Asia for twelve years and taught at the University of the Philippines College of Law for seven years. Lynch holds law degrees from the Catholic University of America and Yale University.

ALLAN MARAT is a practicing attorney in Port Moresby, Papua New Guinea. He has been a professor of law at the University of Papua New Guinea. He holds an LlB from the University of Papua New Guinea, an LlM from Auckland University, and a PhD from Oxford.

SCOTT E. MILLER is an entomologist specializing on Microlepidoptera of the Pacific. He is chairman of the Entomology Department, Bernice P. Bishop Museum, Honolulu, Hawaii.

PATRICK L. OSBORNE is an ecologist, expert on the freshwater wetlands of Papua New Guinea. He was Lecturer in the Department of Biology, University of Papua New Guinea for many years. He is currently Senior Lecturer in biology at the University of Western Sydney, Hawkesbury, New South Wales, Australia.

JOHN PERNETTA is a vertebrate ecologist who for more than a decade was a lecturer in biology at the University of Papua New Guinea. He is currently an environmental consultant based in King's Lynn, United Kingdom.

SIMON SAULEI is a Papua New Guinean ecologist specializing on forest regeneration. He is a Lecturer in biology at the University of Papua New Guinea.

FRANCIS SUMANOP is a Provincial Planner for the Department of East Sepik Planning Office and organizer of the Arapesh Association of Landowners. He holds degrees from the University of Papua New Guinea and the University of Wisconsin.

J. FRED SWARTZENDRUBER is a specialist in international relations and economic development, with more than 10 years' experience in Asia and Africa. He is currently a consultant on contract with BSP.

JOASH YAMBUT is a Papua New Guinean land use specialist who has worked with private corporations and nongovernmental organizations. He is currently employed by the National Alliance of Non-governmental Organisations (NANGO).

SASA ZIBE KOKINO establishes and coordinates model projects and training programs for small-scale, community-based forestry programs. He also directs and manages the Village Development Trust in Lae, Papua New Guinea. He holds a degree in Wood Technology from Buckinghamshire University College, United Kingdom, and a Diploma in Forestry from Papua New Guinea Forestry College.

List of Acronyms

BSP	Biodiversity Support Program, a USAID-funded consortium of World Wildlife Fund, The Nature Conservancy, and World Resources Institute based in Washington, D.C.
CNA	Conservation Needs Assessment
DEC	Department of Environment and Conservation
EIA	Environmental Impact Assessment
FMA	Forest Management Area (see Chapter 2 for discussion)
GEF	Global Environment Facility (under World Bank and UNDP)
GOPNG	Government of PNG
ICAD	Integrated Conservation and Development Project
LFA	Local Forest Area (see Chapter 4 for discussion)
LO	Landowner ("Papa Graun") or Resource Owner. Refers to clan groups who have customary rights over land and resources as recognized by the national government.
NANGO	National Alliance of Non-governmental Organisations, an umbrella organization to which more than 100 PNG NGOs belong.
NFCAP	National Forestry and Conservation Action Programme, the Papua New Guinean adaptation of the Tropical Forestry Action Plan (TFAP).
NGO	Nongovernmental Organization
NROC	Natural Resource Options Centre (see Recommendations section in Chapter 4 for further information)
PNG	Papua New Guinea
SPREP	South Pacific Regional Environment Programme (see Chapter 2 for Discussion)
TRP	Timber Rights Purchase (see Chapter 2 for discussion)
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WMA	Wildlife Management Area, established at the request of Landowners and managed by LOs with assistance from DEC
WS	Wokabaut Somil (see Chapter 8)

Chapter One

Introduction to the CNA Report, Volume 1

Janis B. Alcorn[1]

Volume 1 of the Papua New Guinea Conservation Needs Assessment Report (CNA Report) analyzes the issues arising as conservation action proceeds in PNG, and offers recommendations to improve the chances for conservation success in PNG. It includes detailed analyses by lawyers, social scientists, NGOs, Landowners, and an information specialist. Volume 1 also covers the CNA Workshop and presents its main products: the CNA consensus maps of biologically important areas, points of agreement and unresolved issues identified during the workshop, and the CNA recommendations.

Given the importance of customary Landowners' rights in PNG, and the growing, global recognition that effective conservation action requires participatory approaches, the CNA Report opens with an assessment of the legal issues related to the rights and obligations of the State, individuals, and Landowner groups in relation to conservation action. In Chapter 2, Owen Lynch and Allan Marat assess the implications of strong Landowners' rights for strategies to achieve national conservation objectives. Lynch and Marat compare the situation in PNG with that of other countries, and concludes that PNG's national laws and policies require that conservation action be accomplished through meaningful collaboration between government and Landowners. Lynch and Marat summarize the 1991 Forestry Act and the Conservation Areas Act of 1978, and assesses their implications for Landowner-State relationships. They describe a strategy, based on existing laws and policies, for developing conservation partnerships between customary Landowners, the Government of PNG, and supportive international organizations. They recommend that Landowners be provided better information in order to make informed decisions about management of their resources. Pending the establishment of a Natural Resources Options Centre[2], every effort should be made to inform customary Landowners of the nature and full extent of their rights before customary owners are urged to exercise their rights, whether for conservation or commercial exploitation purposes.

Chapter 3, by James Fingleton, provides detailed information about specific environmental laws. Fingleton discusses the Constitutional principles related to conservation and assesses their legal implications. He outlines the legal and procedural aspects of the environmental impact assessment process, and analyzes their implications for environmental

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[1] Biodiversity Support Program, c/o WWF, Washington, D.C., U.S.A.

[2] The NROC is described in detail in Chapters 4 and 12.

protection. He describes legislation addressing water resources, plants and animals, and assesses the relationship of these laws to traditional rights over these resources. He also assesses laws related to National Parks and Conservation Areas, and the roles of government administrative units in relation to these laws. Fingleton summarizes land laws and tenure, and assesses their implications for conservation and resource exploitation. He notes that the statutory powers vested in customary Landowners allow them to perform environmental regulatory functions, but concludes that communities require better information in order to exercise such functions. This chapter also contains an outline of the steps for incorporation of landowning groups as an option for implementing conservation covenants and enabling Landowners to exercise their statutory powers to regulate environmental impact. Fingleton concludes that the impact of existing legislation depends upon the state's political will to balance environmental protection with resource exploitation.

Given that conservation is essentially a social and political process, and that conservation projects need to incorporate clearly-defined steps and processes for collaboration, the CNA Report next focuses on the critical relationships among stakeholders in resource management. In Chapter 4, Michael Brown and Hartmut Holzknecht present the sociocultural information relevant to conservation. They begin by describing the general relationships between people and nature in PNG. They identify the stakeholders in conservation -- the State, Landowners, business, national NGOs, and international conservationists -- and describe their interests and assumptions. Then they explore the conflicts between these stakeholders and the conservation issues arising from these conflicts. Brown and Holzknecht also focus on institutional capacities and relationships relevant to carrying out conservation action, particularly those affecting the prospects of collaboration 1) between NGOs and government, and 2) between Landowners and government. They conclude with recommendations. An appendix includes guidance for sociocultural feasibility assessments that must be done at the local level once a site has been selected for conservation action.

It is clear from the sociocultural and legal analyses that no one stakeholder can successfully implement conservation actions without active assistance and support from the other stakeholders. Neither the state nor NGOs can force Landowners to give up land for conservation objectives. Ultimately the Landowners will make choices to initiate activities that they perceive as being in their own short-term, medium-term and long-term benefit. Thus, detailed, two-way discussions with Landowners are essential processes for initiating, developing, and implementing any conservation project in PNG. Conservation decision options must be developed by Landowners, not framed by outsiders. Talking about "participation" is not sufficient, and perfunctory consultations do not substitute for collaboration. Continued failure to collaborate actively with Landowners on an ongoing basis will lead to failure of national conservation efforts in PNG.

Given the critical importance of Landowner participation in conservation planning, the next section of the CNA Report communicates NGO and Landowner perspectives on PNG's conservation needs and their concerns about the lack of formal mechanisms for Landowners to collaborate with government in resource management. Chapter 5, by Joash Yambut, contains the results of a Landowner survey conducted by the National Alliance of NGOs

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(NANGO). The survey found that Landowners are concerned about unclear mechanisms for Landowner representation in conservation planning and decision-making. Furthermore, Landowners aren't quite sure what outsiders mean by "conservation" and are therefore reticent to discuss it until they understand it better. NANGO recommends that a public awareness effort is essential so that Landowners have sufficient information in order to participate in conservation planning.

Chapter 6, by Joseph Kau of Melanesian Environment Foundation, is a critique of the CNA process from an NGO point of view. Kau questions whether those who don't have to live with the consequences of their decisions should be directing conservation efforts in PNG. He expresses concern that outside conservation interests will ultimately expose the people of PNG to further exploitation. Kau says that the focus of conservation action in PNG should not be on drawing circles around biodiversity-rich areas on maps, but rather the government should stop the current exploitation of resources and Landowners by enforcing existing laws. He recommends that Landowners receive information about resource use options and their consequences, as well as information about the benefits of conservation.

Chapter 7, by Francis Sumanop, a land use planner representing the Arapesh Association, defines Landowner Groups and outlines their values and limitations. He stresses that support for Landowner groups will ensure that development is appropriate, environmentally sound, and sustainable. Landowners without official organizational representation are especially vulnerable to exploitation. When they realize they are being exploited, Landowners are often forced to resort to illegal methods to express their grievances to authorities. Sumanop recommends that: Landowners be involved from the beginning to the end of any project; Landowners be given sufficient information to make sound choices; government develop communications linkages with Landowners; and projects recommended by Landowners be funded.

Chapter 8, by Sasa Zibe-Kokino of Village Development Trust, assesses the role of government and Landowners in conservation. He asserts that government and Landowners should not exaggerate or suppress the needs and rights of either side. Zibe stresses that good management of PNG's resources requires investment in fair treatment for all and ongoing negotiation to resolve conflicts. Since small blocks of forest are managed by different members of the Landowning group (individuals who may have different or conflicting interests), management of community forests requires attention to linking management planning to existing social and administrative organizations. Good information and education for government and local communities must be a management priority, because good long-range planning can only be done with knowledge of long-term impacts, benefits, and costs. Only then will local communities be able to effectively collaborate with government for conservation action. In conclusion, Zibe describes the Lasanga Protection Program initiated by Landowners and VDT in the Nasau Timber Rights Purchase (TRP) area. Landowners have seen the environmental damage and lack of spin off benefits in the nearby Kui TRP logging area, and are very interested in the Conservation Area option. Zibe recommends that the Lasanga-Lake Trist Conservation Area Project be funded as a pilot project under the new UNDP GEF project.

Given the importance of access to information, Chapter 9, by Peter Hobby, contains an assessment of issues and options for a PNG Biodiversity Data Center in the Department of Environment and Conservation. Hobby lays out the logistical, planning, and management issues that will require attention by DEC as they design their new information center.

Chapter 10, by Janis Alcorn, describes the CNA Workshop, including its objectives, the workshop process, the information and recommendations presented, the discussion, the general points of agreement, and the core issues. The CNA Workshop was designed to bring together conservation-related information for discussion by a broad-based forum, recognize the legitimacy of the various stakeholders in conservation decision-making, encourage lively debate in order to clarify issues, and stimulate dialogue in order to encourage collaboration. Unresolved issues included: concerns about how the CNA Maps will be used, disagreements about the appropriate mix of Landowner and state rights and obligations for achieving conservation, questions about the strength of the government's political will to support conservation, disagreements over the appropriate role of NGOs in conservation, and concerns over the distribution of benefits from scientists' work. Despite their diverse interests, workshop participants reached consensus on a number of points outlined in this chapter.

Good, geographically-based information is necessary for monitoring the national loss of biodiversity and establishing mechanisms for slowing that loss. Without nationwide geographic information about biodiversity, environmental degradation and loss of biological resources can be ignored at any specific location, because development planners can argue that national loss or mismanagement of biological resources can be addressed somewhere other than the geographical site of the immediate development in question. The CNA has created a GIS system containing existing information on PNG's biodiversity. Chapter 11, by Bruce Beehler, describes the CNA maps of biological diversity and the process by which they were generated. The maps in Chapter 11 include: a map of 16 biologically unknown areas that merit immediate survey and study; a map of 30 marine/coastal biologically important areas and 5 watersheds critical to the health of those marine/coastal areas; and a map of 42 terrestrial biologically important areas and 16 important wetland habitats. The CNA maps show specific terrestrial and marine areas of PNG where biodiversity conservation must be addressed at the national and provincial planning level. Biologists' detailed technical reports, bibliographies, and additional maps are presented in Volume 2 of the CNA Report.

Chapter 12 contains the CNA consensus recommendations drafted by representatives from the various teams after plenary discussion and approval of each teams' recommendations. Together the CNA maps and the CNA recommendations can be used to enable the PNG government and donors to target their limited financial resources more effectively. Because 97% of PNG is under private ownership by clans, conservation implementation issues are complex. Donors should not encourage the PNG government to develop top-down programs. In PNG, state-sponsored conservation will require public participation at a scale not yet achieved anywhere else in the world.

The Government of Papua New Guinea requested a "Stage One" Conservation Needs Assessment. Thus, the CNA was designed to be an initial assessment that should be followed by further action. The CNA increased public awareness of conservation issues and made a step toward increased public participation in conservation decision-making in PNG. Further CNA activities should be carried out at provincial and local levels to provide guidance for PNG's national effort to stimulate sustainable development. Following the CNA process, a nation-wide discussion of conservation and development issues, similar to the nation-wide discussion of issues that preceded Independence, would provide all Papua New Guinean citizens with the information necessary to make decisions, bring all the stakeholders into the debate and decision-making process, and provide the PNG government with a mandate on how to proceed with conservation and development of PNG's biological resources.

Chapter Two

A Review and Analysis of National Laws and Policies Concerning Customary Owners' Rights and the Conservation and Sustainable Development of Forests and Other Biological Resources[1]

Owen Lynch[2] and Allan Marat[3]

We have reached a time where the lines are not drawn between the known and the unknown but between belief systems....[W]e line up behind the banners of preservation, conservation, development, or restoration and then subdivide on points of human involvement, responsibility, and equity in resource management. The only realities left between these polemics are the resources and the people who use them.

A. Gómez-Pompa and A. Kaus[4]

Development should be a process of empowerment for decision making, and not a process of decision making for empowerment.

Vincent Manukayasi
Secretary-General
NANGO/PNG

Introduction

Papua New Guinea (PNG) is richly endowed in natural resources, biodiversity, cultures, and undocumented customary ownership of natural resources. The importance of PNG's human and natural resources is gaining increasing recognition on national and international levels. Widespread deforestation throughout much of tropical Asia, Africa and Latin America raises the commercial value of unharvested timber and other forest products. At the same time, the world's remaining tropical forests are being valued as biodiverse

[1] An initial draft of this paper was originally presented at the Conservation Needs Assessment workshop in Madang, Papua New Guinea, on April 9, 1992.

[2] Associate, World Resources Institute, Washington, D.C., U.S.A.

[3] Marat, Lawyers, Boroko, Papua New Guinea.

[4] Gómez-Pompa and Kaus 1992.

reservoirs and pharmacopeias, as well as carbon sinks which help slow the rate of global warming.

The land mass of PNG encompasses 46.3 million hectares, of which approximately 34.23 million ha are still covered by closed natural forests. Millions of hectares of marine resources are within PNG's exclusive economic zone that, in most instances, extends 200 miles from the nation's outermost coastlines.[5] On land, less than half of PNG's closed forests, or an estimated fourteen million ha., are considered to be accessible for commercial exploitation.[6] The estimated annual rate of deforestation ranges between 22,000 ha., or less 0.1 percent, to 290,000 ha., or about 0.6 percent.[7]

The government of Papua New Guinea recognizes that local people, pursuant to undocumented customary property rights, own 90 to 97 plus percent of the nation's total land mass, including almost all forests.[8] This extraordinary fact, mirrored elsewhere in Oceania, is globally anomalous. Throughout Asia, Africa and Latin America, most national governments do not provide any meaningful recognition of, or support for, undocumented customary property rights.[9]

The customary owners of terrestrial-resource rights in PNG are well aware of their status as owners, but many lack access to vital information needed to exercise their rights in ways which contribute to material well-being and sustainable development. Some customary owners have sold their rights, especially to timber, in return for cash payments and other inducements that are economically and environmentally inadequate. Others, confronted with increasing external pressures, strive to control the pace of economic development and natural resource exploitation.

This paper will review and analyze various perspectives concerning conservation and customary ownership in national laws and policies which bolster, or undermine, short-and long-term local incentives for conservation and sustainable resource management in PNG. It will contrast some prevailing assumptions about local resource use and capacities to manage forests and other biological resources in PNG. Lastly, it will describe a strategy, based on existing laws and policies, for developing conservation partnerships between customary

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[5] Articles 56 and 57, United Nations Convention on the Law of the Sea.

[6] Lamb 1990, 22.

[7] World Resources Institute 1992, Table 19.1, 287 is the source of the smaller estimate, which is based in part on satellite imagery. The larger estimate is found in Table 2.9, 44 of the 1991 Papua New Guinea National Report. It includes an estimate of 200,000 ha. a year for the "mainly disturbance" outcomes of subsistence agriculture. See p. 42 for additional estimates.

[8] The wide ranging extent of customary ownership is recognized despite PNG's comparatively low population density. Most references to customary owners, however, are to land owners. This paper invokes a broader reference to customary owners of natural resources.

[9] Lynch 1990, 1992; Plant 1991.

Landowners, the Government of Papua New Guinea, and supportive international organizations.

The Participation Imperative

Globally, there is a growing recognition of the need for innovative and participatory approaches to developmental and conservation initiatives. Much of the recognition is still largely rhetorical, but the emergence of a new and more substantive paradigm is becoming more evident. The Declaration of Forest Principles agreed to in June 1992 at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro states that "Governments should promote and provide opportunities for participation of interested parties, including local communities and indigenous people." It also provides that "National forest policies should recognize and duly support the identity, culture and rights of indigenous people [and] their communities."[10]

The Global Biodiversity Strategy Programme, which was launched in March 1992, places great stress on the need for local participation. The relationship between non-participation and the degradation and loss of biological resources was repeatedly raised throughout the developing world in consultations held to review the draft Strategy. The need to promote effective community-based biological resource management was likewise stressed repeatedly. A product of comprehensive dialogue with an array of local, national, and international stakeholders, the Strategy concluded that tenurial and related community resource management issues are key areas for action in the 1990s.[11]

The foremost objective of the IVth World Congress on National Parks and Protected Areas, held during February 1992 in Caracas, was to "demonstrate that protected areas can be a focal point of much more broadly-based rural development initiatives which can bring genuine benefits on a long-term basis to rural communities."[12] The regional review on the Pacific presented at the congress reported that

> One of the major lessons learned during the past decade is that the establishment of protected areas in the island countries of Oceania will require the consent of the custom or other land or resource owning groups. The corollary to this is that the permanent alienation of the land for protection is unlikely to occur.[13]

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[10] "Non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests," Sections 2(d) and 5(a).

[11] See. e.g., World Resources Institute 1992, proposed Actions 32 - 44, 57, 60.

[12] "Parks for Life: Enhancing the Role of Conservation in Sustaining Society," Programme 1992, p. 2.

[13] "Chapter 11. Pacific," Regional Review 1992, p. 11.7.

The need to meaningfully involve local people in all stages of project design and implementation was also evident in a recently published review of twenty two case studies of integrated conservation-development projects (ICDPs). A substantial portion of the study focused on the participation of local people in managing protected areas. It concluded that most of the projects "treated local people as passive beneficiaries" and "failed to involve people in the process of change and their own development." According to the authors, one of the principle lessons of this failure is that "the sustainability of project benefits depends strongly on the effective participation of local people."[14]

In view of the generally negative assessment, the authors of the review posed the question: "Why bother? Why promote the expansion of a concept that appears to be difficult to put into practice." Their published answer was that "ICDP approaches must be reinforced and expanded simply because there are few viable alternatives."[15] Their answer in an earlier draft was more candid and stated flatly that there was "no choice."[16]

These perceptions were also reflected in another review of ICDPs. It concluded that although "we are not very far along the ICDP learning curve, ... we are left with few other options." The authors added that

> we must wholeheartedly embark on the path of ICDPs, with all the uncertainties involved....If this sounds to you like a case where a certain amount of conviction, intuition or belief in the potential of an approach is required to help make the project work, you have understood perfectly a fundamental precondition for the successful design and implementation of an ICDP.

Constitutional Imperatives

Papua New Guinea is uniquely positioned to build on thes insights. Indeed, if PNG is a global anomaly in terms of its recognition of customary rights to terrestrial resources, it is likewise a global paradigm. National laws and policies mandating recognition of natural resource rights, in effect, also require that there be meaningful participation in local development and conservation projects. This fact provides fertile ground to establish innovative and democratic strategies that promote sustainable development and the conservation of biological diversity.

The most important law is the Constitution of the Independent State of Papua New Guinea. The fourth goal in the Constitution calls for the nation's "natural resources and environment to be conserved and used for the collective benefit of us all, and to be replenished for the benefit of future generations." The fifth goal is "to achieve development primarily through the use of Papua New Guinean forms of social, political and economic

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[14] Wells, Brandon and Hannah 1992, 47 and 63.

[15] Wells, Brandon and Hannah 1992, 60-1.

[16] Quoted in Brown and Wyckoff-Baird 1992.

organization." These goals provide constitutional guidance in the effort to develop conservation partnerships between the government and customary Landowners.[17]

Additional guidance is found in Section 53 of the Constitution which provides PNG citizens with protection against the taking or acquisition of customary property rights. Such a taking is only allowed if the property is required for a public purpose or for "a reason that is reasonably justified in a democratic society that has a proper regard for the rights and dignity of mankind, that is so declared and so described, for the purposes of this section in an Organic Law or an Act of Parliament."

Local Resource Ownership in PNG

The Independent State of Papua New Guinea recognizes that long-term use and occupation of terrestrial resources vests local people with ownership of these resources, irrespective of any documentation or registration. These rights of ownership cover 90 to 97 percent of the nation's territorial land mass. Perhaps most important, customary resource owners know that they have rights and they frequently do not hesitate to assert them.

Prior to PNG's independence in 1975, there were several attempts to legislate means for documenting and registering customary ownership rights, none of which were notably successful.[18] Most efforts were motivated by the colonial governments' determination to establish processes for: 1) the identification of customary owners; 2) the resolution of disputes over customary ownership; 3) the commoditization (i.e. marketability) of customary rights; and 4) government acquisition of customary rights. The primary economic driving force behind these laws was a desire to help expatriate colonists acquire tenurial security.

Widespread dissatisfaction with existing land laws among PNG nationals prompted a Commission of Inquiry into Land Matters (CILM), composed entirely of indigenous Papua New Guineans, to be constituted in 1973. The CILM report laid the foundation for many of the new land laws enacted after independence.

Local Conservation

Local conservation values in PNG manifest themselves in many ways. "[T]raditional customs and practices have played an important role in conserving natural resources as well as protecting habitats for wildlife." This has included "excluding hunters, fishermen and collectors who do not come from the land-[and marine-] owning groups." Some of these

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[17] Section 25 of the Constitution mandates that it is "the duty of all government bodies to apply and give effect to these goals." The same section adds, however, that the goals are "non-justiciable." The legal significance of this is that legislation enacted by Parliament is not legally challengeable even if it conflicts with the goals. This situation is quite different from constitutional jurisprudence in the United States. The Constitutional Planning Committee's intention, nevertheless, was "to contribute to the direction taken by the people and their government." Brunton and Colquhoun-Kerr 1984, 68.

[18] For a brief overview of these attempts see Mugambwa, 94-108.

values are rooted in traditional religious and magical beliefs that "are known to be prominent means of protecting plant and animal species and certain habitat areas."[19]

Many local communities have looked to the government for support in their efforts to conserve natural resources. At present, over 90 applications are pending in the Department of Environment and Conservation (DEC) to establish Wildlife Management Areas.[20] Although most have yet to be officially responded to, the applications are nevertheless proof positive that at least some local communities desire to conserve their natural resources and limit extraction and exploitation activities.

Customary Ownership: Help or Hindrance?

During the Conservation Needs Assessment (CNA) workshop held in Madang during April 1992, there was much discussion about the best ways to invoke customary ownership and promote conservation in Papua New Guinea. Representatives of resource owners and non-government organizations (NGOs) at the workshop repeatedly expressed concern about the need to involve resource owners at the outset of any conservation project or initiative. Many stressed that government-sponsored conservation initiatives in PNG should reflect the nation's Melanesian culture and build on local conservation values that still prevail in many rural communities.

The belief that many resource owners value and promote conservation on their own initiative was met with skepticism at the CNA workshop by some expatriate participants. The skeptics appeared to reflect the perspectives of past colonial overseers and view customary ownership as an obstacle to developmental and conservation activities in the now-independent country. Not all expatriates, of course, share this view. One long-time observer of Papua New Guinean ways, in obvious exasperation, attacked the traditional perspective eight years ago and asserted that

> It can be categorically stated that <u>this attitude itself</u> is the biggest obstacle to development in PNG. The real problem is a widespread lack of imagination in finding creative responses to customary land tenure.[21]

Expatriates at the CNA Workshop, espousing skepticism about traditional conservation values, correctly observed that resource owners are eager to improve their material well-being. Unfortunately, the skeptics correlated this eagerness with a need to pay people to conserve. The NGO and resource owners' representatives at the workshop countered that it was culturally inappropriate and morally wrong to conceptualize environmental initiatives in PNG on the premise that people must be paid to conserve.

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[19] Ila 1986, 22-3. For additional insights see the special 1985 issue on the "Environment in Melanesia" in <u>Catalyst: Social Pastoral Magazine for Melanesia</u>.

[20] Peter Hunnam, World Wide Fund For Nature (WWF) Australia, pers. com. (1992).

[21] Powell 1985, 3.

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Despite these conflicting perspectives, all parties agreed that traditional conservation practices in PNG are being undermined by modernization. The primary cause is the growing influence of the cash economy. Eager to improve their material welfare and provide a better future for their children, customary resource owners are being induced to sell their rights to timber and other natural resources. All too frequently, the buyers are unscrupulous logging companies that prey on the ignorance and aspirations of local people. The companies lure local leaders with trips to Port Moresby and cash hand-outs that rarely reflect the value of the rights sold. As a result, many rural communities have been deforested and otherwise environmentally degraded. Unfamiliar with modern banking and investment practices, many communities have also quickly lapsed back into monetary impoverishment.

There is no need in this paper to detail the misdoings in PNG's conventional forestry sector or the failure of the national government to mandate substantive reform or provide more environmentally benign alternatives for commercially exploiting natural resources.[22] As the Barnett Report noted

> There is a fog which is casting its cloud over forestry in this country. It is a mixture of meandering intellectual neglect, bureaucratic inefficiency and lack of honest political commitment to the visionary ideals of the constitution.
>
> Underneath this fog of inertia there are some very active timber companies in partnership with some very greedy citizens whose aim is to cut down trees and transport them to log ships. In this activity they are being very successful.[23]

The New Forestry Act

The government's main response to the problems detailed at length in the Barnett Report was the promulgation in 1991 by the Ministry of Forests of the National Forest Policy and the passage by parliament of the Forestry Act of 1991.[24] The National Forest Policy has two main objectives: first, to ensure that forest resources are exploited sustainably and, second, to use forest resources to promote the economic well-being and participation of Papua New Guineans.

The Forestry Act was designed to be the legislative vehicle for implementing the policy. Its most important provisions include the requirement that the Ministry of Forests be

[22] One alternative currently being promoted under the auspices of the Melanesian Sustainable Forestry Program is the use of portable "wokabaut somil" sawmill technology. The program is being partially funded by a USAID grant to the Foundation of the Peoples of the South Pacific.

[23] Commission of Inquiry [The Barnett] Interim Report No. 5 "Concluding Comments" 1990. See also Marshall 1990.

[24] Although the amended bill passed parliament, extra-legal behind-the-scenes maneuvering prevented the new law from being published in the official gazette as scheduled on April 15, 1992. Until published in the gazette, the new Forestry Act will not become legally binding.

reorganized into a professional Forest Authority that is to be overseen by a comparatively independent National Forest Board. Unfortunately, vested interests within the conventional forestry sector weakened the proposed act after it was submitted to Parliament. The result of the amended bill was "to transfer much of the decision-making power to the Minister of Forests ... a strategy which had always been at the root of criticism over forestry in PNG."[25]

Another important change in the new Forestry Act is its repeal of the Forestry (Private Dealings) Act.[26] Enacted in 1974, one year before political independence, the Private Dealings Act authorized customary owners to sell their timber rights via agreements entered into with private parties. The Private Dealings Act was the outcome of a "strong political battle" fought in the behalf of customary owners who were "seldom happy with the amount of consultations that occurs under Government mediated Timber Rights Purchases (TRPs), particularly where the concession is held by an international company."[27]

Unfortunately, under the Private Dealings Act, the Timber Rights Purchase agreements were often entered into by local headmen who failed to consult the national government, or sometimes even their co-owners, before agreements were entered into. Many agreements also contained no provisions for environmental safeguards or long range planning and sustainable development. The Barnett Report summed up one outcome of the Private Dealings Act by concluding that "In many cases the timber industry has made life harder for the Landowners at all levels. Not only do they have to face destruction of their environment, but they face the destruction of their society."[28]

The new Forestry Act reverts to the previous mode of concession-making. It states that "The rights of the customary owners of a forest resource shall be fully recognized and respected in all transactions affecting the resource."[29] Customary owners, however, will only be able to enter into Forest Management Agreements (FMAs) with the Papua New Guinea Forest Authority. FMAs vest "the exclusive right of cutting and removing timber from the area covered by the Agreement" in the Forest Authority, which will then grant concessionary rights to commercial extraction enterprises.[30] Ostensibly enacted to protect customary owners and their local environments, these provisions nevertheless reflect a growing pattern of state usurpation of customary property rights.

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[25] Wau Ecology Institute 1992, preface. See also Millett 1991, 11.

[26] Chapter No. 217. (All Acts in PNG [including any amendments thereto and their associated Regulations] have a unique Chapter Number in the Revised Laws of Papua New Guinea.)

[27] Sargent 1989, 30-31.

[28] Summary of the Barnett Report, p. 18.

[29] Forestry Act, Section 46.

[30] Forestry Act, Section 60.

National Legal Usurpation Paradigms

The attempt to circumscribe customary ownership rights in the new Forestry Act has parallels in other laws enacted before and since independence. Indeed, it is not far-fetched to conclude that the Independent State of Papua New Guinea is embarked on a systematic strategy to circumscribe, and in some instances usurp, customary rights to natural resources.

> Most of the laws relating to natural resources date from the pre-independence period [1975], and they reflect the prevailing Australian attitude that such "God-given" resources are naturally the property of the State . . . . Meanwhile, elaborate and artificial arrangements are resorted to, in order to adapt to the reality that peaceful and reliable access to minerals, petroleum, etc., is not possible without including customary owners in the benefit-sharing.[31]

Usually invoked on behalf of such lofty purposes as the "public good," the strategy of usurping undocumented customary property rights in the name of the state is well-developed and established in the neighboring nations of Indonesia and the Philippines, as well as many other developing countries.[32] The usurpation undermines local systems of natural resource management. It is perpetuated in ways that are often confusing to and beyond the range of influence of most customary owners.

> For legislation to be effective it must be seen to be working with a wider public acceptance. Most laws in Papua New Guinea are too complicated to be understood by ordinary village people. It is important that legislation is simplified and incorporates indigenous customary law and traditional environmental management practices within a modern legislative framework.[33]

Unfortunately, although such advice is especially apropos in a country that recognizes customary natural resource rights, it has been largely ignored, even after 1975. The Petroleum Act of PNG is one of the most complicated examples of legislative usurpation. It provides that "[N]otwithstanding anything contained in any other law or in any grant, instrument of title or other document, all petroleum and helium at or below the surface of any land is, and shall be deemed at all times to have been, the property of the state."[34]

The Water Resources Act establishes that "the right to the use, flow and control of water is vested in the State." The state's claim is limited, however, in that it "does not

[31] Fingleton 1992.

[32] See, e.g. Lynch 1990, 1992.

[33] Ila 1986, 66.

[34] Chapter No. 198, Section 5.

affect customary rights to the use of the water by the citizens resident in the area in which those rights are exercised."[35]

The Land Act authorizes the Minister for Lands, after a two months notice, to invoke "compulsory acquisition" and usurp customary property rights "for a public purpose specified in the notice."[36] The Land Registration Act precludes the transfer of any rights or interests in land unless any certificate of title or document pertaining to the deal is registered.[37]

The recently superseded Mining Act flatly asserted that "All gold and minerals in or on any land in the country are the property of the State."[38] Perhaps because of some nascent concern regarding the state's expanding usurpation of customary property rights, this blanket assertion was modified in the new Mining Act of 1992. It declares that "All minerals existing on, in or below the surface of any land in Papua New Guinea, including any water lying on any land in Papua New Guinea, are the property of the State."[39] This provision is qualified by an ambiguous proviso that provides

> Nothing in Subsection (1) shall be construed as an additional acquisition of property in relation to Section 53 of the Constitution beyond that which prevailed under ... all previous Acts.

Although it has yet to be judicially interpreted,[40] the qualification appears to benefit customary-rights holders. The previous Mining Act already usurped customary rights to minerals. Furthermore, Section 53 of the Constitution authorizes compulsory takings if the property is required for a public purpose or for "a reason that is reasonably justified in a democratic society that has a proper regard for the rights and dignity of mankind."

It will eventually be necessary for the courts of PNG to define "public purpose" and "reasonable justification" in the context of democratic society and within the broader confines of the PNG Constitution. This paper is not the place to attempt to articulate such definitions in the context of Papua New Guinea. Reflecting on experiences in Southeast Asian nations,

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[35] Chapter No. 205, Sections 5(1) and (2). Emphasis supplied. The underlined phrases could be read as limiting the extent of customary rights, rather than as a limitation on the State's assertion.

[36] Chapter No. 185, Section 17.

[37] Chapter No. 191, Section 17(1).

[38] Chapter No. 195, Section 7.

[39] Chapter No. 195, Section 5(1).

[40] A prominent lawyer in PNG, Peter Donigi, has filed a legal challenge against the national government concerning its assertion of ownership of minerals and petroleum resources. Donigi wants the court to rule that mineral and petroleum deposits belong to customary resource owners. The case was dismissed in February 1992 in the National Court for lack of standing and Donigi subsequently filed an appeal in the PNG Supreme Court. Kone 1992, 19.

however, it should be evident that the "public good" needs to be defined in a broad context that, at minimum, factors in the rights, claims, and aspirations of all the citizenry, and in particular those who may be adversely affected by the specific state action being considered.

In negative terms, the "public good" should never be defined solely in reference to the potential of political and economic elites, whether domestic or foreign, to profit from the action under consideration. Yet this occurs all too often in many countries where political and economic elites use the authority and power of the nation-state to enrich themselves and their families and friends.[41] This type of behavior exists in PNG but apparently it is not as rampant as in other countries. This is probably due, in large measure, to the State's recognition of undocumented property rights which has, among other things, hindered efforts to promote rural development schemes that would benefit a few while displacing or otherwise disenfranchising large numbers of rural people. The growing penchant for using national laws to arbitrarily and indiscriminately usurp customary property rights to natural resources, however, is an potentially ominous portent of future developments in PNG.

Formal Recognition of Customary Rights

Despite these concerns, the national legal landscape in PNG remains much more hospitable to local resource users than other tropical countries rich in biodiversity and other terrestrial and marine resources. The government and people of PNG have had considerable experience in devising means for recognizing customary rights, identifying customary ownership groups, and resolving conflicts that arise where claims and rights overlap.

Difficulties persist with efforts to formally recognize, i.e., officially document, customary rights. The primary problem arises from the Western-inspired overemphasis on segregating individual customary rights from the more broadly defined clan holdings. By contrast, the Land Groups Incorporation Act and the Land Disputes Settlement Act have proven to be much more successful. The law on dispute settlement establishes a decentralized, three-tiered process for resolving conflicts over property rights. The group incorporation law provides a process by which customary groups can be recognized as landowning entities. "The importance of this law cannot be overstated, for it means that the legal system of PNG recognizes the corporate nature of that social unit which exists at the intermediate level between the State and the individual."[42]

In order to achieve the fourth goal in the Constitution (see page 4), certain directive principles have been provided:

We accordingly call for -

(1) wise use to be made of our natural resources and the environment in and on the land or seabed, in the sea, under the land, and in the air, in the interests of our development and in trust for future generations; and

[41] See, e.g., Rush 1991.

[42] Fingleton 1992.

(2) the conservation and replenishment, for the benefit of ourselves and posterity, of the environment and its sacred, scenic, and historical qualities; and

(3) all necessary steps to be taken to give adequate protection to our valued birds, animals, fish, insects, plants and trees.

Pursuant to these Directive Principles certain Acts of Parliament have been passed wholly or partly for protection and conservation of the natural environment. Some of these Acts are referred to in this paper.

The government desires conservation of PNG's natural environment. It wants to fully realize the directive principles for full attainment of the fourth goal in the Constitution, in particular the directive principle that "all necessary steps [are] to be taken to give adequate protection to our valued birds, animals, fish, insects, plants and trees." In effect this means protecting and conserving biodiversity.

Attempts to enter into legally binding conservation agreements with Landowners is a necessary step, but what are the Constitutional, legal and social ramifications of such a move? Obviously it has constitutional backing, and other constitutional checks are in place. The state cannot simply force its way into customary land areas and implement its conservation ideas. Landowners are specially protected from unjust deprivation of property (Constitution, Section 53). This right is enforceable by the highest court of PNG (Constitution, Section 57); infringement of it is compensable (Constitution, Section 58). In coming to Landowners the state must do so fairly and in principle be seen to act fairly -- the principles of natural justice (Constitution, Section 59). Landowners' awareness of their constitutional rights in this regard has enable the state to observe the constitutional requirements. And in view of entering into conservation agreements the state has observed and encouraged Landowners to exercise their qualified rights to liberty, freedom of conscience and thought, freedom of expression and freedom of association.

Legal Framework and Perspective

For certainty of continuous observance of conservation agreements the parties must be identifiable. Given the nature of land tenure among customary Landowners throughout PNG it seems inevitable that Landowners incorporate themselves as separate single entities.

The Forestry Act and other Acts of Parliament relating to developments in agriculture, tourism, etc. provide only for consultation with Landowners but do not spell out the issue of identification of Landowners. This, of course, is better left to the Land Courts if necessary; for instance Section 4(2) of the new Mining Act which provides that a dispute arising as to interests in customary land or the position of boundaries of customary land shall be settled as provided for by the Land Disputes Settlement Act. The new Mining Act <u>does not</u> provide for involvement of land<u>owners</u> in consultation; it only provides for consultation with land<u>holders</u>. This appears to be a deliberate choice of word by somebody perhaps insensitive to cultural realities in PNG. Many outsiders frown upon the term "Landowner" in PNG. Holding or possessing land does not necessarily mean owning it. A foreign perception of landholding seems to have been deliberately orchestrated throughout the new Mining Act and one can infer from such orchestration that the new Mining Act has created more potential problems for the mining industry in this respect. One need only look at the Mount Kare problem as a classical example of what can happen when true customary land<u>owners</u> are not identified properly and only land<u>holders</u> are involved in the mining industry in Papua New Guinea.

Land Disputes Settlement Act: In 1975 the Government of Papua New Guinea enacted the Land Disputes Settlement Act to deal with disputes over ownership, boundaries, usufructuary rights or other interests over customary land. The Act provides for mediators and establishes the Local and District Land Courts throughout PNG. These, collectively satisfied the need for a just, efficient and effective machinery for the settlement of disputes by encouraging self-reliance through the involvement of the people in the settlement of their own disputes and the use of the principles underlying traditional dispute settlement processes. The Act has operated with a certain degree of success in many Provinces.

Disputants are encouraged to amicably settle their disputes within a legally monitored framework. This is seen in the provisions for mediation at which level the parties are encouraged with reason in the presence of mediators and other interested persons to arrive at an agreement on the issues before them.

An agreement reached on the issue or issues during mediation is forwarded to the Local Land Court which makes preliminary enquiries on the propriety of the agreement. When the Local Land Court is satisfied that the agreement was properly reached between the disputing parties it approves the agreement as being an order of the Local Land Court under the Act.

When there is no agreement at the mediation level the dispute is transferred to the Local Land Court for determination of the customary rights issues. The procedures are informal and the strict rules of evidence are inapplicable. There is no restriction as to the number of witnesses. Only when each party has indicated that it no longer intends to call any other witness does the court close the process of adducing evidence. Given this informality the trials, on numerous occasions, are prolonged. The intention is to give each party every conceivable opportunity to present its case in whatever way it deems sufficient and to put an end to the disputes.

Appeal from a decision of the Local Land Court lies to the District Land Court which is supposed to be the highest court of appeal. However, certain provisions in the Constitution enable an aggrieved party to apply further to the National Court for judicial review. The National Court has not shied away from exercising its inherent powers under the appropriate constitutional provisions to review decisions of either the Local Land court or the District Land Court.

Decisions of the Local Land Court, the District Land Court and the National Court after judicial review do not give any certainty of title. Even the Act does not provide for it.

An agreement reached during mediation and approved by the Local Land Court has the same effect as an order of the Local Land Co rcising its original jurisdiction. An individual securing a favorable decision on ownership by the Land Court is left with nothing more than an authoritative decision on ownership or other customary rights. He cannot secure loan fundings for any development he may want to effect on the land. Uncertainty and an enormous amount of risk would surround any agreement to develop the land he may enter into.

Many Landowners who have secured favorable decisions from the Land Courts have not hesitated to take further steps in the direction of tenure conversion and incorporation of the Landowners as a Land or Business Group. Even with tenure conversion there are problems. For instance, only a maximum of six names of persons of a customary group is allowed in the application and subsequently the Certificate of Title (freehold title document) issued.

<u>Business Groups Incorporation Act</u>: This Act enables the incorporation of customary groups for business and other economic purposes, and provides for the control and regulation of the conduct of business by such groups. The linkage is there between the purposes of the Act and the Integrated Conservation and Development Projects (ICADs or ICDPs). Business groups, as corporations (though not corporations for the purposes of the Companies Act), are conferred power to conduct business enterprises, borrow money, and acquire, hold, dispose of and manage land. It seems then that Business Groups would do more in contributing to the facilitation of conservation agreements and the design, execution, and monitoring of ICADs (ICDPs).

The Act falls short of defining "customary groups" although it may be seen as facilitating collective decision capacity (CDC).

<u>Land Groups Incorporation Act</u>: Another option is for Landowners to be incorporated as Land Groups and vested with power to acquire, hold, dispose of and manage land and other ancillary powers. Linkages can be seen between Land Groups and conservation agreements and ICADs (ICDPs). The Act does not define the term "customary groups". The drafters' perception of "customary groups" may have been different from that of Landowners. The latter sees "customary groups" more in terms of lineal descent and other relationships appropriate to ownership. The term "similar group" is used but, again, not defined. The term is taken to mean that people not from the lineage system may be co-opted as members of the "customary group" to be incorporated under the Act. It does not work this way in customary groups.

In Section 8 of the Land Groups Incorporation Act the <u>constitution</u> of an incorporated Land Group must set out, *inter alia*, the "qualifications for (and disqualifications, if any, from) membership of the group." This implies inclusion of other persons -- an action conducive to problems over ownership of land.

Both the Business Groups Incorporation Act and the Land Groups Incorporation Act supplement the leadership structure within the Landowner Group itself in terms of increasing certainty in the group's CDC. This eases any anxiety in the process of realization of conservation agreements with Landowners.

The procedures facilitate determination and identification of owners. Both the Business Groups and the Land Groups can operate with some sense of security following determination by either the Local Land Court and/or the District Land Court.

Once an area rich in biodiversity is identified the process of identification of the true Landowner may begin. In the event that there are conflicting claims as to ownership, the procedures for identifying the true owners pursuant to the Land Disputes Settlement Act may be adopted. Once the identity of Landowners has been established the Landowners may consider incorporation either under the Business Groups Incorporation Act or the Land Groups Incorporation Act. After incorporation as a Business Group or Land Group, Participatory Rural Appraisal (PRA) may then commence, involving both the state and the Business or Land Group and other Landowners whose land might adjoin target areas.

Certainty of ownership of land designated as areas rich in biodiversity may be established if the process of identification of Landowners have some legal sanctions such as provided under this Act and the Land (Tenure Conversion) Act, which latter Act provides for the conversion of the tenure of customary land into individualized tenure and other related purposes.

Customary rights are manifold. The Customs Recognition Act contains provisions for the recognition of customs generally. The right of ownership and other rights relating to customary land are currently governed by the Land Disputes Settlement Act. But while this Act provides the mechanism for resolving disputes it falls short of providing certainty of title.

Constitutional and legislative support for conservation agreements stemming from provisions on conservation of the natural environment is not lacking. What is needed is a model comprehensive social framework which may be remolded and redeveloped from time to time and within which careful PRA is to be conducted with a view to securing optimum results in the design, implementation and monitoring of conservation agreements and ICADs (ICDPs). More social knowledge of each Landowning Group's needs (social and economic) and cultural aspirations is required before informed decisions on how best conservation agreements and ICADs (ICDPs) can be fitted to Landowners are arrived at.

Legislative support for Landowners to organize themselves is also not lacking. Landowners' CDC has been reinforced in many instances with the incorporation of either Business or Land Groups. Practical organization of Landowners is needed. Then Landowners will have legally sanctioned CDC. This may not make much difference to what is naturally existing in the customary groups but at least certainty of identity for future dealings especially for purposes of input to conservation will have been established. The process of identification of owners of customary land has legislative assistance but needs to be further developed in terms of providing certainty of title.

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Conservation, Law, and Customary Tenure

The need for local participation in conservation activities in PNG is more likely to be met because of the wide ranging extent of recognized customary resource rights. Another hopeful sign is the widespread belief in PNG that

> for nature conservation to succeed, people must be offered adequate inducement to cooperate and collaborate with the national agencies to promote nature conservation programmes and projects. Because most land in Papua New Guinea is owned by the people, it is appropriate that traditional Landowners are involved in decision-making and planning processes.[43]

The foremost law in PNG for promoting conservation of biodiversity and forests is the Conservation Areas Act of 1978.[44] According to this law, conservation areas can be established by the Head of State pursuant to a recommendation by the Minister of Environment and Conservation or a "person, group of persons or authority may make a written request to the Minister." The recommendation should include an inventory within the area of: 1) residents; 2) land ownership; 3) land uses; and, 4) features of special significance.

Once a conservation area is declared, a Management Committee is constituted by the National Conservation Council. The committee "shall reflect the interests of" customary owners within the area, as well as local government officials. Among other things, the management committee is responsible for preparing an area management plan, recommending rules to the Minister, and directing the work of rangers assigned to the area.[45] The rules "for the protection, development, land use activities, management and control of the conservation area" should only be drafted after consultation with "as far as is practicable the owners of the land within the conservation area."[46]

As the foregoing review demonstrates, the Conservation Areas Act requires customary resource owners to cede a considerable degree of their existing rights in return for unspecified potential future benefits. Despite this uncertain trade-off, there are indications that some customary owners are prepared to establish conservation areas in their locales. But the law remains unimplemented thirteen years after it was enacted.[47]

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[43] Ila 1986, 65.

[44] Chapter No. 362.

[45] Fingleton (1992) observed that under the Conservation Areas Act "Landowners could have even greater 'hands-on' involvement by being appointed as rangers."

[46] Conservation Areas Act, Sections 27 and 28.

[47] The primary reason cited for the law's non-implementation has been the failure to establish the National Conservation Council. The failure has been ostensibly attributed to Section 4(2)(b) of the law which required

(continued...)

Until the Conservation Areas Act is implemented, efforts to promote conservation under the auspices of national law must rely on the National Parks Act[48] and the Fauna (Protection and Control) Act.[49] The National Parks Act is unappealing to customary owners since it requires them to cede their rights to the national government before a national park can be established.[50] After a cession of rights, customary owners would have no legally enforceable means for participating in decisions regarding how resources within the reserved areas are utilized or conserved. As a result, less than 3 percent of the country's land mass has been reserved in three national parks.

The Fauna (Protection and Control) Act of 1978 is largely limited to protecting animals. The act, however, is more akin to the Conservation Areas Act insofar as customary rights are concerned. It is also operational and provides for a more streamlined process for establishing wildlife sanctuaries. As of December 1991, 18 Wildlife Management Areas had been established. In addition, as noted above, over 90 applications are pending in the Department of Environment and Conservation (DEC) to establish Wildlife Management Areas.[51]

Like the Conservation Areas Act, the Fauna Act requires consultation with "as far as is practicable the owners of the land within the area." The Conservation Areas Act consultation-requirement, however, only applies to the promulgation of rules for managing the area. Under the Fauna Act, consultation with customary owners is required before the Minister of Environment and Culture establishes a Wildlife Management Area and before rules for the area are being promulgated.[52]

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[47](...continued)
that at least one member of the council be nominated by the Local Government Association, an entity that does not exist. As of April 1992, a bill was pending in the parliament that repealed Section 4(2)(b) and replace it with a requirement that at least one member of the council be "nominated by the Premiers' Council established by Section 82 of the Organic Law on Provincial Government."
A major impetus behind recent efforts to implement the law has been the World Bank's National Conservation and Resource Management Programme.

[48] Chapter No. 157.

[49] Chapter No. 154.

[50] "Public" land reserved as a public park under the Land Act can be "committed to the care, control and management" of the National Parks Board." Customary property rights bequeathed or gifted to the government can also be accepted by the Board. Chapter 157, Sections 14(1) and 15(1).

[51] Peter Hunnam World Wide Fund for Nature (WWF), pers. com. (1992).

[52] Sections 15(2)(a) and 17(2)(a). Other laws mandating the involvement of customary resource owners include the Environmental Planning Act, the Environmental Contaminants Act, the Water Resources Act.

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Natural Resources Options Centre

Current laws in Papua New Guinea related to conservation, development and customary ownership, as well as widespread cultural values, provide an adequate, although improvable, means for ensuring local participation and benefit sharing. Examples of local conservation initiatives abound. Although there is a need to develop and provide more opportunities for economic development, equally if not more important is the need to provide customary resource owners with information regarding the various ways that they might currently exercise customary rights and the short- and long-term implications of their decisions.

The need for customary owners to have access to information has been gaining increased recognition in PNG. The primary impetus has been the growing pressures on customary owners to sell their rights to exploit natural resources and the unsustainable exploitation that has subsequently ensued in many locales. During the past few years, three major studies have been conducted as a prelude to a possible Landowner Awareness Project (LOAP). The latest study, conducted during June and July 1991, was a by-product of the ongoing review of PNG's Tropical Forestry Action Programme.[53]

The study noted that "[a]wareness campaigns in Papua New Guinea have had an uneven track record," and it identified two common reasons: first, basic and important principles of communication have been ignored by project planners and designers, and second, models developed in other countries have been indiscriminately applied in PNG "with predictable negative results." The report then offered two "guiding principles" for effective awareness work in PNG. The first principle is that "[e]ffective communication cannot go in one direction only, it must flow back and forth in a dialogue process." The second principle is that "[e]ffective communication cannot go very far without a set of shared assumptions and values . . . . not only about communication itself, but also about the reasons and motivations for engaging in the communication process in the first place."[54]

Issues related to information management and distribution among customary owners were discussed at length during the Conservation Needs Assessment. A consensus recommendation of the participants was that

> An autonomous Natural Resource Options Centre (NROC) should be established to collect, create and disseminate information relevant to conservation and development. The NROC should act in the public interest through: a) the development of broad-based awareness programmes on environment and development, and b) the provision of balanced and detailed information, especially to Landowner groups, on the available natural resource

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[53] Faraclas, et al. 1991.

[54] Faraclas et al. 1991, p. 34.

development options, their consequences and impacts, and the positive and negative development experiences of other Landowner groups.[55]

The concept of an options center conforms to the first guiding principle in the 1991 LOAP report. Customary owners possess a great deal of local knowledge that should be tapped. As holders of recognized natural resource rights, they already possess important economic and legal incentives to conserve and sustainably use natural resources for their benefit and the benefit of future generations. What they lack, and sorely need, is an independent institution that can service their needs for factual and unbiased information regarding possible developmental choices and likely outcomes. Customary owners who opt to sell or cede their rights also need to be able to learn about investment and other financial choices available to them.

The NROC should be as decentralized as possible. Indeed, it may be preferable to establish a Natural Resource Options Centre that has the same functions envisioned for the options center, but is organized in a way that ensures the maximum degree of sensitivity and responsiveness to the informational needs of customary owners.

Meanwhile, pending the establishment of an options center or network, every effort should be made to inform customary owners of the nature and full extent of their rights before any effort is exerted -- by government officials or commercial entrepreneurs -- to get customary owners to exercise their rights, whether for conservation or commercial exploitation purposes.

Conclusion

The rich forests and other biological resources of PNG, coupled with the unique status of customary Landowners, provide PNG with exciting opportunities to conserve and sustainably develop the nation's forest resources. National laws provide an adequate framework for promoting these opportunities. The Melanesian cultures of PNG also weigh in favor of sustainable development, although the pressures and demands of the growing cash-economy are undermining many traditional values. The most pressing unmet need is to provide customary resource owners with relevant and accurate information on their development options. It remains to be seen whether this need will be met.

[55] See Chapter Twelve of this Report.

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Chapter Three

Conservation, Environment Protection and Customary Land Tenure

James S. Fingleton[1]

INTRODUCTION

The Government of Papua New Guinea, through its Department of Environment and Conservation (DEC), has approved the conduct of a Stage One Conservation Needs Assessment (CNA), as a preliminary step in developing a long-term strategy for the conservation and sustainable development of its natural resources. Among the recent factors behind this initiative have been

(a) the major build-up in PNG over the 1980s of mining and petroleum development;

(b) preparation under the World Bank of a Tropical Forestry Action Plan for PNG (now called the National Forestry and Conservation Action Plan - NFCAP), following on the highly critical Barnett Report into the forest industry; and

(c) partly in response to (a) and (b), an increased awareness about environmental degradation and a growing public concern, reflected in the appearance of a number of new environmental Non-Government Organizations (NGOs).

The CNA's main aims are to analyze

(i) what is known about PNG's biota and ecosystems, and their conservation values;

(ii) the cultural, institutional, and legal context for conservation action; and

(iii) land owners' assessment of conservation needs.

During the CNA project, teams of biologists and social scientists will review scientific data and analyze the issues, and an information management team will work towards setting up a comprehensive biodiversity database for PNG. The National Alliance of Non-Governmental Organizations (NANGO-PNG) will assist in canvassing the concerns of customary landowners, and their perspectives on conservation. Towards the end of the

[1] Palata Pty., Ltd., Canberra, Australia.

project, a workshop will focus on technical aspects of PNG biodiversity and produce a priority list of areas warranting long-term preservation, followed up by a seminar to identify the necessary conservation action. A report, giving a final biodiversity assessment and implementation recommendations, will then be submitted to the PNG Government.

Among the outcomes of the CNA, it is anticipated that it will be possible to select areas

(i) for declaration as Conservation Areas;

(ii) for inclusion in a Representative Protected Areas System; and

(iii) as pilot areas in an Integrated Conservation and Development Program,

all of which components have been included in PNG's request for support through the Global Environment Facility (GEF).

As the great bulk of PNG's land is held under customary tenure, both the NFCAP and the GEF documentation rightly stress the need for full involvement of the customary landowners. The GEF Activity Objectives state that the intended national conservation program "will integrate conservation of biodiversity with the complex land tenure systems of Papua New Guinea, designing and establishing mechanisms for landowners and community groups to participate directly in projects for the conservation and sustainable use of natural resources" (GEF n.d.:103). Under the proposed GEF project it is also intended to trial the new concept of conservation covenants, under which it is proposed that the "conservation interest" in land could be legally acquired just like mineral, oil, or timber rights (ibid.).

In contrast to its Southeast Asian neighbors, PNG shares the South Pacific Islands tradition of giving definite legal recognition to customary land ownership. Customary land is not State land or public land, or even "common" land; rather, it is owned by kinship groups, under customary tenure. In PNG's case, customary land amounts to more than 97% of the total land area -- a much higher proportion than for most other island states. PNG is also somewhat special for the fact that only the U.S. Territory of Guam preceded it among the island states in establishing a government agency to develop and implement conservation and environment protection law (Carew-Reid 1989:32). The present project, therefore, requires a good understanding of the current PNG law on customary land ownership, conservation and environment protection. On this basis, legal and administrative options for conservation management which are appropriate to PNG's circumstances can be recommended. The purpose of this background paper is to analyze the relevant laws and make such recommendations on appropriate options, for consideration in the first place by the CNA social science team, and ultimately by the Government of PNG.

The present treatment will begin by examining how conservation is addressed under PNG's legal system -- how the law deals directly with conservation and environment protection, how the environment is affected by laws dealing principally with other subject matters, and how the relationship between resource conservation and exploitation is legally ordered. The role of custom in PNG's legal system and the differences between the legal regimes applying to State land and to customary land will also be treated. Administrative structures and the distribution of functions between national, provincial and local levels must be considered too, to fill out the formal picture of PNG's conservation landscape. Having set the scene, the rest of the paper identifies and appraises the various alternatives -- in PNG's legal, administrative and cultural circumstances -- for promoting the more effective conservation and management of natural resources, in particular by local landowners. This includes setting out the legal and administrative steps involved in carrying out the different options.

CONSERVATION AND ENVIRONMENT PROTECTION IN PNG

Laws dealing directly with conservation and environment protection

(a) Constitutional principles

As mentioned in the introduction, PNG has a relatively well-developed set of conservation and environment protection laws, with antecedents dating to before independence in 1975. Whereas the pre-independence laws applied only to particular aspects of the environment (fauna protection and water resources) and to the limited scope for declaring national parks over State-owned land, the body of law introduced in 1978 took a more comprehensive approach to environment protection, and supported a more participatory approach to conservation. This was consistent with the ethos of independent PNG, projected by the National Goals and Directive Principles contained in the 1975 *Constitution*. The five National Goals are:

1. *Integral human development*
2. *Equality and participation*
3. *National sovereignty and self-reliance*
4. *Natural resources and environment*

   ("We declare our fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit of us all, and to be replenished for the benefit of future generations.")

5. *Papua New Guinea Ways*

   ("We declare our fifth goal to be to achieve development through the use of Papua New Guinean forms of social, political and economic organisation.")

In the mood of the times, conservation and resource use on a sustainable basis were seen as self-evident public duties, rather than as essentially the responsibility of the State. The scheme of legislation introduced in 1978 comprised the *Environmental Planning Act*, *Environmental Contaminants Act*, and *Conservation Areas Act*. Their contents will be outline below.

A country's constitution is its supreme law, and in a general sense it prevails over all other laws in the event of conflict. Statements of Goals and Principles are, however, treated rather differently from other legal formulations: they are regarded as "programmatic" rather than prescriptive. Section 25 of the PNG *Constitution* therefore says that, while it is the duty of all governmental bodies to apply and give effect to the National Goals and Directive Principles, and while all laws should be applied and all powers should be exercised, as far as possible, so as to give effect to them, at the end of the day they are "non-justiciable". This means that, if Parliament enacts legislation, it cannot be challenged before the courts on the ground that it conflicts with the Constitution's National Goals. The constitutional commitment to environment conservation and sustainable resource use must, therefore, be treated as a statement of intent -- serious and deliberate, but not, ultimately, enforceable, except as provided from time to time in the general laws of the land. The following treatment of those laws will deal first with the more general laws on environmental planning and protection, then with the laws addressing specific elements of the environment (water resources, fauna and flora), and finally with the two laws providing for the declaration of National Parks and Conservation Areas.

(b) Environmental planning and protection generally

In introducing three new laws to the National Parliament on World Environment Day in 1978, the Minister for Environment and Conservation[2] stated that the laws formed a "complete package", and were a major step in installing the National Goals in the machinery of government in PNG. Two of those laws were concerned with environment protection, and the third with special areas conservation. The Minister referred to the important roles the laws gave to provincial governments, and he emphasized that under them a "wise balance" between development and conservation was being sought. While he assured investors that there would be no arbitrary or short-term changes in environmental policies, at the same time he warned anyone coming to PNG to "rip off our resources, or despoil our environment and short-change our people", that they would run up against the new legislation. Conscious of foreign investors' concerns in the immediate post-independence period, however, the legal package took a gradualist approach to implementing the new environmental requirements: the Minister called the laws "enabling legislation", and he pointed out that environmental guidelines had to be prepared in a consultative manner, and it might take "up to ten years" to fully implement the new laws. The main instrument intended to be used for balancing conservation and development was the *Environmental Planning Act* (Chapter No. 370).[3]

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[2] Where in this paper the term "the Minister" is used, it means the Minister for Environment and Conservation of the National Government, unless the contrary intention appears.

[3] All Acts in PNG (including any amendments thereto and their associated Regulations) have a unique Chapter Number in the Revised Laws of Papua New Guinea.

A key factor in the Act's operation is the issuing of guidelines for the preparation and content of environmental plans. These can be general, or specific to particular classes of development project (e.g., forestry, mining or petroleum), and they are issued by the Minister -- after consultation with industry representatives in the case of specific guidelines (see sec. 5). The Minister can also exempt certain classes of development project from the environmental planning requirements. The Act lists a wide range of matters which must be considered in preparing guidelines, some of which are environmental concerns (including social and cultural matters) while other address commercial and economic considerations. If a development proposal involves a class of project for which guidelines have been issued, then the Minister may require the preparation of an environmental plan under the Act (sec. 4). Alternatively, a developer may submit an environmental plan before receiving a requisition to do so from the Minister -- sec. 4(6). Finally, a developer may apply to the Minister for exemption from submitting an environmental plan, under sec. 10. The procedural steps which follow differ depending on which of the three options is adopted -- seeking an exemption, voluntarily submitting an environmental plan, or being served with a requisition to submit a plan.

The shortest course for satisfying the Act's requirements is for the intending developer to submit its own environmental plan, before being required to do so. A plan submitted in this way, if it meets the general requirements for plan contents set out in secs. 4(2) and 5 of the Act -- i.e., briefly, that is based on the National Goals and Directive Principles of the *Constitution*, and on any issued national or provincial development goals, environmental guidelines, etc. -- can be approved immediately by the Minister, either with or without conditions. Alternatively, the Minister may refuse approval to the environmental plan, in which case the developer must negotiate all the steps for approval which apply where a requisition to submit a plan has been served. This is the most demanding option, involving up to a dozen steps before approval is finally achieved.

In outline, they involve service of the requisition on the developer, and a copy on the provincial and other authorities concerned, as well as gazettal of a public notice describing the development proposal and advising that a statutory restraint on any grants of licenses, permits, leases, or loans, etc., is in place until the proposal has been approved (sec. 6). After the environmental plan is submitted, the Minister causes an assessment to be made of the development proposal -- sec. 13(1). The next step is for a copy of the plan and the assessment to be sent to the Provincial Secretary concerned, and for notices to be published widely, stating where the plan and assessment may be inspected, and calling for representations to be made to the Minister.

Upon expiry of the time specified for making representations, the Minister causes a recommendation to be prepared, based on the environmental plan and a summary of the representations received (sec. 15). At this point the Minister may submit the recommendation and supporting papers to the National Executive Council (NEC), or, if he feels that "substantial unresolved matters" exist in the environmental plan or that further consultation, etc., is necessary he can first engage in a further round of notification and publication, this time including the recommendation and summary of representations for public inspection, before finally submitting the matter to the NEC (sec. 16).

The NEC can then decide the matter or, if it believes that further investigation is required, establish a Board of Inquiry or refer the matter to another body for its opinion. Section 17 sets out the requirements for any further inquiry, etc., resulting in a final report which goes to the NEC. The NEC either approves the development proposal, with or without conditions, or refuses its approval -- sec. 18 (1). That decision is publicized, and a notice gazetted advising of the decision, and, where approval is refused, declaring that the development proposal is "prohibited" -- sec. 18 (2). The "teeth" of the Act appear in sec. 19: any person who proceeds with a prohibited proposal, or in contravention of the conditions imposed on an approved proposal, commits an offense, and is liable to a fine of K40,000 and additional default penalties of K4,000 for each day that the offense continues after being convicted.

The third option a potential developer has is to apply for an exemption from the requirement to submit an environmental plan. Such an application receives an abbreviated form of the preceding treatment, involving notification and public scrutiny, the making of representations to the Minister, and a decision by him to grant or refuse the exemption (secs. 10 - 12). Although not specified by the Act, a proposal refused an exemption can proceed through either of the two earlier options -- with the developer voluntarily submitting an environmental plan, or being required to do so.

The Act broadens the scope for its enforcement by requiring all public authorities to advise the Minister of any development proposal coming to their attention which could have significant environmental implications (sec. 7), by providing for a public register of environmental plans and associated documents (sec. 26), and by enabling any member of the public to commence proceedings for offenses against the Act (sec. 27 (1)). While the Act is carefully integrated and has many desirable features, it must be noted that it depends for its full effectiveness upon a well-motivated Minister, active and well-informed provincial governments, and appropriate guidelines both for general purposes and for particular classes of development.[4] The biggest extractive projects at the time of the Act's introduction -- Bougainville Copper and Ok Tedi -- were both excluded from its ambit (sec. 3), leaving environmental considerations to be dealt with by the specific enactments applying to those projects.

Later in this paper, further comments will be made on the effectiveness of the *Environmental Planning Act*, in the general context of PNG's legal and administrative system. The next law dealing directly with conservation and environment protection to be considered is the *Environmental Contaminants Act* (Chapter No. 368). This law relates to the prevention, abatement and control of environmental contamination by any substance or form of energy which, when released into the environment, could cause an alteration of the environment "so as to affect adversely its beneficial use" (see sec. 3). The term "beneficial

[4] At the time of writing only general guidelines had been issued, requiring environmental plans to address such matters as existing environment, environmental investigations, likely impacts and safeguards and environmental monitoring, all in a specified manner.

use" is defined to mean a use conducive to public benefit, welfare, safety or health, or the health or productivity of flora or fauna.

The Act operates in a familiar way, by requiring any person discharging a contaminant into the environment to apply for a license, and then by prohibiting the release of any contaminants except under, and in accordance with the terms and conditions of, a license (secs. 16 and 18). Provision is made for exemptions (sec. 28), and the accidental release of environmental contaminants must be notified (sec. 30). Part V of the Act sets up a permit system for the importation and distribution of declared hazardous environmental contaminants, and Parts VI and VII deal with particular pollution offenses -- pollution of waters, the atmosphere and land, littering, breaking of glass and noise pollution. The Minister may take protective action against anticipated contamination by declaring an area to be a protected area under the Act (secs. 63 - 65). In 1988 the *Environmental Contaminants (Pesticides) Regulation* declared pesticides to be a hazardous environmental contaminant, and regulated their importation and distribution.

(c) <u>Water resources, fauna and flora</u>

After the legislation dealing generally with environmental planning and protection, the next set of laws to be examined addresses specific elements of the environment, the first being the *Water Resource Act* (Chapter No. 205). Based on a pre-independence law, the Act provides in conventional form for the management and protection of the nation's water resources -- lakes, swamps, rivers and other watercourses whether natural or not, all surface and underground waters and coastal waters. It is administered by a large Water Resources Board, to which the Prime Minister and ten other Ministers nominate members. The Act vests the rights to the use of all water in the State, but rights to use water for domestic purposes are protected, and it is provided that the Act "does not affect" customary rights to use water (sec. 5). The three main ways by which controls are exercised under the Act are by creating a range of offenses to do with water, by requiring permits for certain types of water use, and by enabling the declaration of Water Control Districts, within which strict environmental safeguards apply.

The general offenses are set out in sec. 58 of the Act, and include damming a river or stream, diverting water, discharging waste into water and taking or using water -- in each case without a permit. If a person does hold a permit to do any of these things, it is an offense to contravene the conditions of the permit -- sec. 58 (1). Scattered through the Act there are various specific offenses. For example, while any person may take water, without charge, for domestic purposes from any watercourse to which the public has road access, it is an offense to place a permanent installation for that purpose (sec. 21). In the case of private landowners or occupiers, they may install permanent water-collection facilities, but must not obstruct the flow of water (sec. 22). In declared Water Control Districts, acts such as the destruction of trees, construction of drains or embankments, burning-off of grass, etc., are prohibited unless expressly authorized (secs. 24 and 25), and further requirements -- e.g., adoption of specified farming practices, and action to prevent soil erosion -- may be imposed on landowners or occupiers, by notice (sec. 27).

Any person or body (including a governmental authority) wishing to construct waterworks, flood land or discharge waste into water must apply for a water use permit. The application is submitted to the Water Resources Board, whose functions then include advising the Minister for Environment and Conservation whether an environmental plan should be prepared under the *Environmental Planning Act* (see above), and considering a whole range of environmental and developmental matters set out in sec. 29 (2)(d)-(r). The Board must consult any concerned government body, arrange for public hearings, and finally make a decision recommending the grant of a permit or its refusal (secs. 30, 31). Fairly elaborate provision is made for administrative appeals from the Board's decision (in Part VI of the Act), following which the Minister for Minerals and Energy (who is responsible for the Act's administration) grants the water use permit to a successful applicant. The maximum length of the permit is 25 years -- sec. 40(7) -- and no permit can be granted until any environmental plan required under the *Environmental Planning Act* has been approved -- sec. 40(9). A permit confers on its holder the right to construct works, flood areas, generate hydro-electricity or discharge waste, etc., in accordance with its terms and conditions. In the case of the discharge of water or waste under a permit, the prescribed conditions and standards must also be complied with (sec. 42(f)), and sec. 7 and schedule 4 of the *Water Resources Regulation* lay down the quality standards and maximum permitted concentrations after discharge into both fresh and sea water.

Provision is also made in the Act for water investigation permits (for surveys, test drills, etc.), and special controls in drought-stricken areas (Parts VIII and IX). A public register of permits must be kept (sec. 61), and any person may institute proceedings for breaches under the Act, either in a personal capacity or on behalf of a class of persons or the public as a whole (sec. 56). Charges can be levied for water consumption, or the use of water as a carrier following the discharge of waste (sec. 64). All in all, the Act contains a sensible balancing of public and private interests, and of environmental and developmental concerns, with adequate protection for customary interests. Its regulatory machinery and enforcement provisions seem appropriate for controlling water use in all its various forms. It provides strong powers of official investigation and inspection (secs. 17, 19) but, as is often the case, the law's effectiveness in meeting its purposes of managing and protecting the nation's water resources ultimately depends on the adequacy of the administrative resources made available for its enforcement.

The *Fauna (Protection and Control) Act* (Chapter No. 154) was one of the laws in operation before independence, and it provides in conventional manner for strong State intervention to protect specified animals, by a range of measures, beginning with a vesting of protected fauna in the State (sec. 7). The Minister declares "protected fauna", and the present list includes goura pigeons, eagles, ospreys, all members of the birds of paradise family and bird-wing butterflies. It is an offense to take or kill any protected fauna (including disturbing or injuring them) and to possess a protected animal (including a part or product), and it is an aggravated offense (with a higher penalty) to kill protected fauna with a firearm (see secs. 8 and 9). The Conservator of Fauna can issue permits to approved scientific organizations to take protected fauna (sec. 10), and exemptions from the Act's prohibitions may be granted if the Minister.

Thus, automatic citizens of PNG have been exempted from the above restrictions, provided that mist-nets, guns and explosives are not used, and that animals are only taken for use in "traditional native ceremonies", from land over which the person has a traditional right to hunt.

Apart from declaring protected animals, the other main protective devices under the Act relate to according special status to particular areas -- as Sanctuaries, Protected Areas or Wildlife Management Areas. The differences between the three categories are not great -- in a Sanctuary it is an offense to take or kill any animal other than those declared by the Minister (an exclusive standard), while in a Protected Area it is an offense to take or kill any animal declared by the Minister (an inclusive standard) -- secs. 12 and 14. Wildlife Management Areas are more participatory in their approach: consultation with the local landowners is necessary before they are established by the Minister, Wildlife Management Committees are appointed, and rules may be made for the protection, management and exploitation of the fauna -- again, by the Minister, after local consultation (secs. 15-17). These rules may provide for hunting licenses, license fees and royalties to be paid for animals taken. The Minister may also make rules for fauna protection and control in Sanctuaries and Protected Areas (sec. 24), and any device, equipment or method for taking or killing animals may be prohibited (sec. 27). It is also an offense to set an imported animal free, unless approved by the Conservator of Fauna (sec. 30).

The other main fauna protection law in PNG is the *International Trade (Fauna and Flora Act)* (Chapter No. 391), implementing CITES -- the Convention on International Trade in Endangered Species of Wild Fauna and Flora -- to which PNG is a party. Trade in the endangered or threatened species listed under CITES is strictly regulated, and export of any such animal from PNG is only legally possible under an export permit issued upon satisfaction of a number of requirements, one of which is that the specimen was not obtained in contravention of the *Fauna (Protection and Control) Act* just examined. Any such illegal trade is a prohibited export, attracting the penalties provided under the *Customs Act*.

(d) National parks and conservation areas

The final set of laws dealing directly with conservation and environment protection relates to the dedication of land to conservation purposes. The *National Parks Act* (Chapter No. 157) is another of the pre-independence generation laws, and it allows land to be dedicated for a wide range of uses -- biological, topographical, geological, historical, scientific or social. However, the Act can only be invoked in the case of less than 3% of PNG's land mass, the Act's scope is very restricted.

The Act is short, its method being to commit reserved land to the "care, control and management" of the Director of National Parks (sec. 4), and then give that official broad functions and wide powers to control, manage and develop the land for the purpose for which it was reserved, be that for public recreation and amusement, a national park, a botanical or zoological garden, or a reserve or sanctuary for the protection of flora and fauna -- see secs. 8 and 9. The Act also gives power to make regulations in respect of a wide range of park management matters (sec. 11).

The other law under this heading is the *Conservation Areas Act* (Chapter No. 362), one of the three new laws introduced in the conservation package of 1978 (see above). In his speech when introducing the package to the National Parliament, the Minister for Environment and Conservation said that the Government rejected "the idea that the only way to conserve anything is for the Government to take it away from the people." In contrast to the last Act, this law applies to land under any form of ownership, and it proceeds with conservation along participatory and consensual lines. The basic approach is to provide for an area to be declared a Conservation Area, with its own Conservation Area Management Committee which prepares a management plan for the Area, and then to restrict any development of land in the Area except in accordance with that management plan.

The Act provides for a 5-member National Conservation Council, as the expert body to advise and assist the Minister in administering the Act's provisions (see Part II). The first step in declaring a Conservation Area is for the Minister, based on criteria established by the Council, to recommend that an area having "particular biological, topographical, geological, historical, scientific or social significance or other special value for the present community or for future generations" should be declared a Conservation Area - sec. 12(1). This can be done on the Minister's own initiative, or after receiving a request from a person, group or authority - sec. 12 (2). The recommendation must be made available for public inspection, and must be publicly notified (sec. 13). There is then a 90-day period for written representations, after which the Minister must submit a final recommendation and associated papers to the National Executive Council for its decision on whether to declare the Conservation Area or not (secs. 14 - 16).

When an area is declared, the Minister establishes a Conservation Area Management Committee, reflecting the interests of the landowners and provincial and local governments, which body is responsible for preparing a management plan for the Area, coordinating development, directing the work of rangers, etc. (sec. 25, 27). The Minister can make rules applying to Conservation Areas, after consultation with the Management Committee, National Conservation Council and the landowners (sec.28). Failure to comply with a rule attracts a penalty up to K500. Part VI of the Act regulates development in Conservation Areas. In general, no person (including a landowner) may develop or alter the existing use of an Area except in accordance with the terms of its management plan, or with the written approval of the Minister (sec. 31). Sections 32 to 34 provide a process for seeking such Ministerial approval, involving an application with supporting plans, consultation, and decision one way or the other. The State, too, is bound by this procedure. The result is that development in a Conservation Area can only proceed if it is allowed under the management plan, or if the landowners agree to the development and the Minister, after due consideration, approves it. To this there is an exception, if the development is by the State for a public purpose. In this case the landowners' consent is not necessary, but the Minister must still consult and exercise his discretion in deciding whether, considering the environmental impact, the State's application to develop the land should be approved.

The penalty for developing, or permitting the development of, land in a Conservation Area contrary to the above restrictions is severe -- a fine up to K40,000, with K4,000 default penalty for continuing offenses (sec. 35). The same high penalties apply for developing land recommended for a Conservation Area, and it is no defense in either case to claim that the development did not adversely affect the environment -- sec. 35(3).

Other laws affecting the environment

The previous section examined laws dealing directly with conservation and environment protection. This section of the paper looks at those other laws which , while dealing principally with other subjects, nevertheless can have a major impact on the environment. Many laws can affect the environment; consideration here is confined to the laws which, by their nature, have the potential for major environmental impact. These laws are of three main types -- those dealing with planning and administration, land law and tenure, and resource exploitation (forestry, mining, oil production, fishing, etc.).

(a) Planning and administration generally

Although PNG has legislation on almost every subject, planning and administration are largely left to the executive, the political processes and the public service structures for their conduct, while business is conducted essentially along free enterprise lines. Special provision for the regulation of foreign investors is made by the *National Investment and Development Act*, and concessional development finance for local businessmen is covered by the *Agriculture Bank Act*, but government in PNG has generally intervened less in commerce than has been the case in many Third World countries. Minority shareholdings in key companies are held by the National Investment Corporation, in which national individuals and companies can take up equity, and the State is a direct equity participant in major resource projects, especially in the mining industry. But otherwise the government's role is seen as being to put in place the infrastructure and regulatory mechanisms for development, and leave the actual development to the private sector. One law that sets out to lay down the parameters for development is the *Physical Planning Act*, but its scope is largely confined to urban areas.

Looking at administration, PNG has three tiers of elective government -- national, provincial and local (or community) -- but only one public service. The distribution of powers and functions between the different levels is governed by the *Organic Law on Provincial Government*, one of the constitutional laws. A commitment was made at independence to devolve decision-making and government administration to lower levels than the national, but the experience of decentralization since 1975 has not been a happy one, with many Provincial Governments having been suspended, and frequent calls from national politicians for the system to be abandoned. While on paper substantial powers have been devolved to provincial governments, in practice the limited financial and skilled manpower resources available in the provinces mean the powers cannot be exercised. There is little scope for provincial governments to initiate anything very meaningful, and provincial initiatives cannot survive without active national government support.

Thus while the Organic Law places natural resources, wildlife protection and parks and reserves within the list of "concurrent" subjects upon which laws can be made at either the national or provincial level (see sec. 27), in fact all the important laws on these subjects have been made at national level, in effect shutting out provincial legislation. This does not have to mean the end of effective decentralization, however, for two other main factors enable devolution of decision-making. The first is the provision made in some national laws for the involvement of provincial and local bodies in the decision-making process. Examples of this approach in the environmental field are the provisions made for consulting provincial governments on environmental plans for development proposals under the *Environmental Planning Act*, the consultation with local-level governments on Wildlife Management Areas under the *Fauna (Protection and Control) Act*, and the provision for provincial and local representation on Conservation Area Management Committees under the *Conservation Areas Act*, all examined above. The other major decentralizing factor is the very considerable power held by the local landowning communities under PNG's legal and political system. This is the next main matter to be addressed.

(b) Land law and tenure

In stark contrast to countries under authoritarian regimes where land and natural resources are all State-owned, the predominant consideration for resource management in contemporary PNG is the attitude of the customary landowners. Nor is this confined to matters concerning development of that 97% of PNG's land area held under customary tenure, for the Government's title to land acquired long ago is often hotly contested, while the State's statutory title to minerals, petroleum and other natural resources cannot be safely relied upon without including landowners in any negotiations (see below). To outside developers, this cultural fact of life is seen as a threat over-shadowing any investment in PNG. Projects operate under the constant fear of landowner disruptions, the most notorious example of which being the forced closure of the vast Panguna gold and copper mine on Bougainville in 1989. Despite the special demands involved in dealing with customary landowners, however, it is a mistake to treat customary tenure as an impediment to orderly development in PNG. Custom is installed by the *Constitution* as one of the primary sources of the country's legal system (Schedule 2.1), and it supports the very fabric of PNG society. It is unavoidable under the legal and political system that people who want access to customary land in PNG must deal with the customary landowners.

The legislative enactment dealing with land generally is the *Land Act* (Chapter No. 185). Little changed since its introduction 30 years ago, this law mainly deals with State-owned land -- how the State acquires land, and then how it is allocated under the different types of Government leases, etc. By one such provision (sec. 25), State-owned land can be reserved for the purpose of a national park, thereby bringing it under the *National Parks Act* already examined.

Part IX of the Act makes provision for customary land. By sec. 73, customary land can only be disposed of "to natives in accordance with custom", or the State. The term "native" is defined by the *Interpretation Act* to mean automatic citizen, so sec. 73 prevents non-citizens from buying or leasing customary land. This prohibition on acquisitions of customary land by outsiders goes back to early colonial days, and was inspired partly by the desire of colonial administrations to maintain a monopoly over the supply and use of land.

While the latter controls continue in the case of non-citizens, dealing in land among automatic citizens is left entirely unregulated. The only question is whether a disposal is "in accordance with custom", but the legislation gives no clue how such compliance is to be assessed.

Other legislation on particular resource exploitation allows outsider access to be gained to customary land and for fundamental changes in the land's character to be made thereby (see next heading). But under land law, the general position is that access to customary land for development must be either via the State, or by Papua New Guineans themselves over their own land, or over land in which they have acquired an interest under custom. In the past this meant fairly conservative use of customary land, but the promotion of cash crops since World War II, growth of the cash economy, population increase and increased mobility, mechanization, consumerism and many other developmental factors have combined to exert far greater pressure on land and land-based resources. The search in PNG is for appropriate mechanisms to respond to these developments -- "appropriate" in environmental terms, but also in the cultural and governmental context of PNG. As a major shift of authority from landowners to the State is improbable, the appropriate response will depend upon the direct involvement of landowners in decision-making over the use, management and protection of their land and other resources. It is, therefore, necessary to examine how customary land is owned and used.

Papua New Guinea is justly famous for its cultural diversity. Although nationwide this presents a pattern of great complexity, one should not be overwhelmed, for it is possible to make some broad generalizations about the basic nature of customary land tenures. While almost endless variations will be found, there is a consistent theme running through Melanesian land tenures, and for present purposes it is enough to identify their distinguishing characteristics, for these will be found anywhere in PNG, subject to local qualifications and variations.

The most important characteristic to recognize is that, under Melanesian land tenure, land is owned by groups but used by individuals (or, more precisely, households).[5] The groups which own land are kinship groups (usually clans), to which membership is recruited mainly by descent -- either patrilineal or (quite commonly in PNG) matrilineal. Membership of a clan carries with it the rights to use clan land, and in general a person's most important access is to his or her own clan's land. Cash crops will be grown there, but short-term access for gardens, for example, may be gained to surplus land owned by another clan from the same village. It is most unlikely for land access to be granted in the absence of some pre-existing relationship, whether based on descent, marriage or common residence: as has been remarked more generally, customary tenures are essentially a manifestation of social relationships (see Lynch 1991:13-14). The social unit which uses group-owned land is usually the household -- a man and his wife, their non-adult children and possibly a brother, unmarried sister, or other close relatives.

[5] The English word "own" is used as the best term available, but the author shares other critics' objections to the notion of land being "owned" as personal property (see e.g. Lynch 1991:11).

There have been many attempts during PNG's history to legislate for increased security of tenure over customary land. Early measures aimed at promoting communal ownership and use, but from the mid-1950s the emphasis shifted to individualizing customary land ownership. Remnants of the pre-independence approach survive in the form of the *Land (Tenure Conversion) Act* enabling the registration of freehold titles in customary land, and the *Land Titles Commission Act*, which established a special body to adjudicate over customary land ownership. In preparation for independence a Commission of Inquiry into Land Matters prepared a major report (in 1973) recommending comprehensive reforms of the inherited land laws. During the 1970s parts of that report were implemented, but a long period of inactivity in the 1980s was followed by a large World Bank loan in 1989 to fund the Land Mobilization Project. Spread over a five-year period, it is too early to say yet what will emerge under this costly project, but one of the options again being considered is customary land registration.

Laws on the books already which are relevant to the present project are the *Land Disputes Settlement Act* (Chapter No. 45), which sets up a decentralized system for handling disputes over customary land involving a three-level process of mediation by local Land Mediators, arbitration where necessary by the Local Land Court, and a right of final appeal to the District Land Court, and the *Land Groups Incorporation Act* (Chapter No. 147). This latter law provides a simple process for the legal recognition of customary landowning groups, so that they can hold, manage and deal with land in their own names. The importance of this law cannot be overstated, for it means that the legal system of PNG recognizes the corporate nature of that social unit which exists at the intermediate level between the State and the individual. This group unit -- in most cases, the clan -- has always been vital to the functioning of PNG society, playing essential roles in people's social, economic, spiritual and political lives. The Act enables clans to continue to perform these functions in the modern legal environment. Its utility to the present project will be examined under the final section of this paper.

Registration of land titles (sometimes called "the Torrens system") also enjoys a long history in PNG. All titles in alienated land are registered, affording them the benefits of indefeasibility. In essence, these are that a title, once registered, is protected by statute from being "defeated" by an unregistered interest. For the last two decades moves to extend this system to customary land have gone on and off the Government's reform agenda, but for the moment action is delayed pending results of the Land Mobilization Project (see above). Again, the value of any such customary land registration system will be considered towards the end of this paper.

(c) Resource exploitation

Most of the laws relating to major natural resources (forests, minerals, petroleum, etc.) date from the pre-independence period, and they reflect the prevailing Australian attitude that such "God-given" resources are naturally the property of the State. Forests were treated somewhat differently, and are the only area where major new legislation has been introduced since independence. The other resource laws remain largely unreformed, reflecting attitudes and administrative structures which run counter to the current reality in

PNG. A constitutional challenge has even been mounted to the validity of the underlying concept that "natural" resources are the property of the State. Meanwhile, elaborate and artificial arrangements are resorted to in order to adapt to the reality that peaceful and reliable access to minerals, petroleum, etc., is not possible without including customary landowners in the benefit-sharing.

Looking at the particular resource laws, another complicating factor is that, while the general law is set out for example in the Mining Act, the practice for the most significant projects has been to enact a special law, which is then made to prevail over the general law, whether on mining itself or on any other subject. This "super-law" approach reflects the major contributions such projects make to the national economy, and it is understandable from the developer's viewpoint. But the consequence is that operations with the greatest likelihood to damage the environment, for example, are excluded from the general environmental law, and the matter is addressed only as set out in the project documentation. Thus, the *Mining (Ok Tedi Agreement) Act* 1976 gives "the force of law" to the agreement between the State and the developer, and provides that it applies "notwithstanding anything to the contrary in any other law in force in the country" (sec. 3 (1)). The agreement referred to does require an environmental impact study (at a cost in 1976 of no more than K150,000) to be conducted, on the basis of which proposals had to be prepared and approved for environmental management and protection. This "contractual" approach to environment protection is, however, a considerable watering-down of mandatory statutory requirements. Regulation is even more likely to be relaxed where the State itself is a direct equity partner in the development project, as in the case of Ok Tedi.

The resource exploitation laws are lengthy (all major ones running to well over one hundred sections), and this is not the place for a detailed exposition of their contents. Suffice it to observe here that minerals and petroleum are essentially treated as being at the disposition of the State, and that persons holding concessions from the State can enter any land and do anything necessary for their operations, subject only to the requirement to compensate the landowners for the damage caused (see, in particular, the *Mining Act* secs. 100 - 103 and the *Petroleum Act* secs. 38, 50, and 81). There are some requirements for rehabilitation of land damaged during mining or petroleum operations, but these are generally less demanding than the kinds of conditions which could be imposed upon an approval of a development proposal, under the *Environmental Planning Act* examined above.

Despite the fact that customary landowners' rights under the mining and petroleum laws are largely compensatory, the Government has found it necessary to involve landowners much more directly in the negotiation of major resource projects, because without their approval the access to resources would be unsafe. While this "development forum" approach, as it is called, yields considerable economic benefits to landowners, it might be doubted whether any environmental concerns which they might have could be so readily accommodated.

Under the new *Forestry Act* of 1991 the rights of customary owners to the forest resource on their land are "fully recognized" (sec. 46), and they can enter into logging agreements either with third parties directly, or by disposing of their timber rights to the

PNG Forest Authority, a statutory body set up by the Act (see sec. 55). The scope of permissible forestry operations is circumscribed by the intended National Forest Plan, the aim of which is sustainable timber production (secs. 54 and 47). Provincial bodies have roles in planning -- preparing Provincial Forest Plans, including Forestry Development Guidelines (sec. 49) -- and in administration -- vetting timber agreements with customary landowners in the province (secs. 58(f) and 87(2)(f)), recommending on the grant of small- and medium-scale logging concessions (sec. 89), participating in the evaluation of large-scale logging proposals (secs. 67 - 69) and negotiating forestry agreements (sec. 71). Apart from sustainable yield, conservation considerations do not figure in preparation of either National or Provincial Forest Plans, and only where a proposed operation will exceed an annual timber cut of 5000 m^3, thereby necessitating a feasibility study by the National Forest Board, are environmental and social impacts of the operation required to be investigated (see sec. 62(3)). Again, only for such large-scale and long-term projects are environmental plans, approved under the *Environmental Planning Act*, made necessary -- see sec. 77(2). Many small operations can log out an area just as effectively as one large one, but the only constraint under the Act is that they should be conducted by different operators -- see sec. 87(5). The Act gives far greater power over forestry to provincial bodies than ever before, but this does not guarantee any greater concern for environmental matters than the national forestry authorities have so far demonstrated.

Other natural resource laws concern aquatic animals -- the *Continental Shelf (Living Resources) Act*, *Crocodile (Trade Protection) Act*, *Fisheries Act*, *Tuna Resources Management (National Seas) Act*, and *Whaling Act*. There is also the *Prevention of Pollution of the Sea Act*. Customary landowners certainly claim ownership of creeks, rivers, swamps, estuaries and reefs and the aquatic life that they contain. While the State recognizes some rights in the land itself under inland and coastal waters, and certain royalties are sometimes paid for bait-fish, etc., in general customary rights in this area are more honored in the breach than the observance.

CONCLUSIONS

The foregoing examination of laws affecting the environment both directly and indirectly shows that, while PNG's performance since independence has been generally strong in legislating directly to promote the constitutional goals of conservation and environment protection, this specific environmental legislation has tended to be intersected by laws dealing with the exploitation of natural resources. There is, indeed, no shortage of environmental law, whether dealing with the environment generally, or with its components. If anything, some overlapping has become evident, for example, Government land can be committed for the purposes of a wildlife sanctuary under either the *Fauna (Protection and Control) Act*, *National Parks Act*, or *Conservation Areas Act*.

Having the right laws on the books and seeing them implemented can, however, be two quite different matters. A forward-looking law such as the *Conservation Areas Act*, though passed in 1978, is still in 1992 awaiting appointment of the National Conservation Council, so that it may become operative. Any legislation must be drafted with a realistic appreciation of the resources in finance and skilled manpower which will be available to enforce it. This is ultimately a matter for governments to determine, and not unnaturally scarce resources tend to be applied to development and the generation of income, rather than to inhibiting freedom to exploit resources.

The Department of Environment and Conservation (DEC) has not lacked bureaucratic clout in recent years, although much of the expansion has been in headquarters, or in unskilled laboring staff. The middle-management area of trained field officers seems to have been neglected. In an authoritative review of PNG's environment situation prepared for Australia's official aid agency, the University of PNG's commercial arm (Unisearch) concluded on the effectiveness of the environmental legislation that there has been "considerable difficulty in effectively implementing it because of manpower, financial and information constraints" (Unisearch 1991:18). The report continued:

> "The dilemma in which the PNG government sometimes finds itself in trying to resolve its often conflicting constitutional role as advocate of development of the nation's natural resources on the one hand and as protector of these resources and the environment on the other, is compounded when the government takes up equity participation in development projects [such as has been] convincingly demonstrated for the Ok Tedi project. When conflicts have arisen, the responsible department, Minerals and Energy, has usually taken the position of the State as shareholder rather than as the advocate for environmental protection. These conflicts can never be completely avoided, but they can be more fairly resolved only if the views of the government's environmental managers, in this case DEC, are given equal weighting to those of the relevant department advocating resource development." (ibid.)

Generally, the report applauded the standard of environmental plans prepared for mining projects, and government infrastructural projects such as sewerage and hydro-electric schemes (ibid., p. 19). On the other hand, performance in the forest industry has been very poor (ibid.), although new legislation may improve the situation (see above). In the case of major agricultural projects, environmental planning was found to have been deficient, especially with respect to the social impact of large-scale resettlement, which is usually included in the project (ibid.). One major weakness the report identified was that social impact assessment is not installed under present arrangements as a central plank in project planning and implementation (ibid., 19 - 21), despite the notorious susceptibility of major resource projects to breakdown over community dissatisfaction.

A positive feature of the environmental law is the participatory approach taken to decision-making, in particular (for purposes of the present project) the efforts to involve affected landowners. Under the *Environmental Planning Act* the steps in processing environmental plans receive wide and effective publicity, representations from the public are called for and must be addressed, a public register is kept of environmental plans, and any member of the public can initiate proceedings for offenses under the Act. Similarly, under the *Environmental Contaminants Act*, any person likely to be aggrieved can oppose the grant of a license to discharge waste, and any member of the public can institute a prosecution. A water use permit for discharging waste, for example, under the *Water Resources Act* can only be granted after a public hearing, and again a public register of permits must be kept, and any person may begin proceedings for offenses. Customary landowners are directly involved in the establishment of Wildlife Management Areas, their Committees, rules and management plans under the *Fauna (Protection and Control) Act*, and in the declaration of Conservation Areas, their Management Committees, rules and management plans under the *Conservation Areas Act*. Landowners could have even greater "hands-on" involvement by being appointed as rangers under the Act. The stated policy of the Act is to involve people actively in the conservation of their own resources. This highly desirable approach is only marred by the fact that no Conservation Areas have ever been declared.

The actual performance under the range of options for committing areas to conservation purposes, as of December 1991, is:

Wildlife Management Areas	18
National Parks	15
Protected Areas	2
Wildlife Sanctuaries	2

(Statistics provided by Peter Hunnam, World Wide Fund for Nature [Australia].)

These are spread over almost all of the eighteen provinces in PNG, averaging about two such areas per province.

Perhaps the most important scope for landowner involvement in resource management and conservation lies in the fact that 97% of PNG's land mass is under customary ownership, and even where natural resources such as minerals and petroleum are legally owned by the State, the customary landowners have a major say in the terms for their exploitation. Melanesians have managed their resources successfully for some 10,000 years. Many new pressures are being exerted on those resources, and Melanesians can just as easily succumb to the attractions of "get rich quick" resource projects as any others. Decisions aimed at short-term profits, without the necessary information and advice, have already been made in parts of PNG, with disastrous consequences for both landowners and their resources. The key to improved resource management lies in enhancing the decision-making of the landowning groups.

LANDOWNERS' RIGHTS TO PERFORM REGULATORY FUNCTIONS

The consultant's terms of reference require him, among other things, to identify the legal rights of customary landowners to control "pollution and other environmentally degrading activities, such as logging, either by members of the same or other landowning kinship groups or other external sources, to enact quarantines to control spread of pests, exotic species or crop pathogens, or otherwise perform regulatory functions relevant to conservation." The above review of the laws shows that customary landowners have the necessary authority to exercise controls of this nature, either

(i) as members of the general public, invoking provisions for public representations, prosecutions by members of the public, etc.;

(ii) as landowners, exercising the statutory rights and powers given to landowners to participate in decision-making; or

(iii) as landowners, involved in negotiations for access to resources on or in their land.

For convenience, the table on the following page summarizes these powers as they relate to proposed activities which might affect their customary land.

Given the comprehensive range of these powers, the main issue for customary landowners is how they can best be organized to invoke the powers at their disposal. In the present author's view, the best method for organization of customary landowning groups available in PNG is found in the *Land Groups Incorporation Act.* Already outlined under 2.2(b) above, this law allows legal recognition of the corporate nature of customary landowning groups, and provides the machinery for their responsible decision-making over matters affecting their land. The powers conferred by the Act on incorporated land groups relate to the use and management of their land (sec. 13), for which purposes they may enter into agreements in accordance with custom. Such agreements could relate to resource exploitation and the terms and conditions thereof, or they could be "conservation covenants."

The idea of acquiring the conservation interest in land has a precedent in New Zealand where, under the *Queen Elizabeth the Second National Trust Act* of 1977, the Trust Board can enter into an "open space covenant" with a private landowner or Crown lessee, whereby, on whatever terms are agreed, the land concerned is committed to be maintained as open space -- a term defined as meaning land or water which preserves "any landscape of aesthetic, cultural, recreational, scenic, scientific, or social interest or value" (secs. 22 and 3). Under the New Zealand law, the public is guaranteed free access to land subject to an open space covenant (sec. 33).

Conservation covenants are an interesting idea, and may be invoked in PNG to commit customary land to conservation purposes, in return for guarantees of compensation in the form of services, etc. Any such dealing should be preceded by incorporation of the customary landowners as land groups under the above Act, so that the "covenant" is legal and reliable. Unfortunately under the law as it presently stands such dealings are impossible with anyone except "automatic citizens" (*Land Act* sec. 73). It is true that such an undertaking is not a "sale, lease or disposal" of the customary land in the terms of the section, but "land" is defined to include an interest in land, so the legality of a conservation covenant with any non-citizen or corporate body would be questionable.

The safest course under the current law is to mobilize landowners to invoke the range of legal avenues presently open to them to conserve and protect their resources. Organizational inputs are the main requirements here -- informing, advising and assisting villagers to exercise the statutory powers set out in the above table. The *Land Groups Incorporation Act* procedures can be invoked for these purposes, but it is not essential to do so. The present law already provides for landowner representation in Wildlife and

Statutory powers vested in customary landowners

(i) as members of the general public

**Environmental Planning Act*
- to make representations on a project's environmental plan - sec. 14(1)
- to initiate prosecutions for offenses - sec. 27(1)

**Environmental Contaminants Act*
- to oppose grant of a license to discharge waste or other pollutants - sec. 20
- to initiate prosecutions for offenses - sec. 58

**Water Resources Act*
- to take part in a public hearing of an application for a water use permit - sec. 30
- to initiate prosecutions for offenses - sec. 56

**Conservation Areas Act*
- to request declaration of a Conservation Area - sec. 12(2)
- to make representations on a proposed Conservation Area - sec. 14

(ii) as landowners, exercising statutory powers

**Fauna (Protection and Control) Act*
- to be consulted on the declaration of a Wildlife Management Area - sec. 15(2)
- to be consulted on rules for a Wildlife Management Area - sec. 17(2)

(- in addition, individual landowners may be appointed to Wildlife Management Committees, and as rangers - secs. 16, 20)

**Conservation Areas Act*
- to be represented on a Conservation Area Management Committee - sec. 25(3)
- to veto any development contrary to a management plan - sec. 32(1)

(- in addition, individual landowners may be appointed as rangers - sec. 38)

(iii) as landowners, in project negotiations

**Land Act*
- to negotiate terms of land acquisitions for project purposes - secs. 15, 15A

**Forestry Act*
- to negotiate agreements for forestry operations - secs. 58, 87

**Mining Act*
- to compensation - secs. 100 - 103
- to 5% of royalties - sec. 107(2)

(- in practice, landowners are included in negotiation of a development package)

**Petroleum Act*
- to compensation - secs. 38, 50, and 81

(- in practice, landowners are included in negotiation of a development package)

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Conservation Area Management Committees, and an effective extension service under DEC could ensure that the remedies available to the general public under laws regulating environmental impacts are invoked in good time by the customary landowners -- either individually, or as a group.

Where a greater responsiveness of the landowners to the proposed environmental impact warrants the incorporation of landowning groups, the steps involved are listed in the following table.

Land Group Incorporation

Step 1:	Preparation of land group's draft constitution (secs. 5(2) and 8);
Step 2:	Application for incorporation (sec. 5(2));
Step 3:	Notification and publicity of the application (secs. 6(1) and 33(2));
Step 4:	Consideration of any comments received (sec. 6);
Step 5:	Incorporation by the Registrar (sec. 5(1)).

While land group incorporation provides a safer basis for responsible landowner decision-making, all of the measures for landowner involvement in environment protection and conservation examined above are available without moving this far. Assuming that the State acquisition of customary land for conservation purposes is regarded as too extreme a measure for the purpose, the main options landowners have are Wildlife Management Areas and Conservation Areas -- both of which leave the land ownership intact. The former are set up under the *Fauna (Protection and Control) Act*, and the latter under the *Conservation Areas Act*. The steps involved in each case are shown on the tables on the following page.

As between the two options, Conservation Areas are far more comprehensive in their management interventions -- the management plan regulates land use in the area and sets out how its special features will be conserved, while penalties for unauthorized development in a Conservation Area are severe. Wildlife Management Areas, on the other hand, are concerned with fauna protection and control, and breach of their management rules attracts only a minor penalty. They are really only an extension of the sanctuaries and protected areas approach, to involve customary landowners in wildlife management. The big drawback with Conservation Areas is that, at the time of writing, the Act is not operational, by reason of the failure so far to appoint the National Conservation Council. If Conservation Areas are to play the important part they are capable of, clearly this omission must be rectified as soon as possible.

Wildlife Management Area

Step 1:	Consultation with landowners and Local or Community Government (sec. 15(2));
Step 2:	Declaration of WMA by the Minister (sec. 15(1));
Step 3:	(or at the same time as Step 2): Establishment of Wildlife Management Committee by Minister (sec. 16);
Step 4:	Consultation with landowners and WMC on rules for WMA (sec. 17(1) and (2));
Step 5:	Rules for management of WMA made by Minister (sec. 18).

Conservation Area

Step 1:	(optional): Written request to Minister that area be declared (sec. 12(2));
Step 2:	Recommendation by Minister that CA be declared (sec 12(1));
Step 3:	Notification to public of recommendation, which is made available for inspection (secs. 13 and 12(4));
Step 4:	Representations to the Minister (sec. 14);
Step 5:	Submission by Minister to National Executive Council (sec. 15);
Step 6:	Decision by NEC (sec. 16);
Step 7:	Declaration of CA by Head of State (sec. 17);
Step 8:	Minister appoints Management Committee for CA (sec. 25);
Step 9:	Management Committee prepares management plan for CA (sec. 27);
Step 10:	Minister approves management plan (sec. 2);
Step 11:	Consultation by Minister on rules for CA (sec. 28(1));
Step 12:	Rules for management of CA made by Minister (sec. 28(1)).

The other major lack at present is of an appropriate law enabling "conservation covenant"-type agreements to be entered into with customary landowners, so that they can commit some of their land to conservation purposes, possibly in return for development assistance. Dealings in customary land are still covered by laws from the colonial period, and badly need updating. Another matter long outstanding is customary land registration -- which would enable the registration of conservation covenants, etc., over customary land, with a statutory protection of the interest. These matters are at present tied up in the long-term and costly World Bank-funded Land Mobilization Project, and are probably some years off resolution. In the meantime, the existing legislation provides ample opportunity to conserve, protect and manage PNG's natural resources, the main inputs required being information, advice and organizational assistance to customary landowners, and the necessary resources in skilled personnel and funds for the administrative machinery to operate.

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Chapter Four

An Assessment of Institutional and Social Conservation Issues in Papua New Guinea

Michael Brown[1] and Hartmut Holzknecht[2]

People-Environment Relationships in Papua New Guinea

Papua New Guinea (PNG) comprises the eastern half of New Guinea (the world's largest tropical island), the Admiralty and Bismarck archipelagoes, the northernmost islands of the Solomons archipelago and a number of other fringing island groups. At ca. 463,000 km^2, PNG is the largest nation in Melanesia and supports a population of 3.9 million. The population is mainly rural, scattered over the rugged mainland and its many islands. Partly because of its geographic and physiographic isolation and history of colonization and settlement, Papua New Guinea is one of the most culturally diverse nations on earth. The people of Papua New Guinea, living in distinct cultural groups, speak more than seven hundred distinct languages. While English is the main language used in government, business and education, PNG Tok Pisin and Hiri Motu are the two most widely spoken common languages.

In most parts of PNG, societies are strongly egalitarian, lacking a well-defined class system. With few exceptions, status is traditionally acquired or achieved rather than inherited. Papua New Guineans at all levels of education demonstrate strong attachment to their land. Unlike many other countries, PNG officially recognizes customary resource ownership[3]. Customary resource-owning groups living on and using land and other resources are legal owners of those resources, by virtue of state recognition of traditional tenure. Recognition of customary ownership offers a special opportunity for -- and indeed necessitates -- the development of conservation techniques that build on indigenous resource management practices. The development of such techniques would also broaden the range of

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[1] The PVO-NGO/NRMS Project, c/o WWF, Washington, D.C., U.S.A. The PVO-NGO/NRMS Project is a consortium of World Learning, Inc. (formerly Experiment in International Living [EIL]), CARE, and WWF.

[2] Anthropology Department, Australian National University, Canberra, Australia.

[3] See Chapters 2 and 3 for discussions of the implications of customary resource ownership.

options available to resource owners in a region where local leaders and their associated communities still predominantly control land use decisions.

It is important to note that Papua New Guineans do not adhere to the western concept of "wilderness" or "wildlands" or "natural wilderness zones" when assessing or discussing their environment. This concept implies the notion of "no entry or use" by humans, and assumes a separation between zones of human activity and zones of wildlife activity which humans rarely enter. Such restrictions and separation have limited validity in any discussion of conservation and protected areas in PNG.

It is certainly true that there may be parts of a landowning group's territory which members do not use as often as other parts of the territory. Some areas may be used for periodic hunting and gathering trips, according to need or wish. Others are known spirits' places where malevolent spirits are thought to lurk. Still others are "sacred sites" (which may be creation sites or places from which humans emerged from the ground or where a creation figure or god is believed to have created a place for his or her descendants). In most PNG groups, people are discouraged from entering such spirit places or sacred sites either from fear of attack (in the former case) or for fear of upsetting ancestral spirits (in the latter case). The National Museum in PNG maintains a voluntary registry of sacred sites. Environmental impact assessments (EIAs) are mandated to include identification of sacred sites and the possible impact of a project on such sites.

Almost all ethnographic publications on Melanesia emphasize the strong, deep and multifaceted relationships which have existed and continue to exist between human beings and their environment in the region. Few other subjects provoke stronger and more deep-seated emotions in Papua New Guineans than land and its resources.

Although this multifaceted relationship appears to vary greatly from one social grouping to another, a number of common themes about relationships between people and their environment in PNG emerge. A summary of common themes among highly diverse cultural groups will inevitably result in some generalizing and submerging of finer and, in some cases, significant detail. The thematic summary set out below refers in particular to PNG societies and resource-owning communities or groups.

Landowning Groups and Resource Ownership

In any conservation project in PNG, it is the Landowner group which is the key contact group. It is not possible to develop a precise definition of this group since each Landowner group's landholding rights vary from ethnic group to ethnic group. Group characteristics vary depending on the social organizing principle of the group, e.g., patrilineal or matrilineal. *When starting a conservation initiative, Landowner groups need to be identified on the ground in a particular location by people who know what to ask and how to collect and collate relevant information for this purpose. It is also essential to understand how Landowner groups interact with their neighbors concerning land use.*

A wide range of means exists in PNG by which a person can gain access to land and other natural resources. Furthermore, many resource use and allocation systems exhibit flexibility: while there are normative rules, means exist for "outsiders" to resource-owning communities to gain access to productive resources. "Insiders" who, for some reason, fail to gain access to land or resources through the preferred means of attribution and allocation, may also take advantage of these alternative means.

In general, ownership of various rights to resources is vested in groups, best identified as kinship groups. All land and resources in PNG are "owned" in some way. Membership in these resource-owning groups is inherited in various ways through a person's kinship (or in some cases, quasi-kinship) links. Recognized and acceptable ways do exist as well for outsiders to be adopted into and become full members of such groups. All parcels of land are named, and their ownership ancestry and linkage to particular groups and individuals are usually well known and well established.

In large areas of PNG, these kinship groups might be defined as clans or sub-clans in which membership is passed from father to son, i.e., patrilineally (in the male line). In some cases such groups are lineages. In matrilineal societies in PNG, rights to resources pass through the female line but are nevertheless controlled by males; as such, a man may inherit a variety of resource rights from his mother's brother's descent group, e.g., a man passes such rights onto his sister's son. There are also some groups in PNG which are organized along the principles of double unilineal and cognatic descent. In these cases, a man may acquire access to resource rights from either the male or the female line, or a combination of rights from each.

<u>Definition of landowning groups</u>[4]

Although it may be desirable for conservation purposes to define a Landowning group's membership and draw its borders on a map in order to make agreements about resource use, Landowning groups are in fact somewhat difficult to define in that their membership and territory change over time. These groups generally arise when people in closer kinship relationship to each other decide to live in proximity for reasons of social solidarity and access to natural resources. As the population of a group increases, lines of fracture appear: lineages or sub-clans may establish themselves as independent groups. The purpose of such sub-groups may be to strengthen their own group identity, and/or to make claim to part of what was formerly an area of joint territory and joint resources with the "mother" clan. If one such sub-group subsequently dies out or is unsuccessful as a separate entity, its territory is reabsorbed into the "mother" group's territory and resources. Thus a continual redrawing of group boundaries between original and offspring groups can occur.

[4] Landowning groups are called "Papa Graun" in Tok Pisin, which translates roughly to English as "Landowners" or "Resource Owners". In this chapter, we will use the term Landowner to refer collectively to landowning groups.

Over a period of time an offspring group can evolve from an embryonic group to a powerful and influential body of people. A group's leaders can have a great impact in deciding its fate: successful leaders attract followers, and with more followers a group can become even more successful. Or the group may succumb to the depredations of war, disease, and continual competition, dwindling down to only a few members.

Even with flux in the movement of people (individuals or groups) and with frequent redrawing of group resource boundaries, the links between people and their environment endure and are actually strengthened. Elements of resource use systems are changing with the increased contact with "outsiders" (other PNG groups, Westerners, etc.), the emergence of urban areas with wage labor, and the production of perennial cash crops (which restricts the use of large areas of customary land and thereby makes land inaccessible to most of the other Landowners). Nevertheless, the deep spiritual linkage between people and land still exists. Urban wage earners regularly send part of their earnings home to their relatives to keep their names linked with that group and its resources, and will often express the wish to be buried at home on their land.

A number of mechanisms exist in PNG societies to incorporate strangers or people from other groups, e.g., refugees into one's own group and to bind them to that group. Group genealogies are then retroactively revised to conform to the particular society's group ideology. A group ideology sets out who the group members are, who formally has access to the group's range of rights, and who has only circumscribed rights of use.

Rights to land and resource rights

Rights to land and other resources (besides individually owned trees) are most commonly vested in groups such as clans and sub-clans (and in some ethnic groups, in sub-clan structures such as lineages). Few, if any, such rights are vested in higher level groupings such as phratries (tribal subdivisions) or tribes[5] and none are vested in language groups. Landowner groups generally hold resource rights to more restricted territory, and several Landowner groups may hold resource rights simultaneously in different territories in a geographical area.

Resource rights include the following: rights to land for agriculture use, for hunting, fishing and collecting (including materials for house construction) from group resources, rights to build a house, burial rights, and the rights to pass on resource rights to descendants. Distant relatives or childhood friends from another group may be allowed to share in such activities as preparing and planting a new garden and harvesting its produce, but such access is usually only a right of use, not ownership.

Economic trees and vines (such as coconut palms, breadfruit trees, pandanus, "pepper" vines and betelnut palms, i.e., those which need to be planted and kept clear of weeds) are virtually always individual property and, provided they are looked after and

[5] Tribes are defined as clusters of clans generally bound by shared traditions, language, and values.

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maintained, belong to the person who planted them. The plants can be inherited by the planter's descendants. This tradition also applies to the perennial economic tree crops such as coffee, cocoa and coconut plantations, though it sometimes engenders resentment in other group members since such crops can tie up very large areas of good land for many years and remove those lands from the normal circulation of agricultural land to which all members have access.

Rights of use tend to be very flexible in low population areas. Resources there for gardening, hunting, fishing and collecting from the wild are accessible to a wide range of people, including resource-owning (Landowner) group members in those areas. As population pressure on resources increases with natural demographic changes, immigration, or loss of land to another group, access to resources tends to become more favorable to "official" group members. In many parts of PNG, where kinship is reckoned patrilineally, women often return to their natal groups with their children if husbands die or marriages are dissolved. The women can be reabsorbed back into their father's or brothers' groups, although their children and grandchildren may later experience difficulties in establishing their respective resource rights in those groups.

It follows from the discussion above that one individual from a Landowner group cannot dispose of any area or parcel of land or alienate any resources (existing ones rather than planted resources) from that land on his own initiative. These inherited group and individual land ownership and resource rights are the birthright of group members and are their link with the past and the future. Parcels of land may be transferred to new owners as part of a brideprice payment or as part of a payment for the establishment of peace between two groups, but such cases are rare.

Spiritual Dimensions that Reaffirm the Relationship between Land and Its Resources and Success

A Landowner group's tie with its land and other resources, e.g. reefs, is not only economic, but has a deep spiritual basis as well, linking the group to its ancestors. The group's ancestors laid claim to the land and other resources many generations before, fighting wars, skirmishes and ambushes over the groups' natural resources. In other cases, the ancestors may have killed trespassers on their land to maintain the land's integrity. All life-taking and life-giving on and around a Landowner group's land is seen as strengthening and deepening a group's bond and multifaceted relationship with its land.

Traditionally, the integrity of a Landowner group in its everyday -- as well as competitive -- situations with other neighboring groups has been completely dependent on maintaining a very positive relationship between group members themselves, and also between group members and their ancestral spirits. Ancestral spirits are believed to maintain ongoing relationships with their human descendants. For example, Landowner groups believe that the positive actions of ancestral spirits make the critical difference between an ordinary harvest of yams and an outstanding crop of yams that outshines and "defeat" other groups' yams at food festival competitions. In most PNG cultural groups, ancestral spirits are believed to continue living in particular trees and places within the Landowner group's territory. The influence of Christian missions throughout PNG may have undermined somewhat the importance of ancestral spirits in everyday life, but the tie to the ancestral land and its resources is nevertheless very strong (John Finch, personal communication, 1992).

Local Resource Management Systems

Locally, biodiversity on a Landowning group's land or reef is managed in the context of farming, fishing, hunting, and collecting. Resource management systems employed by Landowners (individuals and groups) have in the past tended to be based on very conservative risk assessment and risk acceptability principles (Douglas 1985), particularly in relation to the production of food. Risk minimization and optimal use of labor (as opposed to maximizing production) drives decision-making. Landowners combine and manipulate a number of resource management systems at the same time. The combination of these systems in an area may lead to overall success; some systems may decline, though, as others flourish, depending on varying conditions (season, seasonality of plant and animal cycles, rainfall and other weather patterns and microclimatic conditions, soil, wage labor availability, etc.) For example, resource management systems typically include fisheries, hunting, forest extraction, woodlots, as well as subsistence gardening of a large variety of food crops. Wage labor outside the home area is also becoming increasingly important.

Resource management systems can be analyzed at the individual farmer (or "horticulturalist") level. Greater differences in resource management systems (and in their integrated systems) can be found between individuals in different PNG societies than between individuals within a single PNG society. The complexity of resource management systems lies in the individual's manipulation of a number of such systems in order to optimize control over the resource environment. The complementarity of many individual resource management systems leads to macro-level "systems" or resource use "patterns," such as the following.

<u>Subsistence food production</u>: PNG agriculturalists plan and work from one year to the next and from one season to the next, taking into account anticipated rainy and dry seasons, the need to protect against fire and the predations of wild animals and, in higher mountain areas, and the possibility of frosts. The agriculturalists plant a number of different crops, with cassava planted often for food supply in case of famine. In addition to production of food for subsistence, however, many PNG cultural groups place a high value on its production for consumptive values and for distribution.

For example, much planning, organization and preparation goes into food production when a community hosts a competitive food presentation (which is generally part of a cycle of such presentations). Extra gardens need to be planted a year or more before the event, sufficient numbers of piglets need to be acquired up to three years ahead of time, and increased food production is needed to feed the larger number of pigs being raised, all requiring enough man- and woman-power to carry out these extra tasks. Although invitations to other groups to participate in the food competition are issued to the leading personage in each group, that personage must organize and coordinate contributions from others in his group.

Resource management outside of gardens: PNG Landowners have in the past tended to collect materials from the forest or catch fish from streams or the sea and find house building materials or wild fruit, wild food or wild animals on an as-needed basis; long-term food storages were rare. Only items having a particular use were collected. With a relatively small population, this approach of natural resource use as needs arise, with subsistence food production linked to long fallow cycles, can be sustained.

As population increases, though, the pressure on natural resources increases as well. New markets sometimes cause large areas of land to be taken out of circulation for long-term cash crops and ranching. Smaller areas of land must therefore be used more heavily for food production, a situation made possible by the advent of new technology (tractors, plows, pesticides). To increase production on smaller parcels of land, shortened fallow cycles are employed, leading to a decrease in soil fertility and, in turn, increasingly inadequate food production. New technologies that increase the rate of extraction thus can ultimately have a negative impact on the resource base, depleting it faster than it can be replenished.

Local Economies and Development

Since contact was established with the outside world (initially on the islands and coastal areas but eventually even in the most remote valley and village in Papua New Guinea), there has been an increasing demand by Papua New Guineans for access to things the outside world offers. Over time, the cash economy has spread across PNG. Although traditional trading networks still operate in certain contexts, and gift-giving between kin in particular relationship categories to each other continues to take place, more and more people feel the need -- or have developed the need -- for cash income to meet or obtain an increasing range of needs and wants.

Development opportunities are available to Landowners depending on where they live and on their present access, if at all, to government services, and existing infrastructure. In some remote areas, interested people may work together to construct an airstrip to improve access to development opportunities. Yet more remote areas often have fewer opportunities for people to improve their quality of life.

Some development projects can contribute to the economic and cultural viability of a rural community. The prospect of good returns against invested labor often encourages people to remain in their home areas. Other development projects, however, such as timber or logging projects, have often been characterized by exploitation. Landowners have sometimes had to make decisions on such projects without adequate knowledge of options available to them; environmentally and culturally disruptive projects with scant economic return to communities have been the norm. In addition, many resource communities with valuable timber resources, for example, have perceived extraction of their timber resources to be virtually the only option available to get cash in hand and obtain services such as schools and clinics, as well as roads or other access into their area.

Recent logging operations have been characterized by the actions of opportunistic overseas businessmen, who have gone into likely Timber Rights Purchase areas (TRPs) or Local Forest Areas (LFAs) and used cash and other promises to encourage Landowners to agree to a logging operation. However, since the logging operations employ few local people, little economic benefit accrues to the Landowner group. Additionally, only the highest value timber species are extracted, without regard to long-term damage to either young trees or the land itself. There is typically no concomitant reforestation activity and no long-term development planning to complement or mitigate the extraction activities.

Stakeholders' Perspectives on Conservation Problems and Opportunities in Papua New Guinea

The term "stakeholder" refers to a person or group that has an interest, or "stake," in a given issue. Different stakeholder groups in PNG often have different interests in conservation and development in PNG. When interests conflict, mitigation may be possible. The major stakeholders in Papua New Guinea include: the State, local communities (Landowners), provincial government, business, biologists, NGOs, and donors promoting development and conservation programs.

The CNA Social Scientist team attempted to assess the position of different stakeholder groups regarding conservation problems and opportunities. What is discussed here is clearly not an exhaustive or comprehensive coverage of the issue for PNG stakeholder groups, but rather is meant to be indicative of general perceptions of three of the key stakeholder groups -- the State, local communities, and business (see Appendix 4-4 for assumptions and perceptions of these and other stakeholder groups). *Planning specific conservation activities will require analysis of stakeholder interests specific to particular situations.*

Perspectives of Three Key Stakeholder Groups

1. The State

The State in PNG is not a homogeneous entity. It is clear from discussions with government representatives from a variety of different departments and ministries -- National/Provincial Parks, the Department of Environment and Conservation (DEC), Forestry Department, National Museum of PNG -- that many differing opinions about conservation challenges and opportunities exist in PNG. However, all of the above government representatives agree that the constitution of PNG has recognized conservation to be a priority activity nationally, with the caveat that conservation be approached "the Papua New Guinean way."

"The Papua New Guinean way" refers to the necessity for conservation to work with and through Landowners. The State in PNG therefore does not act as the sole agent responsible for designing and implementing conservation initiatives. It recognizes, rather, that its responsibility is to facilitate conservation .

At the same time, the State has also supported large-scale development activities which are not always consistent with environmentally sound projects. The Ok Tedi mining project, most notably, was criticized for a lack of environmental safeguards that allowed the project to damage the entire Ok Tedi-Fly River system (Castell 1991). In Bougainville, Landowners' discontent with the compensation schemes devised to deal with either patrilineal or matrilineal inheritance customs of affected clan groups led to political unrest, eventually bringing about a total shutdown of mine operations.

The State's policy framework for conservation: The PNG constitution set the following goals for conservation and development in PNG: 1) Integral human development, 2) Equality and participation, 3) National sovereignty and self-reliance, 4) Natural resources and environment, and 5) Papua New Guinean ways.

The fourth goal states explicitly, "We declare our fourth goal to be for Papua New Guinea's natural resources and environment to be conserved and used for the collective benefit for us all, and to be replenished for the benefit of future generations."

Additionally, a statement of environment and conservation principles, made in 1977 by the Ministry of Environment, was accepted by the National Parliament. Significant aspects included: the need for ecological, social, and culturally suitable forms of development and their consideration in project planning; sustainability; environmental responsibilities; and environmental education and awareness.

The State in the forestry sector: Government currently plays a major role in mediating between communities and logging companies to regulate the conservation of forest resources. Government can acquire the right to log a forest from customary landowning communities, then grant permits or licenses -- Timber Rights Purchases (TRPs) -- to the acquired forest rights to potential developers. Or the State can allow the landowning communities to dispose of their timber in Local Forest Areas (LFAs) under the Private Dealings Act. As of the end of 1988, 2.8 million hectares of land in PNG had been licensed under TRPs, while .33 million hectares of LFAs had been declared (Unisearch 1992).

The State was criticized by the Barnett Commission of Inquiry for the role it played in allowing "the lion's share of profits [from the timber industry] to be shipped overseas, [with] only the left-overs...available for distribution in Papua New Guinea" (Barnett 1989). Abuses -- transfer pricing, undersetting royalty rates, manipulation of Logging and Marketing Agreements, inadequate supervision and management of expatriate-run logging operations, etc. -- have led to a situation where the forestry sector actors continue to be perceived as inimical to both conservation and Landowners.

2. Local Communities ("Landowners")

Landowners are a heterogeneous group with varying interests in conservation and development, but they share a desire for greater information about the pros and cons of available conservation and development options.

Papua New Guinea comprises thousands of local communities. The individuals who make up these communities are known collectively as Landowners (or, alternatively, Resource Owners). Ethnicity (clan or tribal affiliation), region, and language are all important differentiating criteria between and among communities. Thus, although the term "community" is used below to generalize about characteristics shared across clans, it is not a particularly appropriate term in PNG, in its commonly used sense of referring to a group where values and interests are totally shared.

Several key features serve to unify Landowner groups in PNG, so that logically they can be referred to as a distinct stakeholder group. These key features include the following:

(a) the principle of "wantok" -- people sharing alliances on the basis of kinship and residence -- operates throughout PNG as a means of social organization and differentiation at the community level;

(b) communities in PNG are mainly rural, and are in general undergoing rapid social transformation; and

(c) communities are in similar positions on a structural level with regard to government and NGOs.

In theory, considering PNG's constitution and legal framework, communities across PNG possess an extraordinary amount of power to set their conservation and development agendas. But this power has not always been constructively employed to promote their collective interests.

Communities across PNG have more often than not been uninformed about the real benefits and costs accruing to them from particular development activities. A growing degree of community-level discontent exists concerning how local community interests are represented at the national level. Increasingly, communities, in alliance with service-providing NGOs, are challenging other stakeholders' development -- and sometimes conservation -- initiatives.

In addition, community stakeholder interests may sometimes be jeopardized by poor social impact assessments and environmental impact assessments. Visits conducted by the Social Scientist team during the CNA confirmed that communities are often unaware of the specific content of agreements into which they have entered. Agreements were in all cases facilitated by agents representing individual Landowners from within the community.

In Josephstaal, for example, an agreement had been entered into with the Kosmo Co. regarding logging in 100,000 hectares belonging to 330 clans. But no one in a group sample of 35 people from 13 communities and 17 clans had a concept of the specific benefits and costs in the "agreement." The group members knew, or assumed, that there would be "spin-offs," or development projects. But they were not knowledgeable of the key components of the agreement. A further troubling note in Josephstaal was that many of the particular clans represented at the meeting did not appear on Kosmo's census of clans and villages in the project area which was part of Kosmo's Environmental Plan. This may have been because clans and/or villages have multiple names. It also could mean that the Kosmo census did not capture all relevant clans and villages in the proposed TRP area. Finally, it could mean that some of the participants at the meeting were not actually from the project area, but thought that they were.

The Papua New Guinea Council of Churches and the Starnberg Institute cast the conflict between community and business stakeholder interests in terms of the following assertions:

(a) A stop must be put to the destruction of the natural foundations of life wreaked by the exploitation of mineral resources and the felling of tropical rain forest in a manner which either neglects or runs contrary to social and environmental considerations.

(b) A check must be placed on the supplanting of subsistence/cash crop mixed farming. This would require the cessation of forms of raw material production and felling of the rain forest which are harmful to the environment and a stop to the conversion of land in communal ownership into alienable property.

(c) The State should renounce further any withdrawal from the economy (liberalisation), and hence from any responsibility for economic, social and environmental development.[6]

The CNA team assessment confirmed that these opinions (at least the first two cited above) are at the forefront of many communities' -- and certainly NGOs' -- minds. Communities see that development is happening at the expense of conservation. At the same time, many communities in PNG do want development to occur. But they feel that neither business nor the State has done a good job in promoting development that is both sustainable and in the interest of communities as a stakeholder group.

One of the most complex issues facing communities and the stakeholder groups with which they enter into negotiations, is the negotiation of compensation packages -- including both royalties and employment -- that will satisfy both the current and future demands of the landowning community (Filer 1990). At Bougainville, the compensation packages which were negotiated functioned as "'time bombs' causing social disintegration because they

[6] Starnberg Institute 1991.

involve[d] wealth, power and influence which cannot be distributed by custom and contributed to stratification within the Landowner community" (Filer 1990). Communities have not yet developed a process that addresses unforeseen cultural and social limitations that could emanate from development activities.

Other threats to communities in PNG are inter-communal: the interests of neighboring communities are not always in harmony and are often in conflict. *Any analysis of communities' stake in conservation must examine inter-communal sources of conflict over natural resources, the historical and ecological dimensions of the conflict, and its dynamics.*

Filer (1990) has neatly exposed what he calls

> "the myth of Melanesian communism," that is, of a community whose members lived in complete harmony with each other and with their natural environment, who jointly owned the land to which they had a mystical attachment, who chose their leaders by consensus, settled arguments by compromise, and redistributed the products of their labour to ensure that everyone enjoyed the same condition of subsistence affluence.[7]

While the presumed pristine state of "Melanesian communism" may in fact never have existed (in that conflict over natural resources, among other things, was a fact of life both within and between communities on an occasional, if not cyclical, basis [cf. Rappaport 1968]), accelerating population growth and breakdown of traditional resource and dispute management systems is exacerbating conflict within and between Landowner communities. The ability of communities to self-regulate resource use seems to be diminishing.

However, shifting or swidden agricultural systems have proven to be very resilient to increases in population and gardening pressure. Contrary to predictions made more than 30 years ago such agricultural systems have survived without any major government intervention (Unisearch 1992).

Although resource management systems have not collapsed, communities across PNG can confirm that the systems have in fact changed. They can explain how resource use has changed by community and gender, and can say which species are still abundant and which are rare or have disappeared. People are acutely aware of such changes, and communities have different theories about the causes. Thus while continuity in some aspects of agricultural systems has been maintained, considerable changes in systems have occurred as well. Both continuity and change are thus evidenced in PNG society today, and will be key factors in shaping conservation programs in the country.

[7] Quoted in Unisearch 1992.

3. Business

Business in PNG has varying track records and attitudes. It is therefore difficult to generalize a "big business" stakeholder position. In addition, business's approach to development and conservation in PNG is evolving in response to various experiences in PNG.

Mining companies: Papua New Guinea is rich in mineral resources and the government of Papua New Guinea has negotiated agreements with a number of mining companies in PNG. Mineral resources, those resources occurring on or under any land in PNG, are treated by the State as State owned, even when they occur on lands which are customarily owned. Thus mining businesses historically have had to worry only about dealing with the State as a counterpart stakeholding interest in PNG (Unisearch 1992). As the Bougainville experience[8] indicates, however, mining companies must now acknowledge from the outset of an operation the importance that needs to be attached to the registration of land titles. The approach adopted at Ok Tedi tried to obviate the problems of Bougainville by focussing on inheritance customs (Okole 1990) and devising compensation measures that would satisfy the demands of particular landowning communities over time (Filer 1990).

Logging companies: The forestry sector presents a different set of problems than does the mining sector. Business as a stakeholder interest must therefore be considered differently when looking at forestry, or logging, companies.

In 1988, some twenty logging companies were registered and operating in PNG. Forest products are the fourth largest generator of foreign exchange in PNG, mainly through log export. Much of the known potentially commercial forest area in PNG is committed under existing operations, or in projects being negotiated. The current annual rate of logging is about 70,000 hectares a year, with estimates of total commercially utilizable area ranging from 2 to 15 million hectares (Unisearch 1992).

Oil companies: Chevron Niugini, a major business stakeholder in PNG, is approaching its development and conservation activities with a more careful eye to the social and economic repercussions of its activities than previous mining companies operating in PNG. While it is clearly interested in developing the Kutubu and Kikori Valley oil resources because of the economic rate of return projected, Chevron appears to be interested in promoting sustainable, ecologically sound development, through its impending support of the Kikori Valley project submitted by WWF (WWF 1992). If well implemented in Kikori Valley, benefit flows will be broadened to include community stakeholder groups from five major groups of Landowners, involving 5000 people in the Highlands area and 7000 in the delta (Unisearch 1992). Nevertheless, the difficulties which Chevron has encountered in its dealings with Landowner groups was recently well documented by the Wall Street Journal (McCoy 1992),

[8] In Bougainville, dissatisfaction on the part of landowners over the various compensation schemes devised to deal with different inheritance customs led to political unrest which eventually shut down operations at the mine.

illustrating once again how crucial local collaboration is in any outside-inspired development activity.

Contradictions Between and Among Stakeholder Interests, Development and Conservation

The Unisearch report prepared for the 1992 UNCED meetings describes the differing perspectives of the major stakeholder groups in PNG with the example of how the terms "development" and "deforestation" are used and understood by each of these groups.

> To a commercial logging firm, the clearance of forest for low intensity subsistence agriculture, even if it subsequently regenerates, nevertheless constitutes "deforestation" because all loggable trees are destroyed. To some environmentalists, forest disturbance by selective logging or even subsistence agriculture is unacceptable because of the perceived negative impacts on biodiversity, animal habitat and the stability of soils. To all environmentalists the permanent removal of forest cover is abhorrent, but agriculturalists and villagers might find this acceptable if the forest is replaced by, for example, productive small-holder cocoa plots or oil palm estates.

Landowner resistance historically has been lower to logging operations than to mining projects, despite the fact that the benefits from the latter are higher for Landowners, with no perceptible difference in additional negative environmental impact. This seeming paradox in community stakeholder receptivity to different big business interests may have one or more of the following explanations:

(a) Mining companies have been unwilling or unable to establish the network of bribery and corruption which the logging companies have used to silence the leaders of landowning communities.

(b) Landowners are able to cope with the relatively small-scale and short-term nature of logging projects. The much larger scale, the high technology and the complex organization of mining projects is more difficult to tolerate.

(c) The forestry sector has not been subject to the same process of "media amplification" which has occurred in the mining and petroleum sector.

(d) Landowners undervalue the forest resource. Not only is forest clearance a very ancient practice in PNG, but the erosion of traditional practices -- including religious practices -- and the growth of a market economy have greatly reduced the range of perceived needs which the forest supplies to the average villager.

(e) The negative environmental impact of logging operations is not evident until it is too late for Landowners to mount an effective protest, by which time the contractor has moved on to a new area.

(f) It is not clear whether Landowners are interested in environmental protection for its own sake, or for whatever cash benefits a particular project is expected to produce. What sometimes appears to be a disagreement between Landowners and loggers turns out on closer inspection to be a disagreement between factions within the landowning community whereby one group feels it is not receiving a fair share of the proceeds and therefore has nothing to lose by waving the conservationist flag at its opponents.

(g) Landowners' demands and protests are guided by their perception of the economic benefits which a developer is willing or able to pay, or those which it is obliged to pay as a result of investments already made in the development of a project. The Barnett Inquiry revealed that many logging operations in PNG are so grossly under-capitalized that bribes constitute the major part of the contractor's initial investment, while the 'Landowner company' is left to bear most of the costs of extraction out of its own revenues.[9]

The implication of the above is that forest conservation will not proceed unless conservation interests match the material incentives offered by the timber industry (Unisearch 1992), an assertion not necessarily widely agreed upon (as evidenced by NGOs and social scientists who debated the issue at the CNA workshop[10]).

Conservation Issues Arising from Stakeholder Relationships

Stakeholder collaboration must be a key factor in conservation in PNG. If conservation objectives are to be achieved on a widespread basis, it is important that key potential actors begin communicating; until now they have been talking past each other. No one stakeholder group alone can implement major conservation activities without the active assistance and support of the other groups. Mistrust between or among any of these groups can therefore hinder conservation success.

For example, NGOs and Landowners each believe that they must have input into the conservation planning and implementation process. Both perceive themselves as largely left out of the process. Government conservation planners have sometimes perceived NGOs as being either too activist or technically incompetent to participate as equals. At the close of the CNA workshop, however, DEC personnel did say that DEC was interested in exploring how and where it could begin to collaborate with the PNG National Alliance of Non-governmental Organisations (NANGO). Assessment of Wildlife Management Area (WMA) proposals already submitted by local communities was suggested as an initial area of collaboration.

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[9] Filer 1991.

[10] See Appendix 4-4 and/or Chapter 10.

Conservation Planning: Top-Down (Government-Driven) or Partnership?

Conservation management starts on a unique footing in PNG. As stated earlier, virtually all land in PNG is owned through customary tenure by Landowner social units based on kinship groups. Unless the Landowners embrace conservation planning, successful conservation will not be achieved. This singularity in PNG's land tenure system is still perceived by some (not all) government planners and international conservationists as a problem rather than an opportunity (see Lynch's report, this volume).

The ability of the government to control or force conservation is indeed limited. For example, it is very difficult to remove land from traditional tenure by state fiat. This makes the creation of protected areas such as parks or reserves almost impossible.

If the PNG land tenure situation were perceived as an opportunity, conservation strategies could be developed to take advantage of Landowner propensity to value natural resources for multiple purposes. Such strategies would stress mechanisms to invest Landowners with the information, tools and legal means to promote appropriate conservation to complement the overall sustainable development and welfare of rural Papua New Guineans.

If conservation planning were driven from the top, on the other hand, using the CNA maps as a blueprint for where conservation should proceed, areas may be prioritized on a biological basis, while neglecting a sociocultural perspective. *Selection of conservation areas should be made on the basis of biological criteria in conjunction with social feasibility if conservation measures are to succeed.*

Government-driven planning -- the mapping exercise: Many of the biologists' and conservation managers' assumptions at the CNA (see Appendix 4-4) seem to indicate that they see conservation basically as a planning and execution exercise, i.e., amenable to top-down processes in which situations are technically assessed, plans are drawn up, and implementation proceeds. Many biologists felt that it would be counterproductive to discuss the mapping exercise among Landowners, NGOs and social scientists since it was, in their view, a straightforward and objective process.

Here it is worth noting a caveat from a professional mapmaker (Monmonier 1991:2):

> *a single map is but one of an indefinitely large number of maps that might be produced for the same situation or from the same data* [original emphasis]. How easy it is to forget, and how revealing to recall, that map authors can experiment freely with features, measurements, areas of coverage, and symbols and can pick the map that best presents their case or supports their unconscious bias. Map users must be aware that cartographic license is enormously broad.

L[illegible]y [illegible]owes, co-curator of an exhibition of maps at the Smithsonian's Cooper-Hewitt National Museum of Design in New York City, reminds visitors to the exhibit that "[e]very map is someone's way of getting you to look at the world his or her way. Despite an aura of neutrality, maps present information selectively, shaping our perceptions of the world...By seeing maps for what they really are, by understanding their persuasive power, we can go on to use them to make sense of the world and our place in it (Bolz 1993)."

While drafting a map of biologically important areas was a major CNA objective, again it is debatable as to whether from a conservation perspective biological importance as defined primarily by species richness and endemicity should have driven the mapping methodology <u>if this will be DEC's sole basis for conservation planning in PNG</u>. Another mapping exercise, for example, focussed on prioritizing areas for conservation as a function of threat, defined by economic and/or population pressure indices, might have led to a different map of priority conservation areas.

Priority ranking for conservation in PNG is therefore a <u>relative</u> concept, as opposed to an <u>absolute</u> truth. For example, what the biologists were hoping to achieve with the map, in addition to their choice of criteria to prioritize areas of biological importance, determined to a large extent the amount of land area that showed up on the map. While objective criteria may be used to identify <u>which</u> areas could be prioritized, in order to achieve the World Bank's objective of putting 20% of the country under protected area status (Unisearch 1992), the ultimate decision of how much of the country should be designated as priority conservation areas is highly subjective, and can be politically driven[11].

<u>Conservation planning through a partnership</u>: If the mapping exercise is as subjective as is suggested here, the following assertions make a case for including NGOs, Landowners and social scientists to act as consultants to the mapping exercise:

(a) If NGOs and Landowners do not understand the rationale and value of the maps, they may reject any conservation plans which are generated on the basis of information provided by the maps.

(b) If the final decision to include certain areas on the maps as priority is based on subjective factors (such as the attractiveness to potential donors of having a certain area set aside as a priority area, or the eventual establishment of protected areas on the basis of the maps' information) then non-biologists need to understand the degree to which the maps are subjective -- and why -- before they will accept any subsequent action based on the maps.

(c) Non-biologist NGOs and Landowners can provide information to biologists that can be used to temper the more subjective aspects of mapping decisions, particularly in terms of an overall strategy of prioritizing more or less area on the map.

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[11] During the CNA workshop, apparently under advice from DEC, the percentage of area that the biologists prioritized actually shifted from an initial target of 20% to approximately 50% of terrestrial PNG.

(d) As indicated in the section above, the mapping exercise is not a purely objective process. Therefore, the argument that the mapping should proceed prior to discussions of conservation goals and programs holds dubious merit. Discussing objectives of the mapping and developing an appropriate methodology to incorporate all necessary biological and sociocultural variables should be undertaken prior to any mapping activity aimed at effecting action. This is especially true in PNG.

Furthermore, conservation planning must take threat factors (such as economic or population pressures) into account, so that biological factors alone are not the main programming determinants. A rough comparison of the final CNA map (CI 1993) of biological priority areas with a map of population (King and Ranck 1982) suggests that most of the "very high" and "high," as well as "wetlands" priority sites fall in areas inhabited by fewer than five people per square kilometer. Threats to biodiversity from Landowners and their resource management systems in these areas is likely limited.

Landowners must be involved in the implementation of any conservation areas. If the conservation agenda is set by DEC alone, and if the NGO community and Landowners are not involved in setting the agenda, conservation in PNG will most likely be constrained. *PNG's conservation agenda should be based on the identification of processes, methodologies, and working relationships that can best promote conservation. Landowners and NGOs should be introduced into the conservation planning process in the early stages, rather than consulted on an* ad hoc *basis.*

Strengthening Stakeholders: The Crux of Conservation in PNG

It has been argued that Landowners already emulate a great conservationist tradition in PNG (see Hill, Pernetta, and Rongap 1982). Yet there has not been a systematic attempt on government's part to provide Landowners with the incentives and the rationale to maintain or step up conservation activities. This is where the issue of Landowner awareness and options becomes vital.

Aid agency workers, along with church and NGO staff, agree that Landowners are very concerned that they are not being given complete information about resource options, or sometimes that they are given no options at all. Landowners believe they do not know which questions to ask because they do not know the options available to them. This lack of information will only serve to weaken the Landowners as stakeholders in the political process.

Providing Landowners with good quality information about the costs and benefits of various conservation and development activities (including timber extraction) will be a crucial step in strengthening Landowners as a stakeholder group that can and will promote conservation of biodiversity in PNG.

Institutional Relationships to Promote Conservation

A noticeable lack of coordination or collaboration has existed to date between development and conservation institutions in PNG to achieve specific conservation objectives. Indeed, only recently has consideration been given to integrating conservation and development in PNG. Like institutions with conservation mandates, development institutions will play an integral role in any conservation work in Papua New Guinea, although perhaps for different reasons.

Seven key institutional relationships in PNG are discussed below:

- NGO and government
- NGO and local communities
- timber company and Landowners
- government and Landowners
- government and government (DEC and Forestry Department)
- scientists and government
- scientists and Landowners

NGO and Government

Non-governmental organizations (NGOs) are relatively recent phenomena in PNG, although church missions have historically carried out NGO-type activities (in addition to other activities) with local communities. In many areas of PNG, missions undertook medical, educational and agricultural extension work with local communities long before the arrival of government. These NGOs, now mostly established as PNG chur[illegible] continue to perform many of these same activities, especially in the fields of health an[illegible]ation. However, this work is now done under the overall national policy framewo[illegible] established by the State.

In many places, communities believed that involvement with a church organization would bring development along with it. The evolution of colonial administration to nascent national government and, finally, to independent state government coincided with the flowering of church missions in PNG. Yet, throughout this period of transition, most observers believe that the level and quality of services rendered village communities has largely deteriorated.

Dramatic improvements in services did not occur with establishment of self-government, independence, and a more developed provincial government administration. Landowning and resource-owning communities have thus remained in the position of seeking "spin-off" projects to improve overall quality of life. Additionally, they still maintain a "cargo cult" dream -- intrigued by the unrealistic possibility of planes flying in and dumping their "cargo" (schools, fully staffed and well-equipped clinics, roads, western material goods) in a manner that will change their lives. In many respects, the merchants of TRPs -- foreign timber companies and their government intermediaries from the Department of Forests -- may represent for many resource owning communities the vanguard of "cargo" purveyors.

It is into this arena of overblown expectations that both NGOs and government -- be they in conservation or development -- must operate. In recent years, with financial support from international NGOs, many non-church based NGOs have been established in PNG; UNDP (1991) has identified 103 such organizations. Many of these organizations are part of NANGO, which was established as an umbrella organization to promote collaboration and communication among PNG NGOs (NANGO 1990).

Many of the NANGO NGOs have sector-specific mandates, such as environment or what is called in PNG "integral human development," an amalgam of integrated rural development and human resource development. Most of these NGOs receive funding from overseas sources for administrative overhead and programming, and are still in the process of establishing themselves in terms of self-identity, identity in the eyes of the State, and identity in the eyes of international donors and potential partners in conservation and development. Some of these NGOs have assumed the mandate and philosophical/ideological position of international NGOs. Many PNG NGOs, like NGOs around the world, assume that they can cooperate more directly and effectively with village-based organizations than can government.

In the environmental sector, this attitude has led to some degree of hostility between NGOs and government. NGOs have taken a pro-active role in positioning themselves in "problem areas," such as Timber Rights Purchase or mining concession areas. They generally have taken a confrontational position with regard to private companies and government agencies that they perceive as promoting private sector interests to the detriment of local communities. Government, on the other hand, must carry the burden of disappointment and unrealized expectations that many PNG communities may harbor towards "the system." This seems particularly true in areas where mining operations (Bougainville, Ok Tedi) or TRPs (Jant in the Gogol Valley, heli-logging in the Huon Peninsula) have not led to the "spin off" benefits that local communities had been expecting.

Until very recently, scant coordination of NGO activities with those of government in the area of environment or natural resources management has taken place. Hesitation on the part of government to collaborate with organizations which they perceive as being ill equipped from a professional or infrastructural standpoint to address natural resource management problems has played a role in perpetuating a gap between government and NGOs. NGOs, for their part, have often been highly suspicious of government's ability to address the country's problems with integrity, and with government's ability to deliver services that benefit Landowners.

Government has focussed on the flaws and institutional shortcomings of NGOs. At the same time, some government agencies, like DEC, acknowledge the potentially important and constructive role NGOs may play in conservation work in PNG. By the close of the CNA workshop, plans for DEC to begin collaboration with NANGO, specifically in establishing a joint work program for NANGO's Conservation Networking Officer (CNO) were being discussed by DEC and NANGO. *Small steps such as this are what is needed to build and institutionalize a working relationship to bring the NGO community (as represented by NANGO) closer to government in the planning and execution of conservation work.* This can be a major benefit to all interested conservation stakeholders in PNG.

One strength of PNG NGOs is their potential to approach communities in culturally sound ways. PNG NGOs are generally respectful of indigenous knowledge and local leaders, i.e., local socio-political structure. Historically, while PNG NGOs have been strongest at advocacy, they have been weaker in identifying practical options for communities to promote development and conservation objectives. With strengthening, NGOs could play a more constructive role in helping communities identify development and conservation options, and in implementing specific activities.

In many parts of the world, NGOs are beginning to demonstrate the effective role they can play in providing services to communities and in serving as a conduit between communities and government on certain issues. The same potential exists for PNG NGOs to deliver services that will benefit resource-owning communities and government alike.

NGOs and Local Communities

While some NGOs have excellent relationships with Landowner and other communities (such as youth groups and women's groups), it is unclear whether these relationships have been strong historically, and whether they have always benefited Landowners and local communities. The assumption on the part of many is that NGOs can and do serve as effective intermediaries between communities and outside institutions, e.g., the State, private sector commercial interests, other NGOs. PNG NGOs have not been active long enough to evaluate whether, or under what conditions, they are able to act as useful intermediaries to local communities. Again, however, with appropriate strengthening there is no reason to believe that NGOs could not assume a stronger intermediary role.

The question of the extent to which PNG service-providing NGOs (or others) can represent Landowners needs to be addressed. In general, NGOs do not have a legal mandate to represent Landowners. Indeed, since each of the tens of thousands of Landowner situations in PNG is unique, it is unlikely that any one NGO could fully represent Landowners in general. For this reason, the role of NGOs is still very much in the process of evolution in terms of their relationship with rural-based landowning communities. Ways and means of collaboration are still developing, with the limits of roles and responsibilities yet to be determined.

Timber Company and Landowners

The current process by which Landowners interact with timber companies is at best a haphazard one. After initial resource assessment by the Department of Forests, a Timber Rights Purchase area (TRP) is eventually offered to logging companies on tender. Currently, a Landowner company is formed to represent Landowners in some kind of partnership with the logging company. Logging companies in TRPs are required to produce and operate according to forestry management plans (which include socio-economic and environmental impact statements) that have to be approved by the State.

Under TRPs, the Landowner communities generally have no influence on the logging company that is selected and are involved with that company only through a Landowner company. These Landowner companies, too, are quite variable. In some cases, they are owned and controlled by small numbers of educated people from the area, or by politicians and their cronies. One often finds a situation whereby a small sector of the Landowner community is in league with the company to exploit their own people and are thus equally responsible for the degradation of the Landowner's environment. In other TRPs, the extraction of logs has proceeded much more in line with forest management and logging plans.

A parallel system of Local Forest Areas (LFAs) has been established. The LFAs are meant to be used for log extraction over a limited area or in an area where there are to be very few bureaucratic restrictions. LFAs are much more open to exploitation and manipulation than TRPs.

In both systems, but particularly under LFAs, Landowner communities have become split and polarized by logging companies, leading Landowners have been subjected to blatant bribery and corruption, and loggers have made many unfulfilled promises. Loggers have consistently understated their log totals, named less valuable species for more valuable ones, engaged in transfer pricing and have generally operated without regard to good environmental practices. They have often left behind total devastation with their precipitous departure from an area.

Nevertheless, under both TRPs and LFAs, the amount of money that is eventually returned to Landowners is comparatively small. For many years, all royalties from log exports were retained by the State. With the advent of provincial governments, up to 50% of timber royalties from a province were paid to the provincial government. An increasing percentage of all the royalties -- in some provinces up to 100% -- have been paid to Landowners over time.

Under the new National Forestry Authority (gazetted and established in July/August 1992) both TRPs and LFAs are to be replaced by Forest Management Areas (FMAs) that will have to conform to much stricter requirements, both in terms of the representative composition of the Landowner company and in the operating principles (in plan and execution) of the logging company. How these ideals will operate in practice remains to be seen. With more public knowledge of the overall effects of logging, sometimes due to targeted information campaigns, many Landowners are now becoming increasingly wary of agreeing to logging projects (even in TRP areas where the State has already paid for rights to timber). As they become aware of other development options or the mounting negative effects of a logging project, Landowners may even refuse to allowing logging operations to continue.

In spite of these changes, some Landowner communities feel that they still have little choice but to proceed with logging projects in order to get road and other infrastructural development such as schools and airstrips in their areas. These benefits are usually written into contractual agreements between the State and the logging company and are required to be established by the company. Landowner access to information concerning logging projects is generally very limited and, until quite recently, has been restricted to information given to them by forestry officers at the time of resource assessment and rights purchase -- information that might simply emphasize the benefits to Landowners of logging projects, such as cash in hand, employment, roads, and schools.

Landowner access to information from timber companies has also been strictly limited in the past. This is largely because once a contractual agreement was signed between the State and a timber company the efforts of relevant public servants (such as foresters) went into ensuring that all the provisions of the contract were fulfilled and that the company was happy. Companies wishing exemptions to contractual requirements or extensions to their concession areas were normally given every assistance by forestry officers, locally as well as nationally. Many examples can be found of Landowners putting in complaints of damage, for example, to forestry officers only to have such complaints ignored. Provisions under the new National Forestry Authority and the new Forestry Act may improve Landowner access to such information as options, reporting, and monitoring.

Government and Landowners

It is important to distinguish between government departments when referring to government/Landowner relations. In the environmental sector, government has interacted most notably with Landowners in the area of Timber Rights Purchases (TRPs) and mining concessions. As described above, this intervention arguably has not always been to the benefit of rural communities. The Barnett Commission report on forestry sector activities (1989), including both Department of Forests and private sector interests, has described this situation in detail.

At the same time, DEC has had relatively limited contact with local communities, although there is the potential for expanded contact, as evidenced by Landowners' requests that DEC assist them to establish Wildlife Management Areas (WMAs). DEC will need considerable institutional strengthening to be in the position to adequately respond to community-initiated conservation projects, and to be able to play a more effective oversight role concerning the conservation implications of Forest Department activities through TRPs (or LFAs under the new PNG Forestry sector legislation).

Landowners do not appear to distinguish between different government departments. Thus the Department of Forests's actions will affect how Landowners perceive other departments such as DEC. Since there is in fact a great difference between the objectives and performance of different government departments, it is ultimately up to each government department to distinguish itself from the rest.

DEC's credibility, for example, will clearly be enhanced in the eyes of Landowner communities as DEC becomes more responsive to Landowner requests for assistance, particularly in regard to Wildlife Management Areas (WMAs). In addition, if DEC can play an oversight role in the administration of Environmental Impact Assessments (EIAs) for TRP Environmental Plans, and communities are aware of DEC's role, it follows that DEC's credibility will be enhanced accordingly. Finally, as DEC increasingly demonstrates willingness to collaborate with NGOs, its credibility with Landowner communities will likely further increase.

DEC will likely need additional personnel, as well as more fully trained personnel capable of interacting effectively with Landowner communities, to accomplish the above goals.

DEC, the Departments of Forests, and the Department of Minerals and Energy

A great imbalance has existed in the capacity of DEC versus Department of Forests to deliver services to rural communities. DEC has had limited financial and human resources to develop a conservation program for protected areas (including WMAs), and has not played a visible monitoring role on the environmental impact of forest sector activities. The extremely poor quality of environmental impact assessments (from a social impact perspective) that TRP concessionaires have been able to push through the system is proof of DEC's limited monitoring capacity.

Neither DEC nor Forestry has had the means or the wherewithal to put teeth into the EIA process. From a social soundness standpoint, DEC's weakness in this area has played into Forestry's ability to push through approvals of TRPs of dubious merit. According to Unisearch, the quality of environmental plans prepared for mining projects has been without exception more comprehensive in scope and professional standards than those produced in the forestry and agricultural sectors (Unisearch 1991).

The forestry industry, over which the Department of Forests is responsible, has permitted implementation of projects without heeding requirements of the environmental legislation. Many such projects have been approved under the Forestry (Private Dealings) Act of 1972 and 1974, which does not require that EIAs be carried out. Where EIAs have been undertaken, the full range of environmental impacts have not been assessed. This is particularly true for sociocultural and socioeconomic impacts.

As part of the CNA, the Social Science team looked closely at the Environmental Plan done for the Josephstaal TRP, submitted by the Korean firm Kosmo. While the plan is of superior quality to other plans seen, it does not specifically address issues pertaining to sociocultural and socioeconomic impact. It does provide an inventory of clan groups, numbers of clan members, etc, as well as a very general overview of social life and cultural features in the proposed project area, but by no means does it provide the slightest analysis of how proposed project activities would impact any or all of the 44 villages, 330 clans, or 4,781 people living in the project area. The Environmental Plan provides little more than a simplistic ethnographic recounting of certain social and cultural facts relevant to the area. This type of analysis is wholly unsatisfactory in addressing impact, as well as any necessary mitigating measures which would be required.

DEC to date has not had the technical ability to critically evaluate EIAs, such as the Josephstaal EIA, in order to provide direction and alternatives. *DEC's ability to seriously evaluate EIAs, and to see that its critique is heeded by Forestry in order to prevent the adoption of inadequate plans, is of critical importance to both government and Landowners in PNG. This ability clearly must be strengthened.*

In the mining sector the Ok Tedi case is worth citing as an example of the dilemma in which the PNG government has sometimes found itself -- "as advocate of the nation's natural resources on the one hand and as protectors of these resources and the environment on the other" (Unisearch 1991):

> When conflicts have arisen, the responsible department, Minerals and Energy has usually taken the position of the State as shareholder rather than as the advocate for environmental protection. These conflicts can never be completely avoided, but they can be more fairly resolved only if the views of the government's environmental managers, in this case DEC, are given equal weighing to those of the relevant department advocating resource development.[12]

Scientists and Government

A strong linkage clearly exists between biological scientists and DEC, as evidenced in scientist and government positions regarding CNA workshop objectives and conservation objectives (see Appendix 4-4). Linkage is less clear between scientists and the Department of Forests, where scientists are not generally in accord with the department's procedures for promoting and handling TRPs.

Linkage has historically been weakest between social scientists and DEC; in fact, there has not really been any link between DEC and the small community of social scientists working in PNG. Furthermore, the perception that DEC has had of social scientists may be based on the assumption that social scientists undertake, exclusively, ethnographic work. This assumption may be based on the strong social science (anthropology) and ethnographic research work that has come out of the National Museum of PNG and from foreign and resident anthropologists working in PNG over many years.

[12] Unisearch 1991.

To achieve conservation objectives in PNG, it is clear that social scientists have a major role to play in feasibility analyses, rapid rural appraisals prior to undertaking specific integrated conservation and development projects (ICADs), and in the monitoring and evaluation of conservation work. The CNA workshop may have made DEC more aware of the possibilities of collaboration with social scientists in conservation. In this sense, the linkage which hitherto has been lacking may be in the process of being formed.

Clearly, given the dismal record of EIAs in incorporating social components, an opportunity exists for the Department of Forests to collaborate with social scientists in impact assessments. Whether this potential can be realized is a topic worthy of further study.

Finally, given the extremely limited number of national social scientists available for applied social science work in PNG, it is inevitable that expatriate social scientists will be required for assignments until the time that more PNG nationals have been trained in applied social science methods. If it is assumed that only scientists (whether biologists or social scientists) with long-standing experience in PNG can contribute to conservation in PNG, conservation work will be severely constrained.

Scientists and Landowners

While scientists, both biological and social, may be able to rationalize the value of their research, this perceived value is not always shared by local communities (in PNG or in any other country in the world). It is the responsibility of scientists to demonstrate the relevance of their research to the communities. It is not enough to assume that the mere assertion that research is relevant to a given country will cause local people to respond positively to research efforts.

The picketing of the CNA workshop illustrated that there is still a gap between the perceptions of Landowners and those of scientists about scientific research and its application in PNG[13]. Improvement in communication between research scientists and Landowners, with help from government and NGOs where appropriate, will go a long way toward bridging that gap.

Even with improved communications, Landowners may still fail to see the relevance of scientific research to their lives. Scientists will then need to determine what steps are required to change Landowners' perceptions, and to make the application of science to Landowners' welfare more apparent.

Sociocultural Mapping: Potential Relevance and Limitations

In theory it is possible to map social and cultural diversity. Detailed land rights maps, indicating current boundaries between Landowner groups, could be drawn up to

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[13] See Appendix 10-3 (in Chapter 10) for comments reflecting suspicions about scientists.

complement maps of biological richness. Such maps could indicate the nature of kinship relations within particular Landowner groups and, perhaps, between adjacent Landowner groups. Census information on the numbers of people in particular clans or sub-clans, as well as information on land use or cropping systems, could be provided. Information on land use systems and types of correlated pressure or threat to biodiversity, and population pressures could certainly be mapped and would be an important complement to the CNA maps for biology.

On the other hand, there is no objective way to condense and value society, culture, and its diversity in the way biologists can objectively value (or measure) biodiversity as by counting the number of species in a given habitat, for example. A simple counting of the number of people in a given society can give no indication of the quality or importance of a given culture or of that community's appreciation of different aspects of its environment.

No one PNG society or culture is more important than another (the same can be said for any society in the world). A map of sociocultural diversity in PNG could only show, in the most arbitrary ethnographic terms, what type of society and culture inhabit a particular zone, the type of ecological adaptation of the society, the number of people in the society, the number and location of sacred sites, etc. Questions concerning the values of the society, the society's system of beliefs and religion -- in short, all highly subjective and relative types of data -- could in no way be digitized and put on a map. No tools now exist that can measure or value culture in terms similar to those found on the CNA map of biological importance. Nor is it likely that such tools will be developed. Thus a map of indigenous societies or cultures in PNG cannot be created from the perspective of "importance" in the same way that non-human biological resources can be evaluated. Human societies and cultures present differences in order, magnitude, function and, arguably, reason for being than do other species. This in itself puts human society and culture at a certain disadvantage for mapping priority conservation areas, since no priority of sociocultural systems can be mapped to overlay biological maps.

In addition, the critical cultural and social information relevant to the conservation of biodiversity in PNG cannot be depicted on such maps. It would be difficult to clearly illustrate on a map the dynamism, transactions, and processes of social change and/or adaptation of a given society in regard to the environment. For these reasons, the team did not attempt sociocultural mapping in PNG.

Recommendations

It behooves all protagonists in such a volatile and fluctuating situation to act and advise with great care, altruism, and circumspection. It needs to be remembered that outsiders (i.e., those people who are not from the local area) can leave and return home, but people from an area where a conservation project has gone amiss must still continue to live there and have to cope with the results of decisions made on outside advice.

Maps can be abused or misused in many different ways. *If donors and government rely exclusively on the CNA maps to target conservation activities, then conservation projects may be forced onto people unwilling or unable to comply, in areas where activities are not appropriate. At the same time, the best opportunities for conservation may be lost by failing to target areas where people are most willing and able to participate in conservation or where threat to biodiversity is greatest, because these areas failed to fall onto areas mapped as priorities.*

The recommendations noted here build on the analysis done in previous sections:

1. Natural Resources Options Centre

The State cannot force Landowners to give up land for conservation projects. Nor can NGOs force Landowners to carry out any course of action unless Landowners believe such actions are ultimately to their benefit. Landowners will find it difficult to get access to relevant information and guidance without the cooperation of both NGOs and the State. In spite of their traditional concerns for all creatures within their environments and the legendary and multifaceted deep relationships with their land, ultimately Landowners will maintain or initiate activities which they see as being in their own interests or benefit.

a) As long as Landowners do not know or understand their options, conservation opportunities will be missed and inappropriate development opportunities will be exploited. A Natural Resources Options Centre (NROC) should be established to promote support for conservation among PNG landowning communities. This center could serve as a clearing-house for relevant information on the costs and benefits of different planned or potential activities, available to the general public, government decision makers, and specific Landowner groups.

b) The NROC could compile (from PNG and overseas sources) appropriate natural resources information, the "pros" and "cons" of their development options for resource-owner groups, and initiate and coordinate research and development of a wide range of indigenous plant species (fruits, nuts, timber, other non-timber forest products, medicinal plants, etc.), and evaluate associated development options. The NROC could present broad public education programs for awareness-raising and more targeted campaigns on specific issues; distribute media materials tied into these programs and campaigns; and support active field team(s) for working with resource owner groups in establishing their own development options for their own resources.

c) A preliminary concept paper should be developed which outlines possible methods of NROC operations, sources of materials or information to be used, *modus operandi*, input of Landowners, NGOs, government, scientists, financing mechanisms etc.

d) Ideally, the NROC should be constituted from the start and operate as an independent organization, one which is not totally dependent on Government, nor on commercial interests. The NROC should have its major role in working with, advising, and supporting resource-owning communities in Papua New Guinea, providing considered, targeted, and balanced information on a range of development options (and the physical, environmental, economic, and social consequences of such options) in relation to a range of resources available to such communities. The NROC would also be available to advise government and private enterprise on a range of matters. The NROC could be set up as a non-profit foundation. NROC would be subject to operating guidelines and procedures from a committed and well-informed Board of Directors.

e) The NROC's initial activities should be closely monitored and evaluated so that adjustments to content and means of disseminating information and analysis for Landowners can be made.

2. Landowner Networking and Public Debate on Natural Resource and Conservation Issues

a) Traditional trading systems, churches, local government councils, district planning committees and provincial government channels should be used as information networks at the regional level. The role of NGOs in facilitating networking options should be explored.

b) Continued public debate on conservation action should be encouraged to raise concern and build consensus.

c) Resource Owners should establish and make use of alternative institutional arrangements to ensure that they are fully informed on all aspects of such resource development. One option for such information access would be to fund a representative group of Resource Owner leaders who would, in the company of staff from the NROC, travel to a sample of places within PNG where resource development similar to that proposed for their area had already taken place or was currently underway. They would meet company representatives and Resource Owner groups from that area. Resource Owners could learn from each other's experiences in such a development process. All options and scenarios should be explored, preferably with the assistance of staff of NROC. Local, regional, and national implications should be set out as should short, medium, and long-term implications. Such travel and consultation should take place prior to that group being required to decide on a resource development or conservation project in their own area. The group should meet and have discussions with both company and Resource Owner community representatives.

3. Empowering Landowners to Monitor Resource Degradation

Landowner communities should be given the technical skills to monitor their natural resources and the impact of any conservation, forestry or mining activities on these resources. They should know to whom in government they can turn in the event of problems, and should be aware of their rights for recourse if problems are not resolved. Timber companies should be aware of these Landowner activities, and should be encouraged to support these activities as far as possible. Flexibility should be built into monitoring systems to adapt them to Landowners' monitoring capacity, actual performance and needs for capacity enhancement.

There are many different kinds of monitoring systems depending on the level of sophistication required and the reasons for monitoring particular activities. Hartmut Holzknecht had worked in West New Britain near a logging operation, he began to develop a Resource Owner monitoring system which he called "Forestwatch," which was to operate in areas where actual logging was taking place with a company's concession. The aim was for a group of people from the Resource Owner community to receive basic training in monitoring and in all the requirements to which a logger was required by law to conform. Armed with this knowledge, a daily roster would always have two such monitors on a logging site, right where logging was taking place. They would watch for infringements of the basic legal logging requirements, ensure that important cultural, historical, and other sites were not being tampered with or destroyed, record the number and type of economic trees which were being damaged or destroyed, company dumping of oil and other pollutants, etc.

Recording and summary sheets of these and other company activities would be made as they impacted on a daily basis on the land and other resources of the community. The Resource Owner would retain one copy of these data sheets as the community's record, another copy would go to the company involved, and a third copy would go to the Provincial Forestry Officer for his information and action as required. The monitors would receive a small daily fee to be paid out of the community's royalty payments.

One difficulty with this proposal is that there is no system currently in place in the public service or elsewhere which could receive such monitoring information, process it and then act on it. Provincial forestry offices currently react minimally (if at all) to complaints from Resource Owners and tend in principle to support the logging company in any dispute. A suitable structure may be able to be built into new arrangements under the National Forest Authority.

In addition, contractual agreements must have signatures from one or more Resource Owner community representatives, agents or trustees. It is these individuals who as "agents" are then required to collect royalties on a regular basis. The misuse, squandering and oftentimes the theft by these individuals of such funds which belong to the Resource Owner community as a whole remains one of the time bombs waiting to explode in PNG resource development (and applies also to mining projects, land leased to the State, etc.).

4. Integrated Conservation and Development Projects (ICADs) in PNG

Integrated conservation and development (ICAD) projects may represent an important new wave in conservation methodologies, but they are still far from being proven and packaged methodologies ready for extending the protected areas system in PNG or elsewhere in the world. ICADs are still very much in the development phase, so the immediate priority in PNG must be to test and adapt ICAD methodologies to the range of ecological and sociocultural circumstances. Decisions will have to be made as to (a) where to site an ICAD, (b) what development activities to <u>link</u> to what conservation activities and (c) how, and by whom, the conservation and development agenda will be set.

a) Resource Owners will have to "own" the ICAD if it is to be successful. Ownership can only develop if Resource Owners are involved from the outset in project design and implementation. ICADs can in theory operate in any area and on any scale in PNG. In fact, the actual feasibility of a given proposed ICAD will need to be identified through a combination of rapid rural appraisal exercises to determine potential viability, followed by a collaborative design effort (through rapid assessments) in which Landowners collaborate with scientists and government resource managers in the design of an ICAD. ICADs will likely not be feasible if they are designed by biologists or resource managers without the collaboration of Resource Owners.

b) ICAD project design teams must include appropriate social scientists. Conservation affects the way people interact with their environment. Very often behavior change is involved. The collaboration of various social institutions -- at the community level, local, regional and national government levels, and international NGO and donor levels -- are fundamental to the success of particular conservation activities. Both social scientists and biologists involved in the design or management of conservation should participate at multiple organizational and management levels. It is clearly desirable, for certain aspects of conservation needs assessment work, to retain scientists with experience with academic field research in PNG. But experience, both in applying social science information and in designing and brokering specific working relationships between communities over diverse ecological and socioeconomic adaptations is a fundamental criterion. To develop workable approaches for appropriately identifying how communities in PNG can and should be brought into the conservation process, it is necessary to retain individuals with such experience.

c) There is a greater probability of success if ICADs are built on customary management resource structures. Knowledge of customary relationships and how they operate will therefore be critical. Corporate structures based on traditional groupings and modern requirements for registration need to be considered and discussed at length within the community.

d) For potential ICADs, ways to accomplish formal recognition of customary management rights and responsibilities in the ICAD will need to be determined. A number of issues such as eligibility for group membership, leadership, control of and responsibility for funds, control and care of equipment and other assets (etc.) have to be agreed upon. If an ICAD-type project begins to operate and makes profits, to what purpose might such profits best be put? How are tasks and responsibilities to be divided and shared amongst members of the group? For groups who demand formalizing relationships prior to participating in a particular conservation activity -- from the perspective of management responsibilities and/or legal status of involved land and resources -- procedures for negotiation and implementation will need to be put into place.

e) For any given ICAD, detailed resource land rights boundaries maps based on on-the-ground work with Landowner groups will need to be completed and agreed to by all groups sharing joint boundaries. Kinship relations within such groups, and between them, must be worked out and mapped on paper as part of the preliminary phase of an ICAD or other type of project.

5. Feasibility Analysis

Very little emphasis has been placed on feasibility analysis in the design of conservation programs in PNG, or in the evaluation of proposed development activities such as TRPs. Concerted emphasis, through training programs for both government (DEC) and NGOs, should be placed on establishing and improving feasibility analysis skills. In the short-term, appreciating what is not feasible may be important in preventing unsound development activities from occurring, as well as in proposing specific conservation activities (see Appendix 4-3).

a) All sites which are to be considered for conservation related projects should be initially screened to determine:

- the ability of key Landowner groups to be collaborators in the design of a potential conservation and development activity, as assessed by their readiness to contribute human and material resources;

- baseline data on: (a) sociopolitical indicators including clan groupings, linguistic affiliations, migration histories, population density, inheritance and descent principles, existing land resource tenure systems, resource use rights to areas and specific resources by group (or sub-group), customary disputes between neighbors over such concerns as boundaries and resources, customary and modern sociopolitical institutions and their procedures, demographic information on people and their livestock, church influence/affiliation, gender issues, information on infrastructure; (b) economic data on agricultural patterns (for both subsistence and ceremony), traditional economic activities and their impact as perceived by the population on the resource base, marketing of crops, migration data, savings trends; and (c) conservation activities including: traditional practices, perceived changes or trends to environment, causes of any changes, experience with conservation projects, perception of what conservation is, and what its potential could be.

- potential sociocultural feasibility of the proposed activity (see Appendix 4-3 for a discussion of sociocultural feasibility analysis).

It is important to state that "rapid" must not be synonymous with "dirty and of low value." Rapid appraisals, if well undertaken, can yield interesting and relevant results for the design and implementation of conservation projects or programs.

b) There is no recipe for doing ICAD projects anywhere in the world, including PNG. Flexibility in the design and adaptation of these projects as they are implemented will be crucial. Monitoring of projects so as to evaluate lessons learned for future activities in PNG will be of major importance.

6. DEC and Environmental Impact Assessments

a) DEC's ability to critically evaluate EIAs, as well as its ability to ensure that its assessments and recommendations are received and acted upon by Department of Forests and Minerals and Energy, must be improved. Environmental plans are often wholly inadequate, particularly from a social soundness perspective. Some have gone as far as to say they make a mockery of the EIA process (Hughes and Sullivan 1989).

Training for DEC and other departments' staff in social feasibility analysis, and in rapid appraisal techniques to assess sociocultural and socioeconomic feasibility, is recommended for DEC and other departments (Forests, Minerals, Agriculture, etc.)

b) Clear lines of responsibility for social impact assessment should be given to each department, with DEC having some oversight role for assuring that EIAs, along with their social impact component, are properly enacted.

7. NANGO-DEC Collaboration

The DEC proposal to collaborate with NANGO and NANGO's conservation networking officer in feasibility assessments of already submitted Wildlife Management Area proposals should be strongly supported. Review of WMAs will offer a potential entrée and specific focus to permit collaboration between the two institutions to unfold. Efforts should be made by both parties, with help from unofficial external "facilitators," to give this working relationship the best opportunity to flower and mature.

8. Sociocultural Mapping

a) A mapping exercise which distinguishes land use systems, human and livestock population densities, and sacred sites should be undertaken in PNG as a complement to the biological maps. These maps will not however be able to capture "sociocultural importance," as no tools exist to measure the highly relative and subjective value of culture and society.

The specific mapping exercise should overlay sociocultural groupings based on linguistic differentiation in conjunction with land use systems at as "micro" a level as feasible. TRP areas and other external threat indicators should also appear on the map, or on another overlay.

b) Raise public awareness that communities throughout PNG can write to the PNG National Museum to have their sacred and other culturally important sites registered and legally recognized. The National Museum and provincial cultural bodies should run training programs throughout the country to encourage local communities to identify, describe, record and send for provincial and national registration of their important sites. Once sites are on the national register they must legally be respected and preserved, even if a project is developed around them.

c) The current national register of important sites maintained by the PNG National Museum should be continued and added to. The State should give the Museum more financial resources to maintain, upgrade and strengthen the national register. The National Museum should coordinate their activities with provincial cultural authorities for the purposes of aff..ming sites and providing map location for provincial registers.

d) There should be a legal requirement that all sites identified during an environmental impact assessment for any development project must be added to the national and provincial registers and be subject to all the protection available through this process of registration. In preparing a socio-economic and environmental impact statement (broadly called "environmental statement") of a proposed development project, the developer is required by law to set out information on a wide range of community-related subjects including sites of cultural, historical and other importance. The current legal requirement, however, does not bind the developer to respect and preserve such sites. The legislation setting up the National Forest Authority proposes that integrating the forest harvesting and management plan with the environmental statement into a legally binding development plan for a project will require the developer to respect such sites.

9. Build on PAR Program

The Protected Areas Review being completed by WWF should be reviewed to extract lessons for future conservation activities in PNG.

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APPENDIX 4-2. TEAM TERMS OF REFERENCE AND METHODS

1a. Michael Brown Terms of Reference

Specific duties and requirements expected to be performed by Michael Brown include:

1. Serve as team leader of social scientists' team of two. With full participation of a PNG anthropologist, Hartmut Holzknecht, develop a workplan to make best use of the expertise of both persons. The workplan should address how the team will assess the sociocultural and ecological diversity in PNG in as comprehensive manner as feasible in the time given.

2. Analyze PNG's conservation problems and opportunities from three perspectives/points of view of the stakeholders -- state, the community, and big business (timber, mining, oil).

3. Evaluate what institutional relationships would facilitate the success of long-term conservation efforts, based on those existing efforts and suggest alternatives.

4. Solicit information from communities and concessionaires as to current and prospective effectiveness of national laws and policies pertaining to conservation and resource management. Provide this information to Owen Lynch of WRI who will use it in his report.

5. Assess the options for mechanisms for the state to support communities' decisions to manage timber company actions. Identify what is in place, and whether it is working.

6. Assess the political will of the GOPNG to carry out the proposed Protected Areas System and the Environmental Assessment procedures, based on interviews with government agencies and information from the PNG anthropologist team member.

7. Identify and evaluate the conflicts and shared interests of Landowners, extraction companies (including timber companies), and GOPNG. Assess how shared interests can serve as a basis to support wise use (conservation) of biodiversity.

8. Suggest optional mechanisms for Landowners to seek technical advice on the impact of timber extraction or the impact of other development activities on biodiversity in their ecosystems. Include options for cooperation between NGOs and Landowners to achieve this goal.

9. Accompany representatives of NANGO and member NGOs which are carrying out the Landowner Survey to representative sites. Interview Landowners at representative sites informally to assist NANGO to complete data collection and to interpret their data. Determine in what areas and how NGOs and Landowners can best collaborate.

10. Participate in Landowner Workshop (if one is called, as expected, by NANGO or member NGOs while the anthropologist is in-country). Try to determine what Landowners feel are the weak points that should be strengthened to enable them to better communicate with the government and better equip them to deal with timber companies for greatest long-

term benefits for future generations, etc. Assess variation in Landowner group interest to participate in collaborate approaches to conservation in their respective ecosystems.

11. Serve on Steering Committee for the Madang Workshop (April 5-April 11). Make an effort to ensure equal participation by all stakeholders and participants.

12. Participate in the Madang Workshop. Present a report based on your findings together with the PNG anthropologist team member. Participate in discussions about implementation of conservation action. Recommend the next steps for protected areas development and environmental impact monitoring by communities and government.

13. Using the information and analysis developed under this scope of work and the information and analysis provided by the PNG anthropologist team member, write the anthropologists' report for the CNA.

14. Assist in editing the CNA Report sections containing the anthropologists report, the tenure report, and the Landowner/NGO report.

15. Write introductory and concluding chapters for the CNA Report.

1b. Hartmut Holzknecht Terms of Reference

Hartmut Holzknecht will spend 3 weeks in PNG between March 22 through April 14 (on a 6-day work week). His specific duties include:

1. Team member of the anthropologist's team of two. Develop a workplan in collaboration with the team leader, Michael Brown. The workplan should account for sociocultural and ecological diversity in PNG in as comprehensive manner as feasible in the given time frame.

2. Rather than focusing on the myriad details of the variations among PNG landowning groups, for each sociocultural category of Resource Owner and user, describe the general characteristics of relationships between people and their environment (including Landowner resource management systems) that will affect the success of conservation initiatives (e.g., use of forest/fisheries and other "natural/wilderness zones" outside the agricultural gardens; sacred areas; hunting areas; border/war zones; etc.). Relate this information to the concept of "wilderness" or "wildlands" used in the discussion of protected areas.

Identify the major sociocultural categories of Resource Owners and resource users in PNG. Assess what characteristics of Landowner resource management systems promote conservation of biodiversity. Assess what components of Landowner resource management systems detract from conservation of biodiversity. Identify resource management systems which could serve as models for active stewardship of biodiversity in PNG, in collaboration with other interested stakeholders.

3. Describe the specific types of detailed information which should be investigated locally if a site is nominated for protected area status. Include type of information that conservation implementors should learn before starting any sort of conservation action. Point out possible pitfalls that may be encountered, especially those known to have befallen other government initiatives. Point out possible advantages that current customary relationships offer, and the possible pros and cons of formally recognizing these relationships/authorities.

4. Recommend a general plan for developing an appropriate Landowner Awareness program (including local school programs to document and teach local ecological knowledge) that should be undertaken by DEC and/or NGOs to promote conservation action. Include recommendations on how Landowners should be involved in the development of this program, not just serve as its targets.

5. Assess the maps of sacred areas held by the National Museum and determine their value for selecting protected area sites. Assess whether the mapping should be done on systematic basis, as a country-wide effort to build on the mapped locations randomly donated by Landowners (source of those now in the museum), or suggest other options for bringing sacred areas into the protected areas discussion.

6. Recommend steps to promote Landowner networking on natural resource issues. Assess whether existing trading networks or other kinds of cross-community networks that currently provide social/communication linkages already provide an appropriate mechanism for networking on natural resource issues. Suggest options for designing a monitoring system that monitors damage and provides feedback to potential network of Landowners with similar problems, etc.

7. Suggest what mechanisms should be put in place to ensure continued public debate on conservation action and to ensure continued Landowner input into Government Plans and objectives.

8. Describe and assess the general development opportunities available to Landowners (airstrips, cash crops, timber), determining how these opportunities encourage or prevent communities' options to retain culture, and make their own choices slowly.

9. Describe and assess the current process by which Landowners interact with timber companies, and how they gain information and assistance in dealing with timber companies. Recommend improvements.

10. Accompany representatives of NANGO and member NGOs which are carrying out the Landowner Survey to representative sites. Interview Landowners in the representative sites informally to assist NANGO to complete data collection and to interpret their data.

11. Assist NANGO in representing the views of Landowners at the Madang Workshop as necessary.

12. Assist the team leader with analysis of existing institutional arrangements linking Landowners with GOPNG entities involved in conservation. Recommend alternatives, including ways that government could facilitate Landowners learning from each others' experiences, as well as ways to facilitate utilizing NGOs as go-betweens between government and local communities.

13. Participate in the Workshop. In cooperation with the team leader give a presentation and participate in discussions about implementation of conservation action. Recommend next steps for protected areas development and environmental impact monitoring by communities and the state (e.g., how to use map of biologically important areas in conjunction with existing land use maps, etc.).

14. Participate in Landowner Workshop if one is called, as expected, by NANGO or member NGOs while the anthropologist is in-country. Try to determine what Landowners feel are the weak points that should be strengthened to enable them to better communicate with government and better equip them to deal with timber companies for greatest long-term benefits for future generations, etc.

15. Write a draft report covering items in this scope of work for the team leader who will be responsible for writing the final anthropologists' report.

1c. Methods

The Social Science team was composed of a core team of two Anthropologists: Michael Brown, applied anthropologist and Project Director of the PVO-NGO/NRMS Project (a USAID-funded natural resources management project for NGOs in Africa managed jointly by the Experiment in International Living, CARE and World Wildlife Fund), and Hartmut Holzknecht, a Papua New Guinean anthropologist from the Australian National University. During the CNA workshop held in Madang the team was joined by Vincent Warakai, a sociologist from the University of Papua New Guinea.

Also under the social science component, but working independently of the Social Science team with their own terms of reference, was a team of lawyers, headed by Owen Lynch of the World Resources Institute, and including James Fingleton, an independent Australian consultant on law and land matters, and Allan Marat, an independent Papua New Guinean lawyer. Their work appears in a separate chapter.

This section covers only the Anthropologist section of the Social Science team of the CNA. Any reference hereafter to the "Social Science team" refers to the anthropologist team of two, unless otherwise indicated.

The social scientist methodology employed during the CNA was the following:

1. Establishment of a work plan based on the terms of reference;

2. Establishment of hypotheses for describing the range of "situational diversity" under which conservation actions must proceed in PNG;

3. Field visits to test the hypotheses and to identify the key issues for conservation programming from a sociocultural, socioeconomic and sociopolitical perspective;

4. Participation in an annual NANGO NGO meeting during which the NANGO constitution, the NANGO Action Plan, NANGO participation in the CNA, and the overall objectives of the CNA were discussed;

5. Interaction with biologists, government officials, NGOs, Landowners and other participants during two weeks before and during the CNA workshop, to assess commonality and divergences in different stakeholder positions;

6. Participation in the CNA workshop;

7. Recommendations presented during the workshop for promoting conservation based on fieldwork prior to the workshop, and interactions during the workshop;

8. Preparation by Hartmut Holzknecht of a report focussing on people-environment relationships in PNG;

9. Final writeup of the Social Science Section of the CNA by Michael Brown based on 1-7 above.

CNA Social Science Team Strategy

The Social Science team was responsible for assessing conservation needs and opportunities in PNG from a sociocultural and development perspective. At the same time, the team was responsible for addressing conservation issues raised during the CNA workshop by the Biologist team.

The terms of reference for the Social Science team (hereafter "the team") differed considerably for those of the biologists' team of the CNA. Over the six months preceding the CNA, the biologist team members were at work assembling data on what is and is not known about terrestrial and marine biology in PNG for the express purpose of developing a GIS map indicating priority areas of biological importance in PNG. No such mapping exercise, and no preliminary work of any kind, was part of the CNA Social Science team's Terms of Reference.

Sociocultural diversity in PNG is as notable a phenomenon as biological diversity. Due to time constraints, it was impossible to conduct field research during the CNA to satisfactorily address (a) what conservation can and could mean to the 850-plus language and ethnic groups living across PNG, (b) how richness in biodiversity correlates with differences in socioeconomic adaptation across PNG, and how this should be addressed in conservation planning, (c) how socially sound conservation could be promoted in those areas where either integrated conservation and development (ICAD) projects would most likely occur, or in those areas receiving highest biological priority (unknown prior to the workshop), and (d) those areas where threat to biodiversity is at its greatest, correlated to source or cause of threat.

Given a-d above, the team felt that its greatest contribution in the CNA would be to address those commonly occurring situations in PNG which reflect the diversity of situations challenging conservation work today and at the same time possess a "generic kernel." This generic kernel may reside on the level of perception of PNG social groups with regard to either opportunity or threat, and carries with it important implications for future design of conservation activities, regardless of the specific locale in PNG.

To reach this "generic kernel," existing knowledge of resource use in PNG would be linked to an analysis of impact of potential development and conservation activities. As such, the methodology used here resembles that used in social feasibility assessments, albeit on a much broader programmatic level than commonly used for specific proposed projects.

Interviewers and Background Analyses

In addition to the hypothesis testing exercise, the team drew on Hartmut Holzknecht's knowledge of PNG and field interviews to address: (a) government and NGO attitudes to the role of Landowners in conservation in PNG; (b) what methods are feasible for promoting conservation of biodiversity in PNG; (c) what role government and NGOs should play in conservation and development activities geared to conserve biodiversity in PNG; and (d) the sociocultural context for conservation in PNG.

The Hypotheses

The team felt that a hypothesis-testing strategy which prioritized Landowner issues was appropriate given that 97% of land upon which any conservation activities would take place in PNG is customarily owned.

The following hypotheses or assumptions were developed and tested to the degree possible given time constraints in the field. Two of the hypotheses involved timber industry activities, which the Social Science team considered to be the major threat to conservation in PNG.

The three areas in which the hypotheses were tested were assumed by the team to present biodiversity-rich areas, based on the fact that they are all areas where primary or secondary forests were thought to remain. These sites were selected because in each instance threat -- from either commercial pressure, or endogenous social pressures -- was assumed to place the resource base in potential jeopardy.

- The first case concerned a remote mid-montane area in Madang province (Josephstaal). The hypothesis/assumption was that Landowners are unclear about how development and conservation will proceed in a biologically rich TRP area.

- The second concerned a coastal and lowlands forest area in the Huon Peninsula (the Buhem-Monggi TRP). The hypothesis/assumption was that Landowners are dissatisfied with conservation and development activities in their area.

- The third involved Gahavisuka, a rich highland montane conservation area where threat was largely non-industrial. The hypothesis/assumption was that Landowners and government are collaborating well in a grassroots driven conservation and development activity.

The team felt that if it could either confirm or negate the hypotheses, it would be in a position to objectively discuss:

- what Landowners in biodiversity rich zones perceive as threats to biodiversity;

- how, and under what circumstances, Landowners may be capable of supporting conservation activities;

- what Landowners do or do not understand regarding conservation or development incentives (or disincentives).

These are among the key questions which must be answered, regardless of the geographic or sociocultural specifics, if conservation is to be successfully addressed in PNG. Thus in addressing "situational diversity," the team hoped to reach certain generic conclusions about key sociocultural, socioeconomic and organizational factors impacting conservation in contemporary PNG.

APPENDIX 4-3. CRITERIA FOR SOCIOCULTURAL FEASIBILITY ANALYSIS

Under the new legislation establishing the National Forestry Authority, new projects in proposed Forest Management Areas (FMA) will be required to conform to strict operating guidelines and take these into consideration in preparing their EIAs and their operating plans. The components outlined here relate to the types of analysis which must be done in a limited time framework. Such time-limited assessments are typical of most conservation and development design, monitoring and evaluation exercises.

The criteria identified here are based on the following fields and methodologies: (a) rapid rural appraisal, (b) social soundness analysis, (c) social analysis, (d) sociological analysis, (e) social science knowledge, (f) social impact analysis, and (g) sociotechnical profile. The following list is not exhaustive of the kinds of questions which must be asked to determine sociocultural feasibility.

The objective of sociocultural feasibility analysis is to determine whether the proposed conservation or development activity is socially and culturally sound on the basis of the following criteria:

1. Is the activity consistent with the objectives of the community(ies) which will participate in or be affected by the proposed activity?

2. Will the proposed activity create conflict at any level of the community(ies)? Will it result in increased socioeconomic stratification?

3. Will benefits spread equitably from the proposed activity to different groups (e.g. social or professional groups, men and women, religious groups, different class or caste groups) within the community(ies)?

4. Is there a realistic plan to mitigate any foreseen negative impacts of the proposed activity?

6. How much have local people participated in the design of the activity, and how representative of intra-community sociocultural diversity were these people?

7. Has the project addressed all <u>relevant</u> sociopolitical issues and socioeconomic issues that might impact the project?

It is important to restate that this type of information is required of <u>any</u> proposed conservation or economic activity.

Much of the success of social feasibility analysis as undertaken (in PNG or anywhere else in the world) will depend on (1) **how** questions are asked, (2) **to whom** questions are directed (i.e. all key groups should be represented in the assessment), (3) how well **existing sources of information** are used and (4) how well information is **verified** to determine its credibility. These problems are especially important in making quality rapid appraisals, on which most ICAD project design missions and TRP/FMA social impact assessments will likely be based.

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APPENDIX 4-4. ASSUMPTIONS AND PERCEPTIONS OF STAKEHOLDERS AT THE CNA WORKSHOP

This section addresses the assumptions that different stakeholders brought to the CNA workshop and the implication for conservation in PNG if these assumptions endure. Identification of assumptions is at best an uncertain venture, since it demands a certain amount of "reading between the lines" and interpretation (decoding) of what people have said. Nevertheless, unless these assumptions are recognized, there is little chance, from a social feasibility perspective, that conservation plans in PNG will be successful. For this reason it appears worth assuming a certain amount of risk, provoking a certain amount of debate, and either correcting mistaken assumptions or accepting them accordingly.

Although workshop organizers invited representatives from all stakeholder groups, stakeholders were not equally represented at the CNA Workshop. The most visible participants in the CNA workshop were scientists -- mostly expatriate biologists and social scientists. Government perspectives were primarily represented by DEC. For the most part, Department of Forests personnel and representatives from other government departments did not attend the full week. Only one provincial government official participated. Only a handful of Landowners, a major stakeholder group, participated directly. Non-governmental organizations actively participated and represented Landowner views to some extent.

The following sources were used to identify assumptions: (1) statements made in the CNA workshop forum or elsewhere; (2) responses in the CNA evaluations submitted by participants; and (3) other communications during and after the CNA workshop by members of different CNA teams.

Assumptions will be identified from the following stakeholder groups: scientists (biological and social), government representatives, Landowners, and NGOs. It was apparent during the CNA workshop that different participants to the CNA had very different assumptions about what was to be accomplished during the CNA, along with perceptions (and interpretations) about what was happening during the CNA.

It is also apparent that a diversity of viewpoints <u>within</u> a given stakeholder group -- NGOs, biologists etc. -- existed (and likely still exists), which makes sweeping generalizations about any stakeholder category problematic. Thus the assumptions listed below each group sometimes reflect contradictory perspectives.

Biologists' Assumptions

- The most important activity of the CNA was the mapping exercise.

- The mapping exercise could be conducted independently prior to opening discussions on conservation strategies.

- The mapping exercise undertaken as the CNA priority activity will lead to some form of protected area system in PNG, placing as much as 20% of PNG's land and marine surface under protected area status.

- The mapping exercise identifying biological priorities is by and large an objective exercise separable from theoretical discussions about conservation. Therefore biologists do not need to explore the social ramifications of CNA mapping.

- Differences in values have little to do with mapping biological priorities, since identifying conservation priorities is an objective exercise from a biological perspective.

- Doing conservation in PNG (with mapping biological priorities as a first step) does not require thinking much about, or talking much about, the social feasibility of conservation (as the Social Science team attempted to do).

- Biologists with first hand, long standing experience in PNG can, in the absence of quantitative data, assess and prioritize areas of biological importance in PNG on the basis of primarily qualitative work that may have been undertaken as long ago as 20 years or more.

- Even in cases where biological research may have been undertaken as long as 20 years ago, for mapping purposes it is reasonable to assume that there have not been major changes to the biota.

- Biologists doing taxonomic research get to know the areas they live and work in not only from a biological perspective, but also from a human perspective. They can therefore speak authoritatively on issues pertaining to human cultural ecological systems.

- Programs for calls to action can best be designed by conservation planners and managers, who will most likely have training in biological or natural sciences.

- Biologists should prioritize where conservation should be undertaken in PNG; conservation managers should develop conservation plans for PNG; Landowners and NGOs should be consulted during the planning process.

- Conservation comes through tough decisions, sacrifice, and stirring calls to action. The type of change that social scientists wished to promote during the CNA by individual needs and consensus cannot produce the action necessary to effect meaningful conservation in PNG.

- Conservation in PNG will require the country and its populace to sacrifice over the short-term in order to reap the benefits of conserving natural resources over the long-term.

- Identification of conflict of opinion of different stakeholder groups as expressed through open forum discussion is counterproductive to conservation.

- NGOs have been given the chance to collaborate with government on conservation in the past and have proven themselves not fully up to the task.

- Outsiders to PNG (particularly social science outsiders) have little to contribute to conservation work in PNG.

Social Scientists' Assumptions

- The most important activity in the CNA was the bringing together of different stakeholder groups to identify constraints and opportunities to conservation in PNG, and to develop potential tools, methodologies and collaborative ventures to undertake innovative activities which will promote conservation in PNG.

- The process of bringing different stakeholders together to think through and debate issues, even if this leads to conflict of opinion, is a necessary step to achieving conservation in PNG.

- Conservation in PNG will only be achieved if Landowner communities and NGOs participate forthrightly and as equals in whatever process is instituted, the CNA included.

- The NGO and Landowner communities do not share unanimity of viewpoint, but do share enough common ground to enunciate an initial position regarding conservation in PNG.

- While there is diversity of opinion within any potential category of stakeholder group -- government, Landowners, NGOs, international conservationists, etc., -- it is possible for analytical purposes to identify viewpoints or positions for different stakeholder groups.

- One does not need to interview every single Landowner to assess (1) how sociocultural and socioeconomic systems work in PNG and (2) how Landowners may be expected to act (or react) to particular conservation and development approaches and specific activities.

- Creating maps will not provide a blueprint for conservation through a protected areas system in PNG, as the social feasibility of conservation through any type of "protected area system" may not correspond to identified biological priorities as mapped.

- A protected areas system as exists in other parts of the world is likely to be inappropriate in PNG.

- Landowners and NGOs should understand the significance, limitations and implications of the CNA maps as they were being done, particularly given the importance that biologists, DEC and donors seem to be attaching to the maps.

- Maps are not value-free; what is designated on maps, and the methodology used to designate features on maps, impacts on future understandings and actions by map users and those impacted by the activities of map users.

- Conservation is a social activity, and the *raison d'être* for which any tools (such as maps) will be used in conservation must be appreciated by all involved in conservation.

- It is naive to think that conservation implies action first and foremost as opposed to dialogue and negotiation first and foremost, particularly in a country like PNG where any conservation that external change agents (conservation planners and implementors) would like to promote, will occur on the 97% of the land which is held through customary tenure.

- Extensive knowledge or experience of aspects of PNG social life and a biological reality does not automatically qualify one to be an expert on doing conservation work in PNG.

- It is potentially counterproductive to lump all biologists or Papua New Guinean conservation managers together as if their viewpoint is one; some biologists and conservation managers could support "process" issues in as committed a way as given social scientists.

- Living in PNG for a long period of time does not confer the credential of "expert," whether one is a social scientist or biologist, in regard to the conservation and development aspirations, needs, and *modus operandi* of landowning Papua New Guineans.

- "Outsiders" to PNG can, despite PNG's uniqueness, pose questions and develop analysis and recommendations in a manner which could promote conservation in PNG.

Government (DEC) Assumptions

- The CNA maps would be the most important product of the CNA.

- The CNA would lead to a clearer definition of conservation priorities from a biological perspective.

- Government should set the conservation agenda in PNG, and DEC is mandated to "manage" conservation activities in PNG.

- The methods and tools exist in PNG to promote conservation, and it is mainly now a question of getting on with the job.

- To play an effective role in PNG conservation the capacity of DEC would need strengthening.

- DEC is "competing" with actors from the forestry and mining sectors, and the CNA (and particularly the maps produced) would help DEC increase its ability to strategically plan and compete against competitors to conservation.

- NGOs and Landowners could be consulted in the process at a later time once the maps were completed.

- The planning process will bring NGOs and Landowners in for "consultation" once the agenda has been set from the top.

- NGOs are incapable of carrying out much conservation work of consequence.

- NGOs are confrontational and are more likely to fight with government than to collaborate effectively with government.

<u>NGO Assumptions</u>

- The CNA mapping exercise would not identify priority conservation areas and needs in PNG.

- Priority conservation areas and needs in PNG must be determined at the local level based on what people already do in conservation, and by what they want to do in conservation <u>if</u> they understood their full range of options.

- The greatest contribution may be on the level of awareness raising -- helping Landowners gain access to information and access to other organizations, so as to empower communities to gain control over their respective destinies.

- A balance must be struck between development needs and conservation needs of Landowners, but dispensing cash incentives or cash compensation may not promote conservation in PNG, and may risk creating unsustainable cash dependencies.

- Conservation, as westerners understand it, will not be achieved in PNG unless planners adopt culturally appropriate methods to address conservation in PNG.

- NGOs can contribute a lot to achieving conservation in PNG.

- Government is not really interested in collaborating with NGOs in conservation.

Landowners' Assumptions

- Conservation could bring in big cash flows to local communities.

- The CNA is just one more outside-inspired activity in a series of activities over the years which bring no benefits to Landowners, only costs.

- Landowners' viewpoint is not seriously considered in conservation planning exercises in PNG.

- If permitted, Landowners could participate effectively in the CNA and follow-on processes.

Chapter Five

NANGO Landowner Survey Report

Joash Yambut[1]

On the basis of survey findings in selected areas of Morobe, Madang, East Sepik and West New Britain provinces, the common themes from Landowners include the following:

A. Setting up of Conservation Areas (CAs)

Among the essential aspects of restructuring to ensure democratic development processes, Landowners have to make decisions on the formulation of policy and develop strategies about resource use in their areas. They should be seen as a partner to the project and not a puppet as the case now with logging operation. Government, foreign investors and ordinary people in the street think that the Landowners are fairly represented by Landowner companies, but in practice this is not the case.

B. Ownership of CAs

The ownership of projects must remain with resource owners[2] and monitoring agents can be provided from established institutions such as Forestry, Environment and Conservation, Tourism and Culture, etc.

C. Revenue-Generating Activities

Creating of revenue-generating activities and spin-offs[3] should be geared towards local participation which may yield direct benefit to the resource owners by means of tangible goods and service. An example is to encourage tourists to travel to remote outlying areas rather than stay in the main urban centers.

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[1] Conservation Networking Officer, National Alliance of Nongovernmental Organisations (NANGO), Port Moresby, Papua New Guinea.

[2] Resources owners -- another term for Landowners.

[3] Spin-offs are community benefits, such as clinics, schools, and roads which are provided by companies and attached to a resource extraction venture.

D. Large-scale vs. Small-scale Logging

Conventional logging should include proper formulations of Landowners' companies. Distribution of share equity and proper environmental plans should be discussed with resource owners and their other requirements spelled out clearly before the granting of licenses and the signing of agreements. Publicity and awareness campaigns should be conducted in Tok Pisin or the local language.

E. Areas Not Recognized as CAs

The Government should make funds available to develop small-scale conservation activities to conserve areas which are of sacred, cultural, and historical value as an incentive for the preservation of traditions. This will be a long-term incentive for the majority of the population to practice conservation rather than depleting the environment.

F. Training to Landowners

The Landowners should be trained in all aspects of monitoring and managing conservation areas, rather than paying for costly technical assistance. The Landowner can be taught basic monitoring skills to manage these areas.

G. Information Resource Centres

There should be coordinating centers known as "Information Resource Centres" to coordinate activities of these conservation areas. There should be networking with other existing institutions to provide, organize, and disseminate information through many linkages.

H. Follow-up Activities

The bulk of the population from areas visited expressed the view that they are not quite aware of the subject matter and as such are not in the position to actively participate in discussions by contributing ideas and their assessment of conservation needs.

Recommendation

Stage 2 of this survey should be geared towards educationally-oriented means to educate the bulk of the population and increase their awareness. This can be done in many ways -- conducting workshops and dramas, video and film shows, organize TV programs, materials and properly developed educational materials in the schools, etc. Publicity material for awareness must be translated into Tok Pisin. The idea of a "pilot project" is highly recommended in this regard at selected sites in order to assess various methods.

Chapter Six

An NGO Perspective on the CNA

Joseph Kau[4]

Definitions of Conservation, as NGOs perceive it

> Conservation is about allowing informed indigenous peoples to decide for themselves the best use of their resources.
>
> Conservation refers to the processes which create a balance between ecological, cultural, social, economic and maybe political elements to sustain life.
>
> Conservation is about people and how they interact with the ecosystem.
>
> Conservation is about meeting our current needs and requirements without endangering the resources for our future generations.

Some people may have differing views, but as far as NGOs are concerned, the CNA exercise does not cater for the above definitions at all. And I will try and show why this is so.

Firstly if we look at the way the CNA has come about, it seems obvious that the decisions about how the exercise has been carried out did not allow for any local Landowner participation. This was clearly demonstrated by the encounter yesterday, where Landowners and local NGOs picketed and protested at the CNA workshop. Conservation needs in this country cannot continue to be determined in Washington, DC. Why should we listen to the advice of people who do not have to live by the consequences of that advice.

Secondly we do not see any attempt at all to create a balance between the ecological, cultural, and social and economic aspects of conservation, an integrated approach to conservation.

CNA, we are told, is an exercise to collect data on biodiversity for the purposes of identifying conservation needs in Papua New Guinea.

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[4] Melanesian Environment Foundation, Boroko, Papua New Guinea.

But what are the conservation needs of this country? Is it to put dots and circles on a map so that the government could madly rush into conserving these areas? This conservation need is important, but should not be the priority this country has.

The CNA exercise seems to be telling us that data about the biodiversity would trigger people's desire for conservation. Papua New Guineans, informed Landowners have seen a need for conservation. I have been told that dozens of applications from Landowner groups to register their land as conservation areas are still pending action, some dating three years back. This indicates that the local people have a need for conservation, but these needs are clearly not being met.

Another question which needs an answer is, from whose perspective has this whole conservation needs assessment come about? I do not think I have to tell you. Yes, you might say the government of Papua New Guinea initiated the exercise. Ladies and gentlemen, I must tell you that the government of Papua New Guinea is very far removed from the people. More than 90% of the people do not have access to affecting government decision making.

On top of that, if there was no money, the exercise would not have come about. The availability of money seems to have closed the eyes and ears of the government on what the real needs of the country are.

Conservation Needs Assessment in Papua New Guinea should not have biodiversity as its primary objective. Instead these objectives must come from informed Landowners.

My colleague Sasa Zibe will try and highlight some of these objectives. How Landowners through their own initiatives have decided to conserve their environment but at the same time meet their other needs. The applications for conservation areas I mentioned above is another example.

The purposes of the CNA seem not to be of advantage to Papua New Guinea. I do not need a PhD or 20 years of experience to see that inevitably the CNA will expose the people of Papua New Guinea to further exploitation.

Ladies and gentlemen, there are more important questions which must be answered before the question of conservation and its requirements is relevant.

There is a far greater need for the people of Papua New Guinea than the need for a Conservation Needs Assessment on the biodiversity. That need is to direct the focus of the changes that need to happen, on to the companies who are exploiting the local people and the government which seem to be disinterested, instead of focusing on the local Landowners.

Lawyers tell us that we have all the laws that we need to conserve 100% of Papua New Guinea. Had the money used for this CNA exercise been redirected to the Department of Environment and Conservation or maybe the police and the justice system to enforce the laws, we would have no need for a biodiversity assessment to define the needs for conservation.

Lastly, the Landowners must be the beneficiaries of whatever assessments are carried out. That is yet to be seen with the CNA. We should redirect our efforts to informing the Landowners about all the consequences of the exploitation of their environment and how they would benefit by conserving.

If the Landowners are well informed about all the options and the consequences, and the government has the capabilities and the capacity to enforce all the laws of Papua New Guinea, I have not doubts at all that there will be 100% conservation. There would be no need whatsoever for a conservation needs assessment.

Chapter Seven

Landowners' (Papa Graun) Perspective on Conservation Needs

Francis Sumanop[5]

A. LANDOWNERS - Definition

(a) Broad heading which encompasses PNG people who own natural resources including land. Land, all there is, is owned by someone in PNG.

(b) Landowners' Association, Company, Group, etc., encompasses Papua New Guineans who organize themselves for a common cause.

There are now many Landowner groups and associations in existence in PNG. Landowner groups -- could be classified as a form of pressure or interest groups. Landowner groups are formed to have a membership with a purpose of pursuing a common objective.

B. ALL RESOURCES IN PNG ARE OWNED BY SOMEBODY

Therefore, any conservation needs assessment must begin with the so-called grassroot resource owners.

C. LOCAL KNOWLEDGE

People at the village level are in a better position to determine their own needs. They have their own perception/ideas and beliefs about the world they live in.

D. PLANNING FROM LAND/RESOURCE OWNERS' PERSPECTIVE

Planning/analysis for mobilization of natural resources must emerge from the land/resource owners (bottom level up to the top/out to the world).

E. INITIATION AND IMPLEMENTATION OF PROJECTS FROM LANDOWNERS

Projects/action plans must be initiated by the people after acquiring certain information/awareness to determine appropriate steps/methodology for action.

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[5] Arapesh Association, P.O. Box 125, Wewak, East Sepik Province, Papua New Guinea.

F. IMPOSED WESTERN MODELS MUST BE MODIFIED TO SUIT LOCAL NEEDS

Plan projects/strategies imposed from outside will not work properly for village land/resource owners. Imposed ideas will be up against local knowledge and practices.

G. LANDOWNERS' IDENTITY

Land/resource owners oftentimes have no official Government affiliation or recognition -- operate in isolation and therefore are vulnerable to becoming extinct.

Exist to seek assistance from Government when there is no assistance. They have in some cases the potential to use illegal methods to express their grievances to the legitimate authorities (e.g., Government of PNG) or to a particular Agency which they have grievances against.

H. LEGISLATION TO PROTECT LAND/RESOURCE OWNERS' RIGHTS TOWARDS EXPLOITATION OF THEIR RESOURCES

- Customary Land Registration Act
- Landowner Companies as joint venture business partners with foreign investors towards exploitation of the Landowners resources
- National Department of Lands and Physical Planning initiating an umbrella National Legislation or Customary Land Legislation

I. LANDOWNERS' HAVE NO REDRESS TO RESOURCES ALREADY EXPLOITED/CONSERVATION OF ENVIRONMENT. DEC NEEDS TO EFFECTIVELY POLICE CONSERVATION LAWS IN PNG.

RECOMMENDATIONS

1. INVOLVEMENT OF LAND/RESOURCE OWNERS FROM BEGINNING TO END

Whatever is done in this workshop in relation to conservation needs assessment must begin with land/resource owners full participation and end in terms of formulated strategies and implementation phase.

Non-involvement of land/resource owners will pose problems at implementation phase of projects.

2. AWARENESS/INFORMATION OUTLETS/CHANNELS

To be given to land/resource owners. Having access to relevant information on exploitation of Landowner resources will help them make rational choices/decisions.

3. NETWORKING/LINKAGE

(a) National Government or Departments need to establish linkages with all land/resource owner groups with regards to exploitation of their resources. Use of the existing NANGO-PNG/Communication Network.

(b) Some land/resource owner affiliation with NANGO-PNG/wider network to create public awareness on environment conservation needs.

4. INSTITUTE AND FUND PROJECTS

As recommended by land/resource owners. This would contribute towards training land/resource owners to be better managers of their own environment. Support/fund projects to promote local scientific knowledge.

Chapter Eight

VDT's Conservation Needs Assessment and Proposal for Lasanga-Lake Trist Conservation Area Project

Sasa Zibe-Kokino[6]

Introduction

I'd like to present to this conference the case study which was started 12 months ago. The Landowners of Huon Gulf have experienced four decades of forest resource exploitation in their area. They want other alternatives to be made available to develop their vast forest resources rather than traditional conventional operations. We have the project already in place with lots of local initiatives. The Landowners and some local and international NGOs have already undertaken initial activities.

The Landowners and the NGOs endorse the Proposed Lasanga-Lake Trist Conservation Area to become the initial model project for the Conservation Area Management Committee to use as one of the pilot projects to collect data for planning other Conservation Areas in Papua New Guinea.

Social and Economic Elements

The following information reflects the views and the ideas of Landowners collected over last 10 months:

We believe that, for any forms of projects to be successful in Papua New Guinea, land tenure, local people's needs and involvement must be addressed at all costs.

The CNA concept is not new to PNG and in fact it is a duplication of existing National Parks and Wildlife Sanctuary, TFAP or NFAP concept and policies. These concepts have indeed failed to achieve their objectives.

The CNA program will also fail in this country, if involvement of local people (Landowners) in regards to social and economic elements are not addressed.

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[6] Village Development Trust, P.O. Box 2397, Lae, Papua New Guinea.

Local people must be involved in planning and execution of conservation management decisions and operations. Successful long-term management is possible only where there is sufficient level of consensus and cooperation among the people living in the area. Therefore Landowners must be involved in the early stages of management and planning. The Conservation Area objectives will not be successfully achieved unless the wishes and objectives of land owners have sufficient effect on management.

Natural justice requires that people be allowed to keep their homes and livelihoods, or be compensated for loss or damage and usage.

"Compensation" is the fastest growing industry in PNG, and CNA is here to address that, or face the consequences.

However, national laws and customs determine how national and natural resources are divided and used.

Good management involves fair treatment for all concerned, whether employees, residents or users of the forest. Incentives must be provided and existing projects and facilities be improved to accommodate new projects. New ideas and projects are unlikely to succeed if there is no local initiatives.

Great care is needed to avoid either suppressing or exaggerating needs and rights. It is stressed that this involvement is necessary to ensure that appropriate objectives are identified, and to ensure success in achieving them. The amount and form of involvement and consultation will vary according to local circumstances and must be decided and evaluated on the spot.

For example if there is a dispute in a Conservation Area, clan tribal groups and the management agent should sit down and renegotiate the contract. There is no long-term contract.

It is usually appropriate to link management planning with existing forms of social and administrative organization. That is, the capabilities of local people, NGOs and other organizations must be addressed. This involves and training for local people.

When rights of use or ownership of land or resources are vested in communities of any kind, management is unlikely to succeed unless these communities take a leading role in planning, management and implementation. This helps to ensure that benefits go to those who have a right to them, that negative impact on traditional communities are minimized, and that factors encouraging forest conservation by forest dwellers are taken into account.

Management of communally owned forest by Government departments without full consultation, public relations and awareness program is unlikely to succeed.

When forest are owned by Landowners, in clans, etc., in individual blocks or small plots, management must take into account individual different and often conflicting interests.

Management may be institutionalized through cooperatives, or through an extension program, to suit local conditions.

Elsewhere, state management of state forest may succeed with minimal consultation in areas of low population without social conflicts, for as long as those conditions continue; for example, Bulolo forest plantations, Morobe Province.

Information and Education

The information and education of people affected by a Conservation Area operation must be a management priority. Many management practices are new and unfamiliar. To achieve the objectives requires considerable discipline. All who contribute to management decisions will be faced with situations in which they have to think ahead, not always choosing the usual short-term options and benefits.

To assist in making national decisions, adequate information must be made available, and training and education provided. These must be an integral part of Conservation Area management in areas affecting or involving local communities.

Proposed Lasanga-Lake Trist Conservation Area

The proposed Conservation Area starts from the Lasanga Island group in the Huon Gulf, and extends to Lake Trist in the Kupper Range of mountains (approximately 220,000 ha total area). It comprises many different vegetation types: lowland tropical rain forest and tree swamp, low, mid and high montane forest, savannah grassland and dipterocarp forests.

There are extensive areas of mangroves, coral reefs, estuaries, waterfalls, fresh-water lakes and rivers, notably Lake Trist at 1700 m above sea level. Initial bird and marine life surveys by a team from the Wau Ecology Institute, and timber resource surveys by the National Forest Department, indicate an exceptional level of biodiversity in this area.[7]

With the exception of a few coastal villages, the area has a very low population. The inland zone is virtually uninhabited, although a number of villages owning land in the proposed Conservation Area fall just outside its perimeter.

The fundamental approach to managing and sustaining this particular Conservation Area, is to actively involve the local land-owning communities through environmentally sound income-generating projects such as eco-tourism (small-scale, nature-based tourism) and eco-forestry. As such, the Lasanga-Lake Trist Conservation Area is intended to serve as a model for Papua New Guinea.

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[7] The Lasanga-Lake Trist area falls within the priority areas identified on the CNA maps.

VDT, together with land owners, has already initiated an eco-tourism and eco-forestry program in part of the proposed Conservation Area, called the "Lasanga Protection Program."

Lasanga Protection Program

Village Development Trust has designed this program to protect the forest resources of the Lasanga area. The site has been identified as in need of immediate action because of the threat to clear-fell the uninhabited Lasanga Island and an area on the mainland covering 35,400 ha, approximately 5 km from the Lasanga Island group.

Both these areas are owned by the Kui, Buso, Siboma, Lababia and Paiewa villages and have been designated as the Nasau Timber Rights Purchase (TRP) area. Although the TRP has expired, renewal of the permit is being pursued by the logging company who recently completely exhausted the adjacent Kui TRP area. The resulting environmental damage together with a lack of benefits is causing growing concern to communities in the area.

Most of the Nasau TRP area is ecologically sensitive, encompassing the headwaters and catchments of three major rivers emptying into the Lasanga Island region. This harbors a highly diverse marine wildlife including over twenty square kilometers of tropical coral reef. If conventional logging were to proceed, large-scale ecological disturbance would be inevitable.

After being approached by the Landowners for assistance, VDT has drawn up a program for the Lasanga area comprising:

- Development of an eco-tourism project on Lasanga Island involving environmental awareness training and the construction of simple bush-material accommodation and training facilities. These will enable people to come to the islands for study and recreation.

  Spin-off projects such as handicrafts, local food production, small-scale fishing and cultural displays would also be a possibility. World Wide Fund for Nature (South Pacific Program) has offered some technical, consultative and financial assistance in planning, implementing, managing and monitoring the project.

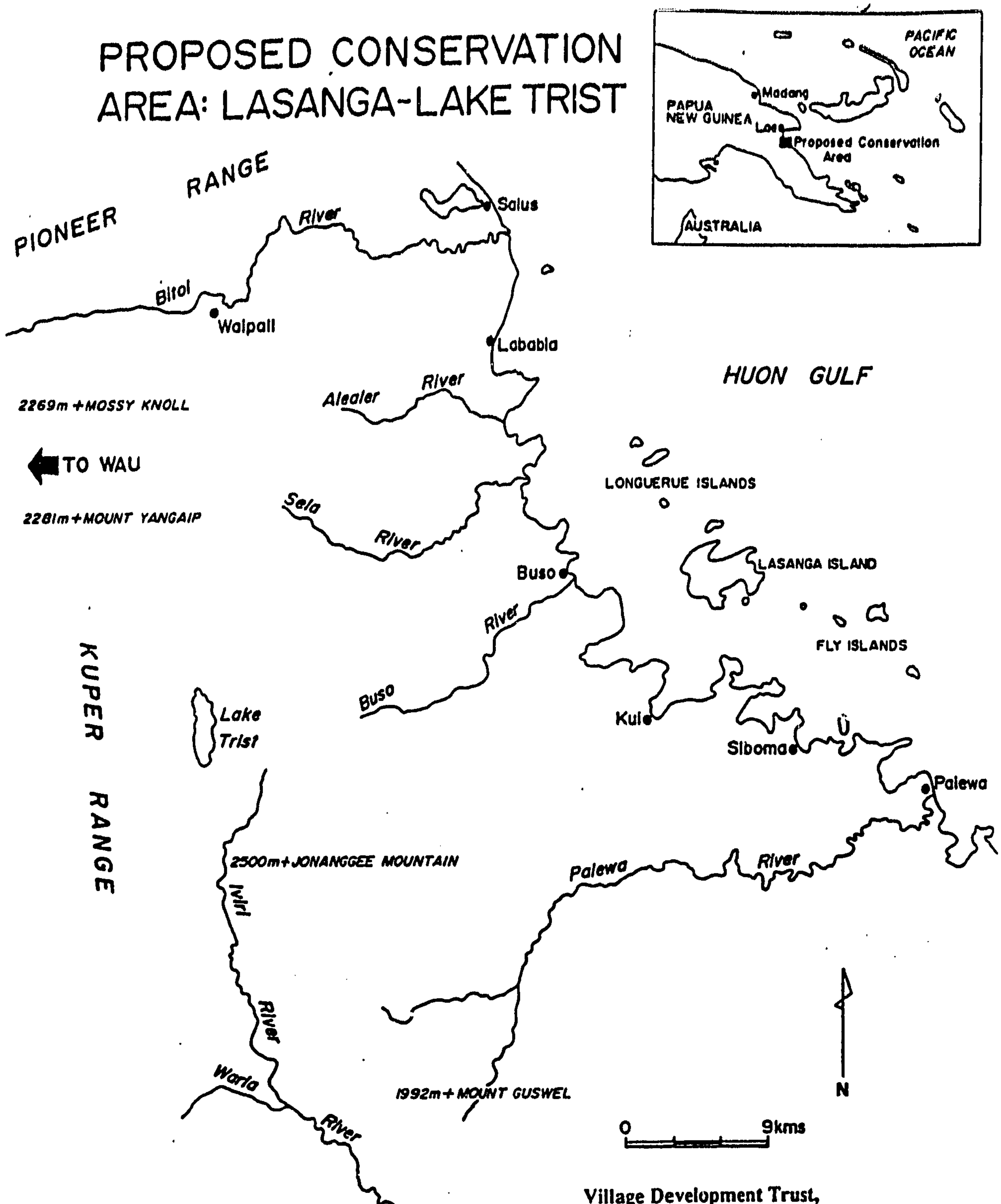
- Introduction of an eco-forestry project on the mainland through appropriate training in forest management techniques, alongside the use of a Wokabaut Somil (WS). Sustainable community-based forestry provides an environmentally sound and economically viable alternative to clear-felling.

  Timber produced using the WS can be used for construction work in the eco-tourism project, for other community projects, and as a revenue source by selling it on local markets. Both the Australian and New Zealand High Commissions are interested in funding the WS.

In addition, German Development Services have agreed to assign one of their volunteers to this program to oversee the day-to-day running in its first phases. The South Pacific Regional Environment Programme (SPREP) has also offered assistance in getting any necessary technical and consultative expertise the program may require.

The local communities will play a key role, enabling them to take control of the benefits of managing their own natural resources. This will substantially reduce the risk, scale, and nature of environmental damage by the large-scale harvesting techniques currently threatening the area.

Figure 8-1. Proposed Conservation Area: Lasanga-Lake Trist



Village Development Trust,
P.O. Box 2397,
Lae, Papua New Guinea
Phone: 42 4824 Fax: 42 5790

Chapter Nine

Issues and Options for Establishing a Biodiversity Data Center in Papua New Guinea's Department of Environment and Conservation

Peter Hobby[1]

Executive Summary

This report is intended to outline the steps required and effort involved with establishing a Biodiversity Data Center (BDC)[2] within the Department of Environment and Conservation. The approach taken was to treat information as a capacity building tool for a department with expanding responsibilities and serious resource constraints in fulfilling its mandated responsibilities. The focus on the BDC as both repository and source for information in service of better management planning and evaluation is a purposeful attempt to keep information use relevant and accessible. Access by the scientific, social development and NGO communities will be crucial in capturing and disseminating new data, and maintaining the credibility of the BDC. The importance of proper staffing and training can not be overstated as the BDC's capacity to organize and disseminate information is based more on human than computer capacity. The report has been purposefully general in referring to staffing levels, computer support and content of the BDC, as these areas will be greatly effected by the final outcome of the strategic planning exercise and computer needs assessment. As stressed throughout this paper, sound and responsive management from the start is the best insurance policy to keep biodiversity information working for all resource managers in Papua New Guinea.

Background

Before moving to specific recommendations for the setup of what for the purposes of this report is called a Biodiversity Data Center (BDC), a brief comment on the administrative background provides important context. When DEC became a full department within GOPNG in 1985 it was tasked with the following broad responsibilities:

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[1] AID/POL/CDIE, Washington, D.C., U.S.A.

[2] The DEC BDC discussed in this paper should not be confused with the Natural Resource Options Centre (NROC) presented in the CNA Recommendations. If a BDC is created within DEC, linkages should be established between the BDC and the NROC.

- Policy formulation regarding environment and conservation.
- Administering legislation guiding environmental planning (licensing for flora/fauna gathering and exporting-CITES, and review of forestry environmental plans).
- Species/habitat conservation and wildlife/national parks management.
- Water resource management and conservation.

In order to better direct scarce resources, DEC is presently in the process of a strategic planning exercise that is intended to help define the above responsibilities and define concrete steps to strengthen the capacity of DEC to live up to its legislative mandate. Just prior to the start of strategic planning, DEC commissioned a study of its computer needs and is also involved with the Conservation Needs Assessment which includes this information needs assessment, a conservation mapping exercise, review of land tenure issues, and NGO report on local conservation issues. There is no shortage of attention presently focused on DEC. Although results of all these activities will have repercussions on the scope and nature of the BDC in the long term, there are several steps that can be taken in the short term to enhance information management and provide a solid foundation for a future BDC.

The first step has already been taken. This study is the result of a five week trip[3] to review representative systems for organizing biodiversity data and to perform an information needs assessment of DEC. Although the need for better information management holds for DEC as a whole, the focus of this study is to identify central issues in establishing a Biodiversity Data Center focused on biodiversity information, and to suggest options for establishing and maintaining a BDC. The primary rationale behind the BDC is that more accurate and accessible information empowers resource managers at all levels. DEC can better meet its monitoring and evaluation objectives, more effectively represent biodiversity conservation outside the department, and better plan viable representative protected areas while village level resource managers can contribute to expansion of the information base as they draw on existing maps and reports for improved local management.

Logistical Issues

Financing

In the process of choosing appropriate systems and gathering source material for a new BDC, there are several logistical questions that should be addressed at the outset. The first, and most fundamental, is the question of financing. There may well be sufficient short term interest in start-up of the BDC from outside the GOPNG to warrant some level of bilateral or multilateral financial aid. If so, it will be vital to the longevity of the BDC to use start-up funds to both create short term products useful, for instance, to strategic

[3] The five-week trip in November-December 1991 consisted of visits to the World Conservation Monitoring Center, The Nature Conservancy workshop on databases in Indonesia, Australian data centers, and Papua New Guinean data centers, including UPNG, UNITECH, the Melanesian Environment Foundation, and DEC.

planners, and, longer range systems and products worthy of continued DEC financing. The BDC can be an important actor in building capacity for DEC, but if it is viewed and run as an expatriate research tool its long term viability will be jeopardized.

Strategic Choices

Also, presuming that DEC does make available funds for the BDC, the source of those funds will have considerable effect on the nature of a BDC. Will funds be forthcoming for systems supporting the broad spectrum of environmental monitoring and assessment activities envisioned for DEC, or will funds be available for parks management and biodiversity conservation monitoring alone? Perhaps both? In the short term, will the BDC act as a research incubator, of sorts, providing space, supplies and logistical support for visiting research teams? To what degree will the Center utilize Non-Government Organizations for data gathering and dissemination? A BDC could work to fill all these needs, but if so, the BDC and expected outputs should be integrated from the outset in any strategic planning exercise. It is also important to continue consulting information management specialists and stakeholders outside DEC during planning as many senior managers know just what they want by way of information but are not familiar with how to get it, the effort involved or all the potential uses.

Management Structure

Following close behind the issue of who will finance the BDC is the issue of who will get the prototype center off the ground. It has been suggested by DEC staff that the manager of the BDC be directly responsible to the DEC Secretary's office. Given the potential importance of the BDC, this seems the appropriate level for BDC management to report to, keeps the idea of information as senior management tool at the fore and works to dispel the stigma of resource centers as arcane libraries. To facilitate capacity building from the outset, it would also be best to have one expatriate BDC manager and one PNG national, the two functioning as equal partners with shared responsibility for planning, systems design and collections development.

The roles for the two managers will be largely as information brokers and lobbyists during the early stages of implementation. There will probably be repeated attempts to define information needs and scope for the DEC during the strategic planning process and having qualified staff on hand to both answer queries and suggest initial means to meet data needs will be invaluable. Also, the anticipated relocation of the DEC offices to a single central location will provide an opportunity to weed the existing documents, both in formal DEC systems such as the library and in personal collections of trip reports and field data. Having clear guidance from BDC management on what to keep, what to toss and how to integrate the remaining material can best be done during the weeding process itself and will require management input throughout the process. The actual review of material can be delegated to part time help, student interns or some other means to tap cost effective labor. It will also be important to have early, effective BDC management to quell the concerns already expressed within DEC that centralized information systems are inaccessible and unaccountable, hence the reluctance to turn over personal files.

Space and Site

The last general logistical issue to be addressed is space. The BDC should be on-site within DEC but be housed in its own suite of rooms. The present situation, with both the library and publications material stored off-site, is not acceptable for efficient management of the BDC. Proximity and ease of access can make or break a resource center. A separate but convenient space is important for several reasons. Security of documents, data and equipment is most easily achieved through separate facilities while research and report preparation is most easily carried out away from main traffic areas. Close proximity ensures BDC staff involvement in all appropriate department activities and encourages more frequent use. The BDC may not need much space, especially if the resources are limited to key technical documents, paper copy files, a set of computer programs and staff offices. If the intent is to use the space as a staging area for research and processing the results of field trips or preparing educational materials for Landowner groups, then more space will be needed, but probably not much more than the size of the existing DEC library. If the BDC is seen as growing beyond biodiversity information and will be covering all of DEC's information needs, this will require more space, staff and computing power than will be described presently for the BDC. It would be logical for reasons of economies of scale to consolidate DEC-wide information services in one location, but that is an issue beyond the scope of this study and best left to the strategic planning team.

Planning Issues for the BDC

The first major issue in design of any information center is to determine information for whom and for what purpose. This design is in turn premised on a clear mission statement laying out the role of the information center within the larger organization. This is particularly important in a setting like that envisioned for the Government of Papua New Guinea's Department of Environment and Conservation (DEC). GOPNG has a now increasingly rare opportunity to manage and preserve large tracts of virtually pristine habitats and with them many rare or endangered species. GOPNG also has the opportunity to mitigate effects of resource extraction now rather than pay the price of degraded resources in the future. In a best case scenario, with ample technical staff and funding, this is a major undertaking as efforts to both document and conserve species can create copious amounts of data and extensive demands on resource managers. The present situation within DEC is not optimal but does provide some real opportunities for improved information management to aid decision makers.

BDC: For Whom and To What End

Having outlined the present fluid state of finance, strategic planning and space, there are tangible next steps for planning a BDC. In order to answer the question of information for whom to what end, a clear, concise statement of the rationale or mission of the BDC will help in focusing design efforts. The rationale mentioned above -- to provide accurate and accessible information on biodiversity to all levels of resource managers for park planning, conservation management, impact assessment, and representation outside DEC -- is the working definition used as a mission statement throughout this study. Before committing resources toward a BDC, however, DEC management, the strategic planning team and representative stakeholders should come to agreement on a mission statement, while GOPNG explores funding levels and sources, staffing levels, and space, to minimize delays in implementation.

There are several underlying principles inherent in the following suggested plan which are based on the information needs assessment carried out in November/December 1991. The BDC could act as a capacity building mechanism by: organizing existing material, providing the foundation for data analysis, creating a repository for new biodiversity information, creating a mechanism for better inter- and intra-agency liaison under the rubric of data sharing, set standards for new data, and, ultimately, provide mid and upper level managers with information for better planning and evaluation. The end product of building DEC capacity in this fashion will be an increase in credibility outside the department. Universities, non-government organizations and private firms could all come to regard the quality of information coming from a BDC as state-of-the-art. Movement in this direction will certainly enhance the likelihood that these same types of organizations will contribute to the start-up of the center.

Initial Cataloging and Review of Existing Information Collections

The first step in setting up the BDC as a service oriented office is to review existing materials within DEC and GOPNG. Understandably, given lack of budget, the existing filing and library systems are poorly maintained and relatively inaccessible. The BDC provides the opportunity to compensate for lack of staff and training through a selective review of existing files and library collections already under DEC control. As mentioned earlier, the two BDC managers should be on staff to guide this process and oversee the early cataloguing efforts.

Computerizing

As the weeding of material relevant to a BDC gets underway, the question of when and how to computerize arises. The use of even a basic library program will mean having a computer available, staff training time and data entry time. Depending on expected staff levels and the timeline for implementing the BDC, working with a paper copy form may be a viable interim solution. The form would mirror the type of information to be entered into the computer and would allow several people to work in several locations at the same time. The type of information to be captured includes bibliographic information on title, author, subject, publisher and date along with information useful to the BDC like species covered, if any distribution or habitat data is present, and location of the document at that time. This level of effort is appropriate only for those items seen as relevant to biodiversity. The BDC managers will need to develop a set of key words for the subjects and standard nomenclature for the taxonomic and habitat information. Coming up with the lists will be less problematic than ensuring consistent use by all those involved in the weeding process. To aid consistent use of terms, the library computer system can be set to check for data errors when filling in standard fields. It is also important for BDC management to plan for some of the material being subsumed under a library collection and some providing raw data for either a GIS system or a biodiversity database.

It is important to computerize the document collection as soon as possible for ease of access and control over the collection. Any sort of text relevant to biodiversity, from legislative materials to technical reports and magazine subscriptions, should be captured on the library system. The benefit to computerizing the collection is that items can be searched by key words, author, title, actually any consistently used set of terms chosen for the system. If portions of the collection circulate, the computer system can automate recalling overdue materials. Given that a GIS computer system is already being provided to DEC by the CNA, computerizing the library collection may prove to be less important than getting the GIS fully operational. If this is the case, the paper system of card indexes for texts, journals and technical reports should be initiated with the thought of subsequent automation. Keeping consistent the use of terms and range of fields or topics catalogued for each item will go a long way toward speeding automation.

Software

As the resource review process continues, the question of when and how to computerize non-bibliographic material should be addressed. The CNA will have provided a computer and GIS system by this time that is intended to capture species distribution data initially. The GIS system will provide an important object lesson in how new technology is incorporated within DEC. With sufficient software capacity and disk space, the GIS system can provide the organization needed to manage most of DEC's non-text data. Park boundaries, areas under various forms of cultivation, species distribution, habitat types and more can all be handled by GIS systems.

The question becomes one of ease of access and ease in updating data sets. Training in not only software management but also data interpretation for at least one DEC staff member will be required to keep the GIS system pertinent to DEC planning and monitoring activities. This may be best achieved by a cooperative arrangement for training with the University of Technology in Lae[4] or some similar organization. The importance of continued software training can not be overemphasized. GIS systems serve to integrate databases and files with spatially relevant material. New files can be created to capture new types of data such as the distribution of export licenses, extent of commercially important fish species or watersheds affected by mining activities. Some files may act as proxies for a natural process such as watershed degradation while others are simple organizational tools such as license distribution. The benefit of a GIS system is that it facilitates comparisons of disparate types of information across space and time. For example, permit sites, habitats, village locations, forest concessions, and land use patterns can all be mapped individually or overlayed onto a single map.

[4] The CI GIS system, CISIG, containing CNA information, was provided to DEC and to UNITECH. Both DEC staff and UNITECH staff were trained in CISIG's use.

The down side to GIS is that it is data and technology intensive. The system is only as accurate as the information entered and new applications are only useful if well integrated into the initial software package. The GIS system could prove to be a locus of information management and a basic justification for data gathering from outside DEC. Along with the two BDC managers, a staff member exclusively responsible for upkeep of the GIS should be appointed at the start of BDC activities. As with the two BDC managers, it may prove necessary to have one expatriate GIS staff and one from DEC. In both cases, the intent is to establish a turnkey operation where full responsibility will be turned over to DEC staff after complete training. During this process it may be advantageous to develop in-depth job descriptions and employee training materials in anticipation of turnover. This in-service training approach is probably the most efficient means to get the BDC started and build capacity of both systems and human resources. It will be important to allow time and resources in planning activities for the BDC for staff training.

It is difficult at this time to ascertain whether or not a library system and GIS will meet all of DEC's information needs. There may well be a need for a relational database to capture information not resident in the library or with an explicitly spatial nature captured by the GIS. Given the flexible nature of library and GIS systems, and the capacity of DEC, it is advisable to thoroughly test these two systems before investing resources in a third computer system. This is not to say that considerable revisions to the GIS system are not called for as information needs are better articulated. It may be most appropriate to link more in-depth tabular and text materials with the GIS system. For instance, text could be entered on a specific park's conservation status, land owner issues and planned improvements and all be linked to the GIS files covering boundary data. This would limit access to this material to accessing the park boundary file and not searchable by topic as would be possible with a relational database. The more sophisticated answer to the question of multiple access needs is to have a relational database running in tandem with the GIS. The less sophisticated but more manageable approach is to have files covering select topics on a given park, for instance, entered as a type of document on the library system and have searchable fields for topics such as clan affiliation, type of habitat/species, park type. In fact, a library system is a relational database oriented toward document management. Each approach has its tradeoffs in terms of simple information management and data analysis. Much of this debate over appropriate mechanisms for data management versus data interpretation and analysis will have to be decided by the BDC managers in conjunction with DEC staff as the first stages of the basic library and GIS systems are implemented.

A separate issue from DEC's use of library and GIS databases is the use of more presentation oriented software packages such as spreadsheets, graphics and desktop publishing. These systems are used less to manage large sets of data than to provide presentation graphs, graphics and text. Spreadsheet software does offer some statistical analysis capacity and might prove a useful middle ground for certain types of data interpretation. If, indeed, the BDC is to have a major role in report preparation, then these types of computer software will prove invaluable. They come with the same caveats as the GIS and library systems in that they require computer access and training. They are, however, somewhat easier to learn and have few rigid data requirements. In the case of any of the above computer systems, thorough training and consistent upkeep of the systems will be very important as software support and hardware maintenance are likely to be poorly accessible.

Hardware

Having covered the main points in types of software, a related topic is appropriate hardware. The GIS system provided to DEC by USAID through the CNA comes with a personal computer using an 80386 processing chip, 2 megabytes of memory and an eighty megabyte hard drive. At the start, this is probably adequate capacity to manage both the GIS system, library software and basic presentation oriented software. The various software packages available on any one computer should be accessible with a graphic user interface (something akin to Microsoft Windows or MacIntosh-type front end). These systems use pull down menus and pictorial icons, not command line computer language, for end-user access. This has proven to be a far more user-friendly method making systems easier to manipulate and more likely to be used by non-computer experts. For quality output from the GIS, a plotter for printing maps will be necessary. In order to keep the system updated with new cartographic information, a digitizing pad will also be necessary.

In the near term, as data sets grow and maps become better elaborated, it is quite likely a second computer will be required for the GIS. At this point the original computer can still be used for the library system and basic desktop publishing. In choosing the next computer, some of the generic specifications are; a central processing unit (CPU) using an 80486 chip with at least eight megabytes of Random Access Memory (RAM) and an approximately two hundred megabyte hard disk. A non-interlaced color monitor supported by a super VGA card with one megabyte of memory is also needed to view and interpret material on-screen to best advantage. The CPU is most easily expanded with additional hard disk memory and peripherals (plotter, digitizer, laser printer, CD-ROM reader etc.) if it is configured in a tower case. This provides more flexibility for integrating additional hardware than the standard desktop configuration. The above system is presently available in the United States for roughly $3,000 and the prices are anticipated to come down further. If the plotter and digitizer have not been purchased by the time the first computer is installed, the capacity of a second computer should be considered when purchasing them.

The same caution for adding more than GIS and library software packages to the BDC applies to additional hardware. See if the original system works, and is expanded to stress that systems' capacity, before moving forward. The above description of a second computer system may sound like overkill, but if DEC really intends to use computer systems fully for biodiversity conservation, this is actually a modestly sized system for a national level effort.

Budget

Through the CNA and NFCAP assistance, DEC BDC managers have the DEC resource review and initial document gathering process underway, the GIS system installed and at least one technical person responsible for GIS upkeep. This scenario assumes a preliminary budget has been approved for start-up of the BDC and at least office space for staff has been made available. Until now it has not been essential to have library space or a more complete budget for library collections development, support and technical staff, furniture, training, computer peripherals, and GIS data acquisitions. These broad budget categories and a realistic timeline should now be under development by BDC management. In formulating a budget, thought should be given to not only one time start-up costs but also recurring costs of data gathering and training (including travel for both). There is a wealth of material available in Australia that would provide important input to both the library and GIS. Australia may also be the nearest location for in-depth training on software use and data interpretation. The decision on how best to tap Australian resources through either repeated field trips or consortium arrangements with sister organizations such as CSIRO will shape a major portion of the recurring cost budget. As the nature of the BDC data collections and basket of technical skills is somewhat unique, the budget should reflect the need for creative solutions to data gathering and training. Relatively little of the information for the GIS is available in neatly packaged electronic form, dictating a labor intensive gathering and entry process. Training, similarly, will provide challenges due to potential access problems within PNG, and a unique mix of technical management and resource management skills required for BDC staff to best serve DEC managers.

Managing and Responding to Growth

During the start-up and budget development process, the applied uses of the BDC will be developing. Rush requests for presentation materials, quantitative measures, or conservation management for biodiversity may well have come up. Requests from Landowners for protected area status will continue to come in along with possible requests for practical information on resource management. The nature of the requests and a sense of the daily information needs of management in performing tasks will be vital in forming the complete BDC. Correctly gauging the information needs of management in performing key tasks is the basis of setting up the BDC as a service to managers. Elaborating the means for collaborating with NGOs will allow access to a growing pool of human resources for information gathering and dissemination and provide the basis for education and outreach efforts from the BDC.

In contrast to what the BDC can do for top DEC management is the question of what technical DEC managers, and other technical information sources within PNG, can do for the BDC. The BDC provides an avenue for standardizing types of data and collection methods. The ability of DEC to meet its own data gathering needs will prove important in both capacity building and filling gaps in data. By formalizing standards for field techniques and reporting, the BDC can not only streamline in-house processing but also provide important input to research methodologies and products under the auspices of the National Research Institute (NRI) and other public and private PNG sources of information. As the central authority coordinating research in PNG, NRI could provide BDC access to invaluable input from research funded outside DEC. The enhanced use of standards, in turn, will facilitate expanded, cost effective analytical output from the BDC.

Role of NGOs

Local NGOs comprise one extensive network for gathering information. With the provision of data standards and a central repository, information such as land use patterns, traditional conservation and Landowner issues could well be garnered from a cooperative relationship with NGOs. Both the NGOs and DEC face resource constraints seriously affecting the scope of possible activities. By pooling data gathering efforts, the BDC could provide an important forum for collaboration between organizations with similar interests. This sort of relationship has proven very successful in many other contexts ranging from project specific provision of research by an NGO for a government department, to completely contracting out the central research and data gathering functions of a government office to an NGO.

The advantages to having NGOs share the burden of managing and staffing appropriate activities are not to be dismissed lightly. The government is not expected to provide benefits or scarce government jobs for tasks carried out by NGOs. NGOs, in turn, are expected to provide timely and relevant products to meet the needs of government staff. In the case of PNG, where formal contracting methods for employing NGOs may not be well articulated, an exchange of information from NGOs in trade for access to the BDC could be a viable alternative. This is not to say the BDC should make available all its resources to NGOs based on the provision of select data gathering exercises. Rather, in a purposeful effort to tap cost effective sources of data and cost effective means to disseminate BDC and DEC material, the BDC managers could formulate something akin to a binding cooperative agreement. For instance, by providing base maps printed from the GIS and access to technical documents on conservation management, DEC could make significant progress in meeting NGOs needs for "Best Practice" knowledge in the field in the process of gaining new data and a vehicle for field representation of DEC activities. This is one of the central areas where improved liaison through the BDC could significantly raise the profile of DEC not only as a credible source for state-of-the-art data but also innovative management practices as well.

Once the budget categories and amounts have been established, staffing and collections development for the library can begin. Support for information requests from text sources and collections development of those same sources are the two most basic functions to build into the library. These functions are complimentary and can be delegated to a single staff member, assuming a manageable workload. A solid reference collection of relevant statistical sources and directories of both organizations and people will provide support to research and data gathering outside DEC. The library should also house documents on conservation management, research methodology, environmental science and social science relevant to PNG biodiversity. The emphasis should be on gathering accessible material to support current activities immediately and expanding on that base as time and money permit. The BDC should be careful not to duplicate material available locally through inter-library loan unless these materials are central to BDC's functions. One way to keep staff current is to have a small serial collection and from that circulate topical clippings. Collections development not only requires identifying and obtaining existing documents but also staying current on new material. This may best be accomplished by regular communication with library staff at appropriate institutions both in PNG and abroad. Book vendors will be of some help in this regard, but given the technical nature of the BDC, a hands-on approach to collections development will be most successful. By keeping up a well focused reference collection, select periodicals, key texts and DEC technical reports, the BDC library will go a long way toward organizing printed materials and building an information base for analytic work.

Access to BDC

Once the library and GIS are established and reliable channels for new information for the two systems have been established, the issue of who will use the BDC arises. As stated earlier, the idea is to establish an information resource base for better management of biodiversity. Just as important as having material available is ensuring the material gets used. It is unlikely the Secretary or any of the First Assistant Secretaries will spend time in the BDC writing reports in response to Parliamentary inquiries. It is equally unlikely that every village farmer with a question on pest management or forestry will walk in to the BDC. Therefore, other options for using information are needed. In the case of evaluation and assessment work, if the DEC technical staff know of, and can find, the right data when reviewing environmental plans, the BDC will greatly compensate for trying to manage local activities from the capital city. At this level, using information is part and parcel of mid-level management doing its job. Getting in the habit of turning over field data to the BDC and in turn using that data later should not prove a problem at this level. It will entail some re-training if data standards are set and breaking old habits of coveting personal collections.

To reach distant local resource managers, an active and targeted outreach program will be needed. Expansion of branch BDCs to the provincial level would be one method to extend the range of impact of the central BDC. These regional centers need not duplicate all the data management facilities of the central office but could act as local support for data gathering and educational efforts by providing guidebooks and manuals while acting as a local repository for new field data. Expanding on the initial BDC will require an established central system and a strong commitment on the part of DEC to have a heightened provincial presence. These provincial centers may be most successful if they are incorporated into existing regional government facilities as long as their goals of data gathering and dissemination are not compromised.

The real need for analytic capacity within the BDC will come when top management needs a report or issue brief on a certain region or topic. In this case, having research capacity built into the BDC will be very important. BDC management would have to get a feel for the frequency of this sort of report preparation, but it seems reasonable at this point to suggest that a small staff of technically trained researchers with resource management experience be added to the BDC. As is true the world over, the higher up in a hierarchy the request for research comes from, the more general the request will be and the shorter the deadline. The BDC's ability to turn around reports on biodiversity conservation, habitat encroachment, parks status etc. relies on having the right people using the right information to their best advantage. If appropriate staff are not available within DEC or GOPNG as a whole, either UPNG or Unitech may be a good source of recent graduates to build on analytical capacity. In fact, it may be that recent graduates from a university setting would have the subject matter experience and be trained in the most current research methodologies.

Information Exchange and Linkages to Other Institutions

Another question is to what extent universities, private businesses and NGOs will participate in the BDC. The BDC may well have called on all these sources for data in setting up and maintaining the BDC, but how much will the above types of organizations get back in return? Many information centers use a set of varying levels of service to provide access to a wide range of users. This may prove to be the most workable way to facilitate sponsored research and support information use by local level concerns. If a set of options were developed whereby senior GOPNG management has use of all source materials and research staff while non-government users have access to most paper files and select portions of the computerized data, everyone's needs are met and staff time is reserved for those who need it most. In order to keep the BDC credible and encourage local level institutional strengthening, NGOs and private concerns should have access to as wide a variety of material as possible without hampering GOPNG use of the BDC. For example, BDC access may become one of the best consensus building tools when DEC is dealing with local Landowners. Maps with proposed activities and written material elaborating those activities, generated by the BDC, could be a good vehicle for DEC to educate Landowners and for Landowners to contribute new information to the BDC. As reactions to a proposed plan are elicited, a sample map could be generated and selected texts made available to address specific concerns. Likewise, BDC should develop a good relationship with the proposed Natural Resources Options Centre so that conservation options are well presented and integrated into other options for Landowners' consideration.

Monitoring BDC

With a newly organized text collection, state-of-the-art data on GIS, and staff to maintain and interpret this material, the BDC is ready to grow into its role as information service, data repository and training aid. As the BDC becomes a more formal entity it will be important to monitor the progress in developing data sources and products to support its mission. Establishing monitoring criteria by setting in-house goals and objectives and checking progress is one way to keep the BDC an active part of the DEC planning and assessment process. The key to keeping the BDC used is to keep it useful. This means data must be current, staff well trained and computers and printers functional. The monitoring process for the BDC would not only keep top management abreast of changes in BDC performance but also help make management accountable in remedying acknowledged shortcomings in BDC activities.

Checklist for Planning a Biodiversity Data Center

- Establish mission statement for BDC as repository and source for information. Prepare budget to cover start-up and recurring costs for staff, computers and peripherals, software and updates, text and data acquisitions, training, report preparation, furniture etc.

- Bring BDC managers on board early to help with planning and early logistics. Begin development of in-house guides on BDC policy for collections maintenance, staff performance and staff responsibilities

- Begin centralizing information resources through review of present documents, installation of GIS and initial liaison with sources outside DEC (DOF, Mines, Unitech, CSIRO, NGOs, etc). Hire GIS staff.

- Phase in computerization of library as coordinated with data acquisitions for the GIS and workable balance of software for data organization versus interpretation. Hire library reference staff.

- Begin acquisitions of new text material and establishment of network for continued collections development.

- Begin process of setting data standards and integrating BDC into DEC workload. Hire research staff. Plan BDC workload to cover data maintenance, provision of standard reports (i.e., newsletters, management issue briefs), special reports (reports to NEC, etc.) and training materials.

- Monitor BDC for utility of information, applicability of services. Continue data gathering and training for improved analytic capacity.

Recommendations for Establishing a Biodiversity Data Center in Papua New Guinea's Department of Environment and Conservation

- DEC management and the Strategic Planning team should develop a mission statement for the BDC outlining key functions, the location of the BDC within DEC's organization, expected outputs and a timeline for the center.

- Management level staff (one expatriate and one GOPNG staff) should be hired at the earliest possible time to speed planning and implementation of specific BDC activities.

- The BDC should be located within the DEC main office but have separate room(s) to enhance data/hardware security, research and report preparation while still providing the close proximity to DEC staff for ease of access.

- During the consolidation of DEC office space, weeding and cataloguing of existing documents/files relevant to biodiversity should be carried out.

- Emphasis in planning the BDC should be given equally to issues of interpretation and dissemination and not simply data gathering (i.e., role of outside organizations such as NGOs, Universities, etc.; continued staff training; provision of full range of presentation oriented software and hardware). The relative importance of data gathering and management, versus outreach and training, should be thoroughly explored.

- Do not expand data gathering efforts until GIS and library systems are in place and operational (library may not require automated system at the outset). Fully implementing systems already under design by the CNA and Protected Area Review activities will test the limits of a BDC. There will inevitably be lessons learned in this process.

- Initially, data gathering should expand on data sets provided by the CNA process (largely species distribution, bibliographies, and supporting maps). Soon after, park boundary and related information from the Protected Areas Review, as mapped by WWF, should be added to the CNA GIS, or the data on the two GIS systems should be otherwise merged. Once this is resolved, more refined distribution and habitat data can be added as other data sets are designed (for example, forest/mining concessions, license distribution, GOPNG planned land use-airports, roads, etc., and qualitative notes fields on all the above topics).

- GIS staff (one expatriate, one GOPNG) should be hired early in the implementation process to speed both data/software acquisitions and interpretation. GIS staff should be fully trained in data entry, software uses and data interpretation.

- All BDC staff should have thorough job descriptions and operations manuals developed for key BDC functions to account for turnover and build in sustainability.

- The BDC should develop performance monitoring and evaluation guidelines to keep the BDC responsive to DEC management and make DEC management aware of constraints in meeting goals.

- Access to the BDC should be as open as possible to outside organizations/individuals to gain greatest impact from materials under BDC control. BDC management should actively pursue cooperative arrangements with NGOs for data gathering and dissemination, universities for data gathering and training, and scientific/conservation organizations for data gathering and current "best practices" type literature.

- Human capacity is at least as important as computing capacity. Ongoing training for all staff levels should be budgeted for and the possibility for travel factored in.

- BDC should expect to outgrow a single computer for GIS, library and presentation purposes and will need to plan for purchasing a better suited system for the GIS component. Additional hardware in the form of a laser printer, plotter and digitizing pad are essential to data maintenance and report preparation. Purchase of these items should be part of BDC start-up and planned to mesh with expanded computer capacity envisioned for GIS.

- The library collection should be viewed like the other data gathering exercises and be fully funded throughout the life of the BDC to keep printed material current.

- Every attempt should be made to buffer the BDC from political fads in financial allocations. A good resource center is ageless, an under-funded resource center becomes obsolete quickly.

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Chapter Ten

The CNA Workshop

Janis B. Alcorn

The Conservation Needs Assessment included a workshop to create an opportunity for biologists and social scientists to engage in dialogue with the PNG government's conservation experts, representatives of PNG NGOs, and representatives of Landowners.[1] The CNA Workshop brought together representatives of stakeholder groups who share an interest in conservation but hold divergent viewpoints[2] and different agendas. The CNA Workshop was facilitated by The Keystone Center and held at Christensen Research Institute in Madang, 5-11 April 1992.

Six months prior to the workshop, CNA teams began preparing assessments for discussion at the workshop. Teams of international expert biologists developed analyses of PNG's biological diversity, including maps, for each of their particular sub-groups.[3] The National Alliance of NGOs (NANGO) and member NGOs carried out a survey of Landowners and held discussions among themselves. Teams of social scientists and legal experts carried out fieldwork, interviewed stakeholders, and prepared their assessments.[4]

During the CNA Workshop, biologists used GIS software to overlay the maps they had prepared, discuss what was known about each of the selected areas (including the areas of overlap and areas where there was no overlap), and then reached consensus on a suite of areas that best represented the full range of biological diversity in Papua New Guinea.[5]

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[1] Appendix 10-1 contains a full list of participants. Most of the staff of the Department of Environment and Conservation were present. In addition, representatives of the following PNG government departments were also present: Forests, Agriculture and Livestock, Fisheries and Marine Resources, Finance, and the Department of the Prime Minister. Jant, representative of PNG's logging business interests, was also invited, but declined to send anyone to the workshop.

[2] The divergent perspectives of PNG's conservation stakeholders are discussed in Chapter 4.

[3] The biodiversity analyses are found in Volume 2 of the CNA Report.

[4] The NGOs', social scientists', and legal experts' analyses are found in Volume 1 of the CNA Report.

[5] Chapter 11 contains a detailed description of the process used to create the CNA consensus maps of the representative suite of high biodiversity areas of PNG.

Biologists from the staff of PNG's Department of Environment and Conservation, Papua New Guinean biologists, and internationally recognized biologists were actively involved in these deliberations.

The CNA Workshop was more than a mapping exercise, however. The workshop was designed to achieve all of the following objectives:

1) Understand the current status of biodiversity, policy, and social information available for conservation and land use planning, and identify significant information gaps;

2) Develop dialogue and working relationships among biologists, NGOs, Landowners, and the government;

3) Develop maps of biodiversity information useful for land use planning;

4) Identify constraints and opportunities for conservation;

5) Propose culturally appropriate processes and options to conserve biodiversity; and

6) Propose ways to address remaining issues.

The CNA Workshop agenda[6] was not shaped to smooth over or ignore differences between stakeholders.[7] Rather, the workshop agenda was designed to create a process that recognized the legitimacy of all stakeholders as participants in conservation decision-making; encouraged lively debate to make obvious the differences and similarities in their viewpoints and agendas; and stimulated dialogue among the stakeholders in order to make progress toward reaching consensus on how the different players can collaborate to achieve shared goals.

SUMMARY OF INFORMATION PRESENTED AND ANALYZED AT THE CNA WORKSHOP

The workshop participants assessed the information presented during the workshop to reach the consensus on particular points. Only a subset of the information contained in the detailed chapters in the CNA Report was shared at the workshop. Other information shared at the workshop is not captured in any of the other chapters in the CNA Report.[8] This section provides a summary of the information that served as the basis for discussions from

[6] Appendix 10-2 contains the Workshop agenda.

[7] See Chapter 4 for a description of stakeholders, their assumptions, and interests.

[8] Additional information was provided in oral presentations by DEC, DOF, WWF, and PNG NGOs.

which emerged the consensus recommendations,[9] the points of agreement, and the list of unresolved issues.

Biology:

On Day 1 and Day 2 of the workshop, biologists presented summaries of their reports. Despite 50,000 years of human occupation, PNG retains 65-70% of its original forest cover. Biologists expect that the flora of PNG includes 25,000 species, 30% of which remain to be described by science. 85% of PNG has not been adequately inventoried. Lowland forest areas are especially poorly collected. Endemicity is very high. Lowland species tend to be widespread, but many highland species have very restricted ranges. Each mountain has its own endemics, although the total species on that mountain may be low. Because it would be difficult to include all the small areas that contain endemics on the CNA map, botanists suggested that the CNA team should pepper the map with small circles to illustrate the highly-localized distribution patterns of endemics. In an effort to highlight the importance of smaller areas, botanists prepared a list of small, known important areas that weren't included on the map of highest priority areas. They also supported the establishment of small local reserves to protect endemics.

PNG's zoological heritage is equally rich. Two hundred species of mammals and 650 species of birds are recorded for PNG; of these, 56 mammal species and 76 bird species are endemic. While the birds of PNG are well-known, the distribution patterns of mammals and the seasonal distribution patterns for birds are poorly known. In order to compensate for this lack of knowledge, the warm-blooded vertebrate team divided the country into 30 biographic districts. Species richness indices were based on distribution of a selected subset of well-known genera. There are 282 species of fresh-water fish, and 505 species of reptiles and amphibians in PNG. It is expected that there are many undescribed species. Of the 785 known species, 365 are endemics. The cold-blooded vertebrate team weighted centers of endemicity in selecting biologically important areas. No estimate was made of the total number of invertebrate species in PNG. The invertebrate team analyzed the distribution of indicator species (ground beetles, butterflies, cicadas and tiger beetles), as well as analyzed the distribution of a subset of aquatic insects.

The aquatic and marine biodiversity of PNG contributes a large part of PNG's biotic heritage, but marine biologists at the workshop stressed that the marine diversity is very poorly known to science. Major wetlands are associated with the two major river systems, the Fly and the Sepik, but these two wetland systems do not support the same sets of species. PNG's 5000 lakes generally have low species diversity, but often contain endemic species. The coastal-marine systems of PNG are extremely diverse and rich in fishery resources, coral reefs, sea grass beds, and lagoons. Biologists identified the major watersheds that affect the health of PNG's coastal-marine resources. Marine experts strongly recommended that further efforts should be made to identify the conservation needs of coastal-marine areas, because so little information is available for decision-making.

[9] Found in Chapter 12.

Information from NGOs and Landowners:

On Day 3 of the workshop, NGOs presented their analysis of constraints and opportunities for conservation in PNG. They stated that existing laws to protect the environment are not being adequately enforced.[10] NGOs discussed the inadequacy of the environmental plans approved by DEC and stated that Landowners' requests for gazetting Wildlife Management Areas are not being processed[11]. Specific Landowner and NGO conservation initiatives were described, including the Lasanga-Lake Trist Conservation Area project.

During Workshop discussions, Landowners expressed their need for better information for evaluating land use choices. They also described the problem of "Landowner Companies" that do not represent communities but are nonetheless allowed to make deals with timber companies. Such companies do not share the benefits they receive with all Landowner community members.

Further information was provided by two anti-CNA demonstrations staged by Madang area Landowners and NGOs.[12] Landowners and NGOs are concerned that biologists may be exploiting Landowners for their own gains. They felt the CNA funding would have been better used to support Landowners' own assessments of their conservation needs and to defend Landowners from exploitation by timber companies.

Information from representatives of the Government of PNG:

On Day 4 of the workshop, a panel of DEC's First Assistant Secretary Kula's Conservation Division staff and his advisors provided information about the activities of DEC, the National Forestry and Conservation Action Plan, and the draft DEC strategy.[13] Approximately 2 percent of PNG's area is currently under some kind of protected area status, including four national parks, three provincial parks, sixteen Wildlife Management Areas, and an unspecified number of sanctuaries and other types of conservation areas.

In the DEC draft strategy distributed at the CNA Workshop, DEC proposes to develop a formal "conservation system" that includes "all areas and all resources protected in some way under conservation management methods. It does not mean only areas protected under the Conservation Areas Act, 1980." DEC will use information from the CNA to extend PNG's conservation system under the Conservation System Design project. The UNDP Global Environmental Facility project for PNG will include support for a Conservation Resource Center inside DEC and pilot integrated conservation and development (ICAD) projects implemented through DEC.

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[10] Chapters 5-8 contain some of the information presented by the PNG NGOs and Landowners represented at the Workshop, but more information was presented during discussions and by the demonstration.

[11] Corroborated by DEC -- a backlog of more than 100 applications.

[12] Appendix 10-3 contains a transcript of comments made during one demonstration.

[13] Contact the Department of Environment and Conservation for further details.

Peter Hunnam of World Wide Fund for Nature (WWF International) described the WWF-DEC joint effort to implement the Protected Areas Rehabilitation Project.[14] William Asigau of DEC presented a summary of a participatory, marine, protected area project being supported by the South Pacific Regional Environment Programme (SPREP) and Greenpeace.[15] John Douglas, advisor to DEC's Water Resources Division and Kembi Watoka, First Assistant Secretary of DEC's Environment Division, presented information about environmental plans required from development projects (environmental impact statements).[16]

Legal Framework:

On Day 5 of the workshop, the legal team provided a description and analysis of the legal landscape in which conservation action takes place in PNG.[17] They concluded that, although PNG has an adequate legal basis on which to proceed, better mechanisms are needed to ensure that Landowners are able to exercise their rights to regulate the environmental impacts of development. Public access to environmental plans and other documents needs to be improved. The Conservation Areas Act of 1978 has never been implemented, because the National Conservation Council was never been formed. The legal team recommended that representatives of Landowners and NGOs should be active members of such a Council. Information on the Forestry Act of 1991 was provided by speakers from the Department of Forests.[18] Under this Act, Forest Management Agreements (FMAs) replace the old TRPs and LFAs.[19]

Social Information:

On Day 5 of the workshop, the Social Scientist team presented the following conclusions from their assessment[20]:

1) Communication between the key conservation stakeholder groups (government, NGOs, Landowners, business, and scientists) is poor and needs to be strengthened;

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[14] A report from the first phase of the Protected Areas Rehabilitation Project should be available from DEC in 1993.

[15] Further information is available from the San Francisco office of Greenpeace.

[16] Detailed information is available from DEC.

[17] See Chapters 2 and 3 for the full final reports.

[18] Representatives of DOF distributed detailed pamphlets outlining the new Forestry Act.

[19] Implications of the new Forestry Act are summarized in Chapter 2.

[20] Their detailed final reports are found in Chapter 4.

2) Environmental impact assessments need to be strengthened, particularly in terms of socio-economic impacts; and

3) Lack of social feasibility analysis of conservation projects will undermine the prospects for success of conservation in PNG.

During the workshop, the Social Scientists did not attempt to map the sociocultural diversity of PNG. While in theory it would be possible to map sociocultural diversity, it would not be possible to judge which areas of PNG are "Important Areas" as was done regarding biodiversity. Judgments about the value of societies, systems of religion, and languages would be highly subjective, and could not be prioritized on a GIS map. Linguistic maps showing linguistic diversity already exist, and maps of population distribution also exist. The PNG National Museum is developing a map of sacred areas from their voluntary registry. Provincial maps of land use are being prepared by Australian National University.

The Social Scientist team stressed that sociocultural information most relevant to conservation decision-making is not geographic. Communication processes, rights adjudication, conflict resolution mechanisms, and attitudes toward biodiversity, for example, are dynamic processes. Their "importance value" for conservation lies in the ways that they are engaged by conservation planners and implementors. The outcome of that interaction is not predictable; it depends on the terms of the engagement and the process that unfolds "at the table" or "in the field."

Threats:

Although there was no formal presentation on threats, and although an analysis of threats to biodiversity was not part of the CNA process requested by the GOPNG, a report commissioned by DEC, "Impact Study of Future Logging Proposals," prepared by Sally Townley, was available for discussion and reference during the CNA Workshop.[21] and known TRPs were mapped in to the CISIG GIS system used at the workshop. Approximately half of PNG's loggable forests have been logged or allocated for logging under TRPs. Half of the lowland rain forest is either under timber lease or being assessed for timber leases as of early 1992. The report recommends creating protected zones within timber leases. A preliminary assessment of existing Wildlife Management Areas is also included in Townley's report. A more in-depth assessment, the DEC/WWF-International Protected Areas Review (PAR), should be available in 1993. Maps showing threats from planned and existing mining or major agricultural plantations were not available at the workshop.

[21] Townley's report includes a province-by-province review, for 13 lowland and island provinces, of Timber Rights Purchase timber leases (TRPs), Local Forest Areas (LFAs) -- locally arranged timber leases on which information is difficult to obtain -- and Wildlife Management Areas (WMAs). It also includes maps showing current TRPs as well as existing and proposed WMAs. The report and maps are available from DEC.

CNA WORKSHOP RESULTS

Plenary and Working Group discussions followed the presentation of information by each team. There were points of agreement[22] and disagreement.

Points of Agreement:

The central points of agreement were:

1. PNG is a unique and rich repository of biodiversity.

2. That PNG's biodiversity is under immediate threat from development activities and action is needed.

3. Action must be appropriate to Papua New Guinean ways and systems of resource ownership.

4. Government, scientists, NGOs, and Landowners must cooperate if the conservation goals are to be achieved, but such cooperation is only beginning.

5. Information and better means of information dissemination are needed for making decisions and setting priorities at local and national level.

6. There is insufficient funding and Government support for conservation action.

7. Landowners and Government need better means of communication about conservation and development options.

8. Innovative options that link conservation with local economic benefits are needed.

9. All Landowners should be encouraged to undertake conservation actions for sustainable use of their natural resources.

10. Consensus maps. Three synthesis maps of high biodiversity areas were created:[23] a) a map of 16 biologically unknown areas that merit immediate survey and study; b) a map of 30 marine/coastal biologically important areas and 5 watersheds critical to the health of those marine/coastal areas; and c) a map of 42 terrestrial biologically important areas and 16 important wetland habitats. Given PNG's global status as an area of high biodiversity when compared to the areas represented by other countries in the world, the fact that areas are not assigned to priority "circles" on the CNA map does not mean that the "unassigned" areas are low in biodiversity. Areas of "unassigned" priority on these maps may contain locally

[22] Chapter 12 elaborates the points of agreement on Recommendations.

[23] Chapter 11 contains these maps. A separate, full-color CNA wall map is also available from Conservation International, DEC, BSP, and NANGO.

important biodiversity and may be rich in biodiversity when compared on a global scale. The maps do represent a consensus among biologists who were attempting to compare areas within PNG as to their relative richness, levels of endemicity, ecological diversity, and rarity in order to select a suite of areas containing representative samples of PNG's biological heritage.

Core Issues

The Workshop was successful in identifying issues related to conservation planning and implementation. These issues are an important product of the CNA. Any conservation effort in PNG will have to confront these issues. These issues were not resolved during the Workshop, and they will remain at the core of conservation debates in PNG during the coming years.

The purpose of presenting these issues in the CNA Report is not to endorse any one perspective, but to report accurately the views expressed at the CNA Workshop by the major stakeholders and identify points where disagreement exists. The issues are taken from formal reports from each discussion group, comments made during plenary, and comments made during informal discussions.[24]

The major issue that emerged during the early days of the CNA Workshop revolved around the purpose of the CNA map. The "map issue" remained unresolved at the end of the workshop. The social legend that appears on the map was designed to address concerns about the map. In many ways, this issue captures the other issues that arose at the workshop, as well as symbolizes the opportunities presented by a mapping exercise such as that undertaken by CNA.

The process of mapping the biological information was, as is common to science, isolated from the human communities that claim the spaces on the map. This process runs contrary to traditional Papua New Guinean relationships to nature. Humans and their ancestral space are not separable entities. One Papua New Guinean pointed out that Landowners could kill outsiders for drawing lines on maps of a Landowner's land without permission of the Landowner. Given that any person does not have the right to talk about land issues if one is standing on someone else's land in PNG, the concern was culturally appropriate. This local, culturally-supported concern about rights to make decisions about others' resources served, therefore, to heighten the globally-debated issue regarding "who" manages biodiversity "for whom."

Two demonstrations by local Landowners and NGOs carrying placards interrupted the planned workshop proceedings, but they provided useful information for the workshop

[24] Caroly Shumway and Jim Rieger of USAID compiled a detailed set of notes on the workshop discussions, including copies of the reports from discussion groups. The plenary sessions were also taped by Bruce Beehler. Notes and tapes are available at the BSP and NANGO offices.

deliberations.[25] The demonstrators also contacted the local press and provincial government officials to protest the CNA Workshop, because they felt that CNA impacted local resources without conferring with Madang Landowners (especially the Landowners of the land on which the deliberations in the buildings of Christensen Research Institute and Jais Aben were taking place).

1. The Map Issue

There was a strong concern that the CNA maps could be used in ways that would not benefit conservation. Some participants expressed their wish that the maps should not be made because of anxieties about how the maps might be used. Concerns about the use of the maps included:

a. The CNA project should map areas where Landowners are interested in taking conservation action, and that "landowner-interest" map should be used with the other CNA maps to identify priority areas for conservation action.

b. The map could be used to make it difficult for Landowners outside the CNA maps' priority areas to get funding for conservation activities.

c. The map could be used to restrict Landowners' abilities to make decisions about resource use.

d. The map could have a negative impact on Landowners that would lead to financial benefits for non-Landowners. An example given was that government had funded a marine study and then later allowed an Indonesian company to fish for sharks in that area. Villagers arrested the boat for being in their waters, but the fishermen said they'd made an agreement with the government. Villagers believe the biodiversity research led to the agreement which was bad for Landowners and profited the Government and the outsiders.

e. The map could be used by the Department of Forests to restrict options for Landowners. In particular, areas not designated as high biodiversity areas would be logged and could not be included in any conservation initiative.

f. Environmental impacts outside the map's high priority areas ("circles") would not be monitored or prevented. Environmental assessments would become even weaker and developers would have free rein in the rest of the country.

g. Landowners inside the circles will be forced to be part of Conservation Areas even if they don't want to do so.

[25] Appendix 10-3 contains a transcript of comments made during one demonstration.

h. Landowner Awareness[26] about conservation would only be done inside the circles, not nation-wide, thus not encouraging conservation and sustainable resource use nation-wide.

There was a concern, particularly on the part of biologists and government advisors, that priorities must be set, because conservation could not be achieved nation-wide. They felt that if they did not proceed with selecting limited, priority geographic areas for conservation, they would not be able to achieve their conservation goals anywhere. The map would help them to select geographic areas (selected from among circles on the map) about which they could negotiate with other, much more powerful, government departments in order to save a representative sample of PNG's biological heritage.

Others countered that Landowner participation and interest are criteria that are equally important as biological criteria for designating conservation areas, and biodiversity conservation requires a landscape-wide strategy. If the government wanted to successfully conserve biodiversity in both the short- and long-term, they must encourage biodiversity conservation wherever Landowners actively seek assistance for conservation.

2. The Rights Issue

The issue of the appropriate mix of Landowner and State rights and authority for achievement of conservation was hotly debated. Some of the perspectives were that:

a. Landowners have the constitutional, legal, and cultural right to make decisions about management of their resources, but the State often ignores these rights in implementing conservation and development projects.

b. Landowners don't know what the term "conservation" means. There needs to be a national discussion of the meaning of conservation so that Landowners can understand how "caring for things"[27] includes exercising their rights to protect their environment from negative impacts by outsiders.

c. Conservation should be about empowering Landowners to make their own decisions about making the best use of their resources.

d. It is dangerous to put complete control in the hands of Landowners. Landowners should not be allowed to make some choices. The State has the right to make decisions when the greater good is at stake. For example, do a group of upstream Landowners have the right to pollute or otherwise destroy the water resources of those downstream?

[26] See Chapter 4 for a discussion of the proposed Landowner Awareness programs.

[27] Conservation is usually translated as "caring for things" in Papua New Guinean languages.

e. There is no regulation of whether Landowner agents represent the interests of Landowners.

f. While Government claims it wants to interact with NGOs and Landowners, the record shows that they don't. Landowners and NGOs find it very difficult to interact with government. Poor communication between Landowners and government, and lack of information, has led to confusion over what is being done by government.

g. Government should fund local initiatives instead of being driven by what donors want to do.

h. The goal of conservation should be first to serve local interests, and this will ultimately benefit the national interests.

Workshop participants were particularly passionate about this issue. The discussion clearly left the impression that while PNG's Constitutional Principles elaborate upon the rights and authority accorded to Landowners, in practice Landowners often were not exercising their rights, because the government does not inform Landowners about decisions that are being made. Outsiders' decisions often have had negative effects upon Landowners in the past.

In the case of the CNA maps, it was not clear what the consequences of the mappers' decisions would be for Landowners. People were suspicious that increased government decision-making about "conservation" would have a negative impact upon them, and they wanted to participate in the decision-making.

3. The Political Will Issue

This issue was not the object of direct debate during the Workshop, given that the Workshop was requested by the Government of PNG. Yet a concern about government commitment to conservation underlay much of the discussion at the CNA Workshop, particularly given that the reforms of the 1991 Forestry Act were being blocked by powerful elements in government at the same as the CNA Workshop was being conducted.

There was a general suspicion that the lack of political will to implement conservation would result in government making inappropriate use of the maps. There was a concern among all present that the GOPNG has not demonstrated a strong political will to protect the environment and the public good. In so far as government staff were present at the Workshop in their official capacities, it could not be expected that any frank discussion of "political will" would occur, or that such issues could be resolved during this workshop.

Some of the major concerns discussed were that:

a. The government is primarily interested in making money off PNG's natural resources, not in protecting them for the long-term good, as evidenced by their approval of projects with poor environmental impact assessments, lack of action on Landowners' requests for Wildlife Management Areas, lack of pro-active conservation action, failure to incorporate environmental concerns into line agencies, and underfunding of the Department of Environment and Conservation.

b. Sustainable resource use is not a goal of the government; instead concern for maximum revenues and rents drive government decisions, as evidenced by the Barnett Inquiry.[28]

c. At the national level, the political will to maintain Landowners' rights to make decisions about their resources is weak. Although government officials speak about Landowners' rights, government makes very little effort to enable Landowners to exercise their rights and enacts new laws that limit Landowners rights.

The Department of Environment and Conservation (DEC) staff are dedicated to conservation goals, but they can only achieve their objectives in the context of a larger government policy environment that supports DEC's efforts within the context of broad development decisions.

4. The Role of NGOs Issue

This core issue is related to the political will issue. Specific concerns raised include:

a. An important role of NGOs is to provide information, but it is difficult to get information from government, and funds to support information dissemination are very limited. NGOs need to have greater access to information, including what documents exist and how to get them.

b. Despite attachment of an NGO liaison to the National Forestry and Conservation Action Plan's Technical Assistance team, effective liaison has not developed. Donor funds through NFCAP have not been made available to NGOs and Landowner initiatives.

c. At most only 5% of Landowner communities have access to or interact in any formal way with NGOs.

[28] It should be noted, however, that the existence of the Barnett report demonstrates that there is a level of political will, in some quarters, to support the public good. No other such in-depth, national investigation of timber trade corruption has been carried out in other countries.

d. NGOs have no effective representation in decision-making and policy bodies.

e. Government officers do not come to meetings with NGOs when they are invited.

f. It is virtually impossible for NGOs and Landowners to obtain copies of environmental plans (environmental impact assessments).

g. NGOs need to improve their technical capabilities.

h. NGOs should be involved at earliest stages of projects. Projects tend to be "top-down." The conservation projects under discussion (specifically the UNDP GEF project) are being designed "top-down" without substantive NGO involvement.

Although NGOs and DEC share conservation concerns, the relationship between NGOs and DEC appears to be one in which both parties are suspicious of the other's commitment and ability to achieve conservation objectives. A more cooperative relationship will be necessary for conservation success in PNG.

5. The Expatriot Scientist Issue

Concerns about the motives and behavior of expatriate scientists, who appear to be concerned about biodiversity and not about human welfare, also surfaced during the CNA Workshop. Concerns that were expressed included:

a. Landowners sometimes think scientists are just like loggers, exploiting them for gain. Outside scientists don't leave anything behind that is useful to Landowners.

b. Scientists' surveys, especially those that include PNG students, make Landowners aware of the conservation values of their land.

c. Scientists support "protected areas" which are inappropriate for PNG.

d. The academic community in PNG is small, but outside experts should work with them.

e. Outside ideas need to be filtered through Melanesian context; urban Papua New Guineans educated overseas often fail to use the Melanesian filter and hence behave like expatriates and fail to design programs that are appropriate to Melanesia.

f. PNG has a wealth of local knowledge about local biota, their uses, ecology and management. PNG needs to take the initiative to preserve local knowledge about biota and enable Landowners and government to link that information to scientists' information.

Biologists at the workshop, who have worked for many years in PNG, defended their concern about the welfare of Papua New Guinean people. They have dedicated years to teaching biology to Papua New Guineans, and highly respect Papua New Guinean rural people's knowledge of natural history. Biologists at the workshop felt that they were contributing their scientific knowledge for the benefit of Papua New Guineans, and felt that their motives were misunderstood.

These five broad issues will continue to shape conservation action and policy, whether they are faced directly or ignored.

Public awareness created by the CNA workshop

The CNA workshop made an initial step toward creating a process for public participation in conservation in PNG. It succeeded in increasing public awareness of conservation issues. Provincial and national press carried articles on the CNA Workshop. The CNA was also a major topic of discussion at the annual meeting of the National Alliance of NGOs. The Workshop was followed by a presentation of workshop results at a meeting to which donors, scientists, NGOs, and other government departments were invited, in Port Moresby on 13 April, 1992.[29] DEC chaired the presentation during which the CNA consensus maps were shown and the CNA Recommendations were distributed.

Suggestions for CNA next steps

Regarding next steps in identifying conservation needs, the following suggestions emerged from the Workshop:

1) Implement the CNA Report recommendations.

2) Public awareness campaigns should create a national dialogue to decide "what does conservation mean in PNG" and "what are the appropriate conservation mechanisms that should be supported by the government and local communities."

3) CNA assessments and Workshops should be held at local, regional and/or provincial levels.

[29] The agenda is found in Appendix 10-2. Unfortunately, the presentation occurred in the afternoon, rather than in the morning, as was programmed, due to the unavoidable cancellation of the flight carrying workshop participants from Madang back to Port Moresby.

RECOMMENDATIONS FROM THE CNA TEAMS

On the 6th day of the workshop, each team presented a set of recommendations to the plenary. After these recommendations had been presented to the plenary, workshop participants discussed the recommendations and reached consensus on endorsing them. A consensus document drafting committee was appointed to summarize the recommendations into a single document.[30]

The recommendations, authored by each team, appear below as they were presented to the plenary.

Biologists' team recommendations:

1. Conservation Research

   a. Survey of unknown biotas. Areas considered as potentially biologically important, but as yet unknown, should be surveyed.

   b. A biological survey. An organized effort to collect and manage biological information for monitoring the use of and potential threats to PNG's biological diversity should be mounted. This effort should include a comprehensive database on the study and management of PNG's natural resources (incorporating data from published literature, museum collections, living and germplasm collections, and GIS). Enhancement of national collections and taxonomic resources are vital (e.g., Lae Herbarium, National Museum, DAL insect collection, DFMR fisheries collections) and international cooperation should be fostered.

   c. Threatened species. DEC should foster field studies on threatened and endangered species to develop species management plans.

   d. Studies of marine biodiversity and ecology. PNG's near-shore marine communities are highly diverse yet poorly understood. Because the government plans to intensify coastal fishing, biological research on these marine communities is imperative.

   e. Rain forest studies. Lowland rain forests are one of the most immediately. threatened habitats in PNG, and are in urgent need of survey and research.

   f. Traditional knowledge and use of natural resources. Traditional knowledge should be recognized, surveyed, recorded, and used.

   g. Genetic resources. Study and preservation of genetic diversity, especially of crop plants, should be encouraged.

[30] See Chapter 12.

2. Training

It is vital to strengthen PNG's conservation infrastructure through training in research and resource management -- including the training of extension workers, para-naturalists, technicians, information managers, resource managers, and professional scientists.

3. Conservation Areas

a. Parks and protected areas. We recognize that the western model of national parks is not appropriate in PNG and encourage development of alternatives.

b. Important areas. The CNA map of biologically important areas should be used to gradually create a system of conservation areas that include the involvement of Landowners. Pilot studies that integrate conservation and local development should be initiated in a representative sample of areas.

c. Government-authorized conservation areas. DEC must increase its capacity to address Landowner-initiated requests for Wildlife Management Areas.

d. Locally-initiated conservation areas. Informal conservation activities -- those without formal government recognition -- should be encouraged through government outreach and extension programs.

4. Conservation Action

a. Guidelines for sustainability. Strict guidelines should be developed to define and implement a policy of sustained yield for forestry, fisheries, and other resource uses.

b. Exotic species and quarantine. Introduction of foreign plants, insects, and other animals threatens natural ecosystems. Strict quarantine controls are vital to prevent accidental introductions. In addition, we strongly oppose the deliberate introduction of exotic plant or animal species except under the strictest supervision and with clear support from impartial national and international experts.

5. Environmental Legislation

a. Environmental laws. PNG has excellent environmental laws pertaining to land-based activities, but requires stronger capacity to effectively enforce them. Environmental laws addressing marine conservation are needed.

b. International conventions. PNG should sign both the World Heritage Convention (sites of outstanding universal value) and the RAMSAR Convention (to conserve internationally significant wetlands). International initiatives protecting shared marine resources should also be promoted.

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6. Trust Funds for Conservation

PNG needs a permanent environmental trust fund, overseen by an independent statutory board, to give grants to local organizations for either local or national conservation action. This fund could be supported through an environmental levy on extractive industries (logging, petroleum, mining, and fisheries) and multilateral donors.

7. Marine and Coastal Recommendations

<u>Research needs</u>:

a. Database collation in central repository
b. Intensive resource surveys in Milne Bay, West Sepik, Hermit Island area, Eastern North Solomons
c. Community: Systems ecology in well-studied areas
d. Identification of true bio-indicators on a site-by-site basis
e. Open ocean studies:
   a. Impact of commercial fisheries on ecosystem
   b. Identification of major migratory routes
   c. Maximizing enforcement effort for fisheries and shipping
f. Stock assessments -- observer program
g. Reinforcement or amendment of scientific knowledge with traditional knowledge
h. Survey of sustainable uses and marine tenure system
i. Review of legislation and its impacts (both effectiveness and applicability of terrestrial legislation for marine <u>and</u> use shifts that legislation causes)
j. Marine CNA or BA (including physical oceanography)

<u>Immediate management needs</u>:

a. Effective assessment of dynamite fishing problem, management plan, and enforcement
b. Integration of fisheries development and management with environmental management and conservation
c. Planning and financial support for a coastal management authority
d. Integration of watershed and coastal management (legislative requirements for marine EISs in watershed development projects)
e. Training: Marine science inst., oceanographic capabilities, mid-level managers in all sectors
f. Public education and awareness.

NGO and legal teams' recommendations:

In accordance with the belief that protecting the environment in Papua New Guinea is best promoted by processes of empowerment for decision making rather than processes of decision making for empowerment, the following recommendations are made:

1. The DEC should appoint a NGO representative, from a list nominated by NANGO, to the National Environment and Conservation Working Group and the National Conservation Council.

2. There should be a NGO representative on the upcoming GEF formulation mission.

3. The DEC and DOF should establish NGO desks responsible for coordinating activities and establishing processes for the regular sharing of information.

4. Government-sponsored conservation initiatives in general, and the GEF support initiative in particular, should emphasize extensive approaches geared towards providing Landowners with information and encouraging and reinforcing grassroots conservation initiatives.

5. Government-sponsored conservation initiatives should not be based on a "we'll give you something, if you give us something" approach, but should be geared towards helping Landowners sustainably develop their natural resources, irrespective of any contractual agreements.

6. An autonomous Natural Resource Options Center should be established to provide information on local levels to Landowners concerning their legal rights and duties, their options when deciding how to use and develop their natural resources, and the potential and probable implications of their decisions.

7. A note should be placed on the final CNA map that contains the following information:

NOTE

1. The Constitution of Papua New Guinea promotes equality and participation, the wise use of natural resources, and Papua New Guinean forms of development.

2. Ninety-seven percent of Papua New Guinea is owned according to customary tenure.

3. This map was prepared by biological scientists and, based on available knowledge, identifies areas richest in biodiversity.

4. This map is not intended to, nor should it be used to, exclude any areas or any Landowners from conservation programs and initiatives.

5. When identifying appropriate conservation strategies and areas, local initiative is as important a criteria as biodiversity.

Social scientists' team recommendations:

I. Training

A range of training needs and different institutional levels are recommended to promote conservation in PNG. These include the following:

1. NGOs

a. Participatory Rural Appraisal (PRA). Participatory rural appraisal training for NGOs -- both service-providing NGOs and local communities -- is recommended. This training will provide skills to NGOs to identify conservation opportunities and needs. The training will lead to production of resource management plans and maps at the community level for conservation and development activities.

Where: PNG; 2 village communities in Year 1
Length of time: 1 month training; ongoing development of the plan
Who for: PNG NGOs
By whom: IIED/London

b. Rapid Rural Appraisal (RRA). Skill training in rapid rural appraisal is recommended for NGOs. This is different from PRA training. RRA training will sharpen NGO analytical skills useful for feasibility analysis work in project design or exercises such as TRP environmental impact assessment. This will be directed at the broad community of NGOs.

Where: PNG; classroom and field
Length of time: four regional 2-week training sessions
Who for: PNG service-providing NGOs; at least one potential NGO representative who will serve on the NROIC (see below)
By whom: IIED/London or private consultants

c. Feasibility analysis. Skill training in feasibility analysis is highly recommended for a small group of PNG NGOs so that they can participate in TRP environmental impact assessment missions, and/or work independently with communities prior to the formal conduct of an EIA. This training will incorporate a strong land tenure component which focuses on customary use and ownership rights.

Where: PNG or elsewhere
Length of time: to be determined
Who for: NGOs demonstrating (1) a certain technical capability in socioeconomic survey work; (2) the desire to work objectively on thorny EIA issues with forestry sector stakeholder groups.
By whom: Land Tenure Center/IIED team

d. Project design. A series of project design workshops is recommended for service-providing NGOs in PNG. These workshops will coalesce in an integrated manner the types of skill training indicated above. They will provide the technical basis for developing project concepts into formal, socially and technically feasible proposals. This will be a generic skill area useful not only in conservation, but in any development sector as well. This will ultimately culminate in the design of a number of pilot ICADs through different regions of PNG, along with the design of appropriate feasible awareness-raising programs for the extensive conservation activities in PNG.

Where: PNG

Length of time: Two one-week workshops per participating NGO over 1 year

Who for: above

By whom: WWF/US, World Education, EIL, or a similar capable international NGO

e. Mediation/negotiation. Skill building in mediation and negotiation is recommended for NGOs. This training will increase the capability of NGOs to identify productive techniques to interact with different stakeholder groups. Included in this will be training in speech presentation and group discussions.

Where: to be determined

Length of time: to be determined

Who for: NANGO-selected NGOs

By whom: WWF/US, Keystone, etc.

f. GIS. It is recommended that the Conservation Networking Officer (CNO) and at least one other NGO representative receive a tailor-made course in GIS. The objective of the training should be to provide the skills to understand the strengths and limitations of GIS and specifically resource maps, with emphasis on how NGOs could positively use GIS information to promote conservation. Attention should also be given as to how GIS information and maps could possibly be abused by groups not interested in promoting conservation.

Where: UNITECH

Length of time: to be determined

Who for: NANGO CNO and at least one other NANGO NGO representative

By whom: UNITECH

2. Government

Training for government is recommended in several areas. These include the following:

a. Rapid rural appraisal. This training will sharpen the skills of field-level public servants in DEC who do or should work with Landowner communities. These skills will systematically hone perceptual and planning capabilities of DEC, but in a manner which will not presuppose top-down planning to conservation. Rather, this will support bottom-up PRA-type resource management planning. These will be particularly useful skills in assisting in the identification of potential ICAD projects.

Where: PNG

Length of time: to be determined

Who for: DEC and other willing government departments (such as DOF)
By whom: IIED or consultants

b. Mediation/negotiation. Better mediation and negotiation skills are needed by DEC for working with NGOs, Landowner groups, and other interest groups. Training should focus on identifying areas of disagreement and potential agreement, and developing the communication skills to coax a negotiation process along.
Where: to be determined
Length of time: to be determined
Who for: DEC staff at all levels
By whom: WWF/US, Keystone, etc.

3. University
a. Courses. Various courses for the limited number of existing social science professionals in PNG are needed. These should be in the following areas:
i. rapid rural appraisal/participatory rural appraisal
ii. social impact assessment
iii. environmental science (for social scientists)
iv. feasibility analysis of forestry sector EIAs
Where: UNITECH/UPNG
Length of time: to be determined
Who for: PNG social science professionals
By whom: to be determined

b. More social scientists. Training should be provided to increase the number of social scientists in PNG.

II. Information

a. National Resources Options and Information Centre (NROIC). The generation and dissemination of information relevant to conservation from the point of view of opportunity and threat are needed at both a national and local level. It is recommended that a center be established which is independent of existing departments, which can serve as objective a role in information generation and dissemination as possible.

It is recommended that a Natural Resources Options and Information Center (NROIC) be established to amass, create and disseminate information on traditional resource management systems, changes in those systems, tradeoffs from different development and/or conservation options, etc. The ultimate beneficiaries of NROIC will be (1) Landowner groups who will receive better information on potential impacts and options and (2) DEC and other government departments.

NROIC should not be attached to a line department. Staffing and funding needs are to be determined.

b. Public awareness. It is recommended that access to NROIC be guaranteed to the public at large, to individuals, communities, Landowner groups, NGOs and government. Specifically targeted information packages or broader based awareness programs should be prepared both from suitable materials gathered from all sources, and from locally produced materials. This will be made available for dissemination and use in awareness raising through the formal education system, churches, NGOs, and all media.

III. Institutional Issues

The functioning of existing conservation institutions needs to be strengthened. The following are recommended:

a. Processes be identified and mechanisms instituted to guarantee that DEC personnel are better able to carry out their mandate.

b. Should DEC be serious about its desire for NGOs to become more involved in conservation in PNG, it is recommended that clarity in both statements and action be demonstrated to the NGO community. To accomplish this, it is recommended that NGOs -- both Landowner groups and service-providing members of NANGO -- be included in planning, design, and implementation discussions with DEC from here on out. It is further recommended that explicit mechanisms to guarantee this be negotiated between DEC and NANGO to see that this is implemented.

c. NANGO addresses the issue internally and explicitly as to the degree to which it wishes to serve as a facilitating/collaborating NGO with government, or otherwise.

d. Should NANGO determine that it wishes to increase collaboration with government, it is recommended that it explicitly convey this in word and deed to government.

e. To improve communication, collaboration, and eventually partnership between NGOs and government (in this case DEC), it is recommended that government should also have representation in NANGO to a degree to be determined. This of course implies that points (c) and (d) above are affirmed.

f. To demonstrate existing capacity, NANGO should compile a resource inventory of its members indicating their sectoral expertise and experience. In regard to potential for collaboration in conservation programming, this should be submitted to DEC and other departments to enable them to make decisions on the potential for NGO participation in activities DEC hopes to initiate.

g. To assist in the consideration of traditional conservation practices in conservation, in terms of their need for preservation or possible adaptation, it is recommended that it be government policy to develop provincial conservation committees to work more closely with the proposed NCC to be established by DEC. These committees should have as their mandate the two-way channeling of information on conservation threats and options to government, as well as to the NROIC.

IV. ICAD and Other Issues

a. It is recommended that a realistic and flexible approach to designing and implementing ICAD projects be taken. It is recommended that emphasis be put on developing ICAD methodologies and on monitoring ICADs as they are implemented so as to refine the methodologies for potential replication elsewhere. It is recommended that ICADs not be used in the short-term to extend the protected area system in PNG as is now indicated by DEC documentation. Rather, ICADs should be viewed as a means for potentially achieving sustainable conservation and development in PNG, in high biodiversity-rich areas as identified through the CNA mapping or otherwise, once they demonstrate their substantive and methodological merit.

b. It is recommended furthermore that ICADs be seen as a complement to other "extensive" conservation approaches, such as Landowner awareness programs instituted by NGOs and NROIC.

c. It is highly recommended that in any Landowner awareness program, emphasis should not be placed on convincing people not to exploit their natural resources in a particular way unless feasible alternatives are presented. For example, it is strategically unwise and arguable immoral to tell people that they should not harvest their own timber resources for their own development unless as or more attractive an alternative is provided. This same recommendation also applies to slash and burn agriculture.

d. It is recommended that Landowner awareness programs should not be designed on the assumption that Landowners prefer to conserve their resources over exploiting them for development alternatives. While this may be the case in some, or even many, instances, empirical field research has shown that communities are as often or more often opting for development options which will not optimally preserve natural resources. Therefore, awareness raising programs should be directed to raising awareness of the potential impacts of a given activity, and provide alternatives to a given activity where alternatives exist. It is recommended furthermore that awareness raising programs be designed in a way which facilitates Landowner decision making for how natural resources should be managed. This is empowerment.

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e. It is recommended that much tighter sociocultural and socio-economic criteria for environmental impact assessments be applied to assessing environmental impact by DEC. These criteria should include (but are not exclusively limited to):
   i. the impact of proposed actions on specific groups of people in particular areas -- i.e. community, Landowner groups, women, professional groups, religious groups, etc.
   ii. how different options for conservation and development activities will have different impacts on the groups indicated in point (i) above).
   iii. has the process for introducing a development or conservation option been approached in a socially sound manner?

These and other criteria could be used equally well by the Department of Forests for TRP areas.

f. It is recommended that point (e) above be implemented by an independent body from the private sector interest proposing the specific activity.

Landowners' recommendations:

a. Get Landowners' views on traditional management and means of conservation before GOPNG can go ahead with programs.

b. Notice in advance and reasons before coming in to do work/research.

c. GOPNG workers must live and work with Landowners so they understand problems of Landowners.

d. No quick visits. Officers must stay for a long time with Landowners before writing reports.

e. Experiences in other countries should not be used as an example for PNG cases.

f. Involvement of land/resource owners from beginning to end. Whatever is done in this workshop in relation to conservation needs assessment must begin with land/resource owners full participation and end in terms of formulated strategies and implementation phase.

   Non-involvement of land/resource owners will pose problems at implementation phase of projects.

g. Awareness/information outlets/channels to be given to land/resource owners. Having access to relevant information on exploitation of Landowner resources will help them make rational choices/decisions.

h. Networking/linkage. (1) National Government or Departments need to establish linkages with all land/resource owner groups with regards to exploitation of their resources. Use of the existing NANGO-PNG/Communication Network. (2) Some land/resource owner affiliation with NANGO-PNG/wider network to create public awareness on environment conservation needs.

i. Institute and fund projects as recommended by land/resource owners. This would contribute towards training land/resource owners to be better managers of their own environment. Support/fund projects to promote local scientific knowledge.

CONCLUSION

The CNA Workshop was successful in reaching its immediate objectives. Biodiversity priority maps were created, conservation constraints and opportunities were identified, and a consensus was reached on recommendations for future area. Dialogue among divergent stakeholder interest groups was begun, but it is too early to tell whether the CNA succeeded in catalyzing further collaborative conservation efforts involving Landowners, NGOs, government staff, and scientists.[31]

[31] As of early 1993, there are indications that the National Resource Options Centre is beginning to take shape, the UNDP GEF ICAD project is using the CNA biodiversity maps to identify potential project sites, and BSP supported training of a DEC officer and the NANGO conservation officer in the Community Issues Management Forum technique.

APPENDIX 10-1. Participants and Team Members

A. CNA WORKSHOP PARTICIPANTS' ADDRESS LIST

AGARDY, Tundi
World Wildlife Fund
1250 24th Street, NW
Washington, DC 20037
USA
Fax 202 2939211

ALCORN, Janis
Biodiversity Support Program
c/o World Wildlife Fund
1250 24th Street, NW
Washington, DC 20037
USA
Fax 202 8628324

ALLISON, Allen
Bishop Museum
1525 Bernice Street
PO Box 19000A
Honolulu, HI 96817-0916
USA
Fax 808 8418968

ANTIKO, Samuel
Dept. Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

ASIGAU, William
PO Box 344
University, NCD
PNG
Fax 271044

BEEHLER, Bruce
c/o Division of Birds
NHB MRC 116
Smithsonian Institution
Washington, DC 20560
USA
Fax 202 3571628

BIGILALE, Ilaiah
National Museum
PO Box 5560
Boroko, NCD
PNG
Fax 251779

BONACCORSO, Frank
Dept. Zoology
University of Florida
Gainesville, FL 32607
USA
Fax 904 3923704

BROWN, Michael
PVO-NGO/NRMS
World Wildlife Fund
1250 24th Street, NW
Washington, DC 20037
USA
Fax 202 2236971

BUN, Yati
Department of Forests
PO Box 5055
Boroko, NCD
PNG
Fax 254433

121

BURG, Charles
Smithsonian Institution
NHB 336
Washington, DC 20560
USA
Fax 202 3571628

BARKER, Paul
Dept. of the Prime Minister

CLARK, Lester
Tourism Resource Consultants
PO Box 2515
Wellington,
New Zealand
Fax 64-4-4730020

CORTESI, Lafcadio
Greenpeace
139 Townsend Street
San Francisco, CA 94107-1922
USA
Fax 415 5128699

DOUGLAS, John
Advisor,
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

DUB, Mr. Poipoi
PO Box 831
Madang
PNG

GENOLAGANI, John-Mark
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

HIBBERD, John
International Forest Research
and Management (IFERM)
GPO Box 2546
Canberra, ACT 2601
Australia
Fax (06) 2575336
in Solomons:
PO Box 1132
Honiara
Ph/Fax 677 22505

HOLZKNECHT, Hartmut
Dept. of Anthropology, RSPacS
Australian National University
GPO Box 4
Canberra, ACT 2601
Australia
Fax (06) 2571893 V:F7

HOWLETT, David
International Institute of
Environment and Development
3 Endsleigh Street
London WC1
UK
Fax 071-388-2826
or
PO Box 910
Boroko, NCD
PNG
Fax 257780

HUBER, Mike
M.I.R.D.
University of PNG
PO Box 320
University, NCD
PNG
Fax 267187
Ph/Fax/(Message) 258093

HUNNAM, Peter
World Wide Fund for Nature
Lvl 10, 8-12 Bridge Street
Sydney, NSW 2000
GPO Box 528
Sydney 2001
Australia
Fax (02) 2478778

HUTCHINSON, Charles
Conservation International
1015 18th Street, NW
Washington, DC 20036
USA
Fax 202 8875188

HUYLER, John
The Keystone Center
1320 Pearl Street, #300
Boulder, CO 80302
USA
Fax 303 4441286

JEBB, Matthew
Christensen Research Institute
PO Box 305
Madang
PNG
Fax 823306

JEFFERIES, Bruce
Technical Support Project for the Forestry Sector
PO Box 342
Boroko, NCD
PNG
Fax 257780

JOHNS, Robert
Royal Botanic Gardens
Kew, Richmond
Surrey TW9 3AE
UK
Fax 81 3325278

KALIM, Mr.
PO Box 831
Madang
PNG

KANAKO KIWURAM, Michael
Melanesian Solidarity
(East Timor-West Papua-Kanaky Campaign)
Journalist/Coordinator
PO Box 347
Madang
PNG

KAU, Joseph
Volunteer
Melanesian Environment Foundation
PO Box 4830
Boroko, NCD
PNG

KEKENG, Gebob
SIKB Development
PO Box 3593
Lae, Morobe Province
PNG

KIATIG, Mr.
PO Box 831
Madang
PNG

KISOKAU, Karol
General Manager
Research and Conservation Foundation of PNG
PO Box 495
Port Moresby
PNG
Fax 213657

KULA, Guy
FAS-Nature Conservation
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

LAUP, Samson
Entomologist
Agricultural Protection Div.
Dept. Agriculture & Livestock
PO Bo ^141
Boroko, NCD
PNG

LELANG, Joseph
Assistant Coordinator - NFCAP
PO Box 1059
Boroko, NCD
PNG
Fax 213826

LOTU, Mary Ann
East New Britain Sosel
Eksen Komiti
PO Box 780
Rabaul, ENBP
PNG

LYNCH, Owen
World Resources Institute
1709 New York Avenue, NW
Washington, DC 20006
USA
Fax 202 6380036

MANUKAYASI, Vincent
National Coordinator
PNG Trust
PO Box 279
University, NCD
PNG
Fax 261118

MARAT, Allan
Marat, Lawyers
PO Box 7431
Boroko, NCD
PNG
Fax 254298 V:F7

MERCER, Christopher
Department of Forestry
PNG University of Technology
PMB
Lae
PNG
Fax 424067

MILLER, Scott
Bishop Museum
1525 Bernice Street
PO Box 19000A
Honolulu, HI 96817-0916
USA
Fax 808 8418968

MILLIN, Paul
Dept. of Surveying and Land
Studies
UNITECH
PMB
Lae, Morobe Province
PNG
Fax 457483

OLIVIERI, Silvio
Conservation International
Suite 1000
1015 18th Street, NW
Washington, DC 20036
USA
Fax 202 8870193

ORSAK, Larry
Christensen Research Institute
PO Box 305
Madang
PNG
Fax 823306
or
Scientific Methods Facility
PO Box 599
Durham, CA 95938
USA
Fax 916 8945865

OSBORNE, Patrick
Fac. Science and Technology
University of Western Sydney
Richmond, NSW 2753
Australia

PEUTALO, Basil
NGO Component
Technical Support Project for
the Forestry Sector
PO Box 910
Boroko, NCD
PNG

RAGA, Mick
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271[illegible]

RAU, Monika
Biology Dept.
University of PNG
PO Box 320
University, NCD
PNG
Fax 267187

REDFERN, Vaughan
Land Utilisation
Dept. Agriculture & Livestock
PO Box 1863
Konedobou, NCD
PNG
Fax 211753

RIEGER, Jim
R&D/ENR, Room 509, SA-18
US Agency for International
Development
Washington, DC 20523-1812
Fax 703 8754639

SAHL, Birgitte
UNDP
PO Box 1041
Port Moresby
PNG
Fax 211227

SAULEI, Simon
Biology Dept.
University of PNG
PO Box 320
University NCD
PNG

SEM, Graham
Dept. of Geography
University of PNG
PO Box 320
University, NCD
PNG

SERI, Lester
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

SHUMWAY, Caroly
R&D/AA, Room 522, SA-18
US Agency for International Development
Washington, Dc 20523
USA
Fax 703 8754639

SOONDRAWU, Mary
East Sepik Council of Women
PO Box 75
Wewak, East Sepik Province
PNG
Fax 862626

SUMANOP, Francis
Arapesh Association, Inc.
PO Box 125
Wewak, East Sepik Province
PNG

TAMBI, Noah
Dept. of Forests
PO Box 5055
Boroko, NCD
PNG
Fax 254433

TANGLEY, Laura
Conservation International
Suite 1000
1015 18th Street, NW
Washington, DC 20036
USA
Fax 202 8875188

TENAKANAI, Charles
Fisheries Research and Survey Branch
Dept. of Fisheries and Marine Resources
PO Box 165
Konedobu, NCD
PNG

TAYLOR, Rod
6/4 Patricia Pde
Lennox Head
NSW 2478
Australia

TOWNLEY, Sally
Centre for Coastal Management
Univ. of New England, Northern Rivers
PO Box 125
East Lismore, NSW 2480
Australia
Fax (066) 212669

ULAI, Mr.
PO Box 831
Madang
PNG

WARAKAI, Vincent
Dept. Anthropology & Sociology
University of PNG
PO Box 320
University NCD
PNG
Fax 267187

WATOKA, Kembi
First. Asst. Sec.-Environment
Dept. of Environment and Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

WERNER, Tim
Melanesia Program Coordinator
Conservation International
1015 18th Street, NEW
Washington, DC 20036
USA
Fax 202 8875188

WILMOT, John
Dept. of Environment and
Conservation
PO Box 6601
Boroko, NCD
PNG
Fax 271044

YAMBUT, Joash
Conservation Networking
Officer
NANGO - PNG
PO Box 434
University, NCD
PNG
Fax 254309

ZAMUNU, Gewai
Village Development Trust
PO Box 2397
Lae, Morobe Province
PNG

ZIBE, Sasa
Village Development Trust
PO Box 2397
Lae, Morobe Province
PNG

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B. CNA WORKSHOP TEAMS

Social Science:	Michael Brown (BIL/CARE/WWF) Hartmut Holzknecht (ANU) Vincent Warakai (UPNG)
Legal:	Owen Lynch (WRI) Allan Marat (PNG private practice)
Biology:	Bruce Beehler (WCI, CI, SI) Bob Johns (Kew) Simon Saulei (UPNG) Allen Allison (Bishop) Scott Miller (Bishop) Tundi Agardy (WWF) Patrick Osborne (UWS) Monika Rau (UPNG) Lester Seri (DEC) William Asigau (DEC) Frank Bonaccorso (U. Florida) John-Mark Genolagani (DEC) Mike Huber (UPNG) Peter Hunnam (WWF-I) Matthew Jebb (CRI) Guy Kula (DEC) Samson Laup (DAL) Christopher Mercer (UNITECH) Larry Orsak (CRI) Mick Raga (DEC) Charles Tenakanai (DFMR) John Wilmot (DEC)
NGOs:	Vincent Manukayasi (NANGO/PNG Trust) Joash Yambut (NANGO) Michael Kanako Kiwuram (Melanesian Solidarity) Joseph Kau (Melanesian Environment Foundation) Karol Kisokau (Research and Conservation Foundation of PNG) Mary Ann Lotu (East New Britain Sosel Eksen Komiti) Mary Soondrawu (East Sepik Council of Women) Sasa Zibe Kokino (Village Development Trust) Larry Orsak (CRI)
Information Management:	Silvio Olivieri (CI) Chuck Hutchinson (CI)

Landowners[32]: Poipoi Dub (Madang)
Mr. Kalim (Madang)
Gebob Kekeng (Lae)
Mr. Kiatig (Madang)
Francis Sumanop (Wewak)
Mr. Ulai (Madang)
Gewai Zamunu (Lae)

Government: Guy Kula, DEC - Conservation
John-Mark Genolagani - DEC
Mick Raga - DEC
Lester Seri - DEC
John Wilmot - DEC
Kembi Watoka, DEC - Environment
John Douglas, DEC - Water Resources

NFCAP: Bruce Jefferies
Joseph Lelang
Basil Peutalo
Lester Clark

Others present from:

Greenpeace, IIED, WWF-International
Conservation International, Smithsonian Institution
Christensen Research Institute
National Museum, UNITECH
USAID, UNDP, UPNG
And the following government agencies:
- Dept. of Forests
- Dept. of Agriculture and Livestock
- Dept. of Fisheries and Marine Resources
- Dept. of Prime Minister
- Dept. of Finance

[32] All Papua New Guinean people present were Landowners insofar as they are members of Landowner groups, but these individuals participated in the Workshop specifically as Landowner representatives.

APPENDIX 10-2. AGENDAS

A. CNA WORKSHOP

CONSERVATION NEEDS ASSESSMENT WORKSHOP
Madang, Papua New Guinea
April 5-11, 1992

Sunday, April 5, 1992

Major goals for the day: Presentations by biodiversity topic leaders to provide common information base and basis for initial discussions. Characterize the state of knowledge in each topic area and explain criteria used to identify areas of biological importance. Following the presentations, discuss and agree upon methodologies to be used in the mapping sessions during the days that follow.

6:30 - 7:30	Breakfast available
8:00 - 8:45	Convene and Introductions Facilitator role
8:45 - 9:00	Overview of goals for biological mapping and workshop as a whole Agenda review
9:00 - 9:20	Botany #1
9:20 - 9:40	Questions, Answers, and Initial Discussion
9:40 - 10:20	Botany #2
10:20 - 10:40	Questions, Answers, and Initial Discussion
10:40 - 11:00	Break
11:00 - 11:20	Vertebrates #1: Warm-blooded
11:20 - 11:40	Questions, Answers, and Initial Discussion
11:40 - 12:10	Vertebrates #2: Cold-blooded
12:10 - 12:30	Questions, Answers, and Initial Discussion
12:30 - 1:30	Lunch
1:30 - 1:50	Entomology

1:50 - 2:10	Questions, Answers, and Initial Discussion
2:10 - 2:30	Wetlands
2:30 - 2:50	Questions, Answers, and Initial Discussion
2:50 - 3:10	Marine Ecology
3:10 - 3:30	Questions, Answers, and Initial Discussion
3:30 - 3:45	Break
3:45 - 5:45	Methodology: - the Manaus example - the original terms of reference for analysis of information under CNA - discussion of methods to be used
6:30 - 8:00	Dinner
8:30	Workshop Steering Committee meeting

Monday, April 6, 1992

Major goals for the day: Focus on individual maps in biology workgroups. Use map overlays to begin identification of biologically important areas. Provide opportunity for Landowners, NGOs and social scientists to meet separately to determine their working agenda. Produce new set of maps. Identify special gaps in knowledge. Map threats as possible.

6:30 - 7:30	Breakfast available
8:00 - 8:30	Welcome to All Formal Opening Introductions Opening Remarks: - Janis Alcorn (Biodiversity Support Program) - Guy Kula (Department of Environment and Conservation) - Vincent Manukayasi (NANGO) - John Huyler (The Keystone Center) Agenda Review
8:30 - 9:00	Summary of Sunday's work by biologists' team
9:00 - 11:30	Instructions on use of maps and GIS Mapping workshops by topic area: - Botany and Entomology - Warm-blooded Vertebrates - Cold-blooded Vertebrates - Marine - Wetlands
9:00 - 11:30	Landowners, NGOs, and Social Science Team meet to discuss and suggest their agenda. Non-biologists are free to observe the biological workgroups as they wish.
12:00 - 1:30	- Working lunch for biology workgroup leaders, facilitator, Steering Committee, and representatives of social/policy particpants.
1:30 - 1:45	Report to full group on agenda for addressing social/policy topics during the workshop.
1:45 - 3:15	Workgroup reports by the three biology workgroups.
3:15 - 3:30	Break
3:30 - 5:30	Biology focus in workgroups by geographic area.

6:00 - 7:30	Dinner
8:00	Workshop Steering Committee meeting.

Tuesday, April 7, 1992

Major goals for the day: All participants hear and discuss results of NANGO Conservation Needs Assessment. Landowner concept of conservation needs, NGOs' concept of conservation and case study on NGO/Landowner involvement. Small groups discuss these topics and report back to plenary. Continued opportunities for additional presentations by NGOs. In the afternoon, continue developing maps to identify biologically important areas after the NGO and Landowner portion of the program.

6:30 - 7:30	Breakfast available
8:00 - 10:30	Information from NGOs, Landowners, and NANGO Team: - NANGO CNO's Report - Landowners' concept of conservation needs - NGOs' concept of conservation: How government cooperates with NGOs - Case study (NGO/Landowner involvement)
10:30 - 11:00	Break
11:00 - 1:00	Small group discussions
1:00 - 2:00	Lunch
2:00 - 3:00	Reports of small group discussions to plenary
3:00 - 6:00	- Continue biological mapping - Possible ongoing small group discussion of Landowner and NGO issues
6:00 - 7:30	Dinner
7:30	Workshop Steering Committee meets
Evening	Ongoing mapping

Wednesday, April 8, 1992

Major goals for the day: Panel-led discussion of topics which will include GEF, DEC strategic planning, environmental impact assessments, the new Forest Act and information about DEC's environmental and water resources divisions. Opportunities for field trips and ongoing mapping in the afternoon.

6:30 - 7:30	Breakfast available
8:00 - 10:30	Context panel: DEC Conservation Division: - Guy Kula & the DEC team - Plenary discussion
10:30 - 11:00	Break
11:00 - 12:30	Forestry: - Noah Tambi & Rod Taylor - Plenary discussion DEC Environment Division: - Kembi Watoka - Plenary discussion DEC Water Resources Division: - John Douglas - Plenary discussion
12:30 - 1:30	Lunch
Afternoon	- Continue biological mapping - Optional field trip to Kau Wildlife Management Area
6:30 - 8:30	Dinner

Thursday, April 9, 1992

Goals for the day: Panel discussion of implementation issues and options by social science team and lawyers. Continue refinement of biological maps and social/policy/legal input.

6:30 - 7:30	Breakfast available
8:00	Group photo
8:30 - 12:30	Panel on Implementation Considerations - Michael Brown, Hartmut Holzknecht, Vincent Warakai - General discussion
10:30 - 11:00	Break
11:00 - 12:30	- Owen Lynch, Allan Marat, and Peter Hunnam - General discussion - Work group selection
12:30 - 1:30	Lunch
1:30 - 3:00	Work groups on selected topics - Government (DEC, DOF, etc.)-NGO meeting - Mapping continues - Social/policy discussions continue
6:00 - 7:30	Dinner
7:30+	Evening work as necessary

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Friday, April 10, 1992

Major goals for the day: Continue mapping and drafting recommendations in the morning. In plenary session, review workshop objectives. Presentation of mapping results and recommendations from Biology Team. Presentation of results of GOPNG-NGO meetings. Presentation of Social Scientists' recommendations. Presentation of NGO recommendations. Entertain recommendations from the floor. Discussion of workshop recommendations and products.

6:30 - 7:30	Breakfast available
8:00 - 11:30	- Continue mapping - Continue drafting recommendations to present to plenary
11:30 - 1:00	Lunch
1:00	Plenary meeting - Review of Workshop Objectives: John Huyler - GOPNG & NGOs Meeting Report: Monika Rau, Guy Kula, and Vincent Manukayasi - Introduction of Biodiversity Mapping Results: Patrick Osborne - Biodiversity Mapping Results: Allen Allison and Mike Huber
2:00	Recommendation Discussion - Biologists' Recommendations: Bruce Beehler - NGOs' and Legal Team's Recommendations: Mary Soondrawu - Social Scientists' Recommendations: Mike Brown - Discussion to reach consensus on recommendations
6:30	- Closing Remarks by the Premier, Madang Provincial Government - Reception and Dinner
Evening	Work as needed -- finalize consolidation of recommendation document from recommendations accepted in plenary.

Saturday, April 11, 1992

6:30 - 7:30	Breakfast available
8:00 - 11:30	Finalize CNA Recommendations consensus document
11:45 - 12:00	Closing remarks
12:00	Adjourn
12:00 - 1:00	Lunch
1:00 - Evening of Sunday	CNA Workshop participants leave Madang

B. APRIL 13 PRESENTATION IN PORT MORESBY

Monday, April 13, 1992

Meeting Purpose: Present the results of the Conservation Needs Assessment Workshop held in Madang from April 5 through April 11 during which national and international scientists, resource managers, lawyers, Landowners, and non-government organizations worked cooperatively with GOPNG officials to identify and develop recommendations to conserve biological diversity in PNG.

Chairman: Guy Kula, Department of Environment and Conservation

Program:[33]

8:30	Opening Remarks
	Iamo Ila, Secretary of Dec Louis Kuhn, USAID Janis Alcorn, Biodiversity Support Program Kelly Kalit, National Forest and Conservation Action Program Coordinator
9:00	Biological Assessment
	Introduction: Bruce Beehler, Wildlife Conservation International Lester Seri, DEC Monika Rau, UPNG Patrick Osborne, University of Western Sydney William Asigau, DEC Silvio Olivieri, Conservation International
10:00	Morning Tea
10:30	Social Assessment
	Introduction: Vincent Warakai, UPNG Owen Lynch, World Resources Institute Michael Brown, World Wildlife Fund
11:00	NGO Report
	National Alliance of Non Government Organizations (NANGO) Representative
11:15	Open Forum Discussion

[33] The program was actually shifted to 1:00 - 4:00 in the afternoon due to the delay in the arrival of participants from Madang after the Sunday evening and night flights were cancelled.

11:45 **Conclusion**

Guy Kula, Chairman
Bruce Jefferies, NFCAP

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C. APRIL 30, 1992 PRESENTATION at BSP IN WASHINGTON, D.C.

3:00 <u>Welcome and Opening Comments</u>

PNG Ambassador to the United States Meg Taylor

3:10 - 3:55 <u>Papua New Guinean NGOs' Perspectives on Conservation in PNG</u>

Vincent Manukayasi, Secretary of the National Alliance of NGOs in PNG (NANGO-PNG) & Coordinator of the PNG Trust

Scholla Kakas Warai, Women's Representative of NANGO-PNG & President of PNG Catholic Women's Federation

4:00 - 4:45 <u>Results of USAID-funded PNG Conservation Needs Assessment Workshop held in PNG April 5 - 11</u>

Janis Alcorn, BSP
Michael Brown, EIL/CARE/WWF
Silvio Olivieri, CI
Tundi Agardy, WWF
Owen Lynch, WRI
Vincent Manukayasi, NANGO

4:45 <u>Discussion</u>

APPENDIX 10-3. SUMMARY OF SOME OF THE REMARKS MADE AT THE LANDOWNER DEMONSTRATION AT THE CNA WORKSHOP IN MADANG, 6 APRIL 1992

NOTE: These remarks are translated from Tok Pisin. Not all remarks made, nor replies to those remarks, are given. Instead, this is a summary of some of the points made by the Landowners, as summarized by Larry Orsak of Wau Ecology Institute and CRI.

LO = Landowners
GO = Government representative (First Assistant Secretary of DEC, Guy Kula)
CRI = Christensen Research Institute (CRI Director, Matthew Jebb)

LO: People always do their talking without ever asking the Landowners.

LO: The Environment Minister doesn't ever give information to the villagers. Information from workshops like this never goes any place, except into the government offices.

LO: We are here to state what our rights are. People haven't been teaching people in the village about these things. Maybe it happens in other places, but not in Madang.

LO: We do not want to hear about global issues. Forget about global issues if you are going to forget about the landowners.

LO: You bring white thoughts here. Don't bring your conservation thoughts here because they do not apply.

LO: Landowners don't know what this workshop is about, or what kind of information is being given.

GO: After we get the information from scientists, it will be used to help Landowners.

LO: There are a number of things that have been done before, and nothing ever gets back to us, no matter what are the promises.

LO: Young people before had something. But then outsiders came and gave us nothing. When the meat cannery came in, we were given promises, but we have gotten nothing.

LO: People always destroy everything we have and give nothing.

LO: Bring the concerns we are telling you today to Parliament. Don't just leave our thoughts here.

GO: First, we have to look at all of PNG before we can go to any area in PNG and work at a lower level. Before we didn't have this information. If you want to give these posters to me, I will bring them back to Port Moresby.

LO: You will just throw these posters away, because you will say I'm a rubbish stupid man and won't think about it any more. If you want to learn something, you can come talk to us here and tell me.

GO: If some of you want to come back together later, I can tell you about these projects and what we're doing.

LO: You should have done this before. You should have gone to the Provincial government and told them about this meeting, and not just put the Landowners into the meeting later.

LO: Before you do anything here, you have to first come through the provincial NGOs. You exploit us. We do not get any benefits from any of this work.

LO: Don't mess up our land. We had good land before. Then other people came and sneaked around and took things from us.

LO: If you don't understand about the bush and the animals and plants because you sit in the office all day, then maybe you should come here and learn from us.

LO: Before there were meetings where you [government] said you would help in Landowner Awareness programs. But you have come back again, and haven't done anything for the Landowners.

LO: Landowners do not benefit from CRI or from Jais Aben. Do you respect the Landowners' rights when you have such meetings in places like this? But we cannot fight against this institution. We are not strong enough. By helping this place, you also ignore the rights of indigenous people.

LO: People have been exploited by this place for years. Lots of big men come to this white elephant but no one comes to the village guest houses where it is cheaper to stay.

LO: Whatever you decide, remember that to implement this, you have to consult the Resource Owners. We are the Resource Owners.

LO: You are not allowed to do research in Madang Province afterwards, as far as we are concerned.

LO: Lots of people from other countries have come here and started this research institute. We have been having these problems for a long time. This is not the first time. You need to talk with us. We are all in one country here and we need to work together.

This colonialism is finished. We are independent now. When are we going to be brothers and work together? You have to understand and notice that the people here are not on a strong foundation. For those of you who are here for the first time, we are telling you that we have had this problem for a long time. We will not stop your workshop, but please notice this.

CRI: I too did not know until recently what this workshop was about. I found out it was going to be held at CRI only about a month ago, because there were problems having it at the other place. There are three groups here. Scientists, government, and nongovernmental organizations. Scientists enjoy looking at the wildlife here, like a small butterfly or other animal or plant. Scientists do not put a price tag on things and are not the same kind of white people that you see in town who are taking it easy. We're trying to find out which things are endangered, and which areas in PNG have special animals and plants. Scientists are supporting what you are supporting. Who was it who supported Jant? Certainly not the scientists. Have you heard about the conservation work we have been doing? Chris Mercer found a butterfly that was lost for many years. He is helping the Landowners so they do not have to exploit their resources like they used to do. The information we are gathering here will be put into a book which you can see and study from.

LO: Will you be selling this book? Who will be selling this book? You take information from us and you sell it.

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Chapter Eleven

Mapping PNG's Biodiversity

Bruce M. Beehler[1]

The CNA Workshop mapping process relied on Conservation International's geographic information system -- called CISIG -- a computer program that allows researchers to integrate virtually any number of data layers and to show the results on maps. Designed specifically to work under the conditions prevalent in developing countries, CISIG provides a way to capture and synthesize data and to facilitate the dynamic real-time analysis of the spatial issues that are raised by the process. Participating biologists, who collectively represent the best possible understanding of the region as a whole, input their unique knowledge and experience.

CISIG experts in Washington, D.C., prepared a series of "base maps" to distribute to topic leaders (who used them to draft their teams's maps). These maps brought together -- at the same scale and on one projection -- several essential sets of data: political boundaries; coastlines; rivers, lakes, streams, and other bodies of water; roads; topography; vegetation type and cover; population centers; protected areas; and timber rights purchases (TRPs).

The seven-day workshop held in Madang produced an excellent environment for biologists to work closely together to reassess the initial results of the seven biodiversity analyses drafted by the various topic leaders (found in CNA Report, Volume 2). The nature of this reassessment was diverse but invariably productive. We were able to argue, listen, readjust our viewpoints, and rework many of the recommendations and priority sites that were submitted in draft form. Divergent viewpoints were bantered back and forth in an informal setting -- one in which the attitude of the workers was that of relaxed cooperation, not competition. This produced [illegible] believe, the necessary productive energy for this workshop team to hammer out [illegible] maps and a comprehensive list of recommendations that reflect a heightened understanding of the problems and prospects for biodiversity conservation in Papua New Guinea.

The final synthesis maps were the product of a series of draftings and assessments carried out before and during the CNA Workshop. Each topic leader drafted initial maps for criticism by the topic leader. Based on these critiques, the maps were reworked prior to the workshop. When the biologists gathered in Madang with their draft reports and maps, the

[1] Wildlife Conservation International and Conservation International, c/o Division of Birds, Smithsonian Institution, Washington, D.C., U.S.A.

first step was to "digitize" the data from all seven teams -- that is, to enter the data they had brought into CISIG so all the information would be compatible (among teams and with the base maps) and so the teams would be able to see their important areas of biodiversity together. These new drafts were presented in the plenary workshop sessions, and then were subject to scrutiny and discussion at follow-up focal-group meetings (terrestrial animal life, terrestrial botany, freshwater wetlands, marine/coastal ecosystems). These "break-out" groups met at least once or twice a day (usually afternoons and evenings) in the laboratory of the Christensen Research Institute.

Each mapping group assessed the area recommendations from each topic included (e.g., for terrestrial animals, the topics included warm-blooded and cold-blooded vertebrates, and invertebrates). The biologists worked on a large transparent Mylar map that could be overlaid on individual team maps and on a detailed topographic map of the country. Group members focused on areas of biodiversity one by one, filling out a detailed data sheet for each one and arguing back and forth over what the area's size, shape, and borders should be. Each group then initiated a new draft map that was annotated and reworked and then digitized by the CI GIS team, who produced a new draft for the workshop team's review.

During this stage, CISIG's analytical capacity (in addition to its capacity to make maps) was essential. The biologists could ask the system questions about their results -- how much of PNG's various vegetation types had been included in biologically significant areas, for example -- in order to correct errors and make sure they were including a representative sample of the country's many ecosystem types within a significant area.

After several drafts and reviews, the four groups combined into two groups, terrestrial life and wetlands/marine, in order to produce a pair of pre-final draft maps. These, too, were verbally critiqued and redrafted by participants in the laboratory sessions, and, at this time, the map of major unknowns was drafted by all present. Certainly, the most complex and challenging task was to combine the terrestrial botany map with that for terrestrial animal life. This assessment was led by a team including Johns, Jebb, Miller, Allison, Laup, and Beehler.

The final product of this mapping exercise was a series of the component maps that can be combined to produce a synthesis biodiversity map for all of the biological resources (animal/plant, terrestrial/wetland/marine) for Papua New Guinea. For purposes of clarity of presentation, the three component maps are presented and discussed below.

THE MAPS

What follows are priority maps (major unknown areas, marine systems and critical watersheds, and the terrestrial synthesis) with appended accounts for each of the delineated areas of importance.

The following three maps reflect the effort at the workshop to synthesize the available information and complete a series of biodiversity assessments. These, then, can be presented in map form for the future use of biologists and resource managers concerned with the conservation of Papua New Guinea's remarkable natural resources. For additional data on many of the sites, the reader can refer to individual topic chapters in Volume 2 of the CNA Report but a summary listing of additional supporting data appears with each of the three maps. These supporting data include key information on a focal area's biological richness, its biogeographic and ecological importance, potential threats, and supporting documentation in the literature.

Synthesis Map A. Major Terrestrial Unknowns (Fig. 11-1)

Major areas unknown to science were delineated mainly from a combination of the mapping by the vertebrate and botany teams. These are the two groups for which there is a well-refined knowledge of the major geographic gaps in knowledge of PNG's biodiversity. The sixteen major terrestrial unknowns are shown in Figure 11-1, and are discussed below. The numbering system follows that in the figure.

1. Bewani Mountains. The low coastal range that reaches westward to the Irian border, and the humid lowlands south of this range, are little studied and apparently biologically rich. Recent discoveries of two new mammal species, and a lowland bird of paradise formerly known only from Irian Jaya, support the idea that further survey and research are needed here.

2. Central Range. The high range that rises south of the Sepik basin is little studied and largely forested. Ecologically and physiographically diverse and presumably very rich biologically.

3. Southern Scarp Wet Zone. This is Papua New Guinea's great wilderness area -- lowlands, low hills, and old Pleistocene volcanoes, with a high annual rainfall. Little populated and little known. Notable are the Kikori karst hills and prominent volcanic outliers, including Mount Bosavi and Mount Murray. Eastward one finds rugged wet forests that form the southern foothills of the Kubor Range and Eastern Highlands, Virtually uninhabited and very wet.

4. Finisterre Range. The highlands and hills of the western segment of the Huon Peninsula are virtually unstudied, but certainly comprise a significant biological resource. Alpine peaks exceeding 4000 meters descend to the hilly coastal zone facing the Bismarck Sea.

5. Lakekamu Basin/Chapman Range. Like the Finisterre Range, this area is relatively close to population centers, and yet is both little developed and virtually unknown biologically. From pristine humid lowland forest to subalpine highland zones (>3,000 m) in the Chapman Range. Very rich in wildlife.

6. Bowutu Ultrabasics. Rugged hills and mountains that descend to the rocky coast of Morobe Province. Botanically unusual and virtually unsurveyed.

7. Ioma/Mambare Lowlands. An isolated lowland area that merits study. It supports a large lowland basin that is largely forested -- the largest lowland forest tract on the Papuan peninsula.

8. Musa Basin. Important wetlands and lowland swamp forests that are unknown.

9. Kemp-Welch River Lowlands. A remnant wetland area representative of the dry lowlands of Central Province. Not yet surveyed.

10. Cloudy Mountains. An isolated range of mountains that is, as yet, unsurveyed. Southernmost of mainland PNG.

11. Fergusson Highlands. Zoologically unsurveyed highlands on one of the most complex high islands in Melanesia. Mt. Kilkerran comprises a large forested massif never surveyed zoologically. One of the top priority zoological unknowns.

12. West New Britain. Little known mountains and lowlands.

13. Central and Eastern New Britain. Unsurveyed high ranges and southern scarp lowlands. The Nakanai Mountains comprise a large uplifted plateau (mostly > 1,000 m) in eastern New Britain whose montane fauna has never been surveyed (Coultas failed to collect any of the significant montane birds). Constitutes the largest continuous expanse of montane forest on New Britain.

14. Southern New Ireland. Biologically unknown highlands that constitute New Ireland's most complex environments. The Verron Range is unsurveyed and unknown, with summits higher than 2000 m. The Hans Meyer Range is the highest of any island in the Bismarcks, and still has not been surveyed adequately for vertebrates.

15. Bougainville Bamboo Forests. The only known bamboo forests in Melanesia. Unstudied biologically.

16. Mt. Takuan/Lake Lorolu. Little-surveyed wet highlands forests with a Solomon Islands biota.

Synthesis Map B. Marine Systems and Critical Watersheds (Fig. 11-2)

One of the take-home points of the workshop discussions was that the health of coastal marine ecosystems depended, in part, on the integrity of the watersheds that empty into them. We thus present a map that combines watersheds and coastal/marine ecosystems. We list marine priorities, followed by critical watersheds.

Marine Priorities:

1. Maza/Fly Delta. Mangrove and associated nursery habitats, with seagrass beds, green sea turtle foraging habitats, dugong habitat. Possibly threatened by overfishing and river-borne pollutants.

2. Gulf. Shallow intertidal and soft bottom habitats; mangrove communities that comprise important nursery areas for prawns, barramundi, and other commercially important species. Possible threats from overfishing, oil exploration, and pipeline.

3. Galley Reach. Mangrove forests, wetlands, and reef. Highly productive. Threats from development and exploitation due to proximity to Port Moresby.

4. Papuan Barrier and Lagoon. Barrier reef, coastal lagoon, and mangroves. Hawksbill Turtles, reef fishes, corals, marine invertebrates. High diversity. Threats from dynamite fishing, overfishing, eutrophication from sewage effluents related to Port Moresby development.

5. Dumoulin. Reef in proximity to southern drop-off (potential upwelling). Largely unknown. Giant clams.

6. Rossel Island. Reef systems, lagoons, isolated island areas, upwelling area. Largely unknown biologically. Possible threats from foreign poaching.

7. Pocklington Reef. Extensive reef system, thought to be relatively pristine; isolated by deep water from all other reef systems in Milne Bay. May show affinities to New Georgia reef system.

8. Morobe Coast. Mangroves, sea walls, Leatherback Turtle nesting beaches, fringing reefs. Potential for community initiated conservation program. High beta diversity. Potential threats from nearby Lae town, especially logging of coastal hill forests.

9. Tufi Coastal Fjords. Coral fjords, fringing reefs, mangrove, sea walls, thermal vents. An environment unique in Papua New Guinea. High potential for nature tourism.

10. Trobriand Reef and Drop. Extensive coral reefs. Hawksbill Turtle, beche-de-mer, giant clams, dugongs, Green Sea Turtle, coral reef fishes, and invertebrates. Largely unsurveyed but thought to be highly productive reef systems.

11. Fullerborne. Raised limestone islands, mangrove and associated nursery areas, and seagrass beds. Habitat and structural diversity high. Threats from large-scale timber operations.

12. Talasea. Reef and soft bottom marine habitats. Leatherback Turtle nesting beaches.

13. Rabaul/Duke of York. Mangrove, seagrass, reef, offshore deepwater areas with vents. Threats because of proximity to nearby Rabaul town and timber operations in watersheds above coast.

14. Tigak Islands. Mangroves, seagrasses, reef, deepwater mangrove lagoon. Highly productive fishery. Beta diversity very high. Threat from dynamite fishing.

15. Mussau Island. Reef systems and seagrasses. Sea turtles and dugongs. Some parts of this marine system are relatively pristine due to traditional practices of islanders. Threat from dynamite fishing.

16. Tanga/Tabar/Feni Islands. Subsea volcanic formations, mineral rich areas, isolated island systems; may be very important for endangered vertebrates (sea turtles). Diverse habitats and unusual geomorphology. Possible threat from nearshore and offshore overfishing.

17. Southern New Ireland. Fringing reefs.

18. Buka. Reef-and-lagoon complex; soft bottom communities. Coral reef fishes, but otherwise largely unknown. Buka Channel comprises a unique habitat in PNG. Threats from overfishing and poor land use practices.

19. South Coast Bougainville. Reefs and associated habitats; swamp forest differs from those on mainland. Largely unknown fauna. Selected because of presence of reef systems in proximity to deep open ocean waters.

20. Borone Bay. Largely unknown. Unusual hydrography coupled with steep sloped shore fall-off. Threats from logging and mining in upland areas.

21. Hermit Islands. Extensive, discrete, patch reefs. Sea turtles. Highly productive, fisheries rich. Reef areas far from population centers. Threats from overfishing and poaching. Uncontrolled tourism in western islands may be a potential threat.

22. Manus Complex. Reefs and lagoon complexes, seagrass beds, seabird rookery islands. Presence of green tree snail, reef fishes, pelagics, sea turtles. High beta diversity. Reefs diverse yet highly threatened. Threats from dynamite fishing and phosphate mining on seabird islands.

23. Cape Cretin. Ancient reef faces.

24. Vitiaz Straits. Reefs. Steep land in proximity to reef areas. Threat from land use practices.

25. Volcanic Chain: Manam to Long. Volcanic islands, reef walls, sea mounts, sea turtle nesting beaches, upwelling areas. Pelagic fishes congregating at sea walls and sea mounts. Threats from overfishing and overharvest of sea turtle eggs.

26. Madang Lagoon. Coral reefs, lagoon islands, and mangrove patches. Coral and fish species. Extremely well studied; species rich; high habitat diversity. Threat from commercial development in association with Madang town; dynamiting, logging.

27. Laing Island. Reef system and marine research station. Threats from dynamiting and copra plantation waste.

28. Sepik Delta. Mangrove, brackish lake systems; crocodiles; highly productive; unique hydrology. Threats from watershed mismanagement and introduction of exotic fishes.

29. Vokeo and Islands. Small island systems in association with deep water.

30. Northwest Coast. Sandy beaches; fauna largely unsurveyed. Interesting current regimes and bottom topography; productive waters. Threats from overfishing and coastal logging.

Critical Watersheds:

W1. Sepik/Fly Drainages. These comprise the two largest watersheds in Papua New Guinea. The Fly is of critical importance to the health of the Gulf of Papua. The Sepik supports a large human population dependent on the river for much of its livelihood.

W2. Morobe/Waria Watershed. Important upland drainages that affect the coastal islands and reef of Morobe.

W3. Vanapa/Brown. A compact but important peninsular river system that drains into a significant mangrove system.

W4. Musa/Topographers. A small but important watershed that affects the marine systems around Tufi.

W5. West New Britain. Important to the priority marine systems of West New Britain.

Synthesis Map C. Terrestrial Biodiversity (Fig. 11-3)

Details on all of these priority areas appear in the various topic chapters. Summaries for each appear below. The map shows four categories: (1) unassigned, (2) biologically important, (3) very important biologically, and (4) important wetlands not included in (2) or (3).

1. The North Coastal Hills are lower montane and lowland alluvial forests that are relatively poorly surveyed but known to be rich in Irianese specialties. The area includes the endemic fern genus *Rheopteris* and also interesting coastal limestone communities. The highlands of the North Coastal Ranges support two endemic species of large mammals (the

Giant Glider and Scott's Tree Kangaroo) and a number of isolated and taxonomically distinct bird populations.

2. The Star Highlands include pristine alpine and montane environments descending to mid-montane valleys, foothills, and fringing lowlands. They support a diverse montane and high altitude vegetation with many plant species in common with the mountains of Irian Jaya. The subalpine forests are home to a significant population of the globally threatened Macgregor's Bird of Paradise. The environmental transect from the summit heights northward to the Ai River lowlands has been documented as having the richest known mammal fauna in New Guinea.

3. Central Range/Sepik Foothills comprise a large wilderness area with low human population and remarkable habitat diversity, from lowland to subalpine forest. The area includes extensive stands of *Agathis labillardieri*, which support a highly diverse epiphytic flora. The health of the Sepik hill forests are important to the river and its human cultures.

4. Upper Fly Lowlands. This area of lowland and hill forest is delimited by the Palmer River on the east and Irian border on the west, and the southern scarp of the central cordillera on the north. Except for the extensive settlements related to the Ok Tedi mine (in the west) this area comprises a large expanse of old growth wet rain forest that supports a small human population and is characteristic of the extraordinarily rich biota of the upper Fly platform.

5. Tonda/Bulla Plain. Savanna and riverine gallery forest unique in PNG. The large areas of savanna and seasonally flooded grasslands and marshes constitute a globally significant wintering ground for migratory waders and waterfowl both from Australia and the Palearctic.

6. The Northern Trans-Fly is unsurveyed seasonal forest and woodland that is probably a habitat formation unique in PNG. An undercollected flora closely related to that occurring in the Cape York Peninsula.

7. Mount Bosavi/Aramia Watershed. An outlying Pleistocene volcano and vast alluvial plain. Virtually uninhabited. Proposed for national park status more than a decade ago, the forests of the great extinct Mount Bosavi volcano have long been recognized to be of importance to conservation in PNG. The tract comprises the volcanic cone plus lower slopes to the west and southwest. These forests are faunistically rich and virtually undisturbed.

8. Doma Peaks/Leiwaro Highlands. Rich highlands environments with high scenic and biotic value. Doma Peaks (and Tari Gap) have been considered for national park status. These comprise a large mid-montane and upper montane tract of uninhabited forest that is exceedingly rich in birds of paradise. Road access to 3000 m on Tari Pass. Includes volcanic peaks.

9. Kikori Karst/Lake Kutubu. Unknown and unsurveyed, with a remarkable karst topography and PNG's largest highland lake. Lake Kutubu supports a diverse aquatic plant flora, and eleven of the fourteen known fish species in the lake are endemic to it. The area also includes an enormous tract of tower limestone, which is botanically unknown. Limestone floras in southeast Asia are often very rich, and, if the Great Papuan Plateau reflects this diversity, it is most important that detailed studies be made of its flora. The limestone flora is poorly known from New Guinea, but it will likely include many undescribed species and possibly new generic records.

10. Giluwe. The massive Giluwe shield volcano is capped by the largest contiguous expanse of alpine vegetation in PNG. This is a globally-significant montane and alpine wilderness threatened by logging of the beech-podocarp forests of its middle and upper slopes. Very rich biologically. Subalpine bogs extensive.

11. Adelbert Mountains. Threatened lower montane forests that are home to the endemic Fire-maned Bowerbird, the rarest bird species in PNG and the bird species with the most circumscribed geographic range known for mainland PNG. The forests are little known, but probably diverse.

12. Bismarck Highlands/Ramu Basin. From PNG's highest summit to one of its richest lowland alluvial forests. The Ramu supports extensive areas of lowland rain forest (including swamp forest), some of which is developed on ultrabasic parent rock [with the only known locality of *Lauterbachia* (Monimiaceae)].

13. Kubor Highlands. High peaks and uninhabited montane forests, much on limestone capped with volcanic ash. A fragile ecosystem that probably contains local endemic plant species.

14. Crater Mountain comprises wet lower montane forest and Pleistocene volcanoes. The Crater Mountain ecosystem is a proposed Wildlife Management Area, chosen because of it large expanse of original forest and large populations of a diverse array of birds of paradise, including the rare Black Sicklebill (*Epimachus fastuosus*) and Blue Bird of Paradise (*Paradisaea rudolphi*).

15. Purari Basin. Wet zone lowlands and hills. Virtually uninhabited and little studied. This includes a very diverse area of mangrove and swamp vegetation with lowland rain forest on small limestone hills out of the surrounding swamps. These evidently support many local plant endemics but are virtually uncollected. The area includes numerous species of *Pandanus* and also a rich palm flora, particularly of *Calamus*.

16. Finisterre Range. PNG's youngest mountain range, with alpine highlands that remain little surveyed. This large montane forest tract, with a broad elevational range, from coastal hill forest to the treeline, supports species endemics of three birds of paradise, two honeyeaters, and a tree kangaroo.

17. Saruwaged and Cromwell Ranges. Alpine highlands and hill tracts threatened by development. This and the Finisterre area support numbers of locally endemic bird and mammal species, and the only extensive *Dacrydium* forests in the Southern Hemisphere that remains unlogged.

18. Watut Hills and Watershed. Little-studied hill country east of the central highlands area. The endemic plant genus *Plora* is recorded only from Mt. Plora and Mt. Amungwiwa. The lower reaches of the Watut River drainage support populations of the endemic root parasite *Langsdorfia papuana*, a genus otherwise known only from Madagascar, and Central and South America.

19. Lakekamu Basin/Chapman Range. Includes an entirely uninhabited tract of forest that ranges from pristine lowland alluvial forest to upper montane forest near treeline, all within a transect of no more than 20 km. The lowland forest supports large populations of the Southern Crowned Pigeon, Southern Cassowary, and Pesquet's Parrot.

20. Central Province Dry Zone. Savanna and monsoon forest complex with wetlands, threatened by development. Also includes the second largest mangrove area in Central Province.

21. Bowutu Mountains/Kuper Range. The Bowutu Mountains comprise an area of ultrabasic montane flora, plus coastal, mangrove, and seagrass communities. The Kuper Range is a high coastal mountain complex that is virtually uninhabited and the site of a number of detailed ecological studies on birds and plants.

22. Owen Stanley Highlands. Extensive alpine areas and vast tracts of pristine montane forests, ranging downward in the north to the forested Ioma lowlands. The Mount Albert Edward dome includes the largest alpine uplands in eastern PNG, and thus is a critical montane resource. The lowland forests constitute a critically threatened resource in peninsular Papua, and those suggested for protection here may support populations of the globally threatened (and world's largest) butterfly, *Ornithoptera alexandrae*.

23. Musa River. Little known lowland forests and wetlands.

24. Safia Dry Zone. A low rainfall interior zone with unusual animal and plant communities.

25. Topographers Range. An isolated volcanic cone in association with the coastal fjordlands of Tufi.

26. Mt. Suckling. A large montane wilderness isolated from the main Owen Stanley highlands. Virtually uninhabited and little disturbed at this point. The Suckling massif is the only significant alpine uplands in the eastern peninsula, and, in conjunction with the adjacent Bonua basin, stands as a remarkably pristine aggregate of montane and lowland forest in easternmost mainland PNG.

27. Cloudy Mountains. The most southerly mountain range in PNG. No collections are known from the area. Urgently needs study.

28. Goodenough Highlands. The massive central peaks of Goodenough Island are higher than any other mountains on New Guinea's fringing islands. The mountain forests that cloak these summits are home to an endemic species of forest wallaby and a bat endemic to these eastern islands. Many botanical novelties.

29. Fergusson/Normanby. Unusual montane habitats and (on Normanby) ultrabasic dwarf forest. Fergusson Island is one of PNG's great biological unknowns, with three distinct mountain ranges, geothermal areas, and other natural wonders. The triok possum *Dactylopsila tatei* is a species endemic to Fergusson. Goldie's Bird of Paradise is confined to the forests of these two islands.

30. Woodlark Island. Floristically unusual; the forests of the interior of Woodlark are home to the endemic Woodlark Cuscus.

31. Louisiades. The flora of this archipelago has been recognized as one of extreme botanical interest with high rates of local endemism, particularly at the species level. It includes important stands of *Diospyros* (including an undescribed ebony) and several locally endemic species of *Hopea*. The forests of Tagula Island are home to an endemic species of honeyeater and butcherbird.

32. Umboi Island. Umboi is the largest and richest of PNG's north coastal islands. It is home to populations of large numbers of species endemic to PNG, as well as a remarkable array of fruit bats (eight species). Lake Buan, in Umboi's highlands, supports one of the richest waterbird populations in the Bismarck Archipelago.

33. West New Britain. Mountain and lowland forests distinct from mainland. Threatened by large scale timber operations. The Whiteman Range and its foothills support an important tract of limestone flora, surrounded by forests developed on sedimentary materials. Little is known of the area, but large tracts of *Nothofagus* forest occur on the higher plateaus.

34. Willaumez Peninsula. A remarkable physiographic feature with Lake Dakataua, it includes a very diverse area of lowland rain forest on rich volcanic soils. Threatened by logging and proposed development for oil palm plantations.

35. Eastern New Britain primarily includes the uplifted and limestone-capped Nakanai Plateau. Little surveyed but apparently biotically rich. Lowland rain forest and montane forest, including areas of forest dominated by *Lithocarpus* and *Nothofagus* developed on the limestone substrate. The largest high altitude area in the Bismarck Archipelago.

36. The Baining Mountains, the high ranges of easternmost New Britain, are threatened by logging activities. Not adequately surveyed. These mountains, isolated by

rivers and lowlands from the Nakanai Mountains to the southwest, are certainly as fascinating as the latter. They have not been adequately surveyed, and are 500 meters higher. These mountains are surrounded by lowlands with a growing populace, and probably will be degraded unless action is taken soon.

37. Southern New Ireland. The Verron and Hans Meyer ranges are little known high ranges that merit study and conservation. An area with important montane and lowland vegetation. Brief initial surveys have shown this montane area to be very rich, with a number of bird species endemic to New Ireland.

38. Southern Bougainville Island. Highland wet forests threatened by logging and development. This area includes the central and southern segments of the Crown Prince Range, from Panguna south to Lake Lorolu, and includes mounts Takuan and Taraka. Where appropriate, this area extends downward toward the coast where good original forest prevails. Bougainville is home to many species whose affinities lie with the other Solomon Islands to the south and southeast. Among the many interesting vertebrates is the little known Bougainville Honeyeater (*Stresemannia bougainvillei*), representing a genus endemic to this island.

39. Eastern Bougainville supports the largest stands of bamboos in Papuasia. A variety of vegetation types occur, including remnant stands of *Terminalia brassii* in swamp forests. Threatened by logging and possibly sulfur mining.

40. The Lelet Plateau comprises important hill and lowland rain forests, with some lower montane elements as well. These probably contain many plant endemics with interesting biogeographical relationships with Manus, the Philippines, and the Solomon Islands. Threatened by selective logging in the lowlands.

41. Mussau Island. The interior of Mussau Island, the largest in the St. Matthias group, comprises a large block of rain forest. It supports seven species of birds endemic to PNG, two of which are endemic to Mussau, the Mussau Rufous Fantail (*Rhipidura matthiae*) and the Mussau Pied Monarch (*Monarcha menckei*).

42. Manus Island is the largest of the Admiralty group, isolated both from the great Bismarck islands to the southeast, and from mainland New Guinea far to the south. Not surprisingly, Manus's isolated fauna is rich in PNG endemics (eleven birds, two mammals). Of these, six are endemic to the Admiralties. Botanically, the area includes stands of an endemic *Calophyllum* and *Sararanga*, which are threatened by logging activity.

Wetland Sites Not Subsumed in the Main Terrestrial Selection:

W6. Sissano Lagoon and Wetlands comprise the largest coastal lagoon on the north coast of mainland PNG, associated with a large wetland.

W7. The Middle Sepik is a huge complex of river meanders, oxbows, tributary lakes, marshes, and woodland swamps, both of ecological and economic importance.

W8. Sepik Delta/Middle Ramu. A coastal wetland/deltaic complex (Sepik) in association with a low alluvial meander belt of the Ramu River, the latter rich in swamp forests.

W9. Middle Fly. The Fly River, although only 1200 km long, is, on volume of water discharged, so large that it ranks with the world's great rivers. The middle Fly floodplain, 15-20 km wide, is a mosaic of lakes, alluvial forest, swamp grassland, and swamp savanna. This includes PNG's largest lake (Lake Murray).

W10. Lower Fly. A mosaic of swamps, open water, savanna, and gallery forest. The area has abundant wildlife and is an important tourist destination. It constitutes a very important wetland both for migrating birds and resident waterfowl. In Australian drought years it becomes an important refuge for Australian wetland birds.

W11. Sirunki Wetlands. The Sirunki Basin straddles the main montane watershed divide of PNG, with one segment of the wetlands draining northward into the Sepik, the other segment draining southward into the Fly system. An important highland headwaters.

W12. Lake Tebera is one of PNG's few lower montane lakes. Supports at least one endemic fish, plus other rare fish species.

W13. East Gulf Coastal Wetlands. The greater Purari delta comprises a large complex of mangroves, deltaic swamps, and tidal environments.

W14. Mambare Wetlands. Woodland swamps and mangroves.

W15. Central Province Wetlands. A series of wetlands lie northwest of Port Moresby; because of proximity to the capital these wetlands are under varying levels of exploitation and disturbance. They support large and diverse populations of waterfowl and other wetland birds. The area is particularly important as a dry season refuge for migrant waterfowl from Australia, and as a staging area for Palearctic shorebirds on their way to and from wintering areas in Australia.

W16. Aria Wetlands. Northern coast of western New Britain.

W17. Toriu Wetlands, on the eastern coast of the Gazelle Peninsula, comprise a large area of estuarine marshes and flood plains along the lower courses of the Toriu, Nesai, and Pali rivers. Mangrove forests occur in the north and there are extensive areas of herbaceous swamps.

W18. Bougainville South Coastal Wetlands. Important insular wetlands on the western coast of Bougainville island, dominated by *Campnosperma brevipetiolata*, *Terminalia brassii*, and *Metroxylon solomonensis*.

W19. Lakes Onim and Bune. Small lakes surrounded by herbaceous wetland. (Not shown on Figure 11-3.)

W20. Ramu River at Brahman Mission. Lowland swamp forest dominated by *Campnosperma brevipetiolata*. (Not shown on Figure 11-3.)

W21. Biges River. A short coastal stream with a tidal estuary. The stream supports a diverse fish fauna (28 species recorded). (Not shown on figure 11-3.)

CONCLUSIONS

A number of points were made clear from the assessments and the workshop interactions. First and foremost was that there are large gaps in our knowledge of Papua New Guinea's biodiversity. Whereas birds, rhododendrons, mammals, and birdwing butterflies are fairly well documented, most invertebrates and most plant groups are little known, with many species still undescribed. Large segments of Papua New Guinea remain unstudied and thus are biological unknowns (highlighted in the map of unknowns featured in Figure 11-1). The marine resources, perhaps, stand as the least surveyed of all.

On a more positive note, the agreement between biologists on terrestrial sites of significant biological importance was surprisingly high. Although there was disagreement about the detail of area boundaries, there were very few disagreements about the general location of Papua New Guinea's most important storehouses of biodiversity. We believe this signals that we have sufficient information to make informed assessments in spite of our recognition that there is still a great deal yet to survey and study.

Figure 11-1. Final Map of Major Unknown Terrestrial Areas of Papua New Guinea. See text for key to numbered areas.

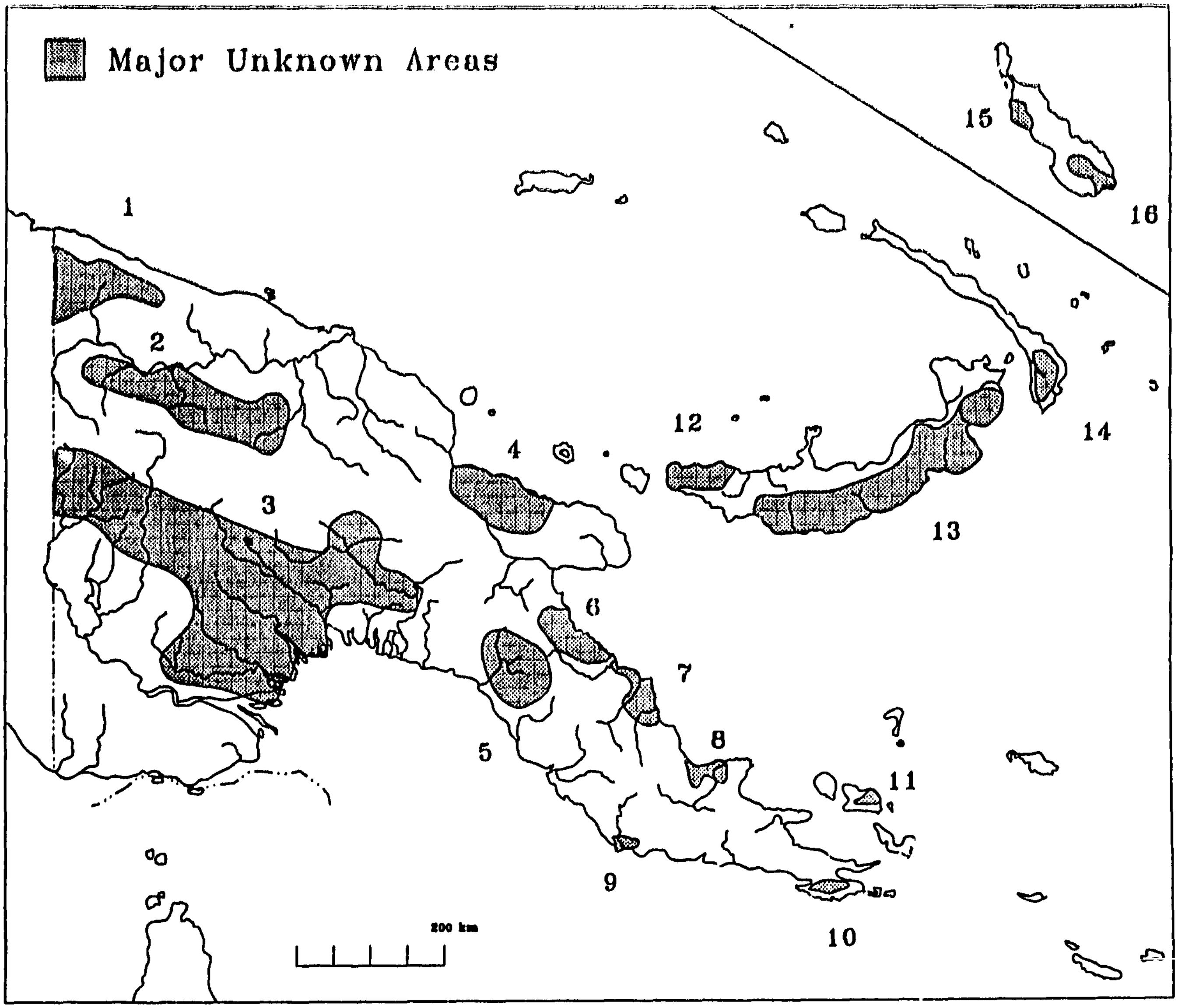


Figure 11-2. Map of Critical Watersheds and Marine Ecosystems. See text for key to numbered areas.

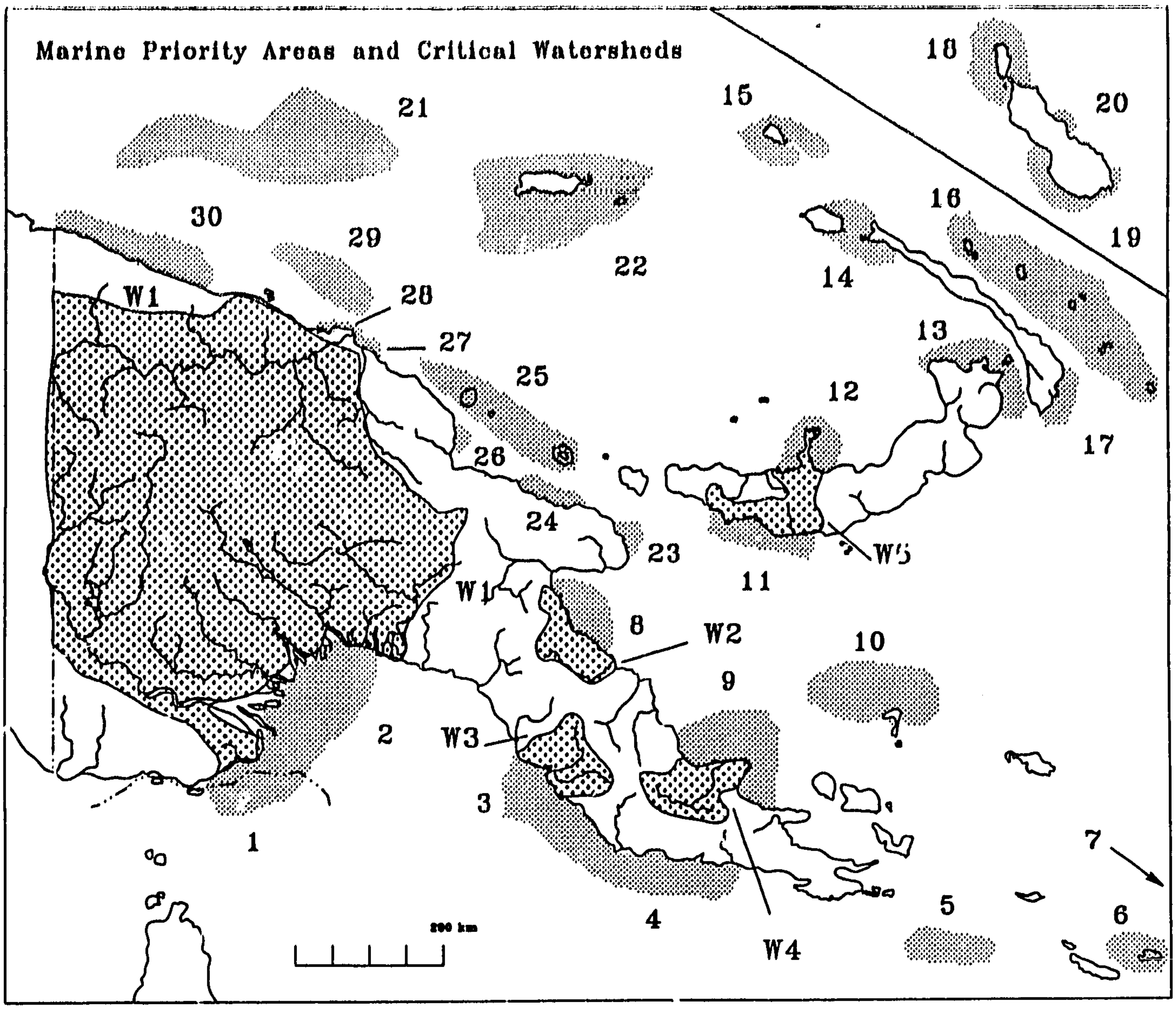
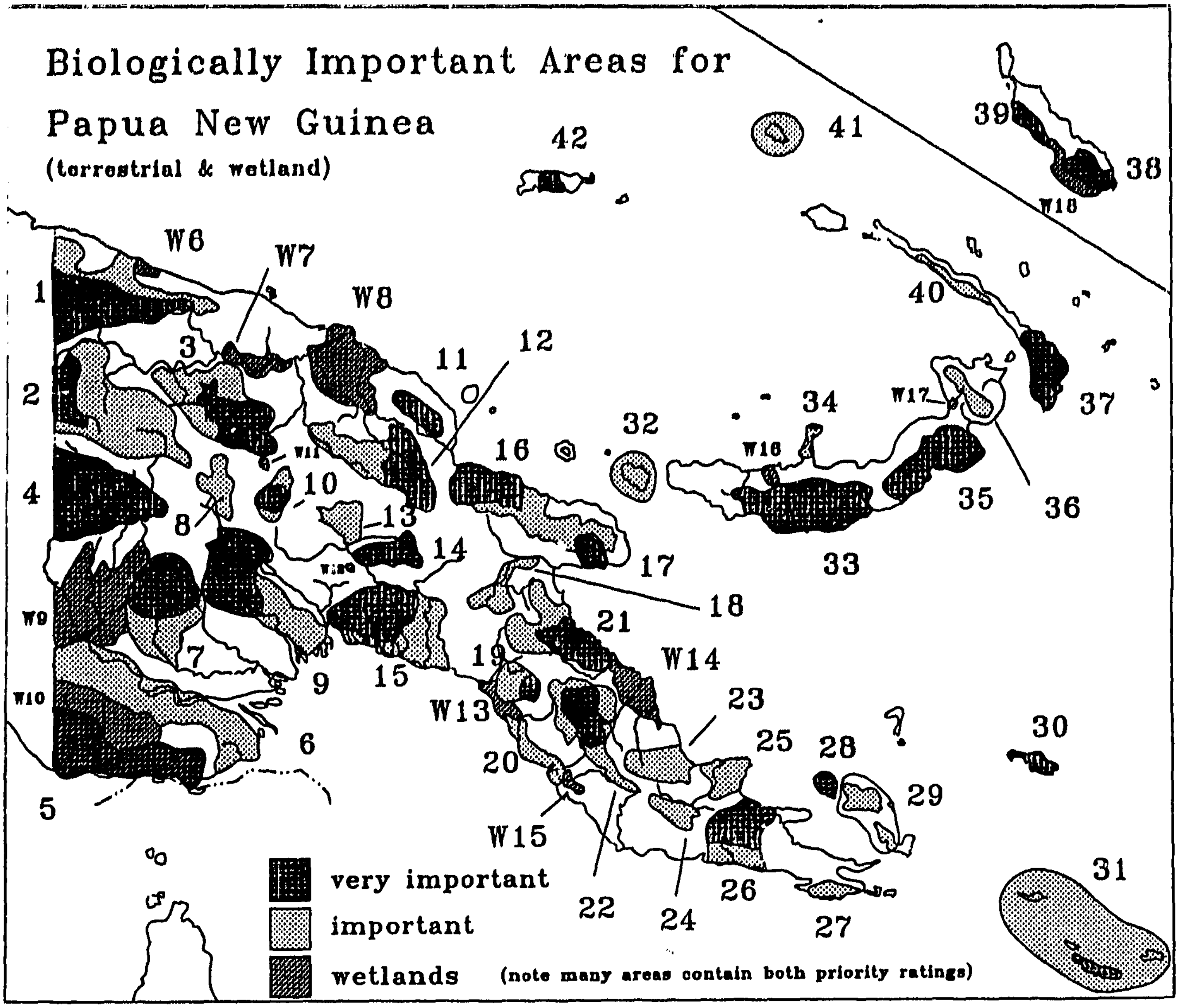


Figure 11-3. Synthesis Map of Important Areas for Terrestrial Animal Life, Vegetation, and Wetlands. See text for key to numbered areas.



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Chapter Twelve

CNA Consensus Recommendations[1]

PREAMBLE

PNG is recognized internationally as a major area of high biodiversity, equal in importance to the Amazon and Congo Basins. The coastal and marine areas surrounding PNG are among the most biodiverse aquatic ecosystems in the world. Our planet and our future are threatened by several environmental crises, including the increasingly rapid destruction of "biodiversity." Biodiversity refers to the diversity of plant and animal species which comprise the living segment of Earth's natural resources. Biodiversity is important to all human beings. Papua New Guineans benefit from biodiversity in many ways, including medicine, food, dress, ornamentation, and cultural tradition and values.

Ninety-seven percent of Papua New Guinea is owned according to customary tenure. Consequently, Landowners already have important customary, economic, and legal incentives to conserve and sustainably use natural resources, including biodiversity, for their benefit and for the benefit of future generations. Traditional conservation values are reflected in the Constitution of Papua New Guinea, which promotes equality and participation, the wise use of natural resources, and Papua New Guinean forms of development. Thus, the Constitution provides a framework for addressing issues concerning biodiversity.

This was the context of the CNA Workshop, held in Madang during the first week of April, 1992. The workshop brought together more than 70 national and international experts and concerned individuals to consider conservation of biodiversity in PNG. Our purpose was to develop an overview of what is currently known about the biodiversity of Papua New Guinea's species and ecosystems and to conduct a conservation needs assessment to help guide the nation towards meeting its goal concerning the wise use of natural resources. Participants included representatives of Landowners, non-government organizations (NGOs), scientists, lawyers, academicians, resource managers, and officials from Department of Environment and Conservation (DEC), Department of Forests (DOF), Department of Agriculture and Livestock (DAL), Department of Fisheries and Marine Resources, and other government agencies.

We recognized that the wise use of natural resources in Papua New Guinea can best be achieved by involving Landowners in decisions concerning the biological resources of the

[1] This consensus statement was drafted by representatives from individual teams after workshop participants agreed to endorse the detailed recommendations, found in Chapter 10, presented by individual teams to the final CNA Workshop plenary session.

nation and its people. This includes the need to provide Landowners with sufficient technical information to empower them to make environmentally informed decisions.

We have prepared maps which identify areas in Papua New Guinea particularly rich in biodiversity. The maps represent the first step in an ongoing process characterizing biodiversity in PNG. These maps should be used by decision-makers only in conjunction with supporting reports and documentation. Together, these documents provide a geographic synthesis of biological information that should be disseminated to Landowners, government officials, representatives of non-government organizations, and other concerned citizens. They should be used as one resource for making informed and environmentally sound decisions concerning the nation's biological resources. However, given the extraordinary biodiversity of the nation as a whole, conservation should be encouraged at sites throughout PNG, whether or not they are in areas of high biodiversity as identified on the maps.

At the workshop, we synthesized data from months of preparatory work. The result was an initial analysis of the biological, social, institutional, and management issues that must be taken into consideration in order to use biological resources wisely. The following recommendations are the outcome of that analysis.

RECOMMENDATIONS

National Environment and Conservation Plan

The proposed National Envi nment and Conservation Plan (NECP) should be developed by the relevant government departments and NGOs. The draft DEC Strategic Plan is the first step toward meeting this objective. The NECP should include the following points:

- Develop formal mechanisms to link NGOs and government agencies whose decisions and activities affect the natural environment so that they may work together in upholding the fourth goal of the Constitution of PNG;
- Increase Landowner awareness of both the consequences of proposed development activities in their areas and ecologically sustainable and socially benign alternatives;
- Address all threats to biodiversity and the natural environment, including loss of habitat, pollution, waste management and the impacts of resource extraction industries;
- Ensure that the uses of forest, fisheries, and agricultural resources are ecologically sound;
- Ensure that environmental plans are prepared and implemented independently, but paid for by the proponents of all major development activities;
- Strengthen the analysis, monitoring, and enforcement capacity of the government to ensure that development actions are environmentally and socially sound;
- Develop a mechanism to ensure that both the positive and negative results of development projects in progress are communicated to Landowners in other areas contemplating a proposed development plan;

- Control development activities which pollute air, soil, fresh water and marine environments;
- Improve quarantine measures to minimize risk to natural ecosystems and prevent the accidental introduction of foreign plants and animals;
- Avoid the deliberate introduction of exotic plant or animal species;
- Strictly control all traffic in wildlife.

Information management and distribution - Natural Resources Options Centre

An autonomous Natural Resources Options Centre (NROC) should be established to collect, create and disseminate information relevant to conservation and development. The NROC should act in the public interest through: a) the development of broad-based awareness programs on environment and development, and b) the provision of balanced and detailed information, especially to Landowner groups, on the available natural resource development options, their consequences and impacts, and the positive and negative development experiences of other Landowner groups. The CNA maps and other biological information could be disseminated through NROC to Landowners, NGOs and other decision makers.

The NROC should be temporarily attached to the Prime Minister's Department until it can be assured long-term funding and autonomy, and it should have only a small secretariat in Port Moresby or Lae. Most of the NROC's information dissemination should be carried out through existing national, provincial, and local networks (including national, provincial, and community governments, NGOs and churches).

Environmental legislation and regulations

PNG has many excellent environmental laws pertaining to land-based activities, but requires stronger capacity to effectively enforce them. Laws addressing marine conservation are needed.

The National Conservation Council should be constituted as soon as possible and the Conservation Areas Act of 1978 should be fully implemented.

The Land Groups Incorporation Act of 1974 should be amended to provide for more culturally appropriate and accurate definitions of customary Landowner groups. The Land Disputes Settlement Act of 1975 should be amended to provide for more certainty in the decisions by Local Land Courts and District Land Courts. The Land Tenure Conversion Act of 1964 should be amended to provide for reconversion, when appropriate, of individual freehold rights to customary tenure.

The moratorium on new forestry projects that was imposed by the Minister of Forests in 1989 should be continued and a reassessment of all forestry projects approved since then should be made. New data and assessment mechanisms are now becoming available for environmental planning; these can help ensure that ongoing forestry projects are conducted with proper sensitivity to conservation and the future needs of Landowners.

The exemption provision in the soon to be enacted Forest Act should be repealed and all exemptions granted since 1989 should be subject to stringent review.

Environmental and conservation management

Conservation management in PNG represents a unique challenge and opportunity because most of PNG is under private ownership. Therefore, models from other countries should not be considered for PNG without careful adaptation and testing because imposed ideas may clash with local knowledge and practices. Implementation of conservation requires a realistic and flexible approach. Emphasis should be put on exploring alternative approaches to conservation of natural resources appropriate to the conditions of PNG. Non-involvement of land/resource owners during design of projects will lead to problems during the implementation phase of projects.

Government-sponsored conservation initiatives in general, and the Global Environment Facility (GEF) initiative in particular, should emphasize broad-based approaches providing Landowners with information and encouraging and reinforcing grassroots conservation initiatives. In general government-sponsored initiatives should not be contingent on contractual agreements offering payment to Landowners, i.e., a "we'll give you something, if you give us something" approach, but should be geared towards helping Landowners sustainably develop their natural resources.

DEC must increase its capacity to address Landowner-initiated requests for Wildlife Management Areas. Informal conservation activities -- those without formal government recognition -- should be encouraged through public awareness and extension programs. Projects instituted and recommended by land/resource owners should receive priority. Landowners views and concepts about traditional resource management and means of conservation must be sought before any conservation programs are implemented.

Conservation research

In order to achieve successful conservation programs, social scientists should be fully involved in analyzing conservation design and implementation methods, and monitoring impact. It is also important for social scientists to identify ways of adapting existing Landowner social structures and information networks.

An organized effort should be made to collect biological information for managing the use of and potential threats to PNG's biological diversity. Priorities include survey of unknown biotas and studies of threatened species, marine systems, lowland rain forests, knowledge of traditional resource uses, and crop genetic resources.

All researchers should notify Landowners in advance before conducting research, and Landowners should be kept informed of research progress and results. Applied research that responds to the needs and priorities of Landowners should be encouraged. In order to develop research capacity in PNG, foreign researchers should seek the collaboration of PNG scientists and students.

Training

PNG's conservation infrastructure should be strengthened through training in research and resource management (e.g., Participatory Resource Appraisal, Rapid Resource Appraisal, feasibility analysis for NGOs and government; professional degrees in social and biological sciences, courses in parataxonomy, and in-service training). Resource owners, in particular, should be trained in basic monitoring skills provided by the NROC and by NGOs.

Institutions

To facilitate NGO input into government decision-making processes, the DEC should appoint a NGO representative to the National Environment and Conservation Working Group and the National Conservation Council. This representative should be chosen from a list nominated by the National Alliance of NGOs (NANGO). In addition, the DEC and the DOF should establish NGO desks responsible for coordinating activities and establishing processes for the regular sharing of information.

DEC's capacities for human resource development should be strengthened, particularly in natural resource management, planning, and conservation and environmental education and extension.

Government officers and researchers engaged in conservation-related work must live and work with Landowners so that they can understand the problems and assess needs before writing any reports.

The government of PNG should establish a permanent environmental trust fund, overseen by an independent statutory board, to award grants to local and national organizations for conservation action in Papua New Guinea. This fund could be supported through an environmental levy on extractive industries (logging, petroleum, mining), fisheries and agriculture, and by contributions from multilateral donors.

Map

We recommend that the following note be placed on the front on any map(s) which are produced from this workshop:

NOTE

1. The Constitution of Papua New Guinea promotes equality and participation, the wise use of natural resources, and Papua New Guinean forms of development.

2. Ninety-seven percent of Papua New Guinea is owned according to customary tenure.

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3. This map was prepared by biological scientists and, based on available knowledge, identifies areas richest in biodiversity.

4. This map is not intended to, nor should it be used to, exclude any areas or any Lndowners from conservation programs and initiatives.

5. When identifying appropriate conservation strategies and areas, local initiative is as important a criteria as biodiversity.

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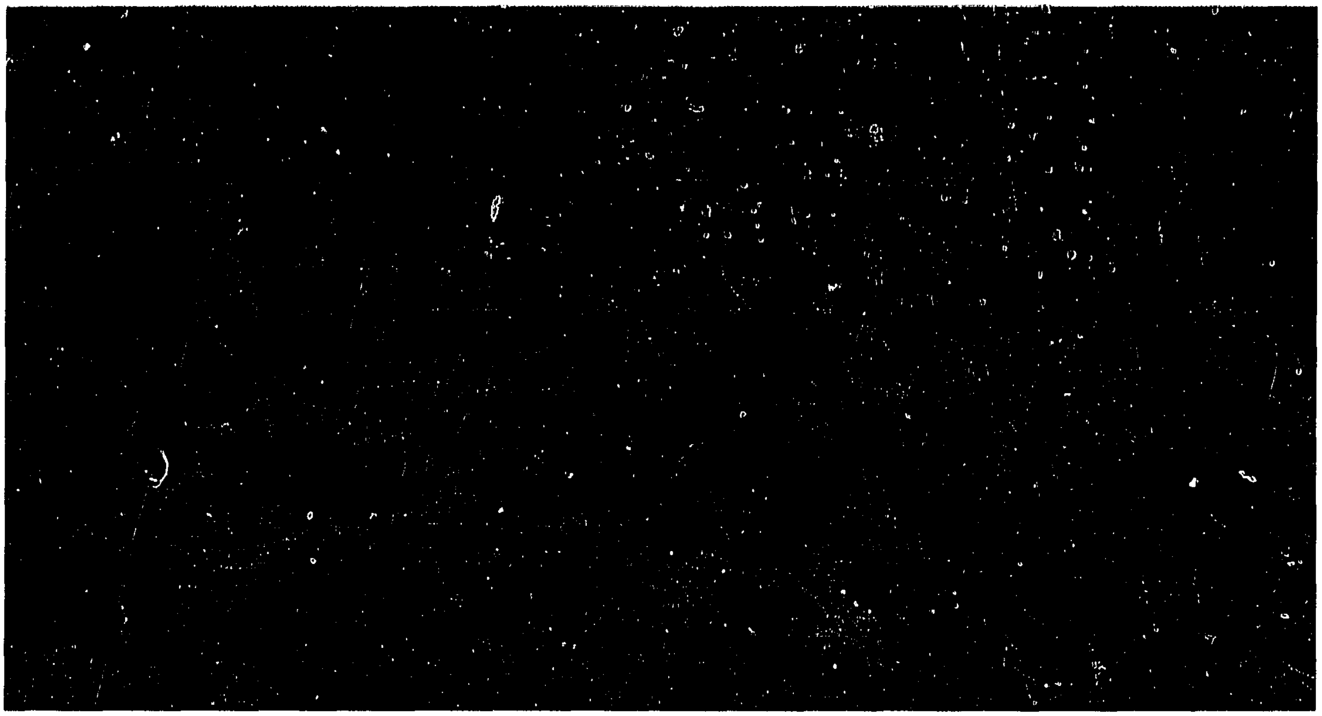
Papua New Guinea Conservation Needs Assessment

Volume 2



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Department of Environment
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Papua New Guinea Conservation Needs Assessment, Volume 2

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Chapter Thirteen

Introduction to the CNA Report, Volume 2

Bruce M. Beehler[1]

The concept of creating conservation maps for the rich biological resources of both the Old and New World Tropics is not a new one, and yet as more data become available, and as levels of habitat degradation rise, it becomes a potentially critical conservation methodology. The 1990 mapping exercise for Amazonia in Manaus (Rylands 1991, Kuliopolos 1990) proved that it was feasible and productive to bring together knowledgeable biologists to focus on the geography of conservation needs. The resulting biodiversity map for Amazonia seems to be serving its purpose: providing a concise geographic delineation of conservation priorities, as well as heightening awareness among various constituencies. In addition, such a map, based as it is on a compilation and assessment of biological data, provides relatively apolitical (and perhaps more objective) first-cut analyses that can initially guide the intensely political process of conservation of tropical environments.

The mapping of biologically important areas in Melanesia has occurred in the past (Schodde 1973, Beehler 1985, Diamond 1986), but never in such a broad or comprehensive fashion as proposed by the Conservation Needs Assessment (CNA). We believe we have built on the success of the formula employed for Amazonia in order to provide a new methodology for regional conservation. The following biodiversity review outlines the process and presents the results of the CNA biologists' team's work prior to the CNA Workshop described in Chapter 10. The mapping process itself is described in detail in Chapter 11.

THE CNA BIODIVERSITY ANALYSIS PROGRAM

As a component of the overall CNA program, which was instituted by agreement between the Government of Papua New Guinea, USAID, and the Biodiversity Support Program, a team of some 40 biologists and technicians[2] participated in an analysis of information available on the biota of Papua New Guinea. These biologists conducted this study with the goal of developing, in stages, a comprehensive biodiversity map, as well as a list of concise recommendations for long-term conservation of Papua New Guinea's

[1] Wildlife Conservation International and Conservation International, c/o Division of Birds, Smithsonian Institution, Washington, D.C., U.S.A.

[2] A list of biodiversity team participants is found in Appendix 13-2.

biodiversity. The exercise in analysis and mapping was conducted with structured guidelines to ensure that the results generated by the different focal groups would be comparable and concordant. Summarized below is an outline of the structure and composition of the biodiversity team, and the guidelines under which the team operated. That is followed by a brief preview of the subsequent chapters in the biodiversity section and a list of contributors to this effort.

COMPOSITION OF THE BIODIVERSITY TEAM

The composition of the biodiversity team was developed by the CNA Oversight Committee established by Papua New Guinea's Department of Environment and Conservation (DEC). The CNA Oversight Committee included Guy Kula (First Assistant Secretary) John Wilmot (DEC), Bruce Jefferies (National Forestry and Conservation Action Plan), Lester Seri (DEC), Bruce Beehler (Wildlife Conservation International/Conservation International), and William Asigau (DEC). It was decided that the team should address a number of distinct topics, some focusing on taxonomic groups, the others focusing on specific environments. The taxonomic groups covered were as follows: (1) botany, (2) invertebrate zoology, (3) cold-blooded vertebrates, and (4) warm-blooded vertebrates. The environments treated were (5) marine ecosystems, (6) freshwater wetlands, and (7) forest ecosystems. There were thus seven focal topics, each represented by a topic leader in alliance with a small correspondent team.

The seven topic leaders were selected by the CNA Oversight Committee, which suggested a list of possible topic leaders for each of the seven topics. From these informal nominations, the topic leaders were selected by discussion and vote.

THE INITIAL ANALYSIS AND ASSESSMENT

Each topic leader assembled a team composed of four to six correspondent experts who, like the leader, were knowledgeable about that particular biological topic for Papua New Guinea. This correspondent team also included a PNG counterpart scientist, selected in consultation with the CNA Oversight Committee. The topic leader relied on this correspondent team for information, advice, and criticism of the assessment and analysis conducted by the topic leader. Each topic leader produced a bibliography for the topic as well as a report on biodiversity as related to the focal taxon/environment. Drafts of these documents were circulated to the correspondent team, and their comments were used to produce a working draft for submission to the CNA Workshop in Papua New Guinea.

GUIDELINES FOR ANALYSIS AND ASSESSMENT

The biodiversity team leader, Bruce Beehler, in collaboration with Kathryn Saterson and Janis Alcorn of the Biodiversity Support Program, produced a specific set of guidelines for the biodiversity assessments (Appendix 13-1). Each topic report included the following

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topics: (a) a brief survey of the discipline's history in PNG, (b) major gaps in knowledge, (c) a current assessment, (d) representative biologically important areas for PNG, and (e) conservation recommendations.

The assessment was to have a strong geographic focus, with mapping (where relevant) of the following: (a) biologically unknown areas, (b) species richness, (c) distribution of rare and endemic forms, (d) ecologically critical areas, (e) ecologically fragile areas, (f) distribution of economically important species, (g) known threats, and (h) disposition of major wilderness areas.

The focus of the topic bibliography was on those publications critical to studies of the biodiversity of the focal habitat or taxon. Thus the bibliography was not to be exhaustive, but was to include those papers and monographs that would be most important to future studies of biodiversity in PNG.

CARTOGRAPHY AND GIS

Since mapping was considered a key component of the biodiversity assessment, Conservation International (CI) was contracted to provide computerized support for cartographic and geographic analysis using CISIG, its geographic information system (GIS). During the assessment phase, CI digitized a PNG base map and a series of environmental overlays (rivers, bathymetry, relief, rainfall) for reproduction at the 1:4,000,000 and 1:2,500,000 scale. These were then made available to each topic leader for the final draft maps that were brought to the CNA Workshop. The use of a uniform set of maps allowed the data to be readily digitized, compared, and analyzed.

THE BIODIVERSITY REPORTS

The seven chapters that follow in Volume 2 of the CNA Report present the topic teams' biodiversity assessments, written up by each topic team leader. Each follows a set format: a bibliography, a text treatment, various tables and appendices of data, preliminary maps that aid in the assessment process, and a final map that attempts to summarize, in geographic fashion, the priority areas for biodiversity conservation as relevant to that particular topic. The data in these chapters reflect the pre-workshop assessment. The organization of chapters features first the terrestrial flora (R. Johns - forest flora); then terrestrial fauna (B. Beehler - warm-blooded vertebrates; A. Allison - cold-blooded vertebrates; S. Miller - invertebrates); followed by focal environments (P. Osborne - freshwater wetlands; M. T. Agardy and J. Pernetta - marine ecosystems; and S. Saulei and B. M. Beehler - forest environments).

Summaries of the topical reports, mapping results, and recommendations, follow.

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PNG's native flora includes at least 15,000 species of vascular plants, but both the vascular plants and the pteridophyte flora are poorly known and need further field and herbarium study. Species endemism is high but endemism at the family and generic levels is low. PNG's natural environments are exceedingly diverse, ranging from coastal savannas and lowland rain forests to subalpine gymnosperm forests and alpine grasslands. Because of a variety of natural and human-caused types of disturbance, most natural environments in PNG are successional and patchily distributed. Forty-three areas of national biological importance and 99 areas of localized importance are defined for PNG's botanical resources.

Papua New Guinea's warm-blooded fauna includes 644 species of breeding birds and 214 species of breeding mammals. Seventy-six bird species are endemic to Papua New Guinea, as are ca. fifty species of mammals. The birds are the best known animal group in PNG, while the mammals are far less well-known, mainly because of their nocturnal lifestyle. Birds and mammals are both economically and culturally important to the local people, and thus are of critical conservation importance. Some of the larger and rarer species are considered threatened. Thirty areas are determined to be of major biological importance to the warm-blooded vertebrate fauna.

Papua New Guinea's cold-blooded vertebrates include ca. 785 species: 282 species of freshwater fishes and 505 species of amphibians and reptiles. Forty-six percent of these species are endemic to PNG. The fauna remains incompletely known, and additional surveys are needed to adequately document the species and their geographic ranges. Thirty areas determined to be of significant importance to PNG's cold-blooded vertebrate fauna are mapped.

PNG's invertebrate fauna is exceedingly rich and only superficially enumerated. The butterflies and larger beetle taxa are well-known, but the vast majority of PNG invertebrate groups are poorly studied, and probably most species have not been described and named. Reviews are presented of the terrestrial insects, aquatic insects, freshwater decapod crustacea, and non-marine mollusca.

Papua New Guinea is a humid tropical country and thus is rich in freshwater wetlands. These include more than 5000 lowland and highland lakes, herbaceous swamps, savanna swamps, woodland swamps, and swamp forests. Lakes and woodland and herbaceous swamps are most abundant in the lowlands. The highland zone has scattered montane lakes and herbaceous swamps. These wetland environments are very rich in wildlife (especially fishes) and comprise an economically important resource for many of PNG's subsistence economies. Thirty wetlands are designated of major importance to conservation.

The coastal and marine ecosystems in PNG rival the terrestrial environments in diversity and richness. These include extensive coastal and estuarine mangroves; fringing, barrier, and patch reefs; small and large island systems; atolls; seamounts; and deep water upwellings. The plants and animals that inhabit these coastal and marine communities, and the processes that support them, are very poorly documented. At the same time ongoing exploitation of many of these environments threatens their viability in the long term. A major effort is needed to survey and study these environments. Additional information is needed to develop guidelines for the maintenance and sustainable use of marine systems.

Ten ecologically-defined classes of forest are outlined for Papua New Guinea. These comprise ca. sixty-five percent of PNG's land area. Conservation of representative tracts of all of these forest environments is imperative for the long-term well-being of Papua New Guinea's economy and its forest industry. We delineate seventeen areas of major importance to conservation of PNG's forest environments.

Based on a reassessment and refinement of the maps presented at the CNA Workshop in Madang, three synthesis maps were produced. A description of the CNA Workshop, the workshop mapping process, the synthesis maps, the supporting data on important areas and major unknowns, and the biologist team's recommendations presented at the workshop are found in Volume 1 of the CNA Report.

The biologists' recommendations, found in each chapter in this volume, stress the need for the following: (1) increased field research related to conservation biology, biodiversity, and survey of unknown biotas; (2) increased efforts at training PNG nationals as biologists and conservation managers; (3) development of novel means of conservation of biodiversity, especially strategies that include the full participation of traditional Landowners; (4) development of means of determining sustainability in industries that extract renewable natural resources; and (5) development of additional means of funding for biodiversity research and conservation action, including the institution of a conservation trust fund for Papua New Guinea.

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APPENDIX 13-1. BIODIVERSITY TOPIC LEADER GUIDELINES FOR ANALYSIS, ASSESSMENT, AND MAPPING

GOALS

It is easiest to carry out a project that has specific and well-defined goals. Our exercise seeks to provide the **scientific data** for a biodiversity assessment for Papua New Guinea. This is primarily an **information exercise.** We will assemble and assess the available data that will provide the criteria to be applied for meeting the following long-term conservation objectives for PNG:

To preserve economically and practically viable populations and communities of all of PNG's native plants and animals.

To preserve adequate samples of intact natural habitats representative of the natural diversity found in PNG.

To provide future habitat for pristine study sites for *in situ* biological field studies of PNG biodiversity and rain forest ecology.

CONTRIBUTION OF THE CORRESPONDENT TEAM

The Topic Leader will work with the Correspondent Team in any way that fosters the creation of an excellent report and maps. At the very minimum, the correspondent team members (who are unpaid) will read and criticize the draft report and draft maps. In some instances it may be possible for the Topic Leader to parcel out work to different team members for completion and integration into the report. It will be particularly important for team members to review and criticize treatment of their sub-specialty (for instance, an ornithologist Topic Leader who oversees the "warm-blooded vertebrates" would ask the mammalogist team member to study closely the mammal section of the report). Correspondents also should provide input on the location and assessment of biologically important areas in PNG. The effort invested by the Correspondents will, in part, be a product of the working relationship between the Topic Leader and team members. Above all, it is most important that the Correspondents read, criticize, and annotate the draft report and maps.

METHODS OF ANALYSIS

The Topic Leader has two major goals: first, to collate and analyze the available data on the topic and synthesize these data in report form; second, to assess the geographic data and to select a series of biologically important areas in PNG representative of the entire range of taxonomic and ecological richness for the taxon or habitat being assessed. Thus each Topic Leader's analysis will produce a summary report and accompanying map(s).

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For the Report, the following preliminary information would be valued: (a) total enumeration of species in Papua New Guinea. In poorly studied taxa this should include (b) number of species described, (c) approximate rate of description, and (d) estimate of total flora or fauna, based on these data and knowledge of the field. Sample species distributions and nature of species endemism is desirable. What is the range of variation in geographic distributions of the taxa in question? For certain taxa, narrowly distributed endemic groups may help define representative biologically important areas. It is also useful, where appropriate, to provide summary information on economically valuable taxa and their distribution.

Whenever possible, provide counts, numerical comparisons, and data based on analyses that can be replicated (methods to be included). Although the ultimate goal of the program is to promote nature conservation, the initial stage of assessment relates strictly to objective assessment of the information.

The Topic Leader should strive to carry out an analysis that is based on a standard and well-resolved methodology which, in itself, must be described in the report. It is preferred that the analysis be based on statistical sampling of the available data, not a recitation of anecdotes. In some poorly studied taxa, this can be done by restricted analysis of subsets of data (for arthropods, this might be a single genus of beetle; for plants, this might be a well-known genus such as *Rhododendron* or *Lithocarpus*. As many of these "focal" taxa should be included as possible to give a well-rounded basis of analysis.

Certain focal topics (Freshwater Wetlands, Marine Environments) do not fit the standard taxonomic mold, and so must be dealt with in a different manner; but counts of focal taxa within the environments can give clear indications of the biological importance of particular areas.

It also will be valuable to help delineate **what we do not know** about the taxon or habitat in question. Where and on what should future research focus? What is critical for our better understanding of PNG biodiversity?

Mapping will be an important component of the assessment process. Much of the information will have a geographic component and will be best represented in map form. Thus we now envision each Topic Leader producing, if possible, a series of basic (and simple) data maps [in many cases just sketch maps] that give a clear idea of a series of specific phenomena or distributions, as outlined below. This will be followed by a synthesis of these data and production of the Topic Synthesis map of representative biologically important areas, based on the analysis of the focal taxon or specific habitat. Thus the mapping is two-staged. The main body of the report should include the preliminary "data" maps, and the final section of the report should include the synthesis map and an explanation of how it was derived from the preliminary data. A final, Full Synthesis Map will be produced at the Workshop.

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OUTLINE OF THE REPORT

The major responsibility for each Topic Leader is the Topic Report. Each Report should be 18-30 single-spaced pages long. Bibliographic citations are required, using the standard in-text notation, for example: (Smith 1991). These should refer to the full citations in the Topic Bibliography, not repeated in a separate "literature cited" within the body of the Report.

Contents of each Topic Report should include the following: (a) Summary, ca. 2 pages; (b) Brief survey of the discipline's history in PNG, 4-6 pages; (c) Major gaps in knowledge, 2-3 pages; (d) Current data assessment (see next section), 6-15 pages (plus maps); (e) Representative biologically important areas for PNG, 2-4 pages (plus synthesis map); (f) Conservation recommendations, 2-3 pages.

In sum, the Topic Report is to comprise an analytical summary of the available information relevant to conservation of the focal taxon or habitat in Papua New Guinea. The maps are to be integrated into the Topic Report.

DATA ASSESSMENT -- INITIAL BASELINE MAPPING

We believe that mapping is an integral part of the assessment process, and believe as many data as possible should be put in geographic form. Most or all of this can be presented in the context of the Topic Report.

Specific Topics of Focus

Below is a list of the topics that, where appropriate, require specific thought, analysis, and mapping (if possible):

Unknown Areas. What areas in Papua New Guinea are virtually unknown and unstudied with regard to your particular habitat or taxon?

Species Richness. From your analysis, where are the areas with highest species richness?

Rare and Endemic Forms. Are there specific areas in PNG that support particularly high concentrations of rare or endemic species?

Ecologically Critical Areas. Where are the areas critical to your taxon or habitat? These might be watersheds upon which an estuary depends, or an expanse of flooded grasslands that serves as a critical wintering area for migratory species, or a mangrove system that is the key breeding area for large populations of marine invertebrates.

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Ecological Fragility. Are there any specific habitats or sites that are ecologically fragile? Such would be environments or natural systems that are easily disrupted or destroyed by even low levels of human interference. These should be mapped (if possible).

Economically Important Species. What economically important species occur in your focal topic? What are their distributions, and are these data relevant to your analysis and assessment?

Known Threats. Map currently known threats to your taxon or habitat.

Major Wilderness Areas. Map PNG's most important major wilderness areas -- areas of "big bush" that constitute important pristine ecosystems.

PREPARATION OF THE TOPIC SYNTHESIS ASSESSMENT AND MAP

Each Topic Report should conclude with a synthesis assessment of the focal taxon/habitat and an accompanying synthesis map of the biologically important areas within PNG, based on the topic assessment. The route to this goal is not simple and straightforward. Judgments based on rational analysis of the available hard data are highly valued, but in some instances professional opinion is necessary. The sum experience of the assembled field experts cannot be measured in simple terms, but one can appreciate how important this "indefinable" is to providing the good judgment necessary to make an objective assessment. Selection of biologically important areas should be made with respect to current biotic potential, and in most cases should not be directly influenced by the data on current or future threat. At this point it is critical to choose the areas most representative and richest, biologically. The political choices will follow, based on the objective data we provide.

The number and configuration of this suite of areas remains the choice of the Topic Leader. It is, of course, important to select habitat tracts of a size that would support a viable genetic stock of the taxa in question. For most plants and animals, minimum size is not critical to preservation. But areas selected will have to be delineated with the more "fragile" populations in mind. In the instance of a large animal like the New Guinea Harpy-Eagle, a 70 km x 70 km tract may not be sufficient for long-term preservation of a viable breeding population because of either stochastic or gene bottleneck effects.

It is expected that some biologically important areas will be relatively small either because the taxon or habitat worth protecting is very restricted in extent, or because this is all that remains of the key population or environment because of habitat alteration. Thus an area to preserve Queen Alexandra's Birdwing Butterfly will possibly be considerably smaller than an area selected for protecting populations of Pesquet's Parrot and the Palm Cockatoo -- the latter being large, wide ranging vertebrates.

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The Topic Synthesis Map

Each Topic Leader produces his/her own synthesis map of biologically important areas (following from data assessment, above).

Biogeographic Regions. It is important to spread the distribution of representative, biologically important areas across the biogeographic regions of Papua New Guinea. Thus one should consider at least one biologically important area for all the major high islands (Bougainville, New Ireland, Manus, New Britain, Goodenough/Fergusson), and for all of the major mountain ranges (Owen Stanley, Star, Central, Saruwaged/Finisterre, North Coastal, etc.) and major lowland humid basins (Fly, Sepik, Purari, etc.)

Major Unknowns. Map areas that have been little studied or are entirely unknown biologically. These might constitute possibly overlooked major wilderness sites worthy of consideration. In addition, these unknowns constitute field assessment priorities for follow-up biological assessment teams (Post-CNA).

Overlap of Distributional Patterns. Plot summary data from preliminary analyses on the geographic distribution of patterns of species richness, rare and endemic forms, major wilderness areas, unknown areas, etc. (from preliminary base map exercise).

Consensus Analysis. Obtain rough "first draft" maps of biologically important areas from Correspondent Team members. Overlay these to determine areas of concordance. These constitute consensus sites. This is a synthetic technique that seeks to extract information that is based on the long-term experience of the Correspondent Team.

Delineation of Representative Biologically Important Areas. By overlaying the data from exercises described above, one then can select areas where concordance between the different assessments produces zones of concordance. Within these zones, analysis of habitat, population, and disturbance should permit the Topic Leader to delineate the boundaries and size of the biologically important area. Here are some additional guidelines:

a. Multi-habitat areas. These are perfectly acceptable, but it is necessary to designate sufficient contiguous acreage of each important habitat. Thus a biologically important area that is a strip of forest ranging from sea level to 4000 m must be significantly larger than a single-altitude area in order to be equally sufficient for future habitat conservation purposes.

b. Siting biologically important areas in relation to population concentrations. It is best if population concentrations lie on the verge (or entirely outside) of the areas designated.

c. Size and shape of the areas. Make the areas as large as possible. Borders can follow natural features, but avoid long narrow shapes, and keep the shape of the area simple (e.g., bloblike rather than starfish-shaped) A suggested minimum adequate area size, for nonspecialized sites, is 30 km x 30 km, or 1,000 km^2. Larger areas are preferable.

d. Areas classification. We suggest each Topic Leader use three designations for the areas selected on his final Topic Synthesis map: (a) major unknowns -- sites, deemed important for future survey study; (b) high quality areas -- areas deemed especially rich in endemics, species richness, or in rare species; and (c) conservation priority sites -- rich or unusual areas that are under some form of threat.

Mapping -- Some Fundamentals

There are excellent maps available for Papua New Guinea. The range of scales and treatments is quite remarkable, from the 1:100,000 topographics to the 1:2,000,000 JNC series (sheet 61 covers all of PNG). Larger scale sheets (e.g., the TPC 1:500,000 or JOG 1:250,000) would be useful for close-up work, and the smaller scale (e.g., the JNC 1: 2,000,000) would be ideal for general mapping of the series of reserves. These maps are available from a variety of commercial and official sources. All are available from the National Mapping Bureau, P.O. Box 5665, Boroko, PNG.

The areas designated in the Topic Synthesis map are then to be carefully transcribed onto a detailed outline map (1:4,000,000) that will be provided by CI Headquarters. The data on biologically important areas placed on this 1: 4,000,000 outline map series will then be digitized and incorporated into the CI GIS for assessment at the Workshop.

With the help of Conservation International, the CNA team is producing a set of overlay maps that will be distributed to all Topic Leaders in advance of the Workshop (in January or February). These should prove helpful in producing the final Topic maps.

Thus the Topic Leaders should work with their own maps initially, with the expectation that their final decisions can be made once the detailed overlay sheets are provided in early 1992.

The CNA overlay series (in four or five overlay sheets) will be 1:4,000,000, and include (1) political boundaries, (2) population centers (population distribution/land tenure?), (3) river systems, (4) topography, (5) vegetation type, (6) rainfall, (7) Lat./Long., (8) known sites of past biological fieldwork or collecting in PNG, and (9) established or proposed protected areas.

Area Fact Sheets. The two-page data sheets that were mailed out in the first set of Guidelines no longer need be completed for each representative site chosen. Instead, these data will be compiled at the Workshop for the overall priority sites selected from the overall assessment drawn from the maps of the various Topic Teams.

CONSERVATION RECOMMENDATIONS

Each Topic Report should include a section focusing on conservation priorities and management issues. This should include (a) discussion of general guidelines for conserving the focal taxon/habitat outside of protected areas; (b) present and future protected areas strategies; (c) thoughts on priorities for long-term management of forests, wetlands, and marine/estuarine environments in PNG; and (d) long-term needs for professional training of Papua New Guinean conservation biologists and managers.

THE BIBLIOGRAPHY

The Bibliography to accompany each Topic Report should include no fewer than 100 and no more than 300 references. Those selected are to be the papers or monographs most directly relevant to an assessment of the biological diversity of Papua New Guinea for that discipline, and should include the range of subdisciplines subsumed in that Topic (e.g., for Vertebrate Zoology, one would include mammalogy, freshwater ichthyology, herpetology, and ornithology).

When possible, photocopies of critical source papers should be included in the mailing. This will greatly aid the collation of material for the future biodiversity information resource center in Port Moresby.

APPENDIX 13-2. LIST OF BIODIVERSITY MAPPING CONTRIBUTORS

Tundi Agardy, marine ecosystems, topic leader, WWF-U.S.
Gerald Allen, freshwater wetlands, correspondent team, Western Australian Museum
Allen Allison, cold-blooded vertebrates, topic leader, Bernice P. Bishop Museum
Samuel Antiko, GIS workshop team, DEC
William Asigau, marine ecosystems, workshop team, DEC
Bruce M. Beehler, biodiversity team leader, warm-blooded, vertebrates topic leader, WCI/CI
Ilaiah Bigilale, warm-blooded vertebrates, PNG National Museum
David Coates, freshwater wetlands, correspondent team, UNDP Fisheries Project
Barry Conn, freshwater wetlands, correspondent team
Robert Cowie, cold-blooded vertebrates and invertebrates, correspondent team, Bernice P. Bishop Museum
Jared M. Diamond, warm-blooded vertebrates, correspondent team, UCLA School of Medicine
Lucius Eldredge, cold-blooded vertebrates and invertebrates, correspondent team, Bernice P. Bishop Museum
Tim Flannery, warm-blooded vertebrates, correspondent team, Australian Museum
John Genolagani, freshwater ecosystems, correspondent team, DEC
Jeremy Holloway, invertebrates, correspondent team, International Institute of Entomology
Helen F. Hopkins, botany correspondent team, University of Cambridge
Michael Huber, marine ecosystems, workshop team, University of Papua New Guinea
Charles Hutchinson, GIS workshop team, Conservation International
Matthew Jebb, botany, workshop team, Christensen Research Institute
Robert Johns, botany, topic leader, Royal Botanic Gardens, Kew
Karol Kisokau, warm-blooded vertebrates, Research and Conservation Foundation of PNG
Samson Laup, invertebrates, correspondent and workshop teams, Department of Agriculture and Livestock
Greg Leach, freshwater wetlands, correspondent team
James I. Menzies, warm-blooded vertebrates, correspondent team, University of Papua New Guinea
Christopher Mercer, invertebrates, workshop team, PNG University of Technology
Paul Millin, GIS workshop team, PNG University of Technology
Scott Miller, invertebrates, topic leader, Bernice P. Bishop Museum
Silvio Olivieri, GIS workshop team, Conservation International
Patrick Osborne, freshwater ecosystems, topic leader, University of Western Sydney
Larry Orsak, invertebrates, workshop team, Wau Ecology Institute
John Pernetta, marine ecosystems, correspondent team, consultant, U.K.
Dan Polhemus, cold-blooded vertebrate and invertebrates, correspondent teams, Bernice P. Bishop Museum
Monika Rau, botany, workshop team, University of Papua New Guinea
Simon Saulei, forest ecosystems, topic leader, University of Papua New Guinea
Richard Schodde, warm-blooded vertebrates, correspondent team, C.S.I.R.O.
Lester Seri, warm-blooded vertebrates, correspondent team, DEC
Sally Townley, workshop and mapping support team, University of New England

Charles Tenakenai, marine ecosystems, workshop team, Department of Fisheries and Marine Resources
Richard Vane-Wright, invertebrates, correspondent team, Natural History Museum, London
John Wilmot, cold- and warm-blooded vertebrates, workshop team, DEC
George Zug, cold-blooded vertebrates, correspondent team, Smithsonian Institution
Richard Zweifel, cold-blooded vertebrates, correspondent team; American Museum of Natural History

Chapter Fourteen

Biodiversity and Conservation of the Native Flora of Papua New Guinea

Robert J. Johns[1]

SUMMARY

Papua New Guinea's native flora comprises an estimated 15,000 to 20,000 species of vascular plants, including ca. 2000 species of orchids, and more than 2000 species of pteridophytes (ferns and allies). The lower plants have not been enumerated, but are known to be species rich. This remarkable subcontinental flora is poorly surveyed, and yet enough is known to delineate a series of forty-three areas of high biological importance for conservation of floral biodiversity. These areas include the range of natural terrestrial habitats in Papua New Guinea, from coastal savannas to alpine summit vegetation. In addition, ninety-nine specific sites of botanical interest are listed (Appendix 14-2) that highlight points of biotic, esthetic, and historic importance not specifically indicated in the initial forty-three major areas. These two focal lists, along with the four specific recommendations for action, should serve as a guide to future conservation initiatives to protect Papua New Guinea's native flora.

INTRODUCTION

The forest flora of Papua New Guinea represents one of the most diverse biological ecosystems in the Old World Tropics. The island of New Guinea is now widely accepted as a biological "hotspot" deserving a focused conservation strategy because of its rich biodiversity. Although actual figures of the floral biodiversity are not known, it is estimated that there are from 15,000 to 20,000 species of vascular plants in New Guinea, including more than 2000 species of orchids. The pteridophytes are represented by at least 2000 species, and, while the number of lower plants is not accurately known, a significant number is expected. Due to the low density of collections (many areas are not collected or are poorly known), there exists only a superficial knowledge of the taxonomic status of most families of plants in New Guinea. Consequently, we have only an incomplete knowledge of the richness of the flora. In Malesia, only the Celebes and Sumatra have comparable low figures of collecting density with less than 50 specimens per 100 km^2. The following map (Figure 14-1) from Stevens (1989) shows the extensive areas that are virtually uncollected

[1] Royal Botanic Gardens, Kew, United Kingdom.

botanically. Even the shaded areas would be considered poorly represented in most collections.

Probably the only area within Papua New Guinea where the flora could be considered adequately known is the Pindaunde valley on Mt. Wilhelm. The early collections by Brass (1964), Hoogland (1958), and subsequent collections for the ecological studies by Wade (1968, see also Wade and McVean 1969) formed the basis for one of the first comprehensive species lists prepared for any area in Papua New Guinea (Johns and Stevens 1972). With additional collections and voucher specimens from the studies of Smith (1974a, 1975a, 1977a, 1977b), Hnatuik (1975), and studies of the vegetation history by Hope (1973, 1976), this list requires updating.

Foreman (1971) produced a checklist of the plants of Bougainville. A species list has also been prepared for the Watut Valley (Streiman 1983), but with only 1789 phanerogram species, this list is obviously incomplete (note that all undescribed and unidentified species are placed in a single list after the last species entry for the genus). Borrell (1989) published a detailed list of the plants of Kairuru Island in the East Sepik Province. It is interesting that Borrel enumerated 1300+ species from Kairuru, while Peekel lists only 900+ species from New Ireland.

Some unpublished species lists have been prepared for Manus Island (Johns 1989i), East and West New Britain (Johns 1989a), and the Herzog Ranges in the Morobe Province (Johns 1970). The areas are not yet adequately collected, and thus the lists represent only a small part of each flora; consequently they have not been published. D. G. Frodin (unpub.) has a detailed list of the collections of the Central Province below 1000 m altitude, and Cruttwell (unpub.) also has a list of plants collected from Gahavisuka Provincial Park (Eastern Highlands Province). Stevens and Veldkamp (1977) have produced a list from Mt. Suckling (Milne Bay Province), and Hiepko and Schultze-Motel (1981) produced a list for Eipomak-Tel in Irian Jaya -- which is relevant to the flora of the border area (Star Mountains) with Papua New Guinea. Coode and Stevens (1972) have also produced a checklist of their collections from Mt. Strong.

The Alpine Flora of New Guinea by van Royen (1980) lists the high altitude flora inhabiting areas above 3000 m, particularly species of the subalpine and alpine zones of New Guinea, including a few species from the upper montane that have a large altitudinal range, and that occur both above and below 3000 m. With these exceptions, there are no detailed lists of species for any substantial area in Papua New Guinea.

With the low intensity of collecting and the superficial nature of taxonomic information, it is not possible to indicate accurately the plant species present in any of the areas of postulated high biodiversity within Papua New Guinea. Thus areas proposed in this chapter are based, instead, on the collective experience of the author and collaborating scientists, all with field experience in Papua New Guinea. The areas are similar to the list included as Annex #4 of the World Bank Report on Forestry.

DIVERSITY IN VEGETATION

Studies of the vegetation of Papua New Guinea were first stimulated by the early German exploration of northeastern New Guinea, resulting in several papers (Bailey 1899, Lauterbach 1910, 1928, Warburg 1892, 1899). Lane-Poole (1925) published the first detailed account of vegetation zonation in Papua New Guinea, which covered all the major formations from the coastal to alpine vegetation. This work was consolidated and expanded by Lam (1924, 1935), and particularly by Brass (1938, 1941, 1956, 1959, 1964) and Brass and Rand (1940) in a series of papers based on the extensive field experience of L. J. Brass in both Papua New Guinea and Irian Jaya. These studies formed the basis for the general papers by McAdam (1951) and Womersley and McAdam (1957).

Postwar studies of the vegetation were dominated by the work of the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Papua New Guinea (CSIRO Land Research Series 10, 12, 14, 15, 17, 20, 22, 23, 27, 29, 30, 31, 32, 35). With the resources available, extensive studies were made of the vegetation and flora (together with climate, soils, geological notes, and local people). Ecologists and taxonomists particularly associated with these studies were Pullen (1957), Paijmans (1970b, 1975, 1976), Hoogland (1958, 1972), etc. Much of the available information was summarized by Paijmans in his notes accompanying the vegetation map of Papua New Guinea (Paijmans 1975) and his book on the vegetation (Paijmans 1976).

During this period, the Australian National University made a major contribution to our understanding of the vegetation. Walker (1965, 1966, 1970, 1972, 1973), Powell (1970a, 1982), Flenley (1967, 1972), and Hope (1973, 1976a, 1976b, 1980a, 1980b) contributed extensively to our knowledge of the history of the flora. In addition various ecological studies have been published, notably by Ash (1975, 1982) on *Nothofagus* and Enright (1978, 1982a, 1982b, 1982c, 1982d) on *Araucaria*. Studies of the high altitude vegetation (above 3000 m) have been made by Wade and McVean (1969), Hnatuik (1975), Hope (1975, 1980b), Smith (1974a, 1977a), and Powell (1970).

Research based within Papua New Guinea has been centered on several institutions: the Department of Forests (including the Forest Research Institute), the PNG University of Technology (PNGUT) (Department of Forestry), the University of Papua New Guinea (particularly the Biology Department), the PNG Forestry College at Bulolo, the Wau Ecology Institute, and the Department of Environment and Conservation. Research based at the University of Papua New Guinea (UPNG) concentrated on mangroves (Johnston and Frodin 1982) and seagrasses (Johnston 1975, 1976, 1982). More recently water plants were studied in detail culminating in the book by Leach and Osborne (1985). Hynes (1970, 1974), while enrolled for a master's at UPNG, conducted a detailed study of *Nothofagus* in the Highlands of Papua New Guinea (based at the Goroka Teachers College). Saulei (1984, 1985, 1987b, 1988a, 1989) conducted detailed studies of rain forest regeneration in the Gogol River Valley (Madang Province) while enrolled for a doctorate at Aberdeen University, and has made detailed studies of soil seed banks (see also Balun 1991). M. Hopkins and E. Brown are at present conducting vegetation studies at Varirata National Park.

At the National Herbarium, work has focused on dipterocarp ecology (Johns 1987a, 1987e), *Nothofagus* ecology (Clunie 1975, 1976) and also on general vegetation studies (Johns 1972b, 1977c, 1977d, 1982c, Clunie 1978). Kiapranis (1990) has published an enumeration of the diversity of plant species in a plot in lowland rain forest in the Gogol Valley. Small-scale surveys were also conducted by the Department of Environment and Conservation as part of their survey work. The Department of Forests has conducted numerous assessment surveys of the forest vegetation of Papua New Guinea. Most of the data are unpublished, but the management files contain an enormous underutilized source of material on the vegetation of Papua New Guinea. Reference to forestry assessments in Central and Milne Bay provinces can be found in Johns (1989f), and surveys in Gulf and Southern Highlands provinces are in Johns (1988c).

Ecological research at the PNG Forestry College, Bulolo was aimed at generalized data collection in O.5 ha plots as part of student studies, in an attempt to describe the diversity of vegetation types. Four permanent plots were also established at Buso (Morobe Coast) in lowland dipterocarp forest. These were measured every two years (until Johns moved to PNGUT), but some later measurements were made. Studies at PNGUT were also conducted on rain forest regeneration (Johns 1975a, 1992) and ecosystem instability (Johns 1985b, 1986c). Most projects were continued at PNGUT after the author moved to Lae. In addition, a detailed study of mangrove ecology was conducted (Johns 1981a, 1986c). Rain forest regeneration studies have been continued by P. Siaguru at PNGUT. Numerous consultancy reports contain data of varying value on the vegetation. A set of these is held in the Library at the University of Papua New Guinea and at the Department of Environment and Conservation.

Some problems still remain in developing a general and widely accepted system of classification for the vegetation, and various classification systems have been proposed. The lowland zone has several accepted vegetation formations although, particularly within the lowland rain forest, no comprehensive attempt at forest typing has proved satisfactory. Classification of the montane vegetation varies considerably. Johns (1976a, 1976b, 1982c) proposed the recognition of three zones: lower, mid- and upper montane. The lower montane zone corresponds to the *Castanopsis*, *Lithocarpus*, *Araucaria*, and *Agathis* zone, the zone of maximum environmental impact due to its suitability for traditional subsistence agriculture (Bowers 1965, 1968, Lea 1975, Lea and Irwin 1967). Above this zone the mid-montane is characterized by forests dominated by *Nothofagus* (Johns 1986a) and the podocarps. The upper montane forest occurs above 2700 m to 3000 m. Grubb and Stevens (1979) discuss the higher altitude vegetation of the montane and subalpine zone in detail (see also Grubb 1971, 1974, Wade and McVean 1969). A generalized comparison of the different classification systems is given (Figure 14-2).

FACTORS OF IMPORTANCE IN MAINTAINING RAIN FOREST

The combination of low population density and rugged topography has ensured that forest vegetation is intact over much of the country, despite the obvious disturbance by natural phenomena over wide areas of the country (White 1975b, Johns 1986b, 1986c, 1988a, 1989h, 1990b). Probably of greater significance for the retention of these largely intact forest tracts is the rarity of dipterocarp trees in the canopy of the lowland rain forests. The dipterocarps, as a family, account for over 80% of the world's trade in tropical hardwoods. As noted in Johns (1987a, 1987e) the family is represented by only three genera in Papua New Guinea, and these, although of local importance, never dominate the lowland rain forest over extensive areas, as occurs in Borneo. In addition, the average volume per hectare of timber that is suitable for extraction is often less than 30 m^3/hectare, and this, especially in combination with extraction difficulties, has resulted in relatively low intensity logging in Papua New Guinea. The major threat to rain forest comes from clearing and burning for agricultural purposes, often as a post-logging operation, not in the actual extraction of timber itself. A recent development is the use of helicopters for extraction, in which environmental damage to the rain forest is reduced, but the rates of extraction are greatly increased. Except as related to large agricultural projects, clear-felling is confined, at present, to the Madang Province, site of a large chip mill (Lamb 1991).

ENDEMISM AT THE FAMILY AND GENERIC LEVEL

Because of the position of New Guinea on a continuous series of islands between southeast Asia and Australia, the absence of endemic families is not surprising. Indeed the only endemic family in Malesia, the Scyphostegiaceae (*Scyphostegia*), is confined to Borneo.

A different pattern of endemism emerges when examining the flora of Papua New Guinea at the generic level. Eighty-four genera are endemic to New Guinea (Johns 1989d), although this number is expected to increase as botanical exploration continues and generic limits are reevaluated within some families. An undescribed genus in the Burseraceae, represented by only two collections from Rossel Island, illustrates our superficial knowledge of the flora. A list of currently accepted endemic genera is given in Appendix 14-1. Accurate mapping of the distribution of the endemic species is difficult because of the enormous gaps in collecting density throughout the country.

ENDEMISM AT THE SPECIES LEVEL

Even in families that are the subject of taxonomic study, our knowledge of many of the species, especially of intra- and interspecific variation, is rudimentary. As studies proceed, even in genera which are dominated by timber trees, many taxa are represented by a single specimen, or only a few collections. This reflects to some degree the collecting policy practiced by the Forestry Department in Papua New Guinea. Herbs, sub-canopy trees, ferns, and especially climbers are under-represented in the collections. Specialized collections of algae, mosses, and lichens have been made but are relatively few in number.

Lack of data in some cases causes difficulties in taxonomic interpretation. In other cases, the taxonomy of some groups may not be resolvable, regardless of the size of collections made. It seems that certain complexes (ochlospecies) cannot be fitted into the straitjacket of a simple species concept.

The revision of *Chisocheton* is an excellent example of the differences in taxonomic interpretation due, at least in part, to a paucity of collections for critical study. Stevens (1975) recognized ten species in the *Chisocheton lasiocarpus* complex; all were treated as a single variable species by Mabberley (1979). A similar dichotomy appeared for *Tasmannia* (A. C. Smith 1969), in which Vink (1970) grouped the thirty described species into a single variable species *Drimys piperita*. Such studies amplify the taxonomic problems that are fundamental to the quantification of biodiversity. This dichotomy of view is unsatisfactory and will only be resolved (if resolution is possible) when more data on the biology of the living populations are available for critical study. With such problems associated with relatively well studied and collected genera, the position for the majority of species is difficult. It is clear that we have a less than satisfactory knowledge of the more than 1500 genera within New Guinea. In many groups, species taxa are represented by single specimens.

Because of the paucity of collections, little is known of local patterns of endemism at the species level in Papua New Guinea. It is suspected that there is a high degree of local endemism, as evidenced by the studies of Kalkman and Vink (1970), but conclusive studies must await a properly coordinated approach to collecting in Papua New Guinea.

AREAS OF HIGH BIOLOGICAL IMPORTANCE

Introductory Notes. Brief notes are given for each major area important to Papua New Guinea's floral diversity. These include a rough estimate (guesstimate!) of biodiversity, altitudinal range, broad vegetation types, threats, and other pertinent data and references.

Areas were selected based on three factors. Ecological diversity is of major importance in area selection. It is important to emphasize that the diversity of the vegetation has at least two components: a high diversity of the vegetation types caused by variation in the physical environment - mangroves and savanna to alpine vegetation; and a high specific diversity within any given vegetation type - the mangrove forest, are the most species rich in the world. The montane forests must compare in diversity with areas in the Andes. High regional variation within the lowland and montane forests is also expected.

Although no comprehensive account of the ecological diversity has yet been made (see Paijmans 1976, Johns 1972b, 1976b, 1977c, 1977d), except for the high altitude vegetation on Mt. Wilhelm (Wade and McVean 1969), an attempt was made on the basis of field experience to include all the major types of vegetation within proposed areas. We have little knowledge of the distributional patterns of species except for the high altitude vegetation (van Royen 1980) and smaller areas where species lists have been prepared. Recent and comprehensive revisions, if available, would enable us to superficially map the distribution of local endemics, but adequate taxonomic studies are available for few families and most of these are of high altitude plants. Most maps, however, would reflect the lack of collections rather than the distribution of the species. Successional status also has a marked effect on the flora and associated fauna (Bowman et al. 1990, Clarke 1966, 1971). The low figures for biodiversity of epiphytes, published by Kiapranis (1990) for the Gogol plot, reflect the

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history of natural disturbance in the country as noted by Johns (1980b, 1985c, 1986c, 1986d).

The second factor to be taken into account is the origin of the flora. The southern regions of Papua New Guinea have much in common with the vegetation and flora of northern Queensland (Heyligers 1966, 1982, Hoogland 1972). Savanna and monsoon areas are dominated by members of the Myrtaceae: *Eucalyptus*, *Melaleuca*, *Leptospermum* (Johns 1981b), and members of the Proteaceae. At higher altitudes the Gondwanic flora (Johns 1987d) has the characteristic forests dominated by *Nothofagus* (Johns 1974a), araucarias and podocarps, including almost pure stands of *Dacrydium* (Johns 1980a). Mixing with these southern elements are elements from Asia: *Castanopsis* (Johns and Burua 1976, Johns 1986a), *Lithocarpus*, and *Rhododendron* (Stevens 1976, 1982).

The origins and relationships of the lowland rain forest are obscure. Conventional wisdom gave the origins of most genera as the southeast Asian region, but recent studies show that extensive areas of lowland rain forest occurred in northern Australia during the Miocene-Pliocene. Perhaps it is in this fossil flora that we will find the closest relationships of the lowland rain forest flora of Papua New Guinea. Certain elements, such as the Dipterocarpaceae, would seem to be related to the Asian and Western Malesia flora (Johns 1987a, 1987e). A small element of Pacific and South American genera also occurs (*Heliconia* and *Eugenia*).

Local endemic genera comprise the third factor to be considered in preparing the following list. It is important to remember that probably some 60% of the plant species are endemic to the island of New Guinea. As studies progress, it will be important to continuously reevaluate the areas listed, and it is envisaged that considerable expansion will be needed.

List of Major Areas of Biological Importance

The following preliminary list gives some information on the more important areas which are of accepted major conservation value for Papua New Guinea. They are modified from those listed in the Forest Action Plan (Annex 4), which was used as a basis for delimitation of the important areas. The recommendations of Schodde (1973, 1974) have also been taken into account. Notes and recommendations on conservation in Papua New Guinea also have been published by Gagné and Gressitt (1982), and Johns (1976c, 1990a).

1. Torricelli Mts. - Bewani Mts. - Prince Alexander Range
(East and West Sepik Provinces)

An area of lowland rain forest and lower montane forest containing extensive elements in common with Irian Jaya (ant plants, etc.) not known elsewhere in Papua New Guinea. The area includes the endemic fern genus *Rheopteris*, which grows on the limestone flora, and also includes coastal limestone communities. The area reaches an altitude of 1859-2000 m. Species diversity: est. 2000+. Apart from emphasizing the importance of further botanical studies, little can be said about the area (CSIRO Land Research Series no. 30, 1972, and no. 31, 1972).

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2. <u>Central Manus - Mt. Dremsel</u>
   (Manus Province)

This area must include stands with the endemic *Calophyllum* species and *Sararanga* (Pandanaceae) (both endemic species of economic importance), which are threatened by logging activity. An area from Mt. Dremsel to the northern coast should be studied and defined to preserve the unique *Calophyllum* forests. The island has several endemic species, including an undescribed species of *Dillenia*, which is apparently a food plant for the endemic green land snail (*Papustyla pulcherrima*). Species diversity: est. 1500+. Alt. range: 0-700 m (Johns 1989i).

3. <u>Schleinitz Range - Lelet Plateau</u>
   (New Ireland Province)

This area represents the hill and lowland rain forests of New Ireland, with some lower montane elements on the Lelet Plateau. Probably contains many endemics with interesting biogeographical relationships with Manus, the Philippines, and the Solomon Islands. Threatened by selective logging in the lowlands. Species diversity: est. 1500+. Alt. range: 200-1500 m. Poorly known but probably quite diverse. Requires future study.

4. <u>Southern Namatanai</u>
   (New Ireland Province)

This area represents diverse hill and lowland rain forests and lower montane forest. Threatened by selective logging in the lowlands.

5. <u>Star Mountains - Telefomin - Tifalmin - Strickland Gorge</u>
   (East and West Sepik, Western Provinces)

Very diverse montane and high altitude vegetation -- many species in common with the mountains of Irian Jaya. Some information on the vegetation of the Star Mountains is available from reports on the combined trip by Leiden and National Herbarium, Lae. Considerable useful information is also available in the reports on adjacent areas in Irian Jaya (Eipomek). Species diversity: est. 3000+. Alt. range: 1800-3500 m. Considerable potential for tourism. The low population means that extensive areas of lower montane forest could be preserved in this area. (Hiepko and Schultze-Motel 1981, Kalkman 1983, Moi and Johns 1977).

6. <u>Hunstein Range - Burgers Mountains - Schatteburg</u>
   (East Sepik Province, Enga Province)

The area includes extensive stands of *Agathis labillardieri* which support a highly diverse epiphytic flora that includes important historical collecting sites, but otherwise is virtually unknown from the botanical standpoint except for some recent collecticns. It includes the type localities for many species of plants based on early German collections. Species diversity: est. 2500+. Alt. range: 0-2000 m. (Veldkamp 1978, CSIRO LRS no. 22, 1968, CSIRO LRS no. 30, 1972.

7. Mt. Giluwe - Tari Gap - Doma Peaks

(Southern Highlands and Enga Provinces)

Mid- and upper montane forest. Subalpine forest, grassland, and shrubbery. Subalpine bogs extensive. Logging of high altitude forests - *Nothofagus*, *Phyllocladus*, and podocarps. Hunting for bird of paradise plumes, and animals and plants for food. Very rich in plant and animal species. Scenically of exceptional interest. The New Guinea Wild Dog (*Canis familiaris hallstromi*) has attracted interest, but this also lives on Mt. Wilhelm and other high peaks. Ornamentals -- rhododendrons, orchids, ferns. High altitude timber species. One of the largest continuous tracts of montane forest in Papua New Guinea. Species diversity: est. 3500+. Alt. range: 1000-4368 m.

The Tari Gap has mid-montane *Nothofagus* forest, upper montane forest, subalpine forest, and grassland. Local reserves. Tourism, logging along roads. Road access to 3000 m on Tari Pass. Includes volcanic peaks and Ambua Lodge. Majestic *Nothofagus* stands and areas with *Astrapia meyeri*. Many bird and animal species. (Ash 1975, CSIRO LRS no. 27, 1970, Gillison 1970, Kalkman and Vink 1970, Johns 1974a).

8. Kubor Ranges

(Chimbu and Western Highlands Provinces)

Extensive area of high altitude vegetation, much on limestone capped with volcanic ash. Probably local endemics. Fragile ecosystem. Poorly known. Alt. range: to 3969 m. (CSIRO LRS no. 27 1970, Smith 1972).

9. Adelbert Ranges

(Madang Province)

Little known, probably diverse but under considerable threat from local village gardening activities. Considerable disturbance because of earthquake activity. Requires an urgent appraisal. Species diversity: est. 2000+. Alt. range: 0-1800 m. (Johns 1986c).

10. Bismarck Falls (Ramu to Bundi) - Mt. Wilhelm - Mt. Otto - Schrader Range - Mt. Hellwig - Gahavisuka

(Madang, Eastern Highlands, and Western Highlands Provinces)

Lowland swamp and rain forest to alpine vegetation. Extensive areas of montane vegetation. High diversity of ecosystems. Includes Gahavisuka Provincial Park, the proposed Wilhelm National Park - not yet implemented. Population pressure, logging, agriculture - coffee, cardamom, small vegetable crops. Chromite deposits extensive on ultrabasics. An area of major scenic and scientific interest of international importance.

This proposed area covers the complete range of vegetation zones, excluding the coastal and mangrove vegetation and the dryland vegetation, which is only of limited distribution in the upper Ramu Valley. It includes extensive areas of lowland rain forest (including swamp forest), some of which is developed on ultrabasic parent rocks (the only known locality of *Lauterbachia* [Monimiaceae]). All three zones of the montane zone (lower, mid-, and upper) are represented, as well as the subalpine and alpine vegetation types.

This area includes the northern and eastern falls of the major alpine fault which bounds the Sepik, Ramu, and Markham depressions. The region has been collected, especially by the early German expeditions prior to 1915. With the exception of these collections, subsequent work has largely been confined to Mt. Wilhelm, although comparatively few collections come from below 3000 m. Some collections originate from Mt. Otto, and Cruttwell has made detailed collections within the Gahavisuka Provincial Park. The proposed area probably includes in excess of 5000-6000 plant species; alone above 3,000 m on Mt Wilhelm there are some 800 species. Species diversity: est. 5000+. Alt. range: 0-4300 m. (Brass 1964, CSIRO LRS no. 27, 1970, Grubb and Stevens 1979, Hnatuik 1975, Hoogland 1958, Hope 1973, 1976a, 1980b, Johns and Stevens 1972, Smith 1974a, 1975a, 1980b, Wade 1968, Wade and McVean 1969, Walker 1968).

11. Finisterre Ranges
(Madang Province)

Important high altitude forests. Important historical sites for old German collections. Alt. range: sea level to 3773 m. (Jermy and Sayers 1967, Johns 1989b, 1989g, Keysser 1913, Schlechter 1911, 1911-1914).

12. Huon Peninsula - Bangeta - Rawlinson Range
(Morobe Province)

Coastal and mangrove, lowland tropical rain forest lower, mid- and upper montane, subalpine forest and grasslands. The only extensive *Dacrydium* forests in the Southern Hemisphere remaining unlogged. Logging restricted to south coast areas. Dahl (1986: 28) lists this as proposed national park. No immediate threats; logging in lowlands; some traditional gardening. One of oldest known areas of human occupancy in southeast Asia, 40,000 (+) YBP is on the Huon Terraces. The Buweng Timber Rights Purchase (logging area) is at present being logged using helicopters, at a rate of ca. 9000 ha/yr. Hardwoods, orchids, fruit trees, ferns. Species diversity: est. 5000+. Alt. range: 0-4121 m. (Clunie and Croft 1977, Costin, Hoogland, and Lendon 1977, Diels 1929, Royen 1964).

13. Willaumez Peninsula - Lake Dakataua
(West New Britain Province)

A very diverse area of lowland rain forest on recent rich volcanic soils. Road access is now possible to the ridge above Lake Dakataua, and intensive collecting should be conducted to ascertain the diversity of the flora in the Peninsula. Johns and Simaga recently collected a species of *Aristolochia* previously known only from the Arfak Mountains (Irian Jaya) in this area. Threatened by logging and proposed development of oil palm plantations. Species diversity: est. 2000+. Alt. range: 0-1155 m. (Arentz et al. 1989, Johns 1989a).

14. Whiteman Range to Southern Coast
(West New Britain Province)

The Whiteman Range and its foothills support an important tract of limestone flora in New Britain, surrounded by forests developed on sedimentary materials. Little is known of the area, but areas of *Nothofagus* forest occur on the higher plateaus. Field studies are required. Species diversity: est. 3000+. Alt. range: 0-2000 m. (Arentz et al. 1989, Johns 1989a).

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15. <u>Nakanai Mountains</u>
(East New Britain Province)
Lowland rain forest and montane forest, including areas of forest dominated by *Lithocarpus* and *Nothofagus* developed on a limestone substrate. The largest high altitude area in the Bismarck Archipelago. A little known area which requires more detailed studies. Under pressure from logging and agricultural development. Species diversity: est. 2500+. Alt. range: 0-1900 m. (Arentz et al. 1989, Clunie 1976, Johns 1989a).

16. <u>Mounts Sinewit and Burringe</u>
(East New Britain Province)
High altitude mountains on the Gazelle Peninsula with important historical collections. No recent surveys.

17. <u>Hans Meyer Range</u>
(New Ireland Province)
An area with important montane and lowland vegetation. Including *Terminalia brassii* stands. Vegetation is poorly known. Alt. range: sea level-2380 m. This area includes some important lowland and montane forests with a high species diversity (at least for island floras). Future study is required. Species diversity: est. 2000+. (M. Sands 1989).

18. <u>Mt. Balbi to southern coast</u>
(North Solomons)
Largest stands of bamboos in Papuasia. A variety of vegetation types occur, including remnant stands of *Terminalia brassii* in swamp forests. Threatened by logging and possibly sulfur mining. Alt. range 0-2685 m. (CSIRO LRS 20 1967).

19. <u>Lake Daviumbu</u>
(Western Province)
The Lake Daviumbu area and surrounding lakes are fed from the Fly River. They include a high diversity of water plants, probably indicative of their important function as feeding lakes for a large number of migrant waders that feed in this area. Species diversity: est. 1000+. Alt. range: 0-200 m. (Brass 1938, CSIRO LRS 29 1971, Johns and Moi 1977, Leach and Osborne 1985).

20. <u>Wassi Kussa</u>
(Western Province)
Traditional food and medicinal plants. Savanna, monsoon, and mangrove communities. Swamps include *Melaleuca* forest and herbaceous swamp communities. Several wildlife areas are declared in Western Province. None in this area. Introduced deer, possible logging. Traditional gardening; fires. Very important area for conservation of the southern floras, which are closely related to the Australian flora. Very poorly studied. Includes more than fourteen species of *Eucalyptus*. Species diversity: est. 2000-3000+. Altitude range: to 100 m. (Brass 1938, CSIRO LRS 29 1971, Johns and Moi 1977, Leach and Osborne 1985).

21. Mt. Bosavi - Nomad River
(Western and Southern Highlands Provinces)
Lowland rain forests dominated by *Hopea celtidifolia* and *Vatica russak*. Mt. Bosavi has endemic tree species including *Gnetum*. Traditional edible and medicinal plants. Lowland and lower montane vegetation. Also lowland dipterocarp forests dominated by *Vatica russak*. Traditional agriculture; logging in dipterocarp forests. Diverse lowland forest, little known. Coode (pers. comm.) notes that nearly all specimens from Bosavi are "tiresomely different" without actually being distinct. Veldkamp described a new species of *Gnetum*, apparently a local endemic. Species diversity: est. 3,000+. Alt. range: 2000-3000 m.

22. Leonard Murray Mountains - Darai Hills - Great Papuan Plateau
(Gulf and Southern Highlands Provinces)
Tower Limestone Region. This unknown area includes an enormous extent of tower limestone, which is botanically unknown. Limestone floras in southeast Asia are often very rich, and, if the Great Papuan Plateau reflects this diversity, it is most important that detailed studies be made of its flora. The limestone flora is poorly known from New Guinea, but it will include many undescribed species and possibly new generic records. Species diversity: est. ?. Alt. range: 0-1500 m.

23. Mt. Michael - Okapa - Crater Mountain
(Chimbu and Eastern Highlands Provinces)
Araucaria forest (Hoop and Klinki), oaks, traditional medicinal and food plants. Nutmeg. Traditional spirit trees. *Castanopsis* and mixed lower montane forest. Not protected except by traditional owners. Potential threats from logging, traditional agriculture, and expansion of subsistence coffee areas. Traditional hunting for Raggiana Bird of Paradise for sale and trade. Important area of lower montane forest in highlands. Much of this forest destroyed in prehistoric times in major highland valleys. Species diversity: est. 2000+. Alt. range: 300-?50 m. (Jebb 1983, Brass 1944).

24. Galley Reach
(Central Province)
Edible plants, fish and prawn breeding. Firewood. Coastal, mangrove, *Nypa*, and lowland swamp forest. Coastal scrub. Second largest mangrove area in Central Province. Accessible from Port Moresby. Logging possible; firewood collecting; tourism. Mangrove communities reach greatest diversity in Papuasia, and Galley Reach includes most of the species. Species diversity: est. 1000-1500. Alt. range: 0-30 m. (Johns 1986c, Johnstone and Frodin 1982).

25. Menyamya - Aseki - Mt. Amungwiwa - Bowutu - Lasanga - Trist
(Morobe Province)
The Menyamya - Aseki area and the remote area to the east of the Watut Valley are little known. Many interesting plants occur in the forests. The endemic genus *Piora* is recorded only from Mt. Piora and Mt. Amungwiwa. Local endemic *Sericolea*. Species diversity: est. 3000+. Alt. range: 1800-3500 m.

The Morobe Coast - Mt. Missim - Bowutu Mts area supports an ultrabasic flora, lowlands and montane forest. Coastal, mangrove, and seagrass communities. Proposed logging areas. Large potential resource of nickel. Traditional agriculture. Extremely important coastal area with high potential for tourism. Very diverse bird and insect fauna, and important plant species. Little studied. The area is probably the oldest continuously exposed land surface in New Guinea (since Cretaceous times) and deserves detailed study. Species diversity: est. 4000+. Alt. range: 0-2800 m. Hardwoods, orchids, begonias (lowland), ferns, palms. (Brass 1964, Enright 1978, Johns 1974a, 1976b, 1987a, 1987e, Streimann 1983).

26. Owen Stanley Mountains
(Northern and Central Provinces)
This proposed area includes all the high altitude area (upper montane 1600 m to the summits of the mountains along the chain from Mt. Albert Edward and Victoria to Mt. Suckling and Mt. Dayman). Many local endemics occur in the montane flora. Their distributions will remain unknown until detailed collections are made throughout the region. Species diversity: est. 4000+. Alt. range: 1600-3500 m. (Brass 1956, Coode and Stevens 1972, CSIRO LRS 10 1964, CSIRO LRS 32 1963, Hope 1975, Paijmans and Loffler 1972, Royen 1967b, Stevens and Veldkamp 1977, Veldkamp 1978).

27. D'Entrecasteaux Islands
(Milne Bay Province)
The island chain includes many locally endemic species. Detailed collecting will turn up many novelties. Urgent action is required. Normanby Island has a large area of ultrabasic soils in the south with several interesting species, including at least two endemic ant plant species. Species diversity: est. 2500+. Alt. range: 0-2500 m.

28. Mt. Takuan - Tonolei Harbour
(North Solomons Province)
The area should include natural stands of the economically important species *Terminalia brassii*. Bougainville includes a large Pacific element in its flora. A checklist of the flora of Bougainville has been published. Species diversity: est. 1000+. Alt. range: 0-2210 m. (CSIRO LRS 20 1967, Foreman 1971, Johns 1987).

29. Louisiade Archipelago
(Milne Bay Province)
Ever since the Archbold expeditions, the flora of this Archipelago has been recognized as one of extreme botanical interest with high rates of local endemism, particularly at the species level. Brass collected an undescribed genus in the Burseraceae from Rossel Island (since recollected by Katik). It includes important stands of *Diospyros* (including an undescribed ebony) and several locally endemic species of *Hopea*. Many other local endemics are known. Misima has some odd species of ant plants, an endemic *Pandanus*, but the gold mine has had a devastating effect upon the local forests. Tagula has a locally endemic species of *Cyrtosperma*, undescribed endemic species of *Pandanus* grow on Woodlark Island, and another local species of *Cyrtosperma* grows on Rossel.

Both Rossel and Misima have quite fragile ecosystems with very poor soil. Woodlark Island contains several endemic elements (including two undescribed species of *Diospyros*), forming a diverse if slightly depauperate island flora. The southern peninsula of Woodlark Island should be studied because, within this group, it includes the most diverse forests. Most island endemics from this area could then be included. Areas are possibly threatened by mining (gold and copper) and logging, particularly Woodlark Island. Species diversity: est. 3000+. Alt. range: 0-2200 m. (CSIRO LRS 32 1963).

30. Cromwell Mountains
(Morobe Province)
A limestone plateau at ca. 2000 m altitude. This has the largest extant stands of podocarps left in the southern hemisphere. It is dominated by *Dacrydium*. Serious threats occur from logging. Some historical collections were made in the area. The flora is poorly known but probably rich in endemic species and very diverse.

31. Tonda Wildlife Management Area
(Western Province)
Woodland and grassland habitats unique in Papua New Guinea. Dominant tree species are *Melaleuca* and *Acacia*. A very high diversity of species, although intensive grazing by naturalized deer is threatening some edible herbs. (Brass 1938, CSIRO LRS 29 1971).

32. Oriomo
(Western Province)
Undercollected flora closely related to that occurring in the Cape York Peninsula. A rare climatic region for Papua New Guinea. (Brass 1938, CSIRO LRS 29 1971).

33. Gulf - Ihu
(Gulf Province)
A very diverse area of mangrove and swamp vegetation with lowland rain forest on small limestone hills out of the surrounding swamps. These evidently support many local endemics but are virtually uncollected. The area includes numerous species of *Pandanus* and also a rich palm flora, particularly of *Calamus*. Some threat from logging. Important prawn, fish, and crocodile breeding areas. (CSIRO LRS 23 1969, Johns 1988c).

34. Varirata and Astrolabe Ranges
(Central Province)
Includes Varirata National Park. Already established as a national park, this area requires more detailed study and an intensive collecting program to make an inventory of the existing flora. The Astrolabe Ranges include important historical collecting sites. (CSIRO LRS 14 1965).

35. Safia Savanna
(Northern Province)
An interesting area of savanna north of the Owen Stanley Ranges. Little known. (CSIRO LRS 17 1967).

36. Topographers Range
(Northern Province)
A little known region of lowland rain forest to the north of the Owen Stanley Range. (CSIRO LRS 10 1964, CSIRO LRS 12 1964, Paijmans 1966, 1970b, Taylor 1957, 1959).

37. Lake Wanum - Red Hill Swamp - Oomsis Ridge
(Morobe Province)
This very old area of grasslands surrounding Lake Wanum (Garrett-Jones pers. comm.) should be preserved. Red Hill Swamp and the Oomsis ridge include diverse habitats of swamp plants, including swamp forest dominated by *Alstonia spatulata* and ridge forest, with considerable genetic variation in the local populations of *Anisoptera thurifera* var. *polyandra*. (Johns 1970, 1987a, 1987e).

38. Porgera Peaks
(Enga Province)
A high altitude plateau above 3000 m. No collections are known from the area. (CSIRO LRS 15 1965).

39. Kiunga - Palmer River - Victor Emmanuel Range
(Western Province)
A very diverse area of lowland rain forest with lower montane elements such as podocarps and *Lithocarpus*. It includes significant numbers of species in common with the forests of Irian Jaya. Some collections, but generally poorly known. (CSIRO LRS 29 1971, Ridsdale 1968, Johns and Moi 1977).

40. Milne Bay - Collinwood Bay - Southern Coast
(Milne Bay Province)
An important area of lowland rain forest, rising to 3670 m on Mt. Suckling, 2980 m on Mt. Simpson, and 2880 m in Mt. Dayman. Also included are important areas of lowland rain forest in Collingwood Bay and on the Southern coast. (Brass 1956, CSIRO LRS 32 1963).

41. Gogol - Sogeram Headwaters
(Madang Province)
This area is adjacent to the logged lowland rain forest of the Gogol, the site of many historical collections in the Madang Province. The area is not collected, but many of the local species probably occur in these upper catchments. Important area of lowland forest for study. (Driscoll 1984, Johns 1975a, 1989g, Kiapranis 1990, Lamb 1991, Saulei 1988a, 1989, Saulei and Swaine 1988).

42. Lower Watut
(Morobe Province)
A little known area of lowland rain forest. If the area is extended along the eastern ridges of the Watut Valley it will include populations of the endemic root parasite *Langsdorfia papuana*, the genus otherwise known only from Madagascar, and Central and South America. Locally the genus is known only from the Watut Valley. No collections known but adjacent areas have species lists. Some mining developments are occurring in the area.

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At the northern end of the river, where it joins the Markham River, there are extensive areas of lowland swamp forest. (Johns 1970, Streimann 1983).

43. Cloudy Mountains
(Milne Bay Province)
The most southerly mountain range in Papua New Guinea. No collections are known from the area. Urgently needs study.

CONSERVATION OUTSIDE MAJOR PRIORITY AREAS

Many distinctive vegetation types and plant species with limited distribution require protection. In many cases these will not occur in areas of high biodiversity, and it is important to recognize their importance for the conservation of the flora of Papua New Guinea. An excellent example is the forest dominated by *Dacrydium nidulum* var. *araucoides*, which occurs in a small area in grassland plains south of Mendi (Johns 1980a). Stands of this species previously occurred in the region of Tari, but these were extensively logged as a source of building timber. Small stands are also reported from Irian Jaya. This unique stand south of Mendi should be preserved. A similar case occurs with the remnant stands of *Eucalyptus deglupta* on New Britain.

Parkia versteegii is a rare legume pollinated by bats. A small stand of this species grows near Kokin village in the Gogol Valley. It is important to conserve such sites. A list of 99 sites has been prepared so that these areas can be mapped (Appendix 14-2) and taken into account in the Conservation Needs Assessment.

ACTION PROPOSALS FOR PROPOSED AREAS OF BIOLOGICAL IMPORTANCE

A concentrated collecting program is required in each of the areas listed. The only way to properly document the biodiversity is to engage in such a program. Due to the limited resources available within Papua New Guinea for the mounting of such trips, it will be necessary to both give priority status to some areas and to fund the field studies from external sources. A detailed botanical report should be produced for each area and include information on the vegetation types and their distribution, natural boundaries, geological and climatic data, and a detailed list of all species (citing collection numbers) occurring in each area.

An important component of any project will involve future training of local staff in collecting, field description, identification, and the processing of duplicates. It is suggested that the resources initially be aimed at the designated high priority areas. With the low intensity of collecting, even in better known areas, most regions will continue to produce important novelties.

Introduction of a detailed collecting program for each area would involve several botanists, plus support staff, collecting in each area for periods of up to three months.

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Staffing would also be required for the detailed study and identification of the specimens. A detailed species database should be set up for the collections: this would be partly based on the information already published by Johns (1987 - Magnoliidae, 1988 - Hamamelidae, 1989 - Caryophyllidae: In prep. 4 Dillenidae, 5 Rosiidae, and 6 Asteridae). Such a database would enable rapid production of species lists for the proposed areas and, in addition, provide an excellent basis for the production of a Flora of Papua New Guinea in a format and at a cost which would make it available within Papua New Guinea.

Production of a Flora of Papua New Guinea (probably best treated as a series of family fascicles) could be funded as a collaborative project between the National Herbarium in Lae, Papua New Guinea, and a major overseas collaborating herbarium. This preferably would be a herbarium with a strong interest in southeast Asian botany, with access to available collections of historical material. A strong training component should also be included in such a project. The only long-term basis for preserving the biodiversity of the flora of Papua New Guinea is to educate and train a cadre of national counterpart botanists who can help make the populace of PNG fully aware of their most important heritage. Funding of a Tree Flora of Papua New Guinea could attract funding as part of such a project.

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Figure 14-1. Major areas important for botanical diversity in Papua New Guinea. Darker shaded areas are judged to be of highest priority. See text for key to numbered areas.

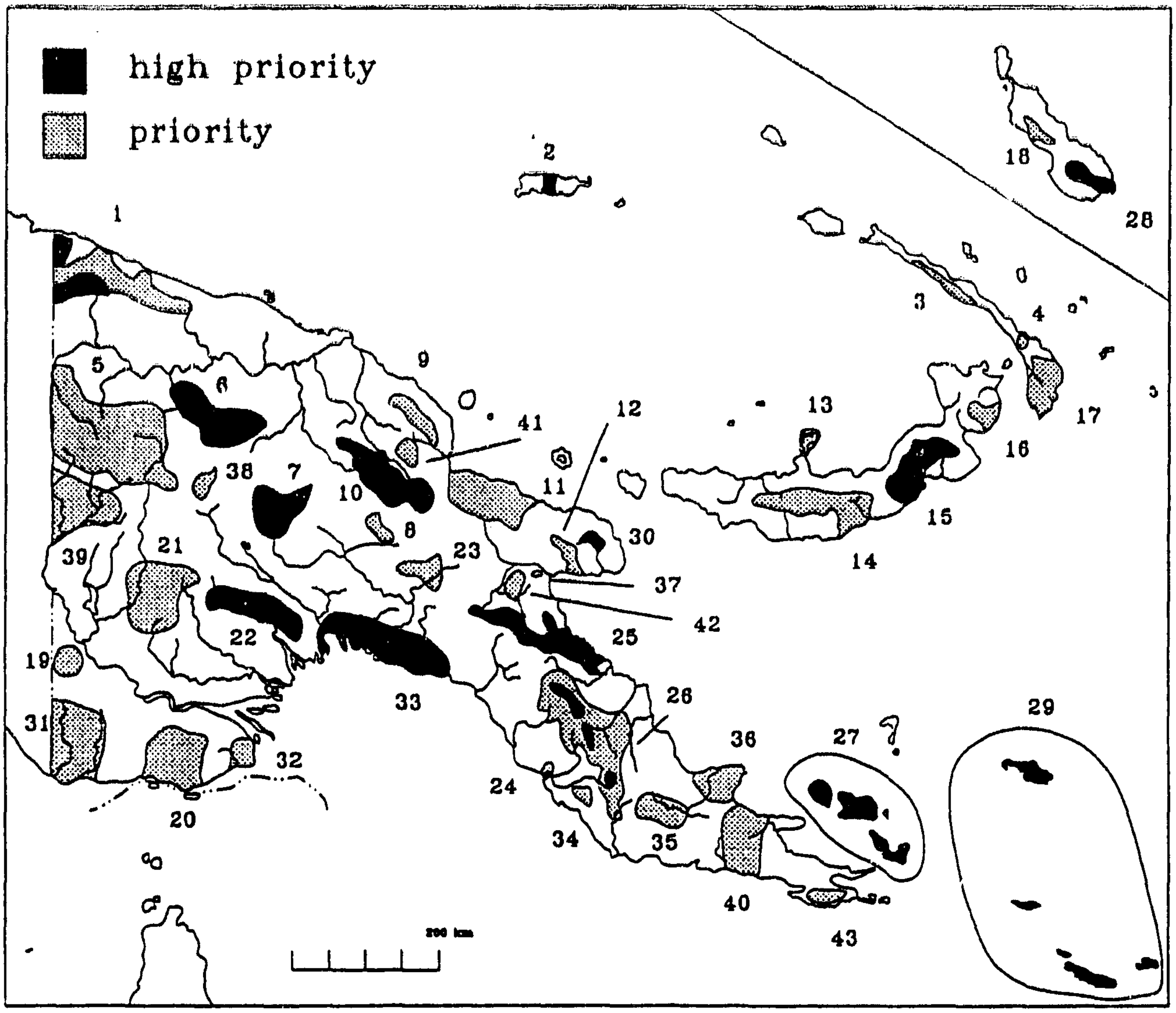

Figure 14-2. A comparison of the major systems of classification published for the vegetation of Papua New Guinea (modified from Johns 1984).

JOHNS (1972, 1976)	PAIJMANS (1976)	WALKER (1973)	CLUNIE (1976)	BRASS (1959)	LANE-POOLE (1925)
Coastal Vegetation	Beach ridge and flats		Littoral and Beach Vegetation		
Mangroves	Saline and Brackish Swamps			Mangroves	Mangrove Forest
Anthropogenic Grassland	Grassland		Grassland	Grassland	Grassland
Swamp Vegetation	Lowland Fresh Water Swamps		Swampland. Tree and Palm		Swamp Rainforest
Savannah	Lowland Alluvial Plains and Fans		Dry Evergreen Forest and Woodland Savannah	Savannah & Savannah forest	Rain Forest
Monsoon				Monsoon	
Lowland Tropical Rainforest			Alluvial Forest	Rain Forest	
	Hills and Low mountains		Lowland Rain Forest		
Lower Montane		Lower Mountain	Lowland Hill Forest		Foothill Forest
	Lower Montane		Lower Mountain		
Mid Montane			Mid Mountain	BEECH FOREST / Mossy Forest	Mossy or Cloud Forest
Upper Montane	Upper Montane	Upper Mountain	Upper Mountain		
Sub-alpine Forest and Grassland				Sub-alpine Forest	High Mountain Forest
Alpine			Sub-alpine	Alpine Grassland	Alpine Grassland

APPENDIX 14-1. LIST OF ENDEMIC GENERA IN PAPUASIA

Mosses
Crepidophyllum
Cryptodicranum
Orthothuidium
Pseudopiloecium
Inouethiudium

Pteridophytes
Papuapteris (2)
Rheopteris (1)

Gymnosperms
Papuacedrus (1-2)
Gen Nov. (ex Dacrydium)

Angiosperms
Acanthaceae
Calycacanthus (1)
Gymnophragma (1)
Hulemacanthus (1)
Jadunia (1)

Annonaceae
Oreomitra (1)
Petalolophus (1)
Schefferomitra (1)

Apocynaceae
Delphyodon (1)
Papuechites (3)

Araceae
Holochlamys (1)

Araliaceae
Anakasia (1)

Asclepiadaceae
Papuastelma (1)
Quisumbingia (1)
Spathidolepis (1)
Streptomanes (1)

Begoniaceae
Symbegonia (15)

Bignoniaceae
Lamiodendron (1)
Boraginaceae
Crucicaryum (1)

Burseraceae
Gen. Nov. (1) Rossel Is.
Campanulaceae
Ruthiella (5)

Celastraceae
Brassiantha (1)

Compositae
Brachionostylum (1)
Ischnea (5)
Papuacalia (14)
Piora (1)

Cunoniaceae
Aistopetalum (2)

Elaeocarpaceae
Sericolea (16)

Epacridaceae
Decatoca (1)

Euphorbiaceae
Annesijoa (1)
Kairothamnus (1)
Octospermum (1)

Gesneriaceae
Sepikea (1)

Gramineae
Buergersiochloa (2)

Icacinaceae
Pseudobotrys (2)

Loranthaceae
Distrianthes (3)
Papuanthes (1)
Rhizomonanthes (1-2)
Tetradyas (1)

Melastomataceae
Dicerospermum (1)

Menispermaceae
Chlaenandra (1)
Macrococculus (1)

Monimiaceae
Faika (1)
Kairoa (1)
Lauterbachia (1)

Moraceae
Antiaropsis (1)

Myrsinaceae
Fittingia (5)

Myrtaceae
Basisperma (1)
Octamyrtus (6)

Opiliaceae
Gjellerupia (1)

Orchidaceae
Calymmanthera (3)
Chitonanthera (11)
Chitonochilus (1)
Codonosiphon (3)
Cyphochilus (7)
Dryadorchis (2)
Guilianettia (7)
Hymenorchis (6)
Ischnocentrum (1)
Kerigomnia (1)
Papuaea (1)
Porphyrodesme (1)
Saccoglossum (2)
Sepalosiphon (1)

Palmae
Actinorhytis (2)
Brassiophoenix (2)
Ptychoccus (7)
Sommieria (3)

Proteaceae
Finschia (3)

Rubiaceae
Anthorrhiza (9)
Chaetostachydium (1)
Maschalodesme (2)
Pachystylus (2)
Rhadinopus (1)
Siphonandrium (1)
Versteegia (1)

Rutaceae
Clymenia (1)
Monanthocitrus (2)

Sapotaceae
Krausella (4)
Magodendron (1)

Scrophulariaceae
Detzneria (1)

Theaceae
Archboldiodendron (2)

Tiliaceae
Eleutherostylis (1)

Urticaceae
Gibbsia (2)

Verbenaceae
Archboldia (1)

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APPENDIX 14-2. LIST OF ADDITIONAL SITES OF BOTANICAL IMPORTANCE

Area	Locality	Notes
1.	S of Mendi	A unique area of *Dacrydium nidulum* var. *araucarioides* swamp forest. This forest type was originally rare near Tari and in Wissel Lakes (Irian Jaya). Stand has size of ca. 5 ha. (Johns 1980a).
2.	Mid-Waghi	The only remnant stand of lower montane *Castanopsis* forest in the Waghi Valley. Important stand - local traditional value. Only extensive indicator of original highlands vegetation still extant in valleys. (Not studied).
3.	Lake Kutubu	*Araucaria* swamp forest. Small stand of distinctive swamp vegetation - only swamp site known for genus in Papuasia (see Gray 1973).
4.	Manus	Small stand of mangroves including the only site in Papuasia for *Merope angulata* - previously known only from the Philippines.
5.	Waghi-Jimi Divide	Extensive ridge top stands of *Nothofagus* with emergent *Pandanus antaresensis* to 33-35 m tall. Unique habitat although both species widespread.
6.	Lake Kutubu	Low altitude *Nothofagus* spp. forming pure stands at c. 400 m altitude. Compare with normal range above 1700-2000 m in Central Highlands. Unique associated flora.
7.	Lake Murray Catchment	Important (extensive) stands of dipterocarps (*Hopea celtidifolia*, *Vatica russak*), *Lithocarpus* (low alt.), *Elmerrillia tsiampacca*, etc. Important to conserve dipterocarp genotypes.
8.	Sattelberg	Very important historical sites for early German collections (only a small area not destroyed by coffee pltn.) Still includes only known localities for many species and genera such as *Petalophus* (*P. megalophus* - Johns 1990).
9.	Karkar I.	Central area of Karkar covered by rain forest and successional vegetation. To conserve slipper orchid areas (if any remain) and also local endemics such as *Turpinia pentata*.
10.	Long Island	Successional vegetation on Volcano, with diverse habitats.

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11.	Manam Island	An important area of successional vegetation. Also very important sites for selection of local trees with edible fruits.
12.	Buka Island	To emphasize an important area for local cultivars of *Barringtonia*. Most diverse site in Papuasia (Jebb).
13.	Kerevat	An internationally important collection of native fruiting plants and cultivars of agricultural crops.
14.	Lae Botanic Gardens and National Herbarium	Nationally and internationally the most important collection of the native plants of Papua New Guinea in cultivation. The National Herbarium is the major repository for the collections from Papua New Guinea and the Solomon Islands.
15.	Mt. Shungol	A small area of montane forest with a high degree of local endemism including species of *Agapetes*. Rich flora with many species of Hymenophyllaceae.
16.	Wagau Swamp	Mid-altitude basin with many areas of successional swamp vegetation and areas of *Pteridium*, tree ferns, etc.
17.	Lake Wongri	Small lake in southern foothills of the mountains with mineralization in local area. Five species of duck recorded on lake (Lamothe pers. comm.). Also areas of old *Araucaria* trees.
18.	Upper Markham	Savanna areas in the upper Markham area with associated grassland and herb spp. Epiphytic orchids (*Dendrobium* sp.) previously abundant.
19.	Upper Ramu	Savanna areas - as 18.
20.	Lower Markham	Important freshwater swamp forest dominated by *Sonneratia caseolaris*.
21.	Sialum Grasslands	An area of diverse grasslands along the Sialum terraces.
22.	Crater Lake	Lake Onim, south of Giluwe. A high altitude lake with a rich flora surrounded by *Nothofagus* forest.
23.	Mt. Erimbari	Highest altitude forests dominated by *Nothofagus* in Papua New Guinea. The "forest" is a short shrub type of 1-2 m height. Unique.

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24.	Chuave-Kundiawa Road	Limestone cliffs and pinnacles. Includes a diverse flora of the cliff faces incl. several undescribed species (*Asplenium*) and pure stands of *Araucaria* on small limestone knoll.
25.	Ramu Plain	An area of swamp forest to the east of the lower Ramu, very rich in canopy palms.
26.	Aseki Area	Limestone areas with distinct flora and isolated buttes with a rich flora and forests dominated by *Casuarina*.
27.	Chimbu Gorge	Limestone flora on cliffs. Also rock paintings on cliff faces.
28.	Area not localized	Important locality for *Paphiopedilum praestans* in diverse limestone areas.
29.	Waria Valley	Remnant areas of *Paphiopedilum violascens*.
30.	Mt. Lamington	Secondary succession on recent volcanics including summit area with *Rhododendron*.
31.	Lake Myola	Diverse grassland valley including only known site of *Arthropogon* (grass) in New Guinea (1 collection).
32.	Kokin Village	One of few sites of *Parkia versteegii* in Papua New Guinea.
33.	Oomsis-Gabensis	Very high diversity of genotypes of *Anisoptera thurifera* var. *polyandra*.
34.	Kairuru Island	A small very diverse island with an interesting montane forest along central ridge. Flora (1200 + species) (William 1989).
35.	Umboi I.	Coastal savanna vegetation with *Cycas rumphii* and *Albizzia*. Also a diverse associated grassland flora.
36.	Embri Lakes	Interesting swamp area with surrounding forest and lake plants (1922).
37.	Talasea Geothermal Region	Interesting successional communities associated with local area. *Nepenthes* and diverse fern flora.
38.	Wulai Island	Diverse orchid flora including local endemic *Dendrobium wulaiensis*.

39.	Mussau Island	Locally endemic flora.
40.	North Coast, Madang	Area with *Aristolochia schlechteri* and associated fauna in good lowland forest.
41.	Lavangai Harbour - New Hanover	Only known locality of *Aristolochia gaudichardii*.
42.	Felspitze	Important historical collecting locality by Lauterbach.
43.	Etappenberg	Important historical collecting locality by Lauterbach.
44.	Lordberg	Important historical collecting locality by Lauterbach.
45.	Schrader Mts.	Important historical collecting locality by Lauterbach.
46.	Hood Lagoon Region	Area of dense *Cycas circinnalis* (CITES).
47.	Kalo/Aroma	Coastal sand dune vegetation.
48.	Port Moresby	Rich water plant communities - *Caldesia oligococca*. In seasonal swamps.
49.	Sirinumu Dam	*Aponogeton loraie* (local endemics).
50.	Oriomo River	*Aponogeton womersleyi* - local endemic species.
51.	Kikori River	*Cryptocaryne versteegii* local sp.
52.	Hisiu	Complex of fresh water aquatics - unknown and surrounding savanna/rain forest vegetation.
53.	Mt. Ialibu	High peak with diverse vegetation surrounded by *Lithocarpus* on N side and rich vegetation with *Pandanus* on S side.
54.	Ihu	Only locality of *Wolfia globosa*.
55.	Murua	Extensive ground communities dominated by seasonal communities of *Curcuma*.
56.	Rouna Falls	Classical collecting locality. Genera such as *Torrenticolla*.
57.	Modeni	Locality of undescribed species of *Potamogeton*.

58.	Gogol Valley	Two undescribed species of *Friesodielia* collected from this locality.
59.	North New Britain	Extensive remnant stands of mature *Eucalyptus deglupta* with heart rot, so unlogged.
60.	Kairuku-Gulf	Important savanna, monsoon communities. Unstudied.
61.	Nissan I.	Stands of *Metroxylon salomonensis*.
62.	Kani Ranges	Locality of Schlechter Types including *Oncodostigma* and *Oreomitra*.
63.	Goilala	*Wilkea foremanii* - local endemic.
64.	Tokeamaima	Pure stands of *Avicennia marina*.
65.	Sepik	Only known locality of *Ceuthostoma* in Papua New Guinea.
66.	Gabagaba	*Tecticornia* - only locality.
67.	Port Moresby	Dry edge mangroves - *Aegialites annulata* and *Osbornia octadonata*.
68.	Murik Lakes	Extensive mangrove forests and rain forest in poorly drained areas.
69.	Passam High	Area of *Elmerrillia tsiampacca* forest with *Licuala* sp. forming a dense subcanopy to 3 m tall.
70.	Hood Lagoon	Mangroves.
71.	Cloudy Bay	Mangroves.
72.	South of Finschhafen	*Hanguana* wet land.
73.	Fly Islands	Several seagrasses including an indet. species.
74.	Motupori I.	Sea grass beds.
75.	South Daru I.	Only record of *Zostera* from Malesia.
76.	Tami	Old collecting locality. Also a rich area for sea grass communities.

77.	Central Province and Gulf Province Border	Extensive areas of undisturbed savanna and lowland rain forest
78.	Kuvuna	Sandalwood areas - locality of *Santalum macgregorii.*
79.	Kassam Pass	Important zonation from savanna and lowland tropical rain forest through patches of *Castanopsis* and *Araucaria* forest to ridge top patches of *Nothofagus* above the road to the south of Kassam Pass.
80.	Yonki Dome	Area of midmontane forest with lower margin of *Castanopsis* into mixed mid-montane and ridge *Nothofagus* forest.
81.	Aiyura (ridges to south and southeast of Aiyura NHS)	Ridge top *Nothofagus* area with diverse epiphytic communities including an undescribed species of *Loxoscaphe.*
82.	Lake Murray	Important area of freshwater vegetation including *Blyxa* spp., savanna and monsoon forest.
83.	Kiunga	Very diverse border communities rich in species from Irian Jaya.
84.	Omaru Plateau	Limestone vegetation on Pleistocene reef areas.
85.	Upper Watut	Montane forests rich in parasitic plants *Balanophora, Langsdorffia papuana* and *Santalaceae.*
86.	Markham Point	Low level upper montane forest with Podocarpaceae, to lowland tropical ridge forest. Alt. range to 1800 m.
87.	Labu Lakes	Rich lowland swamp and mangrove forests including pure *Nypa* stands.
88.	Manus I.	Many endemic species including two spp. of *Calophyllum* of high commercial value.
89.	Kavieng	Presence of *Rhizophora lamarckii* - very rare in New Guinea.
90.	Lihir I.	Bamboo thickets on island with associated orchid flora.

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91.	Karkar I., and coast north of Madang	Heavy use of galip spp.
92.	Coastal strip between Lae and Finschhafen	Galip nuts, *Barringtonia* spp., also taro cultivars.
93.	Markham Valley, esp. NW of Leron River	Cultivated *Musa* with very many cultivars; main food plant in large perennial banana plantations.
94.	Umi River headwaters and Leron Valley	*Pandanus* (marita) - many varieties.
95.	Highlands, general	Very great variety and diversity of sweet potato cultivars.
96.	Sepik area, Milne Bay islands, Markham Valley	Yam species and a number of cultivars.
97.	Guavi and Wavoi Rivers	Four species of wild rice.
98.	Hawoi River	Low altitude tall montane forest.
99.	Padi-Balima	Mature *Eucalyptus deglupta* stands.

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APPENDIX 14-3. BIBLIOGRAPHY OF THE VEGETATION AND PLANT ECOLOGY OF PAPUA NEW GUINEA[2]

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[2] Note: Consultancy Reports are available at the Department of Environment and Conservation, Port Moresby. Unpublished reports from the PNG Botanical Society are available in the Libraries at the P.N.G. University of Technology, Lae and in the University of Papua New Guinea, Port Moresby.

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Chapter Fifteen

Biodiversity and Conservation of the Warm-Blooded Vertebrates of Papua New Guinea

Bruce M. Beehler[1]

SUMMARY

Based on available knowledge of the distribution and ecology of birds and mammals in Papua New Guinea, and knowledge of the patterns of species richness and localized species endemism, an assessment is made of the disposition of biologically important areas for the nation. These selections are further influenced by analysis of data on (a) species rarity, (b) ecologically fragile habitats and communities, (c) rare and vulnerable species, (d) major wilderness areas, (e) biologically unsurveyed areas, and (f) a delineation of biogeographic districts within PNG. From these analyses, an array of thirty areas representing the richest and biologically most important areas for birds and mammals has been selected (Figure 15-8).

To ensure the conservation of PNG's rich biological diversity, the following recommendations are made, based on our analysis of warm-blooded vertebrates: (a) the Department of Environment and Conservation (DEC) should focus on developing a system of large conservation areas to serve as a biological reserve for the nation; (b) the conservation areas should be large (>8000 km^2), locally owned but administered with the assistance of DEC; (c) the system should reflect the consensus of biologically important areas developed at the CNA Workshop; (d) PNG's current legislation on conservation areas and species conservation needs to be simplified, made more practical, and be based on local conditions and practical enforceability; (e) we endorse the notion of an environmental levy, the proceeds of which should be placed in an environmental trust fund for PNG, to be administered by an independent board; the funds would be disbursed locally to support efforts that would promote the study and conservation of biodiversity in PNG; and (f) we propose that the Government of Papua New Guinea (GoPNG) develop a formal program to encourage conservation biology studies of PNG's threatened species of birds and mammals.

CORRESPONDENT TEAM

This analysis was conducted with the assistance of Professor Jared M. Diamond (UCLA School of Medicine), Dr. Timothy Flannery (Australian Museum), Mr. James I.

[1] World Conservation International and Conservation International, c/o Division of Birds, Smithsonian Institution, Washington, D.C., U.S.A.

Menzies (University of Papua New Guinea), Mr. Lester Seri (Department of Environment and Conservation), and Dr. Richard Schodde (CSIRO, Canberra).

ORNITHOLOGY IN PNG

Birds are, without question, the best known animal group in Papua New Guinea. This has a clear historical cause, as the birds and butterflies were the two groups of greatest interest to the many European closet naturalists of the nineteenth and early twentieth centuries. Many pioneering expeditions to the New Guinea region were financed by sedentary European naturalists eager to describe new species brought back from the Far East by pioneering commercial field collectors.

In the last fifty years, PNG's birds have received considerably more professional attention than the butterflies, thanks, primarily, to ornithologists such as Ernst Mayr, E. Thomas Gilliard, Austin Rand, Tom Iredale, Fred Shaw Mayer, Jared Diamond, Richard Schodde, and others (see bibliography, Appendix 15-2).

Initial studies focused on collecting specimens from previously unsurveyed sites. In more recent years, studies have broadened to include behavior, ecology, and island biogeography. In the last decade, a knowledgeable array of amateur field ornithologists (e.g., Brian Coates, Brian W. Finch) have made significant contributions, and this has been expanded by the survey work carried out by the Department of Environment and Conservation, Biology Department of the University of PNG, and the National Museum and Art Gallery.

Today, the avifauna of Papua New Guinea can be described as well known, as evidenced by the availability of the remarkably comprehensive, two-volume Birds of Papua New Guinea, authored by Brian Coates (1985, 1990), complemented by a multi-authored field guide to the birds of New Guinea (Beehler et al. 1986). Field work continues in two forms. Locally-based ornithologists (amateur and professional) conduct a variety of field studies based primarily on banding and mist-netting forest bird populations, and overseas fieldworkers conduct short-term, intensive studies primarily focusing on distribution, sociobiology, systematics, and evolutionary problems.

MAMMALOGY IN PNG

The knowledge of the mammals of Papua New Guinea has lagged behind that of the birds. The mammals, with a few exceptions, are far more difficult to observe and enumerate. This is because they are, unlike birds, primarily nocturnal, cryptic and nonvocal, and generally more difficult to trap. Mammals received only minor attention on many of the early expeditions, so this whole group of vertebrates did not receive the intensive surveying that would have been required to produce equivalent results that were being achieved for the more visible and colorful birds and butterflies.

The single major effort in which mammals were not slighted was the series of Archbold Expeditions conducted in the 1930s through 1950s (mammalogists Richard Archbold, G. H. H. Tate, and Hobart van Deusen). These were expedition based, systematic collecting efforts, with the prime objective being the description of new taxa and documentation of their distribution in New Guinea and neighboring islands. Our knowledge of the details of species level systematics of the mammals of Papua New Guinea is only now receiving the more in-depth, population- and country-wide attention that it merits. New species are described annually, and species groups are being reworked, with the net effect that there is considerable nomenclatural and taxonomic instability, with multiple (often conflicting) treatments available. This ferment adds confusion to the literature, but is a sign that progress is being made.

Two signal events have taken place in PNG mammalogy in the last several years. These were the publication of Mammals of New Guinea, by T. F. Flannery (1990), and A Handbook of New Guinea Marsupials and Monotremes, by James I. Menzies (1991). Thus we now have available important compendia of systematic, bibliographic, and natural history data on regional mammals in a form most useful to conservation analyses.

Today's mammalogical studies in PNG, both by in-country and overseas workers, focus almost exclusively on distribution, systematics, and evolutionary studies. To a smaller extent there have been studies of ecology and population biology. With regard to synthetic knowledge of the biology of the living animals in their natural habitat, the birds remain better known than the mammals.

MAJOR GAPS IN KNOWLEDGE

Ornithology

The major gaps in our ornithological knowledge can be broadly classified into four groups: (a) distributions, (b) populations, (c) life cycles, and (d) movements.

Distributions: This can be subdivided into two types: general distributional patterns and species distributions. Our ignorance of general patterns relates to our failure to fully analyze the distributional patterns of birds on mainland New Guinea and on New Britain. This, in part, can be blamed on inadequate field surveying. A number of publications (especially Diamond 1972, 1974, 1975, and publications cited therein) have drawn some generalizations about the biogeographic patterns exhibited by birds in PNG, but this requires refinement that will be based on future field study and laboratory analysis.

Major questions remain: Just where are the major distributional breaks on mainland PNG and what causes (or caused) them? What are the distributional patterns of endemic bird species on New Britain? What is the pattern of distribution of montane birds in New Britain?

For purposes of conservation, individual species patterns focus on the larger and rarer species. What can explain their particular distributions today? For those bird species that exhibit seemingly anomalous ranges (e.g., Blue Bird of Paradise [*Paradisaea rudolphi*]

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ranging westward only to Tari and being absent from segments of eastern Papua [Figure 15-1]), what factors have promoted such range abbreviation? Why do ranges end abruptly even though forest types appear to continue, uninterrupted for hundreds of kilometers? What causes patchiness of distribution? What limits the occurrence, for instance, of Pesquet's Parrot (*Psittricyhas fulgidus*), which, though widespread, is present in some locales and absent elsewhere? To answer these questions will require active species-level investigation in the field, and will form the basis of future studies in PNG conservation biology.

Populations: For species endemic to PNG there are virtually no population estimates, even of the rarest and most obvious forms, such as the New Guinea Harpy-Eagle (*Harpyopsis novaeguineae*) or Southern Crowned Pigeon (*Goura scheepmakeri*). These data are required before meaningful species action plans can be formulated. We would argue that action plans are needed for some of PNG's rarer vertebrates.

Life Cycles: We know nothing of the population dynamics of the large and/or rare species that inhabit PNG. These data are critical to determining objectively whether a species is potentially in trouble or not. Witness the preliminary data we have for some of the lek-breeding birds of paradise. Tens of thousands of *Paradisaea* skins were exported annually from New Guinea at the turn of the century, and there were great fears for the future of these bird species. We now know that, because of the behaviorally-mediated delayed plumage development by males in the lek-breeding species, the culling of plumed males still allows full-scale reproductive activity to continue (with unplumed subadult or non-lek-attending males inseminating females when necessary). These species thus have a natural population "buffer" in their life cycle, and hence were never really threatened by culling for the plume trade.

Quite a different phenomenon might threaten other species and hide the evidence of threat, as with monogamous, long-lived species exemplified by a large forest eagle like *Harpyopsis*. In this scenario, some aspect of nesting and reproduction might create critical vulnerabilities in populations. And because the adults may live for decades, the evidence of a population decline (from failed reproduction) might not become obvious until the situation is beyond redemption. If, in fact, the New Guinea Harpy-Eagle raises but one offspring every two or three years, it means the potential for rapid population increase simply does not exist for this species. Thus knowledge of age structures, age of first reproduction, clutch size, and offspring raised per annum are of critical importance for gauging threat.

Seasonal or Age-related Movements: Bird species that migrate between Australia and Papua New Guinea constitute a well-known regional phenomenon, but what of within-country movements? Montane species, especially those depending on fruit and nectar resources make significant, but poorly documented, elevational and geographic movements. Different age groups move in differing patterns, and El Niño events may influence major nonannual movements. We require a better grip on these phenomena if we are to design conservation areas that are to protect a fauna that is not sedentary.

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Mammalogy

For mammalogy, our ignorance is an order of magnitude greater than that for the birds. Mammalogy in PNG is perhaps 30 years behind ornithology, so the potential for study and discovery is truly remarkable at this time. This splendid opportunity for graduate students and field researchers from within and without PNG does mean, however, that our knowledge is very weak when it comes to the facts needed for conservation action. The statements made for birds above (Geography, Populations, Life Cycles, Movements) apply to the mammals, but probably require additional amplification. Examine the distributional maps that appear in Flannery's book. For so many mammals, each species range is but a few scattered dots, often far-flung, with no apparently clear biogeographic pattern (see, for instance, many of the bat ranges).

Considerable field surveying has been conducted by the Department of Environment and Conservation, but these data have not been adequately assembled and analyzed. In some cases it will be necessary to go back into the field and systematically make specific site-based collections of mammals. This would serve several valuable purposes, not the least of which would be to determine the natural ranges of these mammals. It would also train a generation of PNG field biologists, provide material for study and higher degrees, augment the PNG museum collections (which are now incomplete), and encourage the initiation of a PNG biological survey, which also is badly needed. All conservation is based, initially, on biological data. For mammals, we need to collect this basic information, preferably in a systematic fashion.

The tree kangaroos are a prime example. *Dendrolagus goodfellowi*, endemic to the PNG mainland, seems to be quickly extirpated from areas where there has been chronic hunting, even by remarkably small human populations. It appears that a hunter with companion hunting dogs spells doom for this tree kangaroo except in the areas where hunters rarely or never visit. There is almost certainly a biological basis for the extreme vulnerability of this tree kangaroo -- a vulnerability that apparently is not shared by *Dendrolagus dorianus*, whose populations appear much more resistant to overhunting (perhaps because of differing elevational distributions?). We need to study the two species in the field and determine why one is threatened and the other not. These scientific data may provide the insight to allow us to develop a practical conservation strategy for the threatened species. But until we gather these data, the point is moot.

In sum, for the mammals the needs are twofold: more systematic field surveys, and new studies in population biology of the larger, potentially threatened species.

UNIQUE FEATURES OF THE FAUNA

Birds

What about the bird fauna of Papua New Guinea makes it so remarkable? PNG's endemic species (Table 15-1) occur in no other nation on earth. Their survival depends entirely upon the people and government of PNG. Of the 76 bird species endemic to Papua

New Guinea, 12 are confined to New Britain, and 14 to the PNG mainland. They are treated in greater detail in a later section.

Equally important are the major lineages that have achieved their primary radiations in Papua New Guinea. Thirty-one species of birds of paradise (Paradisaeidae) inhabit Papua New Guinea. PNG supports the richest radiation of kingfishers on earth (26 species), exhibiting the greatest range of morphologies and habits. PNG supports important radiations of fruit-pigeons (*Ptilinopus*, *Ducula*), parrots (*Charmosyna*, *Psittacella*, *Chalcopsittu*, *Micropsitta*), and honeyeaters (Meliphagidae). These lineages constitute globally important biodiversity, and must be considered in any long-term conservation strategy.

Mammals

Some 56 species of mammals can be considered technically endemic to PNG (Table 15-2). Of these, the list "true endemics" is probably closer to 35, when one excludes species that range westward to the Irian border but which, for lack of collecting, have not been recorded in Irian Jaya. More species of *Dendrolagus* tree kangaroos inhabit PNG than any other country. The two extant genera of echidna (*Zaglossus*, *Tachyglossus*) inhabit PNG. The murid rodents and pteropodid fruit bats probably achieve their greatest species richness in Papua New Guinea. Finally, PNG, without question, supports the richest forest-dwelling marsupial fauna on earth.

DATA FOR ASSESSMENT

Our analysis is based on compilation of a series of data sets relevant to biodiversity and ecological biogeography in Papua New Guinea. These include restricted groups of birds and mammals that are particularly relevant for conservation analysis; data on regions needing survey; data on regional species richness; regional disposition of endemic species; rare species; ecologically critical or unique areas; ecologically fragile areas; economically important species; known threats; and the location of major wilderness areas in PNG.

Taxonomic and Ecological Focus

For purposes of analysis, we have selected a series of bird and mammal sample groups, based on rarity, endemism, and potential threat at species and populational level. These, then, constitute the initial data set that will provide the guidelines necessary for selecting the biologically important areas for PNG.

I selected four data subsets: (1) PNG endemic birds, (2) large, rare, and vulnerable birds, (3) globally restricted endemic birds occurring in mainland PNG (from an ICBP analysis by Alison Stattersfield), and (4) six species-rich mammal genera with large body size and widespread distribution in PNG (*Dendrolagus*, *Dorcopsis*, *Pseudocheirus*, *Phalanger*, *Pteropus*, and *Dobsonia*).

I mapped the distribution of these species taxa through PNG, building species lists for thirty biogeographic districts (see species lists in Appendix 15-1). These district listings give a preliminary regional measure of biodiversity for PNG for the purposes of creating priorities for conservation.

Unknown Areas

Although well studied when compared to some other tropical nations, PNG still has areas that have eluded biological survey or study of any kind. Some of these "unknown" areas are bracketed by well studied regions, and thus are probably of minor interest to biogeographers and conservationists. The areas that I treat below are significant unknown areas that are probably distinct biogeographically or ecologically from the nearest studied areas, and thus are potentially important sites, biologically. It therefore is clearly important for conservation planners to consider some of these unknown sites, as well as the rich well-known sites, when planning a system of conservation areas. Some of these unknown areas are uninhabited or sparsely so, and would lend themselves to potential protection.

I have mapped fourteen significant "unknowns" for Papua New Guinea (Figure 15-2). Nine lie on the mainland, and five on the islands. I discuss them briefly below:

Upper Strickland. This lowland and hill region is defined by the Strickland River on the west, the Muller Range to the north, and the Nomad River on the south. Much of the land to the west has been little studied, and this "unknown" area probably should range westward to the Blucher Range. Apparently very wet climatically, and rich in birds and mammals.

Hegigio/Mount Murray. Karst hills and outliers, including the Mount Murray volcano. Apparently unsurveyed and probably rich, but of difficult access. Low population.

Maramuni. This eastern section of the Central Range, its northern scarp, and the low foothills at its base, are unsurveyed. These mountains rise to 3700 m.

Finisterre Range. Although the Saruwaged Range is relatively well studied, the Finisterre Range to the west is virtually unstudied. Mostly (uninhabited) highlands.

Tua/Kaugel Drainages. This perhumid hill forest basin drains the southern slopes of the Kubor Range and the western slopes of Mount Karimui. Virtually uninhabited.

Crater Mountain/Pio. A hill forest basin, much like the Middle Tua, that drains Crater Mountain and the eastern slopes of Mount Karimui. Sparse population and very wet climatic regimes.

Mount Favenc. Southeasternmost montane isolate of the southern slopes of the central cordillera. Never surveyed; rises to 1550 m. Southeast of Mt. Murray, and west of the Purari. A large massif completely isolated by lowlands.

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Lakekamu/Chapman. Lowland forest basin rising sharply to more than 3000 m. Uninhabited and rich in wildlife.

Bowutu Range. Large expanse of mid-montane forest on ultrabasic soils of these north coastal ranges. Uninhabited.

Kilkerran/Fergusson. Large forested massif never surveyed zoologically. One of the top priority zoological unknowns.

Nakanai Range. A large uplifted plateau in western New Britain whose montane fauna has never been surveyed (Coultas failed to collect any of the significant montane birds). Constitutes the largest continuous expanse of montane forest on New Britain.

Gazelle Highlands. Highest mountains of New Britain; high montane fauna never surveyed.

Verron/Hans Meyer Ranges/New Ireland. The Verron Range is unsurveyed and unknown, with summits higher than 2000 m. The Hans Meyer Range is the highest of any island in the Bismarcks, and still has not been surveyed adequately for vertebrates.

Crown Prince Range/Bougainville. Very wet and little studied. Mainly highland forests.

Species Richness

Counts of breeding species for mammals and birds in PNG (and various sectors thereof) appear in Table 15-3. These provide a rough measure of the numerical richness of species assemblages on a geographic scale. These numbers (especially for the insular mammals) should be considered approximations.

On a smaller, regional and local scale, species richness varies a great deal from site to site in PNG, dependent upon location (island or mainland), elevation, and habitat. A ten-hectare patch of lowland rain forest might be expected to support as many as 140 species of breeding birds. Such a count would fall to ca. 100 species at 1500 m elevation, and perhaps to 40 at 3500 m. Savanna habitats and grassland/garden complexes would be much impoverished, with fewer than 40 breeding bird species. Island populations are generally much impoverished (Table 15-3), and the species counts in forest plots there are generally very low when compared with similar mainland plots. This is evident to the fieldworker both in numbers of species and numbers of individuals.

For mammals, the data are fewer and sketchier. Flannery's work in a very rich section of forest in the West Sepik Province indicates that local mammal faunas can exceed 130 species under certain conditions. The impoverishment of insular faunas is perhaps more extreme for the less mobile mammals than it is for birds (Flannery & White 1991), and the data have been blurred by human introduction of a range of mammalian species to many of the offshore islands.

Endemic Species

For birds, at least, Papua New Guinea is home to two classes of important "endemic" groups -- regionally endemic species, most of which inhabit only the New Guinea mainland (but that occur in Irian Jaya as well as PNG), and true PNG endemics (the largest portion of which inhabit one or more of the PNG islands, most typically New Britain).

The critical subset of regionally endemic birds has been characterized by ICBP as those species whose world ranges are smaller than 50,000 km^2. Fifty-seven of these species are found on mainland PNG (Table 15-4). These species merit scrutiny in future analyses of regional threats to species populations.

The insular endemics form the largest subset of PNG's true species-level endemics (Table 15-1). Many of these comprise allospecific forms that have vicariated from mainland species populations, but some (e.g., *Cichlornis* spp.) are truly oceanic, with their nearest relatives found on other island groups north or east of New Guinea.

Fewer generalizations can be made about mammals, except to say that from the smaller data set, trends appear similar to those for the birds. Most New Guinea mainland endemics occur both in PNG and Irian Jaya (with notable exceptions -- there seems to be a notable faunal break for montane taxa associated with the Strickland River). The insular species are fewer, except in the pteropodid fruit bats, which show a propensity for colonizing small islands and a tendency to be wide-ranging.

Rare Species

Papua New Guinea supports many species that can be judged as truly rare, although the reasons for such rarity are not readily forthcoming. Most ecologists argue that this rarity is often a product of the complexity and richness of the communities in which the species live -- less niche space for species that are packed tightly into a single habitat. Such a generality holds no real value for the conservation manager, and I suggest the question must be answered, practically, on a species-by-species basis.

I provide a list of the twenty rarest birds and mammals in Papua New Guinea (Table 15-5). In this table I consider only species whose world ranges are exclusively or largely in Papua New Guinea. Such an assessment is easier for the birds than for the mammals, for which the data are so often incomplete. These species merit study, and there should be incentives to encourage future fieldworkers and students to focus on these.

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Ecologically Critical/Unique Areas

This can be somewhat subjective, depending upon how one defines critical or unique. Fewer is better, so I will pinpoint six areas only, based on their importance to birds, mammals, and unusual PNG biotas (Figure 15-3).

Mount Albert Edward Massif. This and Mt. Giluwe comprise the two largest tracts of alpine habitat in PNG. Albert Edward is home to the endemic Calaby's Wallaby (Flannery in press), and the Alpine Giant Rat.

Mount Giluwe Volcano. The largest single tract of alpine habitat in PNG. One of PNG's most remarkable landforms.

Doma Peaks/Mt. Leiwaro Uplands. A huge undisturbed tract of montane forest between the population centers of Tari (to the west) and Margarima/Mendi (to the east). Rich in birds of paradise.

Bosavi/Great Papuan Plateau. PNG's great, isolated Pleistocene volcano; a major landform outside of the central cordillera.

Upper Fly Lowlands. The great Fly watershed is born in the high rainfall zone in the shadows of the central cordillera. These lowland rain forests constitute an ecologically critical area to the health of this, the third largest drainage on earth.

Upper Sepik Lowlands. The Sepik is perhaps PNG's most important river system (because of the human population associated with it). Thus the health of the forests of the Sepik's upper reaches will have important effects on the river and its human cultures.

Ecologically Fragile Areas

Given how little we know about the environments of Papua New Guinea, selecting the most fragile is no simple process. Based on studies outside of PNG, it is established that alpine environments above the treeline are particular susceptible to disturbance or long-term damage (especially from global climate change). Thus the major alpine tracts in PNG (all mainland) are plotted (Figure 15-4). Other fragile environments certainly exist, but remain to be determined by other studies.

Economically Important Species

Among the birds and mammals, there are two classes of economically important species: (a) those that are traditionally bought and sold in the marketplace, and (b) those that are important as village commodities in the noncash subsistence economy (dietary staples/important sources of protein). These two groups are listed in Table 15-6. The conservation importance of these taxa is uncertain. Most have widespread distributions (e.g., cassowaries) or else have regional representatives (e.g., the *Paradisaea* birds of paradise), thus these data offer no clear imperative with regard to regional planning for biodiversity conservation.

Known Threats

For the birds and mammals, the most obvious threats come from the black market skin trade and the market for captive live birds and mammals. The informal, regionally based plume/fur trade is sizable, and most directly threatens the larger species such as the New Guinea Harpy-Eagle, Pesquet's Parrot, Black Sicklebill, and the larger marsupials with ornamental fur (used for hats and headbands). For reasons discussed above, although many paradisaeid species are harvested for their plumes, the threat is reduced because of their population dynamics (the Sicklebill excepted).

The live animal trade in PNG is primarily domestic, with large birds, cuscuses, and tree kangaroos being most popular. This market is informal and unorganized, and probably only represents a diffuse and weak threat to particular species populations. The international (illicit) trade of live birds and mammals from PNG probably exists but is poorly documented, data being clouded by the large volume of illicit trade that takes place in neighboring Irian Jaya. Unless there are clearly marked subspecific populations, in many instances it is difficult to determine the origin of an animal smuggled from New Guinea.

Major Wilderness Areas

The large expanses of undisturbed forest and alpine habitats that are uninhabited or only very sparsely inhabited are most abundant in the PNG uplands and in the wet lowlands on the verge of the southern scarp of the central cordillera (Figure 15-5). These areas offer high potential as sites for future conservation areas because of their combination of pristine habitats and low (or no) population.

They can be named as follows: Star Highlands, from the highlands of the PNG border, north along the montane spur west of May River. Upper Fly, east and south of the Blucher Range, across lowlands to the Nomad River and the Karius Range. The Central Range, a high, unpopulated northern cordillera facing out on the Sepik basin. Papuan Plateau/Doma Highlands, a huge tract of virtually uninhabited lowlands and montane forest. Purari Wilderness, wet hill forests of the southern scarp. Huon Highlands, pristine highlands wilderness in the Huon Mountains. North Peninsular Highlands, a heterogeneous tract of mountain and alpine forest, ranging from the Kuper and Bowutu ranges, south through the Chapman, Wharton, and Owen Stanley ranges -- continuous wilderness above 1900 meters. East Peninsular Highlands, comprising Mount Suckling, Mount Dayman, and the Bonua basin. Whiteman Range, the major cordillera of central New Britain. The Nakanai Plateau, the uninhabited uplands of western New Britain. New Ireland Highlands, the rugged high ranges of the southern bulge of New Ireland -- uninhabited and little visited.

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BIOGEOGRAPHIC DISTRICTS FOR PNG

An objective assessment of a fauna should be based, in part, on a biogeographic assessment that delineates the regional disposition of that fauna. Based on the known distribution of warm-blooded vertebrates in Papua New Guinea, I thus propose a series of thirty biogeographic districts (Figure 15-6, Table 15-7), whose boundaries follow major geographic, physiographic, or environmental dicontinuities, and which, in many cases, conform to current range boundaries of diagnostic mammals and birds. I have taken care to subdivide PNG into as many districts as practical, in order not to overlook any possible areas of endemism or high species richness.

The main purpose of this districting is to create a basis for "scale" in the siting of a series of biologically important areas (see below). I believe it is important to spread the placement of important areas over the map in a fashion that does not exclude any biogeographically distinct area. I attempt to locate at least one biologically important area in each of the biogeographic districts.

BIOLOGICALLY IMPORTANT AREAS

Comparing the disposition of the sample taxonomic groups, in consultation with the other mapped data (biogeographic districts, critical areas, wilderness areas, major unknowns), now permits selection of an array of biologically significant areas for PNG, as listed below. I have placed each of these in one of two categories, Priority One (☼☼☼)= the most critical areas, biologically; Priority Two (no star)= important areas. The unspoken assumption is that areas not designated are considered of lowest priority, biologically; however, many tracts outside of these designated zones could represent important biotas, worthy of designation as conservation areas.

Part of the selection process involved comparing first-cut selections made by Beehler with those made by members of the correspondent team, Jared Diamond, Tim Flannery, James Menzies, and Richard Schodde (Maps 15-7a, 15-7b, 15-7c, 15-7d). Their selections, based on their experience and knowledge, showed a considerable level of overlap (Figure 15-7e), and confirmed the importance of a number of areas. For workshop analysis by the CI computer GIS, we treat their selections as distinct data sets, but the pre-workshop map selections (Figure 15-8) are, in part, influenced by their selections. These are discussed individually below.

Mainland Areas

1. Mount Menawa and Mt. Somoro ☼☼☼. West Sepik Province [North Coast]. (3°20'S, 141°45'E, and 3°25'S, 142°10'E, elevation: 500-1850 m). These are the highest peaks in the Bewani and Torricelli mountains, respectively, of PNG's north coastal ranges. Both of these great outliers are critical to the survival of a distinct montane fauna. Mt. Menawa is higher and much less disturbed than Somoro, and the population in the area is

much smaller. The highlands of the North Coastal Ranges support two endemic species of large mammals (*Petaurus abidi* and *Dendrolagus scottae*) and a number of isolated and taxonomically distinct populations of birds (see Appendix 15-1). A race of the Black Sicklebill (*Epimachus fastuosus ultimus*) was described from material collected on Mount Menawa. The lower slopes of the area support the Pale-billed Sicklebill (*Epimachus bruijnii*), whose world range is confined to northern New Guinea, and whose PNG range is tiny (and recently discovered). The Black Tree-Kangaroo (*Dendrolagus scottae*) is the most recently described large mammal for PNG, and is reputed to be the largest (and most threatened) native forest mammal in Papua New Guinea.

2. April River/Hunstein Range. West Sepik Province [Sepik-Ramu Lowlands]. (4°40'S, 142°38'E, elevation: 100-1400 m). Although containing no PNG endemics, the forests of the Sepik basin are remarkably rich and support numbers of western species of birds and mammals (Appendix 15-1). The forests at the base of the northern scarp of the central cordillera are probably among the richest in PNG.

3. Star Mountains ☼☼☼. Western and West Sepik provinces [Star Mountains]. (5°5'S, 141°5'E, elevation: 500-3800 m). The Mount Scorpion massif is a great mountain block that is uninhabited, rarely visited, and rich in alpine biota with western affinities. The environmental transect that ranges from the summit heights northward to the Ai River (a branch of the upper Sepik) includes a remarkable range of environments rich in western forms rarely encountered in PNG. The subalpine zone of Mount Scorpion supports a good population of Macgregor's Bird of Paradise (*Macgregoria pulchra*) that is apparently not hunted. This is a globally-threatened species.

4. Palmer River ☼☼☼. Western Province [Upper Fly]. (5°45'S, 141°30'E, elevation: 100-1200 m). This area of lowland and hill forest is delimited by the Palmer River on the east and Fly (Wai Pinyang) on the west, and the scarp of Mount Uni and Mount Karik on the north. This area comprises a large expanse of old growth wet rain forest that supports a tiny human population and presumably is characteristic of the extraordinarily rich biota of the upper Fly platform. To the west lie areas of relatively high human population and development activities related to the huge Ok Tedi mine. The Palmer River tract is likely to be rich in birds of paradise and species with globally restricted distributions.

5. Tonda. Western Province [Trans-Fly]. (8°50', 141°30', elevation: sea level-100 m). Currently subsumed in the Tonda Wildlife Management Area, this is a large area of savanna and seasonally flooded grasslands and marshes that constitutes a globally significant wintering ground for migratory waders and waterfowl both from Australia and the Palearctic. Its significance is reduced by the occurrence of conservation areas harboring similar faunas in both Irian Jaya and Northern Australia.

6. Aramia/Soari. Western Province [Eastern Fly] (7°30'S, 142°20'E, elevation: sea level-100 m). This expanse of lowland alluvial rain forest is bracketed by the Aramia River on the west and the Soari River on the east. It perfectly represents the flat alluvial forest habitat that abounds on the lower Fly eastward to the Purari River. These forests are under direct threat from logging plans, and representative tracts must be preserved before they are

gone. The vertebrate fauna of this tract is presumably rich, but rather undistinguished biogeographically, and yet this should not detract from its critical importance as typical of a dominant environment in PNG -- one that will be the first to disappear under large-scale logging and pulpmill operations.

7. Mount Bosavi ☼ ☼ ☼. Southern Highlands Province [Southern Scarp] (6°40'S, 142°55'S, elevation: 300-2400 m). Proposed for national park status more than a decade ago, the forests of the great extinct Mount Bosavi volcano have long been recognized to be of importance to conservation in PNG. The tract comprises the volcanic cone plus lower slopes to the west and southwest. These forests are faunistically rich and virtually undisturbed.

8. Doma Peaks ☼ ☼ ☼. Southern Highlands Province [Southern Highlands] (5°55S, 144°10'E, elevation: 1800-3600 m). This tract, too, has been considered for national park status. This comprises a large mid-montane and upper montane tract of uninhabited forest that is exceedingly rich in birds of paradise and a number of little known bird species whose ranges are primarily Irianese.

9. Mt. Giluwe ☼ ☼ ☼. Southern Highlands Province [Southern Highlands] 96°3'S, 143°55'E, elevation: 1900-4300 m). The massive Giluwe shield volcano is capped by the largest contiguous expanse of alpine vegetation in Papua New Guinea. This is a globally significant montane wilderness threatened by logging of the beech-podocarp forests of its middle and upper slopes. Very rich biologically.

10. Bürgers Range/Upper Maramuni ☼ ☼ ☼. East Sepik Province [Central Range] (5°5'S, 143°25'E, elevation: 300-3690 m). This large, sparsely inhabited tract of montane forest that descends abruptly into the Sepik lowlands includes the highest peak in the Central Range (Yakopi Nalenk, 3690 m) and some of the least-known (but probably very rich) tracts of humid forest habitat in Papua New Guinea.

11. Adelbert Mts. Madang Province [Adelberts] (4°50'S, 145°20'E, elevation: 300-1650 m). This isolated range is home to the Fire-maned Bowerbird (*Sericulus bakeri*), the rarest bird species in PNG, and the bird species with the most circumscribed geographic range known for mainland PNG.

12. Crater Mountain. Eastern Highlands/Chimbu/Gulf provinces [Eastern Highlands] (6°45'S, 145°15'E, elevation: 500-3100 m). The Crater Mountain area is a proposed Wildlife Management Area, chosen because of its large expanse of original forest, low population density, and large populations of a diverse array of birds of paradise, including the rare Black Sicklebill (*Epimachus fastuosus*) and Blue Bird of Paradise (*Paradisaea rudolphi*).

13. Sirebi River/Mt. Murray. Gulf/Southern Highlands provinces [Southern Scarp] (6°51'S, 144°5'E, elevation: 100-2100 m). The largest expanse of karst topography in Papua New Guinea lies in the central segment of the southern lowlands and hills, between

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the Purari River in the east and Mount Bosavi in the west. The Sirebi/Mt. Murray tract features Mount Murray, an isolated volcano only slightly smaller than Mount Bosavi.

14. Finisterre Range ☼☼☼. Morobe Province [Huon] (5°50'S, 146°8'E, elevation: 500-4150 m). This large montane forest tract, with a broad elevational range, from hill forest to the treeline, supports more PNG mainland species endemics than any other. This includes three birds of paradise, two honeyeaters, and a tree kangaroo. This area is poorly surveyed and probably exceedingly rich. It should be the focus of much future research and exploration.

15. Kuper and Bowutu Ranges. Morobe Province [Northern Peninsula] (7°30'S, 146°50'E, elevation: 300-2950 m). A large tract of hill and montane forest quite accessible to the population centers of Wau/Bulolo. This uninhabited series of ranges is well studied in the northwest (Mount Missim) but virtually unknown in the southeast (Bowutu Range). Rich in birds of paradise and montane species with restricted ranges, its biological importance relates to being representative of middle-altitude forests of the Papuan peninsula.

16. Lakekamu Basin/Chapman Range . Central Province [Owen Stanleys] (7°50'S, 146°38'E, elevation: 50-3000 m). Here is an entirely uninhabited tract of forest that ranges from beautiful, lowland alluvial forest to upper montane forest near treeline, all within a transect of no more than 20 km. The lowland forest supports good populations of crowned pigeons and wallabies, and the highland forest is unexplored but presumably rich. This tract will include southern watershed species absent from the Kuper/Bowutu tract.

17. Mount Albert Edward/Ioma lowlands ☼☼☼. Central Province. [Owen Stanleys] (8°25'S, 147°25'E, elevation: 1000-3950 m). The Mount Albert Edward dome includes the largest alpine uplands in eastern Papua New Guinea, and thus is a critical montane resource. The lowland forests constitute a critically threatened resource in peninsular Papua, and those suggested for protection here may support populations of the globally threatened (and world's largest) butterfly, *Ornithoptera alexandrae*.

18. Mt. Suckling/Bonua Basin ☼☼☼. Northern/Central/Milne Bay provinces. [Eastern Peninsula] (9°45'S, 149°5'E, elevation: 200-3650 m). Another vast wilderness area that is virtually uninhabited and little disturbed at this point. The Suckling massif is the only significant alpine uplands in the eastern peninsula, and, in conjunction with the adjacent Bonua basin, stands as a remarkably pristine aggregate of montane and lowland forest in easternmost mainland PNG. Rich in eastern isolates such as the Streaked Bowerbird (*Amblyornis subalaris*) and Eastern Parotia (*Parotia lawesii helenae*).

Insular Areas

19. Goodenough Highlands. Milne Bay Province. [D'Entrecasteaux] (9°20'S, 150°15'E, elevation: 500-2500 m). The massive central peaks of Goodenough Island are higher than any other mountains on New Guinea's fringing islands. The mountain forests that cloak these summits are home to an endemic species of forest wallaby (*Dorcopsis atrata*) and a bat

endemic to these eastern islands (*Dobsonia pannietensis* -- sometimes considered a race of *D. moluccensis*). These forests are uninhabited, rarely visited, and little known biologically. They strongly merit conservation and additional field survey.

20. Fergusson Highlands. Fergusson Island, Milne Bay Province. [D'Entrecasteaux] (9°30'S, 150°48'E, elevation: 100-1850 m). Fergusson Island is one of PNG's great unknowns, with three distinct mountain ranges, geothermal areas, and other natural wonders. The northeasternmost mountain massif, Mount Kilkerran, promises to be a treasure trove to the first vertebrate biologists who climb to its heights. *Dactylopsila tatei* is endemic to Fergusson. One can only imagine what undescribed populations of vertebrates inhabit the wet montane forests above 1500 meters there. These uninhabited montane forests merit protection.

21. Mount Riu. Tagula Island, Milne Bay Province. [Eastern Islands] (11°30'S, 153°25'E, elevation: 100-800 m). The forests of Tagula are home to an endemic honeyeater (*Meliphaga vicina*) and butcherbird (*Cracticus louisiadensis*). It would be useful to designate a tract of interior forest, ranging from Mount Riu in the east to Mount Gangula in the west, as an area of high priority. According to vegetation maps, the forest of the eastern two-thirds of the island are degraded.

22. Woodlark Island. Milne Bay Province. [Woodlark] (99°10'S, 152°50'E, elevation: 100-350 m). Forests of the interior of Woodlark are home to the cuscus *Phalanger lullulae*, strictly endemic to this island.

23. Umboi Highlands. Umboi Island, Morobe Province. [Northern Islands] (5°38'S, 147°55'E, elevation: 100- 1500 m). Umboi is the largest and richest of PNG's north coastal islands (arrayed west off the western tip of New Britain, up the northern coast of mainland PNG). It is home to populations of large numbers of species endemic to PNG (Appendix 15-1), as well as a remarkable array of fruit bats (eight species). Lake Buan, in Umboi's highlands, supports one of the richest waterbird populations in the Bismarcks.

24. Whiteman Range. West New Britain Province [Central New Britain] (5°50'S, 149°50'E, elevation: sea level-1900 m). This reserve comprises the highest range in central New Britain and an expanse of hill and lowland forest north and south of the range. Much of the western section of the area is karst. This area includes the largest single selection of PNG species endemics of any in this list. *Pteropus gilliardi* is known only from this area, and is perhaps indicative of the area's unsurveyed richness. It is very little studied and merits special attention, especially when considering the potential effects of the planned timber development projects in the region.

25. Nakanai Range ☼☼☼. East New Britain [East New Britain] (5°15'S, 151°45'E, elevation: sea level-1960 m). Here is yet another of PNG's great wilderness areas -- uninhabited and unsurveyed. It is certain to be biologically rich, and there is little doubt that taxonomically new birds and mammals inhabit this area. It is isolated from the Whiteman Range (to the west) by extensive intervening lowlands. This tract would include lowland forest in the interior of the southern watershed.

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26. Mount Sinewit/Mount Biririnia. East New Britain [Gazelle Peninsula] (4°45'S, 152°5'E, elevation: 300-2400 m). These mountains, isolated by rivers and lowlands from the Nakanai Mountains to the southwest, are certainly as fascinating as the latter. They have not been adequately surveyed, and are 500 meters higher. These mountains are surrounded by lowlands with a growing populace, and probably will be degraded unless action is taken soon.

27. Hans Meyer/Verron ranges ☼ ☼ ☼. New Ireland Province [New Ireland] (4°20'S, 152°55'E, elevation: 300-2400 m). Brief initial surveys have shown this montane area to be very rich, with a number of species endemic to New Ireland itself (Table 15-1, Appendix 15-1). This biotic resource is as important as that of any of the three sites in New Britain.

28. Mussau. New Ireland Province. [St. Matthias] (1°25'S, 149°40'E, elevation: sea level 700 m). The interior of Mussau Island, the largest in the St. Matthias group, comprises a large block of rain forest. We suggest that the major portion of this tract be designated as a priority site. It supports seven species of birds endemic to PNG, two of which are endemic to Mussau, the Mussau Rufous Fantail (*Rhipidura matthiae*) and the Mussau Pied Monarch (*Monarcha menckei*).

29. Manus ☼ ☼ ☼. Manus Province. [Admiralties] (2°5'S, 147°0'E, elevation: 100-700 m). Manus is the largest of the Admiralty Islands, isolated both from the great Bismarck islands to the southeast, and from mainland New Guinea far to the south. Not surprisingly, Manus's impoverished fauna is rich in PNG endemics (eleven birds, two mammals). Of these, six are endemic to the Admiralties. The designated priority area comprises a large segment of the uninhabited interior forest tract, including its highest mountain, Mount Dremsel (702 m).

30. Mt. Takuan/Lake Lorolu ☼ ☼ ☼. Bougainville Island, North Solomons Province. [Bougainville] (6°30'E, 155°35'E, elevation: sea level-2200 m). The priority area includes the spine of the central range and southern segments of the Crown Prince Range, from Panguna south to Lake Lorolu, and includes mounts Takuan and Taraka. Where appropriate, this area extends downward toward the coast where good original forest prevails (primarily in the vicinity of the Wapiai River, due south of Mount Taraka). The verges of this area support relatively large rural populations -- more so than in the other areas designated for PNG. Because of its isolation from the Bismarck Islands and mainland PNG, Bougainville is home to many species whose affinities lie with the other Solomon Islands to the south and southeast. Because of the uncertainty of the future of the forests of the Solomon islands, it is imperative to conserve representative biotas on Bougainville. Among the many interesting vertebrates is the little known Bougainville Honeyeater (*Stresemannia bougainvillei*), representing a genus endemic to this island.

CONSERVATION RECOMMENDATIONS

From the results of this assessment, the following recommendations can be put forward:

Research Priorities

Research provides the needed scientific information that can be applied to specific conservation problems. Thus, although immediately pressing problems are not answered by research that often takes years to complete and publish, in order to develop an effective long-term strategy for conservation, one must institute research programs that will, in time, provide the answers that are today not forthcoming because of our lack of scientific data.

For birds and mammals, the research should take three courses. First, we must return to the primary survey efforts that were more popular in the 1950s and 1960s. The unknown areas need to be visited and vigorously surveyed, and the poorly known areas need to be revisited and resurveyed with specific focus on the more elusive species and genera of mammals and birds. These surveys will uncover a wealth of new data (especially on mammals) that can be applied to future conservation action.

The second line of investigation should be biodiversity studies that focus on the interrelationships linking birds, mammals, arthropods, and the rain forest flora. Simple sampling regimes that measure species richness still remain to be carried out for any forest in PNG. These initial studies will provide a rough understanding of the ecological interactions that promote the biological diversity of the PNG humid forests, which today remain in the realm of speculation. These studies should then be broadened to encompass research on seasonal reproductive cycles in the humid forest and patterns of movement among key birds and mammals. These data are needed to determine the effective minimum size of conservation areas to maintain good genetic stocks of particular threatened species.

A third line of investigation would focus on single-species studies of keystone and threatened species -- the large, charismatic species that remain little known. We need to understand their biology before we can plan for their long-term future.

Future PNG Conservation Areas

The size, shape, and disposition of PNG's future conservation areas are dependent upon a myriad of factors, some political, some practical. From the biologist's viewpoint, there are certain rules that merit consideration. These have been enumerated by Diamond (1975) and are summarized below. The biogeographic considerations have been treated above, so need not be reiterated here.

Size: It is well-known now that larger is better in nearly all instances, and it is essential that most of the future conservation areas exceed 8000 km^2 wherever possible. This will not be feasible in some sites (Mount Somoro/Mt. Menawa), but iscertainly feasible in areas such as Palmer River, Bosavi, Crater, Maramuni, Nakanai, and others. Areas larger than this are preferable. Why is this minimum size limit a necessity? Simply stated, PNG's larger species (Harpy Eagle, Pesquet's Parrot, Goodfellow's Tree Kangaroo, etc.) occur in such low numbers, or in such a patchy fashion, that smaller reserves cannot be expected to support viable populations over the long term.

Elevational Zones: In montane areas, which dominate in PNG, it is critical to consider the elevational distribution of discrete faunas when designing reserves. Thus a reserve that ranges from sea level to 3000 m must be much larger than a sea level reserve in order to act as an effective genetic reserve for certain taxa whose ranges are elevationally restricted.

Species Richness: For nonspecialized reserves, it is useful to combine habitats and elevation zones (given adequate coverage and size), and reserves should maximize the number of species contained in them. In PNG, this can best be done by situating a reserve on a major topographic or physiographic discontinuity -- usually the interface between a scarp of a major mountain range with an alluvial lowland plain. The montane/plain interface is usually an area of perhumid conditions and high species richness, in part because of mixing from upland and lowland communities.

Classification of conservation areas in PNG remains too complex and unwieldy. There are too many categories, and too few examples of each type. We recommend a bare minimum number of types, perhaps two or three, maximum: (a) Forest Reserve, for large blocks of habitat that will serve as biological reserves; locally authorized, but overseen, in part, by national authorities; (b) Park, smaller areas sited at points of historical or natural interest, mainly for the recreational pleasure of visitors; (c) Local Hunting Preserve, locally instituted tracts of forest, preserved for local hunting and cropping for non-timber forest products, most applicable for village-instigated efforts in nonpriority areas. It is important that the government of Papua New Guinea fosters the conservation ethic whenever it appears.

Legislation

PNG already has a wealth of legislation focused on protecting the environment and protecting threatened species. Much of this is either too complex to enforce or not sufficiently fine tuned to treat the problems at hand. Future legislation should be written with the following principles in mind: (a) simplicity of interpretation and simplicity of enforcement; (b) creating economic incentives for corporate or citizen behavior that will favor conservation and the environment; (c) statutes that are practical and sensitive to local rural conditions, rather than idealistic and vague; (d) legislation that avoids hindering scientific research.

Here are some possible examples:

Locally-based Conservation Areas: Any new legislation to promote locally-based conservation areas (now called Wildlife Management Areas) should include explicit incentives for the local Landowners. These should come in the form of non-cash aid to village (health and education) infrastructure or local economies.

Protected Species: The current list of species formally protected by law is not based on threat or enforceability. The list should include only truly threatened or endangered species, should offer means of enforcement on a local level, and should be promoted with educational campaigns and public outreach.

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Environmental Levy: The idea has been floated recently, in which a small percentage tax is levied from gross revenues from export of timber and minerals from PNG. The proceeds from such a levy would be placed in an environmental trust fund that would be administered on behalf of the government by an independent board, composed of local and international environmentalists and PNG government authorities. The funds from the trust would be disbursed in grants for conservation activities in PNG, or to support local economies in exchange for agreements to ensure the protection of critical forest tracts.

Threatened Species Survival Plans

Although PNG is home to few truly threatened species, those that are suffering known threats in PNG should receive specific attention in order to devise survival plans based on good biological data and practical knowledge of local conditions. The key to this program will be continuous adequate funding, and sufficient manpower to conduct the research and to formulate the survival plans. Their absence has hampered the development of such a program.

We believe it will be possible for PNG to develop a model list of needs, and then to solicit international assistance in the form of grant funds and non-national fieldworkers, who would receive the formal encouragement and authority of the PNG government to carry out the work. This, then, would be government sponsored studies in directed conservation biology, a concept that has not yet been considered in PNG.

International fieldworkers should be encouraged to work in PNG if they agree to conduct specific research related to study of specific threatened species. Current research by foreign nationals is eclectic and nondirected, and does not receive more than token official support from GoPNG. We suggest that the nondirected research be allowed to continue as before, but that the GoPNG create a list of conservation biology projects that would be given priority. Thus the Government of Papua New Guinea would aid and facilitate all (nonfunding) aspects of the priority research -- speeding visas and local permissions, providing infrastructural support, DEC counterparts, etc. Such a program might encourage the best fieldworkers to work in PNG, and could be structured in order to provide useful in-the-field training for PNG students and departmental technicians.

ACKNOWLEDGMENTS

I thank my correspondent team: J. M. Diamond, J. I. Menzies, T. Flannery, L. Seri, and R. Schodde, for their help with the analysis and report. Thanks are offered to Alison Stattersfield and ICBP-Cambridge for permission to cite unpublished data and analyses on bird species with globally restricted distributions. Charles Burg and Frank Bonaccorso read and corrected earlier versions of this manuscript.

Figure 15-1. Known range of the Blue Bird of Paradise.

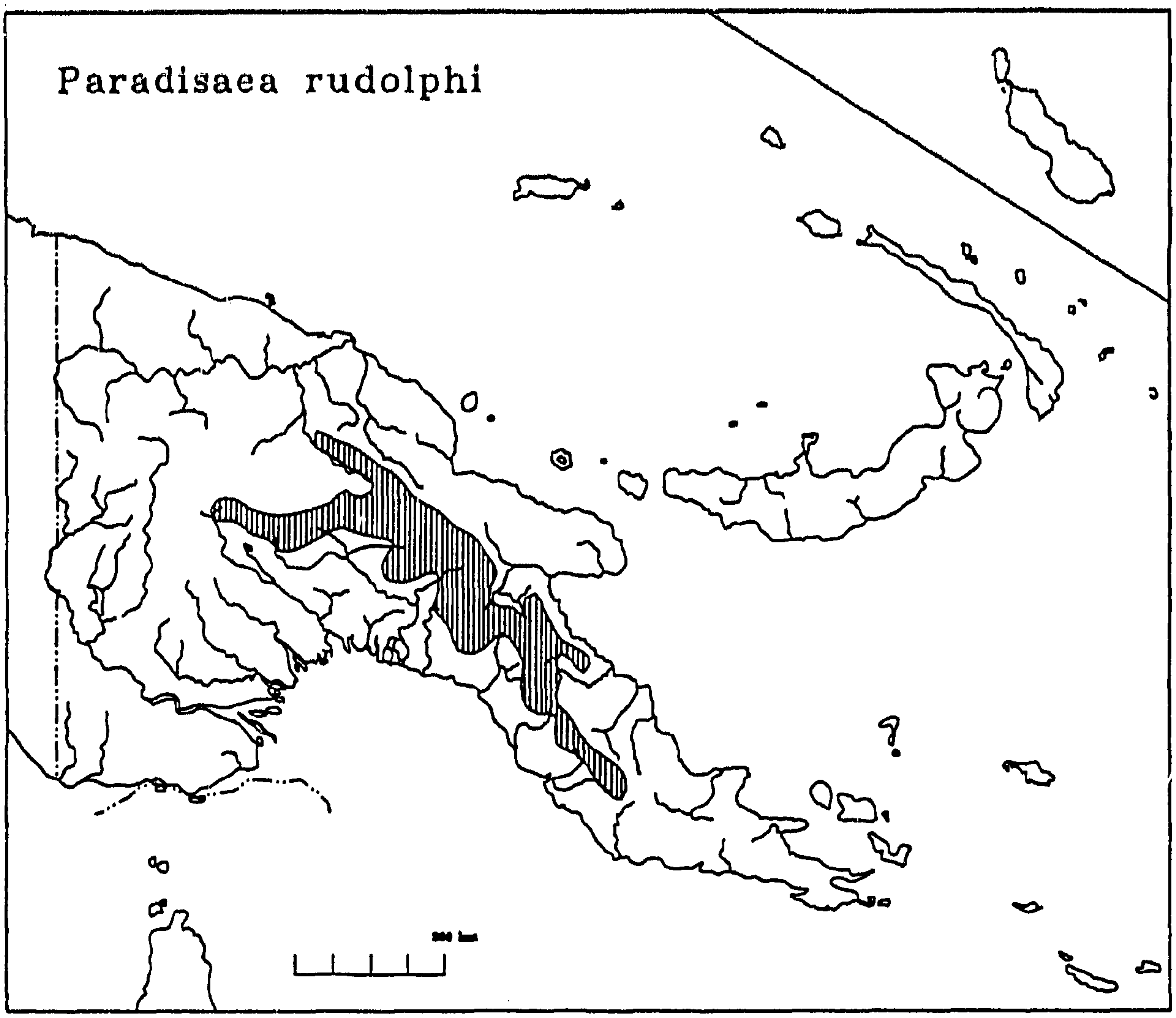

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Figure 15-2. Major areas that are biologically unknown.

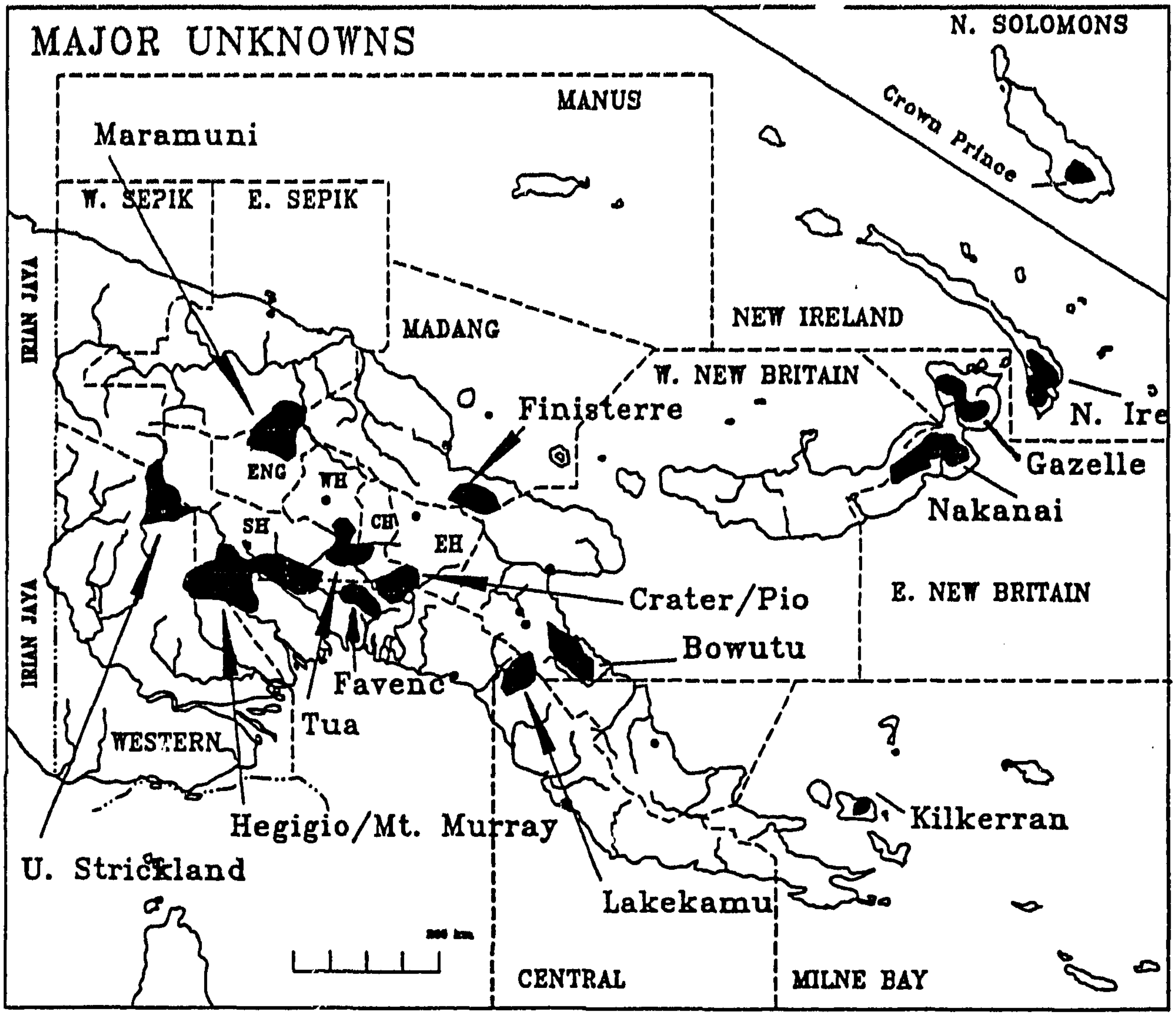

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Figure 15-3. Ecologically critical areas.

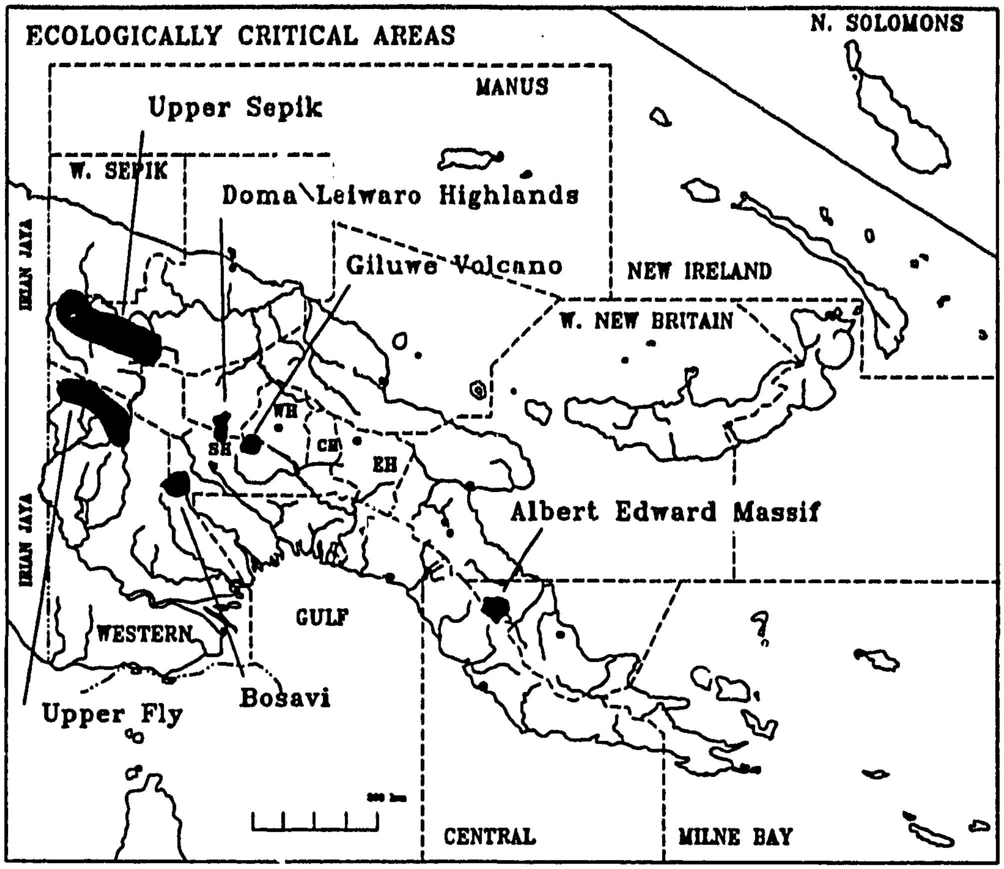

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Figure 15-4. Ecologically fragile (alpine) areas -- those > 3000 m.

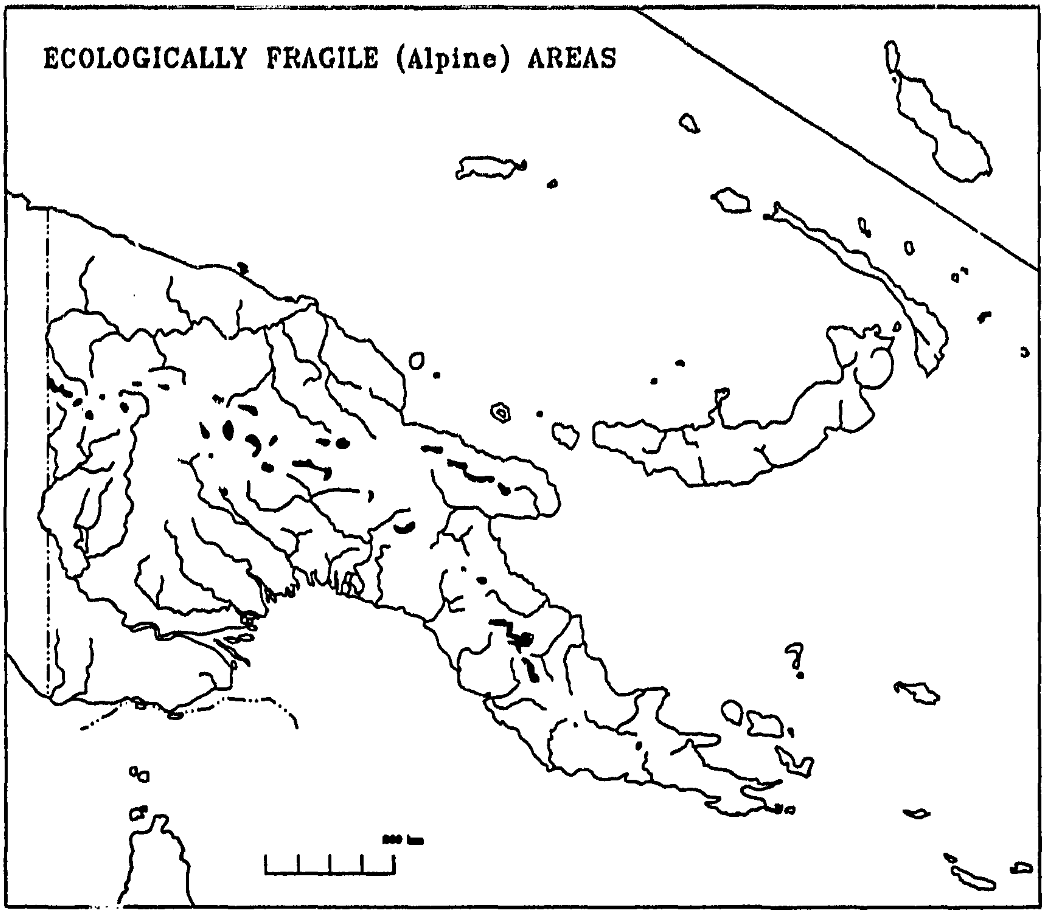

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Figure 15-5. Major wilderness areas.

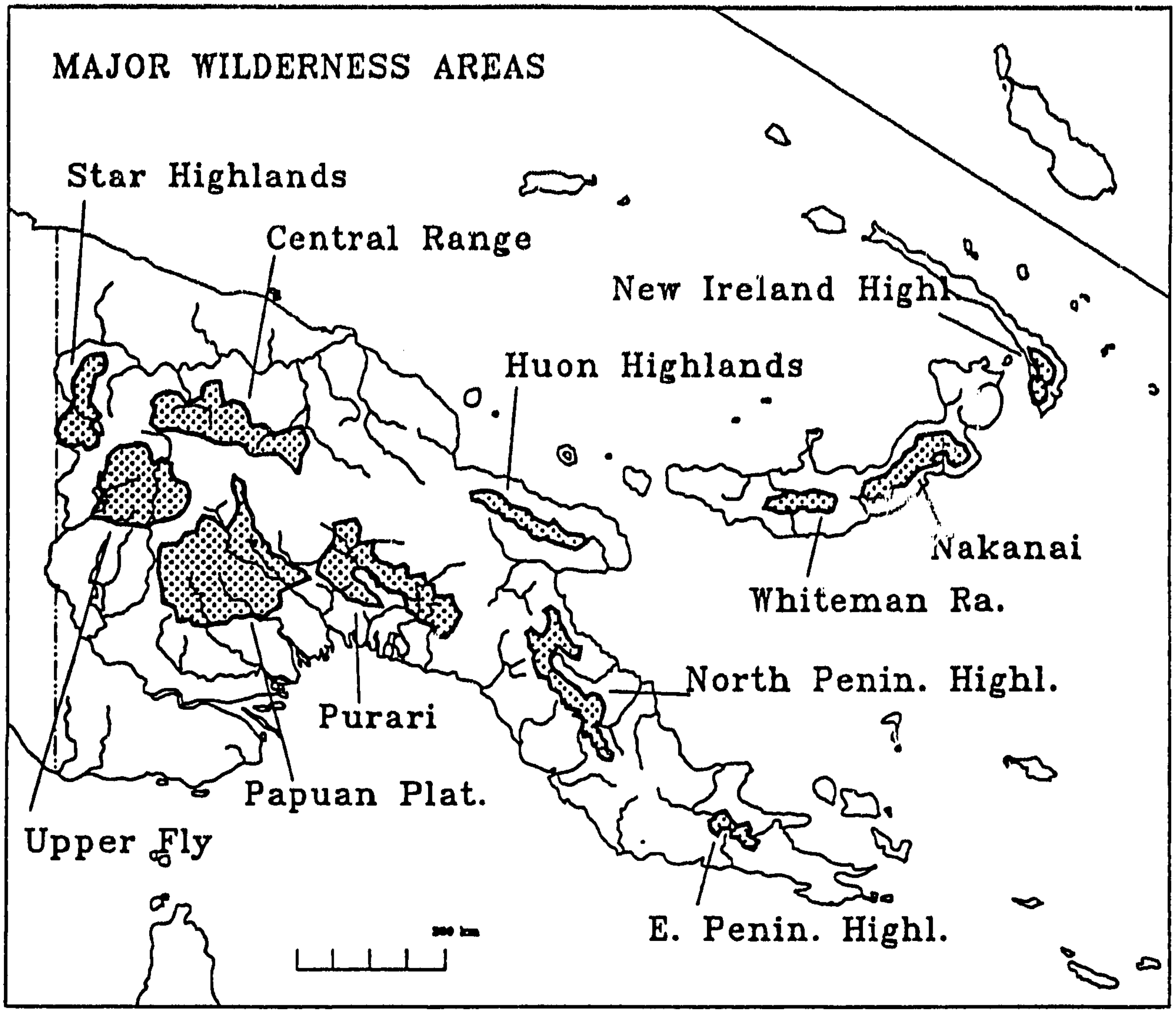

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Figure 15-6. Biogeographic districts for Papua New Guinea.

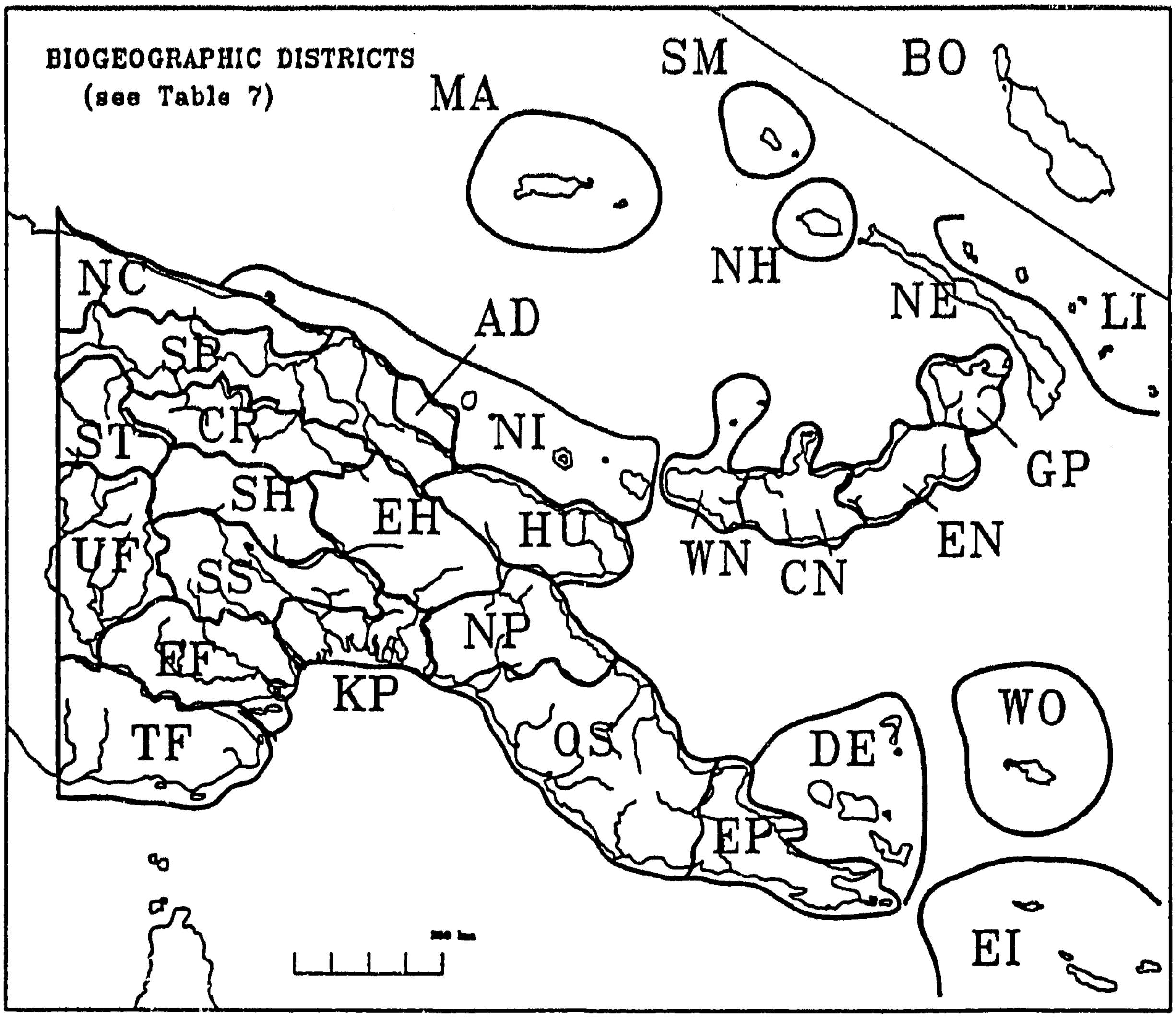
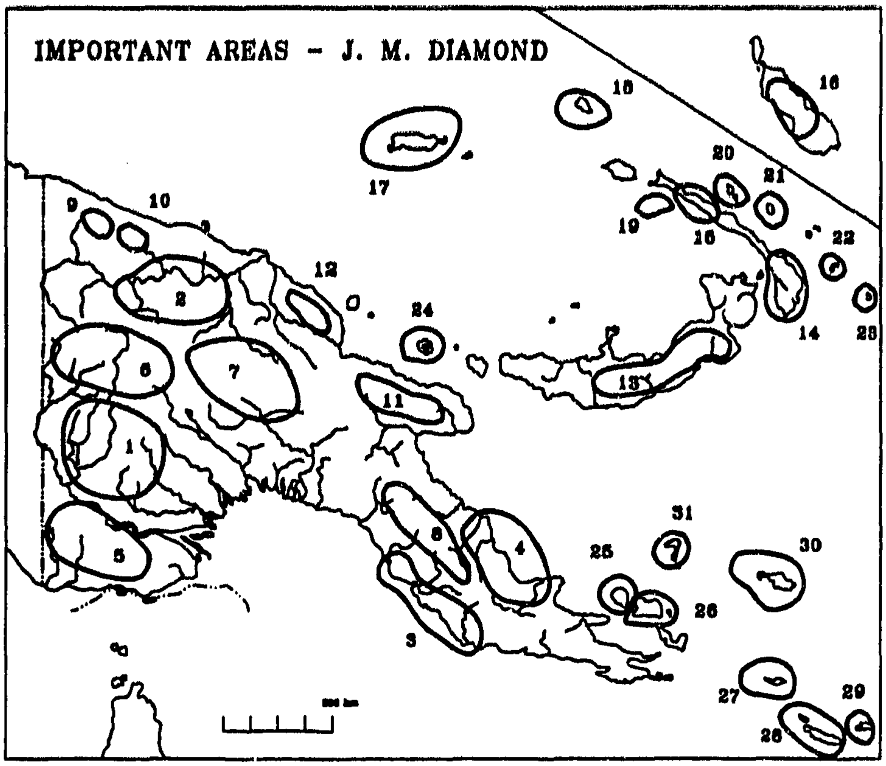


Figure 15-7a. Important Areas (J. M. Diamond)



1. **Lowlands of Mainland PNG.** Biogeographically, the two main blocks with endemics are 1) the wet inland areas of the Fly River bulge on the southern watershed, and 2) the Sepik basin on the northern watershed. The 3) southern and 4) northern watershed lowlands of the southeastern peninsula also have some endemism (e.g., the Queen Alexandra Birdwing near Popondetta). 5) The dry trans-Fly savannah near the Irian Jaya border has many dry-country specialties.

2. **Mountains of the Central Range.** The Central Range in PNG falls biogeographically into three blocks, each with its own endemics (e.g., the astrapias). The blocks are 6) western, 7) central, 8) southeastern. Different species occur at different altitudes, while the southern and northern watersheds are disjunct below 5000 feet and each has specialties. Hence, within each block, there should be representation of both southern and northern watersheds from about 1500 to 5000 feet, and representation from 5000 feet to the summits. Within each block, these needs should be met in at least one undivided altitudinal transect, because of altitudinal movements. That is, it would be fatal to have protected forest above

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5000 feet in the western block on one mountain, protected forest below 5000 feet on a different mountain.

3. **Outlying Mountain Ranges of the Mainland.** Several mountain ranges along the north coast have endemics and similarly require protected areas from 1500 feet to the summits. The second richest is 9) the Bewani Mountains; this protected area must be centered on Mount Menawa, by far the highest mountain of the Bewanis. The 10) Torricellis around Mount Somoro have significant mammalian endemism (e.g., New Guinea's largest tree kangaroo). The 11) Huon Peninsula is the richest of these outlyers, while the remaining one is 12) the Adelberts.

4. **Bismarcks and Solomons.** Many islands have lowland endemics, and the higher islands have montane endemics as well. On the lower islands (like Manus and Mussau) the reserve should be centered in the lowlands (competing commercial interests may favor relegating the reserve to the hard-to-log highest peak, but that may miss some lowland endemics). On high islands--especially New Britain, New Ireland, and Bougainville--the reserve must range from the lowlands to the highest summits. The richest islands are New Britain, New Ireland, and Bougainville. 13) I suggest the New Britain reserve to be located in the high and little inhabited Whiteman Range, and to include both the very wet southern and dry northern watersheds in the lowlands. New Ireland deserves a separate 14) southern reserve around the highest mountains (Hans Meyer Range) and 15) northern reserve, because of some differentiation between northern and southern ends of the island (e.g., *Lonchura hunsteini/forbesi*, *Halcyon chloris* races). If there is an adequate reserve on 16) Bougainville, I see no need for a reserve on Buka, which shares almost all of its species with Bougainville. The most important smaller islands are 17) Manus and 18) Mussau, followed by 19) Dyaul, 20) Tabar, 21) Lihir, 22) Feni, and 23) Nissan. 24) Long deserves a reserve to include the lake and much of the lowlands for scenic and geological as well as biological reasons (unique supertramp biota).

5. **Southeastern Papuan Islands.** For the same reason as on the lower Bismarck Islands, all reserves should be centered in the lowlands, except that the Goodenough reserve should extend from the lowlands to the summits. The most important islands are 25) Goodenough, 26) Fergusson, 27) Misima, 28) Tagula, 29) Rossel, 30) Woodlark, and 31) Kiriwina.

6. **Small Islands and Marine Reserves.** The above list does not take account of marine conservation needs, nor of terrestrial needs associated with remote islands (turtle nesting beaches, colonial pigeon breeding colonies, and supertramp populations).

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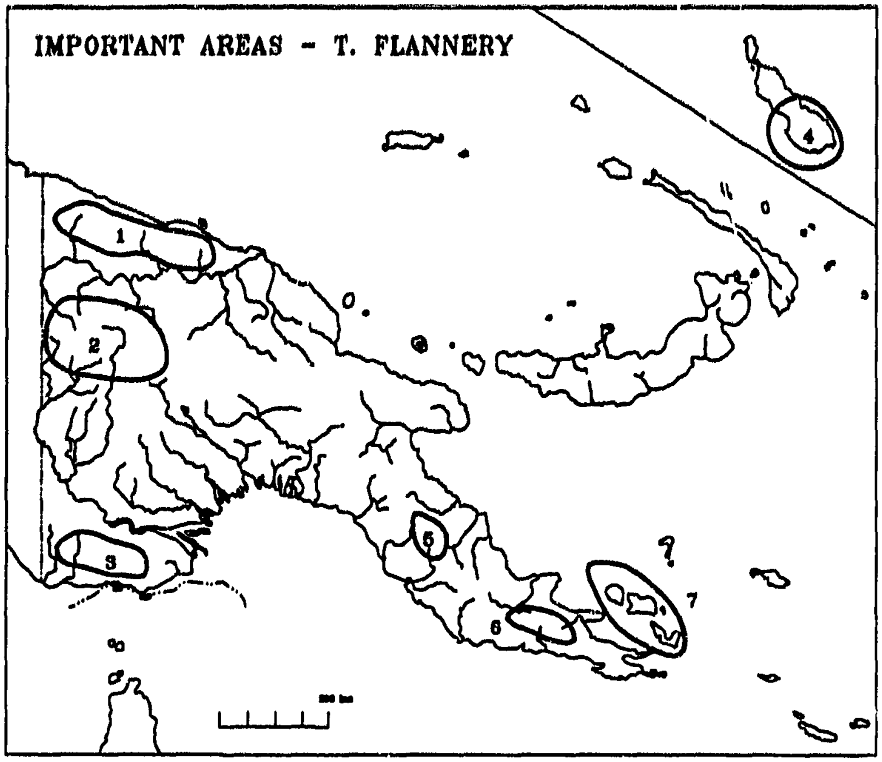
Figure 15-7b. Important areas (T. Flannery)



1. **The North Coast Range** is home to a very heterogeneous and highly endemic fauna (more than 70 mammals) which is under increasing pressure from the large populations on its southern slopes. The larger mammals in particular are suffering; some are locally extinct already.

2. **The Telefomin area** is home to the greatest diversity (up to 130 spp. in an area smaller than greater Sydney) of mammals in Australasia, and there is considerable endemism.

3. Considerable endemism has been recorded in the **Morehead area.**

4. **Bougainville** has a highly distinctive fauna (ca. 30 mammal species) which is not well conserved in the Solomon Islands (political).

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5. **Mt. Albert Edward** has some of the least disturbed subalpine grassland in the entire island. Such endemics as Calaby's Thylogale (*Thylogale n. sp.* in press) and the Alpine Giant Rat (*Mallomys istapantap*) are unique to these habitats. The long-beaked Echidna also remains abundant there.

6. The same can be said for the **Mt. Dayman area,** where there is also considerable endemism at lower elevation.

7. The **D'Entrecasteaux islands** have considerable endemism. Their small area makes them vulnerable.

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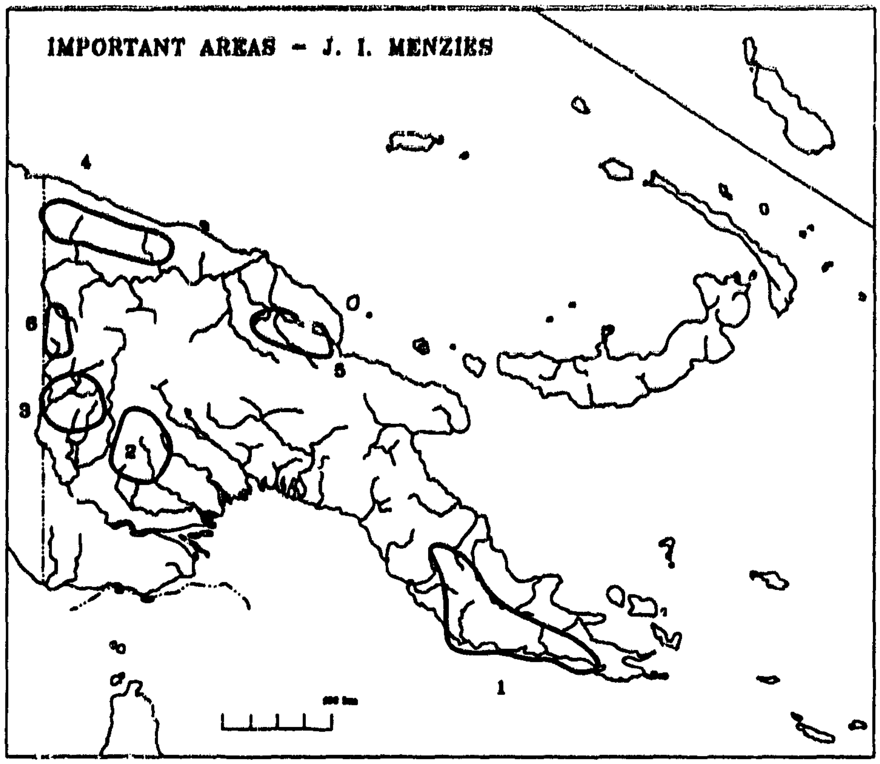
Figure 15-7c. Important areas (J. I. Menzies)



1. **The southeast peninsular.** The narrow coastal plain south of the Owen Stanley Ranges still carries extensive forest east of the Cape Rodney Rubber settlement area, though, with the extension of the highway through to Milne Bay, it will become increasingly accessible. There are several rare (or hardly known) mammals in this area, Broadbent's Bandicoot (*Peroryctes broadbenti*), Macleay's Forest Wallaby (*Dorcopsulus macleayi*), and, at higher elevations, the Papuan Striped Bandicoot (*Peroryctes papuanus*) and *Murexia rothschildi*. The southern forest wallaby, (*Dorcopsis luctuosa*), is still very common, but subject to extreme hunting pressure and deserves some protection in a forest reserve. The Owen Stanley Mountains themselves are not well explored zoologically and, as parts of the range are virtually unpopulated, it would be comparatively easy to set aside land for reserves.

2. **The Gulf-Western-Southern Highlands Province boundary area.** The area south of Mount Bosavi, including the valleys of the Turama, Wawoi, Guavi, and other rivers, is hardly known zoologically. All specimens of the rare tree kangaroo *Dendrolagus spadix* have come from this area or rather further to the east, and the species is unusual being the only known species of tree kangaroo that occurs at low altitudes.

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3. **The upper Fly River forests** in the general latitude of Kiunga and Ningerum. Here, a number of species more characteristic of western New Guinea (Irian) are found. Somewhere here the western forest wallaby (*Dorcopsis muelleri*) reaches its eastern limit and the greater bird of paradise (*Paradisaea apoda*) overlaps with the common eastern species (*Paradisaea raggiana*). The area is not well known zoologically, and doubtless other western species will be found to occur here. The recent discovery of a new species of bandicoot (*Echymipera*) suggests that further unknown fauna may await discovery in this area.

4. **The northwestern border area.** A number of other western species occur here but not much further to the east. The most outstanding is the grizzled tree kangaroo (*Dendrolagus inustus*) which seems to be quite common there, but, like all tree kangaroos, vulnerable to hunting. This is also the only known occurrence in Papua New Guinea of the western ringtail possum (*Pseudocheirus albertisi*). The bandicoot (*Echymipera clara*) and the northern forest wallaby (*Dorcopsis hageni*) are also common in these forests but do occur as far east as the Ramu.

5. **Lowlands of the Madang Province.** A number of western species reach their eastern limits here, the bandicoot *Echymipera clara*, for instance, while the northern forest wallaby is still common. The exact eastern limits of this species are unknown. Fauna of this area is particularly vulnerable due to the concentration of timber extraction businesses in Madang.

6. **Star Mountains.** These mountains form an extension of West New Guinea into Papua New Guinea. Species endemism is high (see Hyndman & Menzies, Journal of Biogeography, 1991). Human population density is very low, and there should be no problem in finding an extensive area that can be set up as a reserve.

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Figure 15-7d. Important areas (R. Schodde)

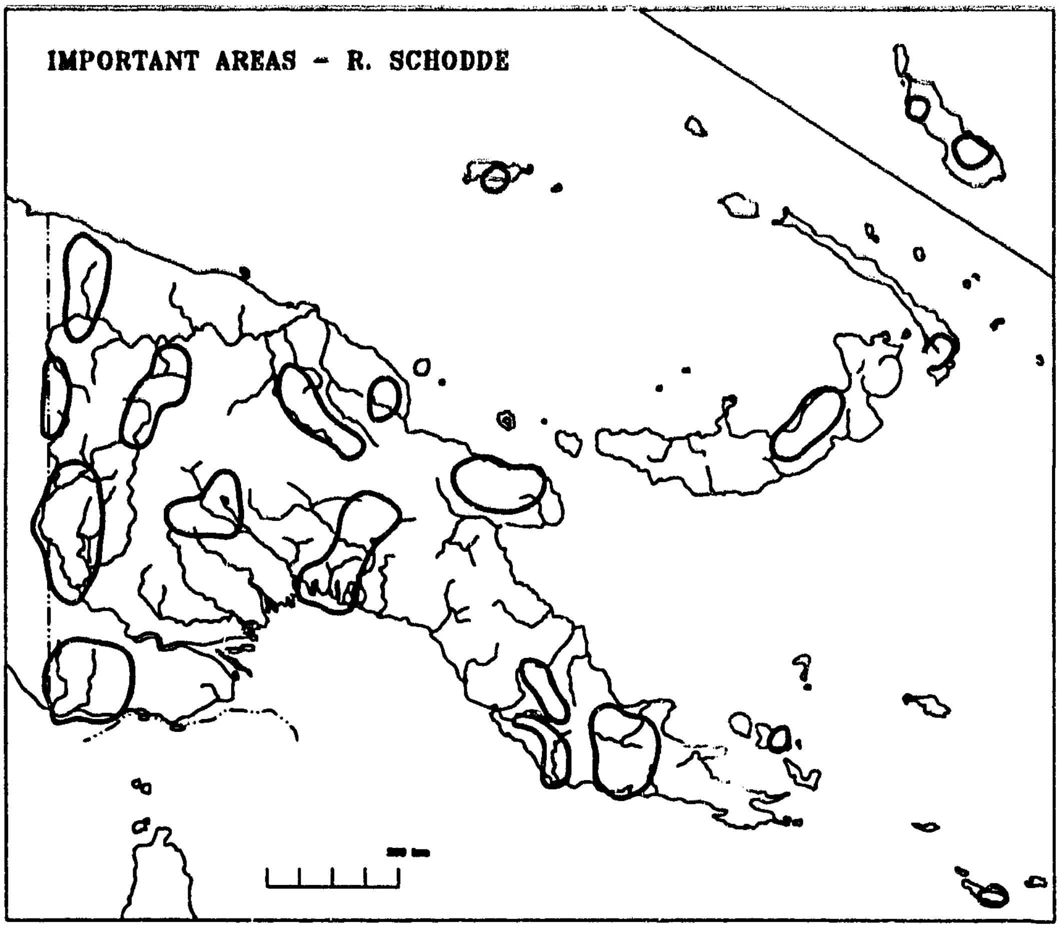

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Figure 15-7e. Important areas combined (with areas of overlap shaded)

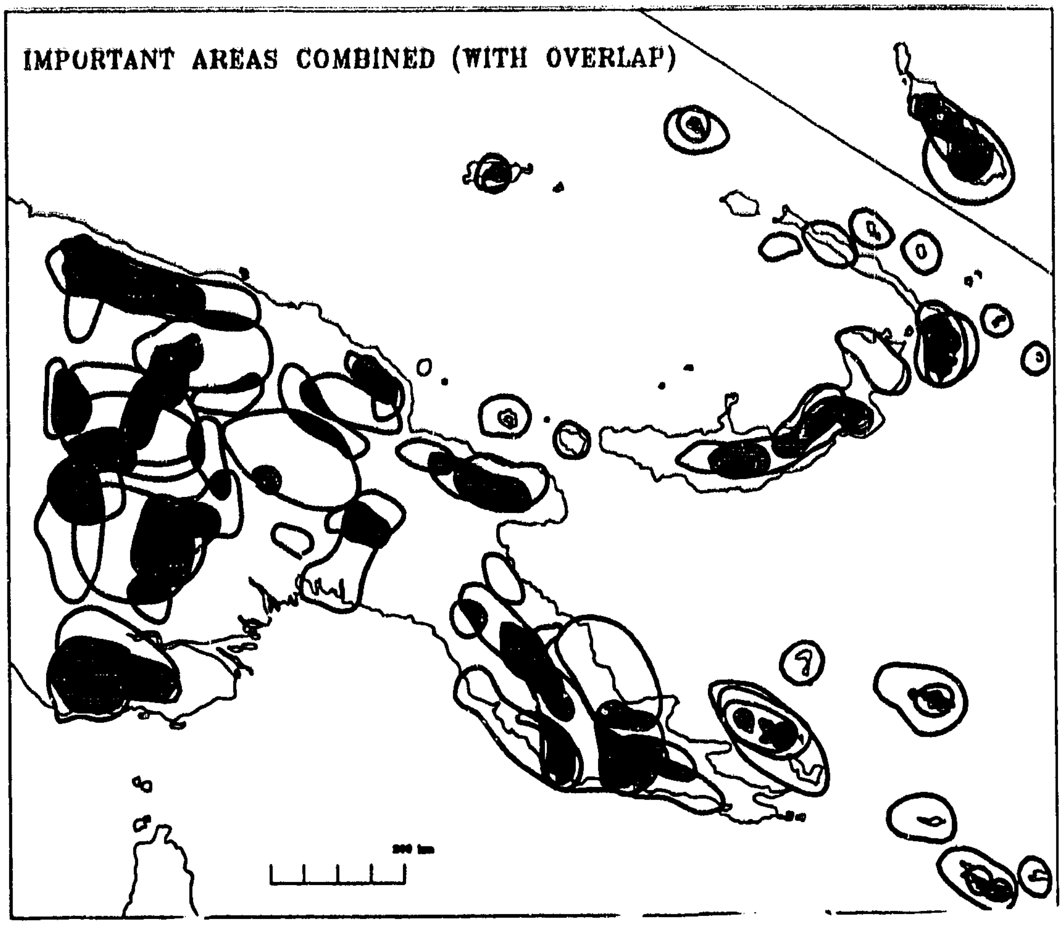

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Figure 15-8. Biologically important areas (Beehler summary selection)

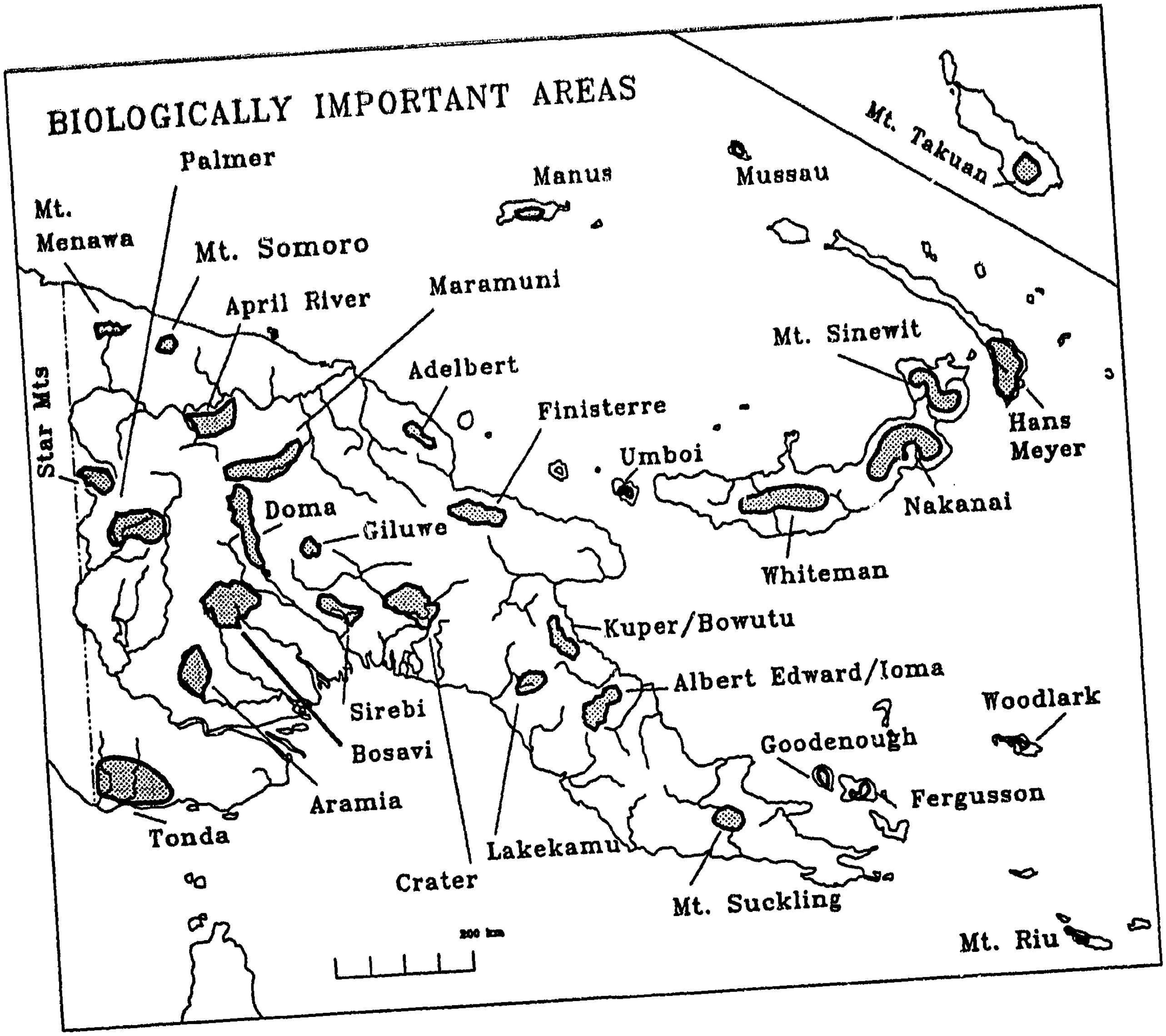

Table 15-1
Endemic Bird Species of Papua New Guinea
(x = present; o = absent)

	Main	NCI	NBR	N.IRE	ADM	SMT	BOUG	E.ISL
Henicopernis infuscata	o	o	x	o	o	o	o	o
Accipiter brachyurus	o	o	x	o	o	o	o	o
Accipiter leucoschistaceus	o	x	x	o	o	o	o	o
Accipiter princeps	o	o	x	o	o	o	o	o
Rallus insignis	o	o	x	o	o	o	o	o
Ptilinopus insolitus	o	x	x	x	x	x	o	o
Ducula melanochroa	o	x	x	x	o	o	o	o
Ducula finschii	o	x	x	x	o	o	o	o
Reinwardtoena browni	o	x	x	x	x	x	o	o
Henicophaps foersteri	o	x	x	o	o	o	o	o
Lorius albidinuchus	o	o	o	x	o	o	o	o
Charmosyna rubrigularis	o	x	x	x	o	o	o	o
Micropsitta meeki	o	o	o	o	x	x	o	o
Cacatua ophthamica	o	o	x	o	o	o	o	o
Loriculus tener	o	o	x	x	o	o	o	o
Centropus violaceus	o	o	x	x	o	o	o	o
Centropus ateralbus	o	x	x	x	o	o	o	o
Tyto aurantia	o	o	x	o	o	o	o	o
Ninox meeki	o	o	o	o	x	o	o	o
Ninox variegata	o	o	x	x	o	o	o	o
Ninox odiosa	o	o	x	o	o	o	o	o
Ceyx websteri	o	x	x	x	o	o	o	o
Halcyon albonotata	o	o	x	o	o	o	o	o
Tanysiptera danae	x	o	o	o	o	o	o	o
Tanysiptera nigriceps	o	x	x	o	o	o	o	o
Pitta superba	o	o	o	o	x	o	o	o
Zoothera talaseae	o	x	x	?	o	o	x	o
Megalurulus rubiginosa	o	o	x	o	o	o	o	o
Megalurulus llanae	o	o	o	o	o	o	x	o
Megalurulus grosvenori	o	o	x	o	o	o	o	o
Rhipidura dahli	o	x	x	x	o	o	o	o
Rhipidura semirubra	o	o	o	o	x	o	o	o
Rhipidura matthiae	o	o	o	o	o	x	o	o
Dicrurus megarhynchus	o	o	o	x	o	o	o	o
Monarcha verticalis	o	x	x	x	o	o	o	o
Monarcha ateralba	o	o	o	x	o	o	o	o
Monarcha menckei	o	o	o	o	o	x	o	o
Monarcha infelix	o	o	o	o	x	o	o	o
Myiagra hebetior	o	o	x	x	o	x	o	o
Myzomela albigula	o	o	o	o	o	o	o	x
Myzomela cineracea	o	x	x	o	o	o	o	o
Myzomela pammelaena[1]	o	x	o	o	x	x	o	o
Myzomela erythromelas	o	o	x	o	o	o	o	o
Myzomela pulchella	o	o	o	x	o	o	o	o
Myzomela sclateri[1]	o	x	x	o	o	o	o	o
Philemon cockerelli	o	x	x	o	o	o	o	o
Philemon eichhorni	o	o	o	x	o	o	o	o
Philemon albitorques	o	o	o	o	x	o	o	o
Vosea whitemanensis	o	o	x	o	o	o	o	o

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Table 15-1 (cont.)

	Main	NCI	NBR	N.IRE	ADM	SMT	BOUG	E.ISL
Melidectes princeps	x	o	o	o	o	o	o	o
Melidectes foersteri	x	o	o	o	o	o	o	o
Melipotes ater	x	o	o	o	o	o	o	o
Stresemannia bougainvillei	o	o	o	o	o	o	x	o
Meliphaga vicina	o	o	o	o	o	o	o	x
Dicaeum eximium	o	o	x	x	o	o	o	o
Zosterops hypoxantha	o	x	x	o	x	o	o	o
Zosterops meeki	o	o	o	o	o	o	o	x
Zosterops griseotinctus	o	x	o	o	o	o	o	x
Lonchura hunsteini	o	o	o	x	o	o	o	o
Lonchura melaena	o	o	x	o	o	o	x	o
Lonchura spectabilis[2]	x	x	x	o	o	o	o	o
Lonchura forbesi	o	o	o	x	o	o	o	o
Lonchura monticola	x	o	o	o	o	o	o	o
Artamus insignis	o	o	x	x	o	o	o	o
Cracticus louisiadensis	o	o	o	o	o	o	o	x
Amblyornis subalaris	x	o	o	o	o	o	o	o
Sericulus bakeri	x	o	o	o	o	o	o	o
Manucodia comrii	o	o	o	o	o	o	o	x
Astrapia mayeri	x	o	o	o	o	o	o	o
Astrapia rothschildi	x	o	o	o	o	o	o	o
Parotia wahnesi	x	o	o	o	o	o	o	o
Parotia lawesii	x	o	o	o	o	o	o	o
Paradisaea decora	o	o	o	o	o	o	o	x
Paradisaea guilliemi	x	o	o	o	o	o	o	o
Paradisaea raggiana	x	o	o	o	o	o	o	o
Paradisaea rudolphi	x	o	o	o	o	o	o	o
totals	15	20	37	22	10	7	4	7

[1] *M. pammelaena* and *sclateri* occur on small islands along the north coast and in the Bismarcks. Absent from main large islands.

[2] *L. spectabilis* is a "virtual endemic" whose range marginally edges into Irian Jaya in the Jayapura area, at the border.

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Table 15-2
Endemic Mammal Species of Papua New Guinea[1], [2]
(x = present, o = absent, ? perhaps present, x? probably present)

	Main	NCI	NBR	N.IRE	ADM	SMT	BOUG	E.ISL
Murexia rothschildi	x	o	o	o	o	o	o	o
*Planigale novaeguineae**	x	o	o	o	o	o	o	o
Dasyurus spartacus	x	o	o	o	o	o	o	o
Peroryctes broadbenti	x	o	o	o	o	o	o	o
Microperoryctes papuensis	x	o	o	o	o	o	o	o
*Echymipera echinista**	x	o	o	o	o	o	o	o
Dorcopsis macleayi	x	o	o	o	o	o	o	o
Dorcopsis atrata	o	o	o	o	o	o	o	x
Dendrolagus spadix	x	o	o	o	o	o	o	o
Dendrolagus goodfellowi	x	o	o	o	o	o	o	o
Dendrogalus matschiei	x	o	o	o	o	o	o	o
Dendrolagus scottae	x	o	o	o	o	o	o	o
Thylogale n. sp. "Calaby's"	x	o	o	o	o	o	o	o
*Phalanger matinim**	x	o	o	o	o	o	o	o
Phalanger lullulae	o	o	o	o	o	o	o	x
Petaurus abidi	x	o	o	o	o	o	o	o
Dactylopsila tatei	o	o	o	o	o	o	o	x
*Neohydromys fuscus**	x	o	o	o	o	o	o	o
Pseudohydromys murinus	x	o	o	o	o	o	o	o
*Mayermys ellermani**	x	o	o	o	o	o	o	o
Hydromys neobrittanicus	o	o	x	o	o	o	o	o
*Crossomys moncktoni**	x	o	o	o	o	o	o	o
Chiruromys forbesi	x	o	o	o	o	o	o	o
Chiruromys lamia	x	o	o	o	o	o	o	o
*Chiruromys vates**	x	o	o	o	o	o	o	o
Mallomys aroaensis	x	o	o	o	o	o	o	o
Mallomys istapantap	x	o	o	o	o	o	o	o
Uromys neobrittanicus	o	o	x	o	o	o	o	o
Melomys arcium	o	o	o	o	o	o	o	x
Melomys fellowsi	x	o	o	o	o	o	o	o
*Abeomelomys sevia**	x	o	o	o	o	o	o	o
Rattus giluwensis	x	o	o	o	o	o	o	o
Rattus novaeguineae	x	o	o	o	o	o	o	o
Rattus mordax	x	o	o	o	o	o	o	x
Rattus owiensis	o	x	o	o	o	o	o	o
Pteropus gilliardi	o	o	x	o	o	o	o	o
Dobsonia pannietensis	o	o	o	o	o	o	o	x
Dobsonia praedatrix	o	o	x	x	o	o	o	o
Dobsonia remota	o	o	o	o	o	o	o	x
*Aproteles bulmerae**	x	o	o	o	o	o	o	o
*Syconycteris hobbit**	x	o	o	o	o	o	o	o
Nyctimene vizcaccia	o	o	o	x	o	o	o	o
*Paranyctimene raptor**	x	o	o	o	o	o	o	o
Melonycteris melanops	o	o	x	o	o	o	o	o
*Hipposideros corynophyllus**	x	o	o	o	o	o	o	o
*Pipistrellus angulatus**	x	o	x	x	o	o	x	o
*Pipistrellus collinus**	x	o	o	o	o	o	o	o
Pipistrellus wattsi	x	o	o	o	o	o	o	o
Pharotis imogene	x	o	o	o	o	o	o	o

Table 15-2 -- continued

	Main	NCI	NBR	N.IRE	ADM	SMT	BOUG	E.ISL
*Nyctophilus microtis**	x	o	o	o	o	o	o	o
*Nyctophilus microdon**	x	o	o	o	o	o	o	o
*Nyctophilus bifax**	x	o	o	o	o	o	o	o
Kerivoula agnella	o	o	o	o	o	o	o	x
*Kerivoula muscina**	x	o	o	o	o	o	o	o
Tadarida kuboriensis	x	o	o	o	o	o	o	o
Otomops papuensis	x	o	o	o	o	o	o	o
Otomops secundus	x	o	o	o	o	o	o	o
totals	43	1	6	3	0	0	1	8

[1] The abbreviations for the regions are: Main=Mainland PNG; NCI=North Coastal Islands (west of New Britain); NBR=New Britain; N.IRE=New Ireland; ADM=Admiralty Islands; SMT=St. Matthias group; BOUG=Bougainville Island; E.ISL=the islands off eastern Papua.

[2] Species marked with an "*" probably range into Irian Jaya; although no record exists for Irian, the PNG records range to the border, thus they probably cross in the absence of distributional barriers.

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Table 15-3[1]
Species-Counts of Breeding Birds and Mammals
for PNG -- By Region

	Total	Mainland PNG	Britain	New Ireland	New Manus	Islands	East.[2] ville	Bougain- Other[3]
Breeding Birds	644	536	159	129	67	151	125	165
Breeding Mammals	214	184	34	36	10	26	31	?

[1] Tentative counts, subject to revision; mammal counts are, in particular, suspect, especially for all insular counts.

[2] Includes D'Entrecasteaux, Trobriand, Woodlark, and Louisiade islands.

[3] Small islands, such as the north coastal fringing islands, the islands north of New Britain, and islands fringing New Ireland and New Hanover.

Table 15-4
ICBP - Restricted Area Endemic Bird Species[1]

(Bird species with ranges less than 50,000 km^2,
occurring on the PNG mainland)

Chestnut Forest Rail (*Rallina rubra*)
Mayr's Chestnut Rail (*Rallina mayri*)
Brown Lory (*Chalcopsitta duivenbodei*)
Striated Lorikeet (*Charmosyna multistriata*)
Edward's Fig-Parrot (*Psittaculirostris edwardsii*)
Yellow-capped Pygmy-Parrot (*Micropsitta keiensis*)
Painted Tiger-Parrot (*Psittacella picta*)
Modest Tiger-Parrot (*Psittacella modesta*)
Archbold's Owlet-Nightjar (*Aegotheles archboldi*)
Archbold's Nightjar (*Eurostopodus archboldi*)
Spangled Kookaburra (*Dacelo tyro*)
Lesser Paradise-Kingfisher (*Tanysiptera hydrocharis*)
Red-breasted Paradise-Kingfisher (*Tanysiptera nympha*)
Brown-headed Paradise-Kingfisher (*Tanysiptera danae*)
Alpine Pipit (*Anthus gutturalis*)
Greater Melampitta (*Melampitta gigantea*)
Painted Quail-thrush (*Cinclosoma ajax*)
Fly River Grass-Warbler (*Megalurus albolimbatus*)
Broad-billed Fairy-wren (*Malurus grayi*)
Mountain Robin (*Petroica bivittata*)
Greater Ground-Robin (*Amalocichla sclateriana*)
Banded Yellow Robin (*Poecilodryas placens*)
Green-backed Robin (*Pachycephalopsis hattamensis*)
Lorentz's Whistler (*Pachycephala lorentzi*)
Golden Whistler (*Pachycephala aurea*)
Sooty Whistler (*Pachycephala tenebrosa*)
Mottled Whistler (*Pitohui incertus*)
Pink-faced Sittella (*Daphoenositta miranda*)
Long-bearded Melidectes (*Melidectes princeps*)
Cinnamon-browed Melidectes (*Melidectes ochromelas*)
Foerster's Melidectes (*Melidectes foersteri*)
Spangled Honeyeater (*Melipotes ater*)
Leaden Honeyeater (*Ptiloprora plumbea*)
Yellow-streaked Honeyeater (*Ptiloprora meekiana*)
Mountain Firetail (*Oreostruthus fuliginosus*)
White-spotted Mannnikin (*Lonchura leucosticta*)
White-crowned Mannikin (*Lonchura nevermanni*)
Black Mannikin (*Lonchura stygia*)
Eastern Alpine Mannikin (*Lonchura monticola*)
Yellow-eyed Starling (*Aplonis mystacea*)

Table 15-4 (continued)

Archbold's Bowerbird (*Archboldia papuensis*)
Streaked Bowerbird (*Amblyornis subalaris*)
Fire-maned Bowerbird (*Sericulus bakeri*)
Crested Bird of Paradise (*Cnemophilus macgregorii*)
Yellow-breasted Bird of Paradise (*Loboparadisea sericea*)
Macgregor's Bird of Paradise (*Macgregoria pulchra*)
Pale-billed Sicklebill (*Epimachus bruijnii*)
Black Sicklebill (*Epimachus fastuosus*)
Splendid Astrapia (*Astrapia splendidissima*)
Ribbon-tailed Astrapia (*Astrapia mayeri*)
Stephanie's Astrapia (*Astrapia stephaniae*)
Huon Astrapia (*Astrapia rothschildi*)
Wahnes' Parotia (*Parotia wahnesi*)
Carola's Parotia (*Parotia carolae*)
King of Saxony Bird of Paradise (*Pteridophora alberti*)
Emperor Bird of Paradise (*Paradisaea guilliemi*)
Blue Bird of Paradise (*Paradisaea rudolphi*)

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[1] Thanks to Alison Stattersfield and ICBP/Cambridge for use of these unpublished data for our analysis. The original list has been slightly reduced after consultation with the correspondent team.

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Table 15-5

Papua New Guinea's Rarest and Most Threatened Birds and Mammals

RAREST BIRDS

Chestnut-mantled Goshawk (*Accipiter buergersi*)
Nicobar Pigeon (*Caloenas nicobarica*)
Victoria Crowned Pigeon (*Goura victoria*)
Southern Crowned Pigeon (*Goura scheepmakeri*)
Pesquet's Parrot (*Psittrichas fulgidus*)
Superb Pitta (*Pitta superba*)
Manus Rufous Fantail (*Rhipidura semirubra*)
Archbold's Bowerbird (*Archboldia papuensis*)
Fire-maned Bowerbird (*Sericulus bakeri*)
Macgregor's Bird of Paradise (*Macgregoria pulchra*)
Black Sicklebill (*Epimachus fastuosus*)
Blue Bird of Paradise (*Paradisaea rudolphi*)

RAREST MAMMALS

Long-beaked Echidna (*Zaglossus bruijni*)
Fly Spiny Bandicoot (*Echymipera echinista*)
Scott's Tree Kangaroo (*Dendrolagus scottae*)
Goodenough Wallaby (*Dorcopsis atrata*)
Calaby's Thylogale (*Thylogale sp.*)
Black-spotted Cuscus (*Spilocuscus rufoniger*)
Fergusson Striped Possum (*Dactylopsila tatei*)
Bulmer's Fruit Bat (*Aproteles bulmerae*)

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Table 15-6
Birds and Mammals of Economic Importance in Papua New Guinea
(x = present, o = absent, ? = unknown/possible)

SPECIES	Subsist.[1]	Local Markets	PNG-wide	Illegal Export?	Use?
Birds					
Southern Cassowary (*Casuarius casuarius*)	x	x	x	o	meat
Northern Cassowary (*C. unappendiculatus*)	x	x	x	o	"
Dwarf Cassowary (*C. bennetti*)	x	x	x	o	"
various waterfowl (ducks, coots, etc.)	x	x	o	o	"
white egrets	o	x	x	o	plumes
New Guinea Harpy-Eagle (*Harpyopsis novaeguineae*)	o	x	x	o	feathers
Long-tailed Buzzard (*Henicopernis longicauda*)	o	x	?	o	"
Common Scrubfowl (*Megapodius freycinet*)	x	x	o	o	eggs, meat
Island Scrubfowl (*M. eremita*)	x	x	o	o	"
Black-billed Brush-turkey (*Talegalla fuscirostris*)	x	x	o	o	"
Browned-collared Brush-turkey (*T. jobiensis*)	x	x	o	o	"
Wattled Brush-turkey (*Aepypodius arfakianus*)	x	x	o	o	"
Crowned Pigeons (*Goura* spp.)	x	x	x	?	meat, plumes
Imperial Pigeons (*Ducula* spp.)	x	o	o	o	meat
various ground-pigeons	x	o	o	o	meat
various small lorikeets (*Charmosyna*)	x	x	o	o	feathers
various medium-sized parrots (*Lorius*, etc.)		x	x	?	pets
white cockatoos (*Cacatua* spp.)	o	x	x	?	pets, feathers
Pesquet's Parrot (*Psittrichas fulgidus*)	x	x	x	o	feathers
Blyth's Hornbill (*Rhyticeros plicatus*)	x	x	x	o	beak, meat
various plumed birds of paradise	x	x	x	?	plumes
Mammals					
Dendrolagus tree kangaroos	x	x	x	o	meat, pelage, pets
Dorcopsis and *Macropus* wallabies	x	x	o	o	meat
various cuscuses and possums	x	x	o	o	meat, pelage, pets
the larger Pteropodid bats	x	x	o	o	meat

[1] Subsistence = for village and home use, rarely sold; local markets = sold in local markets for cash; PNG-wide = traded in markets outside of local area of capture.

Table 15-7
Biogeographic Districts for Papua New Guinea
(for location, refer to Figure 15-6)

1. North Coast (NC)
2. Sepik/Ramu basin (SP)
3. Star Mts. (ST)
4. Central Range (CR)
5. Southern Highlands (SH)
6. Adelbert Mts. (AD)
7. Upper Fly (UF)
8. Trans-Fly (TF)
9. Eastern Fly (EF)
10. Southern Scarp (SS)
11. Kikori-Purari (KP)
12. Eastern Highlands (EH)
13. Huon (HU)
14. North Coastal Islands (NI)
15. Eastern New Britain (EN)
16. Central New Britain (CN)
17. Western New Britain (WN)
18. Gazelle Peninsula (GP)
19. New Ireland (NE)
20. Lihir and Islands (LI)
21. New Hanover (NH)
22. St. Matthias group (SM)
23. Admiralty Islands (MA)
24. Bougainville (BO)
25. Northern Peninsula (NP)
26. Owen Stanleys (OS)
27. Eastern Peninsula (EP)
28. D'Entrecasteaux Islands (DE)
29. Woodlark group (WO)
30. Eastern Islands (EI)

APPENDIX 15-1. LISTS OF FOCAL BIRD AND MAMMAL SPECIES FROM THE BIOGEOGRAPHIC DISTRICTS OF PNG (BY DISTRICT)

Coding: key+ =selected larger mammal genera and important larger and rarer bird species (see text for explanation of selections); icbp=restricted range species for mainland New Guinea as determined by ICBP study; bop=bird of paradise. The number codes preceding each species refers to particular reference books and page numbers (1.0570 = Volume 1 of Coates Birds of Papua New Guinea, page 57, the first or only focal species on page; 2.xxx refers to Coates, Volume 2; 3.xxxx refers to Honacki, etc., Mammal Species of the World, 1982; the decimal digits: place 1-3, page number, place 4=order on page). For location of Districts, see Map 6, Table 7).

North Coastal Ranges

		Category
1.0570	*Casuarius unappendiculatus*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3100	*Chalcopsitta duivenbodei*	icbp
1.3290	*Psittaculirostris edwardsii*	icbp
1.3370	*Probosciger aterrimus*	key+
2.0661	*Melampitta gigantea*	icbp
2.0880	*Malurus grayi*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.3980	*Sericulus aureus*	key+
2.4300	*Manucodia atra*	bop
2.4320	*Manucodia jobiensis*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4430	*Epimachus bruijnii*	bop,icbp
2.4440	*Epimachus fastuosus*	bop,key+
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5190	*Paradisaea minor*	bop
3.03702	*Phalanger orientalis*	key+
3.0410	*Pseudocheirus albertisii*	key+
3.04304	*Dendrolagus inustus*	key+
3.04315	*Dendrolagus scottae*	key+
3.04401	*Dorcopsis hageni*	key+
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Sepik-Ramu

		Category
1.0570	*Casuarius unappendiculatus*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3100	*Chalcopsitta duivenbodei*	icbp
1.3290	*Psittaculirostris edwardsii*	icbp
1.3370	*Probosciger aterrimus*	key+
1.4321	*Tanysiptera nympha*	icbp
2.0880	*Malurus grayi*	icbp
2.2120	*Pachycephala aurea*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.4300	*Manucodia atra*	bop
2.4320	*Manucodia jobiensis*	bop
2.4430	*Epimachus bruijnii*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4870	*Cicinnurus regius*	bop
2.5190	*Paradisaea minor*	bop
3.03702	*Phalanger orientalis*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04401	*Dorcopsis hageni*	key+
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

Star Mountains

		Category
1.1270	*Harpyopsis novaeguineae*	key+
1.1530	*Rallina rubra*	icbp
1.3220	*Charmosyna multistriata*	icbp
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	icbp
1.3490	*Psittacella modesta*	icbp
1.3850	*Aegotheles archboldi*	icbp
2.0300	*Anthus gutturalis*	icbp
2.0880	*Malurus grayi*	icbp
2.2080	*Pachycephala lorentzi*	icbp
2.2120	*Pachycephala aurea*	icbp
2.2200	*Pachycephala tenebrosa*	icbp
2.2661	*Ptiloprora plumbea*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.3360	*Oreostruthus fuliginosus*	icbp
2.4220	*Cnemophilus loriae*	bop
2.4280	*Loboparadisea sericea*	bop,icbp
2.4290	*Macgregoria pulchra*	bop,icbp
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4390	*Paradigalla brevicauda*	bop
2.4440	*Epimachus fastuosus*	bop,key+,icbp
2.4450	*Epimachus meyeri*	bop
2.4480	*Astrapia splendidissima*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4640	*Lophorina superba*	bop
2.4720	*Parotia carolae*	bop,icbp
2.4840	*Pteridophora alberti*	bop,icbp
2.4960	*Cicinnurus magnificus*	bop
3.03701	*Phalanger matanim*	key+
3.03702	*Phalanger orientalis*	key+
3.03703	*Phalanger vestitus*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.0420	*Pseudocheirus mayeri*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+

3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+

Central Range

1.1270	*Harpyopsis novaeguineae*	key+
1.1530	*Rallina rubra*	icbp
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	icbp
1.3490	*Psittacella modesta*	icbp
2.0300	*Anthus gutturalis*	icbp
2.2200	*Pachycephala tenebrosa*	icbp
2.2370	*Daphoenositta miranda*	icbp
2.3980	*Sericulus aureus*	key+
2.4220	*Cnemophilus loriae*	bop
2.4230	*Cnemophilus macgregorii*	bop,icbp
2.4280	*Loboparadisea sericea*	bop,icbp
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4390	*Paradigalla brevicauda*	bop
2.4410	*Epimachus albertisi*	bop
2.4440	*Epimachus fastuosus*	bop,key+
2.4450	*Epimachus meyeri*	bop
2.4490	*Astrapia mayeri*	bop,icbp
2.4520	*Astrapia stephaniae*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4640	*Lophorina superba*	bop
2.4720	*Parotia carolae*	bop,icbp
2.4760	*Parotia lawesii*	bop
2.4840	*Pteridophora alberti*	bop,icbp
2.4960	*Cicinnurus magnificus*	bop
2.5320	*Paradisaea rudolphi*	bop,png
3.03702	*Phalanger orientalis*	key+
3.03703	*Phalanger vestitus*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+

Southern Highlands

1.1270	*Harpyopsis novaeguineae*	key+
1.1530	*Rallina rubra*	icbp
1.3220	*Charmosyna multistriata*	icbp
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	icbp
1.3490	*Psittacella modesta*	icbp
1.3870	*Eurostopodus archboldi*	icbp
2.0300	*Anthus gutturalis*	icbp
2.1850	*Petroica bivittata*	icbp
2.1870	*Amalocichla sclateriana*	icbp
2.2120	*Pachycephala aurea*	icbp
2.2370	*Daphoenositta miranda*	icbp
2.2580	*Melidectes princeps*	png,icbp
2.2670	*Ptiloprora mayri*	icbp
2.3360	*Oreostruthus fuliginosus*	icbp
2.3850	*Archboldia papuensis*	icbp
2.4220	*Cnemophilus loriae*	bop
2.4230	*Cnemophilus macgregorii*	bop,icbp
2.4280	*Loboparadisea sericea*	bop,icbp
2.4330	*Manucodia chalybata*	bop
2.4390	*Paradigalla brevicauda*	bop
2.4410	*Epimachus albertisi*	bop
2.4440	*Epimachus fastuosus*	bop,key+,icbp
2.4450	*Epimachus meyeri*	bop
2.4490	*Astrapia mayeri*	bop,icbp
2.4520	*Astrapia stephaniae*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4640	*Lophorina superba*	bop
2.4720	*Parotia carolae*	bop,icbp
2.4760	*Parotia lawesii*	bop
2.4840	*Pteridophora alberti*	bop,icbp
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5320	*Paradisaea rudolphi*	bop,png,icbp
3.03702	*Phalanger orientalis*	key+
3.03703	*Phalanger vestitus*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.0420	*Pseudocheirus mayeri*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+

Adelbert Mountains

1.0570	*Casuarius unappendiculatus*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3100	*Chalcopsitta duivenbodei*	icbp
1.3280	*Psittaculirostris edwardsii*	icbp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
1.4321	*Tanysiptera nympha*	icbp
2.1920	*Poecilodryas placens*	icbp
2.4020	*Sericulus bakeri*	icbp,png
2.4300	*Manucodia atra*	bop
2.4320	*Manucodia jobiensis*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4640	*Lophorina superba*	bop
2.4690	*Parotia wahnesi*	bop,png,icbp
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5190	*Paradisaea minor*	bop
3.03702	*Phalanger orientalis*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1230	*Pteropus neohibernicus*	key+

Upper Fly

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3350	*Micropsitta keiensis*	icbp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
2.0680	*Cinclosoma ajax*	icbp
2.0880	*Malurus grayi*	icbp
2.2120	*Pachycephala aurea*	icbp
2.2290	*Pitohui incertus*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.3361	*Lonchura leucosticta*	icbp
2.3570	*Aplonis mystacea*	icbp
2.3980	*Sericulus aureus*	key+
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop

2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5170	*Paradisaea apoda*	bop
3.03702	*Phalanger orientalis*	key+
3.04405	*Dorcopsis luctuosa*	key+
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Trans-Fly

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3350	*Micropsitta keiensis*	iobp
1.3370	*Probosciger aterrimus*	key+
1.4110	*Dacelo tyro*	iobp
1.4320	*Tanysiptera hydrocharis*	iobp
2.0680	*Cinclosoma ajax*	iobp
2.0840	*Megalurus albolimbatus*	iobp
2.3361	*Lonchura leucosticta*	iobp
2.3410	*Lonchura nevermanni*	iobp
2.3460	*Lonchura stygia*	iobp
2.4300	*Manucodia atra*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4570	*Ptiloris magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
3.03702	*Phalanger orientalis*	key+
3.04405	*Dorcopsis luctuosa*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1201	*Pteropus alecto*	key+
3.1221	*Pteropus macrotis*	key+
3.1230	*Pteropus neohibernicus*	key+
3.1241	*Pteropus scapulatus*	key+

Eastern Fly

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3350	*Micropsitta keiensis*	iobp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
2.0680	*Cinclosoma ajax*	iobp
2.2790	*Lichenostomus obscurus*	iobp
2.3410	*Lonchura nevermanni*	iobp
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4870	*Cicinnurus regius*	bop
2.5080	*Paradisaea raggiana*	bop
3.03702	*Phalanger orientalis*	key+
3.0434	*Dendrolagus spadix*	key+
3.04405	*Dorcopsis luctuosa*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Southern Scarp

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3220	*Charmosyna multistriata*	iobp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
2.0680	*Cinclosoma ajax*	iobp

2.0880	*Malurus grayi*	iobp
2.1920	*Poecilodryas placens*	iobp
2.2000	*Pachycephalopsis hattamensis*	iobp
2.2790	*Lichenostomus obscurus*	iobp
2.3980	*Sericulus aureus*	key+
2.4220	*Cnemophilus loriae*	bop
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4410	*Epimachus albertisi*	bop
2.4440	*Epimachus fastuosus*	bop,key+,iobp
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4720	*Parotia carolae*	bop,iobp
2.4760	*Parotia lawesii*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5320	*Paradisaea rudolphi*	bop,png,iobp
3.03702	*Phalanger orientalis*	key+
3.03706	*Phalanger sericeus*	key+
3.04101	*Pseudocheirus canescens*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.04301	*Dendrolagus dorianus*	key+
3.0434	*Dendrolagus spadix*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Kikori - Purari

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3370	*Probosciger aterrimus*	key+
2.2790	*Lichenostomus obscurus*	iobp
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4870	*Cicinnurus regius*	bop
2.5080	*Paradisaea raggiana*	bop
3.03702	*Phalanger orientalis*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0434	*Dendrolagus spadix*	key+
3.04405	*Dorcopsis luctuosa*	key+
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Eastern Highlands

1.1270	*Harpyopsis novaeguineae*	key+
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	iobp
2.0300	*Anthus gutturalis*	iobp
2.1920	*Poecilodryas placens*	iobp
2.2120	*Pachycephala aurea*	iobp
2.2370	*Daphoenositta miranda*	iobp
2.2580	*Melidectes princeps*	png,iobp
2.2661	*Ptiloprora plumbea*	iobp
2.2670	*Ptiloprora mayeri*	iobp
2.4220	*Cnemophilus loriae*	bop
2.4230	*Cnemophilus macgregorii*	bop,iobp
2.4280	*Loboparadisea sericea*	bop,iobp
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4390	*Paradigalla brevicauda*	bop

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2.4410	*Epimachus albertisi*	bop
2.4440	*Epimachus fastuosus*	bop,key+
2.4450	*Epimachus meyeri*	bop
2.4520	*Astrapia stephaniae*	bop,iobp
2.4570	*Ptiloris magnificus*	bop
2.4640	*Lophorina superba*	bop
2.4720	*Parotia carolae*	bop,iobp
2.4760	*Parotia lawesii*	bop
2.4840	*Pteridophora alberti*	bop,iobp
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5320	*Paradisaea rudolphi*	bop,png
3.03702	*Phalanger orientalis*	key+
3.03703	*Phalanger vestitus*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.04101	*Pseudocheirus canescens*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.04404	*Dorcopsis macleayi*	key+
3.1132	*Dobsonia moluccensis*	key+

Huon Peninsula

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3280	*Psittaculirostris edwardsii*	iobp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
1.3870	*Eurostopodus archboldi*	iobp
1.4321	*Tanysiptera nympha*	iobp
2.0300	*Anthus gutturalis*	iobp
2.2590	*Melidectes ochromelas*	iobp
2.2630	*Melidectes foersteri*	png,iobp
2.2660	*Melipotes ater*	png,iobp
2.2670	*Ptiloprora meekiana*	iobp
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4410	*Epimachus albertisi*	bop
2.4560	*Astrapia rothschildi*	bop,iobp,png
2.4570	*Ptiloris magnificus*	bop
2.4640	*Lophorina superba*	bop
2.4690	*Parotia wahnesi*	bop,png,iobp
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5250	*Paradisaea guilliemi*	bop,iobp,png
3.03702	*Phalanger orientalis*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04303	*Dendrolagus matschiei*	key+
3.04401	*Dorcopsis hageni*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1221	*Pteropus macrotis*	key+

Northern Islands

1.1230	*Accipiter leucoschistaceus*	png
1.2410	*Ptilinopus insolitus*	png
1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.2930	*Henicophaps foersteri*	png
1.3190	*Charmosyna rubrigularis*	png
1.3680	*Centropus ateralbus*	png
1.4050	*Ceyx websteri*	png
1.4340	*Tanysiptera nigriceps*	png
2.1290	*Rhipidura dahli*	png
2.1580	*Monarcha verticalis*	png
2.2410	*Myzomela cineracea*	png
2.2430	*Myzomela pammelaena*	png
2.2471	*Myzomela sclateri*	png
2.2540	*Philemon cockerelli*	png
2.3280	*Zosterops hypoxantha*	png
2.3330	*Zosterops griseotinctus*	png
3.1131	*Dobsonia minor*	key+
3.1132	*Dobsonia moluccensis*	key+
3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+
3.1250	*Pteropus temmincki*	key+
3.1251	*Pteropus tonganus*	

Eastern New Britain

1.1090	*Henicopernis infuscata*	png
1.1220	*Accipiter brachyurus*	png
1.1230	*Accipiter leucoschistaceus*	png
1.1270	*Accipiter princeps*	png
1.1530	*Rallus insignis*	png
1.2410	*Ptilinopus insolitus*	png
1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.2930	*Henicophaps foersteri*	png
1.3190	*Charmosyna rubrigularis*	png
1.3390	*Cacatua ophthamica*	png
1.3510	*Loriculus tener*	png
1.3650	*Centropus violaceus*	png
1.3680	*Centropus ateralbus*	png
1.3710	*Tyto aurantia*	png
1.3780	*Ninox solomonis*	png
1.3781	*Ninox odiosa*	png
1.4050	*Ceyx websteri*	png
1.4190	*Halcyon albonotata*	png
1.4340	*Tanysiptera nigriceps*	png
2.0760	*Megalurulus rubiginosa*	png
2.1290	*Rhipidura dahli*	png
2.1580	*Monarcha verticalis*	png
2.1750	*Myiagra hebetior*	png
2.2410	*Myzomela cineracea*	png
2.2460	*Myzomela erythromelas*	png
2.2540	*Philemon cockerelli*	png
2.2560	*Vosea whitemanensis*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3740	*Artamus insignis*	png
3.03702	*Phalanger orientalis*	key+
3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

Central New Britain

1.1090	*Henicopernis infuscata*	png
1.1220	*Accipiter brachyurus*	png
1.1230	*Accipiter leucoschistaceus*	png
1.1270	*Accipiter princeps*	png
1.1530	*Rallus insignis*	png
1.2410	*Ptilinopus insolitus*	png

1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.2930	*Henicophaps foersteri*	png
1.3190	*Charmosyna rubrigularis*	png
1.3390	*Cacatua ophthalmica*	png
1.3510	*Loriculus tener*	png
1.3650	*Centropus violaceus*	png
1.3680	*Centropus ateralbus*	png
1.3710	*Tyto aurantia*	png
1.3780	*Ninox solomonis*	png
1.3781	*Ninox odiosa*	png
1.4050	*Ceyx websteri*	png
1.4190	*Halcyon albonotata*	png
1.4340	*Tanysiptera nigriceps*	png
2.0760	*Megalurulus rubiginosa*	png
2.0781	*Megalurulus grosvenori*	png
2.1290	*Rhipidura dahli*	png
2.1580	*Monarcha verticalis*	png
2.1750	*Myiagra hebetior*	png
2.2410	*Myzomela cineracea*	png
2.2460	*Myzomela erythromelas*	png
2.2540	*Philemon cockerelli*	png
2.2560	*Vosea whitemanensis*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3740	*Artamus insignis*	png
3.03702	*Phalanger orientalis*	key+
3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1212	*Pteropus gilliardi*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

Western New Britain

1.1090	*Henicopernis infuscata*	png
1.1220	*Accipiter brachyurus*	png
1.1230	*Accipiter leucoschistaceus*	png
1.1270	*Accipiter princeps*	png
1.1530	*Rallus insignis*	png
1.2410	*Ptilinopus insolitus*	png
1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.2930	*Henicophaps foersteri*	png
1.3190	*Charmosyna rubrigularis*	png
1.3390	*Cacatua ophthalmica*	png
1.3510	*Loriculus tener*	png
1.3650	*Centropus violaceus*	png
1.3680	*Centropus ateralbus*	png
1.3710	*Tyto aurantia*	png
1.3780	*Ninox solomonis*	png
1.3781	*Ninox odiosa*	png
1.4050	*Ceyx websteri*	png
1.4190	*Halcyon albonotata*	png
1.4340	*Tanysiptera nigriceps*	png
2.0760	*Megalurulus rubiginosa*	png
2.1290	*Rhipidura dahli*	png
2.1580	*Monarcha verticalis*	png
2.1750	*Myiagra hebetior*	png
2.2410	*Myzomela cineracea*	png
2.2460	*Myzomela erythromelas*	png
2.2540	*Philemon cockerelli*	png
2.2560	*Vosea whitemanensis*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3740	*Artamus insignis*	png
3.03702	*Phalanger orientalis*	key+

3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

Gazelle Peninsula

1.1090	*Henicopernis infuscata*	png
1.1220	*Accipiter brachyurus*	png
1.1230	*Accipiter leucoschistaceus*	png
1.1270	*Accipiter princeps*	png
1.1530	*Rallus insignis*	png
1.2410	*Ptilinopus insolitus*	png
1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.2930	*Henicophaps foersteri*	png
1.3190	*Charmosyna rubrigularis*	png
1.3390	*Cacatua ophthalmica*	png
1.3510	*Loriculus tener*	png
1.3650	*Centropus violaceus*	png
1.3680	*Centropus ateralbus*	png
1.3710	*Tyto aurantia*	png
1.3780	*Ninox solomonis*	png
1.3781	*Ninox odiosa*	png
1.4050	*Ceyx websteri*	png
1.4190	*Halcyon albonotata*	png
1.4340	*Tanysiptera nigriceps*	png
2.0760	*Megalurulus rubiginosa*	png
2.1290	*Rhipidura dahli*	png
2.1580	*Monarcha verticalis*	png
2.1750	*Myiagra hebetior*	png
2.2410	*Myzomela cineracea*	png
2.2460	*Myzomela erythromelas*	png
2.2540	*Philemon cockerelli*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3740	*Artamus insignis*	png
3.03702	*Phalanger orientalis*	key+
3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1200	*Pteropus admiralitatum*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

New Ireland

1.2410	*Ptilinopus insolitus*	png
1.2560	*Ducula melanochroa*	png
1.2600	*Ducula finschii*	png
1.2680	*Reinwardtoena browni*	png
1.3180	*Lorius albidinuchus*	png
1.3190	*Charmosyna rubrigularis*	png
1.3510	*Loriculus tener*	png
1.3650	*Centropus violaceus*	png
1.3680	*Centropus ateralbus*	png
1.3780	*Ninox solomonis*	png
1.4050	*Ceyx websteri*	png
2.1290	*Rhipidura dahli*	png
2.1460	*Dicrurus megarhynchus*	png
2.1580	*Monarcha verticalis*	png
2.1590	*Monarcha ateralba*	png
2.1750	*Myiagra hebetior*	png
2.2470	*Myzomela pulchella*	png
2.2541	*Philemon eichhorni*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3420	*Lonchura hunsteini*	png
2.3440	*Lonchura forbesi*	png
2.3740	*Artamus insignis*	png

3.11335	*Dobsonia andersoni*	key+
3.1134	*Dobsonia praedatrix*	key+
3.1230	*Pteropus neohibernicus*	key+

Lihir and Islands

1.2410	*Ptilinopus insolitus*	png
1.2680	*Reinwardtoena browni*	png
1.4050	*Ceyx websteri*	png
2.3100	*Dicaeum eximium*	png
2.3330	*Zosterops griseotinctus*	png
3.11335	*Dobsonia andersoni*	key+
3.1230	*Pteropus neohibernicus*	key+

New Hanover

1.2410	*Ptilinopus insolitus*	png
1.2680	*Reinwardtoena browni*	png
1.3190	*Charmosyna rubrigularis*	png
1.3510	*Loriculus tener*	png
1.3780	*Ninox solomonis*	png
1.4050	*Ceyx websteri*	png
2.1580	*Monarcha verticalis*	png
2.1750	*Myiagra hebetior*	png
2.2430	*Myzomela pammelaena*	png
2.3100	*Dicaeum eximium*	png
2.3280	*Zosterops hypoxantha*	png
2.3420	*Lonchura hunsteini*	png

St. Matthias group

1.2410	*Ptilinopus insolitus*	png
1.2680	*Reinwardtoena browni*	png
1.3350	*Micropsitta meeki*	png
2.1310	*Rhipidura matthiae*	png
2.1590	*Monarcha menckei*	png
2.1750	*Myiagra hebetior*	png
2.2430	*Myzomela pammelaena*	png

Manus and Islands

1.2410	*Ptilinopus insolitus*	png
1.2680	*Reinwardtoena browni*	png
1.3350	*Micropsitta meeki*	png
1.3770	*Ninox meeki*	png
2.0210	*Pitta superba*	
2.130	*Rhipidura semirubra*	png
2.1600	*Monarcha infelix*	png
2.2430	*Myzomela pammelaena*	png
2.2550	*Philemon albitorques*	png
2.3280	*Zosterops hypoxantha*	png
2.3330	*Zosterops griseotinctus*	png
3.11335	*Dobsonia andersoni*	key+
3.03703	*Phalanger kraemeri*	key+
3.1200	*Pteropus admiralitatum*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1230	*Pteropus neohibernicus*	key+

Bougainville

2.0780	*Megalurulus llanae*	png
2.2700	*Stresemannia bougainvillei*	png
3.11370	*Dobsonia inermis*	key+
3.1200	*Pteropus admiralitatum*	key+
3.1220	*Pteropus hypomelanus*	key+
3.1222	*Pteropus mahaganus*	key+
3.1240	*Pteropus rayneri*	key+

Northern Peninsula

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3290	*Psittaculirostris edwardsii*	icbp
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	icbp
1.3870	*Eurostopodus archboldi*	icbp
1.4321	*Tanysiptera nympha*	icbp
2.1870	*Amalocichla sclateriana*	icbp
2.2120	*Pachycephala aurea*	icbp
2.2370	*Daphoenositta miranda*	icbp
2.2590	*Melidectes ochromelas*	icbp
2.2661	*Ptiloprora plumbea*	icbp
2.2670	*Ptiloprora meekiana*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.4220	*Cnemophilus loriae*	bop
2.4230	*Cnemophilus macgregorii*	bop,icbp
2.4280	*Loboparadisea sericea*	bop,icbp
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4410	*Epimachus albertisi*	bop
2.4450	*Epimachus meyeri*	bop
2.4520	*Astrapia stephaniae*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4640	*Lophorina superba*	bop
2.4760	*Parotia lawesii*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5320	*Paradisaea rudolphi*	bop,png,icbp
3.03702	*Phalanger orientalis*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1230	*Pteropus neohibernicus*	key+

Owen Stanleys

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
1.3480	*Psittacella picta*	icbp
1.3870	*Eurostopodus archboldi*	icbp
1.4330	*Tanysiptera danae*	png,icbp
2.0300	*Anthus gutturalis*	icbp
2.0680	*Cinclosoma ajax*	icbp
2.1850	*Petroica bivittata*	icbp
2.1870	*Amalocichla sclateriana*	icbp
2.1920	*Poecilodryas placens*	icbp
2.2370	*Daphoenositta miranda*	icbp
2.2590	*Melidectes ochromelas*	icbp
2.2661	*Ptiloprora plumbea*	icbp
2.2670	*Ptiloprora meekiana*	icbp
2.2790	*Lichenostomus obscurus*	icbp
2.3360	*Oreostruthus fuliginosus*	icbp
2.3461	*Lonchura monticola*	png,icbp
2.3970	*Amblyornis subalaris*	png,icbp
2.4220	*Cnemophilus loriae*	bop
2.4230	*Cnemophilus macgregorii*	bop,icbp
2.4290	*Macgregoria pulchra*	bop,icbp
2.4300	*Manucodia atra*	bop

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2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4410	*Epimachus albertisi*	bop
2.4450	*Epimachus meyeri*	bop
2.4520	*Astrapia stephaniae*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4640	*Lophorina superba*	bop
2.4760	*Parotia lawesii*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
2.5320	*Paradisaea rudolphi*	bop,png,icbp
3.03702	*Phalanger orientalis*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.04101	*Pseudocheirus canescens*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	key+
3.04404	*Dorcopsis macleayi*	key+
3.04405	*Dorcopsis luctuosa*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1201	*Pteropus alecto*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1221	*Pteropus macrotis*	key+
3.1230	*Pteropus neohibernicus*	key+

Eastern Peninsula

1.0550	*Casuarius casuarius*	key+
1.1270	*Harpyopsis novaeguineae*	key+
1.1300	*Aquila gurneyi*	key+
1.3370	*Probosciger aterrimus*	key+
1.3410	*Psittrichas fulgidus*	key+
1.4330	*Tanysiptera danae*	png,icbp
2.0300	*Anthus gutturalis*	icbp
2.0661	*Melampitta gigantea*	icbp
2.0680	*Cinclosoma ajax*	icbp
2.2590	*Melidectes ochromelas*	icbp
2.3970	*Amblyornis subalaris*	png,icbp
2.4220	*Cnemophilus loriae*	bop
2.4300	*Manucodia atra*	bop
2.4330	*Manucodia chalybata*	bop
2.4370	*Manucodia keraudrenii*	bop
2.4410	*Epimachus albertisi*	bop
2.4450	*Epimachus meyeri*	bop
2.4520	*Astrapia stephaniae*	bop,icbp
2.4570	*Ptiloris magnificus*	bop
2.4610	*Seleucidis melanoleuca*	bop
2.4640	*Lophorina superba*	bop
2.4760	*Parotia lawesii*	bop
2.4870	*Cicinnurus regius*	bop
2.4960	*Cicinnurus magnificus*	bop
2.5080	*Paradisaea raggiana*	bop
3.03702	*Phalanger orientalis*	key+
3.03703	*Phalanger vestitus*	key+
3.03704	*Phalanger carmelitae*	key+
3.03705	*Phalanger sericeus*	key+
3.04101	*Pseudocheirus canescens*	key+
3.0411	*Pseudocheirus corinnae*	key+
3.0412	*Pseudocheirus cupreus*	key+
3.0413	*Pseudocheirus forbesi*	key+
3.04301	*Dendrolagus dorianus*	key+
3.04302	*Dendrolagus goodfellowi*	key+
3.04403	*Dorcopsis vanheurni*	
3.04404	*Dorcopsis macleayi*	
3.04405	*Dorcopsis luctuosa*	key+
3.1132	*Dobsonia moluccensis*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1221	*Pteropus macrotis*	key+
3.1230	*Pteropus neohibernicus*	key+

D'Entrecasteaux Islands

1.1300	*Aquila gurneyi*	key+
2.4360	*Manucodia comrii*	bop,png
2.4370	*Manucodia keraudrenii*	bop
2.5220	*Paradisaea decora*	bop,png
3.03702	*Phalanger orientalis*	key+
3.04402	*Dorcopsis atrata*	key+
3.1133	*Dobsonia pannietensis*	key+
3.11375	*Dobsonia remota*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1220	*Pteropus hypomelanus*	key+

Woodlark group

2.3330	*Zosterops griseotinctus*	png
3.03706	*Phalanger lullulae*	key+
3.1133	*Dobsonia pannietensis*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1220	*Pteropus hypomelanus*	key+

Eastern Islands

2.2400	*Myzomela albigula*	png
2.2940	*Meliphaga vicina*	png
2.3290	*Zosterops meeki*	png
2.3330	*Zosterops griseotinctus*	png
2.3770	*Cracticus louisiadensis*	png
2.4300	*Manucodia atra*	bop
3.1133	*Dobsonia pannietensis*	key+
3.1210	*Pteropus conspicillatus*	key+
3.1220	*Pteropus hypomelanus*	key+

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APPENDIX 15-2. BIBLIOGRAPHY OF ORNITHOLOGY

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APPENDIX 15-3. BIBLIOGRAPHY OF MAMMALOGY

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Chapter Sixteen

Biodiversity and Conservation of the Fishes, Amphibians, and Reptiles of Papua New Guinea

Allen Allison[1]

SUMMARY

There are at least 785 species of freshwater fishes, amphibians and reptiles found in Papua New Guinea (PNG) of which approximately 365 (46%) are endemic. This fauna includes ca. 282 species of freshwater fishes and 505 species of amphibians and reptiles.

Although the first species were described more than 200 years ago, this fauna remains incompletely known, and new species are frequently being discovered and described. At the same time, rapidly expanding human populations and increasing exploitation of mineral and forest resources are reducing natural habitat. This provides a mandate for establishing conservation priorities.

Thirty areas in Papua New Guinea are selected as of major importance to this vertebrate fauna (Figure 16-5). These were selected to subsume habitat occupied by at least ninety percent of the native species. In addition, a series of recommendations are made that include the following: (1) increased survey, assessment, and museum-based systematic and distributional research; (2) intensified training of PNG nationals in research and management; (3) increasing the awareness and participation of traditional landowners in the conservation process; and (4) legislation and enforcement of environmental regulations that protect the native fauna and reduce the threats from pollution, resource extraction, and introduced species.

INTRODUCTION

Inasmuch as PNG still has ca. 65-70% of original forest and is strongly committed to conservation, it is appropriate to review what is currently known about the "cold-blooded" vertebrate fauna in order to develop research priorities and to identify areas of biological significance that should be conserved.

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[1] Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.

Although not particularly large, the freshwater fish fauna of PNG does have a number of interesting endemic elements. The two major rivers, the Fly and Sepik, have well developed fish faunas as does Lake Kutubu in the Southern Highlands. The entire fauna has been treated recently by Gerald Allen (1991) who provided range maps, discussed general patterns of distribution, included a historical summary of the discipline, and made general conservation recommendations. Some 150 species are endemic to New Guinea and a further 30 species are shared with northern Australia. Forty-four species have been recorded from the island provinces, nearly all widespread species. Twelve introduced species were established in PNG.

The amphibian and reptile fauna of PNG, with 505 species, is large and diverse, comprising ca. 5% of the world's total. Many groups are poorly known, and the final species total in these groups may easily exceed 700. General distributional patterns and the composition of the fauna are, however, reasonably well understood. In this chapter's analysis and assessment, I have used this information, together with the excellent coverage provided by 1:500,000 scale Vegetation and Timber Resources maps and the 1:100,000 scale topographic maps of PNG, to determine which areas of the country have good original forest and are known or expected to have rich assemblages of amphibians and reptiles.

HISTORICAL REVIEW

In 1766, Linnaeus formally described four species of marine turtles and a sea snake (*Pelamis platurus*) which are widespread species throughout the oceans of the world and are common in the waters of Papua New Guinea. Although the specimens on which Linnaeus based his descriptions were not collected around New Guinea, the process of discovering and naming Papua New Guinea amphibians and reptiles formally began that year. During the next sixty years, an additional 22 species of amphibians and reptiles that occur in Papua New Guinea, and are still considered valid, were described. Again, these were mostly widespread species that were described from collections made elsewhere, primarily from the Indo-Malayan region and Australia. The first species actually described from the New Guinea region were collected on New Ireland and islands off the Irian Jayan coast by the French expedition, under the command of Captain Duperrey, that toured the world from 1822-1825 in the corvette "Coquille" (Lesson 1826, 1830).

During the remaining part of the 1800s, biological exploration of the New Guinea region increased substantially and nearly 200 additional species were described, including the first species from the interior. The leading workers during this period were mostly from European museums, particularly the British Museum (e.g., J. E. Gray and Albert Günther). In 1844, Gray published a catalog of the tortoises, crocodiles, and amphibians in the British Museum, followed in 1845 by a catalog of the lizards, and in 1849 by a catalog of the snakes. In 1858, Günther published catalogs of the colubrine snakes and frogs in the British Museum. These two authors described at least 23 species of Papua New Guinea amphibians and reptiles that are still considered valid. Between 1878 and 1920, G. A. Boulenger of the British Museum published more than sixty books and papers dealing directly or indirectly with the New Guinea herpetofauna. These included a catalog of the frogs in 1882, followed in 1885-1887 by a three-volume catalog of the lizards, and in 1889 by a catalog of the turtles and crocodiles. During his long career he described more than 60 valid amphibian and reptile species native to Papua New Guinea.

Other significant workers during this period included A. B. Meyer, of the Berlin, and later the Dresden Museum, who reported on collections from Dutch New Guinea that he made during an extended expedition to this region in 1873. He described 15 species of amphibians and reptiles that occur in Papua New Guinea. Most of Meyer's collections were deposited in Dresden and were destroyed during World War II. W. Peters and G. Doria reported in 1878 on the collections made by Beccari, D'Albertis, and Bruijn and described 14 new species from Papua New Guinea. These collections were deposited in Genoa and Berlin. L. von Méhelÿ of the Budapest Museum reported in 1901 on the frog collections made in New Guinea by L. Biro, and established new subfamilies and genera and described a number of new species. A wealthy Australian parliamentarian, William Macleay, commanded the "Chevert" expedition to the south coast of New Guinea in 1875 and published several papers on the amphibians and reptiles (1877-78) in which he described 11 valid species native to Papua New Guinea.

Although much of the early biological exploration of New Guinea took place in what is now Irian Jaya, there were several significant expeditions to localities in what is now Papua New Guinea. In 1876-77, L. M. d'Albertis made two voyages in his steam launch "Neva" up the Fly River, reaching the foothills of the main ranges some 580 miles from the mouth. In 1875 William Macleay visited a number of localities on the south coast and Milne Bay areas. H. O. Forbes, employed as a government geographer-explorer, spent the wet season of 1885-86 collecting in the Sogeri Plateau outside Port Moresby. In 1888 William Macgregor was appointed as Administrator of the Crown Colony of New Guinea. He strongly promoted natural history exploration, leading an expedition to Mt. Victoria in 1889 and organizing or sponsoring a number of other expeditions to the mountainous interior. Most of the resulting collections were deposited in the British Museum.

On the north coast, German explorers were also quite active, primarily in areas around Astrolabe Bay near the present township of Madang and up the Sepik River. Many collections were made in and around mission stations in this region (e.g. Lönnberg, 1900). Beginning in 1893 a Hungarian collector, S. Fenichel, joined in 1895 by a compatriot, L. Biro, spent several years exploring and collecting in lowland areas of the north coast of the New Guinea mainland and the Gazelle Peninsula on New Britain. Biro was the first trained scientist to visit New Guinea, and his collections contributed to an important revisionary study of New Guinea frogs by Méhelÿ in 1901.

Other important workers around the turn of the century were Charles de Vis, reptile curator at the Queensland Museum, who described several species of Papua New Guinea lizards, and F. Werner who, beginning in 1894, described new taxa in a series of papers on the Indo-Australian herpetofauna, including a large paper published in 1900 on the reptiles and frogs of the Bismarck Archipelago. Most of Werner's large collections were deposited in the Vienna Museum, but some of the specimens were distributed to museums throughout Europe and the United States. Otto Boettger, curator of the Senckenberg Museum in

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Frankfurt, published a number of short papers on the New Guinea herpetofauna beginning in 1892 and several longer works including a list of frogs from the Indo-Australian region and catalogs of the Senckenberg collections.

Intense exploration and collecting continued into the twentieth century, culminating in the publication in 1915 of Reptiles of the Indo-Australian Archipelago by Nelly de Rooij which summarized all that was known at the time about the reptiles of this region (which included mainland New Guinea and satellite islands but not the Bismarck and Admirality archipelagoes or the island of Bougainville). In 1924 P. N. van Kampen published a similar volume on the frogs. Beginning in 1914, R. Sternfeld described new taxa from German New Guinea. His primary interest was snakes. J. R. Kinghorn, curator of herpetology at the Australian Museum, Sydney, beginning in 1928, published a number of short papers on the New Guinea and Solomon Islands herpetofauna, incorporating descriptions of several new taxa. Also in 1928 L. D. Brongersma, curator of herpetology at the Leiden Museum, began publishing on reptiles of the Indo-Australian region and summarized his findings in a long paper published in 1934. His interests centered largely on the herpetofauna of Indonesian islands west of New Guinea, but from time to time, until 1969, he continued to publish on the New Guinea herpetofauna. T. Vogt, of the Berlin Museum, described several New Guinea taxa in papers published in 1911-1912. In 1932 he described several new species of lizards that were collected from the Sepik Basin by the Kaiserin Augusta expedition of 1911-1912 which visited the Hunstein and Schrader Mountains. Robert Mertens, who followed Boettger as reptile curator at the Senckenberg Museum, published a type catalog of reptiles in the Senckenberg Museum in 1922, followed by a long series of papers on various reptile groups of the Indo-Australian Archipelago. These included classic papers on variation in the lizard genus *Cryptoblepharus* (1931-34) and a comprehensive monograph of the varanid lizards (1942). His last New Guinea paper, a report on a collection of varanid lizards, appeared in 1971. In 1933-34, H. Hediger published two long papers treating the herpetofauna of the Admiralty and Bismarck archipelagoes, and in 1934 H. W. Parker's classic monograph on the microhylid frogs appeared. Parker established a sound anatomical basis for microhylid classification and briefly reviewed the status and distribution of New Guinea taxa.

In 1933-34 Richard Archbold financed and helped lead a large expedition by the American Museum of Natural History to Mt. Albert Edward in the Wharton Range of Papua New Guinea (Archbold and Rand 1935). Now known as the First New Guinea Archbold Expedition, the primary objective was to collect and study birds, mammals, and plants; however, substantial numbers of amphibians and reptiles were also collected. From 1936 to 1964 there were six more New Guinea Archbold Expeditions, mostly with the same objectives. The second expedition (1936-37) visited areas throughout the Western Province. The third expedition (1938-39) visited the Snow Mountains in Irian Jaya. This was followed in 1948 by an expedition to the Cape York Peninsula in Australia. The fourth New Guinea expedition (1953) went to the eastern Owen Stanley Mountains (Mt. Dayman) and mountainous regions of Goodenough Island. The fifth expedition visited the Louisiades, working in Misima, Tagula, and Rossel Islands. The sixth expedition visited the Eastern Highlands and Morobe Province, including lowlands near Lae and Mt. Kaindi near Wau.

The seventh and last Archbold Expedition (1964) concentrated on the Huon Peninsula. All the animal collections were deposited in the American Museum of Natural History.

Towards the end of World War II, Arthur Loveridge, curator of herpetology at the Museum of Comparative Zoology (Harvard), began publishing on New Guinea amphibians and reptiles, describing a host of new taxa. In 1948, he published a catalog of New Guinea amphibians and reptiles in the collections of the Museum of Comparative Zoology and the U.S. National Museum which included a list of all taxa he considered valid, including many new records resulting from collections made by American military personnel during WW II.

In the early 1950s, J. Linsley Gressitt, an entomologist from the Bishop Museum, began doing field work in Papua New Guinea. By the early sixties he had established a field station at Wau (which later became the Wau Ecology Institute) and expanded the field program to include several expeditions per year to collect ectoparasites and their vertebrate hosts, primarily birds and mammals. Many of the expeditions also collected sizable numbers of amphibians and reptiles. Papua New Guinea localities that were visited, sometimes more than once, included the Star Mountains, Victor Emmanuel Mountains, Eastern Highlands, Western Highlands, Bewani Mountains, Torricelli Mountains, Prince Alexander Mountains, Adelbert Mountains, Mt. Bosavi, Huon Peninsula, Sogeri Plateau, Mt. Dayman, Trans-Fly region, Ekuti Divide, Kuper Range, and the Gazelle Peninsula (New Britain).

In the mid-1950s, Richard Zweifel, curator of herpetology at the American Museum of Natural History, began working on the huge collection of New Guinea amphibians and reptiles that had resulted from the Archbold Expeditions. Since 1956 he has published more than 30 articles and described more than 40 new taxa of New Guinea amphibians and reptiles. Zweifel participated in the Seventh Archbold Expedition to the Huon Peninsula and since then has conducted several major collecting expeditions to various regions in New Guinea including the highland provinces and the Wharton Range. In the early 1960s, Michael Tyler, of the South Australian Museum, spent an extended period in the highlands of Papua New Guinea and began a long series of publications on New Guinea frogs, including a comprehensive monograph of New Guinea *Litoria* (then known as *Hyla*) that appeared in 1968.

In 1967, Allen Greer, initially associated with the Museum of Comparative Zoology at Harvard and now with the Australian Museum, Sydney, often in collaboration with Fred Parker, began publishing on the huge lizard collections that Parker had made in Papua New Guinea, primarily Bougainville Island, Chimbu, and Western Provinces. At about this time Samuel McDowell began working on the snakes that had accumulated in substantial numbers in the collections of the American Museum of Natural History, Bishop Museum, and the Museum of Comparative Zoology. Also, around this same time, James Menzies took up a lectureship at the University of Papua New Guinea and began a productive research program on New Guinea frogs which has included a handbook to common frogs, published by Wau Ecology Institute (1976), and a recent monograph on Papuan species of *Rana*. Menzies has conducted extensive fieldwork throughout the country and made sizable collections which are housed at the University of Papua New Guinea and the PNG National Museum.

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In the late 1940s, Walter Brown, a research associate of the California Academy of Sciences, began working on the amphibians and reptiles of New Guinea and the Solomon Islands and since then has published revisionary studies of the ranid frog genera *Platymantis*, *Batrachylodes*, and *Discodeles*. In 1953, he described several new taxa in the scincid lizard genus *Emoia*, beginning a special interest in this group which culminated in 1991 in publication of a comprehensive monograph of this genus (72 species overall, of which 34 occur in Papua New Guinea).

In 1973, Allen Allison joined the staff of the Wau Ecology Institute, and for two years made general collections in the surrounding region and conducted field work on the population biology of several species of skinks (*Emoia physicae*, *Emoia guttata*, several species of *Papuascincus*). Allison has continued since then to collect throughout the country. Principal areas visited include Finschhafen, Frieda River, Bewani Mountains, Aseki, Ekuti Divide, Hunstein Mountains, Baiyer River, Western Highlands, and Bowutu Mountains.

In recent years the Australian Museum, in collaboration with the South Australian Museum, has sponsored a number of expeditions throughout Papua New Guinea from which significant numbers of amphibians and reptiles have been collected. Areas visited include New Britain, north coast ranges, Star Mountains, and the Southern Highlands.

CURRENT STATUS AND GAPS IN KNOWLEDGE

There are approximately 700 trivial names applied to amphibian and reptile taxa that occur in Papua New Guinea but only 505 of these represent valid species (see checklist Appendix 16-1, Tables 16-1 and 16-2). There are probably an additional 30-40 undescribed species known from material in museum collections currently under study by various specialists. It is difficult to estimate how many additional species await discovery, but this number could be high, especially for frogs. In order to put current knowledge of the herpetofauna into brief perspective, it is useful to consider families within each group separately.

Frogs

Representatives of five frog families are known from Papua New Guinea. However, one of these, Bufonidae, includes only the introduced cane toad, *Bufo marinus*. This species, introduced to Papua New Guinea in 1937, is now known from sea-level to mid-elevation regions throughout the country, mostly from grassland and secondary forest in ecologically disturbed areas. Although *Bufo marinus* feeds mostly on insects, it can attain large size (length > 200 mm) and is known to feed on the adults and young of other vertebrate species (Baily 1976). It is widely thought to have caused the local extinction of various grassland snake species from some regions of Papua New Guinea, but this has yet to be confirmed. It may compete for food, habitat, and nesting sites with native frog species. However, relatively few frog species occupy the same ecological niche as *Bufo marinus*, and its direct impact on the native frog fauna may be minimal.

The remaining four frog families include 196 species. Papua New Guinea representatives of two of these families, Hylidae and Myobatrachidae, are of Australian (= Gondwanan) origin and the other two, Ranidae and Microhylidae, are probably derived from the Indo-Malayan region.

Hylidae: There are two closely related genera of hylid frogs in Papua New Guinea: *Litoria* and *Nyctimystes*. Both genera are also found in Australia. *Litoria*, which has 44 species in Papua New Guinea (55 species are known from the entire Papuan region), has a similar number of species in Australia. At least 8 species occur in both countries; these are generally limited to northeastern Australia and southern New Guinea (Trans-Fly region). Papua New Guinea species occur mostly on the New Guinea mainland; only two species reach the Bismarck Archipelago, and only one of these, *Litoria thesaurensis*, extends farther east to the Solomon Islands. There are 26 currently recognized species of *Nyctimystes*, three of which are restricted to rain forests in northeast Australia. The remaining species are restricted to the New Guinea mainland; 18 species occur in Papua New Guinea, of which 16 are endemic.

Most species groups of *Litoria* and *Nyctimystes* are probably now known but many taxa probably comprise complexes of closely related species. These frogs are often difficult to distinguish morphologically and details on call, habitat and behavior may be required to confirm identification. The number of species is likely to increase substantially with further study.

Myobatrachidae: The frog family Myobatrachidae includes five genera but only seven species in New Guinea, six of which occur in Papua New Guinea. All five genera and three of the species are shared with Australia. *Lechriodus* has four species: one is restricted to Australia; one is endemic to Irian Jaya (but probably reaches Papua New Guinea in hill forest to the north and south of the Star Mountains). Of the remaining two species, *L. aganoposis* occurs throughout highland areas of Papua New Guinea and Irian Jaya, and *L. melanopyga* is widely distributed in lowland and hill forest on the south coast of the New Guinea mainland. *Limnodynastes convexiusculus*, *Ranidella remota*, and *Uperoleia mimula* occur in Papua New Guinea only in the seasonal dry forest of the Trans-Fly region. These three species also occur in similar habitat of the Cape York Peninsula, Australia. *Mixophyes hirihorlo* was recently described from lowland forest in the southern highlands of Papua New Guinea and, so far, is known only from this region.

The myobatrachid fauna appears to be well known and it is unlikely that more field work will turn up many additional species. This group seems to have arrived in New Guinea relatively recently in geological time and has not undergone significant radiation there.

Ranidae: The remaining two families, Ranidae and Microhylidae, are nearly cosmopolitan in distribution. The New Guinea representatives of these families are undoubtedly of Indo-Malayan origin, inasmuch as they are richly represented throughout this region by endemic genera and species and are virtually absent from Australia, where there are only two genera of microhylids, *Cophixalus* and *Sphenophryne*, (with eleven and five species, respectively) and one species of ranid, *Rana daemeli*. Both genera of microhylids and *Rana daemeli* are found in Papua New Guinea, which has fifteen genera and 84 species of microhylids, and six genera and 44 species of ranids.

The Papuan species of *Rana* have recently been monographed by James Menzies (1987) who recognized seven species groups and fourteen species. Morphological differences between many of these species are slight, and it is often necessary to have a large series of specimens and information on call and habitat to confirm identifications. Although restricted to aquatic habitats, most species of *Rana* have fairly wide distributions throughout New Guinea, and it is unlikely that additional field work will turn up many new species. However, a biochemical study being conducted by Ken Aplin (Western Australian Museum) and colleagues at the Evolutionary Biology Unit of the South Australian Museum has identified 8-10 biochemical morphs (= putative species?) from a single drainage basin in the southern highlands. If these biochemical morphs are actually sibling species, the number of New Guinea *Rana* may be far higher than Menzies was able to recognize on morphological grounds.

The ranid genus *Platymantis* is widely distributed from the Philippines and Indonesia, across New Guinea and east to the Bismarcks, Solomon Islands, and Fiji. Nineteen species occur in Papua New Guinea, of which all but one (*P. papuensis*) are endemic to the Admiralty and Bismarck Archipelagos or to Bougainville Island.

As far as is known, all species of *Platymantis* are terrestrial breeders (no aquatic tadpole stage). It is probably this feature that has made it possible for them to disperse so effectively throughout islands to the north and east of New Guinea. However, the known geographic distributions of most of the island species are rather restricted, and several species are known only from type localities. It is extremely likely that additional field work in mountainous areas of Bougainville, Manus, and particularly New Britain and New Ireland will turn up many new species. More than half the species known from Papua New Guinea were described since 1965, and this trend of discovery is likely to continue as upland areas of the island provinces are explored.

Two monotypic ranids, *Palmatorappia solomonis* and *Ceratobatrachus guentheri*, are known from Bougainville and the Solomon Islands. Both are distinctive species that are relatively well studied, and it seems unlikely that additional fieldwork will turn up new species in these genera.

Eight species of the ranid genus *Batrachylodes* are known from Papua New Guinea, all from Bougainville. At least five of these are endemic to Bougainville and the remaining species are shared with the Solomon Islands. Several of the endemic Bougainville forms have very restricted ranges or are known only from type localities. The most recent taxonomic treatment of this group was by Brown and Parker (1970) who based their analysis entirely on morphological characters. They did not have recordings of calls or detailed habitat information on any of the species. Inasmuch as many sibling species of New Guinea frogs can be distinguished only by calls, it is likely that Brown and Parker's treatment of *Batrachylodes* greatly underestimates the actual number of species.

The last ranid genus, *Discodeles*, consists of five species of large *Rana*-like frogs found on the Solomon Islands, Bismarck Archipelago, and Admiralty Archipelago (Rambutyo Island). There are four species in Papua New Guinea. Three of these occur on Bougainville and other islands of the Solomon chain, and the fourth species, *D. ventricosus*, is endemic to the Admiralty Archipelago. Since these are large conspicuous frogs found in lowland areas and described in 1912 or before, it is unlikely that additional species will be found. However, no species are known from the Bismarcks, in the middle of the group's range, and it is possible that undescribed species occur in this region.

Microhylidae: Microhylid frogs found in Papua New Guinea occur primarily on the New Guinea mainland and satellite islands. Two species are found on New Britain; the family is unknown from the Admirality Archipelago or the island of Bougainville. Papua New Guinea microhylids range from small, short-legged burrowing forms to large arboreal tree-frogs. All known species are terrestrial breeders (no aquatic tadpole stage). Many species seem to have rather restricted geographic ranges, and field work in unexplored areas continues to turn up new species. Papua New Guinea microhylids are placed in two subfamilies, the Asterophryinae (34 species) and the Sphenophryninae (50 species). The ranges of both subfamilies coincide largely with the Papuan region. The Asterophryinae were treated in a comprehensive monograph by Zweifel (1972), with further analysis by Burton (1986). Blum and Menzies (1988) recently described a number of additional species in the asterophrynine genera *Xenorhina* and *Xenobatrachus*. The Sphenophryninae are much less well-known. Zweifel has described a number of species on the basis of specimens collected by the Archbold Expeditions (American Museum of Natural History) and has treated the Australian species of *Cophixalus* and *Sphenophryne*) in a comprehensive monograph. However, the three largest New Guinea genera, *Cophixalus*, *Oreophryne*, and *Sphenophryne*, harbor a wealth of taxonomic confusion. Many species are known only from types; other species (e.g., *Cophixalus variegatus*) are known to comprise a complex of closely related frogs that can be separated only by call, and even these differences between species may be slight and difficult to resolve. The species in these genera listed in the checklist (Appendix 16-1) are recognized very tentatively.

Crocodiles

There are two described species of crocodiles known from Papua New Guinea. *Crocodylus porosus* (saltwater crocodile) is widespread in coastal regions of northern Australia and ranges west through the lowlands of New Guinea to Palau and India. The other species, *C. novaeguineae*, has a more restricted range and is found only in New Guinea. Ross (1989) has studied morphological variation in this species and has concluded that two species are actually involved, *C. novaeguineae* on the north coast of New Guinea and a new species on the south coast. Crocodiles are important commercial species in Papua New Guinea and have been well studied.

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Turtles

There are three families (Chelidae, Carettochelidae, and Trionychidae) and seven species of freshwater turtles known from Papua New Guinea. One species, *Carettochelys insculpta*, is so distinctive that it is placed in its own family (Carettochelidae). Although this species also occurs in Australia, in New Guinea it is restricted to the Fly River. Five out of the seven species of freshwater turtles are restricted to the south coast. The biology and the precise distributions of many species are unknown.

In addition, six species of sea turtles occur in the oceans surrounding Papua New Guinea. These species are widely distributed in the tropical Pacific and several occur throughout tropical oceans of the world. All are well understood taxonomically and reasonably well understood ecologically.

Lizards

Five families of lizards occur in Papua New Guinea: Agamidae, Gekkonidae, Pygopodidae, Scincidae, and Varanidae. These are the same five families of lizards that occur in Australia, and the current distributional patterns of the various genera and species groups reflect a complex biogeographic relationship between New Guinea, Australia, and surrounding regions. The Australian lizard fauna seems to have been derived in large part from successive waves of Indo-Malayan elements that migrated down island arcs through what is now New Guinea. Some groups are of relatively recent origin in Australia (e.g., the agamid genus *Hypsilurus* with two endemic species in Australia and at least 15 endemic species in New Guinea and islands west to Wallace's Line), while other groups are of Gondwanan origin or reached Australia long ago and radiated into unique Australian groups that have recently extended their ranges to New Guinea. For example, pygopodids, legless lizards related to geckos, have eight genera and 31 species in Australia. New Guinea has but one genus with two species, one of which is shared with Australia.

Agamidae: There are five genera and 14 species of agamid lizards in Papua New Guinea and an additional genus and approximately 10 additional species in Irian Jaya. All of the Papua New Guinea genera are shared with Australia. Three of the genera each have only one species in New Guinea, viz. *Chlamydosaurus kingii*, *Lophognathus temporalis*, and *Physignathus lesueurii*, all of which are restricted to south coast seasonal dry forest. A fourth genus, *Diporiphora*, has one and possibly two New Guinea species, both shared with Australia and restricted in New Guinea to south coast seasonal dry forest. The species-level taxonomy and ranges of the species in these four genera are well understood, and it is unlikely that more species will turn up with additional collecting. The fifth agamid genus, *Hypsilurus* (formerly known as *Gonocephalus* [see Moody, 1980]), has at least nine species in Papua New Guinea and at least as many in Irian Jaya. The systematics of this group are poorly understood, and re-examination of the status of the various taxa is badly needed. The number of species in Papua New Guinea is probably about fifteen.

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Gekkonidae: There are seven genera and 32 species of geckos in Papua New Guinea. Five of these genera (including three species) also occur in Australia, but, except for *Gehyra*, seem to have arrived there relatively recently and, for the most part, are restricted to the tropical north. Most New Guinea gekkonids are related to groups occurring throughout the Indo-Pacific region, a few of which have produced a number of endemic New Guinea species. Most of the genera are reasonably well understood taxonomically. However, the ranges of many species are poorly known, and it is likely that a number of additional species await discovery. *Gehyra* and *Cyrtodactylus* seem to present special problems in identification, and recent authorities have reached widely different conclusions about the status of several Papua New Guinea taxa.

Pygopodidae: Pygopodids, snake-like lizards related to geckos, are endemic to Australia and New Guinea. This group has radiated extensively in Australia where there are 8 genera and ca. 30 species. There are only two species known from New Guinea, both in the genus *Lialis*. One, *L. burtonis*, occurs throughout much of Australia and in savannas of the south coast of New Guinea. The other, *L. jicari*, is endemic to New Guinea, occurring in lowlands on the north and south coasts. There is one record of this species from east New Britain. The systematics and distribution of this group in Papua New Guinea are well understood.

Scincidae: Skinks (family Scincidae) with 137 species make up 71% of the Papua New Guinea lizard fauna and include at least 18 genera. Two of the genera, *Emoia* and *Sphenomorphus*, are large (> 35 species) and morphologically diverse, but are probably polyphyletic and will eventually be split into smaller, better defined genera. *Emoia* has recently been revised by Brown (1991) who recognized 36 species and subspecies in Papua New Guinea (72 species overall). This is nearly double the number recognized previously, and with further study this number could double again. *Sphenomorphus*, which has 58 species in Papua New Guinea, includes a large number of reclusive species that are easily missed by collectors. The ranges of most species are therefore poorly known. Moreover, a large number of species undoubtedly await discovery.

Each of the remaining 16 genera has fewer than se... species in Papua New Guinea. Most of these genera (with the notable exception of *Carlia* and *Lygisaurus*) are well understood taxonomically, but the geographic distribution of many species remains obscure. It is likely that an additional 10-20 species may eventually turn up in these genera.

Varanidae: The Lizard family Varanidae is represented in Papua New Guinea by eight species in the genus *Varanus*. One of these species, *Varanus bogerti*, is restricted to Goodenough and Fergusson islands; another, *V. telenestes*, is restricted to the Louisiades; a third species, *V. panoptes horni*, occurs in savanna regions of the south coast and in similar habitat throughout much of northern Australia; a fourth species, *V. timorensis similis*, occurs throughout the Trans-Fly region (including Irian Jaya). The remaining three species, *V. prasinus*, *V. indicus*, *V. karlschmidti* and *V. salvadorii*, are widespread throughout lowland New Guinea. *V. salvadorii* reputedly reaches a length of 3-4 m and is the second largest lizard in the world (after the Komodo dragon of Indonesia). The number of varanid species is likely to increase slightly with further taxonomic study of existing material in museum collections. Further collecting is unlikely to produce additional species.

Snakes

In comparison with the frogs and lizards, the Papua New Guinea snake fauna is rather impoverished, with a total of only 98 species. The seven Papua New Guinea families, viz. Acrochordidae, Colubridae, Elapidae, Hydrophiidae, Boidae, Pythonidae, and Typhlopidae are all found in Australia.

Acrochordidae: There are two monotypic genera of acrochordids in Papua New Guinea. Both species occur in estuarine habitats and are widespread in the region. They are well understood taxonomically.

Colubridae: There are nine genera and 32 species of colubrid snakes. Most genera are relatively small and well understood taxonomically. The largest genus, *Tropidonophis*, with 13 species, was recently revised by Malnate and Underwood (1988). The distribution of most of the species is reasonably well understood.

Elapidae: There are twelve genera and 23 species of elapid snakes in Papua New Guinea. McDowell has studied most of the difficult genera and their systematics and distribution are reasonably well understood. Further work is likely to add somewhat to the species total, but perhaps not significantly. The geographic ranges of many species are known with reasonable certainty.

Hydrophiidae: There are nine genera and 22 species of sea snakes (Hydrophiidae) recorded from the waters of Papua New Guinea. Sea snakes tend to have rather large geographic ranges and are reasonably well known taxonomically, so it seems unlikely that there would be more than a few, if any, undescribed species in Papua New Guinea.

Boidae: There is one genus and two species of boids in Papua New Guinea. Both are common lowland species distributed throughout most of the country. This is most likely the final number.

Pythonidae: Pythons are the largest and among the most beautiful snakes of Papua New Guinea. There is one genus (reduced recently from three; Underwood and Stimson, 1990) and eight species, and their taxonomy and distribution are well understood.

Typhlophidae: The smallest snakes in Papua New Guinea are the typhlopids, with two genera and nine species. All are fossorial species superficially resembling worms. They are easily missed by collectors and the ranges of many species are poorly understood. Further work is likely to turn up a few new species.

Summary -- Current Status and Gaps in Knowledge

The taxonomy and distribution of New Guinea amphibians and reptiles are relatively well understood in general terms. However, a number of genera are poorly defined and further taxonomic work is likely to split large genera into better defined, smaller genera, increasing significantly the number of species. In addition a number of species are probably species complexe that will require careful morphological and biochemical study, additional fieldwork, and collecting to resolve. The discovery of species through time (Figure 16-1) has been fairly steady since the 1870s and has yet to reach an asymptote. This reinforces the prediction that many species await discovery.

A particular problem in determining the distribution of various species is the propensity for tropical species to have patchy distributions. This is well known in New Guinea insects (Wilson 1958) and birds (Diamond, 1973, 1980), and preliminary data suggest that a number of lizard species are also patchily distributed.

The basic biology and ecology of most species are completely unknown. There is little available information on population dynamics, life histories, specific habitat requirements, food requirements, predators, and competitive interactions with congeners and ecologically similar species.

DATA ASSESSMENT

Amphibians and reptiles have been collected from at least 800 localities throughout Papua New Guinea and general patterns of distribution are relatively well understood. In general, field workers have collected most intensively in the most promising areas, and a number of regions (e.g., the Star Mountains) have been visited repeatedly. Biologically, the most interesting areas are therefore among the best known. However, many species apparently have spotty distributions, and a significant number, mainly frogs, have very restricted ranges. All areas with significant forest should eventually be surveyed. The following sixteen areas should be given particular attention (Figure 16-2).

Unknown Areas

(Mainland Regions: numbered as in Figure 16-2).

1. Eastern Bewani Mountains - extensive area of lowland and hill forest, includes Mt. Menawa (ca. 1900 m), highest point in the north coast ranges, which has extensive areas of mossy forest inhabited by montane species of lizards and frogs. Also includes foothills of the western Torricelli Mountains. Rich fauna incompletely sampled for amphibians and reptiles. Low human population density.

2. Hunstein Mountains/Central Mountains - extensive areas of lowland/hill forest in the Hunstein Mountains including Mt. Hunstein (1532 m) which has a rich mossy forest at the summit and a weakly developed montane fauna (A. Allison, unpubl.). Includes also significant portions of the Central Range, including Roesike Mt. (2880 m) and Burgers Mountains (highest point 3711 m). Incompletely sampled; preliminary fieldwork suggests

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that the fauna is rich with a significant endemic element. Rich in ultrabasic soils and therefore likely to have unique plant assemblages.

3. Blucher Range/Müller Range - extensive areas of unexplored lowland and hill forest and extensive areas of karst. Includes Mt. Karoma in the Müller Range (3623 m); likely to have rich fauna from the Great Papua Plateau and a rich southern highlands montane element. High rainfall which tends to promote species richness.

4. Mt. Bosavi/Gulf Lowlands - includes Mt. Bosavi (2397 m), an isolated shield volcano, and lowland regions east to the Purari River. Includes the Murray and Kereru Ranges, the latter an isolated massif rising to 1829 m (Mt. Duau) and surrounded by lowlands. High rainfall, sparsely inhabited, virtually unexplored, potentially rich in endemics.

5. Crater Mt. - large drainage area east of the Purari River, bordered on the north by the Tua River and on the south by the Pio River (both tributaries to the Purari). Includes high mountains - Mt. Karamui (2569 m) and Crater Mt. (3231 m) - and extensive areas of montane, mid-montane and hill forest on either side of an extensive tract of lowland forest.

6. Anga Region - large southern drainage area south of the Ekuti Divide that includes parts of the Chapman Range. Rich diversity of vegetation types from alluvial/swamp forest to montane and mossy forest. Extensive areas of lowland and hill forest that are poorly known biologically. Sparsely inhabited.

7. Bowutu Mts./eastern Kuper Range - northern drainage bordered on the southeast by the Waria River; includes north coast hill forest and extensive tracts of mid-montane and montane forest in the Kugeru Gap and eastern Kuper Range (includes Mt. Missim, 2877 m). Rich in ultrabasics, especially around Lake Trist. Preliminary fieldwork suggests that this region has a rich and distinctive fauna.

(Island Regions)

8. Fergusson Island - Mt. Kilkerran (ca. 1800 m) - large mountainous area covered with primary forest; virtually unexplored.

9. Umboi Island - a series of shield volcanoes rising to 1548 m (Mt. Bel) on the eastern part of the island; extensive forest. Probably has a fauna similar to the mountains on the western tip of New Britain (Mt. Talawe - 1824 m), but may harbor endemics because of isolation. Poorly known; may not have a rich fauna, but further study is necessary.

10. Mt. Talawe (1824 m) - western tip of New Britain. Probably has a fauna similar to Umboi island but needs more study (see above).

11. Whiteman Range - mountainous region in central New Britain rising to 2027 m. The largest mountainous region of New Britain; has extensive tracts of lowland and hill forest and fairly extensive areas of montane forest; potentially rich in endemic species; virtually unexplored.

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12. Nakanai Mts. - similar to the Whiteman Range, with extensive areas of montane forest; potentially rich in endemic species; virtually unexplored; active volcanoes.

13. Baining Mts. Gazelle Peninsula - Isolated mountain range with extensive areas above 1500 m; poorly known, preliminary evidence suggests that it is rich in endemic species; rises to a height of 2440 m.

14. Hans Meyer Range, New Ireland - includes the only areas in New Ireland above 2000 m; highest point is 2399 m. Extensive montane areas likely to be rich in endemic species, especially frogs; the New Ireland fauna is very poorly known.

15. Emperor Range - volcanic region of northern Bougainville, includes Mt. Balbi, 2685 m. Poorly explored; very wet; probably rich in endemic frog species.

16. Mt. Takuan (2210 m) - southern Bougainville; rich expanse of lowland and hill forest to mid-montane and montane forest; very wet; probably rich in endemic species, particularly frogs; poorly explored.

Summary -- Unknown Areas: Although some areas of the country, particularly the highland provinces, are relatively well known herpetologically, often all that exists in the literature on the distribution of many species of amphibians and reptiles is a few widely scattered locality records. There are at least 175,000 specimens of Papua New Guinea amphibians and reptiles in museums around the world (at least 85% of this material is housed in ca. 15 major museums). A comprehensive survey of museum collections should therefore be undertaken to summarize all available distributional information in preparation for developing a comprehensive biological survey plan to define the ranges of many species.

A good example of the importance of information from museum collections is illustrated by the range maps of 15 montane species provided in Zweifel's 1980 paper (p. 427) on the Huon Peninsula. Most of the species he mapped are common and richly represented in museum collections, but have seldom been mentioned in the literature. The American Museum has large collections of Papua New Guinea amphibians and reptiles, and Zweifel obtained distributional information largely from this source.

As mentioned earlier, the taxonomy of many groups is in very poor shape; this makes it difficult and often impossible to define precisely the ranges of many species. This point is illustrated in Brown's (1991) monograph on *Emoia*. Previous workers (including Brown) had considered *Emoia baudinii* to be widespread in Papua New Guinea. However, this species is now known to be restricted to the Vogelkop Peninsula in Irian Jaya. Another species, *Emoia mivarti*, was previously thought to occur throughout the New Guinea mainland, but is now known to be restricted to Manus Island. Similarly, a hylid frog, *Litoria bicolor*, has been reported from widely scattered localities throughout the Papua New Guinea mainland and New Britain, but is now thought to be restricted to the Trans-Fly region of southern New Guinea (Menzies 1976). The other forms are probably closely related species that comprise a species complex. This same pattern is seen in many amphibian and reptile groups.

Additional field work and collecting from sites throughout the country not previously visited are clearly needed. However, basic systematic work in many groups should be given high priority. Brown's monograph (which virtually doubled the number of *Emoia* species known from Papua New Guinea) was based entirely on museum collections.

Species Richness

To determine areas of species richness, I divided Papua New Guinea into 38 biogeographical regions (Figure 16-3, Table 16-3) and then determined, as best I could from the literature and limited museum records, which species of frogs and lizards occurred in each region. A preliminary analysis of snake distributions revealed a pattern similar to that for lizards and was not pursued further. I included in the analysis only those species for which some locality information was available (193 frogs and 184 lizards). For example, *Oreophryne giselorum* is known only from its type locality of "Kaiser Wilhelmsland" (northern part of the Papua New Guinea mainland). Although this species is probably from the Adelbert or Finisterre Mts. (Menzies et al. 1980), this is not known with certainty, and *O. giselorum* was therefore excluded from the analysis. All species that are thought to occur in Papua New Guinea but have not been documented to occur there were also excluded from the analysis (see checklist - Appendix 16-1) as were those species whose taxonomic status is uncertain (mainly species of *Sphenomorphus*). The biogeographic regions I used were intentionally large so as to define general patterns of distribution. Regions were based on physiognomic features (e.g., mountain ranges, lowlands) geographic isolation/environmental discontinuities (e.g. Huon Peninsula, islands) and congruence with species boundaries of well known taxa. Areas for which significant information was available (e.g., highlands) were split more finely than relatively unknown areas (e.g., New Britain island). The total number of frogs and lizards known from each region is presented in Table 16-1.

The richest areas for frogs are mostly mountainous regions on the New Guinea mainland and Bougainville. However, the Huon Peninsula, with the most species overall, apparently lacks a montane frog element, but does have a rich frog fauna in hill forest and lowland areas. Except for Bougainville, the island provinces and the satellite islands off the New Guinea mainland have relatively depauperate frog faunas. This may in part be an artifact because some of these areas - e.g., New Britain - are poorly known. In addition the larger biogeographic regions such as the Huon Peninsula generally have greater ecological diversity and therefore more species than do smaller regions (e.g., many of the islands).

It is interesting to compare the frog fauna of mainland Papua New Guinea (160 species total) with that of Irian Jaya (97 species). Papua New Guinea has not only more species overall but also 82% of the 196 species occurring on the New Guinea mainland.

The richest areas for lizards include the north coast ranges, Sepik - Ramu Basin, Gulf Lowlands, Trans-Fly region, Central Province Lowlands, Bougainville Island, and the Great Papuan Plateau. Most highland areas and all islands apart from Bougainville had far fewer species.

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Rare and Endemic Forms

To determine areas important for rare and endemic species, I used the same procedure described above for determining species richness, but restricted the analysis to species endemic to Papua New Guinea. Results for frogs and lizards are presented in Table 16-1, columns 3 and 4, respectively. I then repeated this analysis for those species endemic to a single biogeographic region (herein termed "restricted-range" species) (Table 16-1, columns 5 and 6, respectively).

The patterns of endemicity of frogs and lizards is very different (Table 16-2). Although the total number of frog and lizard species included in the analysis is similar (193 and 184, respectively), only 59 species of lizards are thought to be endemic to Papua New Guinea compared to 115 species of frogs. This same trend occurs in the species limited to single biogeographic regions (38% of the frogs and 19% of the lizards). These differences are probably not attributable to taxonomic artifacts (both groups have similar taxonomic problems), but may be due to the greater need that frogs have for moisture, limiting their dispersal ability. This suggests that frogs may be better indicators than lizards (and snakes) of subtle biogeographic differences within regions.

In general, the areas with the highest overall species richness also had the greatest number of endemic species. However, as expected on the basis of geographic isolation, many of the islands rank high in numbers of endemic species.

The distribution of restricted range species highlights the particular importance of certain biogeographic regions. Restricted range species of frogs and lizards occur in only 22 and 15 regions, respectively, of the 38 biogeographic regions. Several important features emerge. Islands and isolated mountain ranges rank high in this analysis and are dispersed throughout the country. On the other hand certain seemingly isolated regions do not have many restricted range endemics. This and the preceding analysis indicate that the Bewani, Torricelli and Prince Alexander Mountains share a large endemic north coast fauna. There is little endemism in the individual mountain ranges (no lizards and only one frog species each). Similarly many of the species endemic to the central highlands are widespread throughout that region.

Interestingly, the savanna region on the south coast around Port Moresby shows up as an important area for restricted range lizard species. This may be an artifact. This region is better known than other parts of the country, and what appears to be restricted range endemics may simply be wide ranging reclusive species that have not been collected elsewhere. Analysis of the taxa involved suggests that this may be partially true, but that this region is nevertheless an important area of endemism. Inasmuch as it is a lowland coastal area bordered on the other three sides by moist forest, this is not surprising. Similar habitat in the Trans-Fly region also is rich in endemic species.

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Ecologically Critical Areas

Most species of Papua New Guinean amphibians and reptiles occur in primary forest or old regrowth and quickly die out when the forest cover is removed. In addition, the erosion that follows land clearing due to mining, logging, or slash and burn agriculture leads to high sediment loads in streams; this destroys breeding habitat for stream dwelling frogs. Several species of *Litoria* and *Nyctimystes* that were once common on Mt. Kaindi near Wau seem to have disappeared, probably because mining activity produced increased sediment loads in streams.

The savanna forests around Port Moresby are apparently essential habitat to several lizard species, viz. *Carlia bicarinata*, *C. luctosa*, *Lepidodactylus browni*, and *L. orientalis*. Similarly, the seasonal dry forest in the Trans-Fly region also has a large endemic element and is critical habitat for these species.

The Fly River is the sole habitat, in New Guinea for the Pitted Turtle, *Carettochelys insculpta*, a unique species in its own family. Discharge from the Ok Tedi mine has greatly increased the sediment load in the Fly River; this, together with heavy metals also discharged by the mine, is causing an ecological disaster that may very well lead to the extirpation of *Carettochelys* in Papua New Guinea.

In summary, primary forest, or savanna, and good secondary forest are ecologically critical to the survival of most species of Papua New Guinea amphibians and reptiles, particularly frogs. Lizards seem better able to tolerate environmental disturbance than do frogs, and many primary forest species persist in secondary forest.

Ecological Fragility

The ecologically most fragile regions of New Guinea are probably alpine habitats (*Deschampsia - Danthonia* grassland; above 3000 m elevation). Alpine grasslands are very susceptible to fire and are slow to recover. Fossorial frogs inhabit many of these grasslands and would disappear with loss of habitat. All other moist forest ecosystems are also susceptible to fire, and repeated burning eventually converts forest to grassland. Some specialists argue that extensive grassland areas ("kunai") throughout the highland provinces have an anthropogenic origin due to fire. "Recreational" burning is a serious problem throughout Papua New Guinea that deserves close attention.

The most significant regions of alpine grassland in Papua New Guinea include Mt. Giluwe, Mt. Wilhelm, Mt. Albert Edward, Mt. Suckling, and Mt. Dayman.

Otherwise, most Papua New Guinea ecosystems appear to be rather robust. The region is geologically very young, and the steep, highly dissected terrain is prone to landslides and other natural disturbances. The plants are well adapted for this and easily re-colonize disturbed areas. Relatively few alien species have gained entry to intact ecosystems.

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Economically Important Species

There are no economically important amphibians. The only reptiles of economic significance are the crocodiles (two species currently recognized; a third species to be described shortly by C. Andy Ross of the U.S. National Museum) and the marine turtles (six species). These groups are covered by a number of special programs managed by the Department of Environment and Conservation and their status is monitored closely. The crocodile programs have achieved notable success, and crocodiles are being harvested on a sustained yield basis. They are also being farmed commercially. Inasmuch as these species are already receiving close conservation attention, I will not discuss them further.

Major Threats

As mentioned above, the Pitted River Turtle may be in peril due to the discharge of Ok Tedi mining waste into the Fly River. This is a significant potential problem that should be monitored closely.

A number of reptile species are in particular demand by the terrarium trade. These include all the pythons and boas, the varanid lizards, and the prehensile-tailed skink, *Corucia zebrata*, from Bougainville (and other islands in the Solomon chain). These species are all protected under Papua New Guinea law.

One of the pythons, *Morelia boa*, that is restricted to the Bismarck Archipelago, is in high demand by the terrarium trade. It seems to be fairly common and widespread in New Britain and is in no immediate danger of extinction but smugglers could easily decimate local populations.

The remaining species of pythons and boas, except for *Morelia boeleni*, are all widespread and common and probably do not present any significant conservation problems. *M. boeleni* is a very valuable species in the terrarium trade. This species occurs above ca. 1800 m elevation along the central mountain ranges of New Guinea in the east, from the Owen Stanley Range (near Rigo) west to the Wissel Lakes region of Irian Jaya. It appears to be uncommon to rare throughout its range. It is highly sought after by smugglers (several smugglers have been apprehended in Papua New Guinea during the past several years), and smuggling pressure could easily lead to localized extinctions of this large, striking python.

Two of the varanid lizards, *V. bogerti* (endemic to Goodenough and Fergusson Islands) and *V. telenestes* (endemic to the Louisiades), are recently described, and, if they are valid species, this is likely to make them particularly valuable to the terrarium trade. Smugglers will undoubtedly see this as an opportunity and the situation should be watched closely.

A third species of *Varanus*, *V. salvadorii*, is noteworthy in that it attains large size (up to ca. 4 m). It occurs in lowlands and hill forest of far western Papua New Guinea and

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in similar habitat in Irian Jaya. It is apparently rare to uncommon throughout this extensive range. Because of its large size, it is probably vulnerable to hunting pressure.

Although varanids are prized for their skins for kundu drums and are susceptible to hunting pressure, the remaining four species are all common and widespread and seem to persist throughout their ranges even when hunting pressure is high.

Corucia zebrata is fairly common throughout the Solomon Islands. There is nothing remarkable about the Bougainville population, and this species does not present any particular conservation problems for Papua New Guinea.

Major Wilderness Areas

Extensive wilderness areas - large tracts of uninhabited or sparsely inhabited forest - includes all the unknown areas (Figure 16-2) together with the following additions (starred, see Figure 16-4):

1. Eastern Bewani Mountains; 2. ☼Star Mts., including northern foothills drained by the May River; 3. Hunstein Mountains/Central Range; 4. Blucher/Müller Range; 5. Mt. Bosavi/Gulf Lowlands; 6. Crater Mountain; 7. ☼Upland regions of the Huon Peninsula (Saruwaged and Finisterre Mountains); 8. ☼Owen Stanley Mts. (including the eastern extension of Mt. Suckling and Mt. Dayman) and the Wharton Range (which joins up with and is plotted as contiguous with the Bowutu Range and the Anga Region/Chapman Range on Fig 16-3. 9. ☼Mt. Oiautukekea on Goodenough Island; 10. Fergusson Island; 11. Whiteman Range, New Britain; 12. Nakanai Range, New Britain; 13. Baining Mountains, New Britain; 14. Hans Meyer Range, New Ireland; 15. Emperor Range (Mt. Balbi), N. Bougainville; 16. Mt. Takuan, S. Bougainville

The area including the Blucher and Müller ranges (upper Strickland basin) is extensively forested and sparsely inhabited. The wilderness area in this region could probably be expanded to include a significant portion of lowland rain forest of the Great Papuan Plateau.

Biologically Important Areas

In developing a summary of biologically important areas of Papua New Guinea, several important factors emerge from the objective analysis and mapping reported in the preceding section of this report. These are, in no particular order, as follows:

Species richness of amphibians and reptiles is fairly even throughout much of mainland Papua New Guinea. Although some areas have significantly fewer species than others, these are often poorly known areas for which low species richness may be a sampling artifact.

Geographically isolated areas (e.g., islands) with low species richness tend to have a high percentage of endemic species.

Many species have very restricted ranges. Restricted range endemics occur throughout Papua New Guinea and are particularly abundant in some of the mountain ranges and on islands (for reasons of geographic isolation).

Assuming that the strategy for selecting conservation areas should be to maximize species richness, and give highest priority to restricted range endemics, followed by Papua New Guinea endemics, and then Indo-Pacific and Indo-Australian endemics, and that the areas best suited for conservation protection are those that have primary vegetation (e.g wilderness areas) and include a diverse array of vegetation types within a contiguous area, the areas that merit consideration are as follows (numbers keyed to the map, Figure 16-5):

(Mainland Regions)

1. Bewani Mts. (Mt. Menawa) - ca. 100-1900 m elevation [West Sepik Province]. The north coast ranges (Cyclops Mts., Irian Jaya, Bewani Mts., Torricelli Mts., Prince Alexander Mts., Adelbert Mts.) originated as an island archipelago separate from the rest of mainland New Guinea and, probably for these reasons, have a large endemic element. (Most species tend to be shared by the Bewani, Torricelli, and Prince Alexander Mts.); Mt. Menawa seems to offer both the largest expanse of primary forest and the highest elevations (Mt. Somoro, in the Torricelli Mts. might be slightly higher) in the region.

2. Hunstein Mts./Central Ranges - 100-3711 m elevation [East Sepik and Enga Provinces]. As already noted, this area is sparsely populated and includes a wide diversity of vegetation from swamp forest to alpine grassland. Extensive areas of the Hunstein Mts. have ultrabasic soils and a rich, highly endemic flora. The herpetofauna is somewhat less distinctive (many of the Hunstein species are shared with the Bewani Mts. to the north), but does include at least one endemic species (*Sphenophryne hooglandi*). The fauna of the Central Ranges also seems to have a significant endemic element.

3. Star Mountains - 100-3932 m [West Sepik and Western Provinces]. This high mountain range includes an extensive alpine fauna as well as a diversity of mid-montane and hill forest species. Endemism is not particularly high inasmuch as only the western tip of the Star Mts. extends to Papua New Guinea; most of this mountain range is in Irian Jaya where some of the peaks reach 4700 m. However, the fauna is very distinctive, and many of the species found in the Star Mts. do not occur elsewhere in Papua New Guinea.

4. Blucher Range/Müller Range - 100-3623 m [Western and Southern Highlands Provinces]. This area is poorly known but has high rainfall, a diversity of vegetation types including a large expanse of lowland rain forest, large areas of karst, and is sparsely inhabited. The fauna of the Great Papuan Plateau, with many expected endemics, is partially included in this area.

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5. Doma Peaks - 1800-3566 m [Southern Highlands Province]. This region includes one of the largest remaining areas of mid-montane and montane forest in the highlands and would probably protect a high percentage of the endemic highland fauna. There is also easy access and therefore a high potential for ecotourism.

6. Mt. Bosavi - 300-2397 m [Southern Highlands Province]. This includes Mt. Bosavi, an isolated shield volcano, and surrounding lowlands. Mt. Bosavi is known to have a rich fauna, and, on the basis of isolation, probably has endemic species of amphibians and reptiles. This region is sparsely inhabited and original forest is largely intact. Rainfall is high.

7. Trans-Fly region - 0-100 m [Western Province]. This region of seasonal dry forest savanna is practically unique in Papua New Guinea. Although many of the species found in this region are not endemic (occurring also in NE Australia and Irian Jaya), they are unique to Papua New Guinea. In addition, at least 5 endemic species are known from this region. The area designated includes the Tonda Wildlife Management Area. The Trans-Fly region is easily accessible (at least during the dry season) and offers tremendous potential for ecotourism.

8. Adelbert Mts. - 300-1650 m [Madang Province]. The Adelbert Mts. are closely associated geologically with the other north coast ranges of Papua New Guinea (Prince Alexander, Torricelli, and Bewani Mts.). However, they are geographically, quite isolated from these and other mountain ranges and harbor a rich hill-forest to mid-montane fauna with a significant endemic component. These mountains are also densely populated, making it difficult to select an area of undisturbed forest.

9. Mt. Wilhelm - 1000-4509 m [Madang, Western Highlands and Chimbu Provinces]. Mt. Wilhelm is the highest mountain in Papua New Guinea. It has extensive areas of alpine grassland, although these are only half the size of similar areas on Mt. Giluwe. However, Mt. Wilhelm rises abruptly above lowlands of the Ramu Valley to the north, and it is possible to include alpine, mid-montane, and possibly even lowland regions in one contiguous area. Protection of Mt. Wilhelm would protect a high percentage of the highland fauna, which is rich in endemics, together with extensive areas of alpine grassland. An alternative site is Mt. Giluwe, but this offers less altitudinal range than does Mt. Wilhelm.

10. Crater Mountain - 300-3231 m [Eastern Highlands/Gulf Provinces]. Although in a sedimentary belt with potential for oil discovery and environmentally destructive development, this area is pristine and is thought to have a rich herpetofauna. It contains a mixture of southern watershed elements and eastern highland elements, and would therefore protect both. Sparsely inhabited.

11. Kereru Range (Gulf Lowlands) - 100-1829 m [Gulf Province]. Includes part of the Murray Range and extensive areas of lowland rain forest as well as the isolated Kereru Range which rises abruptly to 1829 m (Mt. Duau) from surrounding lowlands. This area has high rainfall and is thought to be rich in species. It is sparsely inhabited.

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12. Saruwaged Range - 300-4160 m [Morobe Province]. Interestingly the mountains of the Huon Peninsula lack a distinctive montane element of amphibians and reptiles. I have therefore tried to extend the boundaries of this conservation area to the coast, largely to include the lowland element which includes at least five endemic frogs. Several of these frog species are known only from the southern lowlands of the Huon Peninsula (in hills not far from the University of Technology) and may not occur in the area selected. However, there did not appear to be suitable candidates for conservation areas in the southern regions of the Huon Peninsula. Detailed ground surveys are required to resolve this issue.

13. Anga Region - 50-3278 m [Morobe, Central and Gulf Provinces]. Southern watershed area which, on the basis of preliminary evidence, has a distinctly different fauna than adjacent northern drainages. Significant areas of karst; poorly known; includes a wide range of vegetation types. Sparsely inhabited.

14. Bowutu Mts. - 600-2877 m [Morobe Province]. Northern drainage with large areas with ultrabasic soil. Poorly known but preliminary evidence suggests that the herpetofauna is rich with many endemics. Most areas sparsely populated; a few areas with significant human settlements in river valleys.

15. Mt. Albert Edward - 300-3990 m [Central and Northern Provinces]. This region includes huge expanses of alpine grassland. The boundaries are drawn to include lowland and hill forest portions of Northern Province which has a rich but not particularly distinctive herpetofauna.

16. Mt. Lamington/Popondetta - 100-1679 m [Northern Province]. This area was selected to include the rich herpetofauna of the northeastern coastal lowlands and hill forests. It includes forests inhabited by the Queen Alexanderae Birdwing Butterfly and is already receiving significant conservation attention.

17. Mt. Dayman - 300-2987 m [Milne Bay Province]. Mt. Dayman and Mt. Suckling to the north both have extensive areas of alpine grassland and diverse herpetofaunas with rich endemic elements. I selected Mt. Dayman because it is slightly better known. The boundaries of the proposed conservation area include lowland and hill forest to the north.

(Island Regions)

18. Goodenough Island - 0-2566 m [Milne Bay Province, D'Entrecasteaux Archipelago]. This region is covered with primary forest and seems to have a rich fauna. The Fourth Archbold Expedition visited Goodenough Island, and the fauna is known largely through this effort. However, our knowledge is almost certainly incomplete, and it is likely that many cryptic species of amphibians and reptiles await discovery.

19. Fergusson Island - 0-2073 m [Milne Bay Province, D'Endrecasteaux Archipelago]. This region is similar to that described above for Goodenough Island. Fergusson Island is virtually unexplored biologically, although the fauna is likely to be very similar to that from Goodenough Island. *Varanus bogerti* is endemic to Goodenough and Fergusson Islands.

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20. Woodlark Island - 100-350 m [Milne Bay Province]. This isolated, rather low island is apparently unremarkable herpetologically (no endemics, widely distributed pelagic species). However, it does have an endemic land mammal (Woodlark Cuscus, *Phalanger lullulae*), suggesting that there is a reasonable possibility of finding endemic species in other vertebrate groups. A thorough survey is urgently needed.

21. Misima Island - 0-1038 m elevation [Milne Bay Province, Louisiade Archipelago]. There is a small patch of good bush on the western peninsula of the island. Inasmuch as Misima is rather isolated from other islands in the Louisiades, it is likely to have endemic species. Eight species are endemic to the Louisiades, five frogs and two lizards.

22. Tagula Island - 0-810 m [Milne Bay Province, Louisiade Archipelago]. Much of the primary forest on Tagula is gone, but there is a tract of good bush on the southern slopes of Mt. Riu which should be preserved if the Louisiade fauna is to survive.

23. Manus Island - 0-702 m [Manus Province]. This rather low, densely populated island has five endemic species (1 frog, 4 lizards). There is an area of reasonable bush on the south central part of the island, including the highest elevations on the island, and this should be protected as a matter of priority. It is likely that additional endemic species will turn up.

24. Umboi Island - 0-1548 m [West New Britain Province]. This high, volcanic island is poorly known. It has extensive forests that very likely harbor undiscovered, cryptic species.

25. Whiteman Mountains - 100-2027 m [West New Britain Province]. As already mentioned these mountains comprise the largest mountainous region of New Britain. Although New Britain has nine endemic species (7 frogs, 2 lizards) it is poorly explored and more species, particularly in highland regions, are likely to turn up when these areas are thoroughly surveyed.

26. Nakanai Mountains - 100-2000 m [West New Britain Province]. Extensive areas of upland and montane forest. Poorly known but likely to have endemic, cryptic species, particularly at higher elevations. Needs a thorough faunal survey.

27. Baining Mountains - 100-2400 m [East New Britain, Gazelle Peninsula]. As is true of the Whiteman and Nakanai Mountains, the Baining Mts. of the Gazelle are poorly known biologically. Preliminary work suggests that a number of endemic species occur there. The Gazelle Peninsula is densely populated, and action is required soon to save representative portions of these interesting mountains.

28. Hans Meyer Range - 100-2399 m [New Ireland Province]. There is apparently only one species endemic to New Ireland (*Lipinia rouxi*, far fewer than for Bougainville (12 frogs, 4 lizards), New Britain (7 frogs, 2 lizards) and Manus (1 frog, 4 lizards). This may be a true representation, but is more likely an artifact due to incomplete surveying and collecting. With additional work many more species endemic to New Ireland will undoubtedly turn up, particularly in the frog genus *Platymantis*. New Ireland has a geological origin separate from nearby New Britain.

29. Mt. Balbi - 100-2685 m [North Solomons Province, Bougainville Island, Emperor Range]. The lowlands and mid-elevations of Bougainville have been well collected by Fred Parker, and, as a result, the herpetofauna of this island is relatively well known. Parker did not spend much time at higher elevations, particularly in areas that are isolated and inaccessible such as Mt. Balbi and surrounding portions of the Emperor Range. Preliminary analysis suggests that a number of species endemic to Bougainville have very restricted ranges and are endemic to uplands of north Bougainville. The area suggested for conservation protection includes areas that have known Bougainville endemics and includes, as well, remote regions that are poorly known and probably have additional endemic species. Bougainville is geographically part of the Solomon Islands, and much of its fauna has affinities to fauna inhabiting other islands in the Solomon chain.

30. Mt. Takuan - 100-2210 m [North Solomons Province, Bougainville Island]. This area is the main region harboring south Bougainville endemics; see explanation for Mt Balbi (area 29, above) for the importance of protecting areas in Bougainville.

CONSERVATION RECOMMENDATIONS

Research Priorities

Sort out the taxonomy of poorly understood groups in order to produce field guides and identification manuals.

Determine species distributions based on the literature and existing museum collections and develop a comprehensive database of this information.

Use information presented above to develop a comprehensive survey plan. Highest priority should be given to the unknown areas identified in this report, followed by the careful survey of selected areas to define better the ranges of many species. This effort should be undertaken within the context of a national biological survey employing modern database technology that includes geographic information systems. The national biological survey will require extensive literature and taxonomic resources and should be developed with these needs in mind at the University of Papua New Guinea, where an effort should be made to enhance and enlarge existing museum facilities.

Review the status, and prepare management plans for, species protected under PNG law (including those listed on CITES appendices I and II) and convene a workshop to determine if additional species merit protection.

Develop and fund long-term ecological research to understand better the basic life history of many species including population dynamics and seasonal patterns (e.g., of reproduction, etc.). This research should also be directed at elucidating the biogeographic history of the region and determining why certain areas are particularly diverse.

Develop a better system for regulating research and issuing research visas to outside researchers. The current system is fraught with delays and uncertainty. Researchers need to be encouraged to come to Papua New Guinea to work collaboratively with the staff in the Department of Environment and Conservation, and the University of Papua New Guinea.

Provide training programs and scholarship support to encourage and facilitate the training of Papua New Guineans in biology and natural resources management at both undergraduate and graduate level.

Implementation Priorities

Develop a national conservation strategy based on information and maps from the CNA workshop; work closely with provincial authorities and village groups to implement this. A comprehensive program in landowner awareness is essential and can perhaps be best developed in collaboration with PNG Non-governmental Organizations (NGOs) active in this area. High priority should be given to establishing protected areas (e.g., Wildlife Management Areas) in each of the biologically important areas of the country. Protected areas should preferably be large and include a wide range of elevations and habitats. They should also provide an economic return (e.g., ecotourism) to landowners to ensure protection in perpetuity.

Papua New Guinea has excellent environmental laws but generally lacks staff and expertise to monitor and enforce these laws effectively. The Department of Environment and Conservation needs to be strengthened in these areas.

Papua New Guinea has a good record of bringing wildlife management to the local level. More than twenty Wildlife Management Areas have been declared throughout the country. This program has tremendous potential and could be the key to protecting the areas selected during the CNA workshop. Local people in many areas are enthusiastic about Wildlife Management Areas, but are often discouraged by the many bureaucratic obstacles and delays that they face in gazetting a Wildlife Management Area. If possible, it would be helpful to simplify procedures and expedite the process. In part this would involve additional staffing from DEC and the Lands Department to work with local groups interested in designating Wildlife Management Areas on traditional land. DEC should also greatly strengthen its programs in land owner awareness and work closely and collaboratively with village groups to explore a full range of conservation options. Also, it would be very helpful to be able to offer incentives (uniforms, badges, scholarships for villagers to become biologists or "para"-biologists [the latter concept has worked well in Costa Rica], grants for ecotourism infrastructure, etc.). The process should be as simple and straight forward as possible.

A complete review of existing protected areas should be undertaken and future priorities for funding and staffing developed. There are a number of National Parks, but, except for Varirata, these are inadequately staffed and in many cases are being seriously degraded by squatters (e.g., MacAdam National Park in the Bulolo River Gorge near Wau).

Inasmuch as significant effort and expense went into designating protected areas (including Wildlife Management Areas), it would be prudent to review these programs thoroughly before developing new programs in response to CNA recommendations.

The Department of Environment is clearly the lead agency in determining conservation priorities for Papua New Guinea. The Department should be strengthened with informational resources (comprehensive GIS with detailed overlays on vegetation, topography, land use, soil, species ranges, and land tenure) and staff expertise. The Departments of Forestry and Minerals and Energy do effective jobs of managing resources under their jurisdictions, often at the expense of the environment. Strengthening DEC will help to advance consideration of environmental concerns to a higher decision-making level within the Papua New Guinea government.

Environmental Threats

Waste discharge from the Ok Tedi mine could have serious long-term consequences to the Fly River drainage. There is growing international attention to this problem, and further study and action is clearly necessary to prevent this from becoming an even more serious environmental disaster. Ok Tedi was apparently able to gain a special exemption from constructing a tailings dam that could have drastically reduced waste discharge into the Fly River. Tailings dams should be mandatory for all future mining projects.

Adverse impacts from alien species are causing serious ecological problems in many tropical countries. Papua New Guinea has reasonably effective quarantine regulations, but has allowed the introduction of a several alien species that have become serious pests. For example, several introduced species of fish have the potential to cause profound ecological change in aquatic ecosystems. The introduction of Rusa deer from Indonesia has had serious impact on grasslands in the Trans-Fly region. The cane toad is a pest throughout lowland New Guinea. The environmental impact of introduced species needs to be carefully studied and the risks fully evaluated before further introductions are made. Quarantine authorities at ports of entry need to remain vigilant to the accidental introduction of pest species.

ACKNOWLEDGMENTS

I am grateful to Jerry Allen, Aaron Bauer, Robert Cowie, Lu Eldredge, James Menzies, Scott Miller, Dan Polhemus, George Zug, and Richard Zweifel for information included herein and for comments on this report. I am particularly grateful to Dan Polhemus for preparing the map of biogeographic zones from my rather crude sketch, and to Arnold Suzumoto for lettering several of the maps.

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Figure 16-1. Cumulative total number of described frog and lizard species for Papua New Guinea.

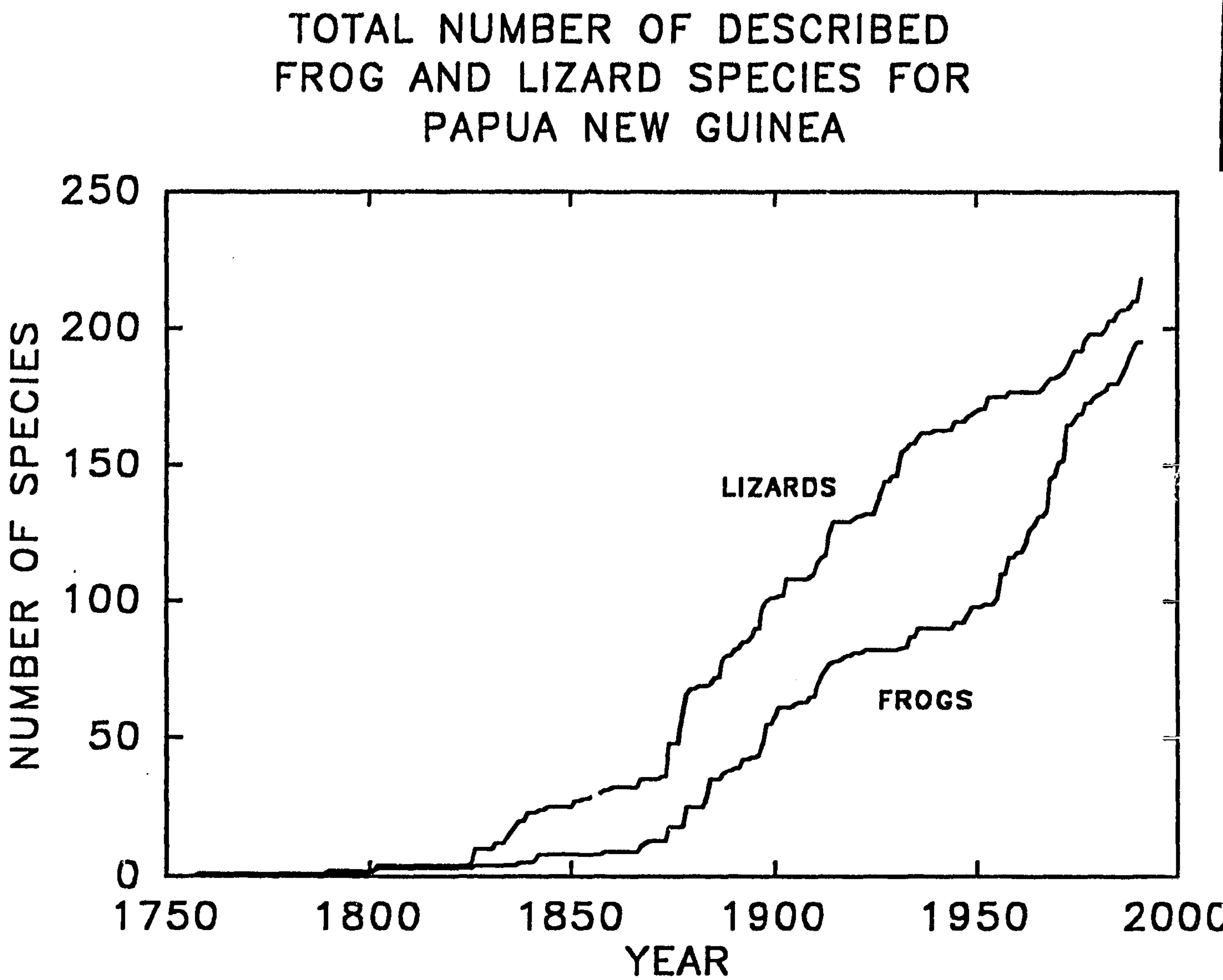

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Figure 16-2. Map of biologically unknown areas. See text for key to numbered areas.

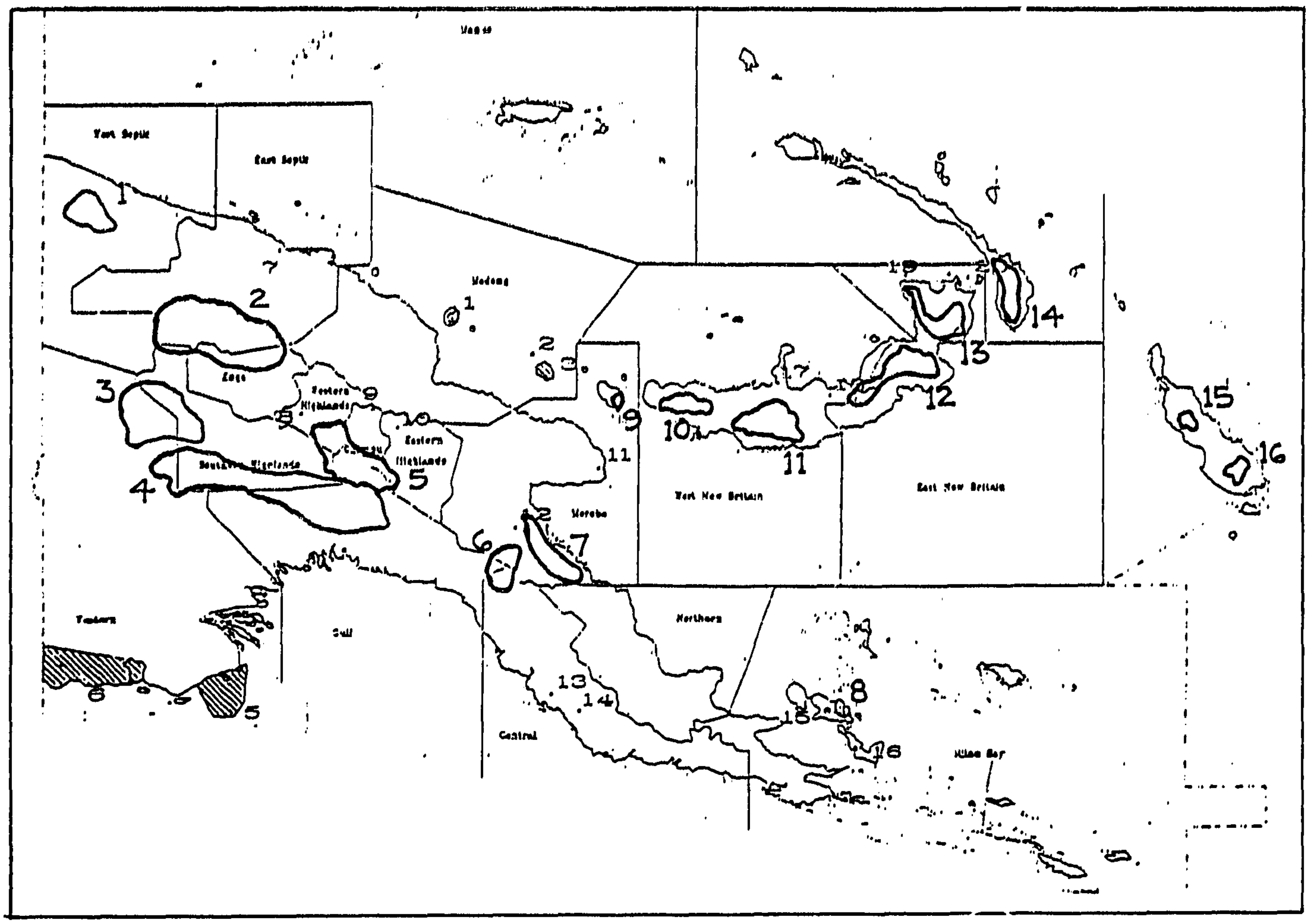

Figure 16-3. Map of biogeographic regions for Papua New Guinea. See Table 16-3 for key to numbered areas.

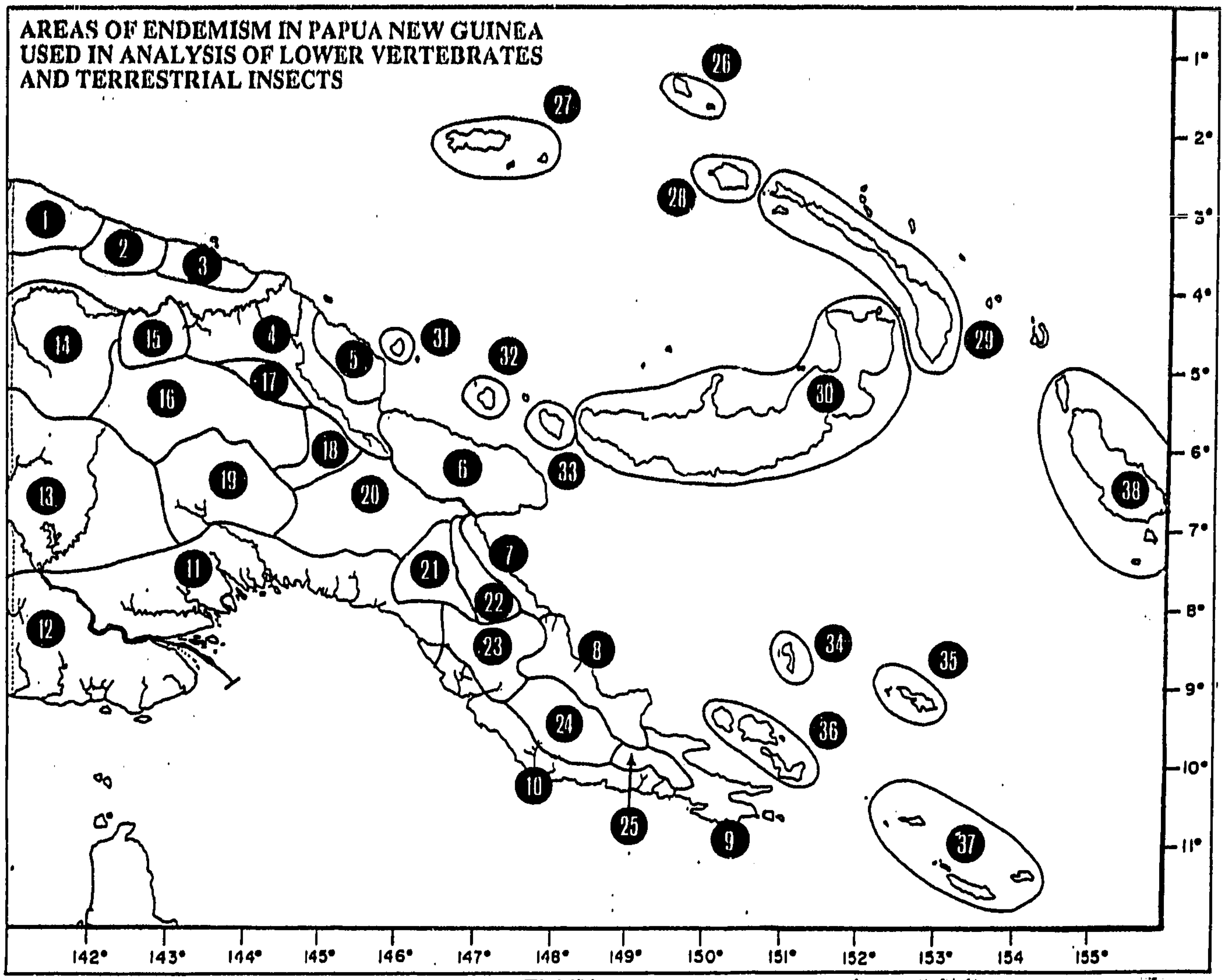

Figure 16-4. Map of major wilderness areas for Papua New Guinea.

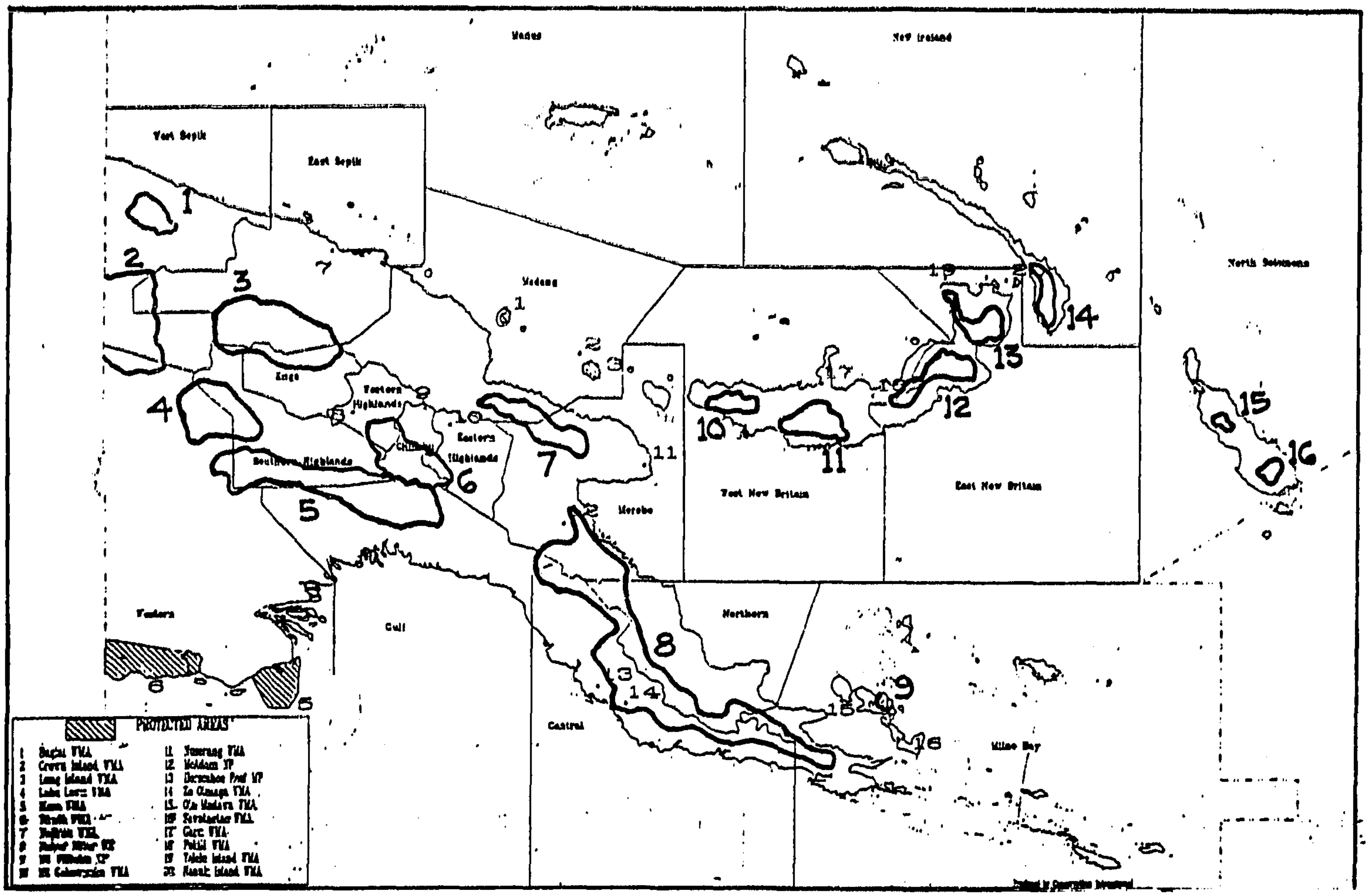

Figure 16-5. Map of biologically important areas for fishes and herps

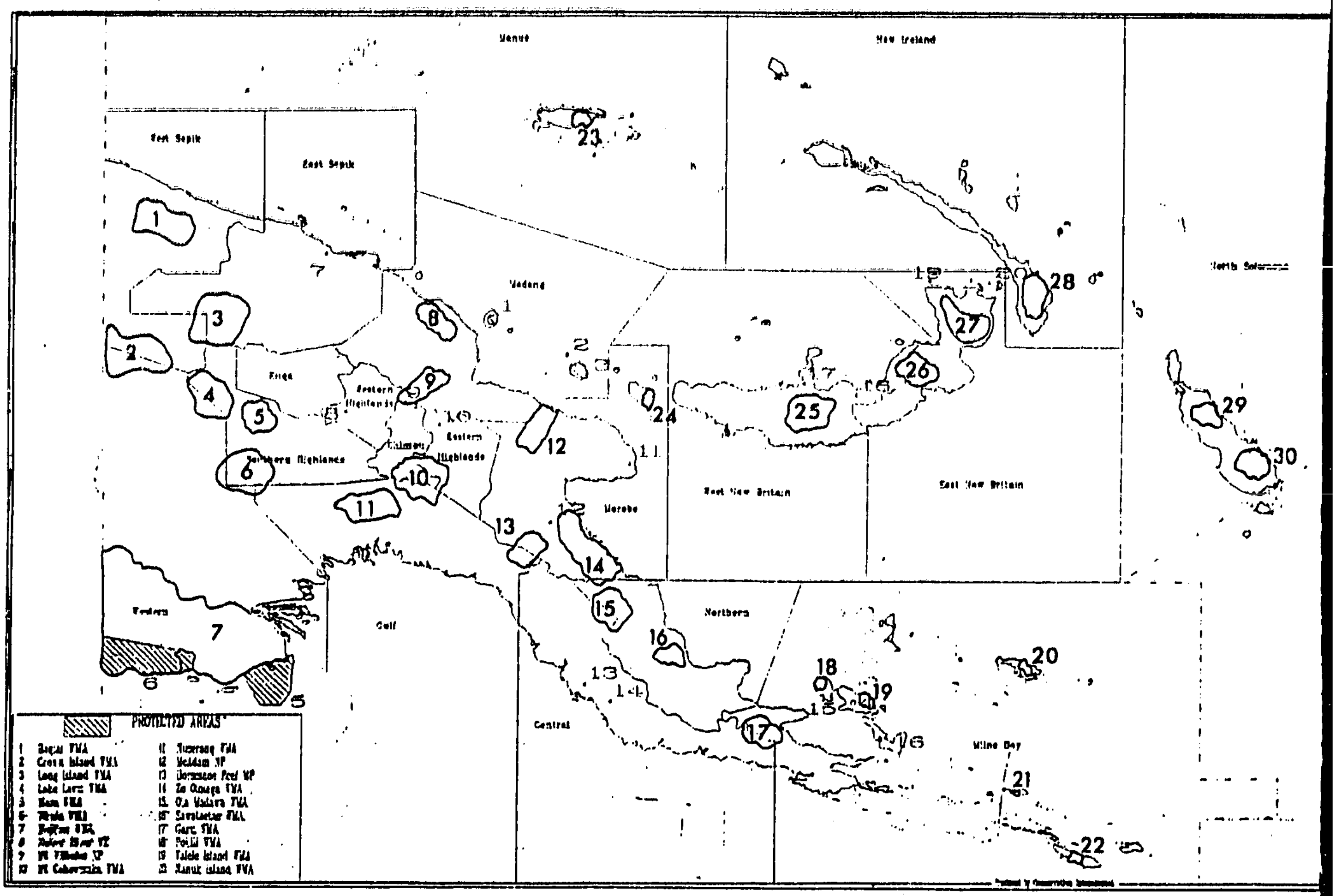

Table 16-1

Numbers of Papua New Guinea frog and lizard species by biogeographic region. Total species includes all species recorded for Papua New Guinea for which locality information is available. Endemic species includes species found only on Papua New Guinea, and restricted range species includes species found only in a given biogeographic region.

LOCALITY	TOTAL SPECIES		TOTAL ENDEMIC SPECIES		RESTRICTED ENDEMIC SPECIES	
	FROGS	LIZARDS	FROGS	LIZARDS	FROGS	LIZARDS
1. Bewani Mountains	23	50	2	0	1	0
2. Torricelli Mountains	24	50	2	0	1	0
3. Prince Alexander Mountains	14	46	1	1	1	0
4. Sepik - Ramu Basin	16	61	2	11	1	6
5. Adelbert Mountains	25	51	5	5	3	1
6. Huon Peninsula	36	61	13	15	5	2
7. S. Morobe Coast	16	38	4	6	0	0
8. N. Province Lowlands	18	37	6	4	0	0
9. Milne Bay Lowlands	17	32	7	3	0	1
10. Central Province Lowlands	19	41	4	10	0	6
11. Gulf Lowlands	23	47	6	5	0	0
12. Trans Fly Region	24	46	3	1	2	0
13. Great Papuan Plateau	25	35	2	4	0	1
14. Star Mountains	28	18	8	2	2	0
15. Hunstein Mountains	16	16	2	1	1	0
16. Western Highlands	28	27	14	5	1	1
17. Schrader Mountains	24	21	11	4	0	0
18. Central Mountains (Chimbu)	34	20	18	4	2	0
19. Southern Highlands	21	22	9	2	1	0
20. Eastern Highlands	34	31	20	6	3	0
21. Anga Region	14	15	6	3	0	0
22. Bowtu Mountains	35	31	20	10	5	2
23. Wharton Range	27	18	16	6	9	1
24. Western Owen Stanley Mountains	20	6	11	0	3	0
25. Eastern Owen Stanley Mountains	13	5	9	0	4	0
26. St. Matthias Islands	0	9	0	0	0	0
27. Admiralty Islands	7	23	4	4	1	4
28. New Hanover Islands	1	17	0	0	0	1
29. New Ireland	5	24	2	2	0	2
30. New Britain	13	30	9	3	7	0
31. Karkar Island	0	16	0	1	0	0
32. Long Island	0	14	0	1	0	0
33. Umboi Island	0	11	0	0	0	0
34. Trobriand Islands	1	20	0	1	0	0
35. Woodlark Islands	2	12	0	0	0	0
36. D'Entrecasteaux Archipelago	15	26	8	5	3	1
37. Louisiade Archipelago	14	27	8	4	5	2
38. Bougainville (incl. Buka I.)	25	38	12	4	12	4

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Table 16-2

Total numbers of Papua New Guinea frog and lizard species. Total species includes all species recorded for Papua New Guinea for which locality information is available. Endemic species includes species found only on Papua New Guinea, and restricted range species includes species found only in a given biogeographic region.

	TOTAL PNG SPECIES	TOTAL ENDEMIC SPECIES	PERCENT ENDEMIC SPECIES	TOTAL RESTRICTED RANGE SPECIES	PERCENT RESTRICTED RANGE SPECIES
FROGS	193	115	60	73	38
LIZARDS	184	59	32	35	19

Table 16-3

Biogeographic Regions for Papua New Guinea

Biogeographic Regions.

1. Bewani Mountains
2. Torricelli Mountains
3. Prince Alexander Mountains
4. Sepik-Ramu Basin
5. Adelbert Mountains
6. Huon Peninsula
7. S. Morobe Coast
8. Northern Province Lowlands
9. Milne Bay Lowlands
10. Central Province Lowlands
11. Gulf Lowlands
12. Trans-Fly Region
13. Great Papuan Plateau
14. Star Mountains
15. Hunstein Mountains
16. Western Highlands
17. Schrader Mountains
18. Central Highlands
19. Southern Highlands
20. Eastern Highlands
21. Anga Region
22. Bowutu Mountains
23. Wharton Mountains
24. Western Owen Stanley Mountains
25. Eastern Owen Stanley Mountains
26. St. Matthias Islands
27. Admiralty Archipelago
28. New Hanover Island
29. New Ireland
30. New Britain
31. Karkar Island
32. Long Island
33. Umboi Island
34. Trobriand Islands
35. Woodlark Island
36. D'Entrecasteaux Archipelago
37. Louisiade Archipelago
38. Bougainville Islands

APPENDIX 16-1. PRELIMINARY CHECKLIST OF AMPHIBIANS AND REPTILES OF PAPUA NEW GUINEA

- Allen Allison

Species are listed alphabetically under family and genus followed by species authority and date. A "(?)" following the species name indicates that the validity of the spec .s is questionable. Questionable or unconfirmed occurrence of the species in Papua New Guinea is indicated by a "?" under status. In seven instances distinctive lizard subspecies are listed in addition to the nominate subspecies; taxonomic work on some of these groups is in progress, and it is likely that many of these subspecies will eventually be recognized as full species. The number of species included in the checklist by family is presented in the table below (the seven lizard subspecies are included as distinct species).

Number of Papua New Guinea amphibian and reptile species by Family

FROGS:		
	Bufonidae	1
	Hylidae	62
	Microhylidae	84
	Myobatrachidae	6
	Ranidae	44
	TOTAL	197
CROCODILES:		
	Crocodylidae	2
	TOTAL	2
TURTLES:		
	Carettochelidae	1
	Chelidae	5
	Cheloniidae	5
	Dermochelyidae	1
	Trionychidae	1
	TOTAL	13
LIZARDS:		
	Agamidae	14
	Gekkonidae	32
	Pygopodidae	2
	Scincidae	149
	Varanidae	8
	TOTAL	195
SNAKES:		
	Acrochordidae	2
	Boidae	2
	Colubridae	32
	Elapidae	23
	Hydrophiidae	22
	Pythonidae	8
	Typhlopidae	9
	TOTAL	98
TOTAL SPECIES		505

PAPUA NEW GUINEA F...

ANURA: BUFONIDAE
Bufo
marinus (Linnaeus) 1758

ANURA: HYLIDAE
Litoria
albolabris (Wandolleck) 1911
amboinensis (Horst) 1883
angiana (Boulenger) 1915
arfakiana (Peters and Doria) 1878
aruensis (Horst) 1883
becki (Loveridge) 1945
bicolor (Gray) 1842
cf. bicolor
bulmeri (Tyler) 1968
caerulea (White) 1790
congenita (Peters and Doria) 1878
contrastens (Tyler) 1968
darlingtoni (Loveridge) 1945
dorsalis Macleay 1877
dorsivena (Tyler) 1968
eucnemis (Lönnberg) 1900
exophthalmia Tyler, Davies and Aplin 1986
genimaculata (Horst) 1883
gracilenta (Peters) 1869
graminea (Boulenger) 1905
impura (Peters and Doria) 1878
infrafrenata (Günther) 1867
iris (Tyler) 1962
jeudii (Werner) 1901
leucova (Tyler) 1968
longicrus (Boulenger) 1911
louisiadensis (Tyler) 1968
lutea (Boulenger) 1887
micromembrana (Tyler) 1968
modica (Tyler) 1968
multiplica (Tyler) 1964
nasuta (Gray) 1841
nigrofrenata (Günther) 1867
nigropunctata (Meyer) 1874
oenicolen Menzies and Zweifel 1974
prora (Menzies) 1969
pygmaea (Meyer) 1874
rothii (de Vis) 1884
rubella (Gray) 1842
spinifera (Tyler) 1968
thesaurensis (Peters) 1878
timida Tyler and Parker 1972
vocivincens Menzies 1972
wollastoni (Boulenger) 1914

Nycti..ystes
avocalis Zweifel 1958
cheesmanae Tyler 1964
daymani Zweifel 1958
disrupta Tyler 1963
foricula Tyler 1963
gularis Parker 1936
humeralis (Boulenger) 1912
kubori Zweifel 1958
narinosa Zweifel 1958
obsoleta (Lönnberg) 1900
papua (Boulenger) 1897
perimetri Zweifel 1958
persimilis Zweifel 1958
pulchra (Wandolleck) 1911
semipalmata Parker 1936
trachydermis Zweifel 1983
tyleri Zweifel 1983
zweifeli Tyler 1967

ANURA: MICROHYLIDAE
Aphantophryne
minuta Zweifel and Parker 1989
pansa Fry 1917
sabini Zweifel and Parker 1989

Asterophrys
turpicola (Schlegel) 1837

Barygenys
atra (Günther) 1896
cheesmanae Parker 1936
exsul Zweifel 1963

.4?

flavigularis Zweifel 1972
maculata Menzies and Tyler 1977
nana Zweifel 1972
parvula Zweifel 1981

Callulops
doriae Boulenger 1888
eurydactylus (Zweifel) 1972
glandulosus (Zweifel) 1972
humicola (Zweifel) 1972
personatus (Zweifel) 1972
robustus (Boulenger) 1898
slateri (Loveridge) 1955
strictogaster (Zweifel) 1972
wilhelmanus (Loveridge) 1948

Choerophryne
rostellifer (Wandolleck) 1911

Cophixalus
ateles (Boulenger) 1898
biroi (Méhelÿ) 1901
cheesmanae Parker 1934
cryptotympanum Zweifel 1956
darlingtoni Loveridge 1948
kaindiensis Zweifel 1979
nubicola Zweifel 1962
parkeri Loveridge 1948
pipilans Zweifel 1980
riparius Zweifel 1962
shellyi Zweifel 1956
sphagnicola Zweifel and Allison 1982
tagulensis Zweifel 1963
verecundus Zweifel and Parker 1989
verrucosus (Boulenger) 1898

Copiula
fistulans Menzies and Tyler 1977
minor Menzies and Tyler 1977
oxyrhina (Boulenger) 1898
pipiens Burton and Stocks 1986
tyleri Burton 1990

Genyophryne
thomsoni Boulenger 1890

Hylophorbus
rufescens Macleay 1898

Mantophryne
infulata (Zweifel) 1972
lateralis Boulenger 1887
louisiadensis (Parker) 1934

Oreophryne
anthonyi (Boulenger) 1897
biroi (Méhelÿ) 1897
brachypus (Werner) 1898
brevicrus Zweifel 1956
geislerorum (Boettger) 1892
inornata Zweifel 1956
insulana Zweifel 1956
kampeni Parker 1934
parkeri Loveridge 1955
wolterstorffi (Werner) 1900

Pherohapsis
menziesi Zweifel 1972

Sphenophryne
brevicrus (van Kampen) 1913
brevipes (Boulenger) 1892
cornuta Peters and Doria 1878
crassa Zweifel 1956
dentata Tyler and Menzies 1971
gracilipes (Fry) 1912
hooglandi Zweifel 1967
macrorhyncha (van Kampen) 1906
mehelyi Parker 1934
palmipes Zweifel 1956
polysticta (Méhelÿ) 1901
rhododactyla (Boulenger) 1897
schlaginhaufeni (Wandolleck) 1911

Xenobatrachus
anorbis Blum and Menzies 1988
bidens (van Kampen) 1909
fuscigula Blum and Menzies 1988
huon Blum and Menzies 1988
mehelyi (Boulenger) 1898
obesus Zweifel 1960

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rostratus (Méhelÿ) 1898
subcroceus Menzies and Tyler 1977
tumulus Blum and Menzies 1988

Xenorhina
oxycephala (Schlegel) 1858
parkerorum Zweifel 1972
similis (Zweifel) 1956

ANURA: MYOBATRACHIDAE
Lechriodus
aganoposis Zweifel 1972
melanopyga (Doria) 1874

Limnodynastes
convexiusculus (Macleay) 1877

Mixophyes
hihihorlo Donnellan, Mahony and Davies 1990

Ranidella
remota Tyler and Parker 1974

Uperoleia
mimula Davies, McDonald and Corben 1986

ANURA: RANIDAE
Batrachylodes
elegans Brown and Parker 1970
gigas Brown and Parker 1970
mediodiscus Brown and Parker 1970
minutus Brown and Parker 1970
montanus Brown and Parker 1970
trossulus Brown and Myers 1949
vertebralis Boulenger 1887
wolfi (Sternfeld) 1918

Ceratobatrachus
guentheri Boulenger 1884

Discodeles
bufoniformis (Boulenger) 1884
guppyi (Boulenger) 1884
ophistodon (Boulenger) 1884
ventricosus (Vogt) 1912

Palmatorappia
solomonis (Sternfeld) 1920

Platymantis
acrochordus (Brown) 1965
aculeodactylus Brown 1952
akarithymus Brown and Tyler 1968
boulengeri (Boettger) 1892
gilliardi Zweifel 1960
guppyi (Boulenger) 1884
macrops (Brown) 1965
macrosceles Zweifel 1975
magnus Brown and Menzies 1979
mimicus Brown and Tyler 1968
myersi Brown 1949
neckeri (Brown and Myers) 1949
nexipus Zweifel 1975
papuensis Meyer 1874
parkeri (Brown) 1965
rhipiphalcus Brown and Tyler 1968
schmidti Brown and Tyler 1968
solomonis (Boulenger) 1884 ?
weberi Schmidt 1932 ?

Rana
arfaki Meyer 1874
daemeli (Steindachner) 1868
garritor Menzies 1987
grisea van Kampen 1913
grunniens Daudin 1802
jimiensis Tyler 1963
kreffti Boulenger 1882
novaeguineae van Kampen 1909
papua Lesson 1826 ?
semelvella Menzies 1987
supragrisea Menzies 1987

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PAPUA NEW GUINEA CROCODILES AND TURTLES

CROCODILIA: CROCODYLIDAE
Crocodylus
porosus Schneider 1801
novaeguineae Schmidt 1928

TESTUDINES: CARETTOCHELIDAE
Carettochelys
insculpta Ramsay 1886

TESTUDINES: CHELIDAE
Chelodina
novaeguineae Boulenger 1888
parkeri Rhodin and Mittermeier 1976
siebenrocki Werner 1901

Elseya
novaeguineae (Meyer) 1874

Emydura
subglobosa (Krefft) 1876

TESTUDINES: CHELONIIDAE
Caretta
caretta (Linnaeus) 1766

Chelonia
mydas (Linnaeus) 1766

Eretmochelys
imbricata (Linnaeus) 1766

Lepidochelys
olivacea (Eschscholtz) 1829

Natator
depressus (Garman) 1880

TESTUDINES: DERMOCHELYIDAE
Dermochelys
coriacea Linnaeus 1766

TESTUDINES: TRIONYCHIDAE
Pelochelys
bibroni Owen 1853

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PAPUA NEW GUINEA LIZARDS

LACERTILIA: AGAMIDAE
Chlamydosaurus
kingii Gray 1825

Diporiphora
australis (Steindachner) 1867 ?
bilineata Gray 1842

Hypsilurus
auritus (Meyer) 1874
binotatus (Meyer) 1874
bruijnii (Peters and Doria) 1878
dilophus (Duméril and Bibron) 1837
geelvinkianus (Peters and Doria) 1878
godeffroyi (Peters) 1867
modestus (Meyer) 1874
nigrigularis (Meyer) 1874
papuensis (Macleay) 1877

Lophognathus
temporalis (Günther) 1867

Physignathus
lesueurii (Gray) 1831

LACERTILIA: GEKKONIDAE
Cyrtodactylus
derongo Brown and Parker 1973
loriae (Boulenger) 1898
louisiadensis (de Vis) 1892
marmoratus Gray 1831
mimikanus (Boulenger) 1914
novaeguineae (Schlegel) 1844
papuensis (Brongersma) 1934
sermowaiensis (de Rooij) 1915

Gehyra
baliola (Duméril) 1851
dubia (Macleay) 1877
interstitialis Oudemans 1894
lampei Andersson 1913
membranacruralis King and Horner 1989
mutilata (Wiegmann) 1835
oceanica (Lesson) 1826
papuana Meyer 1874
vorax Girard 1857

Gekko
vittatus (Houttuyn) 1782

Hemidactylus
frenatus (Duméril and Bibron) 1836

Hemiphyllodactylus
typus typus Bleeker 1860

Lepidodactylus
browni Pernetta and Black 1983
guppyi Boulenger 1884
lugubris (Duméril and Bibron) 1836
magnus Brown and Parker 1977
mutahi Brown and Parker 1977
novaeguineae Brown and Parker 1977
orientalis Brown and Parker 1977
pulcher Boulenger 1885
pumilus (Boulenger) 1885
woodfordi Boulenger 1887

Nactus
pelagicus (Girard) 1858
vankampeni (Brongersma) 1933

LACERTILIA: PYGOPODIDAE
Lialis
burtonis Gray 1834
jicari Boulenger 1903

LACERTILIA: SCINCIDAE
Carlia
bicarinata (Macleay) 1877
fusca diguliensis (Kopstein) 1926
fusca fusca (Duméril and Bibron) 1839
longipes (Macleay) 1877
luctuosa (Peters and Doria) 1878
pulla (Barbour) 1911
storri Ingram and Covacevich 1989

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Corucia
zebrata Gray 1855

Cryptoblepharus
novaeguineae Mertens 1928
pallidus Mertens 1928
poecilopleurus (Wiegmann) 1835
virgatus (Garman) 1901

Ctenotus
robustus Storr 1970
spaldingi (Macleay) 1877

Egernia
frerei Günther 1897

Emoia
aenea Brown and Parker 1985
ahli (Vogt) 1932
atrocostata atrocostata (Lesson) 1826
aurulenta Brown and Parker 1985
battersbyi (Proctor) 1923
bismarckensis Brown 1983
brongersmai Brown 1991
caeruleocauda (de Vis) 1892
coggeri Brown 1991
cyanogaster (Lesson) 1826
cyanura (Lesson) 1826
flavigularis Schmidt 1932
guttata Brown and Allison 1986
jakati (Kopstein) 1926
klossi (Boulenger) 1914
korodana (Meyer) 1874
longicauda (Macleay) 1877
loveridgei Brown 1953
maxima Brown 1953
mivarti (Boulenger) 1887
montana Brown 1991
nigra (Jacquinot and Guichenot) 1853
obscura (de Jong) 1927
oribata Brown 1991
pallidiceps mehelyi (Werner) 1899
pallidiceps pallidiceps (de Vis) 1890
physicae physicae (Duméril and Bibron) 1839
physicae purari Brown 1991
physicana Brown and Parker 1985
popei Brown 1953
pseudocyanura Brown 1991
pseudopallidiceps Brown 1991
submetallica (Macleay) 1877
tetrataenia (Boulenger) 1895
tropidolepis (Boulenger) 1914
veracunda Brown 1953

Eugongylus
albofasciolatus (Günther) 1872
rufescens (Shaw) 1802

Fojia
bumui Greer and Simon 1982

Geomyersia
coggeri Greer 1982
glabra Greer and Parker 1968

Lamprolepis
smaragdina perviridis (Barbour) 1921

Lipinia
cheesmanae (Parker) 1940
longiceps (Boulenger) 1895
noctua (Lesson) 1826
pulchra (Boulenger) 1903
rouxi (Hediger) 1934

Lobulia
brongersmai (Zweifel) 1972
elegans (Boulenger) 1897

Lygisaurus
macfarlani (Günther) 1877
novaeguineae (Meyer) 1874

Papuascincus
morokanus (Parker) 1936
phaeodes (Vogt) 1932
stanleyanus (Boulenger) 1897

Prasinohaema
flavipes flavipes (Parker) 1936
parkeri (Smith) 1937
prehensicauda (Loveridge) 1945
semoni (Oudemans) 1894
virens virens (Peters) 1881

Sphenomorphus
aignanus (Boulenger) 1898
albodorsalis (=*Lipinia* sp. ?) (Vogt) 1932 ?
annectens (Boulenger) 1897
anotus Greer 1973
aruensis (Doria) 1874
brunneus Greer and Parker 1974
cinereus Greer and Parker 1974
concinnatus (Boulenger) 1887
cranei Schmidt 1932
crassicaudus (Duméril) 1851
darlingtoni (Loveridge) 1945
derooyae (de Jong) 1927
forbesii (Boulenger) 1888
fragilis (Macleay) 1877
fragosus Greer and Parker 1967
granulatus (Boulenger) 1903
jeudii (Boulenger) 1914
jobiensis (Meyer) 1874
leptofasciatus Greer and Parker 1974
longicaudatus (de Rooij) 1915
loriae (Boulenger) 1897
louisiadensis (Boulenger) 1903
maindroni (Sauvage) 1878
megaspilus (Günther) 1877
melanochlorus (Vogt) 1932
melanopleurus Inger 1958
meyeri (Doria) 1874
microtympanus Greer 1973
milnensis (Boulenger) 1903
mimikanus (?) (Boulenger) 1914 ?
minutus (Meyer) 1874
muelleri latifasciatus (Meyer) 1874 ?
muelleri muelleri (Schlegel) 1837
neuhaussi (Vogt) 1911
nigricaudis (Macleay) 1877
nigriventris (de Rooij) 1915
nigrolineatus (Boulenger) 1897
nototaenius (?) (Boulenger) 1914 ?
oligolepis (Boulenger) 1914
papuae (Kinghorn) 1928
papuensis (?) (Macleay) 1877 ?
pratti (Boulenger) 1903
rufus (?) (Boulenger) 1887 ?
schultzei (Vogt) 1911
simus (?) (Sauvage) 1879 ?
solomonis (Boulenger) 1887
stickeli (Loveridge) 1948
striolatus (?) (Weber) 1891 ?
tanneri Greer and Parker 1967
taylori Burt 1930
tornieri (Vogt) 1911
totocarinatus (Vogt) 1932
transversus Greer and Parker 1971
undulatus (Peters and Doria) 1878
unilineatus (?) (de Rooij) 1915 ?
wolfi (?) Sternfeld 1920 ?
wollastoni (Boulenger) 1914
woodfordi (Boulenger) 1887

Tiliqua
scincoides gigas (Schneider) 1801

Tribolonotus
annectens Zweifel 1966
blanchardi Burt 1930
brongersmai Cogger 1972
gracilis de Rooij 1909
novaeguineae (Schlegel) 1834
ponceleti Kinghorn 1937
pseudoponseleti Greer and Parker 1968

LACERTILIA: VARANIDAE
Varanus
bogerti Mertens 1950
panoptes horni Böhme 1988
indicus indicus (Daudin) 1802
karlschmidti Mertens 1951
prasinus (Schlegel) 1839
salvadorii (Peters and Doria) 1878
telenesetes Sprackland 1991
timorensis similis Mertens 1958

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SERPENTES: ACROCHORDIDAE
Acrochordus
arafurae McDowell

Chersydrus
granulatus (Schneider) 1799

SERPENTES: BOIDAE
Candoia
aspera (Günther) 1877
carinata (Schneider) 1801

SERPENTES: COLUBRIDAE
Boiga
irregularis (Merrem) 1802

Cantoria
annulata de Jong 1927

Cerberus
rhynchops (Schneider) 1799

Dendrelaphis
calligastra (Günther) 1867
gastrostictus (Boulenger) 1894
lorentzi (van Lidth de Jeude) 1911
papuensis Boulenger 1895
punctulatus (Gray) 1827
solomonis (Günther) 1867

Enhydris
enhydris (Schneider) 1799
polylepis (Fischer) 1886

Fordonia
leucobalia (Schlegel) 1837

Myron
richardsoni Gray 1849

Stegonotus
cucullatus (Duméril, Bibron and Duméril) 1854
diehli Lindholm 1905
guentheri Boulenger 1895
heterurus Boulenger 1893
modestus (Schlegel) 1837
parvus (Meyer) 1875

Tropidonophis
aenigmaticus Malnate and Underwood 1988
dahlii (Werner) 1899
doriae (Boulenger) 1897
elongatus (Jan) 1865 ?
hypomelas (Günther) 1877
mairii (Gray) 1841
mcdowelli Malnate and Underwood 1988
montanus (van Lidth de Jeude) 1911
multiscutellatus (Brongersma) 1948
novaeguineae (van Lidth de Jeude) 1911
parkeri Malnate and Underwood 1988
picturatus (Schlegel) 1837
statisticus Malnate and Underwood 1988

SERPENTES: ELAPIDAE
Acanthophis
antarcticus (Shaw) 1794

Aspidomorphus
lineaticollis (Werner) 1903
muelleri (Schlegel) 1837
schlegeli (Günther) 1872

Demansia
papuensis (Macleay) 1877

Glyphodon
tristis Günther 1858

Micropechis
ikaheka (Lesson) 1826

Oxyuranus
scutellatus (Peters) 1867

Parapistocalamus
hedigeri Roux 1934

Pseudechis
australis (Gray) 1842 ?
papuanus Peters and Doria 1878

Pseudonaja
textilis (Duméril, Bibron and Duméril) 1854

Salomonelaps
par (Boulenger) 1884

Toxicocalamus
buergersi (Sternfeld) 1913
holopelturus McDowell 1969
longissimus Boulenger 1896
loriae (Boulenger) 1898
misimae McDowell 1969
preussi (Sternfeld) 1913
spilolepidotus McDowell 1969
stanleyanus Boulenger 1903

Unechis
carpentariae Macleay 1887
nigrostriata (Krefft) 1864

SERPENTES: HYDROPHIIDAE

Acalyptophis
peronii (Duméril) 1853

Aipysurus
duboisii Bavay 1869
eydouxii (Gray) 1849
laevis Lacépède 1804

Disteira
kingii (Boulenger) 1896
major (Shaw) 1802
stokesii (Gray) 1846

Enhydrina
schistosa (Daudin) 1803

Hydrelaps
darwiniensis Boulenger 1896

Hydrophis
belcheri (Gray) 1849
elegans (Gray) 1842
fasciatus (Schneider) 1799
gracilis (Shaw) 1802
melanosoma Günther 1864
obscurus Daudin 1803
ornatus (Gray) 1849
pacificus Boulenger 1896

Lapemis
curtus (Shaw) 1802
hardwickii Gray 1834

Laticauda
colubrina (Schneider) 1799
laticaudata (Linnaeus) 1754

Pelamis
platurus Linnaeus 1766

SERPENTES: PYTHONIDAE

Morelia
albertisii (Peters and Doria) 1878
amethistina (Schneider) 1801
boa (Schlegel) 1837
boeleni (Brongersma) 1953
mackloti (Duméril and Bibron) 1844
papuana (Peters and Doria) 1878
spilota (Lacépède) 1804
viridis (Schlegel) 1872

SERPENTES: TYPHLOPIDAE

Rhamphotyphlops
affinis (Boulenger) 1889
braminus (Daudin) 1803
erycinus (Werner) 1901
flaviventer (W. Peters) 1865
leucoproctus (Boulenger) 1889
polygrammica (Schlegel) 1839
subocularis (Waite) 1897

Typhlops
depressiceps Sternfeld 1913
inornatus Boulenger 1888

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APPENDIX 16-2. BIBLIOGRAPHY OF FISHES, AMPHIBIANS, AND REPTILES OF PAPUA NEW GUINEA

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Chapter Seventeen

Biodiversity and Conservation of the Nonmarine Invertebrate Fauna of Papua New Guinea

Scott E. Miller[1], with contributions by Robert Cowie, Dan Polhemus, and Lucius Eldredge[2]

SUMMARY

Many conservationists believe that invertebrates, particularly insects, with their apparently overwhelming number of species, are too intractable to study. Insect diversity presents many groups that are highly appropriate for mapping diversity patterns and monitoring environmental quality.

This report will focus on insects, but other terrestrial invertebrate groups (e.g., Crustacea, Mollusca) that show promise as indicator groups for conservation planning and monitoring are addressed also. The core of the discussion is based on an earlier report on the same subject (Miller and Holloway 1992). I have prepared a distributional analysis of selected terrestrial insect taxa, and Dan Polhemus has prepared a distributional analysis of selected aquatic insect taxa. Robert Cowie and Lucius Eldredge have prepared reports on Molluscs and Crustacea, respectively, that are appended to the main report.

Patterns of endemism in terrestrial and aquatic insects in PNG are examined through heuristic approximations. Representative sites within these areas of endemism have been identified for consideration for preservation.

Recommendations for conservation research priorities include construction of databases on selected invertebrates (e.g., butterflies), development of environmental quality monitoring techniques using invertebrates, further development of butterfly farming and ranching, and building local infrastructure (e.g., national identification service and reference collection), and training. Implementation priorities include strengthening existing exclusion and detection programs for pest invertebrates, screening of biological control introductions, and strengthening enforcement of environmental laws.

[1] Department of Entomology, Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.

[2] All co-authors are from the Bernice P. Bishop Museum, Honolulu, Hawaii, U.S.A.

INTRODUCTION

Most conservation organizations have avoided insects because of the inherent problems in dealing with them: (1) the tremendous number of species, especially in tropical areas such as Papua New Guinea; (2) the tremendous number of individuals in most tropical sites; and (3) because of these, problems in information transfer from the research community to the conservation community. It has been common for research entomologists to say that it will take years to produce results from surveys. However, the great diversity of insects is a positive feature, allowing choice of specific groups that can answer specific questions in a statistically meaningful manner. Furthermore, modern information management techniques provide at least a partial solution to the information transfer problem. The Costa Rican Instituto Nacional de Biodiversidad (INBio) provides an excellent example for what can be done with insect surveys.

Insects possess the following positive features for providing conservation data (see also Brown 1991, Holloway and Stork 1991, Rosenberg et al. 1986, Sutton and Collins 1991): (1) generality of distribution -- insects are found in almost every conceivable habitat and niche; (2) within this overall versatility, there is much specialization; (3) many taxa show rapid responses to environmental perturbation; (4) some taxa are readily identifiable without specialized training; (5) many taxa are good indicators of areas of endemism; and (6) many taxa are readily sampled with quantitative methods, providing high quality data for statistical analysis.

BRIEF HISTORY OF ENTOMOLOGY IN PNG

Frodin and Gressitt (1982) presented an excellent history of biological exploration in PNG and only the major elements will be repeated here. The earliest expeditions are not of great importance to this report because they collected relatively few specimens, and these usually have relatively nonspecific locality data. These expeditions provided the first specimens of many species endemic to PNG, but more comprehensive collections must be consulted to understand distribution patterns.

The PNG fauna cannot be understood in isolation because much of the fauna is shared with Irian Jaya, the Solomon Islands, or Australia. The entomological literature for the New Guinea region was compiled by Gressitt and Szent-Ivany (1968). A supplement to this important bibliography is in preparation by Emmett Easton.

Major institutional holdings of PNG insects outside of PNG include the following: Bishop Museum, Honolulu (BPBM); Australian National Insect Collection, CSIRO, Canberra (ANIC); Natural History Museum, London (NHM); Rijksmuseum van Natuurlijke Historie, Leiden (RNH); Museum of Comparative Zoology, Harvard University, Cambridge (MCZ); California Academy of Sciences, San Francisco; American Museum of Natural History, New York (AMNH); and the Australian Museum, Sydney. The two most important collections in PNG are the Department of Agriculture and Livestock, Konedobu, and the Forest Research

Institute, Lae. Smaller collections, in varying curatorial conditions, exist at Wau Ecology Institute, Insect Farming and Trading Agency, and the University of Papua New Guinea.

Some of the first comprehensive insect collecting (especially for Lepidoptera) was undertaken by a series of collectors sponsored by Lord Walter Rothschild from 1894 into the 1930s. These collectors included A.S. Meek, W.G. Meek, A. Eichhorn, G. Eichhorn, A.E. Pratt, H. Pratt, and E. Mayr. These collections, now in the NHM, include probably the largest and most historically significant assemblage of New Guinea Lepidoptera.

The First (1933-34) through Seventh (1964), and especially the Third (1938-39), Archbold Expeditions were important sources of insects (RNH, AMNH). During World War II, many U.S. and Australian entomologists collected in PNG. Especially significant to this report are the beetle collections of P.J. Darlington during 1943-44, primarily around Dobodura (MCZ).

In 1955, J.L. Gressitt initiated the Bishop Museum's ongoing surveys throughout New Guinea. Fieldwork was especially intense during the late 1950s and 1960s. The program included many collaborating researchers and institutions, resulting in large collections at BPBM and elsewhere.

In 1961, the Bishop Museum established a field station at Wau. This evolved into the independent Wau Ecology Institute in 1972 and continues to be a center of biological research and conservation programs. This activity has made the Wau region perhaps the best sampled in all of New Guinea. Earlier samples from Wau were made by Herbert Stevens in 1932-1933 (MCZ).

J. J. H. Szent-Ivany, working for the precursor of the PNG Dept. of Agriculture and Livestock (DAL) from 1954-1966, promoted the study of PNG insects by specialists and built an excellent collection at Konedobu. He continued his studies at Wau Ecology Institute into the early 1970s. His unpublished manuscript on economically important insects of PNG will hopefully be published in the near future. His efforts at Konedobu were continued by J.W. Ismay and R. Kumar. An excellent collection of forest insects has been built at the Forest Research Institute, Lae, through the efforts of E. Gray, R. Wylie, P. Shanahan, J. Dobunaba, and H. Roberts.

Many localities in New Guinea have been sampled for "popular" organisms like butterflies. As noted above, many good collections exist that were made since the turn of the century and have relatively precise locality data. Especially strong collections for butterflies include NHM, RNH, ANIC, BPBM and the collections in PNG (Wau, Bulolo, Konedobu, and Lae). We do not know at this time just how extensive or intensive the existing coverage of butterfly data for New Guinea is, because these data have never been compiled. Plans are now being made to compile these data from the major collections. A similar study in Peru recently showed that coverage of butterfly records was comparable (although somewhat less) than that for birds (Lamas 1989). The Peru study identified 36 unexplored areas for butterflies, 24 of them also being unknown ornithologically.

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MAJOR GAPS IN KNOWLEDGE

Status of General Knowledge

Knowledge of insects and other invertebrates of PNG varies tremendously among taxonomic groups and localities, according to the history of sampling and study, and the biological complexity of the group. For example, butterflies of the Wau-Bulolo valley are well known (Parsons 1992), but nothing is known about soil mites at most sites in PNG. The components involved in understanding insects include the following:

1. Sampling of basic diversity -- collecting and preservation for study. Basic sampling has taken place for many groups, although the smaller and more difficult to study taxa are almost always undersampled. Geographic coverage is poor for most groups (e.g., most records from the Great Papuan Plateau represent only two localities!).

2. Systematic study of these samples -- diagnosis of species and other taxonomic units. The quality and quantity of systematic studies varies with historical interest from group to group. Some taxa are relatively well known, but information transfer is a problem for all groups. The bibliography by Gressitt and Szent-Ivany (1968) is the only broad attempt to synthesize knowledge of PNG insects! The recent text on Australian insects (CSIRO 1991) is very helpful in understanding the PNG fauna.

3. Field studies on the biology, ecology, and distribution of the species. Except for species of economic interest to agriculture, forestry, or medicine, little is known about the ecology of PNG insects.

However, as noted in the introduction, the great diversity of insects is a positive feature, allowing choice of specific groups that can answer specific questions in a statistically meaningful manner. Modern information management techniques provide at least a partial solution to the information transfer problem.

Status of Taxonomic Knowledge

As noted above, taxonomic knowledge of PNG insects varies greatly from group to group. There is no comprehensive review for any major group except the flies, and the bibliography by Gressitt and Szent-Ivany (1968) is the only broad attempt to synthesize knowledge of PNG insects! The following is a brief overview of the state of taxonomic knowledge of PNG insects, including major references. Major taxonomic units follow the recent text on Australian insects (CSIRO 1991) which is an important general review.

Order Collembola (Springtails): Very poorly known for PNG.

Order Protura: Very poorly known for PNG.

Order Diplura: Poorly known for PNG (Paclt 1985).

Order Archaeognatha (=Microcoryphia) (Bristletails): Very poorly known for PNG.

Order Thysanura (Silverfish): Very poorly known for PNG.

Order Ephemeroptera (Mayflies): Very poorly known for PNG (Edmunds and Polhemus 1990).

Order Odonata (Dragonflies and Damselflies): Relatively well known from extensive work of Lieftinck (1949 and subsequent papers).

Order Plecoptera (Stoneflies): Not known from PNG, but an unidentified species has recently been collected in Irian Jaya (D.A. Polhemus, pers. comm.).

Order Blattodea (=Blattaria) (Cockroaches): Scattered literature for PNG, partially reviewed in a series of Australian revisions underway by L.M. Roth.

Order Isoptera (Termites): Scattered literature for PNG. Catalogued by Snyder (1949).

Order Mantodea (Praying mantids): Relatively well known for PNG (Beier 1965).

Order Dermaptera (Earwigs): Scattered literature for PNG. See world checklist by Steinmann (1989).

Order Orthoptera (Grasshoppers, locusts, katydids, crickets): Scattered literature for PNG.

Order Phasmatodea (Stick-insects): Scattered literature for PNG (Nakata 1961).

Order Embioptera (=Embiidina) (Web-spinners): Ross (1948).

Order Zoraptera: Not yet known to occur in New Guinea (Smithers in CSIRO 1991).

Order Psocoptera (Pscoids, booklice): Generally poorly known in PNG, although some groups recently revised (Smithers and Thornton 1981).

Order Phthiraptera (including Mallophaga and Anoplura) (Lice): Generally poorly known in PNG (Ferris 1951, Hopkins and Clay 1952, Kéler 1971).

Order Hemiptera (including Heteroptera and Homoptera) (Bugs, leafhoppers, cicadas, aphids, scale insects, etc.): Knowledge very uneven for PNG. Some groups have modern revisions (especially some Cicadidae, Coccoidea, Miridae, Flatidae, Cicadellidae, aquatic Heteroptera, etc.). See Stonedahl and Dolling (1991) for literature on Heteroptera.

Order Thysanoptera (Thrips): Generally poorly known for PNG but partially treated in recent revisions by L.A. Mound and others.

Order Megaloptera (Alderflies, dobsonflies): Not yet known from PNG.

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Order Raphidioptera (Snake-flies): Not known from PNG.
Order Neuroptera (Lacewings, etc.): Relatively well known in PNG because of publications by T.R. New.

Order Coleoptera (Beetles): A very diverse group in PNG, ranging from relatively well known (e.g., Carabidae, Chyrsomelidae) to very poorly known (e.g., Scarabaeidae, Curculionidae). General review by Gressitt and Hornabrook (1977). Several large families reviewed by Bigger and Schofield (1983).

Order Strepsiptera: A small parasitic group reviewed by Kathirithamby (1989).

Order Mecoptera (Scorpion-flies): Not known from PNG (Penny and Byers 1979).

Order Siphonaptera (Fleas): Relatively well known in PNG; monographed by Holland (1969).

Order Diptera (Flies): A very diverse group in PNG, ranging from relatively well known (e.g., Culicidae) to very poorly known (e.g., Chironomidae). Catalogued by Evenhuis (1989).

Order Trichoptera (Caddis-flies): Reviewed by Neboiss (1986), but many taxa remain to be described.

Order Lepidoptera (Moths and butterflies): A very diverse group in PNG, ranging from relatively well known (e.g., butterflies) to very poorly known. Butterflies partially reviewed by Parsons (1992). Microlepidoptera reviewed by Diakonoff (1952-55), but many taxa remain to be described. No modern review of larger moths exists (Miller and Holloway 1992).

Order Hymenoptera (Wasps, bees, ants, sawflies): A very diverse group in PNG, ranging from relatively well known (e.g., ants) to very poorly known (e.g., many parasitic wasps).

CURRENT ASSESSMENT

Background

The biogeography of insects in PNG reflects the geological history of the region. The island of New Guinea has evolved into a major land area only over the past ten or so million years through fusion and compression of inner and outer Melanesian island arcs between the northward moving Australian continent on the Indian Ocean tectonic plate, and the westward moving margin of the Pacific tectonic plate. Only in the Pliocene and Pleistocene have its mountain ranges been uplifted to the snow line, to be glaciated extensively during the latter epoch. This hypothesized archipelagic development of the island is reflected in present local areas of endemism of the fauna (e.g., Duffels 1977, 1983a, 1983b, 1986).

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Despite this geological youth, the insect fauna has attained a diversity that appears to be equivalent to that of the much older tropical lands of Southeast Asia (Gressitt 1982a). The majority of this fauna has its closest relationships with that of Asia, genera perhaps tending to be fewer in number but more species rich. The majority of genera endemic to Melanesia are restricted to, or have their species richness strongly centered in, New Guinea (Holloway 1984c: 159). This insect diversity provides excellent opportunities for mapping of patterns of endemism.

The indication of rapid build up of high diversity in a geologically young area of the tropics is of itself worthy of study. The combination of localized areas of endemism, high site diversity, and relatively few but speciose genera (also exhibiting high endemism to New Guinea) suggests that understanding of past processes of speciation within New Guinea may reveal much of how high tropical diversity develops and is able to persist (Holloway 1991). Perhaps some components of this diversity could even be considered as threatened phenomena (as defined by Wells et al. 1983: xxi). It is also important to consider future evolutionary potential in conservation decisions (Erwin 1991).

Methods of Analysis

This report is based on data from diverse sources, especially the systematics literature and discussions with taxonomists knowledgeable about PNG invertebrates. Powerful analyses could be undertaken by synthesizing data on butterflies and other insects from museum collections. However, the small amount of time and funding available for this report did not allow the compilation of such data.

As a heuristic approximation, I applied data from selected taxonomic revisions to a simple biogeographic analysis. I used the 38 putative regions used by Allen Allison for reptiles and amphibians, in order to allow comparison of our results (see Figure 16-3, preceding chapter). These regions were based on physiognomic features (e.g., mountain ranges, lowlands), geographic isolation or environmental discontinuities (e.g., Huon Peninsula, islands), and congruence with ranges of well-known reptile or amphibian species. The areas were intentionally large so as to define general patterns of distribution, although areas for which better data were available (e.g., highlands) were split more finely than more poorly known areas (e.g., New Britain).

Data appropriate for the analysis were difficult to find. I searched for taxonomic revisions that included (1) enough species in PNG to be useful; (2) relatively modern species concepts; (3) detailed distribution data, either as locality lists or maps; and (4) organisms that are easily collected and thus the species are generally known from more than one locality. Several otherwise useful revisions (e.g., Sands 1986) had to be rejected because detailed distributions were not provided for common species (e.g., "throughout New Guinea" was not useful). Only full species were used, except in butterflies, where subspecies were included. Species known only from "New Guinea" (e.g., no specific locality) were excluded. The following groups were chosen:

1. Cicadas (Homoptera: Cicadidae): Boer 1989, Duffels 1977, 1983, 1986, Duffels and Boer 1990, 40 species.

2. Ground beetles (Coleoptera: Carabidae: Carabinae, Harpalinae [part]): Darlington 1962 as updated by Darlington 1971 were used. Data from Darlington 1952 were not used because of limited samples (e.g., before BPBM surveys). Data from Darlington 1968 were not used because of time constraints; they would have presumably repeated the patterns of the other carabids. Note that Darlington included only occasional records from the islands of PNG. 134 species.

3. Tiger beetles (Coleoptera: Carabidae: Cicindelinae): Cassola 1987a, 1987b. 69 species.

4. Butterflies (Lepidoptera): Haugum and Low 1978-1985, Parsons 1983 (Papilionidae: *Ornithoptera* spp.), and Ackery 1987 (Nymphalidae: *Tellervo* spp.), 32 terminal taxa (species and subspecies).

Table 17-1 summarizes the distributional analysis. The data are presented for tiger beetles alone and for all four groups pooled. Endemic species includes species found only in PNG, and restricted range species includes species found only in a given region.

Dan Polhemus undertook an analysis of biogeographic regions in the entire New Guinea region based on aquatic insects. He used data from the literature and his current studies on dragonflies and damselflies (Odonata), whirligig beetles (Coleoptera: Gyrinidae), and aquatic bugs (Hemiptera). His approach was the reverse of mine. He plotted distributions of several hundred species and then identified biogeographic regions based on the distribution patterns. The boundaries of his regions for mainland PNG are coincident with those of the 38 predefined regions used in my analysis. However, his regions are larger than mine (e.g., his analysis did not split the north coast mountain ranges or the highlands). He had very little data from the islands of PNG. His analysis and results are detailed in Appendix 17-3. See also Figure 17-1.

DISCUSSION

Unknown Areas

As shown in Table 17-1, the most poorly known regions for all four insect groups on mainland PNG are Bewani Mountains, Adelbert Mountains, Star Mountains, Hunstein Mountains, Schrader Mountains, Central Highlands, Anga Region, and Eastern Owen Stanley Mountains. Although reasonable numbers of species are recorded from the Great Papuan Plateau and the Gulf Lowlands, only a few localities have been relatively well sampled and these regions are in need of further study.

The islands, especially the smaller ones, are generally more poorly sampled than the mainland. However, the data used here may be skewed: Darlington generally ignored the

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islands, so they are underrepresented in ground beetles, but the other groups examined here have been relatively well sampled on the islands.

Several factors complicate the discussion of unknown areas for insects. Generally, insects that are small or require special sampling techniques are more poorly sampled than those that are larger or more obvious to the collector. Likewise, economically important insects (e.g., pests) have been relatively better sampled than those without recognized economic importance. Some groups have been well sampled in few, if any, localities, while others (e.g., butterflies) have been sampled throughout the country. Even where specimens have been collected, many have not yet been recorded in the existing literature. As demonstrated by the carabid beetle distribution example above, a large body of data exists in museum collections that is not readily accessible.

Most of the areas that might be considered reasonably well sampled are around research stations or other centers of entomological activity. This would include the areas around Wau, Bulolo, Port Moresby, Mount Hagen, Keravat, and others.

Species Richness

The term "diversity" means many things, and many measures have been proposed for measurement of diversity (e.g., Cousins 1991, Holloway and Stork 1991, Vane-Wright et al. 1991). At least four major types of diversity measurements can be used: (1) species richness; (2) a combination of species richness and abundance; (3) genetic heterogeneity; and (4) taxonomic distinctness. This report will focus on simple species diversity, as well as areas of endemism. Taxonomic distinctness has many advantages in conservation planning (Vane-Wright et al. 1991), but suitable data were not available for analysis for this report.

Table 17-1 gives numbers of species known from the biogeographic regions. In general, the areas with the highest overall species richness also appear to have the greatest number of endemic species.

The Northern Province Lowlands and Central Province Lowlands are relatively better represented for ground beetles and tiger beetles than would be expected for most insects. This is because of concentrated collecting by Darlington during World War II, especially while he was under medical treatment at Dobodura.

Rare and Endemic Forms

Table 17-1 gives numbers of species known from the biogeographic regions. In general, the areas with the highest overall species richness also had the greatest number of endemic species. However, as expected on the basis of geographic isolation, many of the islands rank highly in numbers of endemic species.

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The far right column of Table 17-1 lists the numbers of taxa known from each region that are known in PNG only from that one region (e.g., they may occur outside PNG also, but are known only from one region within PNG). As noted above, the high values for species restricted to the Northern Province Lowlands are inflated by Darlington's collections. Many or most of these species would be expected to be proven more widespread when adjacent lowland areas are adequately sampled.

The data used for Table 17-1 indicated that 18 taxa were recorded in PNG only from the Northern Province Lowlands. One of these is the birdwing butterfly, *Ornithoptera alexandrae*, which is endemic to the region. Six are carabids that were also known from outside PNG: one from Irian Jaya, one from Asia, one from Australia, and three more widespread. Eleven are carabids that were known only from the Northern Province Lowlands (Darlington 1962, 1971, also Erwin 1975). Of these eleven, four are represented in the Bishop Museum by specimens from outside of the Northern Province Lowlands (*Caelostomus straneoi* Darlington, *Tachyta barda* (Darlington), *Tachys sibling* Darlington, and *Clivina rufula* Darlington; determinations by P.J. Darlington or G.E. Ball). Thus, while the general patterns in Table 17-1 are probably meaningful, previously unpublished data from museum collections will be important to a comprehensive view of insect distribution patterns in PNG.

Ecologically Critical Areas

Little enough is known about the ecology of most PNG insects that this subject is difficult to address. In general, the highest diversity is in primary forest. See the next section for discussion of the impacts of disturbance on forest insects. Little study has been devoted to the ecology of savanna and wetlands insects in PNG -- it is possible that important patterns of diversity are being overlooked (e.g., Pimm and Gittleman 1992).

Because of the need for calcium for shell formation, the highest diversity of land snails is expected in limestone areas with high soil pH (Andrews and Little 1982, Appendix 17-5).

Ecological Fragility

The impact of habitat disturbance on insects depends upon, among other things, the life history strategies of the insect species involved. Although this has received little study in PNG (but see Bowman et al. 1990), most native insects respond poorly to severe habitat degradation. In a comparison of disturbed and undisturbed forest sites at 1800 m elevation in Aseki, PNG, Larry Orsak (unpubl. data) found nearly 50 morphospecies of green geometrine moths at the undisturbed site; at the disturbed site he found only 11 morphospecies.

Loss of diversity from disturbance of forests affects some taxonomic groups more seriously than others (see Miller and Holloway 1992, for an example in Indonesian moths). Insects with narrow dietary requirements or other habitat specialization tend to be most

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readily affected by habitat degradation. However, some insect populations recover relatively well after disturbance. Based on studies in Seram, Holloway has shown that moth diversity in ... ting cultivation areas that were abandoned several decades ago, which are now well forested, is comparable with that of undisturbed forest at similar altitudes (Miller and Holloway 1992). It is, therefore, possible that a sustainable cycle of forest exploitation or farming that permits a full regeneration cycle will only temporarily depress biodiversity, although this may be dependent on the proportion of climax forest present throughout the progression of such cycles. However, conversion of lowland forest to field or cash crop plantations will depress moth diversity to a much lower level, as seen in Sulawesi (Miller and Holloway 1992).

Economically Important Species

The most widely recognized economically important species of insects are pests of agriculture and forestry, and vectors of diseases. Although a great many species have some negative economic importance in PNG, they constitute only a very minor fraction of the total fauna. However, as primary forest resources are depleted in the future, and more plantations (particularly of leguminous trees) are established, these economic activities and developments will be affected by insect attack, particularly from defoliating insects.

In PNG, most of the agricultural pest insects are native, and new "pests" frequently emerge from the indigenous fauna in response to natural or human-induced changes. Szent-Ivany (1961) showed that while 98% of the then insect pests of Hawaii were introduced by man, less than 3% (1 of 34) of the then major agricultural insect pests in New Guinea were introduced. Furthermore, many of the economic crops (e.g., sugar) are native to the region. Thus a high "pest" potential, especially in crop monocultures, exists in this region. The current emphasis in forestry to plant *Acacia mangium*, *Paraserianthes falcata* (Leguminosae), and *Eucalyptus deglupta* (Myrtaceae) in monoculture extensively in the lowlands, from Malaysia to the Solomons once natural forest is cleared, will almost inevitably lead to major pest problems as these crops are in the preferred host families for many moths. Thus, for natural resource management, it will be important to have basic data on the insect fauna of PNG. It will be important to build the tools in PNG for understanding the insect fauna (e.g., Hardy 1983, Holloway and Barlow 1983): reliably identified reference collections of insects, diagnostic reference works, and training in the use and maintenance of these resources.

Large scale conversion of primary forest to other uses can result in outbreaks of a variety of pests, especially disease vectors. This should be factored into cost/benefit analyses of programs. As noted by Jenkins (1992), Ross River alphavirus and Murray River encephalitis present likely prospects for intensified disease prevalence wherever lowland forests are disturbed and people aggregated. Clearing of native forest barriers has allowed pest locusts to move into new areas in Africa and could happen in PNG (R. Kumar, pers. comm.).

The recent establishment of the apple snail in the Lae area (Laup 1991) also underscores the importance of pest exclusion and detection programs: inspections and

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quarantines of incoming commodities, regular surveys for target pests, and local diagnostic services (e.g., DAL) supported by international laboratories (e.g., CABI).

Many of the large, colorful insects of PNG, especially butterflies, have a commercial market value. The Insect Farming and Trading Agency (IFTA) was initiated by the PNG government in 1978 to capitalize on the insect trade. The most notable example of the insect trade are the birdwing butterflies, most of which are protected by PNG law.

The butterfly farming activities of the Insect Farming and Trading Agency are generally considered successful (Clark and Landford 1991, Collins and Morris 1985: 29, Parsons 1992). Nevertheless, a detailed analysis of the economic and conservation impact of butterfly farming would be useful in planning future expansion of the program (e.g., Goldstein 1991). It is clear that outterfly farming has raised the awareness of PNG nationals to conservation issues and to the potential value of their native fauna. Butterfly farming could clearly benefit from more research on effective methods of rearing rare species in captivity.

Known Threats

The most important threat to most insects is habitat disturbance. In most cases, this means destruction of the integrity of primary forests and other natural habitats. Some species might be threatened by introduced species (e.g., by predation, parasitism, or competition). Introduced species are probably a minor threat to native insects in most of PNG, but might be significant on some of the smaller islands (e.g., Howarth and Ramsay 1991). Biological control introductions should be carefully screened to prevent excessive impact on nontarget organisms (Howarth 1991).

Overcollecting is a threat only to large species with very restricted populations, such as birdwing butterflies. Most of the birdwings are already protected by PNG law, although it is not clear how effective this protection has been. Parsons (1983, especially his table IX) suggested that the appropriate protected status of several birdwing butterflies be reviewed in light of current knowledge.

The effects of pollution on invertebrates in PNG have received almost no study, but may prove to be important. Chemical pollutants from mining and increased sedimentation from deforestation are likely to heavily impact aquatic insects, crustacea, and mollusks. Chemical pesticides used for agriculture, forestry, and vector control can impact both terrestrial and aquatic invertebrates.

A recent IUCN review of the status of swallowtail butterfly conservation around the world included the following nine PNG taxa (New and Collins 1991): "endangered": *Ornithoptera alexandrae*; "vulnerable": *O. meridionalis*, *Papilio moerneri*; "rare": *Graphium meeki*, *G. mendana*, *P. toboroi*, *P. weymeri*; "indeterminate": *O. chimaera*, *O. paradisea*. The Queen Alexandra Birdwing, which occurs only in the Popondetta region, is one of the most endangered butterflies in the world. Various efforts have been undertaken to protect it, but more efforts are needed (Parsons 1983, 1991).

Major Wilderness Areas

With present knowledge, wilderness areas are more easily defined based on information from flowering plants, vertebrates, and land use patterns than insects. See Figure 16-4 in the preceding chapter.

REPRESENTATIVE AREAS OF MAJOR BIOLOGICAL IMPORTANCE

The factors discussed above limit the resolution possible with insect data. We have reviewed general biogeographic regions based on terrestrial and freshwater insects. These compare favorably with those for reptiles and amphibians, although the insect patterns are more generalized (i.e., broader). Examination of available data for crustacea and mollusks has been less conclusive, but does not contradict the insect analyses.

The same considerations apply to insects as to reptiles and amphibians, although perhaps more extreme. Species richness, when adequately sampled, appears fairly even throughout mainland PNG. In most cases, areas of apparent low diversity have not been adequately sampled. Geographically isolated areas (e.g., islands) with low species richness have a high percentage of endemic species. Many species have restricted ranges, although few taxa have been well enough sampled to draw broad conclusions.

The one species that stands out for special consideration is the Queen Alexandra Birdwing in the Popondetta region. Given the complexity of land use issues in the area, I do not presume to suggest a specific site, but point this out as an issue for further evaluation (see Parsons 1991). The situation for the tree snail *Papustyla pulcherrima* of Manus Island may be similar, but field surveys are needed to assess current status (Luxmoore et al. 1988, Appendix 17-5).

Parsons (1983) suggested a series of reserves to protect birdwing butterflies. These included sites at Telefomin, Bundi, Naniwe Mission, Tapini-Woitape, and Central Huon for *Ornithoptera chimaera* (IUCN status: indeterminate); South Vanimo, Maprik, Frieda River, Lake Kutubu and East Erave for *O. paradisea* (IUCN status: indeterminate); and Frieda River, Lake Kutubu, Cape Rodney, Mamai Plantation, and Brown and Vanapa Rivers for *O. meridionalis* (IUCN status: vulnerable). It appears that the regions selected below include the same habitats as most of Parsons' sites. The primary exceptions are in Central Province (e.g., Brown and Vanapa Rivers, Cape Rodney), which might be added to the sites selected below. Since the CNA analysis is aimed at identification of high diversity sites, not the preservation of individual species, these sites were not given further consideration.

Assuming that the strategy for selecting conservation areas should be to maximize species richness, with highest priority given to endemics, and that the areas best suited for conservation protection are those that have primary vegetation (e.g., wilderness areas) and include a diverse array of vegetation types within a contiguous area, the following areas were selected. Selections were made using topographic maps after reviewing biogeographic analyses contained in this report and appendices. In some cases areas were chosen to represent regions for which insect data were not available, but for which data on vegetation, reptiles and amphibians (cf. Allen Allison's report), or other organisms, suggested could harbor unique insect faunas. The numbers are keyed to Figure 17-2.

(Mainland Papua New Guinea)

1. Bewani Mountains (Mt. Menawa) [West Sepik Province]
2. Star Mountains [West Sepik and Western Provinces]
3. Blucher Range/Muller Range [Western and Southern Highlands Provinces]
4. Hunstein Mountains/Central Ranges [East Sepik and Enga Provinces]
5. Lake Kutubu [Southern Highlands Province]
   [Note: From available maps, it was not clear where the boundaries should be drawn. It would be good to include the slopes of Doma Peaks or Mount Bosavi in this area.]
6. Trans-Fly region [Western Province]
7. Adelbert Mountains [Madang Province]
8. Mount Wilhelm [Madang, Western Highlands, and Chimbu Provinces]
9. Crater Mountain [Eastern Highlands/Gulf Provinces]
10. Sarawaket [Morobe Province]
11. Bowutu Mountains [Morobe Province]
12. Mount Albert Edward [Central and Northern Provinces]
13. Mount Lamington/Popondetta [Northern Province]
14. Mount Dayman [Milne Bay Province]

(Islands of Papua New Guinea)

15. Goodenough Island [Milne Bay Province, D'Entrecasteaux Archipelago]
16. Fergusson Island [Milne Bay Province, D'Entrecasteaux Archipelago]
17. Woodlark Island [Milne Bay Province]
18. Tagula Island [Milne Bay Province, Louisiade Archipelago]
19. Manus Island [Manus Province]
20. Umboi Island [West New Britain Province]
21. Whiteman Mountains [West New Britain Province]
22. Nakanai Mountains [West New Britain Province]
23. Baining Mountains [East New Britain Province, Gazelle Peninsula]
24. Hans Meyer Range [New Ireland Province]
25. Mount Balbi [North Solomons Province, Bougainville Island,Emperor Range].
    [Note: Bougainville is biogeographically part of the Solomon Islands and has Solomons species not found elsewhere in PNG.]

36. Mount Takuan [North Solomons Province, Bougainville Island]

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CONSERVATION RECOMMENDATIONS

Research Priorities

1. Detailed databases should be constructed, based on literature and museum specimen records, for the distribution of selected taxa. Groups with good potential for use in mapping diversity patterns include butterflies (Appendix 17-1), some aquatic insects (Appendix 17-2), land snails (Appendix 17-4), crustacea (Appendix 17-3), cicadas, carabid beetles, chrysomelid beetles, and moths.

2. Use information from item 1 to develop a specific survey plan for unknown regions.

3. Use information from items 1 and 2 to develop applications of invertebrates to environmental monitoring. Aquatic insects (Appendix 17-2) and moths (Miller and Holloway 1992) show excellent potential for such use. Such a research program for moths might be to examine both taxonomic and aspect diversity along transect samples and to evaluate species associations in comparison to vegetation. The comparison should include (1) quality of information content; (2) cost effectiveness; and (3) effects of mimicry.

4. Develop a more general database on invertebrates as part of an overall database of PNG biodiversity. Biological surveys underway in Australia and Costa Rica provide excellent models (Raven 1992, Richardson 1992). The database should include data from Irian Jaya when appropriate to understanding species in PNG.

5. Based on items 1-4, develop and distribute synthetic overviews and identification guides for priority taxa.

6. Butterfly farming and ranching needs critical economic evaluation leading to a development plan. Research in the distribution, biology, and ecology of target butterflies and other insects is necessary.

7. Develop a better system for regulating research and issuing research visas to outside researchers. Such a system might include features to encourage researchers to come participate in research that is useful to PNG. The Costa Rican INBio may provide a model here also.

8. Develop existing insect collections (especially DAL) into a central identification service and reference collection. CAB International can be contracted to assist in collection development and training.

9. Improve communication between research activities and local people. Specifically, improve integration of local knowledge into research databases and dissemination of research products to the local level. Both government agencies and nongovernment agencies (e.g., Wau Ecology Institute) provide channels for this communication.

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10. There is an overall need for local training and infrastructure development, which should be included in all of the activities discussed above (Hardy 1983, Holloway and Barlow 1983).

Implementation Priorities

1. Department of Agriculture and Livestock: Strengthen existing exclusion and detection programs for invertebrate pests. Screen any biological control introductions with great care.

2. Department of Environment and Conservation: Strengthen staff and expertise to effectively enforce environmental laws.

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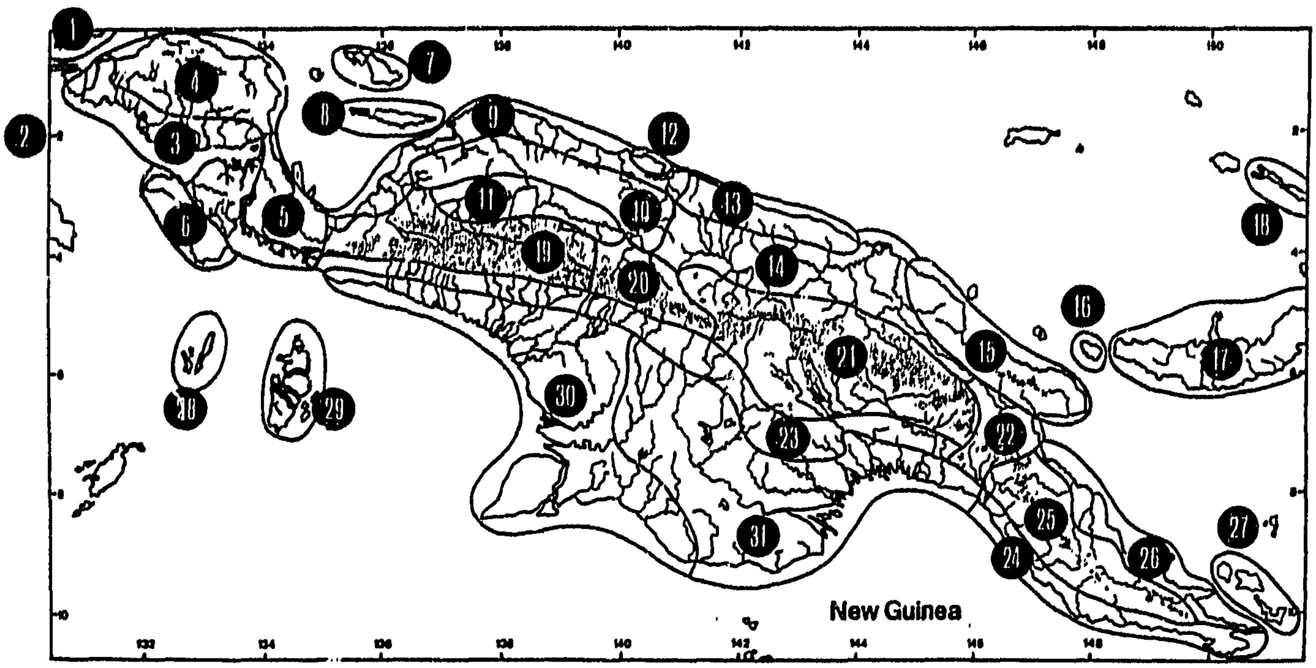
Figure 17-1. Areas of freshwater endemism on the island of New Guinea as identified by analysis of aquatic insect distributions.



Areas of freshwater endemism in the island of New Guinea as identified by the analysis of aquatic insect distributions.

Unit numbers correspond to those in the text. For discussions of individual map units see discussion in text. Map unit 1, the island of Waigeo, continues off the map to the northwest. Map unit 2, the island of Misool, lies off the map to the west. Map units 17 and 18, the islands of New Britain and New Ireland respectively, continue off the map to the east. Unit boundaries are in many cases approximate due to inadequate biological or topographic survey data.

Several portions of New Guinea and nearby islands have not been assigned to map units due to insufficient data. These include Batanta, northern Salawati, the Wandammen Peninsula, Numfoor, Manus, New Hanover, Mussau, Karkar and Long Island.

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Figure 17-2. Biologically important areas for conservation of terrestrial invertebrates in Papua New Guinea.

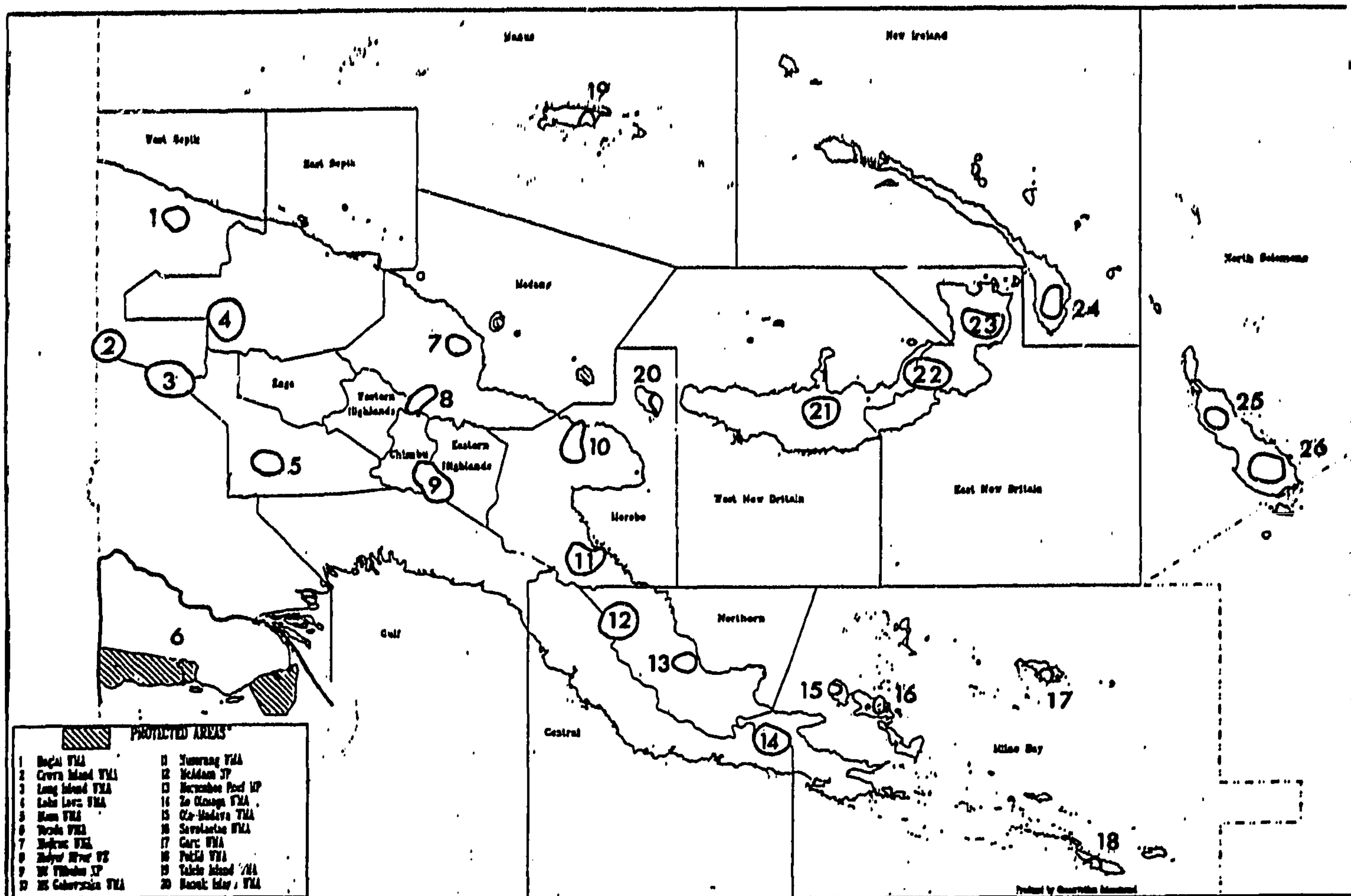

Table 17-1
Species-counts of Selected Invertebrates by Biogeographic District

Numbers of selected Papua New Guinea insect species by biogeographic region. "4 groups" includes cicadas, tiger beetles, ground beetles and butterflies (see text for explanation). Total species includes all species recorded for Papua New Guinea for which locality information is available. Endemic species includes species found only on Papua New Guinea, and restricted range species found only in a given biogeographic region.

LOCALITY	TOTAL SPECIES		TOTAL ENDEMIC SPECIES		RESTRICTED ENDEMIC SPECIES	
	tiger beetles	4 groups	tiger beetles	4 groups	tiger beetles	4 groups
Bewani Mts.	4	6	0	0	0	0
Torricelli Mts.	15	57	3	7	3	9
Prince Alexander Mts.	11	17	0	1	0	0
Sepik-Ramu Basin	15	65	1	12	0	4
Adelbert Mts.	1	5	0	0	0	0
Huon Peninsula	12	54	5	19	2	5
S. Morobe Coast	20	69	6	27	0	2
N. Province Lowlands	15	94	5	37	0	18
Milne Bay Lowlands	11	39	4	17	1	3
Central Province Lowlands	18	55	8	22	1	4
Gulf Lowlands	9	14	4	6	0	1
Trans Fly Region	14	29	3	4	4	8
Great Papuan Plateau	16	37	8	12	6	10
Star Mountains	1	10	0	4	1	1
Hunstein Mountains	0	0	0	0	0	0
Western Highlands	4	15	1	4	0	1
Schrader Mountains	1	9	0	1	0	0
Central Mountains (Chimbu)	1	8	1	5	0	2
Southern Highlands	5	14	1	4	0	1
Eastern Highlands	14	45	5	17	2	9
Anga Region	0	4	0	2	0	0
Bowutu Mts.	12	56	5	18	1	4
Wharton Range	5	23	4	14	2	4
Western Owen Stanley Mts.	11	38	6	17	1	1
Eastern Owen Stanley Mts.	1	4	1	3	0	0
St. Matthias Islands	0	1	0	1	0	1
Admiralty Islands	6	11	1	4	0	3
New Hanover Islands	2	6	0	3	0	1

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Table 17-1 (cont.)

LOCALITY	TOTAL SPECIES		TOTAL ENDEMIC SPECIES		RESTRICTED ENDEMIC SPECIES	
	tiger beetles	4 groups	tiger beetles	4 groups	tiger beetles	4 groups
New Ireland	8	17	2	7	1	3
New Britain	9	36	2	14	2	6
Karkar Island	0	2	0	0	0	0
Long Island	0	1	0	0	0	0
Umboi Island	0	4	0	3	0	0
Trobriand Islands	4	6	0	1	0	1
Woodlark Islands	4	7	0	3	0	3
D'Entrecasteaux Archipelago	7	17	3	8	2	3
Louisiade Archipelago	5	10	0	5	0	5
Bougainville (Incl. Buka)	9	19	2	4	2	8

APPENDIX 17-1. BUTTERFLY DATABASE BACKGROUND

The combination of good taxonomic knowledge, good existing collection resources, reasonable species diversity (some 700 species in New Guinea), modern database technology, and a new analytic methods means that butterflies provide an excellent opportunity for mapping diversity patterns in New Guinea. An obvious part of such a project is the comparison of information content and cost effectiveness of the different diversity measures: species richness, areas of endemism, and taxic diversity.

The plant-feeding immatures of butterflies often show specificity to a limited range of plant taxa (Ackery 1988). Hence, perhaps much more than in the most comparable group, the birds, butterfly diversity patterns are expected to show some correlation with patterns of floristic diversity. This logic applies to all plant feeding insect groups that exhibit significant dietary specialization.

Probably more is known about the classification and distribution of butterflies than any comparable group of invertebrates. In New Guinea it is likely that more information has been recorded for butterflies than for some vertebrate and plant groups. A major overview of PNG butterflies is close to completion, and an abbreviated version, covering the Wau-Bulolo Valley, has been published (Parsons 1992). A large amount of information already exists in scattered technical literature (e.g., Gressitt and Szent-Ivany 1968), although it has never been synthesized into a comprehensive database. A more important and almost untapped resource exists in museum collections.

Allison (1992) discussed the benefits to be derived from taking advantage of data already accumulated in museum collections and literature. The butterflies offer an excellent opportunity to test the cost effectiveness of this approach. Such a project should include gathering distribution data on the butterflies of New Guinea from existing collections, the literature, and unpublished sources (such as the data cards from an earlier mapping attempt by the Insect Farming and Trading Agency -- Parsons 1981). The accumulated database could then be analyzed with different protocols to compare patterns of species richness, areas of endemism, and taxic weighting. Gap analysis could also be applied (Scott et al. 1987), and comparisons could readily be made to patterns from plants and vertebrates.

The importance of considering phylogenetic diversity, rather than just species richness has been discussed for many years, but only recently have practical algorithms by which to measure it been proposed (Vane-Wright et al. 1991, Nixon and Wheeler 1992). Phylogenetic diversity is based on the information content of cladistic classifications and provides a measure of taxonomic distinctness. This provides a means to balance preservation strategies between diverse (i.e., speciose) groups and unique groups. Again, Papua New Guinea's butterflies could provide a practical test of these approaches.

The butterfly database, including the food plant and life history information contained in it, will also be useful to butterfly farming. Extension workers could know before they enter an area what the potential butterfly farming candidates are in the area. This would also focus research in support of butterfly farming (e.g., life history studies).

Aquatic Insects Overview

While vascular plants are the most common tools for mapping general terrestrial ecosystem classification for conservation purposes, vascular plants are poorly represented in inland waters. Insects provide a very useful tool for ecosystem classification in inland waters (Polhemus et al. 1992). Most groups of freshwater insects can be sampled quickly and simply. With appropriate reference materials, sorting and handling can also be simple. Freshwater fish can also be useful, but they are more difficult to sample than most aquatic insects.

Aquatic insects in general have been poorly studied in New Guinea, although taxonomic knowledge is good for some taxa. Table 2 summarizes the current knowledge. Except for Odonata and Hemiptera, which are relatively well known, the numbers of species given are rough estimates of numbers of known species, subject to substantial increase with future research. The Coleoptera and Diptera include many families with aquatic representatives, and the status of knowledge varies greatly from family to family. For example, the Gyrinidae (whirligig beetles) and Culicidae (mosquitoes) are relatively well known, while Dytiscidae (carnivorous water beetles) and Chironomidae (midges) are only poorly understood. Trichoptera and aquatic Lepidoptera show good potential as indicators, and have 100-200 species described, but need more basic taxonomic work. Ephemeroptera need major revisionary work, with many genera and species undescribed.

In mapping patterns of diversity, it is important to keep in mind that patterns often differ between terrestrial and aquatic habitats, because of differential effects of historical biogeography (Darlington 1957). Given the importance of including aquatic organisms in considering diversity patterns in PNG, aquatic insects provide an excellent opportunity, especially the Odonata and Hemiptera.

Aquatic Insects of New Guinea

Order and Common name(s)	Estimated No. of Species	Primary References
Ephemeroptera Mayflies	"many undescribed"	Edmunds & Polhemus, 1990
Odonata Dragonflies and Damselflies	400	Lieftinck 1949 etc.
Plecoptera Stoneflies	>1	D. Polhemus, unpub.
*Hemiptera True bugs	300	J. & D. Polhemus, manuscript
*Neuroptera: Sisyridae Spongillaflies	>1	Unpublished
Trichoptera Caddisflies	>150	Neboiss 1986
*Lepidoptera: Crambidae: Nymphulinae Moths	>150	Klima 1937
*Coleoptera Beetles	>200	Gressitt & Hornabrook 1977
*Diptera Flies	>1100	Thompson unpubl. based on Evenhuis 1989

*Only part of order is aquatic, so species numbers can be hard to obtain.
The aquatic order Megaloptera has not yet been recorded from New Guinea.

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APPENDIX 17-2. AREAS OF BIOTIC ENDEMISM IN NEW GUINEA, AS INDICATED BY THE DISTRIBUTIONS OF AQUATIC INSECTS

- Dan Polhemus

INTRODUCTION

The present report contains the preliminary results of an analysis in which the distributions of aquatic insects were used to define areas of freshwater endemism within the island of New Guinea. Although the Papua New Guinea Conservation Assessment for which this study was undertaken was concerned only with the eastern half of the island, I have included the entire island of New Guinea in the analysis, since many of the larger scale endemic areas transgress international boundaries. Such an approach also allows a cohesive overview of regional geology and its relation to speciation patterns, and provides a more comprehensive picture of faunal evolution within the island as a whole.

Areas of endemism, as treated below, refer to regions within New Guinea containing assemblages of endemic species that appear to display similarly circumscribed distributions. These areas of endemism are considered to be equivalent to nested sets, with larger areas containing smaller distinctive subdivisions. These areas of endemism are outlined below and illustrated in Figure 17-1 (see main Miller text). It must be stressed that the areas of endemism defined herein apply to aquatic insects only, and may not be congruent with those exhibited by other groups of plants and animals.

Defining areas of endemism on the basis of congruent species distributions was used in a previous report dealing with Celebes (Polhemus and Polhemus 1990). In that study it was found that the single island of Celebes could be viewed as at least five separate islands in terms of the distribution of its freshwater biota. The situation in New Guinea is similar, but even more complex, and complicated to a degree by the island's large size and the absence of faunal survey data in many areas. As a result, it has been difficult to ascertain the contact zones between many of the areas of endemism defined herein, and the boundaries depicted on Figure 17-1 should be viewed as speculative in many cases, and open to further refinement as more detailed distributional data become available.

METHODS

Groups Used to Define Areas of Freshwater Biotic Endemism in New Guinea

Although much additional work remains to be done, reliable distributional data is available for certain groups of aquatic insects in New Guinea, including dragonflies and damselflies (order Odonata, suborders Anisoptera and Zygoptera respectively), whirligig beetles (order Coleoptera, family Gyrinidae) and water bugs (order Hemiptera). Based on the primary taxonomic literature and unpublished field data, I have plotted species ranges for taxa in many genera within the above groups, searching for patterns of congruent circumscribed distribution. An attempt was made to include genera from as many different families as possible, so as to compare patterns among many lineages with separate evolutionary histories. On the basis of these range plots, I have then defined areas of endemism that appear to be supported by species in several genera. The species within each genus analyzed and the areas of endemism they occupy are listed in Part 2; the extent of geographical coverage for one of the better known groups (Hemiptera) may be assessed from Figure 17-4.

Since each of the genera under study has had an individual history in the Papuan region, and has received a differing degree of attention by collectors, the distributions of their constituent species and the areas of endemism they occupy are not strictly congruent. None of the genera utilized in this analysis contain species representatives in all of the areas of endemism defined, while in other cases a single widespread species may occur across several areas of endemism. Even so, the observed patterns of distribution are remarkably similar throughout the various groups studied, and indicate that the endemic areas they define are likely to pertain for other elements of the island's aquatic biota.

RESULTS

Areas of Freshwater Endemism in the New Guinea Region

Previous workers who have discussed the biogeography of aquatic organisms within New Guinea have identified four large endemic regions: Vogelkop, the North Coast Ranges, the Central Highlands, and the Southern Lowlands (Lieftinck 1938, 1949, Allen 1991). These areas generally correspond to the broad scale physiographic divisions within New Guinea as a whole, and are relatively self-evident. The present study indicates that these four divisions are indeed valid, but further contain many smaller areas of endemism within them. These smaller areas are depicted in Figure 17-1 and are discussed in further detail (and outlined) below. The numbers in the following discussion match those assigned to units on Figure 17-1; the unit names reflect characteristic geographical or geomorphological features found within them.

1. Waigeo - The large island of Waigeo, lying on the Papuan shallow water platform northwest of the Vogelkop, represents an ophiolite exposure and supports endemic taxa in nearly all groups examined.

2. Misool - The island of Misool lies on the Papuan continental shelf, and is primarily composed of upwardly deformed continental shelf limestones correlative to those of the Fakfak and Kumawa mountains on mainland New Guinea. Endemic taxa occur here in certain groups, while in other cases species are shared with the Vogelkop Lowlands or with the central Moluccas (Ambon, Ceram, Buru) to the west.

3. Vogelkop Lowlands - The southern coastal lowlands of the Vogelkop Peninsula, from Salawati Island southeastward to Etna Bay, including the low central portion of the Bomberai

Peninsula. This is an area of endemism for Zygoptera and certain aquatic Hemiptera (Hydrometridae, Veliidae).

4. Vogelkop Highlands - This area is defined as including both the Arfak and Tamrau Mountains in the northern half of the Vogelkop Peninsula. The Tamrau Mountains contain a core of Paleozoic basement and represent a detached fragment of the Australian craton. Endemic taxa occur in many groups in this highland area.

5. Vogelkop Anticlines - The limestone anticlines of the "Birds Neck," from the Jakati River southeastward to Etna Bay. These anticlines are steeply folded, forming sharp ridges with much karst terrain and poor integration of drainage. Several seasonal lakes occur in the area behind Kaimana. These uplands form a transitional corridor between the Vogelkop Highlands and the mountains in the main body of New Guinea, and, though poorly surveyed, appear to support endemic species.

6. Fakfak and Kumawa Mountains - These ranges are large limestone anticlines of upwardly deformed continental shelf limestone along the western margin of the Bomberai Peninsula. Both ranges are no older than Pliocene, and represent recently uplifted montane islands which have developed a limited endemic biota.

7. Biak-Supiori - This nearly connected island pair lies off the Papuan continental platform, and was not connected to the main body of the island during the Pleistocene. Biak is covered by Quaternary reef limestones, but Supiori, with greater elevation, contains exposures of andesitic island arc volcanics. Sampling for aquatic insects here has been relatively poor, but the presence of endemic species is known among the aquatic Heteroptera in the Gerridae and Notonectidae.

8. Yapen - This island is a fault sliver rifted from the Van Rees Mountains on the main body of New Guinea. Its fauna is allied to the northern coastal ranges of Irian Jaya, but supports endemic species of Zygoptera.

9. North Irian Lowlands - The Korime and Tami River basins at elevations below 400 m appear on the basis of present sampling to be an area of faunal endemism. Future surveys are likely to reveal that this is an artificial picture created by a preponderance of sampling in the Jayapura area, and that the fauna characteristic of this area is, in fact, more widespread throughout the northern coastal lowlands of Irian Jaya.

10. Van Rees and Foja Mountains - The northern coastal ranges of Irian Jaya, north of the Mamberamo Basin. They are quite poorly explored and very little collecting of their aquatic insects has been accomplished, but the few samples at hand indicate that the area supports endemic species in some groups, and is allied to the Bewani, Torricelli, and Prince Alexander Mountains further to the east.

11. Mamberamo Basin - The large structural basin drained by the Rouffer and Idenberg Rivers, which are the upper branches of the Mamberamo. This area is very poorly collected for aquatic insects, but seems to support a distinctive lowland fauna in Zygoptera.

12. Cyclops Mountains - An extremely vertical mountain range immediately west of Jayapura, representing an accreted ophiolite terrane. Endemic species are known in many groups, including Hemiptera (Gerridae, Naucoridae) and Zygoptera.

13. Torricelli and Prince Alexander Mountains - The northern coastal mountain block lying between the Papua New Guinea border and the mouth of the Sepik River. This is a portion of an accreted island arc, and contains endemic species of Hemiptera in the families Naucoridae and Gerridae.

14. Sepik-Ramu Basin - The large structural basin drained by the Sepik and Ramu Rivers. The lowland fauna of this region includes endemic trepobatine Gerridae.

15. Adelbert, Finisterre and Saruwaged Mountains (Huon Peninsula) - The northern coastal mountain block running from east of the Sepik River delta to the tip of the Huon Peninsula. These ranges are also portions of accreted island arcs, and contain many endemic species of Odonata and Heteroptera.

16. Umboi Island - A small volcanic island lying between the tip of the Huon Peninsula and New Britain, and forming part of the Bismarck Arc. Aquatic insect collections from Umboi are limited, but distributions of Gerridae indicate a partially endemic biota with ties to that of New Britain.

17. New Britain - The largest island in the Bismarck Arc. New Britain is of composite geological origin, and has had only limited survey work, mostly in the vicinity of the Gazelle Peninsula and Rabaul. There appears to be species level endemism among Gerridae and Veliidae in the Heteroptera.

18. New Ireland - Another complex island, grouped geographically as a member of the Bismarck Archipelago, but in fact of separate geological origin and related to one of the several arc systems forming the Solomons. Meager data from here indicate the presence of endemic Gerridae.

19. Sudirman Range - The Central Dividing Range, from the Weyland Mountains in the west to the Baliem River in the east. The boundary between this unit and the Vogelkop Anticlines has been plotted southward along the Wamma River and then across to Etna Bay. In the northwest the boundary between this unit and the Foja and Van Rees Mountains has been plotted along the upper course of the Owa River, but should be considered extremely uncertain, as this is basically unexplored terrain. The Sudirman Range contains the highest mountains in New Guinea, and has extensive exposures of karst terrain. The continuous area of extremely high elevation running east to west down the center of the range may represent still another area of freshwater endemism, but present surveys are inadequate to establish this. Endemic species are present in Zygoptera and Heteroptera (Naucoridae, Corixidae, Veliidae).

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20. Star Mountains - The Central Dividing Range between the Baliem River and the upper Sepik River. This is a high mountain block with notable endemism in Zygoptera, and has been sampled by several Dutch and American expeditions.

21. Papuan Central Highlands - The Central Dividing Range between the upper Sepik River and the Bulolo River. This is a complex uplift, with several well separated areas of extremely high terrain centered around peaks such as Mt. Wilhelm and Mt. Giluwe, and contains an extensive exposure of uplifted Paleozoic basement in the Kubor Anticline. Despite its topographic and geological diversity, the present surveys of aquatic insects indicate that it forms a single area of faunal endemism; thus it is treated as an undivided unit in the current report. Survey work has been extensive in this region, perhaps accounting for the apparently widespread distribution of its fauna, which includes endemic Naucoridae and Veliidae.

22. Morobe Highlands - The Central Dividing Range east of the Bulolo River, including the headwaters of the Wampit and Watut Rivers. This unit has also had extensive survey work due to the presence of the Wau Ecology Institute. Its aquatic insect fauna shows notable differences from that of the Papuan Central Highlands, with endemic Gerridae and Naucoridae.

23. Southern Foothills - The south face of the Central Dividing Range between 100 m and 500 m elevation. This unit includes portions of the Papuan Plateau area to the northwest of Mt. Bosavi. Sampling in this remote area has been limited, but it appears to support a rich fauna with many endemic Hemiptera in the families Naucoridae, Gerridae, and Veliidae.

24. Papuan Peninsula Lowlands - The coastal lowlands from Karima to Milne Bay. This area supports endemic Zygoptera and Naucoridae.

25. Owen Stanley Range - The central mountain chain of the Papuan Peninsula, comprised of uplifted ophiolites and subduction melange. An area of rich endemism for aquatic insects, with many endemic species in all groups.

26. Popondetta Lowlands - The large area of coastal lowlands north of the Owen Stanley Range, from Cape Vogel to Manau. Limited collections indicate endemic Zygoptera and Naucoridae.

27. D'Entrecasteaux Islands - A chain of high islands with predominantly metamorphic geology, lying immediately north of the eastern Papuan Peninsula. Collecting here has been centered on Goodenough Island, which shows distinctive endemism in Zygoptera.

28. Kei - A set of low islands, lying off the Papuan continental platform west of Aru.

29. Aru - A set of low limestone islands lying on the Papuan continental platform. The fauna supports endemic species, but also shows alliances to the Asmat Lowlands and Vogelkop Lowlands.

30. Asmat Lowlands - The southern coastal lowlands between Uta and Merauke at elevations below 100 m. This area contains more areas of swamp than the slightly elevated Trans-Fly area to the east, and on the basis of limited aquatic insect surveys appears to support a slightly different fauna. The eastern boundary of this unit has been set west of the upper Digul River, but this is a hypothetical alignment based on the mapped extent of palustrine habitats in the region.

31. Trans-Fly and Papuan Gulf Lowlands - The southern coastal lowlands from Merauke eastward to the mouth of the Purari. Theboundaries of this unit are basically defined along the 100 m countour in the lower Fly, Kikori, and Purari river basins. The area supports endemic species of Veliidae and Hydrometridae.

Summary Outline of Areas of Endemism within New Guinea

1. Vogelkop
    - A. Waigeo
    - B. Vogelkop and Bomberai Peninsulas and associated offshore islands
        1. Misool
        2. Vogelkop Lowlands
        3. Vogelkop Anticlines
        4. Vogelkop Highlands
        5. Fakfak and Kumawa Mountains
2. North Coast Ranges and Valleys, and associated islands
    - A. Northern New Guinea
        1. Biak-Supiori
        2. Yapen
        3. Van Rees and Foja Mountains
        4. Mamberamo Basin
        5. Cyclops Mountains
        6. North Irian Lowlands
        7. Torricelli and Prince Alexander Mountains
        8. Adelbert, Finisterre and Saruwaged Mountains (Huon Peninsula)
        9. Sepik-Ramu Basin
    - B. Bismarck Archipelago
        1. Umboi
        2. New Britain
        3. New Ireland
3. Central Mountain Ranges
    - A. Central Dividing Range
        1. Sudirman Range
        2. Star Mountains
        3. Papuan Central Highlands
        4. Morobe Highlands
        5. Southern Foothills

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B. Papuan Peninsula and associated islands
1. Popondetta Lowlands
2. Owen Stanley Mountains
3. Papuan Peninsula Lowlands
4. D'Entrecasteaux Islands
4. Southern Lowlands
A. Continental Shelf Islands
1. Kei
2. Aru
B. Southern New Guinea
1. Asmat Lowlands
2. Trans-Fly Lowlands
3. Papuan Gulf Lowlands

Areas within the country of Papua New Guinea not treated due to lack of information: Long Island, Karkar Island, Trobriand Islands, Admiralty Islands, St. Matthias Islands, New Hanover, Woodlark Islands, Louisiade Archipelago, Bougainville.

DISCUSSION

Geological factors influencing areas of biotic endemism in New Guinea

Areas of biotic endemism in New Guinea are, in many cases, centered around Tertiary island arc fragments that have been incorporated into the northern portion of the island. These arc fragments are represented by present day exposures of Paleogene volcanics, and Mesozoic to Paleogene ophiolites, which are the respective remnants of the former arc islands themselves, plus the oceanic crust and mantle that underlie them. Such exposures are depicted on Figure 17-3. This mapping is based on information derived from 1:1,000,000 scale geological maps of Irian Jaya (Dow et al. 1986) and Papua New Guinea (Bain et al. 1972), and the 1:5,000,000 scale tectonic map of Hamilton (1979). Units interpreted as ophiolite include Mesozoic basic and ultrabasic rocks (serpentinite, peridotite, pyroxenite, and gabbro), Jurassic metamorphics (amphibolite, schist, and gneiss), and Paleogene to Miocene gabbro, diorite, and granodiorite; these ophiolite complexes are identified as such on the maps of Hamilton (1978) and Dow et al. (1986), but not on the Papua New Guinea sheets (although see discussion in Dow 1977). Units interpreted as island arc volcanics include Paleogene basaltic to andesitic lavas and more recent sedimentary formations derived from them. Also included in this assemblage are Paleogene volcanics capped by Quaternary reef limestones (such as those in the Manokwari area, Biak, and the northern Huon Peninsula). Congruence between rock units defined on the Irian Jaya and Papua New Guinea geologic maps has been implied, even though the authors in many cases used different symbols and somewhat different definitions for what appear to be similar stratigraphic units.

The ages of the island arc fragments become progressively younger from west to east, being uniformly Paleogene in Irian Jaya but becoming as young as middle Miocene in the northern Papuan Peninsula. This is consistent with Hamilton's (1979) interpretation that the collision front between the Australian continental margin (now buried beneath the Central Dividing Ranges) and the Tertiary volcanic arc was oblique, beginning first in the west and then proceeding sequentially toward the east.

More than one arc may have been involved in such a collision. A broad band of ophiolite, relatively cohesive in Irian Jaya but much splintered by faulting in Papua New Guinea, borders the northern margin of the Central Dividing Ranges south of the Mamberamo, Sepik, and Ramu river valleys. This band appears to be correlative with the large ophiolite sheet that forms much of the Papuan Peninsula. Other ophiolite exposures that do not appear to be linked to this central belt occur along the northern coast, particularly in the Cyclops Mountains, and may have been formed by a separate episode of island collsion and onramping.

Another episode of island arc collision appears to have occurred with the Adelbert Range, which possesses a similar Middle Tertiary geology to the islands of the Bismarck Archipelago. This range most likely represents a former component of the Bismarck Arc that is now accreted onto the northern margin of New Guinea; the exact paleoposition of this fragment is uncertain, since tectonic motions in this region are exceptionally complex, with the crust fractured into numerous microplates (see discussion in Hamilton 1979). The remaining islands of the Bismarck Arc are slowly being pushed onto the northern margin of New Guinea: the collision between the Bismarck Archipelago and the Papuan Peninsula continues, with the floor of the Solomon Sea simultanously subducted beneath the Papuan Peninsula on the south and the Bismarck Archipelago on the north. As a result, this system provides a perfect case study of the faunal interactions which occur during arc collision and accretion.

Another final geologic feature that has direct bearing on how New Guinea acquired elements of its biota with Gondwana origins is the basement high of Paleozoic granites that trends northward, from the Cape York Peninsula into central Papua New Guinea. This high represents a northerly extension of the Great Dividing Range, and during the Mesozoic formed a long peninsula or chain of islands extending northward from Australia. The remnants of this basement high are exposed in modern New Guinea in only two locations, a small outcrop on the southern coast immediately north of Saibai Island (west of Daru), and in the Kubor Anticline of the central highlands. The remaining Paleozoic basement associated with this high is covered by the overthrust belts of the Central Dividing Ranges, and any evidence of faunal endemism associated with it has long since been lost. During the Mesozoic and early Tertiary, however, it is likely that the subareal portions of this high provided tropical refugia for taxa that did not occur elsewhere in the main body of Australia, which lay in colder, more southerly latitudes. The case for such refugia in regard to the waterbug genus *Rhagovelia* was discussed by Polhemus and Polhemus (1988).

Additional areas with extensive exposures of Paleozoic basement are found in Irian Jaya, in the finger-like Wondiwoi Peninsula, and in the central core of the Vogelkop Peninsula. These represent old fragments of Australian craton that have been uplifted, and, in the case of Vogelkop, broken away and rotated relative to the remainder of the Australian continental platform. During portions of its history, Vogelkop has been a separate island, and this is reflected by the high degree of species endemism in its biota.

AREAS OF ENDEMISM OCCUPIED BY TAXA EXAMINED IN THIS STUDY

A. Odonata

A-1: Areas of endemism occupied by *Notoneura* species in New Guinea and surrounding islands (Odonata, Zygoptera, Protoneuridae).

Data are taken from publications of Lieftinck (see bibliography). Taxa occurring in more than one area of endemism are marked with an asterisk.

North Moluccas
circumscripta
exul

Kei
eburnea

Aru
rosea

Waigeo
atrocyana
evelynae
erythrprocta

Misool
*plagiata**
pyroprocta

Vogelkop Lowlands
*plagiata**
xanthe

Vogelkop Anticlines
*aurantiaca**
lorentzi

Vogelkop Highlands
dorsonigra

Fakfak and Kumawa Mountains
*aurantiaca**

Yapen
wallacii

Van Rees and Foja Mountains
*erythrura**
*fonticola**
*nigrofasciata**

Star Mountains
beatrix
erythrura efasciata
*fonticola**
irene
melanoxantha
*nigrofasciata**
plagioxantha

North Irian Lowlands
callisphaena
cyaneura
*erythrura**
*nigrofasciata**
*salomonis**
rosea cruentata

Cyclops Mountains
*chalybeostoma**

Torricelli and Prince Alexander Mountains
*chalybeostoma**
*erythrura**
*salomonis**

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Adelbert, Finisterre and Saruwaged Mountains

astrolabica
*chalybeostoma**
*erythrura**
*nigrofasciata**
*salomonis**

Owen Stanley Range

*salomonis**

Asmat Lowlands

rangifera
thalassina

New Britain

commutata

Solomon Islands

*salomonis**

A-2: Areas of endemism occupied by *Palalargia* species in New Guinea and surrounding islands (Odonata, Zygoptera, Coenagrionidae). Data are taken from publications of Lieftinck (see bibliography). Taxa occurring in more than one area of endemism are marked with an asterisk.

North Moluccas
perimecosoma
obiensis
optata

Waigeo
nasisterna

Misool
micropsitta

Vogelkop Lowlands
rubropunctata

Vogelkop Highlands
arses
flavovittata
rubropunctata

Fakfak and Kumawa Mountains
stellata

Sudirman Range
eclecta
myzomela

Star Mountains
alcedo
charmosyna miniata
ceyx ceyx
ceyx flammula

Cyclops Mountains
charmosyna cyclopica

North Irian Lowlands
*charmosyna charmosyna**
halcyon

Adelbert, Finisterre and Saruwaged Mountains
humida

Popondetta Lowlands
*charmosyna charmosyna**

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A-3: Areas of endemism occupied by *Argiolestes* species in New Guinea and surrounding islands (Odonata, Zygoptera, Megapodagrionidae) Data are taken from publications of Lieftinck (see bibliography). Taxa occurring in more than one area of endemism are marked with an asterisk.

North Moluccas
- *alfurus*
- *obiensis*

Waigeo
- *australis**
- *coartans*
- *ochrostomus*

Misool
- *plagiata**
- *pyroprocta*

Vogelkop Lowlands
- *australis**
- *connectens*
- *fontinalis*

Vogelkop Highlands
- *convergens*
- *ornatus*
- *pallidistylus*
- *postnodalis*

Yapen
- *subornatus**

Star Mountains
- *amphistylus*
- *aulicus*
- *lamprostomus*
- *pectitus*
- *simplex*
- *sponsus*
- *subornatus**

Cyclops Mountains
- *subornatus**
- *tristis*

Adelbert, Finisterre and Saruwaged Mountains
- *kirbyi*
- *montivagans*

Owen Stanley Mountains
- *epihippiatus*
- *esuriens*
- *luteipes*
- *microstigma*
- *prothoracicalis*
- *saltator*
- *saltuarius*
- *sidonia**
- *tenuispina*

D'Entrecasteaux Islands
- *annulipes*
- *armeniacus*
- *sidonia**

B. Heteroptera

B-1: Areas of endemism occupied by *Enithares* species in New Guinea and surrounding islands (Heteroptera: Notonectidae). Data are taken from publications of Lansbury (see bibliography). Taxa occurring in more than one area of endemism are marked with an asterisk. Manuscript species are set in quotes.

Waigeo
- *digitata*

Vogelkop Highlands
- "*arfak*"
- *nigra**

Vogelkop Lowlands
- *bakeri* (also in Lesser Sunda Islands)
- *kasim*
- *megalops**

Fakfak and Kumafa Mountains
- *megalops** (also in Central Moluccas)
- *nigra**

Vogelkop Anticlines
- *megalops**

Biak-Supiori
- *vulgaris*

Cyclops Mountains
- *elongata**

Sudirman Range
- *paramegalops*

Papuan Central Highlands
- "*ogelbeng*"
- *stylata**

Morobe Highlands
- *stylata**
- *atra**

Adelbert, Finisterre and Saruwaged Mountains
- *atra**
- *hackeri* (also in northern Australia)

Owen Stanley Mountains
- *loria** (also in Solomons and north Australia)

Trans-Fly Lowlands
- *loria** (also in northern Australia)

New Britain
- *alexis alexis**
- *alexis lairdi*

New Ireland
- *alexis alexis**

Bougainville
- *elongata**

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B-6: Areas of endemism occupied by *Nerthra* species in New Guinea and surrounding islands (Heteroptera: Gelastocoridae). Data are taken from publications of Todd (see bibliography). Taxa occurring in more than one area of endemism are marked with an asterisk.

North Moluccas
toxopeusi (also in central Moluccas)

Waigeo
*collaticollis**
*hirta**

Vogelkop Highlands
*collaticollis**

Vogelkop Lowlands
*laticollis**

Van Rees and Foja Mountains
*recta**

Cyclops Mountains
*hirta**
*mixta**

North Irian Lowlands
*collaticollis**
*recta**

Torricelli and Prince Alexander Mountains
*collaticollis**
*mixtella**
*recta**

Sudirman Range
*collaticollis**
*conabilis**
improcera
monticola

Star Mountains
*conabilis**
*hirta**
infecta
*mixtella**
petila

Papuan Central Highlands
*collaticollis**
*conabilis**

Morobe Highlands
*collaticollis**
robusta
stevensi

Adelbert, Finisterre and Saruwaged Mountains
*ampliata**
*hirta**
*laticollis**
*mixta**

Owen Stanley Mountains
*ampliata**
cheesmanae
*collaticollis**
*mixta**
*mixtella**

Papuan Peninsula Lowlands
hamata

Southern Foothills
breddini

Asmat Lowlands
*mixtella**

New Britain
*laticollis**

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Bougainville

gurneyi
macrostyla (also in remaining Solomon Islands)
omani (also in remaining Solomon Islands)

Note: Two additional species, *N. rugosa* and *N. macrothorax*, occur in New Guinea, but both are widespread coastal species which disperse in floating debris and are thus of little use in defining areas of endemism.

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Figure 17-3. Locations of present exposures of ophiolite and island arc volcanic rocks in New Guinea and surrounding islands.

Exposures mapped are andesitic island arc volcanics of Miocene or earlier age, and the ultramafic ophiolites that are interpreted to represent the former basements of these arcs (for further explanation see text). Not included on this diagram are rock units representing subduction melange that formed at the leading edge of the overriding Pacific Plate; such units are extensive to the south of the ophiolite belt on the northern slopes of the Central Dividing Range and represent the fore arc ridge that formed ahead of the accreted island arcs. Stippling indicates areas where the island arc volcanics are overlain by uplifted Quaternary reef limestones (Biak, Adelbert Range, Huon Peninsula).

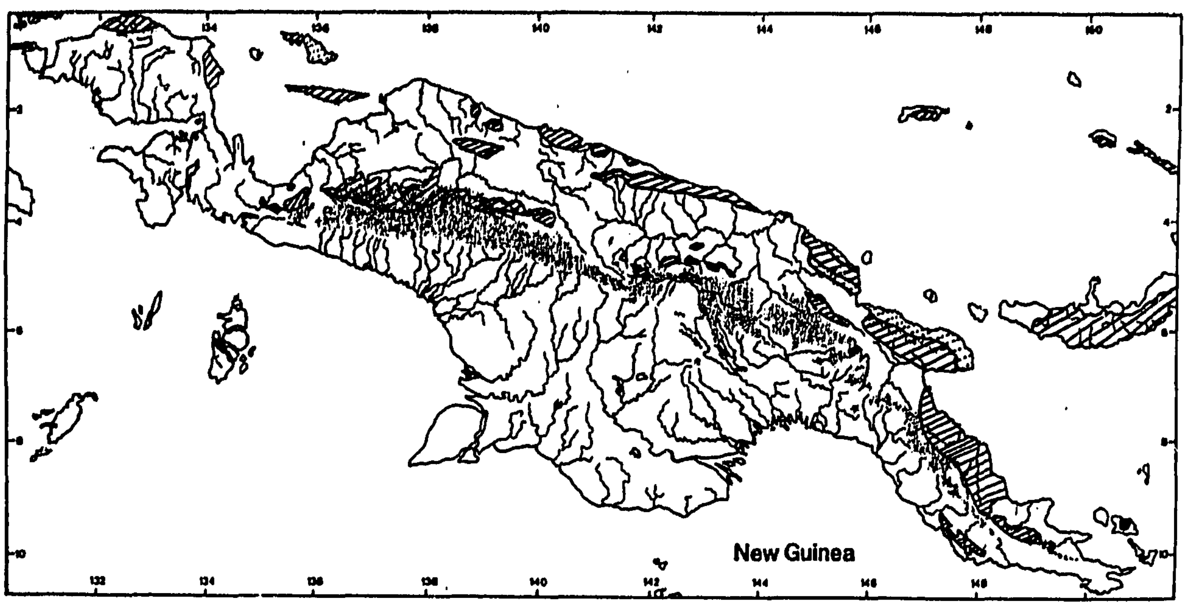
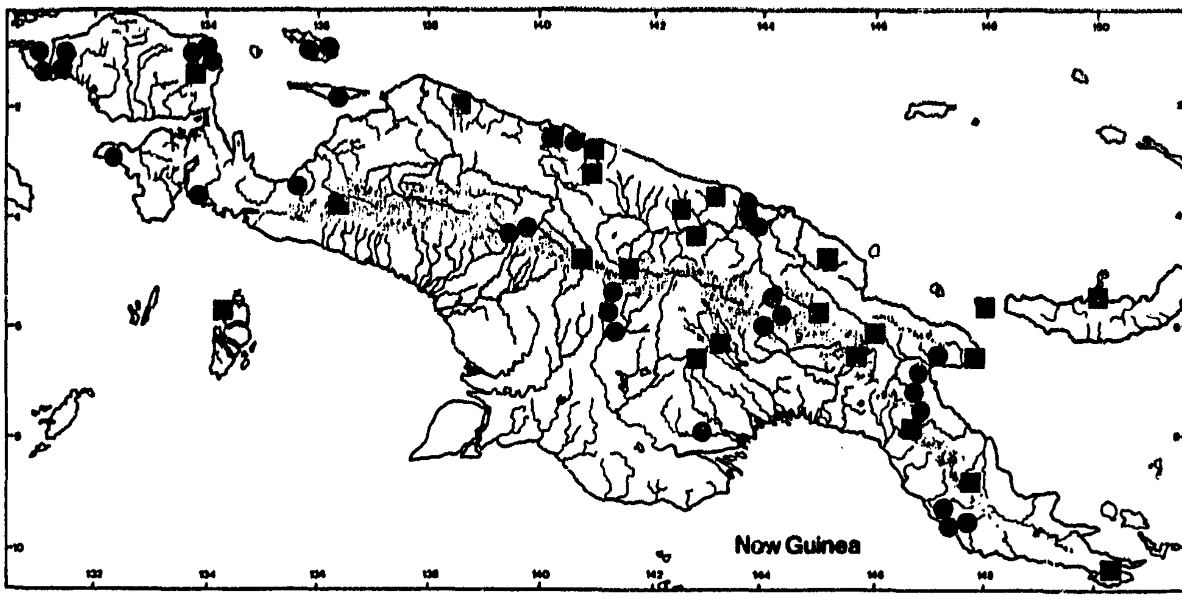


Figure 17-4. Locations from which aquatic Heteroptera have been sampled on New Guinea and surrounding islands.

Circles correspond to localities visited by J. T. and D. A. Polhemus. Squares indicate localities visited by other collectors.



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APPENDIX 17-3. FRESHWATER DECAPOD CRUSTACEANS OF PAPUA NEW GUINEA

- L. G. Eldredge

At best, knowledge of the freshwater crustacea of Papua New Guinea is sketchy, although there is a fair amount known of the major decapod crustacean groups themselves. Information about the microcrustaceans (ostracods, cladocerans, and copepods) is primarily drawn from zooplankton studies. Limnological surveys list and note records (Chambers 1987, Chambers et al. 1987). Most are thought to be widely distributed cosmopolitan species, some with known Australian representatives (Bayly 1962). Zooplankton records can be found in Ball and Glucksman (1987, 1980), Bayly (1962), Bayly and Morton (1980), Bayly et al. (1970), Löffler (1973), and McKenzie (1971). In addition, there are more recent reports on three Central Province freshwater areas (Vlaardingerboek 1984), seven species of *Thermocyclops* (Defaye et al. 1987), and several new species and subspecies of *Mesocyclops* (Dussart and Fernando 1985, van de Velde 1987).

Several species of hermit crabs (*Coenobita* spp.) and the coconut crab (*Birgus latro*) are widely distributed throughout New Guinea and the islands. Interestingly, *Birgus latro* appears to be restricted to the northern areas of New Guinea and the Bismarck Archipelago eastward as far as the Tuamotu Islands. Individuals are either very rare or absent from the southern coasts. No records are known from this area, as well as from the Torres Straits islands, and the north coast of Australia (Reyne 1938). This distribution was further supported by Holthuis (1959, 1963).

These species, along with a number of species from the families Grapsidae and Ocypodidae (*Ocypode* and *Uca*), can be found associated with fresh and brackish water (Burrgren and McMahon 1988), but are not generally considered to be "freshwater" species. Many of these are, however, known to occur in the Madang area (Morgan 1988).

For this review, only those species which can be found exclusively or in close association with freshwater habitats are considered.

The freshwater decapod crustaceans of Papua New Guinea belong to seven diverse families:

Order Decapoda
- Infraorder Caridea
  - Atyidae DeHaan, 1849
  - Palaemonidae Rafinesque, 1815
- Infraorder Astacidea
  - Parastacidae Huxley, 1879
- Infraorder Brachyura
  - Hymenosomatidae MacLeay, 1838
  - Goneplacidae Macleay, 1838

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Gecarcinidae LacLeay, 1838
Grapsidae MacLeay, 1838
Sundathelphusidae Bott, 1969

Members of the Parastacidae and Sundathelphusidae are found exclusively in freshwater. Representatives of the other families tolerate varying degrees of salinity. In the Atyidae, most are found in fresh or brackish water; in the Grapsidae, most species are marine. The Gecarcinidae lead a more terrestrial lifestyle, but are dependent on regular access to water. A checklist of all these species is attached.

This review is based primarily on that of Holthuis (1982a) for the decapod crustaceans of the entire island of New Guinea. Several more recent publications with new records and descriptions from Papua New Guinea and the islands have been included. The scope has been narrowed to that of Papua New Guinea.

Atyidae

The majority of species of *Atyoida*, *Atyopsis*, and *Caridina* are truly freshwater inhabitants; however, some are able to pass part of their life cycle in water with varying amounts of salinity. The atyids are very widely distributed throughout the Indo-west Pacific, ranging from Madagascar to Polynesia. Of the ten species of *Caridina*, three are known only from their type localities in Papua New Guinea (Bougainville and New Ireland). In New Guinea all atyid species have been found in lowland areas in both running and stagnant waters. There is a need to make further collections, and an analysis of the taxonomic situation is necessary.

Palaemonidae

Of the two genera -- *Palaemon* and *Macrobrachium* -- known from New Guinea, the species of *Palaemon* are widely distributed from the Red Sea to Polynesia. A few members of the genus *Macrobrachium* are found in brackish and marine waters. Of the 18 species known from the entire island of New Guinea, 15 are wide-ranging species. Three might be considered endemic. *M. lorentzi*, originally known from only the Lorentz River area in Irian Jaya, was also found in the Ok Tedi River (Holthuis 1984). This species and the other two were originally described from Irian Jaya. As with the Atyidae, more collections are needed to better understand palaemonid taxonomy and distribution.

Parastacidae

This crayfish family is restricted to the Southern Hemisphere -- southern South America, Madagascar, Australian region (Australia, Tasmania, New Guinea), and New Zealand, and none of the genera involved occurs in more than one region. In New Guinea, a

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total of 13 species belong to the genus *Cherax* further divided into two subgenera -- *Astaconephrops* and *Cherax* (Holthuis 1982a, 1986).

Two species of *Cherax (Astaconephrops)* occur in Papua New Guinea -- *C. (A.) albertisii* is found in the Fly River basin westward to the Digul River region in Irian Jaya. *C. (A.) papuanus* appears restricted to Lake Kutubu in the Southern Highlands Province. All members of *Cherax (Cherax)* inhabit the Central Mountain Range in the Wissel Lakes region (Paniai and Tigi Lakes) of Irian Jaya; to date, none known from Papua New Guinea.

The New Guinea crayfish exhibit a restricted distribution, being found only south of the watershed formed by the Central Mountain Range (Figure 17-5). Despite extensive exploration along the northern side of this watershed, no crayfish have been collected or observed (Holthuis 1982a, 1986). [*C. albertisii* appears to have gotten into the aquarium trade; Dr. P. K. L. Ng sent two specimens found in an aquarium shop in Singapore to Dr. L. B. Holthuis for identification verification.]

Hymenosomatidae

Seven species of the family are considered to be freshwater inhabitants. One -- *Amarinus angelicus* -- is found in the Southern Highlands. This interesting species, found further inland and at a higher elevation (1600 m) than any other member of the family, has large eggs and abbreviated development (Lucas 1908).

Goneplacidae

From the continental karst caves of New Britain, the crab *Trogloplax joliveti* has been described as a true troglobitic blind crab, with reduced eyes and pigmentation, and having long, slender legs. This species, neither representative of the Sundathelphusidae nor the Grapsidae, is considered to be an example of the new subfamily Trogloplacinae, tentatively assigned to the Goneplacidae (Guinot 1986) but may be considered a separate family by some authors.

Gecarcinidae

Five wide-ranging species are known from Papua New Guinea (Turkay 1974). All require regular access to either seawater or groundwater in the base of burrows where they can immerse themselves. Individuals may be found a considerable distance inland. Many of these species dig burrows adjacent to freshwater streams (Bright and Hogue 1972). These authors list 140 species of mosquitoes worldwide, reported as either resting or breeding in crab burrows; possible vectors for malaria and filariasis are among them.

Grapsidae

Twelve freshwater species have been reported from all of New Guinea; 14 marine forms from Madang alone (Morgan 1988). One, *Varuna litterata*, is widely distributed from East Africa to Japan and Polynesia. Five freshwater species have been recorded from eastern Indonesia to northern Irian Jaya.

The fifth interesting species, *Sesarmoides novabitannia* -- was described from Arawe Island, New Britain (Ng 1988). Three species of *Sesarmoides* are known to be cavernicolous, but unfortunately, nothing is known about the habitat of this New Britain species.

Sundathelplhusidae

Members of this family are considered truly freshwater crabs. Representatives of four genera -- *Geelvinkia*, *Holthuisana*, *Rouxana*, *Sendleria* -- are known from New Guinea (Figure 17-6). The taxonomy of this family is not well understood.

Of the two subgenera of *Holthuisiana* -- *Holthuisana (Austrothelphusa)* is restricted to Australia and *Holthuisiana (Holthuisiana)* to New Guinea. Some species are widely distributed; others are known from single locales. Zoogeographically, the Central Mountain Range does not form a barrier for this taxon as it does for the crayfish; some species are found both north and south of it. Two species -- *Holthuisana alba* and *Rouxana phreatica* -- are known only from their type localities in the West Sepik Province. *H. alba* is the "first white cavernicolous species known, it is furthermore the second species of white and blind cave crab to be found in the Indo-west Pacific" (Holthuis 1980). *R. phreatica* is the "second cavernicolous crab known from New Guinea" (Holthuis 1982b). One species of *Sendleria* extends to the Solomon Islands, two are known from New Britain, and the third is of dubious identity. *S. genuitei* shows cavernicolous adaptations (Guinot 1987).

ENDEMIC SPECIES

Zoogeographically, the Papua New Guinea freshwater decapod crustacean fall into three categories:

1. species with wide ranging Indo-west Pacific distribution patterns from the Red Sea to Polynesia;

2. species with New Guinea as the eastern limit of their ranges; the western boundary being Malaysia; and

3. endemic species.

Those species belonging to the first two groups all have some tolerance to brackish or marine waters. The endemic species belong to families -- Parasticidae and

Sundathelphusidae -- which are exclusively found in freshwater habitats. *Cherax* and *Holthuisana* have affinities with Australia; *Geelvinkia*, *Rouxana*, and *Sendleria* are found only in New Guinea. The first, only in Irian Jaya; the second, throughout; and the last, eastward to Bougainville. All these endemic species need further research into their habitats, distribution, and biology.

SUGGESTED CONSERVATION AREAS

The wetlands of Papua New Guinea have recently been reviewed (Osborne 1989). For freshwater decapod crustaceans, four areas of major conservation value are as follows (see Figure 17-7):

1. West Sepik area -- several freshwater crabs and the type locality for two cavernicolous crabs -- *Holthuisana alba* and *Rouxana phreatica* are from this region. [This area encompasses part of Osborne's No. 1, p. 1119.]

2. Upper Fly River-Ok Tedi River, Western Province -- *Macrobrachium lorentzi* is unique to this area to the Lorentz River area; the eastern boundary of the crayfish *Cherax albertisii* which is found westward to the Digul River area; and the crab *Rouxana papuana* is known from the mouth of the Fly River. [This area roughly corresponds to Osborne's No. 15, p. 1135.]

3. Southern Highlands (Lake Kutubu) -- this area is the sole location for the crayfish *Cherax papuana* and the hymenosomatid *Amarinus angelicus* which is found further inland and at a higher elevation (1600 m) than any other member of the family; the crab *Rouxana papuana* is also found in this area. In addition, 13 species of freshwater fish, including 11 endemic species, are known from Lake Kutubu (Allen 1991). [This area corresponds to Osborne's No. 22, p. 1143.]

4. New Britain -- four species are known from this island; *Sesarmoides novabritannia*, a possible cavernicole, is known only from Arawe Island, off the southwest coast (4b); two troglobitic crab species -- *Trogloplax joliveti* (representing a new monotypic subfamily) and *Sendleria genuitei* are known from central caves; additionally *S. gloriosa gloriosa* is found only on New Britain (4a).

ECONOMIC CONSIDERATIONS

Both traditional and potential commercial uses of the freshwater crustaceans have been described.

The crayfish *Cherax albertisii* has been investigated for a possible commercial fishery. By the mid-1970s, the Papua New Guinea government had considered a crayfish industry but no exploratory fishing had been conducted (Department of Primary Industry 1976). The first production was from the village of Sigabaduru (65 km west of Daru) in the

Western Province, when 3.7 tons were caught in 1975. In 1976, the production from three villages totaled 11.3 tons. The lack of a freezer boat delayed any further development. Less than 100 kg was reported in 1977. From the Pahoturi River region the production declined, and in 1978 only a few crayfish were collected. During a dry-season survey where the river was narrow, even forming isolated pools, no crayfish were reported. In addition, reports from the river system at the village of Buji (64 km west of Sigabaduru), not previously fished, stated that crayfish had also virtually disappeared. No apparent obvious changes had been reported, and a pathogenic infection was considered (Department of Primary Industry 1980).

Additional surveys were conducted at the village of Kaviapo (on the east bank of the Fly River) where small catches were noted in 1978. In late 1978, a government fisheries extension vessel made one trip into the Aramia River system where low concentrations of crayfish were reported throughout most of the associated lakes and swamps. At about the same time, a freezer vessel was sent to Daru under the auspices of a Food and Agriculture Organization project where a crayfish project officer was to operate the vessel and assess the potential for a commercial fishery. The results of the surveys were disappointingly low, but villagers were encouraging. In 1979 a series of holding tanks were planned, but their outcome is unknown. More research was planned (Department of Primary Industry 1980). With such fluctuations in abundance, plans to initiate a commercial fishery were abandoned (Anon. 1982).

A fishery for the giant freshwater prawn *Macrobrachium rosenbergii* has been investigated. A total of 16,000 kg was suggested as the possible production under the 1976 development plan (Department of Primary Industry 1976). The present status is unknown.

Traditional crayfish fishing is documented primarily for the Wissel Lakes of Irian Jaya (Holthuis 1949). Large numbers of seven species of crayfish were collected during the Dutch New Guinea Expedition of 1939 by paying for specimens with money cowries (*Cypraea moneta*, locally known as "gigi's"). Two types of nets -- dip net and square net -- are used. The square nets may be as large as 4 m by 4 m. They are baited and lowered from small boats where they remain for a day and then are brought to the surface and the crayfish harvested. Shallow water crayfish are also collected with arrows and spears. Large quantities are collected and are among the most important foods for the native population. Information for the Wissel Lakes region was expanded, and notes on the central part of the Vogelkop Peninsula, Sentani Lake, and the Merauke River were added by Holthuis (1956).

The freshwater crabs are also collected in a traditional manner. *Rouxana papuana* "is used rather extensively as food by the population along the Lamari River in the Eastern Highlands" (Dr. Gajdusek in Holthuis 1974). *R. roushdyi*, from Paniai and Tigi Lakes in the Wissel Lakes area, apparently were not used for food because of their small size and the abundance of larger crayfish in the area.

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CHECKLIST OF THE FRESHWATER DECAPOD CRUSTACEANS OF PAPUA NEW GUINEA

Decapoda Natantia (shrimps)

Atyidae [all found in lowlands only, running and stagnant water]

Atyopsis spinipes (Newport, 1847) [found throughout New Guinea; India to Japan and Polynesia]

Atyoida pilipes (Newport, 1847) [in New Guinea, Irian Jaya and Manus; Madagascar to Polynesia]

Caridina buhleri Roux, 1934 [known only from type locality in New Ireland]

C. cognata De Man, 1915 [known only from type locality in Irian Jaya]

C. demani Roux, 1911 [known only from type locality in Irian Jaya]

C. fecunda Roux, 1911 [known only from type locality in Irian Jaya]

C. gracilirostris De Man, 1892 [widely distributed throughout the Indo-west Pacific]

C. nilotica (P. Roux, 1833) [widely distributed throughout the Indo-west Pacific]

C. opaensis Roux, 1919 [Celebes and Aru Islands, but not New Guinea]

C. papuana Nobili, 1905 [known only from type locality in Irian Jaya]

C. rouxi De Man, 1915 [known only from type locality in Bougainville]

C. serratirostris De Man, 1892 [widely distributed throughout the Indo-west Pacific]

C. troglodytes Holthuis, 1978 [known only from type locality in New Ireland, in subterranean stagnant pools]

C. typus H. Milne Edwards, 1837 [widely distributed throughout the Indo-west Pacific]

Palaemonidae

Palaemoninae

Macrobrachium australe (Guerin, 1838) [wide distribution, India to New Ireland and New Caledonia]

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M. bariense (De Man, 1892) [Malaysian species extends to New Guinea]

M. equidens (Dana, 1852) [wide distribution, India to New Britain and New Caledonia]

M. gracilirostre (Miers, 1875) [Malaysia to Polynesia]

M. horstii (De Man, 1892) [Malaysian species extends to New Guinea]

M. idae (Heller, 1862) [Madagascar to New Guinea and Manus]

M. lar (Fabricius, 1798) [wide distribution, India to New Caledonia]

M. latidactylus (Thallwitz, 1891) [Malaysian species extends to New Guinea]

M. latimanus (Von Martens, 1868) [wide distribution, India to Manus and New Caledonia]

M. lepidactyloides (De Man, 1892) [Malaysia to Polynesia]

M. lorentzi (Roux, 1821) [endemic, known from Lorentz R. area, south- western New Guinea and Ok Tedi River, Papua New Guinea]

M. mammillodactylus (Thallwitz, 1892) [Malaysian species extends to New Guinea]

M. microps Holthuis, 1978 [endemic, known only from New Ireland]

M. minutum (Roux, 1917) [endemic, known only from Sentani Lake, northern New Guinea]

M. natulorum Holthuis, 1984 [Wissel Lakes region, Irian Jaya; undescribed sp. (Hothuis, 1982a)]

M. oenone (De Man, 1902) [Malaysian species extends to New Guinea]

M. placidulum (De Man, 1892) [Malaysian species extends to New Guinea]

M. rosenbergii (De Man, 1879) [often found in high salinity water; wide distribution, India to New Guinea and northern Australia]

M. sophronicum Holthuis, 1950 [eastern Malayan Archipelago, Ryukyus, and New Ireland]

M. weberi (De Man, 1892) [Malaysian species extends to New Guinea]

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Palaemon concinnus Dana, 1852 [wide distribution, Red Sea to Polynesia]

P. debilis Dana, 1852 [wide distribution, Red Sea to Polynesia]

Reptantia

Parastacidae [Subgenus *Astraconephrops*: wide ranging]

Cherax (Astaconephrops) albertisii (Nobili, 1899) [southern New Guinea from Fly R. basin westward to the basin of the Digul R. in Irian Jaya]

C. (A.) lorentzi Roux, 1911 [western New Guinea (Irian Jaya) between the Vogelkop Peninsula and the Noord (=Lorentz) R. [with subspecies lorentzi auranus Roux, 1911, Aru Is.]

C. (A.) misolicus Holthuis, 1949 [Misool Is. only]

C. (A.) monticola Holthuis, 1949 [upper reaches of the Baliem R. basin, Irian Jaya]

C. (A.) papuanus Holthuis, 1949 [Lake Kutubu, Southern Highlands]

Parastacidae [Subgenus *Cherax*: all species inhabit the Central Mountain Range in Wissel Lakes region of Irian Jaya, between altitudes of 1650 and 1750 m]

Cherax (Cherax) boschmai Holthuis, 1949 [Paniai Lake only]

C. (C.) buitendijkae Holthuis, 1949 [Paniai Lake only]

C. (C.) communis Holthuis, 1949 [both Tigi Lake and Paniai Lake]

C. (C.) longipes Holthuis, 1949 [Tigi Lake only]

C. (C.) murido Holthuis, 1949 [Paniai Lake only]

C. (C.) pallidus Holthuis, 1949 [Paniai Lake only]

C. (C.) paniaicus Holthuis, 1949 [Paniai Lake only]

C. (C.) solus Holthuis, 1949 [Tigi Lake only]

Brachyura

Gecarcinidae

Cardisoma carnifex (Herbst, 1796) [widely distributed, in Papua New Guinea from Central Province, Admiralty Islands, Bougainville]

C. hirtipes Dana, 1851 [widely distributed, in Papua New Guinea from Admiralty Islands (Tracy Is.), New Britain, New Ireland, Bougainville, Buka]

C. rotundum (Quoy and Gaimard, 1924) [widely distributed, in Papua New Guinea known only from Admiralty Islands]

Epigrapsus notatus (Heller, 1865) [widely distributed from Nicobar Islands eastward to Admiralty Islands and Bismarck Archipelago

E. politus Heller, 1862 [Malaysia to New Guinea and Bismarck Archipelago (Bertrand Is.)]

Gecarcoidea lalandii Milne Edwards, 1837 [widely distributed to Bismarck Archipelago (Mussa Is.), Bougainville, and New Caledonia]

Grapsidae
Sesarminae

Labuanium rotundatum (Hess, 1865) [estuarine, widely distributed, reported from New Britain and New Ireland]

Metasesarma aubryi (Milne Edwards, 1869) [widely distributed, reported from New Britain, New Ireland, and Admiralty Islands]

Sarmatium integrum (Milne Edwards, 1865) [widely distributed, reported from New Britain]

Geosesarma gordonae (Serene, 1968) [originally described from Fak-Fak, New Guinea]

G. ianthina Pretzmann, 1985 [collected by L. Biró in 1903 at Wendessi, New Guinea]

G. maculatum (De Man, 1892) [reported from New Britain]

Sesarmops impressum (Milne Edwards, 1837) [widely distributed, reported from New Hanover]

Sesarmoides novabritannia Ng, 1988 [Arawe Island, New Britian, habitat unknown, ?cavernicole]

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Varuninae

Pseudograpsus crassus A. Milne Edwards, 1868 [freshwater; eastern Indonesia to Irian Jaya]

Ptychognatus demani Roux, 1917 [freshwater, northern Irian Jaya]

P. riedelii (A. Milne Edwards, 1868) [freshwater; Andaman Islands and greater part of Indonesia to Irian Jaya]

Varuna litterata (Fabricius, 1798) [freshwater, brackish, marine; widely distributed: East Africa to Japan and Polynesia]

Hymenosomidae

Amarinus angelicus (Holthuis 1968) [freshwater; known only from type material; Tigibi, Tari Subdistrict, Southern Highlands Province]

Goneplacidae
Trogloplacinae

Trogloplax joliveti Guinot, 1986 [troglobite; continental karst caves of New Britain, Whiteman and Nakanai Mts.]

Sundathelphusidae

Geelvinkia ambaiana Bott, 1974 [Irian Jaya, north of the Central Mountain Range]

G. calmani (Roux, 1927) [Irian Jaya, south the Central Mountain Range]

G. holthuisi Bott, 1974 [Irian Jaya, south of the Central Mountain Range]

Holthuisana alba Holthuis, 1980 ["first white cavernicolous species known, it is furthermore the second species of white and blind cave crab to be found in the Indo-west Pacific;" Askembutem Cave, Wok Askembu near Tabubil, West Sepik Province]

H. biroi (Nobili, 1905) [Irian Jaya, north and south of Central Mountain Range; Wakip R., Aitape Subdistrict, West Sepik Povince; Sepik R., Angoram Subdistrict, East Sepik Province; Koropa, Ramu Valley, Madang Subdistrict, Madang Province; Jal, Gogol Valley, Madang Subdistrict, Madang Province; near Finschhafen, Finschhafen Subdistrict, Morobe Province; Kokoda, Kokoda Subdistrict, Northern Province]

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H. boesemani Bott, 1974 [Irian Jaya, south of the Central Mountain Range]

H. festiva (Roux, 1911) [Irian Jaya, south of the Central Mountain Range; Yangoru, Maprik Subdistrict, East Sepik Province; Bangasap, Josephstall, Bogia Subdistrict, Madang Province; Koropa, Ramu Valley, Madang Subdistrict, Madany Province; Jal, Gogol Valley, Madang Subdistrict, Madang Province; Budi Barracks, Northern Province]

H. subconvexa (Roux, 1927) [Irian Jaya, north of the Central Mountain Range; Omati, Kikori Subdistrict, Gulf Province]

H. wollastoni (Calman, 1914) [Irian Jaya, north and south of the Central Mountain Range]

Rouxana ingrami (Calman, 1909) [Irian Jaya, north and south of the Central Mountain Range; Aitape, West Sepik Province; Wakip R., north coast of New Guinea; Lamari R., Okapa Subdistrict, East Highland Province; Gihiteri Creek, Omati R., Kikori Subdistrict, Gulf Province; Madeu, St. Joseph R., Port Moresby Subdistrict, Central Province; also Madang area (Morgan, 1988)]

R. minima (Roux, 1927) [Irian Jaya, north of the Central Mountain Range; Sepik R., exact locality unknown]

R. papuana (Nobili, 1899) [Irian Jaya, north of the Central Mountain Range; Okapa, Okapa Subdistrict, Eastern Highlands Province; Binaturi R., wsw mouth Fly R., Daru Subdistrict, Western Province; Tigibi, Taru Subdistrict, Southern Highlands Province]

R. phreatica Holthuis, 1982 ["second cavericolous crab to become known from New Guinea;" Hydra Hole, Finim Tel Plateau, Bahrman Mts. near Mt. Fugilil Dabom, West Sepik Province]

R. plana (Calman, 1914) [Irian Jaya, north of the Central Mountain Range]

R. roushdyi Bott, 1974 [Irian Jaya, south of the Central Mountain Range]

Sendleria genuitei Guinot, 1987 [grotto at Tolan, Nakani Mt., New Britian; taxonomic status not known]

S. gloriosa (Balss, 1923) [*S. g. gloriosa* (Balss, In Sendler, 1923, Toma, New Britain; *S. s. salomonis* (Roux, 1934), Bougainville]

S. gjellerupi (Roux, 1927) [Sawia, Arso Lake, Sentani Lake region (considered "dubious species" by Holthuis, 1974 because of possible mislabelling by Bott)]

Figure 17-5. Map of New Guinea, showing the known locations for freshwater crayfish Parastacidae. The interrupted line indicates the main watershed of the island (Holthuis, 1982a).

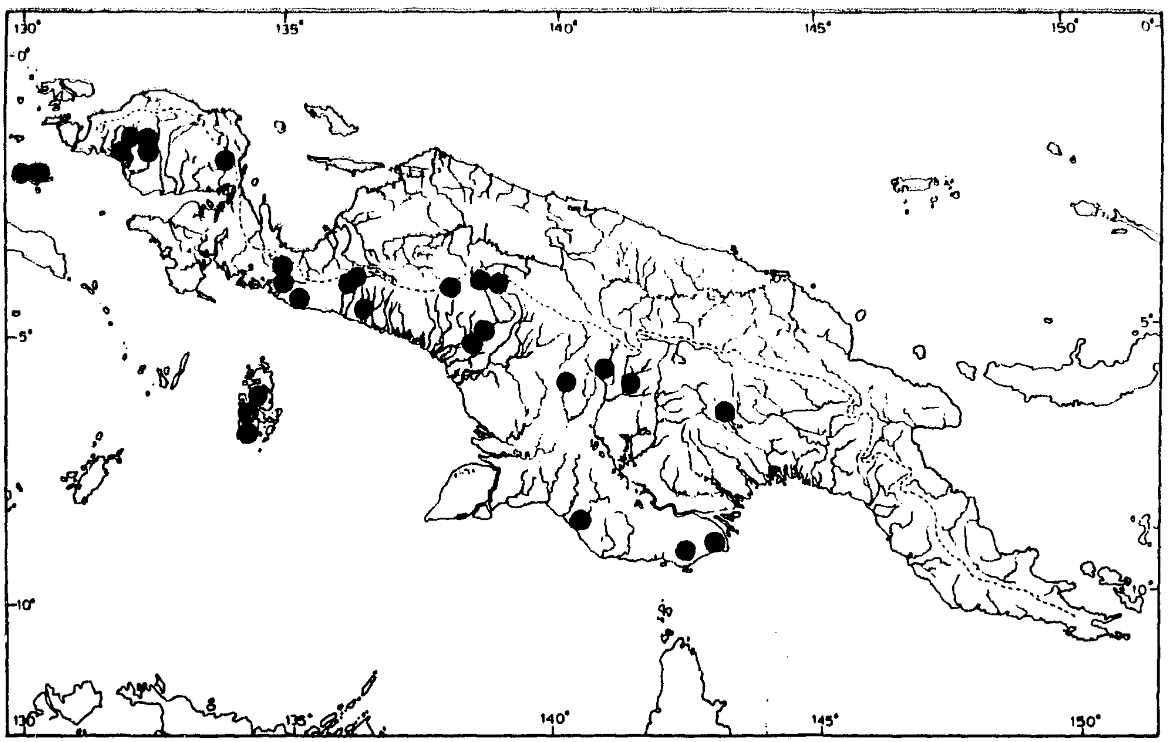

Figure 17-6. Distribution of the freshwater crabs of New Guinea. 1 -- *Rouxana ingrami*; 2 -- *R. papuana*; 3 -- *R. plana*; 4 -- *R. minima*; *R. roushdyi*; 6 -- *Geelvinkia ambaiana*; 7 -- *G. calmani*; 8 -- *G. holthuisi*; 9 -- *Holthuisiana biroi*; 10 -- *H. wallastoni*; 11 -- *H. boesemani*; 12 -- *H. subconvexa*; 13 -- *H. festiva* (Bott, 1974); added since are *H. alba* and *R. phraetica*, both from the West Sepik Province.

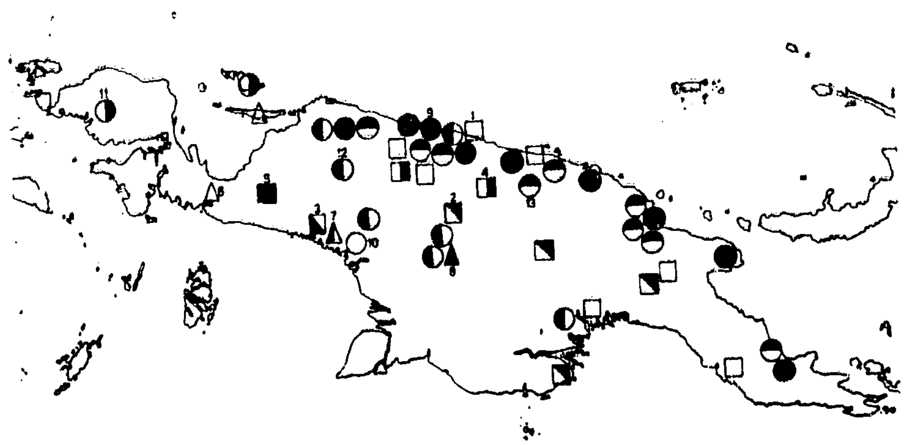

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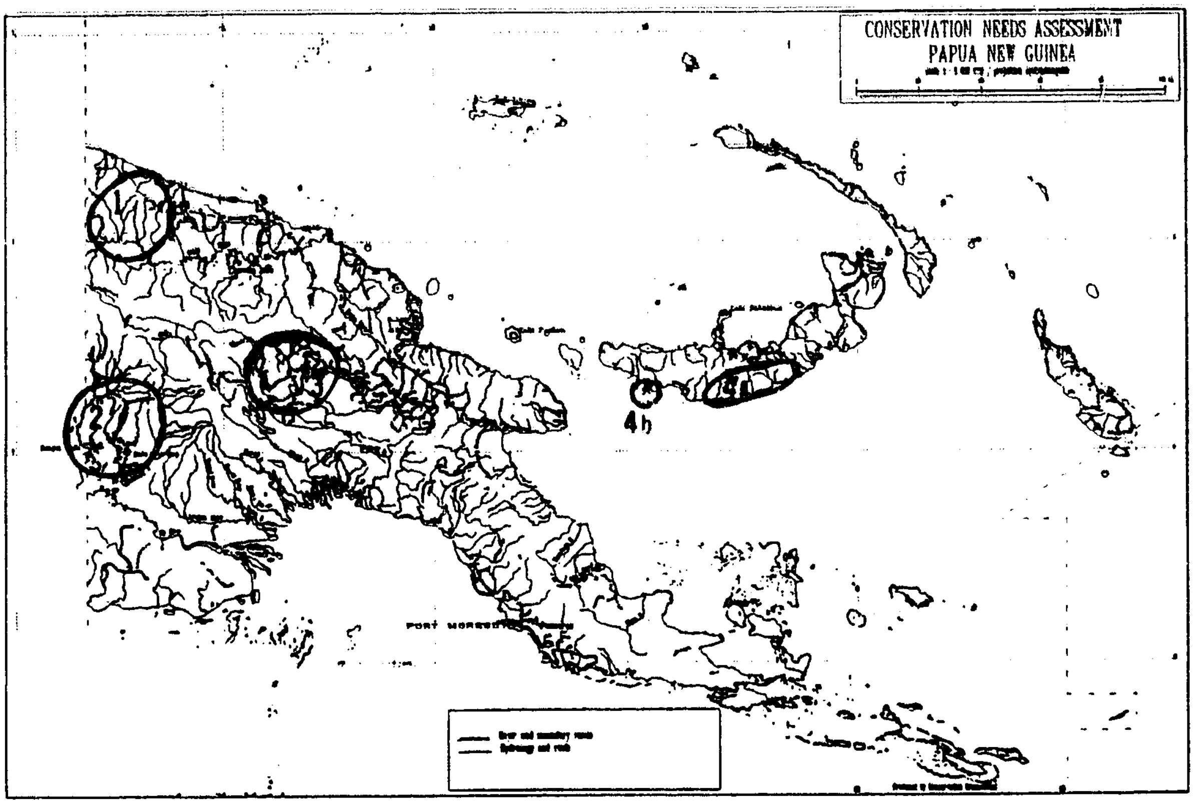
Figure 17-7. Areas of consideration for conservation. 1 -- West Sepik; 2 -- Upper Fly River-Ok Tedi River, Western Province; 3 -- Southern Highlands Province (Lake Kutubu); 4 -- New Britian, 4a central highlands area, 4b Arawe Island.



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APPENDIX 17-4. NON-MARINE MOLLUSCA OF PAPUA NEW GUINEA

- R. H. Cowie

INTRODUCTION

The non-marine molluscan fauna of Papua New Guinea (PNG) is intimately related to that of Irian Jaya, with many species in common. And although there are certainly important differences between the western and eastern parts of New Guinea and its associated offshore islands (Solem 1959), knowledge of the fauna of Irian Jaya is of considerable importance in assessing conservation priorities in PNG. Therefore, this report, while focusing on PNG, refers also to literature dealing with Irian Jaya when relevant.

The first major body of work dealing with the molluscan fauna (terrestrial and fresh water) of New Guinea was by Tapparone Canefri, who synthesized and augmented his earlier work in two major publications (Tapparone Canefri 1883, 1886). The land snail fauna of the former British New Guinea was treated by Hedley (1891, 1894) and the fauna of the Bismarck Islands by Rensch (1934, 1937). The Manual of Conchology (e.g., vol. IX - Pilsbry 1893-1895) deals with some of the major groups of land snails represented in PNG. The most well-known and often strikingly beautiful land snails of PNG are the Camaenidae (e.g., the genera *Papuina*, *Chloritis*, *Theristes*) but other families are well represented (e.g., members of the superfamily Helixarionoidea; and operculate land snails of the families Hydrocenidae, Helicinidae, Assimineidae, and the superfamily Cyclophoroidea). Iredale (1941) listed the land snail species of "Papua" (presumably meaning the former British New Guinea only), although providing little detail. Subsequently, Clench (1957a, b) and Clench and Turner (1959, 1960, 1962, 1964, 1966, 1968) described a number of new species and revised certain genera of land snails from PNG (mainly Papuininae). Solem (1958, 1970, 1982) dealt with the land snail family Charopidae (Endodontoidea), although not comprehensively since his focus was on the islands of the Pacific rather than its rim. Van Benthem Jutting (1963a, 1963b, 1964, 1965) monographed the non-marine Mollusca of Irian Jaya, and her work remains the most comprehensive treatment for New Guinea. Although Iredale (1941) considered there to have been little collecting since the turn of the century, van Benthem Jutting (1964) felt that, for Irian Jaya at least, knowledge of the fauna had increased considerably since that time, as the interior became more accessible. Riech (1937), McMichael and Hiscock (1958), and Starmühlner (1976) have made significant contributions to knowledge of fresh water Mollusca from PNG.

ASSESSMENT OF THE CURRENT STATUS OF THE FAUNA

Land Mollusca

Despite the extensive monographic treatments (above) indicating high diversity, the fauna, especially of the interior and highland regions, remains but sparsely documented. Distribution patterns may well be "complex" (Solem 1959), and although there are suggestions that differences exist between the faunas of the eastern and western parts of New

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Guinea, Solem's (1959) statement that "the fauna of the ... interior is so poorly known" remains true over 30 years since its publication. Clausiliidae, Enidae, and Athoracophoridae have been recorded from only a very few localities, but are probably more widely distributed (Solem 1959).

The faunas of offshore islands appear to differ in significant respects from mainland PNG (e.g., in the presence of Partulidae on some islands, Cowie 1992) and have been treated somewhat separately in the literature, the Bismarck and Admiralty archipelago having received particular attention (e.g., Rensch 1934, 1937, Clench and Turner 1964, Hoffmann 1932). As a broad generalization, most species are probably endemic to New Guinea and the offshore islands. Some are endemic to certain islands or island groups, but within mainland PNG it is not possible to say confidently that particular species are endemic to particular localities; distributions of most are simply not adequately known.

Neither is it possible to give a precise estimate of total numbers of species (cf. Roth 1991). Iredale's (1941) list for the land snails of "Papua" includes 198 species, but it is not clear which of the offshore islands are included. Rensch (1934, 1937) listed 157 land snail species in the Bismarck Archipelago. Van Benthem Jutting's (1963b, 1964, 1965) monographs of Irian Jaya, the most comprehensive works for New Guinea, indicate 481 species-group land molluscan taxa (mostly full species), almost certainly closer to the likely true number for PNG, but also almost certainly a gross underestimate.

During the first half of the twentieth century many new taxa were discovered in New Guinea (see, for example, van Benthem Jutting 1964: 1); but many areas remain unexplored malacologically and new taxa continue to be found. For example, Clench (1957a, 1957b), Clench and Turner (1959, 1960, 1962, 1964, 1966, 1968), and Van Goethem (1984) added species to the known PNG mainland and Bismarck Archipelago faunas; Loosjes (1956) recorded the family Clausiliidae from New Guinea (Irian Jaya) for the first time.

One locality deserves special mention. The land snail fauna of Manus Island is probably the best known local fauna in PNG (e.g., Gardner 1990), even though precise locality data remain poor (Luxmoore et al. 1988). It has attracted special attention because of the spectacular beauty of *Papustyla pulcherrima*, a papuinine tree snail with a bright green shell that is prized by shell collectors, and that has given its name to the newsletter of the Manus Land Snail Society "The *Papustyla*." This species is classified as rare in the 1990 IUCN Red List of Threatened Animals (IUCN 1990) and as endangered under the U.S. Endangered Species Act (Luxmoore et al. 1988), the major threat being habitat destruction due to logging (Abbott 1989, Luxmoore et al. 1988).

The slugs of PNG are virtually unknown. Iredale (1941) was aware of only one record (*Atopos prismatica* - Rathouisiidae - from the Fly River region). Van Benthem Jutting (1964) includes only three slugs (*Laevicaulis alte*, *Atopos australis*, and *Aneitea graeffei papuensis* in the families Veronicellidae, Rathouisiidae, and Athoracophoridae, respectively) in her work on Irian Jaya, *L. alte*, at least, perhaps being an introduced species. Hoffman (1932) listed five slug species from the Bismarck Archipelago, in the families Onchidiidae, Rathouisiidae, and Athoracophoridae.

Huge areas of PNG remain unknown malacologically, and past collecting effort has almost certainly been biased towards the larger and more colorful species and to accessible (especially coastal) localities. With this in mind, it is probably not unreasonable to suggest that the land molluscan fauna numbers well over 1000 species. The distribution of none of them has been adequately assessed.

The following statement of Clench and Turner (1962) remains true: "Difficulties in understanding many species still exist. Many of the species were inadequately described, often without figures, and others with incorrect locality data. Confusion about certain species will naturally exist for many years to come ..."

Fresh (and Brackish) Water Mollusca

Once again, van Benthem Jutting's work (1963a), listing 165 species-group taxa of gastropods and bivalves, stands out as the most comprehensive treatment of the New Guinea fauna. For PNG, Starmühlner's (1976) monograph, including 47 fresh water gastropods (40 from the PNG mainland plus Long Island, and 33 from the Bismarck Archipelago; see Starmühlner 1976: 639-640) is the most comprehensive work, but certainly covers the fauna incompletely. Haynes' (1988) list, covering only Neritidae, is similar. (Mangrove snails e.g., species of Littorinidae, Cook & Freeman 1986, and Reid 1986, are considered marine and are not dealt with in this report.) McMichael's (1956) statement that "New Guinea remains virtually an unexplored territory as far as this group of mollusks [fresh water mussels] is concerned" remains true not only for mussels, but also, to a large extent, for the whole fresh water molluscan fauna. It is not possible to estimate the total number of species in the fauna, nor to make any useful statements about their distributions.

ECOLOGY AND DIVERSITY

The basic systematics of the PNG fauna are inadequately known, but the distribution of particular taxa and the ecological factors determining those distributions are hardly known at all.

An important contribution that begins to address these questions, although dealing with only a small part of the fauna and with only a very few localities (all except one being in low altitude coastal regions), has been made by Andrews and Little (1982). Their conclusions are imprecise but not unexpected. They provide a starting point for identifying regions of high land snail diversity: the highest numbers of Cyclophoridae in PNG occur in association with soils of pH 8 or above, on limestone, below 100 m elevation, and in areas with average rainfall of 200-500 cm yr^{1} and a minimum of about 15 cm each month. Because of the need for calcium for shell formation, it is not unreasonable to suppose that land snail diversity will generally be greater in limestone areas with high soil pH.

It is, therefore, not possible as yet to make sophisticated assessments of likely areas of high relative diversity or endemism, either on the basis of the known distributions of taxa, or on the basis of variation in the abiotic or biotic characteristics of the region.

MAJOR GAPS IN KNOWLEDGE

Essentially, our only knowledge of the fauna is of the basic traditional taxonomy and systematics of perhaps half of the species, and of their distributions as represented trivially by the very few specimens, often with poor locality data, on which the taxonomy and systematics are based. None of these data have been collated, and distribution maps have yet to be produced; it is therefore not yet possible to assess whether even a few areas have been anything like adequately sampled. Nevertheless, the most striking gaps in our knowledge almost certainly relate to interior highland areas, slugs, and, probably, fresh water systems. But even the distributions of the relatively better known lowland land snails are inadequately documented (e.g., *Papustyla pulcherrima*, the Manus Green Tree Snail, Luxmoore et al. 1988).

FUTURE RESEARCH

It is tempting to suggest that extensive faunal surveys, especially of remote areas, followed by full taxonomic evaluation of the material collected, should be undertaken to provide a baseline assessment of diversity throughout PNG. However, this would be a vast task requiring many years and enormous manpower. Nevertheless, as a preliminary baseline for future work, the meagre published distributional data must be combined with unpublished information available from museum collections to produce basic maps of species distributions of both the terrestrial and freshwater faunas. Of course, such maps will necessarily have huge gaps in areas where adequate collecting has not been undertaken, and will only provide a coarse starting point.

Extensive field surveys will not allow rapid assessment of priority areas for conservation, but detailed study of the faunas of selected areas, after the methods of Andrews and Little (1982), but with greater emphasis on accurate assessment of diversity in relation to biotic and abiotic environmental characteristics, would allow the main determinants of molluscan diversity to be identified (at least for land snails). With this background, localities coming within the limits of the parameters circumscribing high diversity could be identified for conservation. No obvious "indicator" species stand out, but the Papuininae are colorful, relatively large land snails that could perhaps be focused upon with the identification of possible indicator species or higher taxa in mind.

Fresh water snails are more difficult, since probably even less is known of possible factors influencing their distributions. Turner and Roberts (1978) recorded wide distributions of certain species in the Fly River, and, although their molluscan data were based on very limited sampling (of molluscs obtained from the guts of fish collected during an ichthyological survey), they did demonstrate the value of interdisciplinary collaboration in survey work.

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CONSERVATION NEEDS

Clearly, with knowledge of the PNG non-marine molluscan fauna being so limited, definition of precise and detailed conservation needs is not possible. Nevertheless, certain key issues should be addressed, as follows:

1. A detailed assessment of distributions should be obtained by mapping localities from taxonomic publications and from museum collections, especially those of The Natural History Museum (London), The Australian Museum (Sydney), the Queensland Museum (Brisbane), the Museo Civico di Storia Naturale "Giacomo Doria" (Genoa), the Naturhistorischen Museum Wien (Vienna), and the Museum of Comparative Zoology (Harvard). Other museums that have significant material include the Academy of Natural Sciences (Philadelphia), the Field Museum of Natural History (Chicago), the National Museum of Victoria (Melbourne), the Senckenberg Museum (Frankfurt am Main), the Museum of Zoology, University of Michigan (Ann Arbor), the United States National Museum (Washington, DC), and the Zoologischen Museum (Berlin). In addition, large amounts of material from Irian Jaya are held in the Zoologisch Museum (Amsterdam) and the Rijksmuseum van Natuurlijke Historie (Leiden).

2. Identification of poorly known areas for basic survey work will follow from (1) and will certainly involve interior, highland regions. Surveys should be undertaken in these areas, and, for fresh water Mollusca at least, the major drainage basins should be surveyed.

3. A concentrated effort to assess the abiotic and biotic determinants of land snail diversity in the better known and most accessible areas should allow generalizations that would lead to more rapid identification of potential areas of high diversity that remain poorly known malacologically. Identification of "indicator" species seems unlikely.

4. Regions of high malacological diversity, identified in (3), may or may not coincide with regions of high diversity of other faunal and floral constituents. But it will be important to coordinate analysis of overall diversity in order to identify regions of more general biotic diversity.

5. Even prior to assessments as in (4), controls must be in place to ensure that agricultural and forestry (logging) operations do not impact large areas of rain forest of potential conservation significance.

6. Strict quarantine measures to prevent the introduction of potentially damaging alien species are essential, and include not only inspection of people entering PNG, but also inspection of agricultural, horticultural, and forestry products. Of particular concern to PNG is the giant African land snail, *Achatina fulica*. This species has been introduced to PNG (Mead 1979), and in some areas has become the dominant land snail (Scrimgeour 1984), possibly outcompeting native species. Attempts should be made to restrict its spread to as yet unaffected areas, but introduction of carnivorous snails (e.g., *Euglandina rosea*) should NOT be considered, as there is no evidence that they control *Achatina fulica*, and they constitute a potentially devastating threat to native snail faunas (Cowie 1992). Other

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introduced snails may become agricultural pests or be disease vectors, as well as impacting native vegetation or outcompeting native snails (e.g., *Pomacea* sp., a freshwater snail recently introduced to PNG -- a potentially serious rice pest and a possible vector of certain human diseases).

7. Shell collectors and dealers do not seem to constitute a significant general problem as yet, although collecting may indeed pose a threat to certain species (e.g., *Papustyla pulcherrima*, Luxmoore et al. 1988). However, collecting and export of shells from PNG should be by permit only, and monitoring of the trade should be improved. There is a need for increased public awareness, among both PNG nationals and foreigners, of current (for *Papustyla pulcherrima*) and future legislation restricting export of shells. If possible, other governments should restrict import of shells. (Import of *Papustyla pulcherrima* into the U.S. is prohibited, Luxmoore et al. 1988).

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Chapter Eighteen

Biodiversity and Conservation of Freshwater Wetlands in Papua New Guinea

Patrick L. Osborne[1]

SUMMARY

Papua New Guinea is predominantly a wet country with rainfall in some areas in excess of 10,000 mm per year, and most of the country receives annual rainfall of between 2500 and 3500 mm. The relief is generally rugged and mountainous except in the southwest and along the banks of the lower reaches of the larger rivers. In the upland regions rivers are usually turbulent, fast-flowing, and turbid. Aquatic plants are generally sparse or absent, and the fish fauna this habitat supports include eel-tailed catfishes, rainbowfishes, hardyheads, grunters, gudgeons, and gobiids. In their lowland reaches (below ca. 30 m above sea level) most rivers form central features of extensive wetlands. There are over 5000 lakes in Papua New Guinea, each with a surface area greater than 0.1 ha; 70.5% of these lakes are less than 6 ha in area. Lake Murray, Chambri Lake, and Lake Wisdom are the largest with surface areas of 64,700, 21,600, and 8590 ha respectively. Twenty-one out of the twenty-four largest lakes are less than 30 m above sea level. The three large lakes which are not situated in the lowlands are Lake Wisdom (180 m above sea level [asl]), Lake Kutubu (808 m asl), and Lake Dakataua (100 m asl). The great majority of lakes (88.3%) are situated at 40 m or less, reflecting the fact that most lakes are associated with the floodplains of the major rivers, particularly the Fly and the Sepik.

The vegetation of the lowland wetlands can be classified into herbaceous swamps, savanna swamps, woodland swamps, and swamp forests. Lower montane and upper montane swamps are largely herbaceous, but some pockets of swamp forest are found in the lower montane zone. Two exotic aquatic weeds are now widespread, but biological control of one of them (*Salvinia molesta*) in the Sepik and other wetlands has been successful.

The fish fauna (316 species plus 13 introduced species) is largely derived from marine ancestors. The distribution of the purely freshwater species can be divided into two major zoogeographic provinces, one north of the central cordillera, the other to the south. The southern province is more species rich, reflecting its long, relatively stable history. The fish fauna within this province shows a close affinity with northern Australia, with about 33 species being shared between these two areas. It appears likely that the northern fauna

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[1] University of Western Sydney, Richmond, New South Wales, Australia.

evolved from ancestral species that became isolated by the geological uplift that produced the central cordillera. No indigenous fishes have been found above an elevation of 1800 m. The introduced *Oreochromis mossambica* provides an important source of protein to villagers living along the Sepik River. *Tilapia rendalli* has recently been introduced to the Sepik, and the Common Carp (*Cyprinus carpio*) is well established in the Sepik and lakes throughout the highlands. *Oncorhynchus mykiss* (Rainbow Trout), introduced to the Central Highlands in 1952, are present in the upper Strickland River, and *Salmo trutta* (Brown Trout) also occur in streams of the Central Highlands. Fish introductions is a controversial topic, and this report recommends a moratorium be placed on all further introductions and in-country intercatchment transfers.

Of the three orders of amphibians, neither caecilians nor salamanders occur in Papua New Guinea. Frogs (Anura: five families) are well represented, with more than 200 species described at present. The majority of species are endemic to either Papua New Guinea or the island of New Guinea. The surrounding islands have, in general, a depauperate amphibian fauna in comparison with the adjacent mainland. Reptiles are represented by two species of crocodiles, 150-200 species of lizards, 90-95 species of snakes and 11 species of tortoises and turtles. The crocodile species are found throughout the low lying wetlands, and crocodile farming is an important village based activity. Over 700 species of birds are listed for New Guinea and 115 are waterfowl, with six of these endemic to Papua New Guinea. Of the native mammals, only four water rats are regarded as wetland species.

Most wetlands in Papua New Guinea are in pristine condition, but one has been markedly altered by sewage disposal, and others are under threat from mine tailings disposal. There is an urgent need to carry out floral and faunal surveys of wetlands in Papua New Guinea to identify areas worthy of conservation. A thorough study of the effects of heavy metals on tropical wetlands is also urgently needed. No significant studies on the impact of forestry (either clear felling or selective logging) on wetlands have been undertaken. The impact of introduced species, especially aquatic plants and fish, needs additional assessment and, until this is carried out, further introductions should be prohibited.

Papua New Guinea is not yet party to the World Heritage Convention or the Ramsar Convention. Papua New Guinea should sign both these conventions. Many wetland areas in Papua New Guinea should be designated as Ramsar sites. Lake Kutubu should be considered for World Heritage listing on the basis of its scenic beauty, flora, and fauna. Lake Dakataua should also be considered as a World Heritage site, although criteria for such consideration would probably not include the composition of its wetland fauna and flora.

INTRODUCTION

The following definition of freshwater wetland has been adopted for the purpose of this study: A freshwater wetland is any area of marsh, savanna, forest, peatland, or open water, whether artificial, permanent or seasonal, with water that is either static or flowing. Conservation of biodiversity within such specified habitats will require that representative areas be delineated, such that the range of wetland organisms inhabiting them are afforded

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suitable protectior. Consequently, wetlands identified may not necessarily be "hotspots" of diversity, but ma/ contain, within a possibly sparse fauna and flora, species that are either endemic to the wetland or have a restricted distribution. Since the ecology of a wetland is so intimately linked with its catchment area, adequate protection will be achieved only through the implementation of conservation measures within the wetland basin as a whole.

Scott (1989) lists 33 (some marine) wetland sites and areas, and provides information on their geographical setting, fauna and flora, land tenure, conservation measures, habitat disturbances, and threats. Osborne (1989; in press a, b) reviews wetland research in Papua New Guinea, and Osborne (1988) provides abstracts of 174 publications in a bibliography of freshwater ecology in Papua New Guinea. Many of the papers cited have a strong bias towards applied ecology: aquatic weed control, fish introductions and fisheries, mercury content in fish and sediments, environmental impact assessments, and eutrophication. An appendix to this bibliography provides an incomplete list of publications on the taxonomy of freshwater organisms.

WETLANDS IN PAPUA NEW GUINEA

Major wetland areas in Papua New Guinea are shown in Figure 18-1. Aquatic habitats in Papua New Guinea can be classified into the following: lowland rivers, blackwater streams, upland tributaries, torrential mountain streams, floodplain lakes and backswamps, upland lakes, high altitude lakes and tarns, herbaceous swamps, swamp savanna, swamp woodland, swamp forest, and montane wetlands.

The very large lowland rivers are slower flowing and meander across broad floodplains. These floodplains constitute the largest areas of wetland in the country, and consist of a mosaic of oxbow lakes, backwaters, herbaceous and forested swamps, and large areas of open water (e.g., Lake Murray and Chambri Lake). Upland streams generally flow through dense rain forest, and flow rates and discharges are highly variable. As a result of the high rainfall and rugged topography, most upland rivers in Papua New Guinea have large flow volumes and high sediment loads, and are generally fast flowing and turbulent. Few aquatic organisms survive in this habitat. The current New Guinea altitude record for a native fish species (*Oxyeleotris wisselensis*) is 1750 m from a site in Irian Jaya (Allen 1991).

Chambers (1987) recorded a total of 5383 freshwater lakes with a surface area greater than 0.1 ha. The lakes are mostly small, with only 22 having a surface area greater than 1000 ha (Table 18-1). Lake Murray is by far the largest (64,700 ha.), some three times greater in area than the next largest (Chambri Lake) (Figure 18-1). However, these two lakes are both shallow (Lake Murray: maximum depth ca. 9 m, mean depth ca. 5 m; Chambri Lake: maximum depth ca. 6 m), and contrast markedly with the depth of caldera Lakes Wisdom (360 m) and Dakataua (120 m) (Figure 18-1). Over 80% of the lakes lie below 40 m altitude reflecting their association with the floodplains of large rivers (Table 18-1).

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WETLAND FLORA

Paijmans (1976) recognized three categories of freshwater wetland vegetation, and subdivisions within these are summarized below.

Lowland Freshwater Swamps

Aquatic vegetation: This type consists of free floating, floating-leaved, and submerged plants. These either form a mixture or are arranged in concentric zones. They occupy the shallow margins between open water and grass swamp, and in places cover entire lakes that have a uniform depth. Representative species include *Azolla pinnata*, *Pistia stratiotes*, *Ceratophyllum demersum*, *Ipomoea aquatica*, *Utricularia* spp., *Nymphoides indica*, *Nelumbo nucifera*, *Nymphaea dictyophlebia*, *N. pubescens*, and *Ludwigia adscendens*.

Herbaceous swamp vegetation: Herbaceous communities consisting of sedges, herbs, and ferns are characteristic of stagnant, permanent, relatively deep swamps. Common species include *Thoracostachyum sumatranum*, *Scleria* sp., *Hanguana malayana*, and the fern *Cyclosorus interruptus*. *Phragmites karka* often dominates along gently sloping swamp margins, whereas *Pseudoraphis spinescens* and *Ischaemum polystachyum* form narrow bands along more steeply sloping, wet-dry margins.

Leersia grass swamp: Grasses such as *Leersia hexandra*, *Echinochloa stagnina*, *Oryza* spp., *Panicum auritum*, and *Hymenachne amplexicaulis* occupy permanently swampy river plains that may be under three meters of water in the flood season. Herbs such as *Polygonum* spp., *Ludwigia* spp., and *Ipomoea aquatica* may be anchored in the grass mat and reach out over open water.

Saccharum-Phragmites grass swamp: Tall swamp grasses, mainly *Saccharum robustum* and *Phragmites karka*, grow in swamps that are shallower than those described above, and may be intermittently dry.

Pseudoraphis grass swamp: *Pseudoraphis spinescens* is a low, creeping swamp grass that is most extensive in southwestern Papua New Guinea. Here it forms dense, almost pure stands on flood plains that are seasonally dry.

Mixed swamp savanna: This is a transitional vegetation type between purely herbaceous swamps and swamp woodland; it occurs in permanent, stagnant swamps. In addition to an herbaceous cover, there is an open layer of trees such as *Nauclea*, *Campnosperma*, *Syzygium*, and *Melaleuca*.

Melaleuca swamp savanna: *Melaleuca* swamp savanna is characteristic of the fluctuating backswamps of the middle Fly and Strickland Rivers, and also occurs along parts of the monsoonal south and southwest coasts. *Melaleuca* trees form an open, almost pure, canopy. In the wet season, *Melaleuca* swamp savanna is inundated and colonized by aquatic plants.

Mixed swamp woodland: In permanent swamps the tree story of mixed swamp woodland is generally open and ranges from low to tall. Common trees are *Campnosperma* spp., *Nauclea coadunata*, *Mitragyna ciliata*, and *Timonius* spp. Palms and pandans fill in much of the space below the trees, and *Hanguana malayana*, sedges, and *Cyclosorus interruptus* form a dense ground cover.

Sago swamp woodland: The sago palm, *Metroxylon sagu*, is a widespread tall palm that grows in more or less permanent swampy woodland. All gradations occur from stands of pure sago to woodland, with a dense layer of trees and an open lower tier of sago. The palm grows best where there is a regular influx of freshwater.

Pandan swamp woodland: Swamp pandans occupy a habitat similar to that of sago palm, but have a wider range. They form open to quite dense, pure stands in shallow, fresh to brackish, stagnant to frequently flooded swamps.

Mixed swamp forest: This is the most common type of swamp forest. It generally has an open but occasionally dense, canopy. Some of the commoner trees include *Campnosperma* spp., *Terminalia canaliculata*, *Nauclea coadunata*, *Syzygium* sp., *Alstonia scholaris*, *Bischofia javanica* and *Palaquium* sp.

Campnosperma swamp forest: The densest stands of *Campnosperma* (*C. brevipetiolta* and *C. coriacea*) are found in permanently flooded backswamps. Sago may form a dense understory.

Terminalia swamp forest: This type is mainly found in North Solomons Province where *Terminalia brassii* grows together with *Campnosperma* spp., and locally dominates in the canopy of open swamp forest. It is found in low-lying, frequently flooded, bouldery and sandy rivers, and peat swamps with flowing water.

Melaleuca swamp forest: *Melaleuca* swamp forest is mainly confined to monsoonal southwestern Papua New Guinea, where it occurs in narrow bands in seasonally dry swamps along rivers. The main species is *Melaleuca cajuputi*.

Lower Montane Zone

Sedge grass swamp: Communities dominated by sedges and grasses occur above about 1800 m in swamps occupying intermontane basins, local depressions in valley floors, and seepage slopes. Many different sedges are present, and they commonly make up most of the ground cover. Characteristic grasses are *Arundinella furva*, *Isachne* spp., and *Dimeria* spp.

Phragmites grass swamp: *Phragmites karka* commonly forms pure stands in seepage areas on slopes and on flat valley floors to over 2500 m. *P. karka* also occurs associated with *Miscanthus floridulus* along river banks and swamp margins.

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Swamp forest: Lower montane swamp forest grows in small patches fringing intermontane basins. The forest has a low and open canopy over a dense layer of small trees and shrubs, and a sparse herbaceous ground cover. Common trees include *Syzygium*, *Garcinia*, and locally *Nothofagus perryi*.

Upper Montane Zone

Herbaceous swamp vegetation: Herbaceous communities consisting of a mixture of low herbs, sedges, grasses, and mosses occupy depressions, fringe open water, and, in the higher parts of the zone, also occur on slopes. Common grasses include: *Anthoxanthum angustum*, *Agrostis reinwardtii*, and *Monostachya oreoboloides*. The sedge *Carpha alpina* and the fern *Gleichenia vulcanica* locally form pure stands. Common shrubs include *Leucopogon*, *Drapetes*, *Vaccinium*, and *Trochocarpa*. There are few aquatic plant species in the alpine zone. *Isoetes stevensii* grows in shallow alpine tarns on Mt. Giluwe (3300 m) and on Mt. Sarawaket. *Scirpus crassiusculus* grows in slow moving streams and alpine tarns up to 3900 m. *Callitriche palustris* has been collected from lakes and tarns on Mts. Wilhelm, Giluwe, and Hagen up to 4100 m.

Taylor (1959), from his study of lowland swamps in northeastern Papua New Guinea, recognized eight groups of lowland swamp communities. The main factors differentiating his groups were the type of water (whether fresh, brackish, or salt), and the depth, duration, and frequency of flooding. The following freshwater sequences were recognized: permanent swamps (swamp forest, swamp woodland, swamp savanna, herbaceous swamp [sedge]); fluctuating swamp sequence (seasonal swamp forest, open seasonal swamp forest, seasonal swamp woodland, herbaceous swamp [tall grass]); semiseasonal swamp sequence (seasonal swamp forest, open seasonal swamp forest, seasonal swamp woodland, herbaceous swamp [sedge]); and seasonal swamp sequence.

WETLAND FAUNA

No systematic or comprehensive surveys have been made of the fauna of any wetland in Papua New Guinea. The vertebrate fauna is relatively well-known, but there is very little information on the distribution and habitat requirements of invertebrates. It is, however, pertinent to note that the very lack of such information reflects the present state of knowledge of the majority of wildlife species in Papua New Guinea.

Twelve zooplankton species have been recorded from the lakes on Mount Wilhelm (Bayly and Morton 1980, Löffler 1973, McKenzie 1971). Low species diversity was attributed to the youthfulness of these lakes compared with the diversity of zooplankton in older, high altitude, tropical lakes. Chambers (1988) recorded 51 zooplankton species from three lakes adjacent to the middle Fly River. Taxonomic works on freshwater invertebrates include Holthius (1974, 1982) (Decapoda); Richardson (1977) (leeches); Robertson (1983) (*Macrobrachium*); Benthem-Jutting (1963) (Mollusca); McKenzie (1956) (mussels); and McMichael and Hiscock (1958) (mussels).

The freshwater fish fauna of New Guinea consists of 329 species (Allen 1991). Of this total, 13 species are introduced forms, and about 102 species are fishes that are believed to have a marine larval stage and are relatively widespread outside New Guinea. In general, the fish fauna of New Guinea is closely related to that of northern Australia. Nearly all the families, most genera, and numerous species are shared between these two areas; two closely related families, Rainbowfishes (Melanotaeniidae) and Blue-eyes (Pseudomugilidae) are unique to the combined region. The freshwater fishes are mainly derived from marine ancestors belonging to the orders Pristiformes, Clupeiformes, Siluroidiformes, Beloniformes, Syngnathiformes, Mugiliformes, Perciformes, and Pleuronectiformes. The country lacks fish belonging to the true freshwater fishes of southeast Asia; the saltwater barrier demarcated by Wallace's line forms an insurmountable obstacle to their eastward progress (Munro 1967, Allen 1991). Further details of the origin and zoogeography of the New Guinea fish fauna are provided by Allen (1991).

At least 22 species of fishes have been introduced into Papua New Guinea, representing 19 genera, and 11 families from all six continents. Most introductions have been unsuccessful or were never released into the wild. Of the successful introductions, most have had a negligible impact as either food fishes or in the control of mosquitoes (Allen 1991). *Oreochromis mossambica* is an exception, as it now provides the major subsistence source of protein to villagers living along the Sepik River and it is the basis of a thriving commercial fishery on Waigani Lake near Port Moresby. The Common Carp (*Cyprinus carpio*) is well established and abundant in highland lakes, and also constitutes a significant component of catches from the Sepik River system and the wetlands in the Port Morseby area. *Tilapia rendalli* has recently been introduced to the Sepik and Ramu Rivers, but it is still too early to say whether it has been successful (D. Coates pers. comm.). Approval has also been given for the introduction of the Java Carp (*Puntius gonionotus*) to highland streams in the Sepik catchment (D. Coates pers. comm.). Gourami (*Trichogaster trichopterus*) are found in the streams of the Port Moresby area and form an important food fish for people living along the mid-reaches of the Lakekamu River (J. I. Menzies pers. comm.). *Oncorhynchus mykiss* (Rainbow Trout) were introduced to the Central Highlands in 1952 as a food and an angling fish. There are apparently few isolated, self-sustaining populations present in highland streams and lakes. It is present in the upper Strickland River, but apparently not utilized for food by local people. Allen (1991) states that the impact of this fish seems minimal as there are few, often no, native fishes above about 2000 m, where most trout introductions have taken place. However, the impact of this species on the aquatic fauna is unknown. *Salmo trutta* (Brown Trout) also occurs in streams of the Central Highlands, and its status and impact are unknown (Allen 1991).

Allen (1991) regards most of the earlier introductions as having had a negative impact through competition for space and limited food resources, or by feeding on native species. Even the popular *Oreochromis mossambica* has adversely affected the environment, creating turbid conditions in formerly clean lakes and overcrowding the indigenous fauna due to its prolific breeding. On the positive side, the number of established introductions is relatively few, and Allen (1991) states that the Fly River appears to be free of introductions. Coates (in litt.), however, indicated that Common Carp (*Cyprinus carpio*) occur in the Fly River, and furthermore, that he recorded the Climbing Perch (*Anabas testudineus*) from the Fly

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River in 1985. Allen (1991) indicates that the latter species has only been recorded from the Morehead River, but points out that this hardy fish is capable of migrating long distances overland. The fish fauna of New Guinea sets it apart from that of the Indonesian Archipelago lying west of "Weber's Line," and Allen (1991) regards it as "particularly sad to witness the introduction of fishes from the Indonesian side of the Line."

Of the three orders of amphibians, neither caecilians nor salamanders occur in Papua New Guinea. Frogs (Anura: five families) are well represented, with more than 200 species described at present, and new species being recognized as current research proceeds. Not all species are aquatic: a large number are forest dwellers which burrow beneath the surface, or live beneath leaf litter. The majority of species are endemic to either Papua New Guinea or the island of New Guinea. A southern group having its origins in Australia can be recognized, as can a group of species originating from the Solomon Islands to the southeast. The surrounding islands have, in general, a depauperate amphibian fauna in comparison with the adjacent mainland. The five families are Bufonidae (one introduced species: *Bufo marinus*), Hylidae (about 70 species, all have an aquatic larval stage and, therefore, all should be regarded as part of the wetland fauna), Leptodactylidae (about 5-10 species, *Lechriodus melanopyga* is the only wetland species), Microhylidae (about 90 species, but only *Sphenophryne palmipes* and *Sphenophryne macrorhyncha* are aquatic, inhabiting mountain streams as adults, but do not have aquatic larvae) and Ranidae (about 10-15 species with the six species of *Rana* as part of the wetland fauna (Menzies pers. comm.).

Reptiles are represented by two (possibly three) species of crocodiles, 150-200 species of lizards, 90-95 species of snakes, and 11 species of tortoises and turtles. The two currently recognized species of crocodile are the New Guinea or Freshwater Crocodile, *Crocodylus novaeguineae*, and the Estuarine or Saltwater Crocodile, *Crocodylus porosus*. Both species are still found in relatively large numbers and are heavily exploited for hides and meat. The endemic Freshwater Crocodile is the commoner species, though less widespread. It is restricted to the mainland, whereas the Estuarine Crocodile is also found on most of the surrounding islands. The Freshwater Crocodile prefers a freshwater environment, but is occasionally found in brackish waters such as the Fly delta. It is more often found in sluggish, shallow water rather than fast flowing or deeper areas (Burgin 1980a). The Estuarine Crocodile characteristically occurs in brackish areas such as estuaries and mangroves. Although once thought to be restricted to the coastal tidal areas, the species is now known to occur well inland. The inland populations are generally associated with freshwater pools and deep rivers, but the species has been recorded from fast flowing rocky streams up to 1000 km inland (Burgin 1981). *C. porosus* is relatively easy to hunt as its nests are easy to locate, and as a consequence, it is now rare in the large mangrove areas of Gulf and Western Provinces and also in East and West Sepik Provinces, where it was once apparently common.

Numbers of both species declined during the late 1950s and 1960s through indiscriminate hunting. In 1969 the Crocodile Trade (Protection) Act (Chapter 213) was implemented, placing a ban on trade in skins greater than 51 cm belly width. This halted further decline in crocodile numbers, as indicated by a steady level of export during the 1970s. In 1981 a ban was placed on trade in skins smaller than seven inches. This ban was established because Papua New Guinea was in a position to ranch crocodiles on a large scale (Bolton 1978, Bolton and Laufa 1979, Burgin 1980b). By 1984, although the number of skins exported was the same as in previous years, 30% were from ranched animals and consequently were of higher grade and greater size. In 1982, extensive monitoring of both species commenced, especially in the Ambunti District of the East Sepik Province. Between 1982 and 1985, the number of *C. porosus* nests virtually doubled in this area, indicating the effectiveness of the management policy.

Of the 150-200 species of lizard belonging to five families, only certain members of the dragon lizards (Agamidae) and monitors (Varanidae) are habitually associated with water. The Water Monitor, *Varanus indicus*, and Gould's Monitor, *V. gouldii*, appear to be equally at home in freshwater or on land, although their food habits show them to be primarily land animals.

Of the six families of snakes recorded from Papua New Guinea, three are typically aquatic and can be expected in the still and slow flowing waters of the lowlands. The file-snakes (Acrochordidae) include one or two genera, with two or three species according to taxonomic opinion. The water-snakes of the family Colubridae (genera *Tropidonophis*, *Cerberus*, *Enhydris*, *Fordonia* and *Myron*) are regular inhabitants of wetlands, though the family also includes many species restricted to land. Sea-snakes (Hydrophiidae) are represented by just over 20 species in eight genera. These are all marine, although *Enhydris* and *Schistosa* have been recorded in some northern rivers away from the sea. Several species are frequently seen in shallow water over reefs and presumably occur in mangrove waters.

There are six species of marine turtles in the seas around Papua New Guinea, and two species of freshwater turtles, the Pit-shelled Turtle, *Carettochelys insculpta*, and the Soft-shelled Turtle, *Pelochelys bibroni*. Both freshwater turtles are found in freshwaters south of the central cordillera; *C. insculpta* is almost totally restricted in distribution to southern Papua New Guinea, while *P. bibroni* is found also in the freshwaters of the Sepik wetlands and occurs west through Indonesia to India. Five species of tortoises (Chelidae) occur in the freshwater wetlands of Papua New Guinea (Goode 1967). Four of these are found only south of the central cordillera, and are inhabitants mainly of still or slow flowing water bodies. *Elseya novaeguineae* and *Chelodina siebenrocki* are endemic to New Guinea, and *Chelodina parkeri* is endemic to the Fly River basin and coastal areas.

The avifauna of Papua New Guinea is relatively well documented, e.g., Beehler and Finch (1985) and Beehler *et al.* (1986). Of the 708 species of birds listed for New Guinea, some 115 are waterfowl, and all but three of these occur in Papua New Guinea. Seven species are endemic to the New Guinea region: the Forest Bittern *Zonerodius heliosylus*, Salvadori's Duck *Anas waigiuensis*, four mountain forest rails of the genus *Rallina* (*R. rubra*, *R. leucospila*, *R. forbesi*, and *R. mayri*), and the New Guinea Flightless Rail, *Megacrex inepta*. All are present in Papua New Guinea except for *R. leucospila*, which is confined to the mountains of the Vogelkop peninsula in Irian Jaya. About 52 species of waterfowl are breeding residents; the remainder are either passage migrants and winter visitors from Asia (over 40 species) or dry season visitors from Australia (about 20 species).

The breeding waterfowl include two grebes, two cormorants, *Anhinga novaehollandiae*, about 12 species of herons and egrets, *Ephippiorhynchus asiaticus*, *Anseranas semipalmata*, nine species of ducks, 15 species of Rallidae, *Grus rubicunda*, *Irediparra gallinacea*, and six species of shorebirds (including the woodcock *Scolopax saturata*). The great majority of passage migrants and winter visitors from Asia are shorebirds (30 regular species and seven vagrants). Several of these occur in very large numbers en route to and from the wintering areas in Australia. Other northern migrants occurring in significant numbers include *Ixobrychus sinensis*, *Anas querquedula*, *Chlidonias leucoptera*, *Sterna hirundo*, and *S. albifrons*. Regular migrants from Australia include *Pelecanus conspicillatus*, several herons and egrets, *Threskiornis molucca*, *Carphibis spinicollis*, *Plegadis falcinellus*, *Platalea regia*, *Haematopus longirostris*, *Stiltia isabella*. *Charadrius cinctus*, *Larus novaehollandiae*, *Chlidonias hybrida*, and *Hydroprogne caspia*. In addition, several species which breed in Papua New Guinea also occur as common dry season visitors from Australia.

There are no less than 22 species of kingfishers (Alcedinidae) in New Guinea, but many of these are birds of forest or savanna, and not particularly associated with water.

Of the 190-200 species of mammals occurring in Papua New Guinea, only four can be clearly tied to the presence of water; two species of lowland water-rat, *Hydromys chrysogaster* and *H. neobrittanicus*, and two upland species, *Crossomys moncktoni* and *Hydromys habbema*. These occur in slow flowing and fast-flowing rivers, particularly with clear water, but are not common elements of the wetland fauna. Mention should also be made of the introduced deer, the Javan Rusa, *Cervus timorensis*, which occurs in large numbers in the seasonally-flooded Trans-Fly area, and in lesser numbers in wetland areas near Port Moresby. These populations are typically swamp dwellers.

ASSESSMENT OF BIOLOGICALLY IMPORTANT AREAS

Low Altitude Wetlands

Fly and Strickland Rivers: The Fly Platform is the largest tract of low-lying land in Papua New Guinea and is drained by the Fly and Strickland Rivers (Figure 18-1). The Fly River, although only 1200 km long, is, on discharge, so large (mean: 6000 m^3 sec^{-1}) that it ranks with the world's great rivers. The gradient in its lower course is extremely gentle, as the river port of Kiunga, 800 km from the sea, is only 20 m above sea level. The river is tidal for 240 km upstream. Rainfall in the upper catchment regularly exceeds 10 m per annum, and, in floods the river level may rise by up to 10 m. In the south, the area is gently undulating and flat areas are poorly drained and swampy. The middle Fly floodplain, 15-20 km wide, is a mosaic of lakes, alluvial forest, swamp grassland, and swamp savanna. The river flows on an alluvial ridge formed by deposition of material eroded from the upper catchment, and as this deposition was more rapid than that of tributary streams, the tributaries became blocked forming numerous tributary lakes (e.g., Bosset Lagoon and Lake Daviumbu). The river meanders extensively in this region, and, in addition to tributary lakes, there are numerous backswamps and oxbows of variable depth depending on age (Figure 18-1).

Besides ten endemic species of fishes, the region is characterized by 33 species that are shared with northern Australia. Ninety-eight species of fish have been recorded (or are very likely to occur in this region) and these are listed below.

* Endemic to the Fly-Strickland Rivers
** Endemic to Strickland (upper)

Pristis microdon, *Scleropages jardinii*, *Megalops cyprinoides*, *Anguilla marmorata*, *Anguilla reinhardti*, *Clupeoides papuensis*, *Clupeoides venulosus*, *Nematolosa flyensis**, *Nematolosa papuensis**, *Thryssa rastrosa**, *Thryssa scratchleyi*, *Chanos chanos*, *Arius augustus**, *Arius berneyi*, *Arius carinatus*, *Arius crassilabris*, *Arius graeffei*, *Arius latirostris*, *Arius leptaspis*, *Arius macrorhynchus*, *Arius taylori**, *Arius* sp., *Cinetodus froggatti*, *Cochlefelis danielsi*, *Cochlefelis spatula*, *Dolichthys novaeguineae*, *Nedystoma dayi*, *Neosiluris ater*, *Neosiluris brevidorsalis*, *Neosiluris equinus*, *Oloplotosus luteus**, *Oloplotosus mariae*, *Plotosus papuensis*, *Porochilus meraukensis*, *Porochilus obbesi*, *Arrhamhus sclerolepis*, *Zenarchopterus novaeguineae*, *Strongylura kreffti*, *Iriatherina werneri*, *Melanotaenia goldiei*, *Melanotaenia iris***, *Melanotaenia maccullochi*, *Melanotaenia oktediensis**, *Melanotaenia sexlineata**, *Melanotaenia splendida rubrostriata*, *Kiunga ballochi**, *Pseudomugil gertrudae*, *Pseudomugil inconspicuus*, *Pseudomugil novaeguineae*, *Pseudomugil paskai*, *Craterocephalus nouhuysi**, *Craterocephalus randi*, *Lates calcarifer*, *Ambassis agrammus*, *Ambassis interruptus*, *Ambassis macleayi*, *Denariusa bandata*, *Parambassis gulliveri*, *Amniataba affinis*, *Hephaestus fuliginosus*, *Hephaestus habbemai*, *Mesopristes argenteus*, *Mesopristes cancellatus*, *Pingalla lorentzi*, *Varia lacustris*, *Kuhlia rupestris*, *Kuhlia marginata*, *Glossamia aprion*, *Glossamia narindica*, *Glossamia sandei*, *Glossamia trifasciata*, *Caranx sexfasciatus*, *Lutjanus goldiei*, *Datnioides quadrifasciatus*, *Toxotes chatareus*, *Toxotes lorentzi*, *Crenimugil heterocheilus*, *Bostrichthys strigogenys*, *Hypseleotris compressa*, *Mogurnda cingulata*, *Mogurnda mogurnda*, *Oxyeleotris aruensis*, *Oxyeleotris fimbriata*, *Oxyeleotris herwerdenii*, *Oxyeleotris nullipora*, *Oxyeleotris paucipora*, *Glossogobius concavifrons*, *Glossogobius* sp. 1, *Glossogobius* sp. 2, *Glossogobius* sp. 7, *Glossogobius* sp. 11, *Stenogobius* sp. 3, *Zappa confluentus*, *Taenioides* sp., *Kurtus gulliveri*, *Aseraggodes klunzingeri*, *Synaptura villosa*, *Cynoglossus heterolepis*.

The following birds have been recorded from lowland areas of the Fly platform: *Tachybaptus novaehollandiae*, *Tachybaptus ruficollis*, *Phalacrocorax carbo*, *Phalacrocorax sulcirostris*, *Phalacrocorax melanoleucos*, *Anhinga melanogaster*, *Pelecanus conspicillatus*, *Ardea pacifica*, *Ardea sumatrana*, *Egretta alba*, *Egretta picata*, *Egretta intermedia*, *Egretta ibis*, *Egretta novaehollandiae*, *Egretta garzetta*, *Ardeola striata*, *Nycticorax caledonicus*, *Ixobrychus minutus*, *Ixobrychus sinensis*, *Ixobrychus flavicollis*, *Ephippiorhynchus asiaticus*, *Plegadis falcinellus*, *Threskiornis aethiopicus*, *Threskiornis spinicollis*, *Platalea regia*, *Pandion haliaetus*, *Haliaetus leucogaster*, *Anseranas semipalmata*, *Dendrocygna guttata*, *Dendrocygna eytoni*, *Dendrocygna arcuata*, *Tadorna radjah*, *Nettapus pulchellus*, *Nettapus coromandelianus*, *Anas gibberifrons*, *Anas superciliosa*, *Anas querquedula*, *Aythya australis*,

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Rallus philippensis, Rallus pectoralis, Porzana cinerea, Porzana tabuensis, Porzana pusilla, Amaurornis olivaceus, Megacrex inepta, Gallinula tenebrosa, Porphyrio porphyrio, Fulica atra, Grus rubicunda, Irediparra gallinacea, Haematopus longirostris, Himantopus leucocephalus, Stiltia isabella, Vanellus miles, Pluvialus dominica, Erythrogonys cinctus, Charadrius mongolus, Charadrius leschenaultii, Arenaria interpres, Numenius madagascarensis, Numenius phaeopus, Numenius minutus, Tringa glareola, Tringa brevipes, Tringa hypoleucos, Tringa nebularia, Tringa terek, Galinago megala, Galinago stenura, Limosa limosa, Calidris tenuirostris, Calidris acuminata, Calidris ruficollis, Calidris subminuta, Chlidonias hybridus, Chlidonias leucopterus, Chlidonias nilotica, Hydroprogne caspia, Sterna hirundo, Sterna albifrons, Halcyon chloris, Megalurus albolimbatus, Gerygone levigaster, Rhiphidura phasiana, Eopsaltria pulverulenta, Pachycephala melanura, Seleucidis melanoleuca.

Important wetland areas in the Fly-Strickland Catchment

1. Tonda Wildlife Management Area, Bensbach River, Western Province
   Geographical coordinates: 8° 55'S, 141° 30'E.
   Area: 5900 km^2. Altitude: 0-40 m.

This Wildlife Management Area contains a mosaic of swamps, open water, savanna, and gallery forest. The area has abundant wildlife including introduced Rusa Deer, and is an important tourist resort for barramundi fishing and wildlife viewing. It constitutes a very important wetland both for migrating birds and resident waterfowl. In Australian drought years it becomes an important refuge for Australian wetland birds. Sixty-three species of fishes have been recorded from the Bensbach River: *Pristis microdon, Scleropages jardinii, Megalops cyprinoides, Anguilla reinhardti, Thryssa scratchleyi, Chanos chanos, Arius crassilabris, Arius graeffei, Arius latirostris, Arius leptaspis, Arius macrorhynchus, Cinetodus froggatti, Cochlefelis danielsi, Cochlefelis spatula, Dolichthys novaeguineae, Neosystoma dayi, Neosiluris ater, Neosiluris brevidorsalis, Porochilus meraukensis, Arrhamhus sclerolepis, Zenarchopterus novaeguineae, Iriatherina werneri, Melanotaenia goldiei, Melanotaenia maccullochi, Melanotaenia splendida rubrostriata, Pseudomugil gertrudae, Pseudomugil inconspicuus, Pseudomugil paludicola, Pseudomugil tenellus, Craterocephalus randi, Ophisternon gutturale, Lates calcarifer, Ambassis agrammus, Ambassis interruptus, Ambassis macleayi, Denariusa bandata, Parambassis gulliveri, Amniataba affinis, Mesopristes argenteus, Mesopristes cancellatus, Pingalla lorentzi, Varia lacustris, Kuhlia rupestris, Kuhlia marginata, Glossamia aprion, Glossamia gjellerupi, Glossamia narindica, Caranx sexfasciatus, Lutjanus goldiei, Toxotes chatareus, Toxotes lorentzi, Hypseleotris compressa, Oxyeleotris aruensis, Oxyeleotris fimbriata, Oxyeleotris herwerdenii, Oxyeleotris nullipora, Oxyeleotris paucipora, Glossogobius* sp. 1, *Glossogobius* sp. 2, *Kurtus gulliveri, Aseraggodes klunzingeri, Synaptura villosa, Cynoglossus heterolepis.* Reference: Allen (1991).

2. Wassi Kussa River, Western Province
   Geographical coordinates: 9° S, 142° E.
   Altitude: 0-5 m.

A wetland area which is poorly known, but probably with a fauna and flora similar to that of the Bensbach River floodplain.

3. Lake Murray, Western Province
Geographical coordinates: 7° S, 147° E.
Area: 64 km². Altitude: 20 m.

The largest lake in Papua New Guinea with a dendritic outline, giving it a very long shoreline (2038 km). The lake is part of an enormous wetland and is drained by the Herbert River, which flows into the Strickland River. The lake exhibits marked seasonal water level fluctuations, with water levels falling between April and December. The maximum depth of the lake is 7 m, but it has been known to dry up completely. The Herbert River has been shown to reverse flow with water from the Strickland River entering Lake Murray. The aquatic vegetation consists of two zones: an outer zone dominated by *Nymphoides indica* with some *Nymphaea nouchali*, *Ceratophyllum demersum*, and *Blyxa novoguineensis* (endemic to Western Province), and an inner zone of hydrophytic grasses, with *Ipomoea aquatica*, *Azolla pinnata*, and *Utricularia* spp. *Limnophila indica* occurred on newly exposed mud and in shallow water. Other aquatic plants recorded include *Stenochlaena palustris*, *Pistia stratiotes*, *Ipomoea aquatica*, *Echinochloa praestans*, *Ludwigia adscendens*, *Polygonum attenuatum*, *Polygonum orientale*. The catchment area is largely undeveloped with a local population of about 1500 people (1980 census).
References: Kyle and Ghani (1982a, 1982b), Maunsell and Partners (1982), Osborne, Kyle, and Abramski (1987), and Natural Systems Research (1988).

4. Bosset Lagoon, Western Province
Geographical coordinates: 7° 15'S, 141° 5'E.
Area: lake area 16 km². Altitude: 20 m.

A tributary lake (catchment area 230 km²) formed by a tributary stream being blocked through accretion by the Fly River. The lake is connected to the Fly River by a narrow channel, 5 m wide. Seasonal fluctuations in water depth (0-6 m) occur with high lake levels from February to October and generally minimum levels in December. The lake dries out completely occasionally. Mean monthly rainfall varies from 330 mm in March to 74 mm in July. Mean annual rainfall is 2540 mm. The lake is surrounded by herbaceous swamp with *Phragmites karka* and *Saccharum* sp. dominant. The aquatic vegetation includes *Pistia stratiotes*, *Ceratophyllum demersum*, *Nymphaea* spp., and *Utricularia* sp. (see freshwater plant list for Lake Daviumbu). Tailings disposal from the Ok Tedi mine may result in some heavy metal pollution.
References: Maunsell and Partners (1982), Chambers (1988).

5. Lake Daviumbu, Western Province
Geographical coordinates: 7° 36'S, 141° 16'E.
Area: lake area 15 km². Altitude: 20 m.

A tributary lake formed by a tributary stream being blocked through accretion by the Fly River. The lake is connected to the Fly River by a narrow channel 5 m wide. Kaviananga Village is located on the lake shore. Seasonal fluctuations in water depth occur, with high lake levels from February to October and low levels in December. The lake dries out completely occasionally. Mean monthly rainfall varies from about 300 mm in March to

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70 mm in July. Mean annual rainfall is approximately 2300 mm. The lake is surrounded by herbaceous swamp with *Phragmites karka* and *Saccharum* sp. dominant. The diverse aquatic vegetation includes *Azolla pinnata, Pistia stratiotes, Lobelia alisnoides, Ceratophyllum demersum, Cyperus platystylis, Hymenachne acutigluma, Ischaemum polystachyum, Oryza rufipogon, Sacciolepis myosuroides, Hanguana malayana, Blyxa aubertii* var. *aubertii, Blyxa japonica, Blyxa novoguineensis, Blyxa octandra, Pogostemon stellatus* var. *stellatus, Utricularia aurea, Nymphoides indica, Nelumbo nucifera, Nymphaea macrosperma, Nymphaea violacea, Ludwigia octovalvis, Limnophila aromatica, Limnophila indica.* Tailings disposal from the Ok Tedi mine may result in some heavy metal pollution. References: Maunsell and Partners (1982), Osborne *et al.* (1988), Chambers (1988), Kyle (1988a, 1988b).

6. Elevata River, Nume River, Bwe River, and Kaim River floodplains, Western Province
Geographical coordinates: 6°-6° 30'S, 141°-142°E. Altitude: 10-20 m.
A poorly studied area of lowland swamp forest. Dominant tree species include *Campnosperma brevipetiolata, C. coriacea, Terminalia canaliculata, Nauclea coadunata, Syzygium, Alstonia scholaris, Bischofia javanica,* and *Palaquium,* but many other species will be found in this diverse vegetation type.

The Purari River: The Purari River (catchment area 33,670 km^2) drains the central highlands and discharges 2667 m^3 sec^{-1} into the Gulf of Papua through an extensive delta (Petr 1983a). The rainfall on the catchment is high, particularly in the foothills where it reaches 8000 mm per year. This high precipitation, coupled with the high runoff, gives this river system an enormous potential for hydroelectric power generation, and a dam planned for Wabo in the foothills was projected to have an installed capacity of 2160 megawatts. Possible environmental impacts of this proposed dam were assessed in some detail (Petr 1983a), but the scheme has not been developed further. Haines (1979a) recorded 49 species of fishes from 24 families from Purari freshwaters, and Liem and Haines (1977) list 143 species from 58 families from the estuarine area of the Purari Kikori deltaic complex. Only a few species are confined to freshwater, most riverine species being also found in the estuarine zones. Allen (1991) records the following 42 species from the Purari River: *Pristis microdon, Megalops cyprinoides, Anguilla marmorata, Anguilla reinhardti, Chanos chanos, Arius crassilabris, Arius graeffei, Arius latirostris, Arius leptaspis, Arius macrorhynchus, Cinetodus froggatti, Cochlefelis danielsi, Cochlefelis spatula, Doiichthys novaeguineae, Nedystoma dayi, Neosiluris ater, Neosiluris brevidorsalis, Arrhamhus sclerolepis, Zenarchopterus novaeguineae, Chilatherina campsi, Melanotaenia goldiei, Melanotaenia monticola, Craterocephalus randi, Lates calcarifer, Ambassis interruptus, Parambassis gulliveri, Hephaestus fuliginosus, Mesopristes argenteus, Mesopristes cancellatus, Kuhlia rupestris, Kuhlia marginata, Glossamia gjellerupi, Caranx sexfasciatus, Lutjanus goldiei, Toxotes chatareus, Mogurnda pulchra, Mogurnda* sp. 3, *Oxyeleotris fimbriata, Oxyeleotris herwerdenii, Glossogobius bulmeri, Glossogobius brunnoides, Stenogobius* sp. 3.

Laloki/Brown River Wetlands: Thirty-five species of fish have been recorded from the Laloki River: *Pristis microdon, Megalops cyprinoides, Anguilla marmorata, Anguilla*

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reinhardti, Chanos chanos, Arius latirostris, Neosiluris ater, Neosiluris brevidorsalis, Zenarchopterus novaeguineae, Melanotaenia goldiei, Melanotaenia papuae, Craterocephalus randi, Lates calcarifer, Tetracentrum apogonoides, Tetracentrum caudovittatus, Hephaestus trimaculatus, Mesopristes argenteus, Mesopristes cancellatus, Kuhlia rupestris, Kuhlia marginata, Glossamia gjellerupi, Caranx sexfasciatus, Lutjanus goldiei, Toxotes chatareus, Cestraeus goldiei, Mogurnda pulchra, Mogurnda sp. 4, *Oxyeleotris fimbriata, Glossogobius giurus, Stenogobius* sp. 3, *Gambusia affinis#, Poecilia reticulata#, Xiphophorus helleri#, Trichogaster trichopterus#, Oreochromis mossambica#* ("#" indicates introduced species).

The wetlands in this area support large and diverse populations of v· terfowl and other wetland birds. The area is particularly important as a dry season refuge for migrant waterfowl from Australia, and as a staging area for Palearctic shorebirds on their way to and from wintering areas in Australia. The following species are of regular occurrence: *Tachybaptus novaehollandiae, Phalacrocorax carbo, Phalacrocorax sulcirostris, Phalacrocorax melanoleucos, Anhinga melanogaster, Pelecanus conspicillatus, Ardea pacifica, Ardea sumatrana, Egretta alba, Egretta picata, Egretta intermedia, Egretta ibis, Egretta novaehollandiae, Egretta garzetta, Ardeola striata, Nycticorax caledonicus, Ixobrychus minutus, Ixobrychus sinensis, Ixobrychus flavicollis, Plegadis falcinellus, Threskiornis aethiopicus, Threskiornis spinicollis, Platalea regia, Pandion haliaetus, Haliaetus leucogaster, Dendrocygna guttata, Dendrocygna eytoni, Dendrocygna arcuata, Tadorna radjah, Nettapus pulchellus, Anas gibberifrons, Anas superciliosa, Anas querquedula, Aythya australis, Rallus philippensis, Rallus pectoralis, Porzana cinerea, Porzana tabuensis, Porzana pusilla, Amaurornis olivaceus, Gallinula tenebrosa, Porphyrio porphyrio, Fulica atra, Irediparra gallinacea, Himantopus leucocephalus, Vanellus miles, Pluvialus dominica, Erythrogonys cinctus, Charadrius dubius, Tringa glareola, Numenius madagascarensis, Numenius phaeopus, Numenius minutus, Tringa brevipes, Tringa hypoleucos, Tringa nebularia, Tringa stagnatilis, Tringa terek, Gallinago hardwickii, Gallinago megala, Limosa limosa, Limosa lapponica, Calidris acuminata, Calidris melanotus, Calidris ruficollis, Calidris subminuta, Calidris ferruginea, Tryngites subruficollis, Philomachus pugnax, Chlidonias hybridus, Chlidonias leucopterus, Gelochelidon nilotica, Hydroprogne caspia, Sterna hirundo, Sterna albifrons, Halcyon chloris, Gerygone levigaster, Rhiphidura phasiana, Eopsaltria pulverulenta, Pachycephala melanura, Seleucidis melanoleuca.*

7. Waigani Swamp, National Capital District
Geographical coordinates: 9° 22'S, 147° 10'E.
Area: Waigani Lake 120 ha. Altitude: 5 m.

A complex of freshwater, shallow lakes and surrounding swamps associated with the Laloki River. Swamps are permanent, but subject to marked water level fluctuations with high levels from January to April. Waigani Lake receives large quantities of untreated sewage effluent from the city of Port Moresby. This nutrient enrichment has caused major changes in the aquatic flora of Waigani Lake (see Osborne and Leach 1985, Osborne and Polunin 1986). The use of this wetland for sewage disposal has reduced its value in terms of its aquatic flora, but has increased its value in terms of the avifauna (see bird list for Laloki/Brown River wetland). The surrounding swamp is dominated by *Phragmites karka*

and *Typha orientalis*, with some *Ludwigia adscendens*, *Ipomoea aquatica*, and *Hanguana malayana*. *Nymphoides indica*, *Ceratophyllum demersum*, and *Nymphaea pubescens* are present in undisturbed lakes. *Salvinia molesta* occurs on the lake but it is under biological control. *Eichhornia crassipes* was introduced in 1989 and large mats have developed. Other aquatic plants recorded from Waigani Swamp include *Marsilea crenata*, *Ceratopteris thalictroides*, *Acrostichum aureum*, *Ampelopteris prolifera*, *Cyclosorus interruptus*, *Sagittaria platyphylla* (introduced species), *Alternanthera sessilis*, *Pistia stratiotes*, *Cyperus platystylis*, *Eleocharis dulcis*, *Scirpus grossus*, *Hymenachne acutigluma*, *Ischaemum polystachyum*, *Leersia hexandra*, *Hydrocharis dubia*, *Spirodela polyrhiza*, *Najas indica*, *Nymphaea dictyophlebia*, *Ludwigia hyssopifolia*, *Ludwigia octovalvis*, *Polygonum barbatum*, *Monochoria hastata*. The lake is heavily fished for the introduced tilapia *Oreochromis mossambica*. Crocodiles are present but in very small numbers.
References: Neill (1946), Saulei (1978), Schuster (1951); Osborne and Leach (1983), Osborne and Polunini (1986), Polunini, Osborne and Totome (1988), Osborne (1991).

8. Hisiu Lagoon, Central Province
Geographical coordinates: 9° 2'S, 146°45'E.
Area: lake area 0.5 km². Altitude: Near sea level.
Hisiu Lagoon, surrounded by savanna with relatively poor drainage, is about 2 km from the coast. The lagoon usually fills during the wet season (December to April), then slowly dries during the dry season. Depending on the year, large areas of mud are often exposed towards the end of the dry season (September to November). This is an important site for waterfowl and terns in the wet season, and large numbers of Little Black Cormorants and egrets frequent the area. Towards the end of the dry season, large numbers of migrating palearctic waders are attracted if water levels are suitable. In good years up to 6000 waders have been counted, and these include species more usually associated with coastal habitats. Plants recorded include *Ceratopteris thalictroides*, *Alternanthera sessilis*, *Ceratophyllum demersum*, *Ipomoea aquatica*, *Scirpus articulatus*, *Echinochloa praestans*, *Sesbania javanica*, *Nymphoides indica*, *Nymphaea pubescens*.

9. Aroa Lagoon, Central Province
Geographical coordinates: 9° 1'S, 146° 47'E.
Area: Lake area 1.5 km². Altitude: Near sea level.
A large freshwater lagoon set in *Eucalyptus* and *Melaleuca* savanna about 4 km from the coast. The lagoon is seasonal, filling in the wet season (December to April), and slowly drying out during the dry season. Depending on the year, large areas of mud are often exposed towards the end of the dry season (September to November). The swamp vegetation includes a large area of freshwater mangroves (*Excoecaria agallocha*) on the northern side. As the largest freshwater lagoon in the area, it is very important both for resident waterfowl and migrating palearctic waders. In the dry season the lagoon supports vast numbers of Green Pygmy Geese, Spotted and Wandering Whistling Duck, egrets, and Little Black Cormorants. At the end of the dry season it can attract large numbers of waders, particularly if expansive areas of wet mud are exposed.

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10. Lake Iaraguma, Central Province

Geographical coordinates: 9° 16'S, 147° 2'E.

Area: Lake area 2 km^2 but part of a much bigger wetland.

Altitude: Near sea level.

This wetland consists of three separate lakes sometimes forming one, situated in the Laloki and Brown River floodplain. The lakes are bordered to the west by *Eucalyptus* savanna. The three lagoons are of different depths. One is nearly permanent, the second generally tends to dry up in November, while the third generally dries up in September or October. Areas of open water have extensive beds of floating and floating-leaved plants, bordered by emergent swamp vegetation with *Phragmites karka* and *Typha orientalis* dominant. It is an important site for resident waterfowl and, in most years, palaearctic waders on passage. When conditions are ideal this wetland provides habitat suitable for about 2000 palaearctic waders. It also has a good range of lowland tropical wetland plants with the following recorded: *Pistia stratiotes*, *Ceratophyllum demersum*, *Ipomoea aquatica*, *Eleocharis dulcis*, *Nymphoides indica*, *Nymphaea pubescens*, *Hydrilla verticillata* (probably a recent introduction), *Hydrocharis dubia*, *Utricularia aurea*, *Nymphaea nouchali*, and *Typha orientalis*.

11. Kemp-Welch River Wetland, Central Province

Geographical coordinates: 10° 00'S, 148° 00'E.

Altitude: Near sea level.

A poorly known wetland area, but probably supports a species composition similar to that contained in the wetlands associated with the Laloki and Brown Rivers.

12. Borowai Swamp Forest, Milne Bay Province

Geographical coordinates: 9° 30'S, 150° 00'E.

Altitude: Near sea level.

A poorly known area of swamp forest dominated by *Melaleuca* and *Eucalyptus* species.

13. Woodlark Island, Milne Bay Province

Geographical coordinates: 9° 10'S, 153° 00'E.

Altitude: Near sea level.

Two small swamp woodland areas occur on Woodlark Island. An undescribed species of *Diospyros* occurs in the wetland on the south coast (R. Johns pers. comm.). The wetland on the east coast is an herbaceous swamp, but little is known about these wetlands.

The Sepik-Ramu Wetlands: The Sepik River (Figure 18-1) with a catchment of 78,000 km^2, is the longest river in Papua New Guinea (1100 km), although it has a lower annual discharge than the Fly River. Its discharge is reported to range between 4500 $m^3\ sec^{-1}$ and 11,000 $m^3\ sec^{-1}$ (Mitchell *et al.* 1980), although the river is poorly gauged. Flows were recorded in June 1988 by the Royal Australian Navy Hydrographic Service to be 6500 $m^3\ sec^{-1}$. The main river channel is deep (over 35 m at Angoram) and, consequently, so are the more recently formed oxbow lakes in the lower floodplain. The river is navigable by large vessels up to 500 km upstream. The river discharges directly into the sea through a single outlet, and habitats are totally freshwater throughout the river length, and can extend up to 35 km out to sea in the plume. This contrasts markedly with rivers in the

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south, which invariably have extensive deltas and much larger estuarine zones. There are numerous (around 1500) oxbow and other lakes associated with the Sepik floodplain; the largest of these is Chambri Lake (Figure 18-1), which is shallow (maximum depth ca. 6 m) and has a highly variable area of up to 250 km^2 in the flood season. The limnology of the lower river and associated floodplain lakes has been described by Coates *et al.* (1983), the floodplain fishery by Coates (1985b), and the fish fauna by Allen and Coates (1990).

The Ramu River is approximately 720 km long, but it has a relatively small catchment area. Near Brahman Mission, the river flows through an area of lowland swamp forest dominated by *Campnosperma brevipetiolata*. In its lower reaches, the floodplain terrain is very flat and swampy, the fall is imperceptible for a distance of 250 km from its mouth, and the floodplain is interconnected with that of the Sepik River. The Ramu floodplain is a mosaic of swamp forest, sago palm swamp, and herbaceous swamp.

Freshwater plants recorded from the Sepik River include *Azolla pinnata*, *Stenochlaena milnei*, *Stenochlaena palustris*, *Equisetum debile*, *Isoetes habbemensis*, *Nephrolepis biserrata*, *Ceratopteris thalictroides*, *Acrostichum aureum*, *Salvinia molesta*, *Ampelopteris prolifera*, *Cyclosorus interruptus*, *Acorus calamus*, *Lasia spinosa*, *Pistia stratiotes*, *Ceratophyllum demersum*, *Cyperus platystylis*, *Eleocharis dulcis*, *Eleocharis retroflexa*, *Scirpus grossus*, *Scirpus mucronatus* ssp. *mucronatus*, *Scirpus mucronatus* ssp. *clemensii*, *Echinochloa praestans*, *Hymenachne acutigluma*, *Ischaemum polystachyum*, *Leersia hexandra*, *Oryza rufipogon*, *Panicum auritum*, *Panicum paludosum*, *Phragmites karka*, *Hanguana malayana*, *Hydrilla verticillata*, *Hydrocharis dubia*, *Pogostemon stellatus* var. *roxburgianus*, *Pogostemon stellatus* var. *stellatus*, *Aeschynomene indica*, *Sesbania javanica*, *Lemna perpusilla*, *Lemna trisulca*, *Spirodela polyrhiza*, *Utricularia aurea*, *Utricularia exoleta*, *Nymphoides exiliflora*, *Nymphoides indica*, *Hydrostemma motleyi*, *Nelumbo nucifera*, *Nymphaea dictyophlebia*, *Nymphaea pubescens*, *Ludwigia adscendens*, *Ludwigia octovalvis*, *Polygonum attenuatum*, *Polygonum minus*, *Eichhornia crassipes*, *Monochoria hastata*, *Monochoria vaginalis*, *Limnophila aromatica*, *Limnophila indica*. Previously infested with the aquatic weed *Salvinia molesta*, the lakes are now clear following successful biological control (Room and Thomas 1985). A major threat now is the rapid spread of water hyacinth, *Eichhornia crassipes*.

Fifty-nine species of fish have been recorded from the Sepik and Ramu Rivers (+ endemic to Ramu River; * endemic to Sepik River; ** endemic to Sepik and Ramu Rivers; *** endemic to Sepik, Ramu, and Mamberamo (Irian Jaya) Rivers; # introduced species): *Pristis microdon*, *Megalops cyprinoides*, *Anguilla bicolor pacifica*, *A. marmorata*, *Chanos chanos*, *Cyprinus carpio**, *Arius (Brustiarius) nox***, *A. (B.) solidus****, *A. velutinus*, *A. utarus****, *A. coatesi***, *Neosilurus gjellerupi gjellerupi***, *N. gjellerupi coatesi**, *N. idenburgi****, *N. novaeguineae****, *Neosilurus* sp.+, *Zenarchopterus kampeni****, *Gambusia affinis#*, *Chilatherina campsi*, *C. crassispinosa*, *C. fasciata*, *Glossolepis multisquamatus*, *Melanotaenia affinis*, *Microphis spinachoides**, *Ambassis buruensis*, *A. interruptus*, *Parambassis confinis*, *Hephaestus transmontanus***, *Mesopristes argenteus*, *Kuhlia rupestris*, *K. marginata*, *Glossamia gjellerupi*, *Caranx sexfasciatus*, *Lutjanus goldiei*, *Pseudosciaena soldado*, *Oreochromis mossambica#*, *Tilapia rendalli#*, *Liza macrolepis*, *L. melinoptera*, *L.*

*tade, Butis amboinensis, Eleotris aquadulcis**, E. melanosoma, Hypseleotris guntheri, Mogurnda bloodi***, M. nesolepis, Ophieleotris aporos, Op. porocephala, Oxyeleotris fimbriata, Ox. heterodon, Glossogobius bulmeri, G. coatesi**, G. korangensis**, G. giurus, G. torrentis**, Mugilogobius fusculus, Redigobius bikolanus, Stenogobius laterisquamatus, Brachyamblyopus urolepis.*

Wetland birds recorded from the Sepik floodplain include *Tachybaptus novaehollandiae, Tachybaptus ruficollis, Phalacrocorax carbo, Phalacrocorax sulcirostris, Phalacrocorax melanoleucos, Anhinga melanogaster, Pelecanus conspicillatus, Ardea pacifica, Ardea sumatrana, Egretta alba, Egretta picata, Egretta intermedia, Egretta novaehollandiae, Egretta garzetta, Nycticorax caledonicus, Ixobrychus sinensis, Ixobrychus flavicollis, Plegadis falcinellus, Threskiornis aethiopicus, Platalea regia, Pandion haliaetus, Haliaetus leucogaster, Dendrocygna guttata, Dendrocygna arcuata, Tadorna radjah, Nettapus coromandelianus, Anas gibberifrons, Anas superciliosa, Aythya australis, Eulabeornis plumbeiventris, Rallus philippensis, Rallus pectoralis, Porzana cinerea, Amaurornis olivaceus, Megacrex inepta, Gallinula tenebrosa, Porphyrio porphyrio, Fulica atra, Grus rubicunda, Irediparra gallinacea, Himantopus leucocephalus, Vanellus miles, Pluvialus dominica, Charadrius dubius, Numenius phaeopus, Numenius minutus, Tringa glareola, Tringa brevipes, Tringa hypoleucos, Tringa stagnatilis, Gallinago hardwickii, Gallinago megala, Calidris acuminata, Chlidonias hybridus, Chlidonias leucopterus, Chlidonias nilotica, Sterna hirundo, Sterna albifrons, Eopsaltria pulverulenta.*

Gogol, Biges, and Other Coastal Rivers, Madang Province: The Gogol River lies in the Gogol depression between the Adelbert and Finisterre coastal ranges. The Gogol River is a large coastal stream approximately 100 km long with a native fish fauna estimated to be 25 species (Parenti and Allen 1991). The fauna is dominated by melanotaeniid rainbowfishes and gobioids, which together comprise 14 species. The Biges River is a short coastal stream with a tidal estuary, and supports a diverse fish fauna of at least 28 species (Parenti and Allen 1991).

Markham River: The Markham River (Figure 18-1) is only 170 km long, but flows through a wide, braided channel and has a high discharge. The river channel is 3 km wide at the Ramu divide and reaches its maximum width at its confluence with the Leron River. The shallow braided channel of this river contrasts with the large, deep, meandering lower Sepik, Ramu, and Fly Rivers, and its physical structure is reflected in its low biological diversity. However, one lake and its associated wetland in the Markham catchment is of some conservation significance.

14. Lake Wanum and Red Hill Swamp, Morobe Province

Geographical coordinates: 6° 38'S, 146° 47'E.

Area: lake area 3.7 km^2. Altitude: 35 m.

Lake Wanum (maximum depth 20 m), surrounded by low hills and patches of *Nelumbo* swamp, is the largest of a number of lakes in the area. There is no permanent inflow and the water budget is largely dependent on direct rainfall. The catchment area of the lake is 8 km^2. The water is very clear and seasonal fluctuations in water depth are small. *Nelumbo*

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nucifera and *Phragmites karka* form dominant swamp vegetation, with *Eleocharis dulcis* on the outer edge. Aquatic plants include *Ceratophyllum demersum*, *Nymphoides indica*, *Vallisneria natans* and *Najas graminea* var. *graminea*. Other plants recorded from this wetland include *Chara fibrosa*, *Lychnothamnus barbatus*, *Nitella pseudoflabellata*, *Stenochlaena milnei*, *Stenochlaena palustris*, *Nephrolepis radicans*, *Ceratopteris thalictroides*, *Microsorium schneideri*, *Acrostichum aureum*, *Cyclosorus interruptus*, *Caldesia parnassifolia*, *Colocasia esculenta*, *Cyperus platystylis*, *Scirpus grossus*, *Scirpus mucronatus* ssp. *mucronatus*, *Ischaemum polystachyum*, *Leersia hexandra*, *Sacciolepis myosuroides*, *Blyxa aubertii* var. *echinosperma*, *Hydrocharis dubia*, *Ottelia alismoides*, *Pogostemon stellatus*, *Aeschynomene indica*, *Lemna perpusilla*, *Utricularia bifida*, *Nymphaea macrosperma*, *Ludwigia hyssopifolia*, *Ludwigia octovalvis*, *Polygonum attenuatum*, *Polygonum barbatum*, *Limnophila aromatica*. The mangrove *Bruguiera gymnorhiza* has also been recorded from the lake, and *Alstonia spathulata* occurs in Red Hill swamp forest. The lake has a significant crocodile population and an endemic rainbow fish (*Glossolepis wanamensis*). Regrettably, *Oreochromis mossambica* has been introduced.
Reference: Garrett-Jones (1979).

15. Lake Wangri, Morobe Province
Geographical coordinates: 6° 05'S, 146° 30'E.
Altitude: 300 m.
One of a number of small lakes in this area, this lake is surrounded by *Araucaria* forest, but very little is known about its fauna and flora. Five species of duck have been recorded from this lake.

Mambare, Opi, Kumusi, and Musa Rivers: The wetlands along this section of the north coast are poorly known. The only study is by Taylor (1957) in which a classification of the swamp communities, including mangroves, is provided. The Mambare River rises in the Owen Stanley Range and drains northeast into the Solomon Sea near Manau. The Musa River flows around the foot of Mount Victory. Swamp forest, swamp woodland, swamp savanna, and herbaceous swamps and areas of open water occur. In some areas a single species (*Campnosperma auriculata*) dominates the swamp forest, whereas in others the layer is of mixed composition. The understorey is dominated by *Metroxylon sagu*. The ground flora consists of scattered tufts of sedges and grasses, notably *Thoracostachyum sumatranum*. This species, together with *Hanguana malayana*, dominates the ground cover in the swamp savanna areas. The herbaceous swamp is dominated by *Phragmites karka*. The freshwater plants collected from the area include *Azolla pinnata*, *Equisetum debile*, *Ceratopteris thalictroides*, *Microsorium brassii*, *Microsorium pteropus*, *Acrostichum aureum*, *Acrostichum speciosum*, *Alternanthera sessilis*, *Pistia stratiotes*, *Callitriche palustris*, *Ceratophyllum demersum*, *Cyperus imbricatus*, *Eleocharis retroflexa*, *Scirpus crassiusculus*, *Hymenachne acutigluma*, *Phragmites karka*, *Sacciolepis myosuroides*, *Hanguana malayana*, *Nymphoides indica*, *Nymphaea nouchali*, *Ludwigia octovalvis*, *Polygonum attenuatum*, *Polygonum barbatum*, *Polygonum minus*, *Monochoria hastato*, *Potamogeton* sp., *Limnophila aromatica*, *Limnophila indica*, *Typha orientalis*, *Hydrocotyle sibthorpiodes*.

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The following wetland birds have been recorded from this area: *Tachybaptus novaehollandiae, Pelecanus conspicillatus, Phalacrocorax sulcirostris, Phalacrocorax melanoleucos, Anhinga novaehollandiaer, Ardea sumatrana, Butorides striatus, Egretta alba, Egretta intermedia, Egretta garzetta, Nycticorax caledonicus, Ixobrychus flavicollis, Pandion haliaetus, Haliaetus leucogaster, Dendrocygna guttata, Dendrocygna arcuata, Tadorna radjah, Anas superciliosa, Pandion halkiaetus, Rallus philippensis, Rallus pectoralis, Porzana cinerea, Amaurornis olivaceus, Porphyrio porphyrio, Vanellus miles, Pluvialus dominica, Charadrius dubius, Limosa limosa, Numenius minutus, Numenius phaeopus, Tringa stagnatilis, Tringa nebulaira, Tringa glareola, Actitis hypoleucos, Heteroscelus brevipes, Calidris acuminata, Calidris melanotus, Calidris ferruginea, Limicola falcinellus, Sterna hirundo, Sterna albifrons, Pachycephala melanura.*

16. Mambare Wetland, Northern Province
Geographical coordinates: 8° 00'-8° 30 'S, 147° 50'-148° 10'E.
Area: 344,100 ha. Altitude: Near sea level.
A vast area of riverine marshes and floodplains, including several small lakes, along the lower Mambare River.

17. Musa Wetland, Northern Province
Geographical coordinates: 9° 03'-9° 27'S, 148° 38'-148° 56'E.
Area: 179,700 ha. Altitude: Near sea level.
A vast area of floodplain wetlands, including levees and backswamps, along the lower Musa River. The fish fauna is relatively impoverished, but it contains one endemic genus (*Tateurndina ocellicauda*) and several endemic species: *Zenarchopterus robertsi, Pseudomugil connieae, Pseudomugil furcatus, Craterocephalus kailolae, Tetracentrum honessi*, and *Mogurnda orientalis*.

Mid-Altitude Wetlands

Apart from Lake Dakataua (100 m), Lake Wisdom (180 m), and Lake Kutubu (808 m), the mid-altitude (40-3000 m) lakes are small by comparison with those near sea level. Only 10.1% of the lakes in Papua New Guinea lie in this altitude zone (Chambers 1987), and in terms of area, the wetlands within this altitudinal zone are also much smaller. The wetlands here are less commonly associated with rivers, which tend to be fast flowing, turbulent, and turbid. Biodiversity of these rivers is low. Apart from three introduced species (carp [*Cyprinus carpio*], Rainbow Trout [*Oncorhynchus mykiss*] and Brown Trout [*Salmo trutta*]), no fish species have been collected in New Guinea from altitudes greater than about 1800 m. Carp occur in many of the lakes in this region, and trout have become established in many highland streams. Greater control on the introduction of fish species needs to be exerted and the value of fish introductions has frequently been questioned (West 1973, Allen 1991), particularly where there has been inadequate or no assessment of the ecological impact. Lake Kutubu, with its small but highly endemic fish fauna, is particularly susceptible. Lakes Wisdom and Dakataua have no fish (Ball and Glucksman 1978, 1980), and the impact on components of the fauna and flora in these lakes to introduced fish would certainly be significant. Wetland birds recorded from the highlands (altitudes greater than

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1500 m above sea level) include *Phalacrocorax sulcirostris*, *Phalacrocorax melanoleucos*, *Anhinga melanogaster*, *Egretta alba*, *Egretta picata*, *Egretta intermedia*, *Egretta novaehollandiae*, *Egretta garzetta*, *Nycticorax caledonicus*, *Ixobrychus flavicollis*, *Pandion haliaetus*, *Haliaetus leucogaster*, *Anas superciliosa*, *Rallabeornis plumbeiventris*, *Rallus philippensis*, *Porzana cinerea*, *Porzana tabuensis*, *Porzana pusilla*, *Amaurornis olivaceus*, *Pluvialus dominica*, *Numenius phaeopus*, *Tringa brevipes*, *Tringa hypoleucos*, *Tringa stagnatilis*, *Gallinago megala*, *Calidris acuminata*.

18. Lake Kutubu, Southern Highlands Province
Geographical coordinates: 6° 25'S, 143° 20'E.
Area: 810 ha. Altitude: 808 m.

A permanent, deep (maximum depth 63 m), oligomictic, freshwater lake with surrounding marshes. Major inflowing drainage is via the Kaimari and Tugibu Rivers at the western end of the lake, and via the Samaka, Sumi, and Geseke Rivers at the eastern end. The lake is flanked by high hills along its length, and present drainage from the lake is via a shallow lip into the Soro River. Lake Kutubu and the upper Soro River are home to eleven endemic fishes; no other mountain lake in New Guinea has such a wealth of species, and Allen (1991) makes the following plea:

> "At present the lake remains in a pristine condition, but its future is clouded. Oil deposits were discovered nearby and now the exotic calls of birds of paradise, parrots, and hornbills compete with the drone of helicopters. There are no roads in the area, therefore these aircraft are used to ferry personnel and supplies to the drilling site. A proposal to link Lake Kutubu by road with Mendi and the Highlands Highway network is presently being considered. There is also a proposition to establish a township of 2000 people on the shores of the lake to provide manpower and support facilities for the drilling operation. This development would be disastrous to the lake's delicate ecosystem. Hopefully the Papua New Guinea Government will take steps to protect this important wildlife refuge."

Osborne and Totome (1991, in press) have carried out a limnological study of Lake Kutubu, including observations of a mixing event within this oligomictic lake. The aquatic flora is typical for a body of water at this elevation, and the following species have been collected from the lake and marginal wetland: *Chara fibrosa*, *Nitella pseudoflabellata*, *Azolla pinnata*, *Caldesia parnassifolia*, *Pistia stratiotes*, *Ceratophyllum demersum*, *Eleocharis sphacelata*, *Scirpus grossus*, *Scirpus mucronatus*, *Leersia hexandra*, *Blyxa aubertii*, *Hydrilla verticillata*, *Ottelia alismoides*, *Vallisneria natans*, *Lemna perpusilla*, *Spirodela polyrhiza*, *Utricularia* sp., *Nymphoides indica*, *Najas tenuifolia*, *Ludwigia adscendens*, *Polygonum attenuatum*, *Potamogeton* sp., *Limnophila indica*, *Typha orientalis*. Conn (1979b) provides a list of plant species growing in the vicinity of Lake Kutubu, and Osborne et al. (1990) pr[illegible] a distribution map of the dominant aquatic plants. The crayfish *Cherax papu*[illegible] endemic to the lake, and the crab *Rouxana papuana* is found in the area. Fourteen species of fish have been collected from the lake of which eleven are endemic (*): *Neosiluris equinus*, *Oloplotosus torobo**, *Melanotaenia lacustris**, *Craterocephalus lacustris**, *K*[illegible]*phaestus adamsoni**, *Mogurnda furva**, *Mogurnda*

*kutubuensis**, *Mogurnda spilota**, *Mogurnda variegata**, *Mogurnda vitta**, *Oxyeleotris fimbriata*, *Glossobius* sp. 8*, *Glossobius* sp. 12*, *Gambusia affinis#*. Osborne *et al*. (1990) provide some information on the fish and fishing within the lake. Natural Systems Research (1990) provides lists of mammals and birds from the Lake Kutubu and environs, and Schodde and Hitchcock (1968) list the birds of this region.
References: Schodde and Hitchcock (1968), Bayly *et al*. (1970), Conn (1979b), Osborne *et al*. (1990), Osborne and Totome (1991, in press).

19. Lake Tebera
Geographical coordinates: 6° 45'S, 144° 40'E.
Area: unknown. Altitude: 790 m.
Glossogobius sp. 13 (Allen 1991) is endemic to this lake. *Melanotaenia herbertaxelrodi* has been collected from the lake and from a small stream flowing into the lake. A single specimen has also been collected from Karamui.

20. Lake Ipea and Sirunki Wetland, Enga Province
Geographical coordinates: 5° 23'S, 143° 32'E.
Area: Lake Ipea: 76 ha, Sirunki Basin 29 km^2.
Altitude: 2570 m.
The Sirunki Basin straddles the main watershed divide of Papua New Guinea. Lake Ipea (maximum depth: 11.9 m, mean depth: 5.7 m) is situated in the northern part of the basin that forms part of the Sepik River catchment. The southern part of the basin, which is some 2 m higher, is part of the Fly River system. The watershed around the basin has many subsistence agricultural gardens. Cattle graze down to the edge of the lake, and there is a forestry plantation above the southern shore of the lake. Much of the lake boundary has a vertical bank with water depths at the edge ranging from 1 to 1.5 m. *Scirpus mucronatus* was dominant at the edge of the sedgeswamp zone. *Potamogeton malaianus* and Characeae were the dominant rooted aquatic plants. Introduced carp are the only fish in the lake. The following wetland and aquatic plants have been recorded from Lake Ipea: *Nitella cristata*. *Nitella pseudoflabellata*, *Azolla pinnata*, *Equisetum debile*, *Thelypteris confluens*, *Acorus calamus*, *Carex* sp., *Eleocharis sphacel*[illegible]*irpus crassiusculus*, *Scirpus inundatus*, *Scirpus mucronatus* ssp. *mucronatus*, *Scirpus* [illegible]*natus* ssp. *clemensii*, *Elatine triandra*, *Phragmites karka*, *Myriophyllum pedun*[illegible]*um*, *Pogostemon stellatus*, *Utricularia australis*, *Utricularia minor*, *Nymphoides geminata*, *Polygonum minus*, *Polygonum strigosum*, *Potamogeton malaianus*, *Potamogeton pusillus*, *Limnophila aromatica*, *Limnophila indica*, *Sparganium simplex*, *Typha orientalis*, *Hydrocotyle sibthorpioides*.
References: Goldsmith *et al*. (1983), Walker (1972), Walker and Flenley (1979), Chambers *et al*. (1987).

21. Lake Onim, Southern Highlands Province
Geographical coordinates: 6° 10'S, 143° 59'E.
Area: 16 ha. Altitude: 2260 m.
Lake Onim (maximum depth: 10.6 m, mean depth: 4.5 m) lies above a densely populated grassy intermontane valley between the extinct volcanic peaks of Mt. Giluwe (4367 m) and Mt. Ialibu (3465 m). Water flows into the lake from the southern and eastern slopes of Mt. Giluwe. The area immediately surrounding the lake is lightly populated with a few houses of

subsistence farmers. Much of the lake was surrounded by *Saccharum* sp. Three distinct zones were apparent in the aquatic vegetation: one dominated by *Scirpus mucronatus* ssp. *clemensii*, with *Eleocharis tetraquetra*, *Nymphoides geminata*, *Hydrocotyle sibthorpioides*, *Paspalum* sp., *Lindernia* sp., and *Cyperus* sp.; the second dominated by *Eleocharis sphacelata* and the third zone by Characeae. Other wetland and aquatic plants recorded from Lake Onim include *Chara fibrosa*, *Chara globularis*, *Nitella cristata*, *Nitella pseudoflabellata*, *Carex* sp., *Eleocharis sphacelata*, *Fimbristylus salbundia*, *Juncus prismatocarpus*, *Gahnia sieberiana*, *Lipocarpha chinensis*, *Rhynchospora rugosa*, *Machaerina rubinginosa*, *Pogostemon stellatus*, *Ranunculus* spp., *Viola arcuata*, *Xyris capensis*, *Wahlenbergia marginata*, *Adenostemma hirsutum*, *Anaphalis lorentzii*, *Eriocaulon hookerianum*, *Haloragis halconensis*, *Trachymene novoguineensis*, *Pogostemon stellatus*, *Utricularia minor*, *Polygonum minus*, *Polygonum strigosum*, *Limnophila aromatica*, *Saccharum* sp. Lake Bune is adjacent to Onim and probably supports similar communities. References: Conn (1979c), Chambers *et al.* (1987).

22. Lake Papapli and Marient Basin, Enga Province
Geographical coordinates: 5° 53'S 143° 36'E.
Area: Lake Papapli: 120 ha, Marient Basin 75 km². Altitude: 2420 m.
The Marient Basin is fed and drained by the Marient River and several tributaries. The Marient River is a tributary of the Lai River and part of the Purari River catchment. Lake Papapli (maximum depth: 3.2 m, mean depth: 2.0 m) is joined to the Marient River by a channel 1 km long. About 5000 people live in the basin, mainly as subsistence farmers on lower slopes and drier parts of the basin floor. Chambers *et al.* (1987) reported that, during their visit, plant cover was continuous over much of the lake with only occasional bare patches of mud. Plants were common at the greatest depth found in the lake (3.2 m), with two angiosperms, *Potamogeton pusillus* and *Ceratophyllum demersum*, and Characeae dominant. There was no zonation and all species occurred as mixed stands or in monospecific clumps. Other aquatic plant species included *Eleocharis sphacelata* and *Nitella pseudoflabellata*. This lake has an interesting flora, as *Ceratophyllum demersum* is considered a lowland species, and this lake is the second known site in New Guinea for *Potamogeton pusillus*, the other being Lake Ipea.
References: Goldsmith *et al.* (1983), Chambers *et al.* (1987).

23. Lake Parago and Kandep Basin, Enga Province
Geographical coordinates: 5° 49'S, 143° 28'E.
Area: Lake Parago 36 ha. Altitude: 2340 m.
Kandep Basin is a swampy alluvial plain fed and drained by the Lai River. The western part of the basin is dominated by limestone formations with smaller areas of sandstones, siltstones, and mudstones. Lake Parago (maximum depth: 7.0 m, mean depth: 4.3 m) is connected to the Lai River by a meandering channel approximately 10 m wide. Water from the Lai River, when the river is high, flows into the lake through a narrow channel. The same channel drains the lake during periods of low river flow. The fringing swamps are dominated by *Phragmites karka* and *Typha orientalis*. In Lake Parago, *Potamogeton malaianus* was common between 1.2-3.3 m, and *Polygonum lapathifolium* occurred between 1-2.2 m. These two species were also abundant in the Lai River. Other species in the lake

included *Acorus calamus*, *Nasturtium officinale*, *Eleocharis sphacelata*, *Nitella pseudoflabellata*, *Utricularia exoleta*, and *Azolla pinnata*. *Limnophila indica* occurred in dense stands in sheltered areas.
References: Goldsmith *et al.* (1983), Chambers *et al.* (1987).

High Altitude Wetlands

With the exception of Mt. Wilhelm, the high altitude wetlands have received scant attention. Deep (ca. 60 m) glacially formed lakes occur on Mt. Wilhelm, and numerous small tarns occur on Mt. Giluwe and Mt. Albert-Edward and presumably on other mountains in Papua New Guinea.

24. Mount Wilhelm Lakes, Chimbu and Madang Provinces
Geographical coordinates: 5° 46'S, 144° 59'E.
Area: Lakes Piunde (130 ha), Aunde (70 ha), Guraguagukl (4 ha), Tegepangua (2 ha), Bendenumbun (125 ha), and Brass' Tarn (800 m^2). Altitude: 3530-3920 m.

These glacially formed lakes, receiving runoff from gabbro and ultrabasic rocks and having very clear water (Secchi disc depths up to 10 m), are of significant limnological and zoogeographical interest. The net phytoplankton flora were qualitatively and quantitatively poor and consisted of mainly desmids and Cyanobacteria. Many were previously unrecorded from the Malesian/Australian region, and although many cosmopolitan species were present, the overall nature of the phytoplankton was northern arctic-alpine. One hundred and twenty-three species of phytoplankton have been recorded from lakes on Mt. Wilhelm. Patches of submerged *Callitriche palustris* and *Scirpus crassiusculus* occur in the shallower parts of Lake Aunde. Two new species of Ostracoda and three species (one a redescription) of Trichoptera have been described from Lakes Piunde and Aunde. A total of twelve crustacean species (cyclopoids, cladocerans, harpacticoids, and ostracods) has been recorded from these lakes. These were mainly cosmopolitans followed by species related to extra-tropical southern hemisphere forms.
References: Illies 1969, Löffler 1973, Thomasson 1967, McKenzie 1971, Bayly and Morton 1980, Petr 1983b.

25. Mount Giluwe Tarns, Southern Highlands Province
Geographical coordinates: 5° 15'S, 144° 5'E.
Altitude: 3500-3800 m.

A series of small, shallow tarns occur on the shoulder below the peaks of Mt. Giluwe. These tarns have been poorly studied. Open *Scirpus crassiusculus* fen is common on Mt Giluwe. *Isoetes stevensii* grows in shallow water (less than 50 cm deep) in these tarns at altitudes of around 3500 m. *Callitriche palustris* has also been recorded from this mountain. *Rhododendron saxifragoides* grows on peat hummocks associated with these bogs.

<u>Wetlands of the Large Offshore Islands</u>

The wetlands in Manus, New Ireland, West New Britain, East New Britain, and North Solomons Provinces, and those on the smaller islands within the mainland Provinces of Madang, Morobe, and Milne Bay have been poorly studied. There are very few lakes within some of these provinces: East New Britain 4; Manus 11; and New Ireland 13 (Chambers 1987). Two caldera lakes (Dakataua and Wisdom) in this region are significantly different from all other water bodies in the country. They are very deep (Wisdom: 360 m; Dakataua: 120 m) and have no fish in them (Ball and Glucksman 1978, 1980). Lake Wisdom does not appear to have any aquatic plants (see Osborne and Murphy 1989). Lakes Billy-Mitchell and Lolorua, both in the North Solomons Province, are maars, formed by a single explosive eruption. These lakes, on the basis of their likely youth and morphometry, are likely to have a very low biodiversity, but this needs to be confirmed. Swamp forest occurs in the lowlands along the southwest and south coasts of Bougainville, and is dominated by *Campnosperma brevipetiolata*, *Terminalia brassii*, and *Metroxylon solomonensis*.

26. <u>Lake Lavu Wildlife Management Area</u>, Fergusson Island, Milne Bay Province
Geographical coordinates: 9° 31'S, 150° 37'E.
Area: Lake area 264 ha. Altitude: 0-40 m.
A freshwater lake surrounded by lowland forest and tall grassland; seasonal fluctuations in water depth. The area was declared a Wildlife Management Area in 1981.
Reference: Lecroy *et al.* (1983).

27. <u>Lake Namo and Mojo River</u>, West New Britain Province
Geographical coordinates: 5° 39'S, 149° 35'E.
Area: Appears to be the largest freshwater lake on New Britain. Altitude: Near sea level.
Lowland swamp and open freshwater lake, surrounded by the proposed Lake Namo Conservation Area, as shown in Bishop and Broome (1980). As the largest lake on New Britain, Lake Namo attracts large numbers of migrating water birds as well as resident species. Bishop and Broome (1980) recorded eight species of water birds during a brief helicopter flight in May 1979: *Dendrocygna arcuata*, *Porphyrio porphyrio*, *Ixobrychus flavicollis*, *Ixobrychus sinensis*, *Egretta intermedia*, *Phalacrocorax melanoleucos*, *Iredipara gallinacea*, and *Gallinula tenebrosa*.
Reference: Bishop and Broome (1980).

28. <u>Lake Hargy</u>, border of West and East New Britain Provinces
Geographical coordinates: 5° 21'S, 151° 11'E.
Area: 930 ha. Altitude: 330 m.
A freshwater caldera lake. A Nature Conservation Area was proposed in 1972 to include Lake Hargy, nearby Lake Gallesuelo (emitting steam), and northern slopes of Nakanai Mountains.
Reference: Miniotas and Lindgren (1972).

29. Lake Dakataua, West New Britain Province

Geographical coordinates: 5° 02'S, 150° 05'E.

Area: 4920 ha. Altitude: 76 m.

A freshwater caldera lake, maximum depth 120 m. Shallow water areas of the lake support heavy mixed growths of *Najas tenuifolia*, *Chara fibrosa*, *C. corallina*, and *C. globularis*. These plants extend to depths of at least 8 m, but appear to grow best between 2-4 m. *Lemna perpusila* occurs in sheltered areas of the lake. Other plants recorded from the lake include *Ludwigia octovalvis* and the fern *Nephrolepis biserrata*. The lake and its catchment have been proposed as a site for a national park.
References: Ball and Gucksman (1980), Miniotas and Lindgren (1972).

30. Lake Wisdom, Long Island, Madang Province

Geographical coordinates: 5° 12'-5° 26'S, 147° 00-147° 13'E.

Area: 8,592 ha. Altitude: 180 m.

Lake Wisdom is a freshwater caldera lake formed by the post-eruptive collapse of a volcanic peak. The lake fills the central crater of Long Island and is surrounded by steep crater walls rising to 1280 m. The water level shows annual fluctuations of approximately 1.0 m. The lake has a maximum depth of 360 m and is one of the deepest lakes in the southeast Asia/Australia region. The presence of chironomids and molluscs below 300 m indicates that the entire water body is oxygenated. This may be due to the active volcanic cone (Motmot Island) in the lake heating up the surrounding water, and thereby creating convection currents strong enough to keep the lake in circulation. There are no aquatic vascular plants in the lake, and no fish have been recorded. Ball and Glucksman (1978) found a simple benthic fauna consisting of one sponge (*Spongilla alba*), four molluscs (*Melanoides tuberculata*, *Amerianna papyracea*, *Gyraulus convexiusculus*, *Thiara scabra*), three ostracods, and small numbers of Hemiptera, Odonata, Chironomidae, Ephemeroptera, Trichoptera, and Lepidoptera. The poor benthic and planktonic faunas of the lake have been attributed to the youth and isolation of the lake. These features, plus the paucity of suitable habitats, have been invoked to explain the absence of aquatic plants. Ball and Glucksman (1978) observed numerous *Anas superciliosa* and smaller numbers of *Tachybaptus ruficollis* on the lake. The lake is limnologically significant.
References: Ball and Glucksman (1978), Osborne and Murphy (1989).

CONSERVATION RECOMMENDATIONS

Areas Requiring Further Study

The lakes on the large offshore islands have been poorly studied, and biological collections need to be obtained from lakes such as Lolorua and Lake Billy-Mitchell (North Solomons Province), the lakes at the southeastern end of New Ireland, and the lakes on New Britain and the islands of Milne Bay Province. On the mainland very little is known of Lake Trist (Morobe Province), and the small tarns and ponds at high altitude, such as the ice-scour lakes on Mt. Giluwe, Southern Highlands Province. Very little is known about Musa and Mambare Wetlands, Northern Province, and further study is required. Wetlands in Bougainville, Manus, and New Ireland Provinces also need to be studied before

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representative areas can be identified for conservation. Little is known about Lake Lavu, Fergusson Island, Milne Bay Province, and Lake Hargy, West New Britain Province. A Nature Conservation Area has been proposed for Lake Hargy and its environs, but little information is available on the organisms inhabiting the area. Our knowledge of lowland swamp forest and swamp savanna is largely restricted to an inventory of the plant species present in these systems.

Recommendation 1. Biological surveys of these poorly studied wetlands should be undertaken. The results of these studies should be used to identify which of these wetlands are worthy of conservation.

Representative Wetlands for Conservation

The wetlands selected below are chosen because (a) they are representative of the various wetland types found within Papua New Guinea; (b) they are areas about which something is known; and (c) they harbour endemics and/or diverse communities.

The Bensbach River and Wassi Kussa River floodplains, Western Province have a diverse aquatic flora and fauna, and are significant sites for both resident and migratory wetland birds. In northern Australian drought years, these areas become important refuges for Australian waterfowl.

North from the Fly-Strickland River junction to the Elevata River floodplain, including Lakes Murray, Daviumbu, Bosset, Kogun, and Staga Lakes, Western Province. This vast wetland area is a mosaic of open water, herbaceous swamp, and lowland swamp forest. It supports a diverse aquatic and wetland flora, and is representative of lowland elements of the Fly River fish fauna. Open water areas form important sites for waterfowl.

The Vanapa, Brown, and Laloki River wetlands, Central Province. These wetlands are under significant threat from forestry projects, the effects of urbanization, and a rapidly expanding population. Little is known about the Kemp-Welch and Mori wetlands to the east of Port Moresby, but these wetlands may be under less threat, and therefore should be considered as alternative sites for conservation.

The Middle-Lower Sepik-Ramu River floodplain, East Sepik Province. Despite significant alteration to this area through the introduction of aquatic weeds and fish species, this area supports a fish fauna almost entirely different from that found in the southern rivers. Two areas on the biodiversity map have been delineated as representative of these systems.

Lake Wanum and Red Hill Swamp, Morobe Province. This lake has an endemic rainbow fish and a diverse aquatic flora.

Lake Kutubu, Southern Highlands Province. This lake is probably the only oligomictic lake in the country, and it supports a diverse aquatic flora and 11 endemic fish species.

Conservation of this lake would require protection of the catchment area and not simply the lake basin.

Lake Ipea and Sirunki Wetland, Enga Province. This area spanning the central divide has a diverse aquatic and wetland flora. Its fauna is largely unknown.

Lakes Onim and Bune, Southern Highlands Province. A diverse aquatic and wetland flora.

Mt. Wilhelm Lakes, Chimbu and Madang Provinces. High altitude ice-scour and cirque lakes with a depauperate, but biogeographically significant fauna and flora.

Lake Dakataua, West New Britain Province. This lake has no fish and a simple benthic fauna. It is a site that requires further study.

Lake Wisdom, Madang Province. This lake has no fish and a simple benthic fauna. The lake is of limnological interest as, despite its great depth (360 m), oxygen and benthic aerobic organisms are present in the deepest parts of the lake. Convection currents in the lake created by local heating in the vicinity of volcanic Motmot Island may be responsible for the transport of oxygen to the bottom.

Southeastern lowlands of North Solomons Province. This wetland area has been poorly studied but contains fine stands of *Terminalia brassii*.

Recommendation 2. Although further work on these areas is essential, these sites should be considered for inclusion in maps of areas of high biological priority and worthy of conservation.

International Conventions

Papua New Guinea is not yet party to the World Heritage Convention or the Ramsar Convention. The World Heritage Convention provides for the designation of areas of "outstanding universal value" as World Heritage sites, in order to promote their significance at local, national, and international levels. The Ramsar Convention provides the framework for international cooperation to conserve wetlands. Contracting parties accept an undertaking to promote the wise use of all wetlands and to designate one or more wetlands for inclusion in the List of Wetlands of International Importance.

Recommendation 3. Papua New Guinea should sign both these conventions. Many wetland areas in Papua New Guinea should be designated as Ramsar sites. Lake Kutubu should be considered for World Heritage listing on the basis of its scenic beauty, flora, and fauna. Lake Dakataua should also be considered as a World Heritage site, although criteria for such consideration would probably not include the composition of its wetland fauna and flora.

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Environmental Impacts

A number of the sites listed above are significantly modified or under threat from waste disposal, catchment area alterations, and from the introduction of exotic species. Notes and recommendations are provided below.

Salvinia molesta and *Eichhornia crassipes* (water weeds): *Salvinia molesta* covered large areas of the lakes in the middle and lower Sepik Valley, but biological control measures have been remarkably successful (see Room and Thomas 1985; Thomas and Room 1986; Creagh 1991/1992). Water hyacinth (*Eichhornia crassipes*) has spread up the Sepik River as far as Ambunti, and D. Coates (pers. comm.) predicts that it will be a significant problem in the near future. The weed has also been found growing in Mount Hagen, and it has infested Waigani Lake near Port Moresby (Osborne unpubl.). It is also threatening Port Moresby's major water supply reservoir (Creagh 1991/1992). Warnings regarding the spread of this weed (Mitchell 1978/1979; Osborne and Leach 1984; Coates pers. comm.) have, until recently, been ignored by Government. However, Creagh (1991/1992) has indicated that the Division of Entomology, CSIRO, Australia and the Papua New Guinea Government Department of Agriculture and Livestock are currently seeking resources to begin a water hyacinth control program. Creagh (1991/1992) reports that water hyacinth was initially found only around Madang, and that it spread from there to the lakes in the lower Sepik. However, an earlier infestation (and most probably the initial one) was in the gold-mining dredge ponds at Bulolo. Water hyacinth spread from there to Lae and Madang in the early 1980s (see Mitchell 1978/1979, Osborne and Leach 1984). In Australia, considerable success in the biological control of water hyacinth has been achieved using the weevil *Neochetina bruchi*, and this success offers some hope in controlling the infestations in Papua New Guinea. *Hydrilla verticillata* is also probably exotic (see Leach and Osborne 1985) and is a serious weed in some countries. *Cabomba caroliniana*, *Sagittaria platyphylla*, and *Sagittaria subulata* are recent introductions to Papua New Guinea.

Recommendation 4. Attempts to eradicate infestations and control the spread of *Salvinia molesta* and *Eichhornia crassipes* should be intensified. The level of public awareness in this issue needs to be enhanced. The spread of *Hydrilla verticillata* and other exotics should be carefully monitored. Mechanisms controlling the import of plant material need to be intensified.

Fish Introductions

Allen (1991) regards most of the earlier fish introductions as having had a negative impact through competition for space and limited food resources, or by feeding on the native species. Even the popular *Oreochromis mossambica* has adversely affected the environment, creating turbid conditions in formerly clean lakes and overcrowding the indigenous fauna due to its prolific breeding. On the positive side, the number of established introductions is relatively few. Coates (in press) indicates that Papua New Guinea is the first country to implement the EIFAC/ICES (European Inland Fisheries Advisory Commission/International Council for the Exploration of the Sea) code of practice on fish species transfers. Coates (in

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litt.) opposes a moratorium on fish introductions, but he does recommend that controls on internal transfers be introduced and urges that areas sensitive to introductions should be identified and afforded protection. However, Allen (1991) states that the uniqueness of New Guinea's fish fauna sets it apart from the Indonesian Archipelago lying west of Weber's Line. He regards it as "particularly sad to witness the introduction of fishes from the Indonesian side of the Line." He recommends that the Government of Papua New Guinea should seriously consider the imposition of a ban on further introductions.

Recommendation 5. A moratorium should be placed on all further fish introductions. This should include the import to Papua New Guinea of new species, and the transfer of species already established within Papua New Guinea into areas in which they are currently not found. The level of public awareness of the negative impact of fish introductions needs to be enhanced.

Wetlands and Climate Change

Significant work has been carried out recently to predict the implications of climate change in the South Pacific, and a number of papers describe the likely effects on wetlands in Papua New Guinea (Bualia 1990, Chappell 1990, Hughes and Bualia 1990, Pernetta and Osborne 1990). Physical consequences include shoreline retreat, increased flooding, and enhanced saltwater intrusion. It is likely that following a rise in sea level, flooding of the low lying land along the Fly River will be more frequent and of longer duration. Pernetta and Osborne (1988) recommend that a detailed study be made of how sediment deposition in Lake Murray and the lakes of the middle Fly region, particularly with regard to mercury and heavy metals, may change with higher river levels.

Recommendation 6. Predictions on the impact of climate change should be integrated with proposals to conserve the biodiversity of wetlands.

Wetlands and Mine Waste Disposal

The Ok Tedi mine, located in the upper catchment of the Ok Tedi, a tributary of the Fly River, is one of the largest open-cut copper and gold mines in the world. Waste rock and tailings are currently dumped into the Ok Tedi, and Pickup *et al.* (1981) identified increased sediment loads leading to increased siltation, and enhanced heavy metal concentrations in the water and sediments, as two potentially detrimental effects on the middle Fly wetlands. Natural Systems Research (1988) indicated that the principal environmental threat from the Porgera copper and silver mine in Enga Province is through disposal of mine waste into the Laiagap-Strickland River system. This mine started production in 1990. Environmental consequences similar to those identified for the Ok Tedi mine are listed by Natural Systems Research (1988) with the additional complication that the Porgera mine tailings are higher in mercury than the natural suspended sediment load of the Strickland River. High levels of mercury in fish of the Fly-Strickland River systems have been known for some time (Lamb 1977, Kyle and Ghani 1982a, 1984). Furthermore, Kyle

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and Ghani (1982b) recorded elevated concentrations of mercury in the hair of the people living around Lake Murray. The Herbert River, which drains Lake Murray into the Strickland, has been shown to reverse flow on occasions, a result of the flatness of the topography and marked seasonal fluctuations in the water level of Lake Murray and the Strickland River (Natural Systems Research 1988, Osborne *et al.* 1987). This discovery indicated a pathway by which mine wastes could accumulate in Lake Murray.

Mowbray (1988a, 1988b) predicted that the effects of tailings from the Ok Tedi mine would probably be confined to the upper reaches of the Ok Tedi, but that chronic effects could extend down the Fly River. Even the mining company projected that the impact on the Middle Fly would be fewer fish species in reduced numbers (Townsend 1988). Osborne *et al.* (1988) showed that sediments transported by the Fly River are deposited in Lake Daviumbu, a backswamp of the Middle Fly region. This contrasts with the environmental impact assessment which predicted that little river borne sediment was expected to reach these backswamps (Maunsell and Partners 1982). So far, apart from a number of critical incidents in the construction and operation of the Ok Tedi mine (see Townsend 1988), it has not been possible to show that either of these mines is having, or will have, long term effects on the middle Fly region, but the threat is real. They will, certainly, have major impacts on the upper reaches of these large river systems, but the distance downstream that these effects may extend is unknown.

Recommendation 7. The impact of tailings disposal on wetlands should be closely monitored.

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Figure 18-1. The major rivers, lakes, mountains and wetland areas in Papua New Guinea. Major wetland sites: (1) Abia (2) Empress Augusta Bay (3) Toriu (4) Namo (5) Rakua (6) Mullins Harbour (7) Kemp Welch and Mori (8) Vanapa (9) LakeKamu (10) Kikori (11) Fly River (12) Vanimo (13) Arnold River (14) Sepik River (15) Ramu River (16) Markham River (17) Mambare (18) Musa (19) Kelaua (20) Malai.

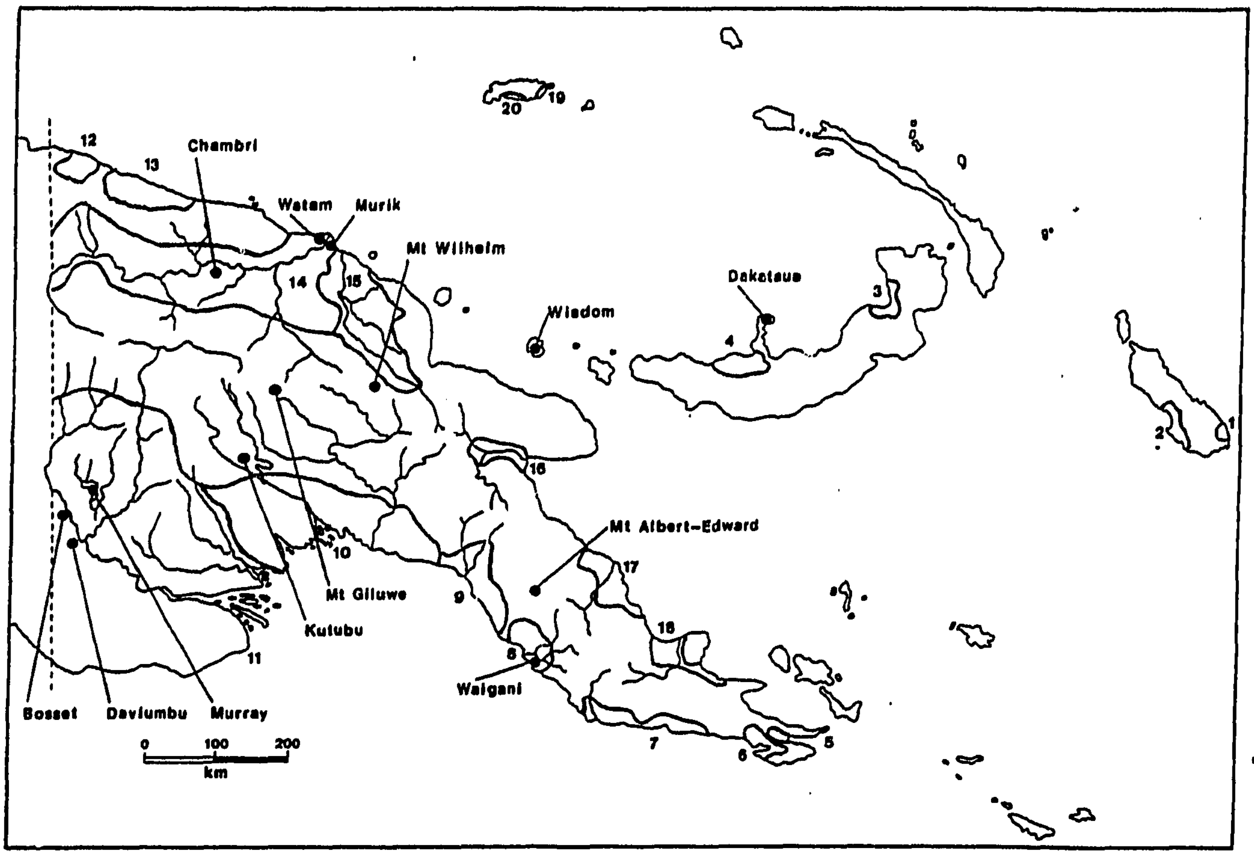

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Table 18-1. The altitudinal zonation of lakes in Papua New Guinea (after Chambers 1987).

Altitude of lake (m)	Number of lakes	% of total
1-40	4753	88.3
41-120	153	2.8
121-1000	149	2.8
1001-2000	106	2.0
2001-3000	133	2.5
3001-4000	88	1.6
>4000	1	-

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APPENDIX 18-1. BIBLIOGRAPHY OF THE FRESHWATER WETLANDS OF PAPUA NEW GUINEA

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Chapter Nineteen

A Preliminary Assessment of Biodiversity and Conservation for Coastal and Marine Ecosystems in Papua New Guinea

M. Tundi Agardy[1] and John Pernetta[2]

SUMMARY

Papua New Guinea coastal and shallow water marine areas are extensive and highly diverse. With a mainland coastline comprised of over 5000 miles of mangrove swamps, lagoons, wetlands, coral reefs and atolls, and seagrass communities, it remain remarkable in its ecological richness even today. Its archipelagos consist of hundreds of offshore islands with varying habitats that largely differ from those on the mainland.

The marine resources in these ecosystems satisfy subsistence needs and provide development income. For this reason, human use of marine resources must be considered concurrently with the development of strategies for biodiversity conservation. Species that contribute most to subsistence economies and thus provide the most accessible information about the status and structure of marine systems include, among others, the marine and estuarine turtles, harvested for meat and eggs; crocodiles, taken for the skin trade; dugongs, important in cultural tradition; and coral reef fishes. The sea turtles are particularly significant because of their link to land in their life cycles; similarly, the barramundi (giant perch) live in inland waters but are linked to coastal waters through spawning grounds.

In general, tropical marine ecosystems are complex and poorly studied. There is an urgent need to fill major gaps in basic marine research and to consolidate scattered information on tropical marine and shallow water ecosystems. Because marine systems are influenced by the use of contiguous lands, conservation strategies should combine land and marine conservation efforts. In PNG it will be necessary to develop strategies that consider the intricate, long established, and locally varied systems of traditional land and resource ownership and management, and recognize these systems as a possible form of management consistent with conservation goals for PNG.

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[1] World Wildlife Fund-US, Washington, D.C., U.S.A.

[2] Environmental consultant, currently based in King's Lynn, England.

INTRODUCTION

Sustainable management and conservation of coastal and marine areas present special problems for resource managers, particularly in tropical regions with a great diversity of species and habitats. These problems include, among other things, (1) a poor understanding of the ecology of tropical marine ecosystems; (2) the absence of a geographically comprehensive inventory of marine habitat and species diversity; (3) ill-defined taxonomies of many marine animal groups; (4) a disparity in the dominant processes and ecological needs of tropical, shallow water, marine communities; (5) confusing classification systems for tropical marine habitats; (6) poorly understood relationships between terrestrial and marine systems; and (7) lack of acknowledgement of the potential suitability of traditional ownership patterns and resource use/management.

In Papua New Guinea, a vast and diverse tropical country with extensive and highly productive marine ecosystems, few regional or nationwide assessments of marine habitats, flora, and fauna have been published. The best studied areas are those near major ports and/or research centers, such as Port Moresby, Lae, the Christensen Research Institute in Madang, Laing Island, and the Motupore Island Research Station in Bootless Bay. Additional, though somewhat preliminary, information has been compiled through the joint Papua New Guinea and Australian program, designed to monitor environmental quality in the Torres Strait (Lawrence 1991), while the government supports various coastal fisheries stations that include research and monitoring of some species within their regular programs. A preliminary bibliography of PNG fisheries, containing in excess of 600 references (Lock and Waites 1985), provides a sound basis for investigating the state of knowledge regarding fisheries and marine species of importance to commercial and subsistence economies in Papua New Guinea.

No documentation exists concerning the relative importance of PNG's different areas to the continued productivity of nearshore waters, or to the maintenance of their important biological diversity. Such information is crucial for developing a national strategy of sustainable use and wise management of marine resources. Both PNG universities and various PNG government agencies are active in marine research and data collecting. Additionally, marine related data are held in the databases of independent research centers, and in the cultural traditions of local communities. Retrieving such information could be greatly assisted by extending and supporting, at low cost, the present western scientific database for collecting and collating the extensive base of traditional knowledge (Johannes 1982, Hill et al. 1982).

A broad overview of the marine habitats and species important to conservation in Papua New Guinea is presented below. This summary is neither complete nor comprehensive due to the lack of resources needed to assemble, collate, and organize the extensive data available, published and unpublished in PNG, and published in international journals. Emphasized is the immediate need to codify such scattered information and data and upgrade methods of recording local marine environmental and resource knowledge. Also indicated are some of the gaps in knowledge that urgently need to be filled.

IDENTIFYING THE CRITICAL ELEMENTS IN COASTAL AND MARINE DIVERSITY

Effective conservation planning requires strategies that address explicitly stated management and conservation goals. In the context of the Papua New Guinea Conservation Needs Assessment, our strategy must (1) identify geographical areas with maximum biodiversity, and (2) make biodiversity conservation compatible with sustainable use.

Responding to the first question requires an area-by-area accounting of species richness in terms of individual species distribution and abundance, i.e., producing a structural view of the way that PNG's biota is organized. The second task requires a knowledge of species interactions, functional population units, critical driving processes that maintain ecosystems, and how ecological communities and species composition change as a consequence of human influence and the earth's dynamic natural processes.

Both issues require a degree of understanding of spatial and temporal variations and trends in natural systems that is not readily available for PNG marine species and systems. It is generally recognized that the Indo-West Pacific represents an area of extremely high marine diversity. Classically, the center of this diversity was considered to be the Indo-Malayan region, from which outlying areas derived their faunas. Recent reevaluations of the processes leading to this "hotspot" of diversity suggest that, rather than being a classical center of speciation, the area represents a point of overlap and aggregation for faunas derived from other centers of diversity (Kay 1984).

Kay (1984) concluded, on the basis of an analysis of the distribution records for some 3000 species and 500 genera of marine molluscs, echinoderms, crustaceans, and fishes, that three centers of marine endemism existed: the Indian Ocean, the western Pacific plate, and the Pacific plate. He furthermore concluded that the western Pacific represents an area of accumulation of species of three origins: species such as *Nautilus* and *Tridacna*, whose ranges were truncated during the Pliocene and Pleistocene; species originating on the Pacific plate; and species originating in the area itself.

One way to approach the identification of conservation needs in species- and habitat-rich Papua New Guinea might be to target areas of maximum marine diversity. "Hotspots" of diversity are certainly worthy of attention: they contain nature's greatest concentrations of evolutionary adaptation and form. But conservation in many such areas tends to center on preservation and protection, including approaches such as the establishment of garrison reserves to keep species and habitats off-limits to human activity (except observation). In countries such as Papua New Guinea, where coastal communities rely on marine resources for both subsistence needs and development income, such an approach is largely unworkable. Safeguarding the ecological processes that maintain complex ecosystems in the context of management and use is a more difficult task, yet it is likely to prove a more effective means of conserving biological diversity over the long term.

Given the fluid, highly interconnected, and dynamic nature of marine environments, conventional resource management has serious limitations. Many resource managers in the northern hemisphere still cling to the idea that biologically diverse, or "rare," coastal and marine habitats can and should be left untouched. In adopting such an approach they are transferring, uncritically, a northern hemisphere, developed country, terrestrial model to the marine domain. With a few notable exceptions (lagoons far from human habitation, for example), such management measures are unrealistic in most developing countries. Papua New Guinea's laudable development of the wildlife management area concept is a more adaptable paradigm for conservation, management, and sustainable use of environments and resources in the marine realm.

Despite the difficulties in identifying critical areas and in protecting them, some attempt must be made to focus the conservation spotlight on areas that harbor the most important ecological processes supporting the coastal/marine complex. Such areas may be defined, broadly, through identifying important fish spawning grounds, feeding areas, areas of nutrient loading, and migration corridors. In addition, it is necessary to identify those habitats or processes that are under immediate or short-term threat from human activities. In Papua New Guinea, present threats to the marine environment have not been comprehensively quantified; it will be difficult to predict the nature and scale of potential future impact.

GEOGRAPHICAL OVERVIEW

New Guinea is geologically a relatively young island that exhibits a varied physiogeography. The mainland portion of Papua New Guinea occupies the eastern half of the island of New Guinea from 141°W to the southeastern tip at around 152°W and from 3-11°S. The mainland includes approximately 85% of the 465,000 km^2 land area of the entire country (Sullivan 1991), and the coastline stretches for approximately 5160 miles. The Exclusive Economic Zone (EEZ) covers approximately 800,000 km^2 of ocean.

The island of New Guinea formed at the collision point between the Pacific and Australian plates. The mainland forms three distinct geological provinces: the southern plains and lowlands represent essentially Australian shelf areas, variously uplifted and covered by deposition of erosional products (Löffler 1982); the central ranges reach over 4000 m and have a mixed geology including volcanic, metamorphic, and sedimentary facies; the intermontane trough is a young, structural depression of extensive plains and swamps (Sepik in PNG, Meer in Irian Jaya) that separates the central cordillera from the northern coastal mountains such as the Saruwaged and Finisterre ranges.

A biogeographical division appears to exists between the marine systems located to the south of the island and those to the north (Jebb pers. comm.). Whereas the coral reefs and platforms of the southern seas are tidally dominated, the tidal influence in the north is minimal. This has major repercussions for marine biota, such that events like coral spawning in the southern area are distinctly seasonal and predictable.

Surrounding the Bismarck Sea are seven large islands and numerous smaller ones that can be structurally separated into two island arcs: the southern arc includes New Britain

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(36,520 km^2) and the chain of volcanic islands off the north coast of the mainland; the northern arc consists of New Ireland (8650 km^2), Lavongai (New Hanover, 1190 km^2), the St. Matthias group (of which Mussau is the largest, approximately 400 km^2), and the Admiralty group which includes Manus (1640 km^2). Along the northern side of the islands in the southern arc lie active or potentially active volcanoes, including Manam, Bam, Karkar, Bagabag, Long Island, Pago, Langila, Ulawun, and Bamus. To the southeast of New Britain, in the northern section of the Solomon Sea, lies the New Britain trench which reaches a depth of 6400 m. Geologically the northern arc represents an extension of the Solomon Islands chain, and included within the political boundaries of Papua New Guinea are the large island of Bougainville (10,619 km^2) and its smaller, northern outlier, Buka (829 km^2) (see Dahl 1986, for details of individual islands).

The Solomon Sea and Coral Sea are isolated somewhat from the main Pacific Basin, lying as they do to the southwest of the major island arc of the Solomons. The Bismarck Sea is less isolated from the influence of the Pacific Basin, lying in the path of the equatorial current. More detailed information about currents is available in the laboratory of Roger Lucas at the University of Hawaii.

Off the southeastern tip of New Guinea in the Solomon Sea lie the island archipelagos of the Louisiades (approximately 1200 km^2), D'Entrecasteaux (approximately 3000 km^2), and Trobriand Islands (440 km^2). The Trobriands consist of raised limestone (reef platforms) with flat or undulating surfaces and karstic features, while the other two groups include volcanic and land bridge islands separated from the mainland during the Pleistocene transgression. Among the 600 or so smaller islands within the country are representatives of virtually all oceanic island types found in the Pacific (Dahl 1986).

Papua New Guinea's coastline is extensive, and the wide variety of coastal habitats contributes to the high biological diversity of shallow water marine organisms. To the south, around 142°W, lies the Torres Strait, with coral reef and seagrass communities that form a northern extension of the Australian Great Barrier Reef system. Separating this from the Papuan Barrier Reef system to the east lies the mangrove fringed Gulf of Papua, an area of high sea snake diversity and extensive mangrove swamps and wetlands. The large Papuan Barrier Reef system parallels the southern coastline two to twelve kilometers offshore, beginning west of Port Moresby and continuing eastwards, where it becomes sunken, eventually forming discontinuous patch reefs in the southern Milne Bay Province (Löffler 1977).

The southern coastline is sinking while, in contrast, the northern mainland coast is subjected to active uplift. Hence, cliffed areas and large areas of raised coral reef terraces are a feature of the north coast, particularly in the area of the Huon Peninsula. Along the northern coast, isolated mangrove swamps occur in the vicinity of the Sepik, Ramu, and Markham River mouths, and on sheltered shores in the Morobe, Madang, and Northern provinces. Patch reefs, shoals, lagoon reefs, platform reefs, atolls, and fringing reefs occur in discontinuous patterns along the north coast and around the islands. Physically, the south coast of the mainland, with its relatively shallow waters and extensive reef systems, is considered by some a physically protected marine environment (Sullivan 1991). The north mainland and offshore island coasts are closer to deep waters offshore and, lacking the protection of barrier reef systems, are subject to strong effects from east coast swells.

Two distinct wind and rainfall seasons occur in Papua New Guinea, as in most of the western Pacific. In the winter months (May to September), the Intertropical Convergence Zone (ITCZ) lies to the north, and southeasterly trade winds dominate the climate; the Huon Gulf coast, and the southern coastlines of New Britain and New Ireland are subjected to steady onshore winds rarely exceeding 15 km/hr on the mainland and 30 km/hr on the islands. During the summer months (October to April), the ITCZ is displaced to the south, and warm monsoonal winds blow from the northwest. Wind velocities during the monsoons rarely exceed 20 km/hr on the southern mainland and 30 km/hr on the north coast (Sullivan 1991). Variations in these patterns occur when the Walker circulation temporally weakens, moving the center of maximum convective activity to the south and raising sea surface temperatures, as occurs during El Niño Southern Oscillation events (ENSO).

Meteorological data (McAlpine et al. 1975) and summary data for coastal stations at or close to sea level, are provided in Table 7-1.

Storm events have had episodic and substantial impact on PNG's coastal habitats. Tsunamis have been recorded at several locations, including Ritter Island in 1888, and Rabaul in 1937 and 1941 (Sullivan 1991). Evidence of cyclone storm surges is shown by depositional landforms at many locations on the islands of the Milne Bay Province. Although cyclone events are relatively uncommon, low magnitude storm events cause alterations of the coastal environment, particularly when these coincide with high relative sea levels as occur during El Niño events (Sullivan, 1991).

Few physical oceanographic data are available concerning ocean and wave climates, nearshore processes, and water temperatures for much of the coastline. Exceptions to this are areas surrounding major cities such as Port Moresby, and research stations like those at Motupore Island and Madang. Sea water temperatures measured by Brouns and Heijs (1985) at noon, 1 m below the water surface at Motupore Island, ranged from 24.9°C in August to 31.6°C in February, with an annual mean of 28.5°C for 1982. The Papuan coastal lagoon is subject to a mixed, predominantly semidiurnal, tidal regime, becoming diurnal during very limited periods each month. Tidal range is approximately 2.8 m. During the northwest monsoon, spring tides occur between 0100 and 0300 in December and January; during the southeast season spring low tides occur between 1300 and 1500. Scant information on tidal variation elsewhere in the country has been published, although extensive tide gauge data exist for a number of stations around the country.

DISTRIBUTION OF KEY COASTAL AND MARINE HABITATS

Major habitat types in Papua New Guinea coastal areas include fringing, barrier, and patch reefs; mangrove forests; seagrass meadows; sand- and mud-accreting shorelines and intertidal flats; barrier dunes and associated lagoons; deltaic floodplains and major estuarine areas; sea mounts; rocky shorelines; and reef walls or drop off areas of the continental slope.

The distribution of each of these habitats is relatively well-known in Papua New Guinea, and can be mapped manually and on GIS systems. Summaries of the biology of the most important coastal and shallow water habitats and their general locations are provided below.

Coral Reefs

Papua New Guinea has a total reef area of approximately 40,000 km^2 (Crossland et al. 1989). In the Torres Strait region immediately to the south of PNG, the southern reefs extend up to the south edge of the Orman platform reef (Whitehouse 1973). The extensive Warrior reefs lie to the east of the Torres Strait axis, running north-south. Farther to the east, the great combination of freshwater and sediment influxes from the Fly, Purari, and other rivers precludes reef development. Two hundred kilometers from land in the Gulf of Papua, however, the Portlock and Boot reefs, and farther offshore, Osprey Reef atoll, mark an area outside the sediment shadow of the greater Fly deltaic system. Farther eastwards, the Eastern Fields patch reefs lie between the Gulf of Papua proper and the Coral Sea (Whitehouse 1973).

Coral reefs begin again off the southern coast to the west of Port Moresby at Yule Island, some 200 km southeast of the Purari delta. This extensive southern Papuan Barrier Reef runs eastwards until it forms a series of discontinuous, easterly trending reefs (Sullivan 1991). It should be noted that the diversity of coral genera in the reefs of Bootless Inlet, Central Province, is higher than at any single location along the Great Barrier Reef of Australia. The barrier reef system extends for approximately 400 km to the eastern tip of the mainland near Samarai and beyond to the Louisiade Archipelago (Whitehouse 1973). Small regions of fringing reefs occur on the coast behind the main barrier reef and around the offshore islands, while discrete patch reefs and shoals are scattered in the barrier lagoon areas. At the edge of the continental shelf in the vicinity of the Louisiade Islands, the reef system weaves its way around many of the islands, forming two substantial lagoon areas at Long Reef and Bramble Haven (Whitehouse 1973). Separated from this Louisiade system by deep water to the north, a barrier reef surrounds Woodlark Island and an atoll occurs at Egum. Abyssal depths of some 10,000 m separate these reef areas from the Bismarck Archipelago to the north.

The profuse development of coral on the southeast coast of New Guinea stops at the narrow peninsula leading to the East Cape; thereafter, around the mainland, the reefs occur only as small fringing or patch reefs (Whitehouse 1973). The shoal ground around Hall Point and Dyke Acland Bay extends out for 100 km. Another area of shoal grounds extends beyond Goodenough Bay and the D'Entrecasteaux Islands to the Trobriands. Thus the coral reefs to the south of the Huon Gulf are limited to areas far enough offshore to escape the nutrient loading delivered from the extensive river systems draining north. Diverse and abundant reefs occur in patches farther along the north coast, near Madang and elsewhere outside the area influenced by sediment from the Sepik and Ramu rivers.

Reefs exist around the islands of the Bismarck Archipelago, including New Britain, and appear to be more abundant and diverse on the north side of this archipelago than on the

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south. Around the islands of New Ireland and Bougainville, fringing and incipient barrier reefs are found (Whitehouse 1973). A bibliography relating to PNG coral reefs can be found in Wells and Jenkins (1988).

Mangroves

Some of the most extensive pristine mangrove areas in the world are found along the south coast of New Guinea. Percival and Womersley (1975) record some 37 species, while Johnstone and Frodin (1982) record 32 commonly occurring species from PNG mangrove communities. The floral diversity is as high as in the center of the Malaysian region.

Distinct zonation characterizes this habitat, with zones tending to be wider in areas of accretion such as the Purari delta. In coastal areas with low sediment inputs or areas exposed to high wave action, zonation tends to be narrower and the mangrove forest itself may be reduced to a thin coastal fringe. Small stands of mangroves, one or two trees thick, may be found on coral coastlines and rocky exposed offshore islands. The best studied mangrove systems are those of the Purari delta (Cragg 1983, Petr 1983, and chapters therein). The south coast mangrove system is distinctive, containing nine species not found on the north coast where the mangrove flora resembles a more generalized Indo-Pacific community (Johnstone and Frodin 1982).

Zonation is controlled by salinity, tidal range, sediment inputs, and degree of exposure. *Avicennia* forms a narrow seaward fringe in stable locations, being replaced by *Rhizophora* in more exposed sites. At around one meter above mean sea level *Rhizophora* gives way to *Brughiera*, and on the landward side may be found a *Ceriops* thicket. In protected areas a seaward zone of *Sonneratia alba* may be found on deep, young, unconsolidated substrates, while along river courses in brackish areas this species is replaced by *Sonneratia caseolaris*. The *Rhizophora* zone is characterized by *R. mucronata* in more saline areas, being gradually replaced by *R. apiculata* as salinity drops. The *Brughiera* forest often includes *Heritiera littoralis* and *Xylocarpus granatum*, while the mixed *Ceriops* thickets may include *Avicennia*, *Brughiera*, and *Xylocarpus* spp. Monospecific stands of *Nypa fruticans* occur along tidal streams flooded by high spring tides, thriving in brackish water environments.

Zonation among the flora is paralleled to some extent by the distribution of associated fauna with penaeid prawns, for example, being replaced in the freshwater reaches by *Macrobrachium rosenbergii* and other freshwater genera. In the Fly River, Roberts (1978) observed a number of instances where species of the same or closely related genera replaced each other upstream, while Haines (1983) provides data on similar congeneric pairs from the Purari delta, together with an analysis of dietary preferences for the fish faunas of eight recognizable zones. The seaward zones tend to have greater proportions of predatory species feeding on other fish, crustaceans (both prawns and crabs), and detrital feeding species than inland zones (Haines 1983, Table 2). In all, Haines (1983) records 63 estuarine, 65 marine, and 16 riverine species from the Purari Kikori mangrove estuarine areas. He further notes that the fish fauna of the lower Purari is adapted to a muddy environment, with a high

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proportion of species having sensory barbels, prominent snouts, and/or thick adipose eyelids, and that turbidity is a major factor in determining fish species distribution within the area.

Detailed forestry maps are available for many of the larger areas of mangrove swamp (see for example Floyd 1977). The molluscan fauna has been examined in the Gulf Province by Poraituk (1982), while insect herbivory has been studied in Port Moresby and Madang by Rau (1991). Haines (1978/79, 1979, 1983), Liem and Haines (1977), and Liem (1983) report on the associated fish and wildlife faunas of mangrove swamps in the Purari delta; Pernetta and Black (1983) have described an endemic gecko confined to the mangrove associations of the Bootless Inlet. In general the fauna of mangrove communities in Papua New Guinea is not well studied, although the importance of such habitats for species of subsistence and commercial importance, such as *Scylla serrata*, barramundi, and the penaeid prawns, is well recognized (Frusher 1980, 1983, Gwyther 1980, 1983, Haines and Stevens 1983). Such habitats are also important to the maintenance of crocodile populations and, in particular, the saltwater species, *Crocodylus porosus* (Pernetta and Burgin 1983). An early, general account of the mangrove faunas of the Indo-West Pacific is contained in Macnae (1968), and a more recent review containing much information relevant to New Guinea is provided by Hutchings and Saengar (1987).

Seagrass Beds - Macrophytes and Macroalgae

The seagrass communities of Papua New Guinea are not well studied, except in isolated areas; distributional data are reviewed by Johnstone (1982). More detailed distributional studies are currently being undertaken by Nason Balat of UniTech. This important habitat for many marine species occurs in soft-bottom areas outside the extremely muddy delta regions of the great rivers. In areas of significant turbidity, seagrasses are restricted to shallow waters (Poiner et al. 1987).

The Torres Strait region has at least 12 species of seagrasses, representing 22% of the taxonomically described seagrass species (Bridges et al. 1982). Twelve species are also recorded from the Papuan Lagoon with ten species occurring in seagrass meadows in Bootless Inlet (Brouns and Heijs 1985). Heijs and Brouns (1987) surveyed seagrass communities in four locations around the Bismarck Sea, identifying ten species of seagrass from Wewak, Manus, and Kavieng, and eight from Rabaul (11 species total). No significant differences were found in the distribution and relative abundance of the seven most common seagrass species around the Bismarck Sea and in the Papuan Lagoon. The four species that were observed only occasionally apparently have more restricted distributions or specific habitat requirements than the common species. *Halophila spinulosa*, recorded from the Papuan Lagoon (Johnstone 1982), was not recorded from the Bismarck Sea.

Although systematic surveys have not been published for all areas of PNG's waters, it is likely that seagrass diversity around the mainland is similar to that of the areas studied to date. Data for species diversity in the Indo-West Pacific are as follows:

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Micronesia:	10 species (Tsuda et al. 1977)
Philippines:	11 species (Menez et al. 1983)
Palau:	9 species (Koch and Tsuda 1978, Ogden and Ogden 1982)
Eastern Indonesia:	12 species (Heijs and Brouns 1984, cited in Heijs and Brouns 1985, Den Hartog 1972)
Torres Strait and Gulf of Carpentaria:	12 species (Poiner et al. 1987)
Papua New Guinea:	10-14 species (Johnstone 1979, 1982)
Papuan Lagoon:	12 species (Brouns and Heijs 1985)
Bootless Inlet:	10 species (Brouns and Heijs 1985)
Wewak:	10 species (Heijs and Brouns 1986)
Manus:	10 species (Heijs and Brouns 1986)
Kavieng:	10 species (Heijs and Brouns 1986)
Rabaul	8 species (Heijs and Brouns 1986)

With the exception of the pantropical *Halophila decipiens*, all the species are restricted to the Indo-Pacific region.

In the Gulf of Carpentaria, three quarters of the 906 km^2 of seagrass habitat occur along open coastlines (Poiner et al. 1987). Elsewhere throughout the region, seagrass meadows are frequently associated with lagoonal areas in the vicinity of reefs. Individual species distributions are influenced by water depth and tidal range (Brouns and Heijs 1987, Poiner et al. 1987), while Brouns and Heijs (1985), and Heijs and Brouns (1986) recognize three broad zones in seagrass and associated macroalgal distributions: a eulittoral, an upper sublittoral, and a lower sublittoral. Johnstone (1982) recognized four zones which he named in accordance with the most common species. The productivity of seagrass meadows has been extensively studied in Bootless Inlet (Brouns 1985a, 1985b, 1985c, 1987a, 1987b, 1987c, Brouns and Heijs 1986) as has their associated fauna and flora (Heijs 1984, 1985a, 1985b, 1985c, 1987a, 1987b).

Heijs and Brouns (1987) record 32 macroalgal species in association with seagrass beds at Wewak, 40 species from Manus, 51 species from Kavieng, and only nine species from Rabaul (71 species in total), while Heijs (1985b) records around 100 species from more extensive surveys of the seagrass habitats of Bootless Inlet. Around the Bismarck Sea the Kavieng area demonstrated the highest abundance and numbers of species, and in comparing the Bismarck Sea with the Papuan Lagoon (Bootless Inlet area), Heijs and Brouns (1987) state that, "conspicuous overall differences in macroalgae around the Bismarck Sea and Bootless Inlet (on the south coast) are a much higher abundance of macroalgae around the Bismarck Sea (except for Rabaul); a higher number of Chlorophyta in the Bismarck Sea (particularly the Caulerpales); a relatively low number of Phaeophyta and Rhodophyta in the Bismarck Sea; and an apparent total absence of the large fucoid macroalgae around the Bismarck Sea."

In comparing their surveys in the Bismarck Sea with those in Bootless Inlet, Heijs and Brouns (1987) conclude that there is no significant difference in the marine angiosperm distribution or abundance, and that the macroalgal component of monospecific and mixed seagrass communities is richer in species and with higher cover in the Bismarck Sea.

Seagrasses are vulnerable yet important habitats that have potential value as bioindicators for the impact of global warming and other regional environmental changes. The upper thermal limit for tropical seagrasses is just above the current summer ambient temperature, and small increases in water temperature are thought to have caused mortality (Hatcher et al. 1989). Future changes in water temperature, as a consequence of global warming, may result in more widespread mortalities in the future.

Barrier Beaches/Lagoons

These habitats occur in association with deltaic floodplains or as smaller and more restricted landforms in areas of alluvial deposition. In PNG, beach ridges are generally of Holocene age (Sullivan 1991). Extensive areas of coastal dunes are rare in PNG, primarily because of low wind conditions, high soil moisture content, and dense vegetation (Löffler 1977). However, at Hood Bay coastal dunes cover more than 10 km^2 (Sullivan 1991), and extensive dunes may be found on the Aroma Coast. An extensive freshwater lagoon, or swamp, formed by the impoundment of river water through closure of an extensive barrier beach ridge, occurs in the Murik Lakes area of the East Sepik Province.

Deltaic Floodplains

Floodplains and subaqueous mud flat systems occur at the mouths of the major river systems around the Gulf of Papua, and at the mouths of the Sepik and Ramu rivers on the north coast (Percival and Womersley 1978, Wood 1982c). Of the two largest southern rivers, the Fly is tidal some 240 km inland. In contrast, the Purari has a river dominated estuary which contributes significant volumes of sediment through longshore drift to the tidally dominated estuaries of the Kikori and neighboring smaller rivers. The Purari Kikori deltaic complex exhibits many of the morphological and environmental characteristics of the Ganges Brahmaputra delta system with which it has been compared (Thom and Wright 1983). This system has been extensively studied and reported on in the Purari River Hydroelectric Scheme Environmental Studies and in Petr (1983). To the east, the Ok Tedi, Strickland, and Fly rivers have been investigated from various environmental perspectives in connection with the development of the Ok Tedi and Porgera gold and copper mines.

On the southern mainland, coastal swamp forest and deltaic floodplains occupy over 50% of the coastline, much of it colonized by mangrove. On the north coast and around major offshore islands, floodplains occupy only 5%-10% of the coastline (Sullivan 1991). The Sepik floodplain is up to 70 km wide, while the final 250 km of the Ramu river have an imperceptible decline.

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Rocky Shorelines

Rocky shorelines exist in areas far from alluvial deposits on mainland and offshore island areas. Such habitats are comprised of coral limestone, and intrusive, volcanic, and metasediment rock types (Sullivan 1991). Fringing reefs are found in association with rocky shorelines, primarily because these areas are distant from sediment-laden deltas. Approximately 40% of the mainland shoreline has rocky features (Sullivan 1991).

Sea Mounts

Little documentation on the existence of sea mounts in PNG waters is available. Sea mounts are volcanic underwater "mountains," thought to play an important role in pelagic fish predation and breeding, and also considered to be an overlooked, highly diverse feature of marine systems.

Sea Walls

Like sea mounts, sea walls and continental steep slope areas are often highly diverse, reflecting strong vertical zonation. Also thought to be important is the role that such physically steep slopes play in prey concentration for pelagic piscivores. The steep slope of the continental shelf drops of PNG can be mapped using bathymetry data. However, their ecological communities and role in biodiversity cannot be elucidated.

Low and Raised Coral Islands

Several hundred low islands exist in PNG waters, more than 200 of which exceed two square kilometers in area. Most of the latter group are permanently or seasonally inhabited. Motus are formed from accumulations of sand- and gravel-sized coral rubble built up on reef platforms (Sullivan 1991). In general, the vegetation consists of a typical Pacific strand line association of salt tolerant plants.

Raised coral islands and high islands are formed on sedimentary, volcanic, and metamorphic rock, and are one order of magnitude less abundant than are the low islands. Limestone islands have a more diverse flora than motus, but forest formations are normally more diverse and well developed on high islands of more diverse geology.

DISTRIBUTION AND STATUS OF SPECIES IMPORTANT TO CONSERVATION

In successional ecology, indicator species are those typical of a particular seral stage In environmental biology, however, biological indicators are those species for which reductions in population sizes can be causatively linked to quantifiable decreases in environmental quality. According to the U.S. Forest Service (cited in Soule and Kohm 1989), "...species shall be selected because their population changes are believed to indicate the effects of management activities." Several of the species groups listed below may not fit

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this definition in its rigorous interpretation; however, the abundance of such species may potentially provide the information necessary to assess conservation needs.

Given the extensive subsistence use in Papua New Guinea of many marine resources, and in particular a number of the species listed below, their present population status may be linked more closely with the size of neighboring human populations and, hence, exploitation rates, rather than with broader environmental quality.

Sea Turtles

Sea turtles are useful indicators of some types of marine environmental change, particularly since they require a string of different intact habitats for survival. Although most marine species require such a network of habitats, sea turtles belong to a limited group of marine organisms with a life history linking them to land. Turtles, being oviparous reptiles with amniotic eggs, must lay their eggs high up on sandy tropical beaches. Both nesting adults and their eggs and hatchlings are made extremely vulnerable by their required emergence from the sea. The harvesting of sea turtles, plus natural predators, inflicts heavy predation on adult females and young--at such high levels that even their extremely high fecundity (females commonly laying over 100 eggs per clutch up to a dozen times during each nesting season) is offset by predation. Compounding the loss of nesting females, eggs, and hatchlings is the loss, alteration, and degradation of critical habitats, including nesting beaches, foraging grounds, and pelagic nursery grounds. At the present time, all species of marine turtles are, to varying degrees, threatened with extinction.

Six species of marine turtles occur in PNG waters, including the green turtle (*Chelonia mydas*), flatback turtle (*Natator depressa*), loggerhead sea turtle (*Caretta caretta*), hawksbill turtle (*Eretmochelys imbricata*), olive ridley turtle (*Lepidochelys olivacea*), and the leatherback turtle (*Dermochelys coriacea*).

Green turtles are the most abundant species in the region. Yet Limpus and Fleay (1983) estimate that, in the Torres Strait region alone, approximately 10,000 green turtles were harvested annually in the late 1970s. This high fishing mortality, combined with significant egg harvests at virtually all nesting beaches close to population centers, slow natural growth and late maturity, and habitat destruction threaten the populations of even the relatively common species (Craik et al. 1990). Green turtles are herbivorous, grazing primarily on seagrass beds.

For the migratory green turtles in southern PNG waters, the Torres Strait acts as an important corridor through which turtles may move from feeding grounds in southeastern Indonesia, the Arafura Sea, and Gulf of Carpentaria, to rookeries on mainland and offshore island beaches. Research is currently underway (C. Limpus pers. comm.) to determine whether green sea turtles in the eastern and southeastern waters of PNG are genetically distinct from *Chelonia mydas* frequenting the Great Barrier Reef of Australia; subsequent studies may attempt to elucidate the stock structure of other regionally important groups as well. Recognizing the potential linkage between Indonesian, Australian, and Papua New

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Guinean turtle populations, the South Pacific Regional Environment Program urged UNEP to assist in the establishment of joint mechanisms between the interested parties to develop common programs for turtle management and conservation in the area.

Miller and Limpus (1991) discuss fluctuations in breeding populations of *Chelonia* in the Torres Strait area and link these to El Niño Southern Oscillation (ENSO) events. The researchers have found a significant correlation between ENSO indices measured two years before the commencement of the nesting season, and numbers of green turtles nesting at certain Great Barrier Reef rookeries. Whether this pattern holds true for PNG rookeries has not been determined, but the implication is important in evaluating sea turtles as potential bioindicators of climate change. This is particularly so in view of the fact that a number of climate change modelers suggest that one consequence of predicted global warming may be an increase in the frequency of ENSO events.

Loggerhead turtles are relatively common in the southern region of PNG, including the Torres Strait, though the region is more important as a foraging ground than as a breeding area (Miller and Limpus 1991). Loggerheads that migrate from the Gulf of Carpentaria to the southern Great Barrier Reef rookeries may pass through PNG waters. Loggerheads are more opportunistic feeders than green turtles, having an omnivorous diet composed primarily of shrimps, crabs, and other crustaceans.

Hawksbill turtles typically forage and breed in coral reef areas. For this reason, hawksbill distributions in PNG are concentrated in the Torres Strait, southern barrier reef of PNG, and in the reef areas around the western and northwestern islands. The Torres Strait and the adjacent nesting population of the Australian Great Barrier Reef is thought to be one of the largest demes of *Eretmochelys imbricata* remaining in the world (Miller and Limpus 1991). Hawksbill turtles are, like loggerheads, omnivorous, but occupy a peculiar niche in coral reef systems by being one of the only animals to regularly consume sponges.

Leatherback turtles, *Dermochelys coriacea*, are the largest species of marine turtles, commonly exceeding 800 kg as adults. The seemingly shell-less condition of the animal, and its distinct grey-black coloration and prominent white-speckled longitudinal ridges, render these turtles markedly different in appearance from all other sea turtles in the region. This species is also the most migratory, commonly moving between tropical breeding areas and temperate, and in some cases even subarctic, feeding grounds. The movements of the leatherback turtles nesting in PNG are not known, though researchers in the region feel it is highly likely that leatherback turtles of PNG are shared by the Solomons (Vaughn 1981) and Indonesia (unpublished information brochure, Department of Lands, Surveys, and Environment 1981). Leatherbacks are pelagic animals, feeding primarily on coelenterates.

Major nesting populations of *Dermochelys* occur along the north coast of the mainland (especially Boiken to Turubu in East Sepik Province; Aitape in West Sepik Province), on Manus (near Tulu and Timonai villages), New Ireland (southeast coast), New Britain (Garu and Ganoi villages), Long Island, Normanby Island in the Milne Bay Province, and Bougainville islands (Spring 1981). A significant rookery has been studied by Quinn and Kojis (1985b) on the coast of Morobe Province at Maus Buang, where an estimated 300-500

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adult females nest. This rookery is protected through a small-scale ecotourism operation. Relative to *Chelonia* abundances in PNG territory, leatherbacks are not common.

The sandy beaches found in the western Torres Strait support the largest documented nesting population of the endemic flatback turtle (Miller and Limpus 1991). The size of this population has not been estimated. The extent to which these flatback turtles venture into PNG waters is also unknown. *Natator* has ecological requirements similar to that of *Chelonia*, though major behavioral differences exist.

Olive ridley turtles are rare in Papua New Guinea; nesting of this species in PNG has not been documented. Most olive ridley sightings are reported from the Torres Strait (Miller and Limpus 1991), and it is likely that olive ridleys found in PNG are transients rather than residents. Ridleys have a highly omnivorous and varied diet.

Sea turtle resources are used throughout the region. Directed harvest affects adult and subadult size classes, with fishing methods including decoy capture, pole and line, and netting. The preferred species for meat is the green turtle, though other species are eaten opportunistically. Around Daru, more than 500 fishermen hunt turtles annually, focusing on Podomaza, Auomaza, and Wapa reefs. Although green turtles are the preferred species, flatbacks, loggerheads, and hawksbill turtles are also taken. Estimated total numbers of adult animals taken yearly in the Daru area range between 5100-6700 (Kwan 1991), which appears to be a significant proportion of the breeding population nesting on nearby Raine Island. Leatherback turtles, though taken incidentally, are less subject to intensive harvest, in part because their meat is less palatable, and also because tambus and other local customs forbid their consumption in some areas (e.g., in Morobe Province).

Marine turtle eggs, on the other hand, are harvested from all species. Especially vulnerable are clutches laid on nesting beaches in proximity to population centers. In certain areas of PNG, egg gathering is regulated by traditional rules. Management areas, under PNG's Wildlife Management Area System, have been set up to protect sea turtles on Crown and Long islands, and Maza in the Western Province.

Turtles of Estuarine and Coastal Swamp Areas

A number of fresh and brackish water turtle species occur in coastal areas of the country, particularly along the south coast. One endemic species is found in the mangrove and swamp forest habitats of the Fly River flood plain and estuary.

The large pig-nosed or pitted shelled turtle, *Carettocheles insculpta*, the sole extant member of its family, is relatively abundant in the coastal and semisaline reaches of the Fly, Kikori, and Purari deltas, being found some distance inland along freshwater riverine reaches. Nesting occurs on the delta sand banks, and the annual harvest of eggs and adults is substantial. Around 20,000 eggs of this species were sold annually in the mid-eighties in Kikori Market (Rose pers. comm.). The ecology, distribution, and abundance of these animals are not well-known, and some evidence for population differentiation exists between demes in the Fly and Kikori areas.

Crocodiles

Two crocodile species are found in PNG, *Crocodylus porosus*, the saltwater crocodile, and *Crocodylus novaeguineae*, the New Guinea freshwater species. Traditionally the take of these species was probably low (Hope 1977). Some cultures are known to have eaten these animals, and the presence of crocodile remains in the Motupore shell midden suggests that this was the case with the people of Central Province. The major decline in crocodile populations occurred in the fifties with the influx of commercial expatriate hunters taking both species for their skins.

Later developments involved the establishment of crocodile "farms" based on wild caught juveniles and their maintenance in village pens until they had reached a suitable size for the skin market. Regrettably, this UNDP program was ill-founded, lacking a proper program of resource assessment, and many of the smaller farms established during the initial phase collapsed due to the unavailability of juveniles to stock them and/or inappropriate husbandry techniques that led to escapes, slow growth rates, disease, and poor skin quality (for a review of crocodile farming in PNG see Burgin 1980). From July 1977 to December 1979 the mean number of crocodiles held in village-based farms declined from around 50 to fewer than 30 (Burgin 1980a). The desire of the government to secure, through small-scale crocodile farming, a source of development income at the village level was not successful, largely due to overestimation of the available wild resource in many areas (Pernetta and Burgin 1982). A subsequent government supported survey of wild crocodile populations was undertaken in the mid-1980s.

Management measures taken, to date, have been based on regulating the size of skins which can be marketed in an attempt to conserve the breeding adults and licensing of exports. Commercial scale farms have been established with varying degrees of success in different parts of the country. Success in hatching eggs and rearing juveniles was initially poor due to inadequate diets being made available to hatchlings (Burgin 1981). Further information on crocodiles and their management may be found in the quarterly reports of the UNDP funded project and in Burgin (1980b, 1981a, 1982).

Dugongs

Dugongs (*Dugong dugon*) are unusual marine mammals belonging to the order Sirenia. In 1974-75, the government of Papua New Guinea, concerned about the status of dugongs, initiated a survey in many coastal areas of the country; the survey indicated that both hunting pressure and dugong densities were highest in the Western Province (Hudson 1977). Hudson (1981a, 1981b, 1982, 1984) provides some information on distribution, status, and management of this species based on work of the Department of Environment and Conservation.

Traditionally around 20 dugongs were taken annually in the Kiwai area, but the take increased steadily from the 1950s, peaking at around 200 in 1979. The hunt declined precipitously in the 1980s, and the impact of establishing the Maza Wildlife Management Area on the Kiwai dugong population has not yet been assessed (Hudson 1984).

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This species is still relatively common in the Torres Strait region, with estimates of abundance greater than 12,000 individuals (Marsh et al. 1984, Marsh and Saalfield 1991). Marsh (1984) provides details of the reproductive patterns of this species and the implications for management. Hunting of this species occurs in virtually all parts of the country close to extensive seagrass beds, their critical foraging area (Johnstone and Hudson 1979). For some societies, such as the Kiwai of the northern Torres Strait area, the dugong is an important cultural symbol, playing a vital role not only in the subsistence economy but also in the social mores of the people concerned (Landtman 1917, 1927, Olewale and Sedu 1982). The breakdown of the cultural traditions associated with the management of this resource are well documented by Olewale and Sedu (1982) for the Kiwai area of Western Province.

Cetaceans

No systematic surveys of whales and dolphins have been undertaken in PNG waters, and although these animals were traditionally taken in small numbers by many coastal peoples (Pernetta and Hill 1981b), only a few cultures on the north coast of New Guinea and the Solomon Islands undertook a more systematic exploitation of these resources (Dawbin 1966, Dawbin and Hill, cited in Pernetta and Hill 1981). However, international whaling fleets did exploit marine mammals of PNG in the nineteenth century.

Coral Reef Fishes

Evidence from long-term studies of coral reef ecosystems suggests that the reef community may be regulated from the top down by predation. Primary production on reefs, including that of photosynthetic zooxanthellae, phytoplankton, and macroalgae, seems to be limited by space and nutrient availability. Yet, in spite of relatively high primary production, high numbers of trophic levels (commonly six levels) limit the production of apex predators and fish high in the food chain (Saila 1990). Thus, predatory fish exert significant effects on community structure, thereby providing a useful indicator for reef system assessment, particularly since these are frequently the first species to decline under heavy fishing pressure.

The total number of fish species in Papua New Guinea waters may be on the order of 2000. Munro (1967) records around 1097, of which some 200 occur in freshwater, with approximately 111 breeding inland. The highest diversity of species is associated with reefs that are also subjected to heavy traditional subsistence based fisheries. Little quantitative evidence of species decline or extinction exists in the literature, although traditional knowledge indicates significant decline of some reef fisheries close to population centers. Recent work by the Department of Fisheries has centered on research and development of coral reef fisheries in support of rural development of coastal populations in less developed areas.

A preliminary fisheries bibliography has been compiled by Lock and Waites and published by the Department of Primary Industry (Lock and Waites 1985).

Barramundi

The barramundi or giant perch, *Lates calcarifer*, is a large catadromous fish species that spends the bulk of its life history in inland freshwaters, but which migrates to coastal areas to spawn. Because of this biotic linkage with interior freshwater systems and coastal ecosystems, the barramundi may be an important bioindicator species, signaling the onset of impact on freshwater systems inland before impact in coastal habitats can be observed.

Barramundi spawn in coastal swamps. Young leave coastal nursery areas six months after hatching to move to more saline coastal and estuarine regions (Moore 1982). Around the second or third year the subadults move to inland waters (Reynolds and Moore 1982), though a residual population of fish stay in estuarine regions for the remainder of their lives. The movement of adult fish to spawning areas is influenced by climatic conditions, although not all adults undertake the spawning migration in any given year (Moore and Reynolds 1982).

Giant Clams

Giant clams (Tridacnidae) have a truncated distribution representing a restriction of their original range to the Indo-West Pacific. Six of the eight species known to science are found in Papua New Guinea: *Tridacna gigas*, *T. derassa*, *T. squamosa*, *T. crocea*, *T. maxima*, and *Hippopus hippopus* (Lucas 1988). These species are susceptible to overharvesting, as the local extinction of *H. hippopus* in Fiji 1000 years B.P. and the devastation of isolated reef populations of *T. gigas* and *T. derassa* by poaching demonstrate (Lewis et al. 1988). The range and abundance of giant clams have been dramatically reduced in areas of high human population density, and small scale commercial exploitation for adductor muscle export threatens populations in areas such as the Trobriand Islands.

Given the success of various agencies, including the University of Papua New Guinea, in developing spawning and mariculture techniques for these species (Bell and Pernetta 1988), it would be possible to establish centers for seed production for reestablishment of wild populations.

DISTRIBUTION AND ABUNDANCE OF COMMERCIALLY IMPORTANT STOCKS

Commercial Fisheries

The biggest of the country's commercial export fisheries is the tuna fishery, and between 1976 and 1978 catches ranged from 24,000 to 42,000 tons per annum (85% of which was skipjack) landed annually by two locally registered tuna fishing companies (Pernetta and Hill 1981, Perry 1982c). The domestic tuna fishery was worked in 1978 by between 40 and 50 pole-and-line boats operating around Manus and in the Bismarck Sea during the southeast monsoon, and on the Solomon and Coral Sea grounds during the northwest season. In addition in 1978, 12 Japanese and two US purse seiners, 12 Japanese long liners, and 23 Japanese long-range pole-and-liners were licensed for operation in PNG waters (Perry 1982c). Estimated sustainable harvest is from 40,000 to 200,000 tons per annum (Kearney 1977, unpublished consultancies). More recent fisheries data have been recorded but were not available for inclusion in this overview.

The Gulf of Papua trawl fishery is based on the spiny lobster, (*Panulirus ornatus*, approximately 100 tons tail weight per annum) and a variety of penaeid prawns of which the banana prawn, *Penaeus merguiensis*, forms about 50% of the annual catch of between 800 and 1100 tons tail weight. Other species in the fishery include the tiger prawns, *Penaeus monodon* and *Penaeus semisulcatus*, and endeavour prawns, *Metapenaeus* spp.

The barramundi, *Lates calcarifer*, is fished commercially for export in the Western Province, and exports to Australia totaled around 280 tons whole weight in 1978.

Subsistence and Small Scale Commercial Fisheries

Subsistence and small scale commercial fisheries continue to exploit the wide range of species used traditionally. In general, reef fisheries are dominated by members of the families Scaridae, Holocentridae, Apogonidae, Epinephelidae, Lutjanidae, Lethrinidae, Labridae, Coridae, Siganidae, Carangidae, and Balistidae; in mangrove areas members of the families Mugilidae, Atherinidae, and Hemirhamphidae make up a larger proportion of the catch. In contrast, estuarine and swamp areas tend to support fisheries dominated by catfishes. Seasonally pelagic species, including trevally, tuna, and barracuda, form important components of local fisheries being exploited when they visit spawning grounds inshore.

The actual number of fish species available at any one location is affected by the nature of the substratum and the proximity of habitats such as reefs, mangroves, and seagrass meadows, the latter two habitats forming important spawning grounds and nursery areas for many species. Birkeland and Amesbury (1988), on the basis of various comparative surveys, concluded that the proximity of different habitats such as seagrasses and mangroves had no effect on adult reef fish diversity in New Guinea and other Pacific island areas. In comparing Caribbean and Pacific reef communities, Birkeland and Amesbury concluded that in the Pacific, fish communities were more discrete and relatively nonoverlapping in different habitats. The implication is, therefore, that the recovery potential in Caribbean reef fish communities may be greater than for Pacific reef fish communities (see also UNEP 1985).

Estimates of annual subsistence catches for the country as a whole are variable: 30,000 tons (Filewood 1972); 18,000 tons (Anon 1972); and 10,000-15,000 tons (West 1977). Kearney (1977) claimed that 13,600 tons of reef fish are harvested annually, with lesser amounts of estuarine fish, crayfish, molluscs, and other species. Haines (1978/1979) estimated the catch for three villages in the Purari River delta, Baimuru subdistrict, at 292 tons of fin-fish and 146 tons of crabs and prawns. More recent figures on subsistence catches are available, but could not be obtained for this study.

Small scale commercial exploitation of species such as Tridacnid clams, green snail (*Turbo*), *Trochus*, and pearl oyster (*Pinctada* spp.) and beche-de-mer has occurred in various areas in the past with varying degrees of impact. Beche-de-mer was exploited commercially

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in the Torres Strait at the start of this century, but the fishery has fallen into disuse, and the various species never appear to have been important in subsistence diets. However, in some places beche-de-mer is still important as a fishery and is overexploited (M. Huber pers. comm.). Tridacnid clams were exploited for the adductor muscle in the Milne Bay Province in the 1980s, but this practice has now ceased. In some areas, like Baimuru, Gulf Province, provision of freezer and marketing opportunities has led to greatly increased catches of species such as the mud crab, *Scylla serrata*, largely for export to Port Moresby (Stevens 1980, Haines and Stevens 1984). It is unclear whether this practice still continues.

In general, small scale commercial fisheries provide products for consumption in PNG, and rely on enhanced transport systems and improved methods of preservation including freezing, smoking, and drying. As such systems are improved, catch rates increase, resulting in increased pressure on the finite resource base. The pressures for providing opportunities for rural income generation must therefore be taken into consideration in any marine management and conservation plan.

TRADITIONAL USE AND PATTERNS OF MANAGEMENT

The history of marine resource exploitation in coastal Papua New Guinea is extensive both temporally and spatially. Few areas of the coast have remained immune to some degree of resource exploitation in the past, and coastal populations continue to exploit a wide range of marine species for both subsistence and commercial use. The earliest coastal sites with shell middens are from island Melanesia, at Matenkupkum (32,700 B.P.), Kilu (28,700 B.P.), Panakiwuk (15,140 B.P.), and Baluf (14,240 B.P.) (Allen et al. 1988, 1989, Wickler and Spriggs 1988). Not only does Matenkupkum represent the earliest occupation of any Melanesian island other than New Guinea (40,000 years B.P., Groube et al. 1986), but it also contains one of the longest records of human use of shellfish anywhere in the world, with the sequence commencing at around 32,500 B.P. and continuing to around 10,000 B.P. when the site was apparently abandoned.

It has been argued that the diversity of marine resources available in Melanesia was crucial to the early successful colonization and spread of human populations throughout the area (Groube and Pernetta, in press). The range of species of both fin-fish and shellfish consumed by coastal communities is high. Shoffner (1986) found that the Teop consumed 350 species of fish, over 19 species of crustacea, and 54 species of molluscs. Liem and Haines (1977) record over 135 species of fish being consumed in the mangrove swamps of the Purari delta. Data from the shell midden at Motupore Island (Pernetta and Groube unpub.) indicate that over 90 species of molluscs, several species of echinoderms and crustaceans, dugong, and marine turtles were regularly consumed by the prehistoric occupants of this site. The present day Motu occupants of this stretch of coast had over 750 names for the different fish species recognized by them in the Papuan Coastal Lagoon (Pernetta pers. comm., Wright and Richards 1985).

The range of species taken and the environments used by prehistoric and contemporary subsistence communities is paralleled by the wide diversity of technologies and techniques used to capture and collect the species for food and other purposes (Anell 1955, Pernetta and Hill 1981a).

The importance of marine resources in the diets of coastal populations has frequently been undervalued in anthropological studies (Pernetta and Hill 1981a, 1981b). Despite the low investment of time involved in the capture and collection of marine species, it has been estimated that they provide between 79% and 95% of the protein, and up to 75% of the fat in subsistence diets in coastal areas of Melanesia and Oceania (Pernetta and Hill 1981a). A national survey in 1963 by the Bureau of Statistics found that 21% of the population at that time made regular use of saltwater fish. A more recent survey done during an ADB consultancy indicates their continued importance (data available through the DFMR). Although more recent figures are not available, it is likely that this proportion has significantly increased due to improved fishing gear, increased fishing effort, and better marketing systems in various areas of the country. In addition, the population has substantially increased over the last three decades, and aggregation in coastal centers such as Port Moresby, Lae, Madang, Wewak, and elsewhere places marine resources in these areas under increasing pressure.

Growing harvesting pressure on marine resources has also occurred as a consequence of the process of monetization of these resources (Pernetta and Hill 1982), and in some instances has led to increased frequency of disputes concerning ownership rights (Johannes 1982) and to the breakdown of traditional management practices (Haines 1982, Olewale and Sedu 1982). Post-colonial overexploitation of marine resources has clearly occurred in the vicinity of major coastal centers such as Port Moresby; but it should also be recognized that prehistoric populations were responsible for the local decline in some stocks (Asigau 1988, Swadling 1976, 1977a, 1977b, 1982) leading, in some instances, to local extinctions such as that of the dugong in the Port Moresby area.

It is important to recognize that traditional patterns of ownership and management of marine resources in Papua New Guinea are as diverse and multifaceted as the wide diversity of cultural and linguistic groups. Unlike many countries where ownership of the coastal and marine environments is vested in the state, traditional, communal ownership of marine areas and resources is the norm for Papua New Guinea. As demonstrated by Carrier for the Ponam people of Manus Province, patterns of traditional ownership may involve not only areas of reef and particular fishing grounds, but also ownership of particular species and fishing techniques. It is imperative, therefore, that any future management of marine environments and resources involve consideration of traditional ownership patterns, and, hence, future management strategies must vary from area to area within the country. A generally applicable, fundamental principle for sound management of marine environments and resources must be the formal, legal recognition of traditional usufruct rights as advocated recently by FAO and the UNCED Secretariat (1991).

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EXISTING LEGISLATION FOR PROTECTING MARINE SPECIES

Existing legislation in terms of legal instruments in Papua New Guinea covers both conservation practices and environmental protection. The Environmental Planning Act (EPA 1978) requires the implementation of an environmental impact assessment for any major development project in the country, while the Environmental Contaminants Act (ECA) regulates the disposal of wastes. Implementation of these two acts has been patchy, with some activities such as the Ok Tedi mine being specifically excluded from the provisions of the EPA because the Ok Tedi Mining Act contained its own provisions for environmental impact assessment. The ECA was not implemented for some time because there were no appropriate standards for discharge to enforce the provisions of the act. The Water Resources Act contains provisions for the control and regulation of waste disposal into freshwater systems within the country, and is designed to sustain water quality.

In terms of conservation legislation, a variety of acts provide for the establishment of reserves, parks, and protected areas: (1) Protected Areas for Special Species, declared under the Fauna Protection and Control Act, are areas designated to protect particular species; (2) Sanctuaries, declared under the same act, protect all animal species in the area; (3) Wildlife Management Areas, under the management of the local landowning group, establishes appropriate rules and regulations governing traditional use and harvest of resources contained within the area; provision contained in the Act for Conservation of Wildlife; and (4) National Parks, declared under the National Parks Act, are areas where all flora and fauna are protected. (There is confusion about whether this act can be applied to marine areas.)

The difficulties of applying such alien concepts in the context of Papua New Guinea, where in excess of 95% of the land is under customary (group) ownership, have been discussed *in extensio* by Eaton (1982). As a consequence of these difficulties, legislation was passed in 1974 to establish the Fauna Protection and Control Act to regulate the hunting of wildlife, and establish different categories of wildlife such as protected and restricted species. Both categories may be taken only by automatic citizens of Papua New Guinea, using traditional means and for traditional purposes. Protected species may also be taken under license on behalf of accredited scientific or zoological institutions, while in the case of restricted species only their export is controlled. In both categories, export is technically restricted to no more than four specimens of each species. More than 17 mammals, 72 birds, 24 reptiles, and seven butterflies are currently listed under this act which, although it covers dugongs, was not expressly designed to cover marine fauna.

Some species, such as crocodiles, are covered by specific legislation such as the Crocodile Protection Ordinance of 1966 which came into force in 1969 in Papua, while the Crocodile Trade (Protection) Bill of 1974 contained amendments on licensing matters. The broad policy objective was the development of a crocodile skin industry to provide village based income. Emphasis was thus made on the preservation of wild populations "with rearing farms as a tool to this end" (Downes 1974).

In general, protection afforded marine organisms or habitats through these acts is inadequate. Although a number of wildlife management areas cover marine resources and environments, the total area of marine habitat afford protected in Papua New Guinea, is grossly inadequate for sustaining the wide diversity of habitats and species found within the EEZ and territorial waters.

MAIN THREATS TO PNG MARINE ECOSYSTEMS

The major long-term threats to marine species stem from potential excessive harvesting by increasing human population size and aggregation in coastal areas. In addition, the development of coastal fisheries to supply the inland populations with much needed protein in the form of smoked and dried fish poses a potential problem if not well managed.

From an ecosystem perspective, threats to coastal habitats from land reclamation, mangrove felling for fuelwood, and, possibly, eutrophication resulting from nutrient enrichment are locally important, but presently not widespread. Sewage and urban waste disposal from the main coastal urban centers causes substantial inputs of nutrients and potential contaminants into inshore waters, since most discharge points have been established without adequate environmental studies of the effects of such wastes.

Inland developments, including forestry activities, changes in land use practice, poor watershed management, discharge of mining wastes, and conversion of forests to open subsistence farmland pose threats to the integrity and productivity of various marine ecosystems. To date such threats seem largely confined to the impact of enhanced sediment loads arriving in coastal and estuarine areas, smothering sensitive habitats and altering coastal geomorphological processes.

Mining at Panguna in Bougainville (now ceased) caused loss of reef amenities and coastal fisheries, while the development of several smaller mines on islands such as Misima poses a potential threat. Unrestricted discharge of mining wastes into the Ok Tedi River threatens the fish populations of the middle and lower Fly, although its potential impact on the estuarine areas and the Torres Strait is both debated and under current investigation. There is little evidence for the impact of heavy metals on marine species in connection with these activities (see Lawrence 1991), but long-term chronic effects on populations of deltaic and estuarine species should not be ruled out. The potential impact of both heavy metals and enhanced sediment loads on the different stages of the life history of anadromous and catadromous species such as barramundi cannot be ignored.

Improper use of resources such as dynamite fishing remains one of the most serious, widespread, and uncontrollable marine conservation problems in PNG. The incidental catch of nontarget species continues to be a problem in virtually all fisheries.

MAJOR OPPORTUNITIES FOR CONSERVATION

Papua New Guinea presents a major and perhaps unique opportunity for successful implementation of a coordinated program of marine conservation and management for a variety of reasons: (1) it is one of the few countries in the world in which the principle of sustainable development is incorporated into the Constitution (the fourth national goal and directive principle), demonstrating a government level commitment to wise use and management of natural resources; (2) much of the population still maintains close links with the natural environment, and grass roots level concern about sustainable use and management of resources is widespread; the pool of traditional knowledge concerning marine resources can be used as a firm basis for future action; (3) population densities in the country are at present well below those of Southeast Asia; hence, the opportunities for successful conservation and management of natural and seminatural marine environments are greater in Melanesia generally and in Papua New Guinea in particular; (4) the diversity of marine environments and habitats within the political boundaries of Papua New Guinea is large, encompassing many of the habitats and species which may be found in more scattered locations throughout the insular Pacific world; (5) the existence of the government departments of Fisheries and Marine Resources, and Environment and Conservation provides a firm administrative base for development of policy and management strategies and actions; and, (6) expertise in marine related research within PNG is located in the universities, government departments, and independent research stations, providing a small but experienced cadre of trained personnel for implementation of future management and conservation programs.

EXPLORING THE LINKS BETWEEN TERRESTRIAL AND MARINE CONSERVATION

Linkages between terrestrial and marine conservation may be viewed in two different but related ways. In the first instance, development activities on land impact on coastal resources and environments, necessitating careful planning and identification of the potential impact prior to the onset of development. Recognition of the physical environmental linkages in explicit terms is a prerequisite for mitigation or avoidance of potentially detrimental coastal impact.

In the second case, establishing conservation or wildlife management areas on land, designed to provide a framework for successful management of natural resources and terrestrial environments should go hand in hand with selecting coastal areas. In a case where a watershed is to be protected, for example, the natural flux of sediments, nutrients, and wastes to the adjoining coastal areas can be expected to be low. We feel priority should, therefore, be given to actions in coastal areas which are "downstream" of land areas under protection or management. This is not to say that only such areas should be considered for conservation action, but rather that such areas offer a higher probability of successful management than areas downstream from major mining, forestry, or other development projects that cause major changes in land use and, hence, changes in the flux of materials and energy to the coastal zone.

In essence, successful management and conservation of marine and coastal environments and species in Papua New Guinea will depend upon identifying natural system boundaries and modifying management regimes and the sectoral responsibilities of government agencies such that management units correspond more closely to marine and coastal systems (Elder and Pernetta 1991).

RECOMMENDATIONS

Immediate Research and Conservation Needs

The following are considered by one of us (JP) to be immediate priorities for marine resource and environmental management and conservation in PNG: (1) initiation of a program of resource and habitat inventory including recording and assessing traditional patterns of use and management of marine species; recording and evaluating traditional scientific knowledge; establishing in PNG a cataloged collection of relevant published literature, including scientific papers; and collating existing data on occurrence, distribution, and abundance of marine species in computerized databases in PNG as has been accomplished for terrestrial mammals; (2) identification of specific areas and species currently under threat from development activities and population growth, and development of appropriate management regimes to safeguard the continued sustainable use of such areas and resources; (3) strengthening and expansion of existing fisheries programs of research into artisanal and subsistence fisheries; fishing communities in areas representative of the wide diversity of habitats and marine ecosystems throughout the country should be targeted, and the program should place an emphasis on assessing the impact of such developments on critical habitats and resources; and (4) development of appropriate guidelines for implementing "wildlife management areas" in the coastal zone and near-shore waters to ensure recognition of local "landowners'" rights, and regulate harvests on the basis of scientific data.

It might be argued, given the present state of knowledge concerning marine environments and species, that immediate efforts should be directed to redressing the present state of knowledge. Although such a superficial view might find some support, implementation of a massive program of resource inventory and habitat survey work is likely to prove ineffective in Papua New Guinea at this time. Such a program would have to rely, at least in part, on external experts whose sensitivity to local conditions, and cultural and social values, would be slight; hence the program would be divorced from the people in whose hands the ultimate fate of the resources and habitats rests.

It is suggested, therefore, that at least initially, such a program be partly based on direct involvement of local coastal and island communities through recording and evaluating scientific knowledge, and through assessment of local resource use and traditional management in areas identified as being important in the context of marine conservation. Traditional ownership rights and obligations need to be recognized by all players active in conservation. In support of these traditional rights, we recommend the development of a network of locally based wildlife management areas that are controlled and managed on a sustainable basis by "owner" groups. These should be supported by scientific advisement from strengthened and expanded Departments of Environment and Conservation and Fisheries and Marine Resources.

Table 19-1
Some Meteorological Data for Coastal Stations in Papua New Guinea (after Spenceley 1982c).

Province Station	Height above sea level (m)	Average rainfall (mm/annum)	Annual Temperatures °C Maximum	Mean	Minimum
Western					
Daru	5	2063	30.5	26.9	23.3
Gulf					
Kerema	5	3612+	29.6	26.2	22.7
Central					
Port Moresby	35	1197	31.0	26.8	22.6
Milne Bay					
Samarai	40	2655	29.2	26.5	23.8
Losuia	3	3942+	29.3	26.6	23.8
Northern					
Popondetta	85	2482	31.2	26.4	21.6
Morobe					
Lae	10	4617+	29.7	26.3	22.9
New Ireland					
Kavieng	10	3183+	30.2	26.3	22.5

APPENDIX 19-1. MARINE ENVIRONMENTS BIBLIOGRAPHY

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Chapter Twenty

Biodiversity and Conservation of Humid Forest Environments in Papua New Guinea

Simon M. Saulei[1] and Bruce M. Beehler

SUMMARY

We characterize ten ecologically defined classes of forests in Papua New Guinea, outline what is and is not known about the ecology of these forests, and offer thoughts on further research to better our understanding of Papua New Guinea's forest resources. Based on a series of ecological criteria, we select an array of 17 ecologically important forest zones in Papua New Guinea. We argue that greatly expanded studies of the ecology and dynamics of PNG's humid forests will be required for the development of a truly sustainable system of timber extraction. We recommend that all timber schemes include regulated preservation of representative tracts of forest for enhanced regeneration.

INTRODUCTION

About sixty-five percent of Papua New Guinea's land area consists of undisturbed humid forest (Beehler 1985: Table 1), and because of this abundance of intact habitat, any program to conserve biodiversity should focus primarily on saving ecologically viable (e.g., large) samples of PNG's forests.

The forests of Papua New Guinea are remarkably diverse as well as species rich (Paijmans 1970, 1976), but have been inadequately studied ecologically. Although we know that some forests in Papua New Guinea are as rich in tree species as virtually any forests on earth (Whitmore 1975, Paijmans 1976, Kiapranis 1990, M. Hopkins pers. comm.), we have only a superficial knowledge of the taxonomic and ecological nature of this species richness, and we do not understand the process that produces such high richness. Virtually nothing has been published on local variation in species richness, so it is impossible to gauge the significance of differing findings concerning the interregional composition of forests in Papua New Guinea.

The present diversity of Papua New Guinea's forests is presumably produced primarily by variation in four factors: rainfall, altitude, soil, and history of disturbance

[1] University of Papua New Guinea, Boroko, Papua New Guinea.

(Johns 1977, Whitmore 1977). Annual rainfall in PNG ranges from as low as 950 mm to as high as 10,000 mm (McAlpine et al. 1983). Elevation varies from sea level to 4482 m. Soils range from old alluvium to those produced by recent volcanism or the weathering of ultrabasic rocks that comprise relict segments of uplifted sea floor. Disturbance of the vegetation in Papua New Guinea is varied, commonplace, can be both natural and human induced, and includes, among other things, periodic large fires, droughts, landslips, volcanism, frosts, and local annual burning (see White 1976, Johns 1986). Thus the remarkable variation among this series of physical parameters indicates that it is to be expected that the forest environments in Papua New Guinea would exhibit a broad diversity of forms.

Since many of the topics relevant to the forest vegetation already have been treated by Johns (Chapter 14), in this chapter we focus on describing succinctly (a) the various identifiable forest types in the country, (b) some of the ecological aspects of these forests, (c) important things that we yet do not know about these forests, (d) sites for conservation of a representative set of forest habitats, and (e) recommendations for conservation action.

CLASSIFICATION OF THE FOREST TYPES

In this classification we focus our analysis on closed canopy humid forests, as the range of open canopy woodland and nonforest habitats are treated by Johns (Chapter 14). Thus our overview examines a range of lowland and montane forests and mangrove forests, but excludes savannas, palm swamp, and a variety of man altered habitats.

Our classification is based primarily on the system devised by Johns (1977), and differs significantly from the several other classifications (Lane-Poole 1925, Brass 1959, Walker 1973, Paijmans 1976). We follow Johns' mainly because his delineation of the elevationally sequenced montane forests seems the most practical for general ecological use. For a comparison of the various systems, see Chapter 14, Table 14-1.

The current geographic disposition of the various forest types in Papua New Guinea is best obtained either from the four-sheet vegetation series (1: 1,000,000, Paijmans 1975) or the eighteen-sheet Vegetation and Timber Resources series (1:500,000, PNG National Mapping Bureau, Port Moresby). These maps, however, are based on data more than twenty years old, and thus underestimate the current percentage of forest that has recently been lost to cultivation and timber extraction.

A brief characterization of the ten forest types we recognize appears below. Note that this classification diverges from earlier systems in our greater reliance on ecological parameters (primarily rainfall). Too little is yet known of floristics of individual communities to provide reliable characterizations based on dominant species or particular suites of species.

LOWLAND SYSTEMS

1. Lowland Wet Forest generally lies below 500 m and receives an annual rainfall of more than 3.5 m. Low elevation wet forest is typically both structurally and taxonomically rich. This is the tropical rain forest -- perhaps PNG's grandest forest formation. It has been little studied because the lowland high rainfall zones are confined to relatively inaccessible parts of PNG (Upper Fly to Purari, Upper Sepik at the base of the central ranges, the islands). No plot work has been published on these perhumid forests. If ecological trends that occur in the Neotropics are applicable to Melanesia (A. Gentry pers. comm.) these wet forests may be the richest in PNG.

2. Lowland Humid Forest generally lies below 1000 m and annually receives more than 2.5 m but less than 3.5 m of rain. Similar and better studied than the lowland wet forest, much of this forest is scheduled for timber extraction. This, too, constitutes "rain forest," and the details of the taxonomic and structural differences between the wet vs. humid types is uncertain, but merits attention in the near future. According to Johns (1977), many of the current lowland forests are secondary, and various types of disturbance create mosaics of vegetation with differing composition and features. This becomes obvious to any botanist studying a tract of forest larger than a few hectares. Typical old forests are rich in canopy species with no single species dominating. Disturbed or old secondary sites are often dominated by one or two common species, but probably are equally rich because of the occurrence of many rare species. Canopy is usually closed and high (35-45 m) and trees are often buttressed. Palms and pandans abound in many of the alluvial sites.

3. Lowland Monsoon Forest occurs mostly near sea level and receives receive less than 2.5 m of rain per annum, and shows a significant prolonged dry season. These occur northwest of Port Moresby (and have been heavily exploited for timber), in Western Province of the southwest, and in the Safia-Pongani region of southeastern Papua. These monsoon forests grade into open savanna woodland where fire is common and along rainfall gradients. Monsoon forests are typically 20-30 m high, relatively open canopied, with many tree species that shed their leaves during the dry season. The forest type is apparently less species rich than typical rain forest, but no plot-by-plot comparisons have been made.

4. Lowland Broadleaf Swamp Forest is inundated for part or much of each year. It is exceedingly varied in composition and structure, in part because of the varying regimes and patterns of inundation. Common canopy tree genera are *Campnosperma*, *Terminalia*, *Nauclea*, *Syzygium*, *Octomeles*, *Pometia*, *Intsia*, *Alstonia*, *Bischofia*, and *Palaquim* (Paijmans 1976: 44, Johns 1977: 1.8), and canopy is often broken and open, with gaps filled by understory broadleaf species or palms and pandans. Some areas are dominated by *Metroxylon* and *Pandanus*.

MONTANE SYSTEMS

5. Lower Montane Wet Forest occurs between ca. 1000 and 2000 m elevation and receives in excess of 3.5 m of rain a year. Wet forests in the hills and mountains are typically low

canopied, small stemmed, with surfaces encrusted with various epiphytes. The small size of the forest is caused by the disturbance promoted by heavy rainfall (land movement and treefalls, because of water and epiphyte load). Presumably very species rich because of the continual patch disturbance. Confined to the high rainfall zones of the southern scarp of the central and western segments of the central cordillera and in the Bismarck islands and Bougainville.

6. Lower Montane Humid Forest lies between ca. 1000 and 2000 m elevation and receives less than 3.5 m of rain per annum. This is one of PNG's most common forest types, although it has been heavily altered by human settlement in much of the interior. Quite variable in structure and composition because of various edaphic factors combined with historical patterns of human disturbance. In some areas *Araucaria* species are a physically dominant component, in other areas the abundant oak *Castanopsis acuminatissima* forms nearly monotypic ridgetop stands. Tends to be structurally better developed than the wet forests because of reduced physical disturbance related to rainfall and waterlogging. Rich in oaks, laurels, mahoganies, and myrtaceous species.

7. Mid-Montane Forest lies between ca. 2000 and 2500 m elevation and is typically ever-wet (perhumid). Because of the lower temperature above 2000 m, the effects of rainfall apparently produce less of a variation than in the lower zones. Fog, mist, cloud, and nearly daily rainfall produce luxuriant growing conditions in virtually all mid-montane areas of PNG. These forests are typically rich in encrusting moss and other epiphytes, and though they can become grand under ideal conditions, their canopies are typically broken, open, and uneven. In some localities the forest type is dominated by *Nothofagus*, *Phyllocladus*, other podocarps, and a series of typical montane broadleaf species (e.g., *Elaeocarpus*, Cunoniaceae, *Castanopsis*). Pandans and a scrambling bamboo are abundant in disturbed areas. This forest type falls prey to much clearing for human settlement in the highlands.

8. Upper Montane Forest, be found between ca. 2500 and 3200 m, is a complex community of primarily gymnospermous canopy tree species. The previous forest type grades into this one with increasing altitude, although, at some point on the mountainside, there can be a fairly significant floristic break, where the podocarps emerge as dominant, and certain beeches and broadleaf species disappear or cease to be dominant. Low canopied and structurally simple, usually heavily encrusted with moss or moss-like epiphytes.

9. Subalpine Forest occurs on mountain tops above 3200 m that give way to alpine shrublands and grasslands. The subalpine forests are usually very species poor and are structurally simple, with canopy height 8-12 m. Usually the forest exhibits a closed canopy that is often dominated by a single species (often *Dacrycarpus*). Trunks are bent and gnarled, and there is virtually no understory except in openings and along edges. *Pittosporum*, *Rhododendron*, *Vaccinium*, and *Gaultheria* are the common woody understory taxa. *Cyathea* treeferns abound locally.

10. Mangrove Forest comprises coastal and riverine/tidal forests that are typically inundated daily by salt or brackish water. These forests are most extensive in the river deltas of the larger rivers primarily on the southern watershed, especially in the Purari, Kikori, and Fly

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river deltas. The dominant canopy tree genera are *Rhizophora*, *Avicennia*, *Brugiera*, *Xylocarpus*, and *Sonneratia*. In mature mangrove stands, the canopy tends to be fairly open, and in many cases the trees are stilt rooted or buttressed. This forest type is typically lower in stature than most lowland forests with trees of smaller girth (Paijmans 1976: 34, Johns 1977: 1.6).

ECOLOGY OF PNG FORESTS

As stated in the introduction, a series of ecological factors can be used to define Papua New Guinea's humid forests. By examining trends or patterns in these factors across PNG, we can obtain a second view of the ecological diversity of the nation, and thereby can increase the resolution of our analysis for conservation purposes.

Rainfall

We believe that rainfall is probably the single factor of greatest importance to forest development. Timing and intensity of rainfall, in tandem with other physical factors, determines potential evapotranspiration, soil desiccation and waterlogging, long-term land instability, and surface erosion. These factors, then, are probably crucial in determining, either directly or indirectly, the distribution of many forest plant species, and thus the geographic disposition of PNG's biodiversity. We thus stress the need to account for significant variation in annual rainfall when selecting major areas of importance to the conservation of biodiversity.

Seasonality

Seasonality is determined primarily by rainfall, and perhaps also cloud cover and evapotranspiration. Although general patterns emerge for the seasonality of PNG's forests, these patterns are very diffuse and subject to innumerable exceptions. Many forest trees do not reproduce on an annual basis, and this further obscures the pattern. The most important aspect of seasonality for selection of areas for conservation is timing and duration of the dry season. Periodicity of significant droughts probably is a major determinant of the current distribution of PNG's dry/monsoonal forests.

Soils

In certain instances, the distribution of unusual or chemically atypical soil types in Papua New Guinea adds an additional diversifying factor in PNG's forest types (Paijmans 1976: 88). The three obvious examples would be vegetation growing on ultrabasic rocks, on limestone, and on recent volcanic depositions (the peat formations so prominent in Borneo are uncommon or absent in most of PNG). The ultrabasic rocks produce the most unusual plant formations, often with plant species unique to them. Limestone floras tend to be those that can survive shallow soils and periodic water shortages. Forests on limestone tend to be lower and more open canopied, and are presumably taxonomically distinct as well. It is probably the lower, gentle slopes of the old Pleistocene volcanoes that support some of the finest forests in Papua New Guinea, both highland and lowland (Burnham in Whitmore 1977: 111). It is thus critical to select representative areas for conservation that include the range of soil types, especially those cited above.

Elevation

After rainfall, elevation is probably the critical determinant of forest type. In fact, the combined factors of elevation and rainfall can probably explain most of the structural variation in PNG's forests. It is thus important to select representative forest tracts that exhibit the range of elevations, from sea level to more than 4000 m.

History of Disturbance

As indicated by White (1976) and Johns (1986), disturbance is an overwhelmingly important factor in the disposition and condition of many of PNG's extant forests. Fire, drought, frost, anthropogenic influences, landslides, earthquakes, and (more generally) El Niño all have had an impact on the forests. It is important to be aware of the localized nature of some of these phenomena when selecting representative forests for study or conservation.

REPRESENTATIVE AREAS OF BIOLOGICAL IMPORTANCE

Our cues to delineating areas of major biological importance have been outlined in the sections above. Our focus is ecological, and naturally is less biogeographically delineated than the analysis of Johns (Chapter 14). Our numbering system refers to the areas exhibited in Figure 20-1.

1. Sepik Alluvial Lowland Forests.
   (East and West Sepik Provinces)

A zone of rich lowland humid forests that receive medium to high annual rainfalls, primarily south of the main Sepik channel reaching south to the foothills of the central cordillera, but also locally south of the north coastal ranges (Bewani, Toricelli, and Prince Alexander ranges). Important representative forests typical of PNG lowland vegetation.

2. Star Mountain Highlands.
   (West Sepik Province)

Large tracts of pristine and well-developed subalpine and upper montane forests with low human pressures.

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3. Central Range Highland Forest.
(West Sepik, Enga, Western Highlands, and Chimbu Provinces)
The high northern ranges from Mt. Wilhelm northwestward to the Schrader Range support important montane forests, especially on the northern slopes.

4. Huon Limestone-capped Highlands.
(Morobe Province)
Wet highland forests on geologically young, fast-rising, limestone capped ranges.

5. Pleistocene Volcanoes.
An arc of great Pleistocene volcanoes ranges from Mount Bosavi in the southwest to Hagen, Giluwe, Ialibu, Murray, Favenc, Crater, and Michael in the east. These support forests that range from very wet in the south, to less inundated and tall canopied in the north.

6. Kikori Karst.
(Gulf Province)
A great swath of karst country forms what is perhaps an important biogeographic barrier extending from Mount Bosavi southeastward toward the Gulf of Papua. Little explored but certainly ecologically distinct.

7. Mid-Fly Monsoon Forests.
(Western Province)
One of the few extensive monsoon forest formations lies just north of the savannas of the Trans-Fly. Little known.

8. Papuan Gulf Mangroves.
The largest complex of mangrove forests in Papua New Guinea lies in the great deltas of the Purari/Kikori.

9. High Rainfall Lowland Forests.
(Western and Gulf Provinces)
The base of the southern scarp of the central cordillera, from the PNG border east to the Purari, comprises a significant wet zone, with large uninhabited tracts of wet lowland forest. Perhaps among the richest forests of PNG.

10. Lakekamu Basin Lowland Alluvial Forest.
(Gulf and Central Provinces)
One of the least disturbed, flat alluvial basins in Papua New Guinea. Much of this lowland forest should be preserved as representative of PNG's typical rain forest.

11. Morobe Ultrabasics.
(Morobe Province)
The most significant area of ultrabasic rock on mainland PNG occurs in eastern Morobe Province, from Lake Trist east to the coast, including the Bowutu Range. Apparently distinct ecologically and floristically, although little surveyed to date.

12. Owen Stanley Alpine Highlands.
(Central and Northern Provinces)
The highlands of the Owen Stanleys comprise important tracts of middle and upper montane (and subalpine) forests.

13. Central Province Monsoon Forests.
(Central Province)
The dry zone in the lowlands northwest of Port Moresby supports a belt of monsoon forest that is threatened by long-term timber and plantation operations.

14. Lamington Recent Volcanics.
(Central Province)
The recent volcanic eruption of Mount Lamington created a remarkable successional forest environment that apparently is botanically distinct (Johns, Chapter 14).

15. Bismarck Limestone Forests.
(East and West New Britain and New Ireland Provinces)
The little known limestone uplands of New Britain and New Ireland are ecologically unique and merit study and preservation.

16. Bougainville Wet Montane Forests.
(North Solomons Province)
The wet highland forests of Bougainville's uplands are remarkable examples of oceanic perhumid environments quite distinct from those of mainland PNG.

17. Normanby Ultrabasic Vegetation.
(Milne Bay Province)
An additional small outcrop of ultrabasics that produces an unusual stunted forest with a strange flora (M. Jebb pers. comm.).

MAJOR UNKNOWNS

When compared to temperate zone forest systems, it is obvious we know very little about the composition and ecological dynamics of PNG's humid forests.

There is a range of unknowns that merit attention, especially with regard to the conservation of Papua New Guinea's forests. We have only a superficial understanding of forest succession in PNG (see Ash 1975, Enright 1982, Enright and Ogden 1979, Saulei 1984, Enright and Watson 1991, Saulei and Lamb 1990). Without a knowledge of how forests recover from various kinds of disturbances, it is not possible to delineate the effects of current and future human caused activities such as mining, selective and clearfell timber operations, and gardening. It is our belief that, because of the range of disturbances in the recent past, and because of indigenous knowledge of this history, it will be possible to study and define the recovery process with some precision. This needs to be done immediately.

The taxonomic and demographic composition of sample forests is still poorly documented and requires much additional effort (e.g., Kiapranis 1990). This, in turn, will require the production of a practical field manual of forest trees for Papua New Guinea. The drafting of this field manual should be a high priority.

The mosaic nature of forest formations needs to be explored in depth. What is the scale and pattern of forest patchiness? Along elevational transects what is the nature of species turnover? This has been studied for birds but has not been adequately addressed for the forest flora.

RECOMMENDATIONS

Our recommendations focus on three themes: study, habitat preservation, and ecological restraints to timber harvest.

Further Study

One of the main points of this chapter is to highlight how little is known of the ecology of the Papuan humid forests. More studies of forest plots that attempt to determine the scope and scale of patchiness of forest communities is essential to good planning for both conservation and timber development. Additional studies of forest regeneration is imperative to aid in the development of sustained-yield policies for forest management.

Habitat Preservation

It is important to preserve large tracts of all ecological forest types that occur in Papua New Guinea. In certain cases in which specialized types are geographically confined and economically important, great care will have to be taken to ensure that these biological resources are not lost in the haste of development.

Ecological Restraints to Exploitation

All forest exploitation projects should be required to preserve significant percentages of every tract of forest exploited, i.e., more than just watershed right-of-ways. Only if representative tracts are saved will there be full potential for rapid and complete regeneration. Then it might be possible for the development of a forestry industry that is truly sustainable.

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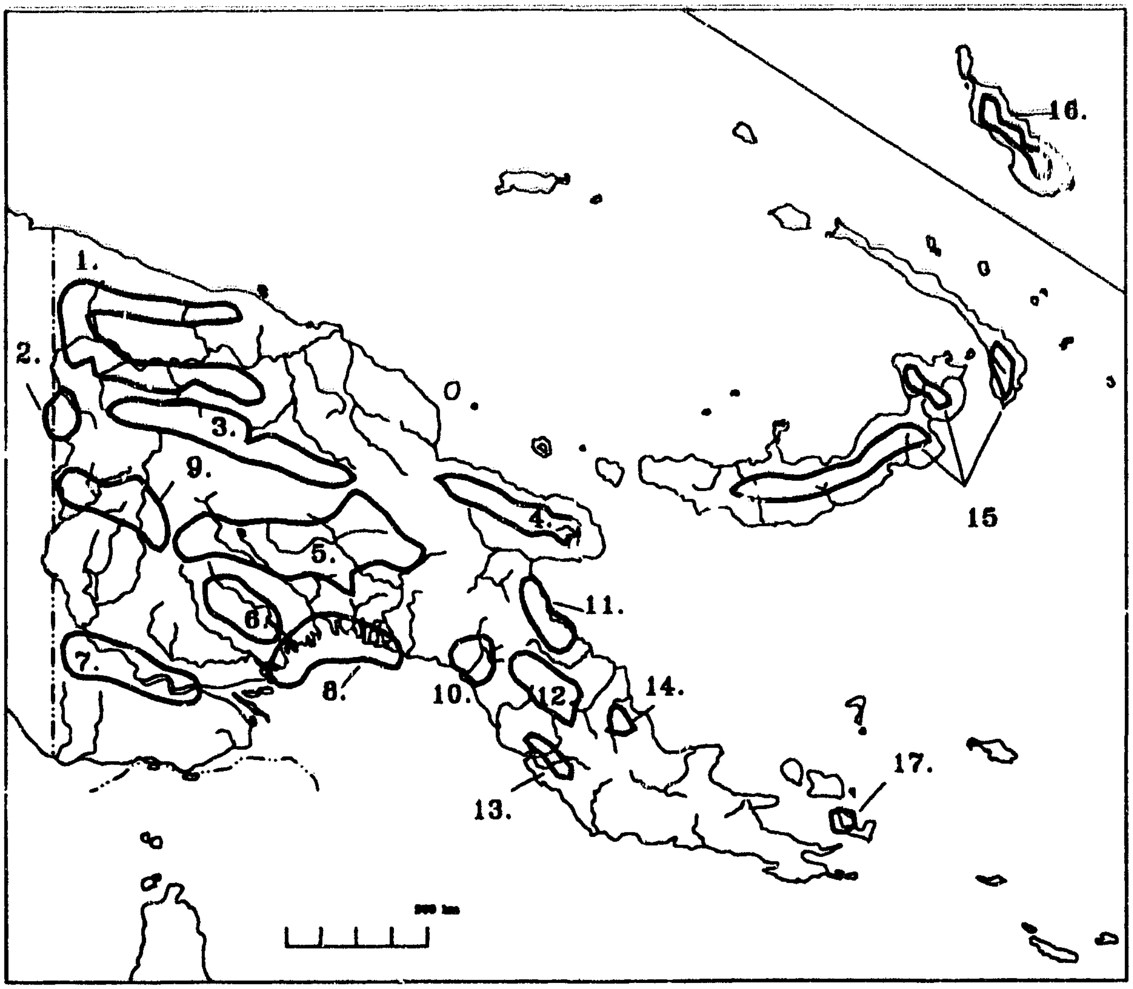
Figure 20-1. Representative areas of biological importance for distinct ecological types of forest. See text for key to numbered areas.



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