Interim National Terrestrial Conservation Assessment for Papua New Guinea: Protecting Biodiversity in a changing Climate

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Foreword

Papua New Guinea contains more than 7% of the world's biodiversity in less than 1% of the land area. PNG has more than 18,894 described plant species, 719 birds, 271 mammals, 227 reptiles, 266 amphibians and 341 freshwater fish species. But this extremely rich biodiversity on which the PNG people depend is under threat. The current status of species in PNG includes: 1 extinct, 36 critically endangered, 49 endangered, 365 vulnerable and 288 near threatened. Moreover, 1 in 5 assessed species in PNG is endemic, that is, they only occur in PNG. The primary threats to biodiversity include forest conversion and degradation from logging, mining, expanding industrial agriculture and a rapidly expanding largely rural human population with expanding needs for cash crops and subsistence gardens. Compounding all of this is the looming threat of climate change.

The establishment of Protected Areas in Papua New Guinea to date has been an extremely challenging process. The complex social, cultural and administrative structures that exist have imposed many demands and obstacles. The complexity of customary ownership and more than 800 different language groups provides further challenges.

But protected areas in PNG represent and enormous opportunity for the PNG people and the world at large. As the world is subject to the increasing impacts of climate change, including: sea level rise, increased intensity and frequency of drought, flood and storms, protected areas will provide the valuable ecosystem services upon which people depend and will help to buffer communities against these rapid changes. An effective National Comprehensive, Adequate, Representative and Resilient (CARR) terrestrial protected area system will help to ensure the persistence of biodiversity for future generations, moderate local climate, assist with food and fresh water security and will provide our first line of defense against climate change.

In addition, as the world moves towards valuing ecosystems services, PNG's people will benefit from payments for ecosystem services in the form of water, carbon and biodiversity credits. PNG's remaining intact forests on flat, arable, accessible and fertile lands represent a major opportunity for the PNG, and a powerful mechanism to mitigate against climate change through the removal of CO^2 from the atmosphere.

As we move forward, the Conservation Priority Areas (CPAs) identified in this report represent key components of a National Conservation Plan to help shape a bright future for the people and the biodiversity of this extraordinary country we call our home. I look forward to seeing these areas, not on paper, but as a tangible reality across our Nation.

Dr Wari-lea Iamo
Secretary - Department of Environment and Conservation.

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Glossary

Biodiversity - The totality of genes, species, and ecosystems in a region or the world

Convention on Biological Diversity (CBD) - The Convention on Biological Diversity is one of the most broadly subscribed international environmental treaties in the world. Opened for signature at the Earth Summit in Rio de Janeiro in 1992, it currently has 190 Parties—189 States and the European Community—who have committed themselves to its three main goals (PNG is one of these):

1. the conservation of biodiversity;
2. sustainable use of its components and
3. equitable sharing of the benefits arising from the utilization of genetic resources.

Ecosystem - A dynamic complex of plant, animal, fungal, and microorganism communities and their associated non- living environment interacting as an ecological unit.

Endemic - Restricted to a specified region or locality.

Marxan - Conservation planning software to assist with decision support

Protected Areas - An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means.

Species - A group of organisms capable of interbreeding freely with each other but not with members of other species.

Sustainable Development - Development that meets the needs and aspirations of the current generation without compromising the ability to meet those of future generations.

Surrogate of Biodiversity - It is impossible to sample the full range of biodiversity in PNG. In order to effectively sample biodiversity we need meaningful groupings or classifications that reflect biodiversity - that is surrogates or substitutes for biodiversity. In this study we used Vegetation types and Land System types as our surrogates.

Acronyms

BLM – Boundary Length Modifier
BPA - Biodiversity Priority Areas
BioRap - Rapid Assessment of Biodiversity
CA - Conservation Area
CAR - Comprehensive, Adequate and Representative
CARR - Comprehensive, Adequate, Representative and Resilient
CBD - Convention on Biological Diversity
CNA - Conservation Needs Assessment
CPA - Conservation Priority Areas
CRES - Centre for Resource and Environmental Studies (Australian National University)
CSIRO - Commonwealth Scientific and Industrial Research Organisation - Australia
DEC - Department of Environment and Conservation
ERIN - Environmental Resources Information Network - Australia
ESEG - Environmentally Sustainable Economic Growth
FIM - Forest Inventory Mapping
GAM - General Additive Model
GBRMPA - Great Barrier Reef Marine Park Authority
GCM - Global Circulation Model
GDP - Gross Domestic Product
GEF - Global Environment Facility
GLM - Generalized Linear Model
HadCM3 - Hadley Centre Coupled Model, version 3 - atmosphere-ocean general circulation model
IUCN - International Union for Conservation of Nature
LDC - Least Developed Countries
MDG - Millennium Development Goals
NCP - National Conservation Plan
NBSAP - National Biodiversity Strategy and Action Plan
OLPLLG - Organic law on Provincial and Local Level Governments
PoWPA - Program of Work on Protected Areas
REDD - Reduced Emissions from Deforestation and Degradation
RePPProT - Regional Physical Planning Project for Transmigration (Indonesia)
NCP - National Conservation Plan
NGO - Non Government Organization
PA - Protected Area
PES - Payments for Ecosystem Services
PNG - Papua New Guinea
PNGRIS -Papua New Guinea Resource Information System
Red list - IUCN Red List of Threatened Species
RRE - Restricted Range Endemic Species
SIDS - Small Island Developing States
SRTM - Shuttle Radar Topography Mission
TNC - The Nature Conservancy
UNDP - United Nations Development Program
USAID - United States Aid
WCPA -World Commission on Protected Areas
WMA - Wildlife Management Area
WRI -World Resources Institute
WWF - World Wildlife Fund
ZC - Zonae Cogito

Executive Summary

At the request of the Papua New Guinea (PNG) Department of Environment and Conservation (DEC), the Nature Conservancy worked with DEC to assist with the completion of a National Terrestrial Gap Analysis, as part of PNG's commitment to the Program of Work on Protected Areas (PoWPA). The project involved: (1) An assessment of the effectiveness the "existing" protected area system in representing PNG's biodiversity, (2) Identification of "potential" protected area systems that best capture representative samples of PNG's ecosystems and plant and animal species, (3) Identification of areas that have the potential to serve as climate refugia for the biodiversity of PNG, and (4) building the capacity of DEC staff to conduct the analyses, interpret the results and define a process to enable the effective implementation of the results.

As part of this process, a draft set of Criteria for the establishment of a National Comprehensive, Adequate, Representative and Resilient (CARR) Protected Areas system was developed. Most criteria for protected areas focus on biodiversity. In PNG's draft National Criteria we recognize the equal importance of biodiversity, climate change, people and the ecosystem services upon which PNG depends.

Approximately 4% of PNG’s land is protected in 53 protected areas, however, most of these are poorly managed. Three biodiversity surrogates: (1) Land Systems, (2) FIM Vegetation Types and (3) observed occurrences of Restricted Range Endemic species, those most vulnerable to climate change, were used to evaluate levels of representation of biodiversity within the existing protected areas system as part of a gap analysis. All three surrogates were poorly represented.

Options for potential protected areas that would improve representation and allow PNG to meet the CBD target of 10% and a climate change target of 20% and also incorporate climate change refugia were explored. A range of options for potential protected area systems were developed using Marxan. As part of this process we evaluated the relative influence of: (1) three different surrogates of biodiversity, (2) inclusion and exclusion of existing protected areas, (3) the inclusion and exclusion of the probability of climate change, (4) 10 and 20% targets and (5) the relative clumping or scattering of priority areas. Based on these results we developed a decision tree to formulate a final set of Conservation Priority Areas that would: maximize the inclusion of all biodiversity, maximize the consideration of climate change refugia and minimize the overall area impact of protected areas on the terrestrial areas of PNG. Given the uncertainty around climate change predictions and the uncertainty regarding how biodiversity will respond to these changes, we developed options that effectively spread the risk of the possible failure of any one approach.

The resulting products represent a robust, repeatable, transparent, interim set of Conservation Priority Areas to guide decision makers regarding priority areas for (1) the establishment of a National CARR protected area system and (2) to inform DEC with development approvals process. It is recommended that these priority areas form the basis for an Interim National Conservation Plan and that these areas are included as part of the Medium Term Development Strategy and implemented as part of the National Development Planning Process.

1 PoWPA Introduction – Background

Papua New Guinea (hereafter PNG) is a signatory to the Convention on Biodiversity (CBD) which requires that member Nations set aside at least 10% of their country in protected areas to slow the global loss of biodiversity. The CBD Program of Work on Protected Areas (PoWPA) adopted by the 7th CBD Conference of Parties in 2004, is a global action plan to address the impediments to the establishment of at least 10% of each country as protected areas. In 2004 this ambitious program included 92 Activities. In 2005-2007 UNDP-GEF redefined PoWPA to a set of 13 priority PoWPA activities. These include:

Activity 1.1.1 - Establish time-bound and measurable (e.g. numerical) national/regional protected area targets and indicators.

Activity 1.1.4 - Conduct, with the full and effective participation of indigenous and local communities and relevant stakeholders, national-level reviews of existing and potential forms of conservation, and their suitability for achieving biodiversity conservation goals.

Activity 1.1.5 - Complete protected area system gap analyses at national and regional levels based on the requirements for representative systems of protected areas that adequately conserve terrestrial, marine and inland water biodiversity and ecosystems.

Activity 1.2.1 - Evaluate national and sub-national experiences and lessons learned on specific efforts to integrate protected areas into broader land- and seascapes and sectoral plans and strategies such as poverty reduction strategies.

Activity 2.1.2 - Recognize and promote a broad set of protected area governance types related to their potential for achieving biodiversity conservation goals in accordance with the Convention, which may include areas conserved by indigenous and local communities and private nature reserves.

Activity 3.1.1 - Identify legislative and institutional gaps and barriers that impede the effective establishment and management of protected areas, and by 2009, effectively address these gaps and barriers.

Activity 3.1.2 - Conduct national-level assessments of the contributions of protected areas, considering as appropriate environmental services, to the country's economy and culture, and to the achievement of the Millennium Development Goals at the national level;

Activity 3.1.5 - Identify and remove perverse incentives and inconsistencies in sectoral policies that increase pressure on protected areas, or take action to mitigate their perverse effects.

Activity 3.1.6 - Identify and establish positive incentives that support the integrity and maintenance of protected areas and the involvement of indigenous and local communities and stakeholders in conservation.

Activity 3.2.1 - Complete national protected-area capacity needs assessments, and establish capacity building programs on the basis of these assessments including the creation of curricula, resources and programs for the sustained delivery of protected areas management training

Activity 3.4.1 - Conduct a national-level study of the effectiveness in using existing financial resources and of financial needs related to the national system of protected areas and identify options for meeting these needs through a mixture of national and international resources and taking into account the whole range of possible funding instruments.

Activity 4.1.2 - Develop and implement an efficient, long-term monitoring system of the outcomes being achieved through protected area systems in relation to the goals and targets of the PoWPA.

Activity 4.2.1 - Develop and adopt appropriate methods, standards, criteria and indicators for evaluating the effectiveness of protected area management and governance, and set up a related database, taking into account the IUCN-WCPA framework for evaluating management effectiveness, and other relevant methodologies, which should be adapted to local conditions.

The program gives priority to Small Island Development States (SIDS) and Least Developed Countries (LDCs) of which PNG is a member.

The primary objective of this project was to strengthen PNG's implementation of the PoWPA, and thus contribute to further consolidation of the country's protected area system. Specifically this project provides assistance to the Papua New Guinea Department of Environment and Conservation (DEC) and addresses **Activity 1.1.5 -** to conduct a National Terrestrial Gap analysis including:

- An assessment of the effectiveness of the representativeness of the "current" protected area system
- Identification of "potential" protected area systems that best capture representative samples of ecosystems and plant and animal species.
- Identification of areas that have the potential to serve as climate refugia for the biodiversity of PNG, and
- Building the capacity of DEC staff to conduct the analyses.

1.1 Biodiversity

The island of New Guinea supports an estimated 5-9% of the world's terrestrial biodiversity in less than 1% of the land area (Mittermeir et. al. 1998, Myers et. al. 2000). It contains the world's third largest contiguous area of tropical rainforest and habitats ranging from alpine grasslands to cloud forests to lowland wet tropical forests, swamps and dry sclerophyll woodlands. PNG has more than 18,894 described plant species, 719 birds, 271 mammals, 227 reptiles, 266 amphibians, 341 freshwater fish and unknown number of invertebrate species (Vie et al. 2009).

1.2 Threats

Rapidly expanding human population - PNG's human population was estimated at 6,331,000 in 2007[1]. The population growth rate between 2005 and 2010 was estimated at 2% per annum[1]. 80% of PNG's population is dependent on subsistence agriculture for food, and increasingly, small scale cash crops which results in increased rates of forest

[1] World Statistics Pocketbook Small Island Developing States - United Nations New York update 2007 http://data.un.org/CountryProfile.aspx?crName=Papua%20New%20Guinea

conversion and degradation. In addition, it is also likely that traditional hunting pressure has also increased, although there is no available data.

Industry - PNG has a nominal GDP of $6.0 billion USD with a growth rate of 6.2%[2]. Major Industries include: Mining, Oil and Natural Gas, Forestry, palm oil, coffee, cocoa, coconuts, palm oil, timber, tea and vanilla. Almost all of these industries are expanding and all have impacts in terms of forest conversion and pollutants into water ways.

Forest Conversion and Degradation - PNG Forests are being degraded at a rate of 1.41%/year (Sherman et al. 2008). For the period from 1972 to 2002, 48.2% of forest change was due to logging (0.9 million ha deforested; 2.9 million ha degraded) and 45.6% (3.6 million ha) was cleared for subsistence agriculture, 4.4% due to forest fires, 1% due to plantations and 0.6% due to mining (Shearman et. al. 2008). It is estimated that by 2021 most commercially accessible forests will be degraded (Shearman et. al. 2008). Most accessible forests are under logging concessions and the remaining accessible areas are subject to industrial agriculture or the impacts of a rapidly expanding human population.

Status of Biodiversity - Knowledge of the status of biodiversity in PNG is poor. Available data from the IUCN Red List suggest the current status of species in PNG is as follows: 1 extinct, 36 critically endangered, 49 endangered, 365 vulnerable, 288 near threatened and 1289 Least Concern (Vie et. al. 2009). Moreover, because 1 in 5 assessed species in PNG is endemic, with the highest number of endemic mammals globally, loss of species in PNG generally means a higher likelihood of extinction. Given the rapid rates of forest conversion and degradation and increasing hunting pressure, it is highly likely that many more species will be added to the list and that existing listed species will move to an elevated threat status.

1.3 Existing Protected Areas

Approximately 4% of PNG's terrestrial area is protected in 53 Protected Areas (see Table 1 and Figure 1 below). Since Independence in 1975 there has been a significant shift in protected areas from those that exclude people (e.g. National Parks) to those where people are a part of the protected area system (Wildlife Management Areas and more recently a Conservation Area (YUS)). Given that 97% of the land in PNG is under customary ownership, it is appropriate that protected areas are inclusive rather than exclusive of people.

Table 1: Existing Protected Areas in PNG

Protected Area Type	Count	Hectares	%
Wildlife Management Area	30	1,631,360	84%
Conservation Area	1	164,070	8%
Sanctuary	5	58,353	3%
Memorial Park	3	39,567	2%
National Park	8	28,025	1%
Protected Area	2	20,068	1%
Provincial Park	1	198	0%
Reserve	2	126	0%
District Park	1	3	0%
	53	**1,941,771**	**100%**

[2] World Statistics Pocketbook Small Island Developing States - United Nations New York update 2007 http://data.un.org/CountryProfile.aspx?crName=Papua%20New%20Guinea

A review for the World Bank/WWF Alliance for Forest Conservation and Sustainable Use showed that 73% of PNG's Protected Areas have minimal or no management structure, 16% had no management at all, 8% had a management structure but there were serious gaps and only 3% were well managed with a good infrastructure (IUCN, 1999:26). The lack of effective management of existing protected areas was reiterated in the more recent PNG RAPPAM Report (Chatterton et al. 2009). In a recent study by Shearman et. al. (2008) in 32 protected areas in PNG, excluding two more remote WMAs (Crater Mountain and Hunstein WMA), 25% of their forests were cleared or degraded during the period from 1972 - 2002 (Shearman et al. 2008). This again demonstrates the lack of effective management, protection or conservation within existing protected areas.

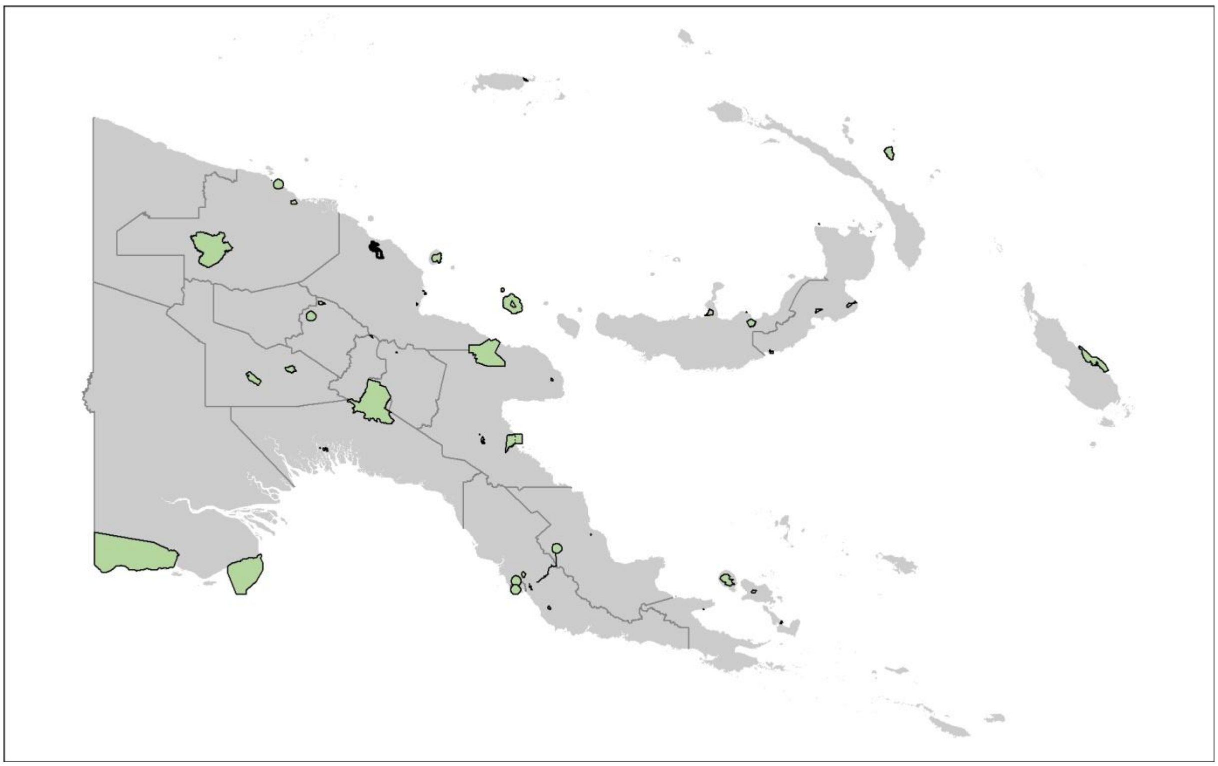

Figure 1: Existing protected areas

1.4 Climate Change

The predicted impacts of climate change on biodiversity are many. The vulnerability of an ecosystem to climate change depends on its species' tolerance of change, the degree of change, and the other stresses that are already affecting it. [3]

Impacts of climate change on protected areas include:

- Loss of habitat
- coastal areas to sea level rise

[3] Climate Change 2007: *Impacts, Adaptation and Vulnerability*. IPCC Summary for Policymakers. (2007)

- high elevation habitats such as mountain tops

Loss of climatic conditions for particular species where species respond in different ways, by:

- moving - migrating upward or poleward
- increase - because of more favourable climate
- decrease - due to limited migration potential, dispersal or shrinking suitable areas
- New pressures - disease and invasives
- Loss of key species - migratory, keystone, pollinators, predators, etc
- Extreme events - drought and increased fire risk and flood
- Expanding human pressure - pollutants, over exploitation, etc. (Dudley et al 2010).

When considering options for protected areas in the context of adapting to climate change, we need to consider:

1. Identifying robust investments including climate change refugia (Saxon 2008)
2. Conserving the geophysical stage (those abiotic features that underpin species distributions) (Anderson and Ferree 2010),
3. Enhancing connectivity, and
4. Sustaining ecosystem processes and functions (Game 2010).

Ecosystems as well as individual species are at risk. Representing major habitats using an ecoregional framework is one of the standard methods for systematic conservation planning (Margules and Pressey 2000). With climate change, it is predicted that the distribution and composition of many ecosystems will change. Gonzales et. al. (2005) predicted the extent of vegetation changes within ecoregions as 34% for global non-ice areas from 1990-2100 varying from 24% in Africa to 46% in Europe. Substantial areas of the globe will come to have future ecological conditions with no current analogue (Saxon et al. 2005). This represents a substantial challenge when planning for biodiversity and representing current and future conditions within protected area systems.

Funding for mitigation of greenhouse gas emissions through the protection of tropical forests and peat lands provides an opportunity to support protected areas through payments for their climate mitigation services. Reduced Emissions from Deforestation and Degradation (REDD) provides the benefits of mitigating climate change through retention of the carbon stocks and carbon storage capacity of natural forests, preserving forests for biodiversity and protecting the other ecosystem services on which forest dwelling communities depend.

1.5 Past Assessments

Past Assessments - Past biodiversity assessments have been completed for PNG including: (1) The Conservation Needs Assessment (CNA) (1993) and (2) BIORAP (2001). Both are described briefly below.

Conservation Needs Assessment (CNA) (1993) - The Assessment was commissioned at the request of the PNG Government. The team was a USAID funded consortium of: WWF, WRI, TNC with the support from DEC. Teams of internationally recognized experts compiled and analyzed the existing base of scientific information on the countries terrestrial and marine ecosystems and the biodiversity they support. In collaboration with PNG scientists, draft reports and maps detailing areas of know biodiversity concentration, unusual ecosystems, and habitats and environmental threats were identified. Data poor areas were also identified. The process identified: 42 terrestrial high biodiversity areas and 13 important wetland habitats, 30 marine and coastal high biodiversity areas and 5 watersheds critical to the health of these and 16 biologically unknown areas that merit immediate survey and study (Alcorn 1993, Beehler 1993).

BIORAP (2001) - The BioRap Toolbox was assembled under the first BioRap Project during 1994-95. This project was carried out under AusAID-World Bank funding, by a Consortium of four Australian scientific and technological agencies: CRES of the Australian National University; CSIRO; the Environmental Resources Information Network (ERIN) and the Great Barrier Reef Marine Park Authority (GBRMPA) (Margules *et al*. 1995; Faith and Walker 1996a; Hutchinson *et al*. 1996). The PNG project applied the BioRap Toolbox to identify an initial Conservation Biodiversity Plan based on a set of Biodiversity Priority Areas (BPAs). These BPAs would be established within the context of establishing a national protected area network and the identification of explicit options and constraints for land management within the forestry and agricultural sectors. The expectation was that BPAs would be subject to ongoing revision by Papua New Guinea Government agencies in response to land use change, change in economic, social and political conditions and change in ecological and biological knowledge. The main project was carried out over a two year period, from July 1997 to July 1999, with workshops presented in Papua New Guinea in 1997 and 1998. Knowledge transfer through workshops and training, for scientists and officers of relevant Papua New Guinea Government Departments plus other planners and policy makers, was provided to assist the Papua New Guinea DEC to apply the BioRap methodology on an ongoing basis. Allocation of 16.8% of PNG's land area to biodiversity protection was required, in order to achieve the targets under the BioRap methodology. This result minimizes potential conflict with forestry production opportunities (Faith et al 1994, Faith et al. 1996a, Faith and Walker 1996b, Faith et al. 1999, Faith et al 2001a, Faith et al 2001b, Faith et al 2001c).

The CNA was largely based on expert opinion and BIORAP was largely a data driven approach. While both past assessments provided significant guidance for the PNG Government regarding biodiversity priority areas for PNG, neither were implemented.

2 Process for PNG PoWPA

A key component of the PNG National terrestrial gap analysis was to build the capacity of DEC staff to conduct their own gap analysis, so that DEC staff could develop and explore options and take ownership of the final products. The process developed to facilitate the capacity building was based on the delivery of four workshops, where TNC took DEC policy and technical staff through the gap analysis process from inception to final product and subsequent interpretation and development of processes for the implementation of the options.

2.1 Workshop I - Introduction to Gap Analysis

The primary objectives of the first three day workshop were to: (1) provide an introduction to Gap Analysis and (2) to obtain agreement on the framework, process and key inputs.

The meeting included presentations and discussions on: (1) Introduction to Gap Analysis (based on CBD Guidance (Dudley et al), (2) Biodiversity surrogates, (3) Existing protected areas, (4) Options for stratification, (5) Planning unit size, (6) Introduction to decision support and Marxan, (7) Threats, (8) Climate Change and (9) Cost surfaces. The meeting resulted in an agreed set of inputs for the Gap Analysis.

2.2 Workshop II - Gap Analysis

The primary objectives of the second three day workshop were to:

- To provide Marxan Training to key DEC technical staff to enable DEC staff to produce first draft Gap Analysis products
- To work with DEC Policy staff to commence the development of a protected areas criteria to support the protected areas in PNG
- To assist DEC with the interpretation of those products

Following introductory presentations, the meeting was divided into a technical team and a policy team.

The technical team was taken through step by step instruction on the process for installing Marxan, building the necessary databases based on the key inputs provided, troubleshooting and testing the system and developing preliminary draft outputs (see PNG PoWPA Marxan Manual - (Game and Segan 2009).

The Policy team was taken through a facilitated process to formulate a National set Criteria for Protected Areas in PNG including: (1) International commitments and PNG Policy context, (2) National Framework for Protected areas and what it should include, (3) Key Principles, (4) Criteria for ecosystems, (5) Criteria for Species, (6) Mechanisms for Protection and management and (7) Reserve Design principles.

At the end of the three days, both teams were reconvened and the technical and policy groups provided group presentations on the key outcomes from their respective groups.

Following the second workshop, the TNC team refined the initial inputs and outputs of the first gap analysis and documented the policy developments.

2.3 Workshop III - Gap Analysis

The primary objectives of the third three day workshop were to:

- To work with DEC Policy staff to refine the Protected Areas framework and criteria to support the development of Protected Areas in PNG
- To work with DEC Technical staff to refine Marxan outputs and develop second draft gap analysis products
- To assist DEC with the interpretation of those products and developing an appropriate draft process for Stakeholder Consultation and mainstreaming outcomes

The technical team was taken through a similar process to the second workshop, but with a greater focus on options development and testing different: BLM's, calibration, surrogates, targets and approaches for presentation. The resulting workshop reinforced the knowledge and practice gained in the second workshop, but also resulted in refined and improved products.

The Policy team was taken through a facilitated process that resulted in the refinement of the draft criteria, but also took the team through the options for stakeholder engagement and options for mainstreaming outcomes using these products to inform broader land use decisions. A range of options were discussed and these are presented in (Papua New Guinea Government 2009).

Again at the end of the three days, both teams were reconvened and the technical and policy groups provided group presentations on the key outcomes from their respective groups.

Following workshop III, the TNC team compiled final options and developed a draft report for review by DEC staff (15 Jan 2010). This was circulated and first draft edits compiled and completed and second draft report circulated (12 Feb 2010).

2.4 Workshop IV - Final Report and Products

The primary objective of the fourth and final workshop was to refine the final report and products to ensure that DEC received the best possible product with which to engage key stakeholders. In addition, discussions regarding the options for endorsement and implementation of the outcomes were discussed.

3 Draft National Criteria for a CARR Protected Area System in PNG

Since Independence in 1975, the competing demands of conservation and expanding use and exploitation of PNG's natural resources has resulted in conflict, debate and controversy. Under the PNG Constitution, Goal Four, DEC has the mandate to conserve natural resources and environment for the collective benefit of all, and for the benefit of future generations. A key component of conserving natural resources for present and future generations is to ensure an effective balance between protection of a representative sample of biodiversity and effective management of the remaining landscape. In order to fulfill this mandate and assist is conserving a representative sample of PNG's natural resources, DEC requires clear guiding criteria. The following criteria represent a starting point for the development of a National set of criteria for the establishment of a protected areas system in PNG. These are based broadly on the Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia (Commonwealth of Australia 1997).

3.1 Principles

A development of a National Protected Area System for PNG should embrace the principles of a Comprehensiveness, Adequacy, Representativeness and Resilience (CARR), where:

- **Comprehensiveness -** *includes the full range of communities recognized by an agreed national classification at appropriate hierarchical level.*

The principle of comprehensiveness requires that the protected area system sample the full range of biodiversity including: ecosystems, species and genetic variation. Our knowledge of PNG's biodiversity is patchy. In order to effectively sample biodiversity, surrogates of biodiversity such as different vegetation types or environmental domains are often used. Some species have distributions that are not readily predicted by either forest types or environmental domains. These species require special consideration.

- **Adequacy -** *the maintenance of ecological viability and integrity of populations, species and communities.*

The principle of adequacy addresses the difficult issue of "how much" and in what spatial configuration. Specifically, what level of protection will ensure that species remain viable in the long term. This is a particularly difficult and contentious when considering space demanding species such as Cassowaries or larger predators. The protected area system should be of suitable size, number and configuration to ensure that those elements of biodiversity dependent on protected areas will persist in the long term.

Replication across the geographic, environmental and biotic range also improves the adequacy of protected area systems. Replication spreads the risk of the failure of any one protected area in maintaining species or community viability in the event of unforeseen catastrophic events such as forest fire, drought or tsunamis, all of which occur in PNG.

- **Representativeness -** *those sample areas that are selected for inclusion in reserves should reasonably reflect the biotic diversity of the communities.*

Representativeness relates to diversity within communities or vegetation types. Again our knowledge of biodiversity in PNG is incomplete. In order to ensure that we have effectively sampled the full range of biodiversity, different vegetation types need to be sampled across their environmental and geographic range.

- **Resilience -** *The areas sampled consider the impacts of climate change and allow natural ecosystems to adapt to climate change (UNFCCC – Article 2)*

Although many forests and terrestrial ecosystems have proved resilient to past changes in climate, today's fragmented and degraded forests and ecosystems are more vulnerable. Adaptation of species to climate change can occur through phenotypic plasticity, evolution, or migration to suitable sites, with the latter probably the most common response in the past. Among the land-use and management practices likely to maintain forest biodiversity and ecological functions during climate change are: (1) representing forest types across environmental gradients in reserves; (2) protecting climatic refugia at multiple scales; (3) protecting primary forests; (4) avoiding fragmentation and providing connectivity, especially parallel to climatic gradients; (5) providing buffer zones for adjustment of reserve boundaries; (6) practicing low-intensity forestry and preventing conversion of natural forests to plantations; (7) maintaining natural fire regimes; (8) maintaining diverse gene pools; and (9) identifying and protecting functional groups and keystone species. Good forest management in a time of rapidly changing climate differs little from good forest management under more static conditions, but there is increased emphasis on protecting climatic refugia and providing connectivity (Noss 2001).

3.2 A Regional Approach

Ecoregions are defined as relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use change (Olson et al. 2001). To address the principle of representativeness, it is necessary to divide PNG into ecologically appropriate regions (ecoregions) within which biodiversity is to be represented (Figure 2).

Figure 2: Stratification – Ecoregions of PNG (Saxon and Sheppard 2009).

3.3 Criteria

Traditionally protected areas criteria consider biodiversity. In PNG protected areas require the effective consideration of: Biodiversity, Climate Change, Customary Landowners and the Ecosystem services upon which people depend. The draft criteria outlined in the following sections were adapted from the Australian Criteria for Forests (Commonwealth of Australia 1997) by the PNG-PoWPA Policy Group. The resulting draft criteria consider biodiversity, climate change, people and ecosystem services (Figure 3). This report focuses specifically on the Biodiversity (Section 4.3.1) and Climate Change (Section 4.3.2) criteria, but recognizes the importance of Customary Landowners (Section 4.3.3) and options for Payments for Ecosystems services (Section 4.3.4), which will be addressed as part of PoWPA Phase II.

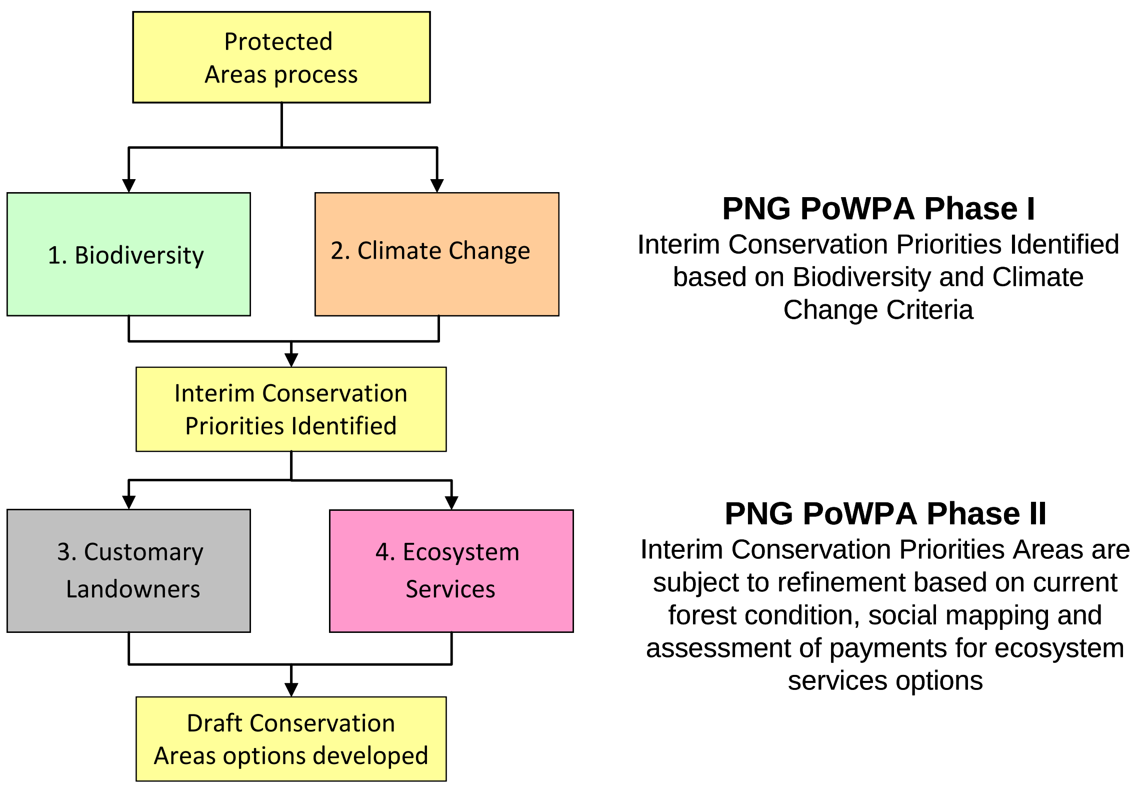

Figure 3: Draft process for the development of protected areas in PNG based on Draft Protected Areas Criteria

3.3.1 Biodiversity

1. **10% of the original extent** of Ecosystems (based on 1975 – benchmark (FIM (biotic) and Land systems (abiotic)).
2. **All remaining occurrences** of **rare and endangered** ecosystems should be reserved or protected by other means as far as is practicable:
   - A rare ecosystem is one where its geographic distribution involves a total range of generally less than 10,000ha per Ecoregion,
   - Rarity is adjusted depending on the size of the Ecoregion as follows:
     - <250,000 (500 ha)
     - 250,000 – 500,000 ha (1,000 ha)
     - 500,000 – 1,000,000 ha (2,000 ha)
     - >1,000,0000 ha (10,000 ha)
   - a total area of generally less than 1000 ha or patch sizes of generally less than 100ha, where such patches do not aggregate to significant areas.
   - An endangered ecosystem is one where its distribution has contracted to less than 10% of its former range or the total area has contracted to less than 10% of its former area, or where 90% of its area is in small patches which are subject to threatening processes and unlikely to persist.
3. **Replication** - Reserved areas should be replicated across the geographic range of the ecosystem to decrease the likelihood that chance events such as wildfire or disease will cause the ecosystem to decline.
4. **Species and other elements of biodiversity** - The reserve system should seek to maximize the area of high quality habitat for all known elements of biodiversity wherever practicable, but with particular reference to:
   - the special needs of rare, vulnerable or endangered species;
   - special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species;
   - areas of high species diversity, natural refugia for flora and fauna, and centres of endemism; and
   - those species whose distributions and habitat requirements are not well correlated with any particular ecosystem.
5. To ensure **representativeness**, the plan should, as far as possible, sample the full range of biological variation within each ecosystem, by sampling the range of environmental variation typical of its geographic range and sampling its range of successional stages.
6. **Adequacy** - Components of a National Conservation Plan (NCP) should be large enough to sustain the viability, quality and integrity of populations (species).

3.3.2 Climate Change

The NCP should seek to ensure the persistence of ecosystems and their natural components under the impacts of rapid climate change and increased climate variability by:

1. Protecting potential **climate change refugia** (areas predicted to change least and change last);
2. **20% of the original extent** of Ecosystems (based on 1975 – benchmark (FIM (biotic) and Land systems (abiotic)). Increasing CBD Target to (20%) provides additional habitat in anticipation that some will be lost within protected areas due to climate change. This invokes the precautionary principle. In many cases we cannot predict the changes that will occur to species and ecosystems in response to climate change. In order to ensure the resilience of ecosystems and species we should also seek to minimize threatening processes by enhancing the adequacy and the effective management of protected areas;
3. Protect **Restricted Range Endemic species (RREs)**, those species with limited geographic and climatic ranges most vulnerable to climate change (Malcolm et. al. 2006);
4. Maintaining continuous connectivity along natural gradients (e.g. montane slopes and river basins), allowing animals to have intermittent passage through areas of high disturbance and preserving small, step-stone patches in quasi-natural condition within managed landscapes (such as riparian corridors within plantations) to allow for the movement of species;
5. Replicating protected areas with similar biota to reduce the risk of species extinctions at a single site due to random events;
6. Protecting representative geophysical settings that are the basis for regional biodiversity regardless of climate. This will help PNG maintain the capacity to support biodiversity, even if it is different from present day (Game et al 2009).

3.3.3 Customary Landowners

People are an integral part of PNG's land and sea, whether protected or managed. More than 800 languages are spoken in PNG (Lewis 2009). Boundaries should be set in a cultural context and where possible and as practical, should be within a single language group (Figure 4). 97% of Papua New Guinea is under customary ownership (Lakau 2001) and 85% of the population is still largely dependent on their forests, freshwaters and seas for their subsistence needs and the ecosystem services they provide. Any protected area system in PNG needs to ensure the effective inclusion of customary landowners and their local needs and forest use.

One of the greatest challenges in establishing protected areas in PNG is the development of effective consultation and binding arrangements across the complex, social, cultural and administrative structures that exist in PNG. Consultation is required across line agencies at the National Level and vertically from Province to Ward when attempting to establish and gazette protected areas. However, the greater challenge is conducting the necessary consultation with the customary landowners, many of whom live in remote rural areas without ready access or are absent from their traditional lands. Regardless of the protected areas or management designation, people are an integral part of landscape and must be consulted to ensure the effective development of a protected area network for PNG.

***Customary Ownership Guideline** – As protected area boundaries are developed and refined, boundaries should be set within an appropriate cultural context, including: consideration of language group, customary land ownership and land/sea boundaries and appropriate governance systems (e.g. Incorporated Land Groups, Conservation Cooperatives, WMA/CA Committee's - Formal and recognized customary governance systems in PNG).*

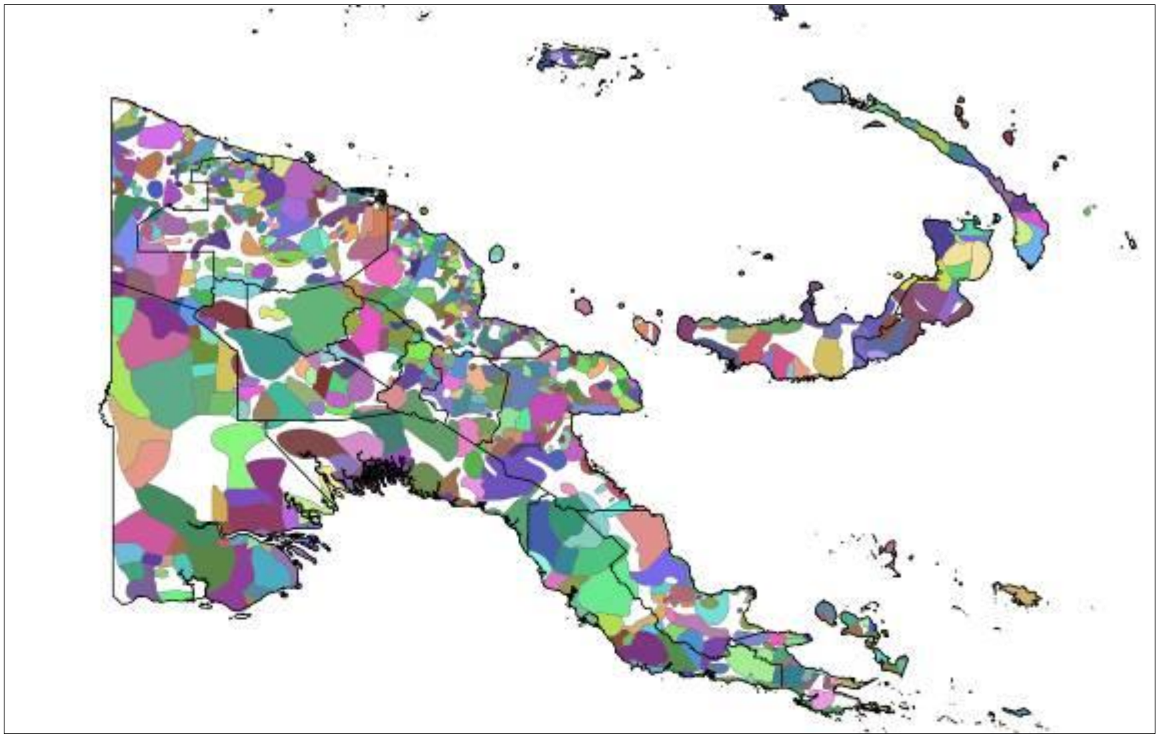

Figure 4: Language groups across PNG. Individual polygons indicate a unique language (Global Mapping International - World Language Mapping System - Version 3.2.1).

3.3.4 Ecosystem Services

As identified above, people are an integral part of PNG lands and seas. Most protected area designations have a regulatory framework (i.e. penalties for non compliance), but lack incentives for effective protection and management. With the development of a REDD Framework for PNG (Reduced Emissions from Deforestation and Degradation) and emerging markets for payments for ecosystem services (PES) such as Carbon, Biodiversity and Water Credits, options and opportunities exist for payments for landowners who protect and manage their customary lands. In addition to these there are a host of conservation compatible business enterprises that can also be considered (e.g. Tourism and the Kokoda Trail).

In addition to the monetary benefits that can be gained from protected areas, there are also a host of other ecosystem services (ES) that can be derived from protected areas including: buffering against the impacts of natural disasters (e.g. mangroves buffering against sea level rise events, safeguarding and providing clean water (fresh water security), providing bush and sea foods (food security) and stabilizing local climate (Dudely et al. 2010)

ES Guideline *- As protected areas boundaries are developed and refined, options for water, carbon and biodiversity credits and other essential ecosystem services need to be assessed and considered as part of the gazettal process.*

3.3.5 Protected Area Design

While the Gap Analysis process identifies an interim set of conservation priority areas to fill the remaining gaps in the National Protected Areas network for PNG, the formal gazettal of areas under law or other secure arrangements requires negotiation and refinement of boundaries at many levels. The following guiding principles provide a check list of some of the key additional considerations required when formalizing the boundaries of protected areas.

Protected Areas Design Guidelines - The way in which a protected area is designed can influence not only the protection of conservation values, but the efficiency and effectiveness of subsequent management for conservation within the protected area (Ervin et. al. 2009). The following criteria should be considered when finalizing the boundaries of a protected area including:

1. Boundaries should be also be set in a landscape context with strong ecological integrity, such as catchments or watersheds;
2. Large protected areas are preferable to small protected areas, though a range of sizes may be appropriate to adequately sample conservation values;
3. Boundary-area ratios should be minimized and linear reserves should be avoided where possible except for riverine systems and corridors identified as having significant value for nature conservation; Protected areas should be developed across the major environmental gradients if feasible, but only if these gradients incorporate key conservation attributes which should be incorporated in the CARR system;
4. Each protected area should contribute to satisfying as many reserve criteria as possible;
5. Protected area design should aim to minimize the impact of threatening processes, particularly from adjoining areas;
6. Protected areas should be linked through a variety of mechanisms, wherever practicable, across the landscape.

4 Gap Analysis - Representativeness of the Existing Protected Area System

4.1 Introduction

The following section addresses the gap analysis component of the project. Specifically, it includes a simple assessment of the effectiveness of the representativeness of the "current" protected area system in sampling biodiversity in PNG.

4.2 Methods

The assessment of the effectiveness of the representativeness of the current or existing protected area system focused on evaluating the relative contribution of three major biodiversity surrogates to the existing protected area system (Figure 1, Table 1).

The three major biodiversity surrogates evaluated included:

- 59 Land Systems - (an abiotic classification)
- 57 Vegetation Types (FIM) - (a biotic classification)
- 123 Restricted Range Endemic (RRE) reptiles, amphibians and 26 RRE mammals - those conservation features with narrow geographic and climatic ranges likely most vulnerable to climate change.

See Section 6 for a detailed explanation and description of these data layers.

Each surrogate was intersected with the existing protected area system using Arc GIS to determine the area contribution of each Vegetation and Land System Type and RRE Species. It was assumed that if >10% of the area of the unique Vegetation, Land System and RRE species types were within an existing protected area, that the conservation feature was effectively represented.

4.3 Results

When evaluating the degree of representativeness of Land Systems within the existing protected area system, 10 of the 59 Land System Types (<17%) were effectively represented (> 10% protected) within the existing protected area system (Figure 5).

Similarly, when evaluating the degree of representativeness of the existing protected area system, 6 of the 57 Vegetation Types (<11%) were effectively represented (> 10% protected) within the existing protected area system (Figure 6)

Finally when evaluating the degree of representativeness of different RRE fauna species within the existing protected area system, for restricted RRE reptiles and amphibians, 17 of 123 species (<14%) were effectively protected (>10% of their defined area) within existing protected areas (Figure 7). For restricted range endemic mammals 7 of 26 (< 27%) of species were protected at greater than 10% of their defined area (Figure 8).

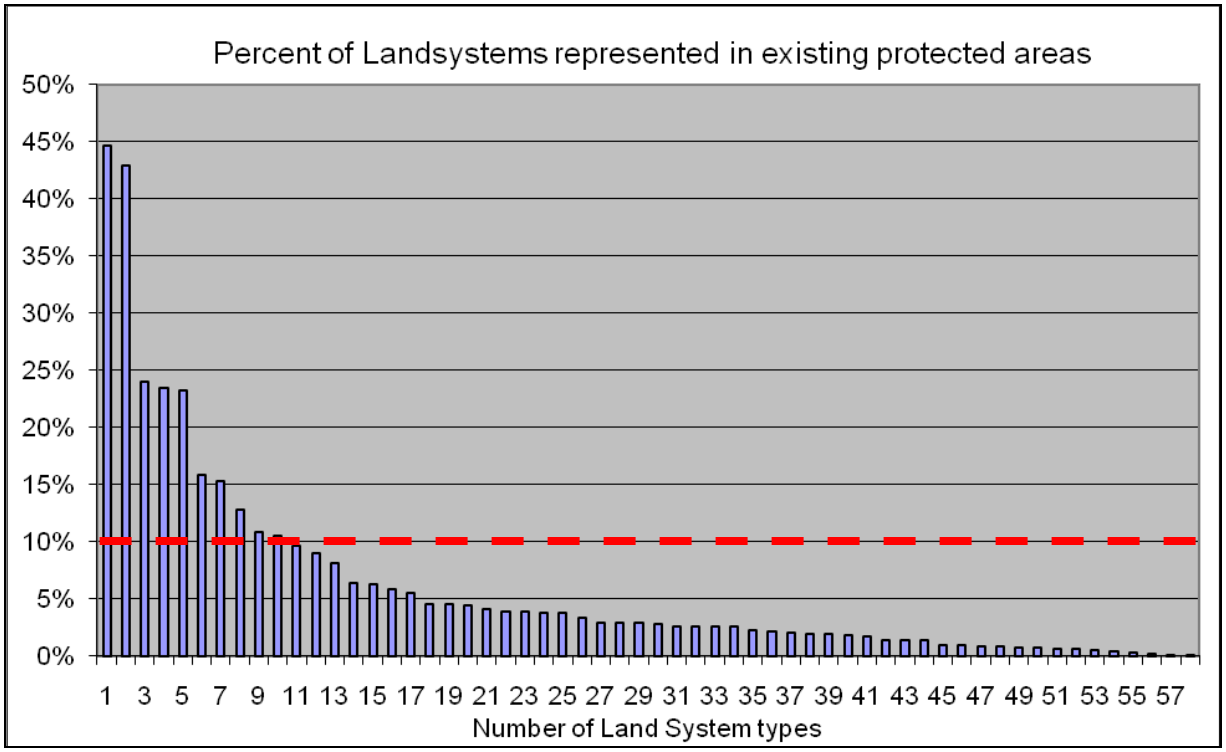

Figure 5: Representation of Land System types within the existing protected area system

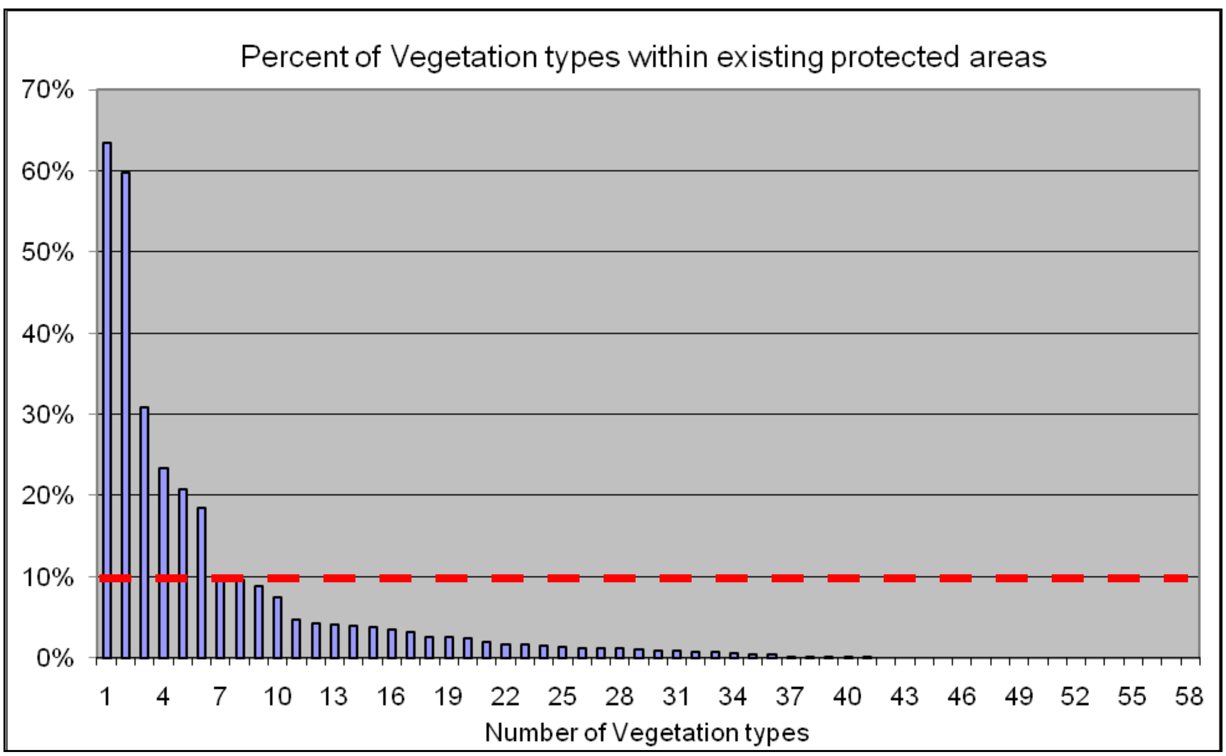

Figure 6: Representation of vegetation types within the existing protected area system

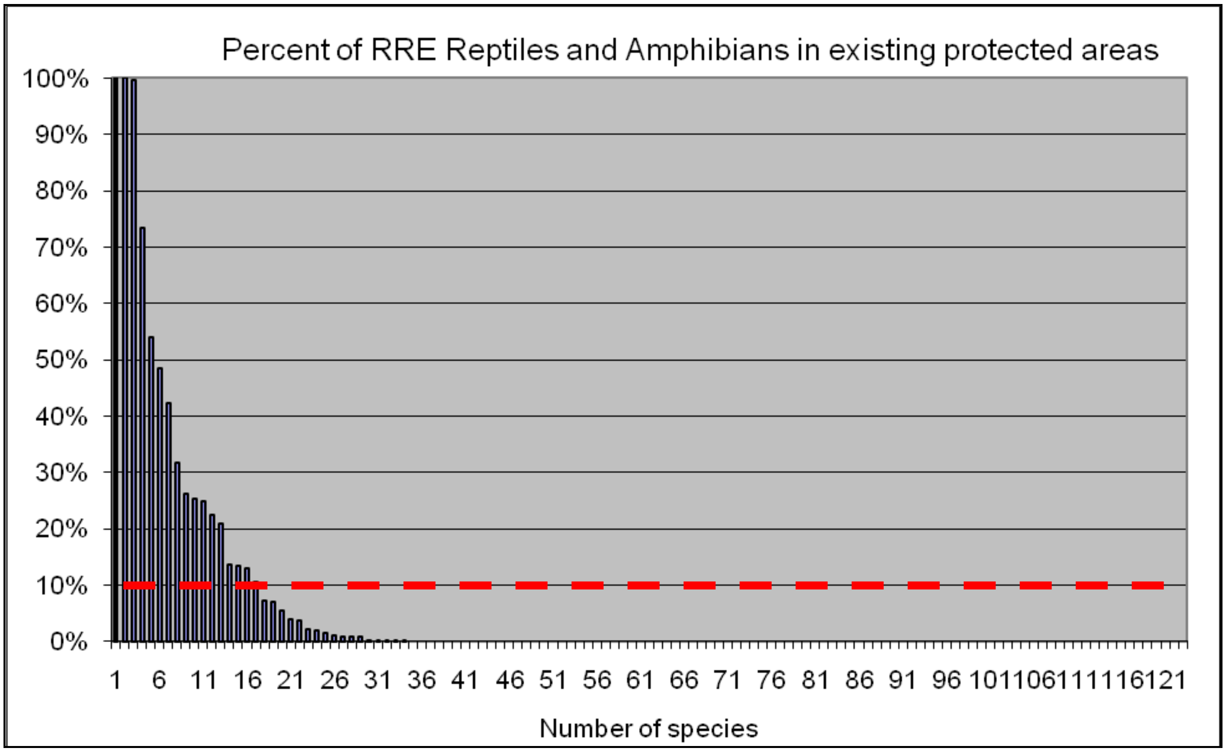

Figure 7: Representation of RRE reptiles and amphibians within the existing protected area system

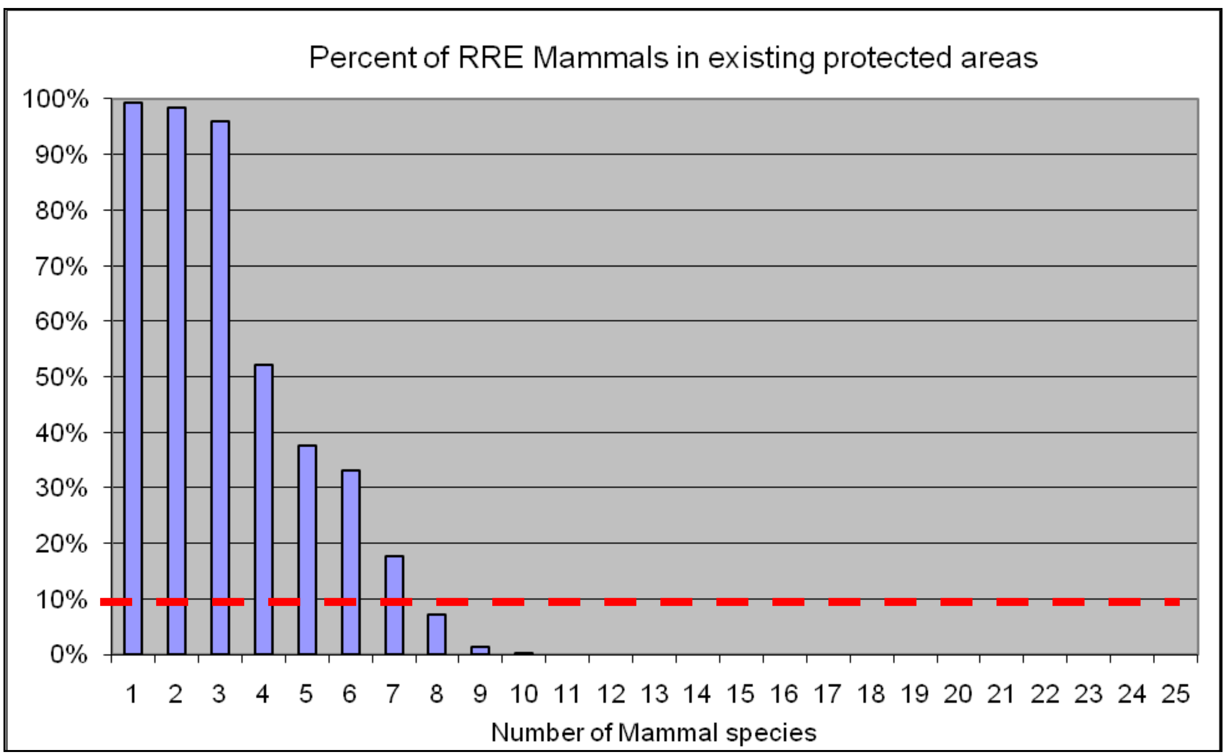

Figure 8: Representation of RRE mammals within the existing protected area system

4.4 Discussion

The terrestrial protected area system in PNG consists of 54 protected areas totaling 1.9 million ha and accounts for less than 4% of the land base, a long way short of 10% CBD Goal. Less than 11% of the vegetation types, 19% of the Land System types and 14 % of the fauna evaluated are represented within the existing protected area system at greater than 10%.

The existing protected area system is not based on the efficient representation of samples of biodiversity but rather the opportunistic protection of areas where land holders were supportive. Although past assessments were available to inform choices regarding areas to protect, these were largely based on expert opinion, rather than an analysis of the representation of biodiversity across PNG (CNA 1992, Alcorn 1993, Beehler 1993). Some of the areas selected for WMA's such as the Hunstein, Tonda and Kikori WMA's reflect an informed choice based on expert opinion.

The BIORAP (2001) tool box was based on the representation of different surrogates of biodiversity, but this product was ultimately not used by DEC to inform decisions regarding the inclusion of new area proposals in the protected area system, or for decisions regarding proposed mining, oil and gas, oil palm of logging operations.

With ongoing conversion and degradation of forests from the rapidly expanding human population and associated expansion of subsistence agriculture and demand for cash crops, expanding impact of industries including: logging, mining, oil and gas, oil palm and other industrial agriculture, there is an immediate need to establish and effectively manage protected areas in PNG to reduce the loss of biodiversity.

There is a backlog of 120 WMA proposals from landowners to DEC (Hunnam 1992).
If DEC is to work with partners to effectively establish a CARR protected area system in PNG, it needs to make informed choices regarding the areas to protect and areas to be developed. DEC needs to evaluate each new area proposal to determine whether it contributes to the CARR protected area system. In this way DEC ensures the efficient use of limited Government resources to establish protected areas that meaningfully contribute to a National CARR protected area system. The next section provides options to inform DEC regarding these choices.

5 Potential Protected Area Systems that also consider Climate Change Refugia

5.1 Introduction

This section focuses specifically on:

1. Identification of "potential" protected area systems that best capture representative samples of ecosystems and plant and animal species.
2. Identification of areas that have the potential to serve as climate refugia for the biodiversity of PNG.

The assessment of the opportunities for potential protected area systems that also effectively serve as refugia for climate change required detailed systematic conservation planning. The approach used is described in this section and includes: (1) stratification of PNG into meaningful ecoregions, (2) the establishment of a planning units layer (the units of selection), (3) the selection of surrogates of biodiversity and conservation features that meaningfully reflect biodiversity in PNG, (4) the setting of conservation targets in accordance with the PNG Draft National CARR Criteria, (5) the inclusion of climate change probabilities to enable the approximation of climate change refugia, (6) the development of a cost surface that would broadly reflect threatening processes and finally (7) the exploration of options using the decision support tool Marxan to enable the determination of the best options to inform DEC regarding terrestrial conservation priorities in PNG.

The resulting products are termed "Interim" as they will provide interim direction for DEC regarding the consideration of new conservation proposals and industrial developments in PNG until such time as better products are available. It also recognizes that as new data become available that DEC will incorporate these new data into subsequent and improved products.

5.2 Methods

5.2.1 Stratification

WWF Terrestrial Ecoregions provide the framework for many terrestrial gap analyses globally (Olson et al. 2001). We delineated more regionally accurate boundaries for the ecoregions by matching them with land system boundaries in the PNGRIS II data and then created larger assessment units by: (a) aggregating adjacent archipelagoes; (b) subsuming coastal units and small, upland ecoregions within their surrounding lowland ecoregions; (c) and aggregating the southern plains, wetlands and savannah ecoregions whose boundaries could not be consistently delineated. The number of ecoregions was reduced from 15 to 9 for the analysis (Table 2 and Figure 2).

Table 2: Ecoregion Stratification Units

WWF Ecoregions	Analysis Ecoregions
101. Admiralty Islands	1. Manus Island
111. New Britain/New Ireland Lowlands	2. Northeastern Islands
112. New Britain/New Ireland Uplands	
119. Bougainville Island	3. Bougainville Island
107. Huon Range	4. Northern New Guinea
115. North New Guinea Lowlands	
116. North New Guinea Uplands	
105. Central Range	5. Central Range
120. Southeast Peninsula	6. Southeast Peninsula
125. Trobriand Islands	7. Trobriand Islands
110. Louisiade Archipelago	8. Louisiade Islands
121. Southern Wetlands	9. Southern New Guinea
122. Southern Plains	
708. Trans-fly	

5.2.2 Planning units

Five thousand hectare hexagons were chosen as the planning units for the analysis. This resulted in 10,693 planning units for the entire study area, which provides an appropriate balance between processing time using Marxan and delineation of broad priorities areas. Note that planning units are clipped to the coastline and therefore are not all equal to 5000 ha.

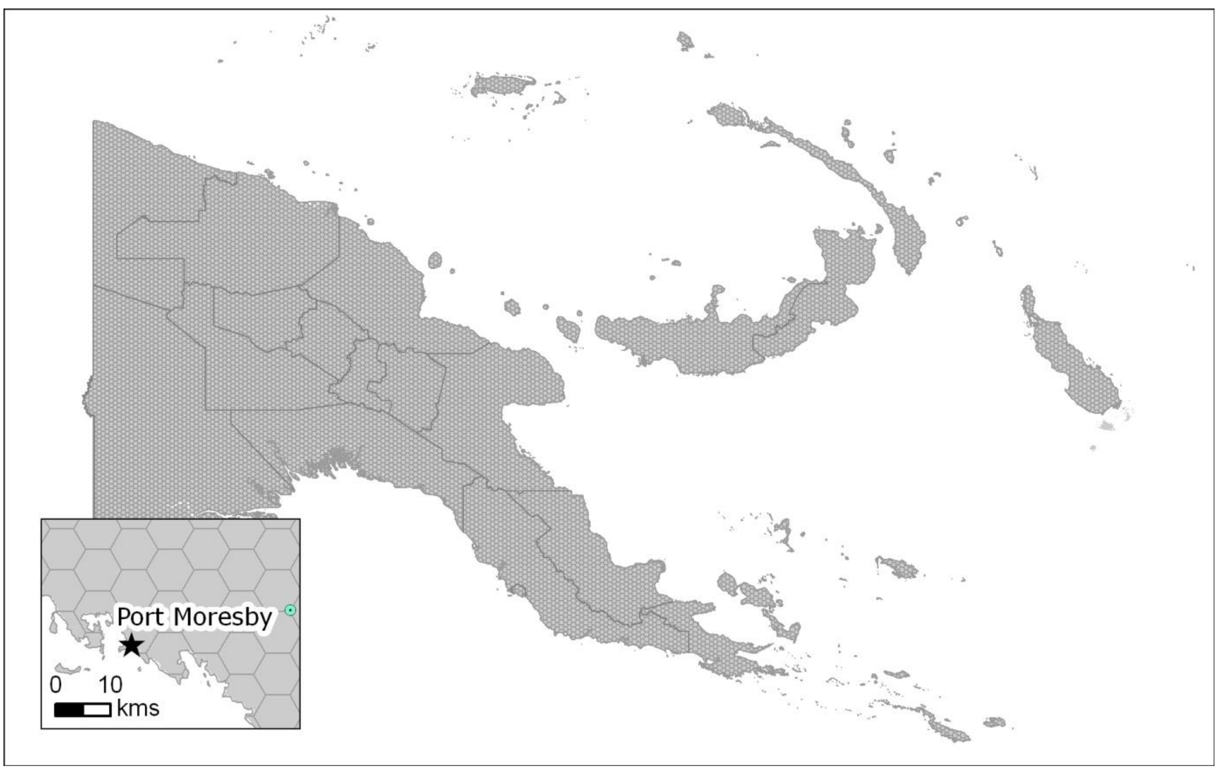

Figure 9: Planning Units. Inset illustrates shape of units near Port Moresby.

5.2.3 Conservation Features

A number of core data sets were used in the analysis including:

1. Land Systems (abiotic)
2. Forest Information Management (biotic) - Hammermaster and Saunders 1995
3. Restricted Range Endemic Species, Birds of Paradise and Tree Kangaroos (special features).

These data sets provide the best available data for a preliminary gap analysis in order to meet some of the key criteria outlined in Section 3.

5.2.3.1 **Land Systems**

Saxon and Sheppard (2008) matched the land systems of Papua New Guinea (Bellamy & McAlpine 1995) with similar land units in Papuan provinces of Indonesia (RePPProT 1990). The resulting units provide uniform abiotic features mapping across the New Guinea archipelago (Figure 11 and see Appendix 2).

Land Systems are areas or groups of areas throughout which there is a recurring pattern of topography, vegetation, and soils at a scale detectable from air photography (Christian & Stewart 1953). Using land systems as conservation targets ensures that areas are selected across the full range of regional ecological gradients. Most boundaries of land systems are abiotic ecotones, hence likely to remain in the same locations even as climate change drives alterations in the ecosystems within each land system.

This study adopted the land systems of Papua New Guinea (Bellamy & McAlpine 1995). Its upland land systems are characterized by distinctive topography and bedrock type. Lowland land systems are characterized by their distinctive terrain form and hydrology (Sheppard & Saxon 2008).

The Land System data were acquired from the PNGRIS digital data set maintained by the PNG Forest Authority. Pre-processing steps included clipping the coverage to a standard PNG coastline and repairing a small number of mismatched labels in polygons crossing provincial boundaries. We produced significantly finer upland units by replacing the original descriptive slope classes with slope classes derived automatically from a 90m digital elevation model (SRTM) (Farr et al. 2007).

5.2.3.2 **Vegetation Types**

The Forest Information Management System (FIMs) mapping provides the best available vegetation data for PNG. FIMs was based on the interpretation of SKAIPIKSA air photography taken in 1973-75 (Hammermaster and Saunders 1995). The 1:100,000 classification includes a total of 59 vegetation types including: 36 Forests, 6 Woodland, 3 Savanna, 3 Scrub, 11 Grasslands, 1 Mangrove and 4 Non Vegetation Types (see Figure 10 and Appendix 2). Each Polygon in the classification is attributed with one to four different vegetation types in the following proportions: 1 class (100%), 2 classes (65%, 35%), 3 classes (65%, 25%, 10%) and 4 classes (65%, 25%, 5%, 5%). In order to calculate the total amount of each vegetation type, areas of each vegetation type for each polygon were allocated in the amounts defined above. The resulting original area of each forest at 1975, and 10% and 20% target are detailed in Appendix 2.

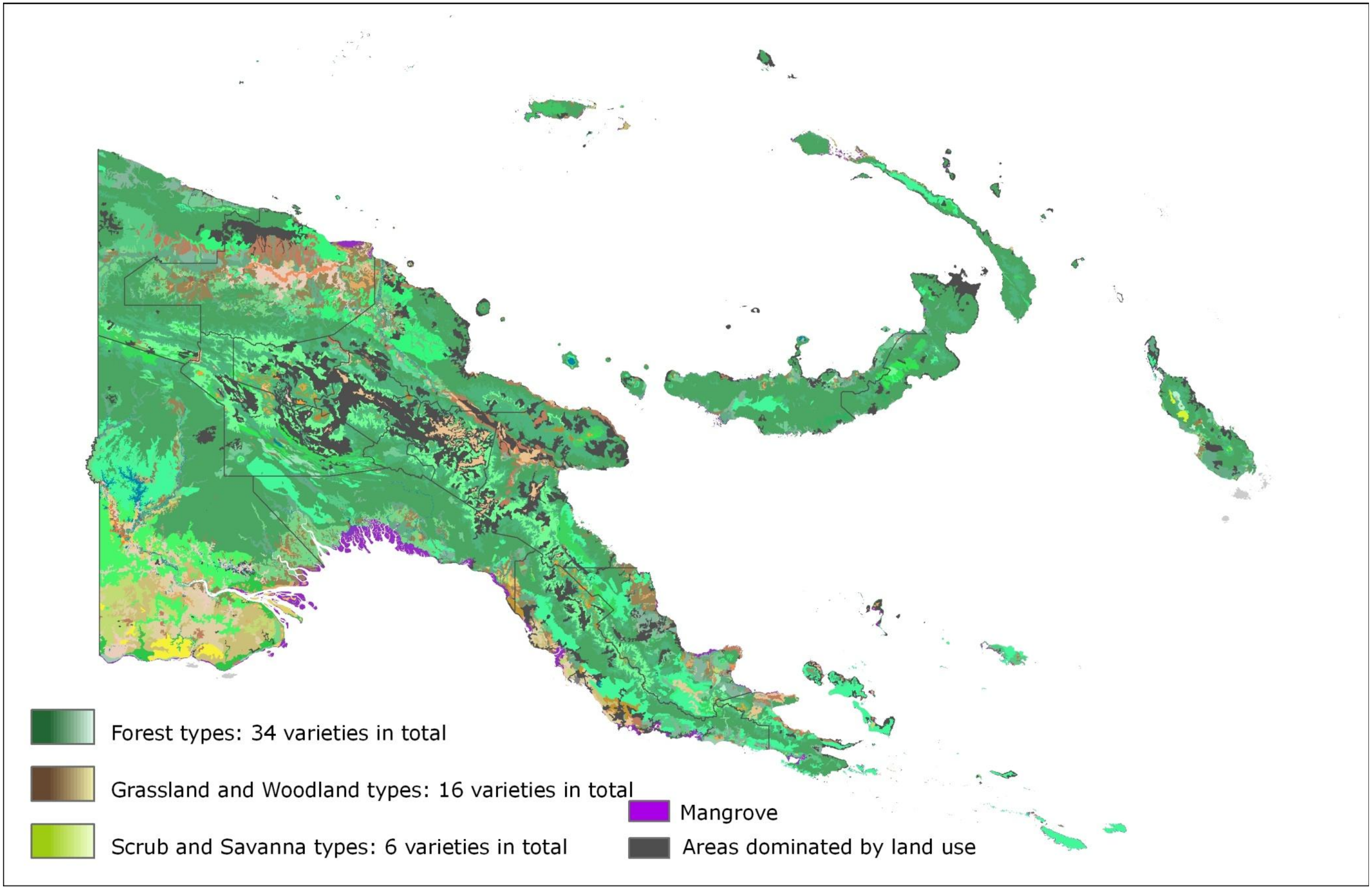

Figure 10: FIMs Vegetation Types

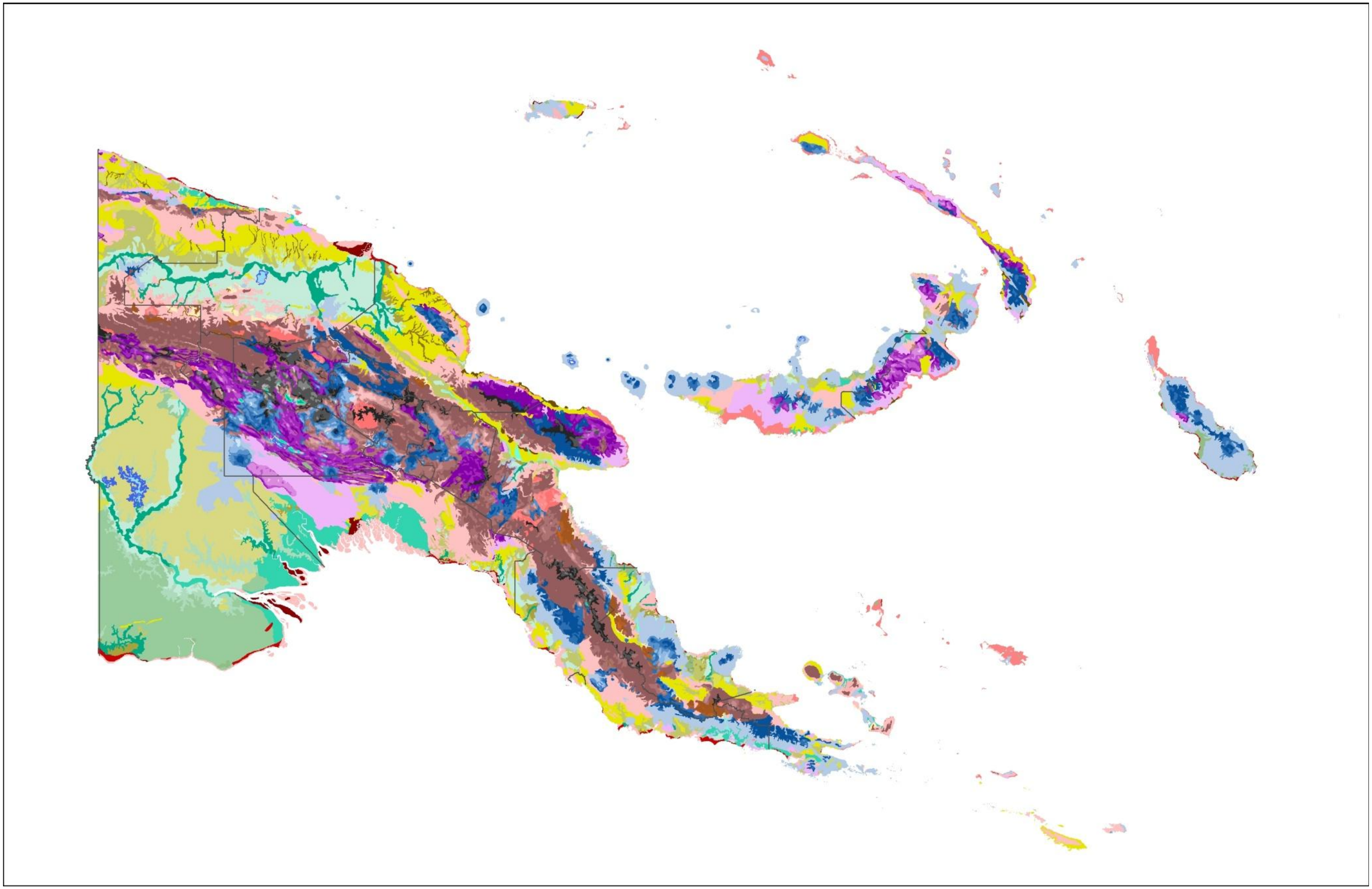

Figure 11: Land Systems

Vegetation change from 1975-2009

Significant logging activity and land use change has occurred since 1975 (Shearman et al. 2008). Unfortunately, the current forest extent data for PNG was not available during the time of this assessment. In the absence of current forest extent/condition data we approximated current forest condition (see Figure 13).

1975 mapping (Figure 12, Table 3) was updated using 1996 Landsat TM imagery at a scale of 1:250,000 (McAlpine and Freyne 2003). The updated mapping provides information on the change in status of:

- Areas logged and left to regenerate
- Areas logged and subsequently converted to other forms of non-forest forms of land use and
- Areas cleared (but not logged commercially) and subsequently converted to other non-forest land use.

The 1996 update provides the starting point for refinement of the FIMs data.

In addition, we made a number of assumptions regarding the condition of the forest subject to different management regarding their ability to support biodiversity, including:

a. Intact forests provide the highest quality habitat for supporting biodiversity
b. The more degraded the forest the less suitable it is for biodiversity
c. Converted forests are unsuitable for biodiversity
d. All lands with extreme constraints in FIM have intact forests
e. All lands in serious constraints in FIM are more likely to be degraded
f. All lands outside of both constraints are most likely to be converted or degraded
g. Forests subject to logging provide less suitable habitat for biodiversity
h. Anthropogenic (human derived) grasslands have little or no value for biodiversity in PNG

The aim here was to approximate current forest condition to provide a meaningful gradient from undisturbed forest to disturbed forests and to clearly delineate those areas less suitable for protection from those areas more suitable for protection. Within the existing schema we assigned the following discounting for forests based on land use intensity classes and logging (Table 3). Discounted areas 1975 and 2009 are illustrated in Figure 12 and 13. Classes detailed in Table 3 below are based land use data from FIMs and concession data from DEC.

Table 3: Discounting rates for FIMs

Discounting of FIM Vegetation and Land Use Types	Discount Rate 1975	Discount Rate 2009
Discounting within Timber Concessions		
Proposed Concessions		
Proposed logging areas	1.0	1.0
Current or Expired Timber Concessions		
Extreme Constraints[1] - land > 30 degrees dominant slope; land > 2400m elevation, land with Polygonal karst landform; land permanently or near permanently inundated extending over 80% of the area; or land covered by mangroves.	1.0	1.0
Serious Constraints - Land with dominant slope of 20-30 degrees and sub-dominant slope over 30 degrees and with high to very high relief; or land permanently or near permanently inundated extending over 50-80% of the area.	1.0	0.8
No Constraints		0.5
Discounting for Land Use Intensity Classes		
Converted Vegetation		
LU0 – Very high intensity with tree crops	0	0
LU1 – Very high intensity	0	0
LU2 – High intensity	0	0
LU3 – Moderate Intensity	0	0
LU4 – low Intensity	0	0
LU7 – Anthropogenic Grasslands		0
C - Converted		0
Intact – Degraded Vegetation		
LU5 – Very low intensity	0.8	0.5
LU6 – Extremely low intensity	0.9	0.7
LU8 – Sago stands significant		1.0
LU9 – Subalpine grassland		1.0
LU10 – Alpine grassland		1.0
LU11 – Savannah woodland		1.0

[1] McAlpine and Quigley 1998

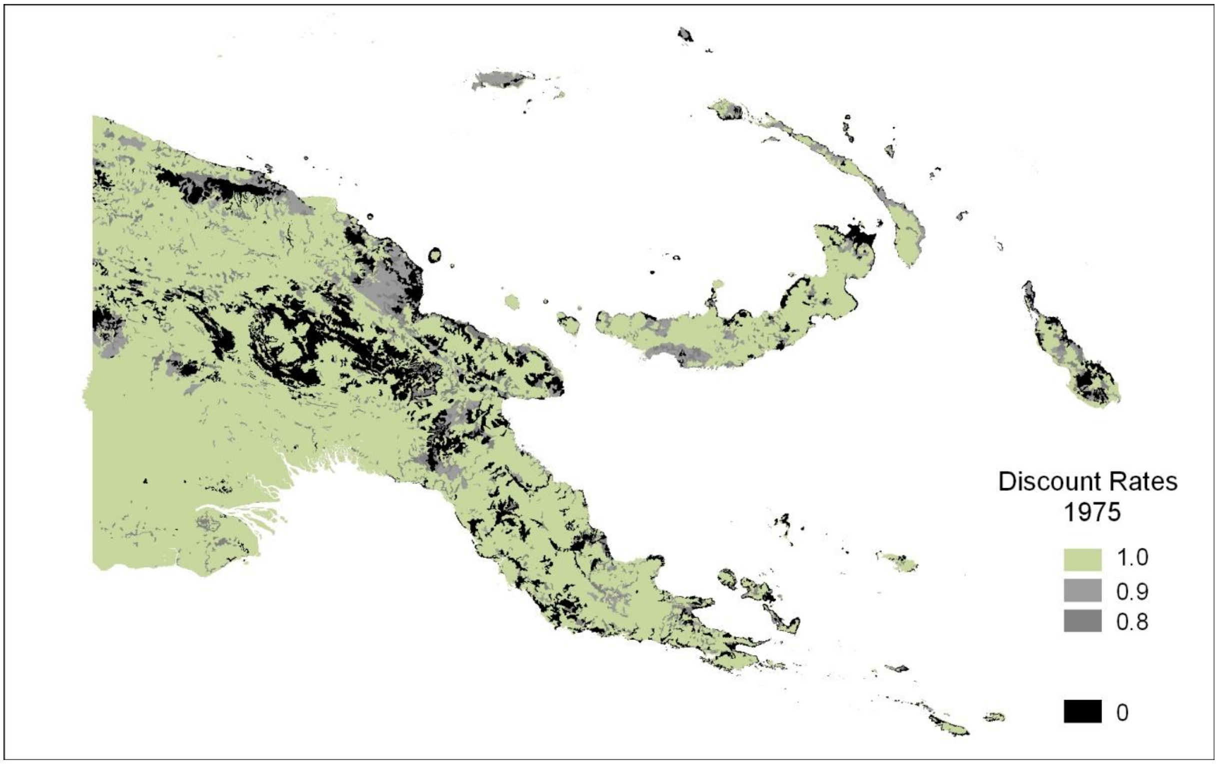

Figure 12: Discounted areas 1975

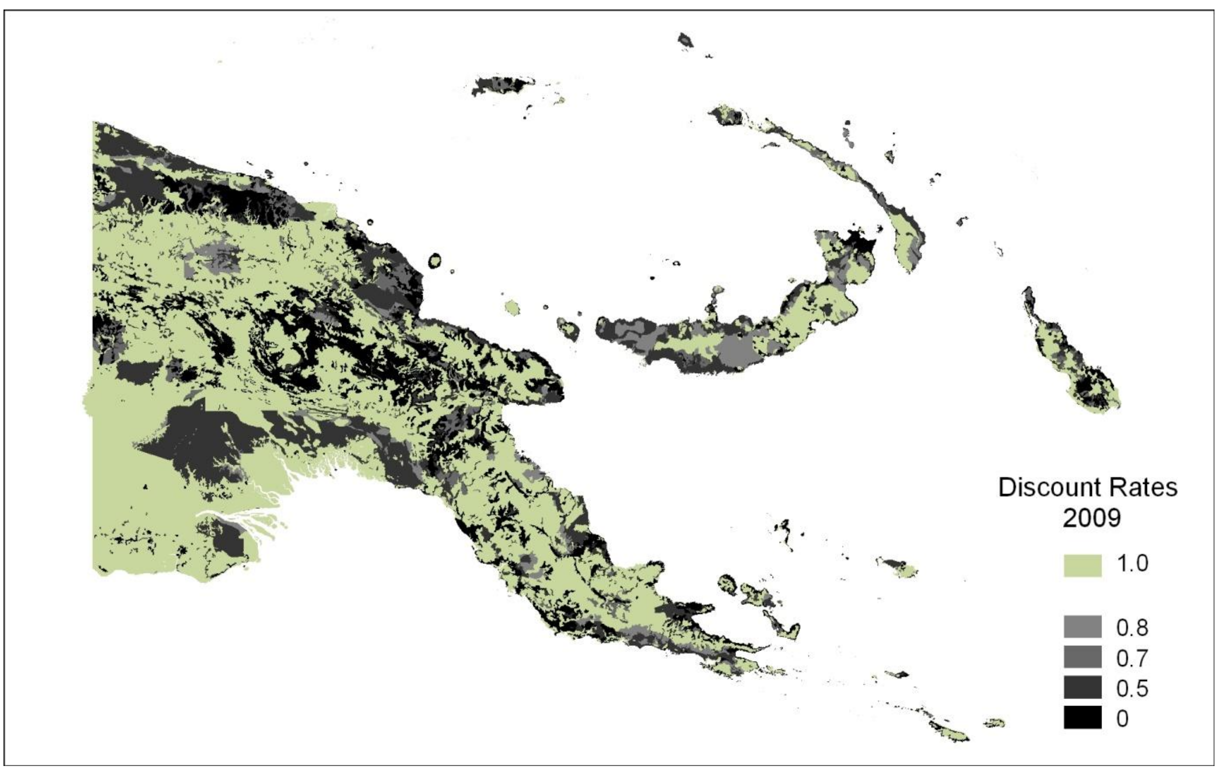

Figure 13: Discounted areas 2009

5.2.3.3 **Species**

Species used in this analysis included 123 species of restricted range endemic (RREs) reptiles, amphibians and 25 species of RRE mammals data (14, Appendix 3). These data were collected and compiled by Allen Allison of the Bishop Museum. Restricted range endemic species data from the Bishop museum represents the best estimates of the current distribution of each species using minimum convex polygons. We focused on the use of RRE's, as these species have the narrowest geographic and climatic ranges and are therefore most vulnerable to the impacts of climate change.

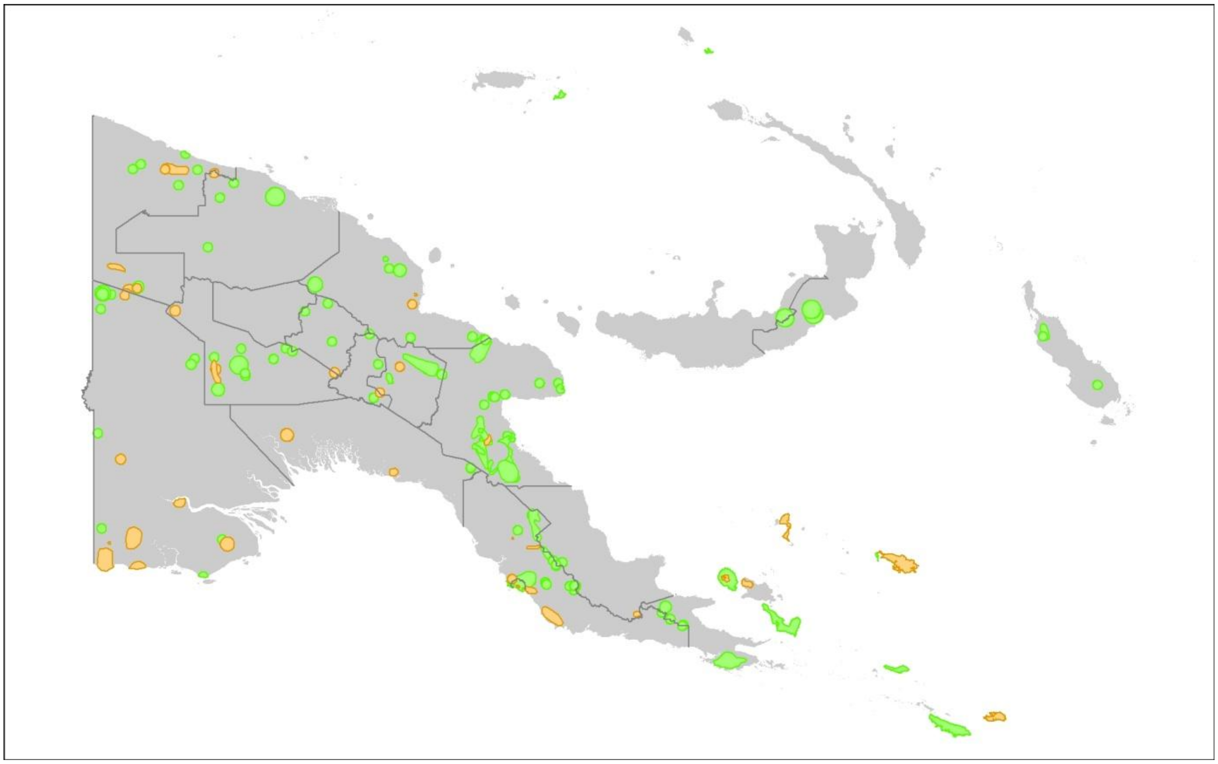

Figure 14: Restricted Range Endemic reptiles and amphibians (green), and Restricted Range Endemic mammals (orange).

5.2.4 Targets

Targets were set based on the criteria outlined in Section 3. In the case of Land systems (abiotic features), 10% or 20% of the original extent was applied to each Land system (stratified) by ecoregion (see Appendix 2). Given the Land systems are abiotic features it was assumed that their extent at the time of derivation and in 2009 remained unchanged.

For vegetation, FIM targets were set according to the Criteria in Section 4, that is, 10% and 20% of the original extent of each vegetation type as at 1975, stratified by ecoregion (see Appendix 2). We know that the forests in PNG have undergone significant deforestation and degradation between 1975 and the present (Shearman 2008), and forests were discounted to approximate this (see vegetation change above).

Recognizing that restricted range endemic species are only found at a single site, these species were given 50% targets (see Appendix 3).

5.2.5 Climate Change Refugia

Refugia were defined as the areas with projected future environmental attributes similar to their current environmental attributes, including both invariant physical attributes and climate variables (Saxon et al. 2005). Projected refugia in the year 2100 were identified under climate scenario A2 (Nakicenovic & Swart 2000), using the HadCM3 general circulation model (GCM) (Gordon *et al*. 2000). HadCM3 is a highly climate-responsive GCM and scenario A2 assumes limited climate mitigation action. These choices were made in order to develop a set of protected areas that would include refugia under severe future conditions, a precautionary approach given the uncertainty around the likely effectiveness of climate mitigation.

In order to preferentially identify conservation areas in locations of likely climate change refugia, each planning unit was assigned a probability that corresponded to the expected extent of climate change (Figure 15). A high probability meant that a planning unit was less likely to act as a climate change refugia, where as those planning units with a lower probability had a higher chance of being refugium. To assign probabilities, the climate change surface developed by Saxon et al. (2005, 2008) was normalized to a scale from 0 to 1, with 1 being assigned to the pixel that was expected to experience the greatest change in climate, across the entire island of Papua (i.e., including the Indonesian portion). Within each planning unit, probabilities were averaged across pixels, to give a mean probability of change per planning unit.

The refugia probabilities were then used as inputs to a modified version of the conservation planning software Marxan. The use of probabilities of change within Marxan is described by Game et al. (2008). Ultimately, the conservation area solutions generated by this modified version of Marxan, are the combinations of sites that offer the greatest possible chance of meeting our conservation targets into the future, given the largely uncontrollable impact of a changing climate.

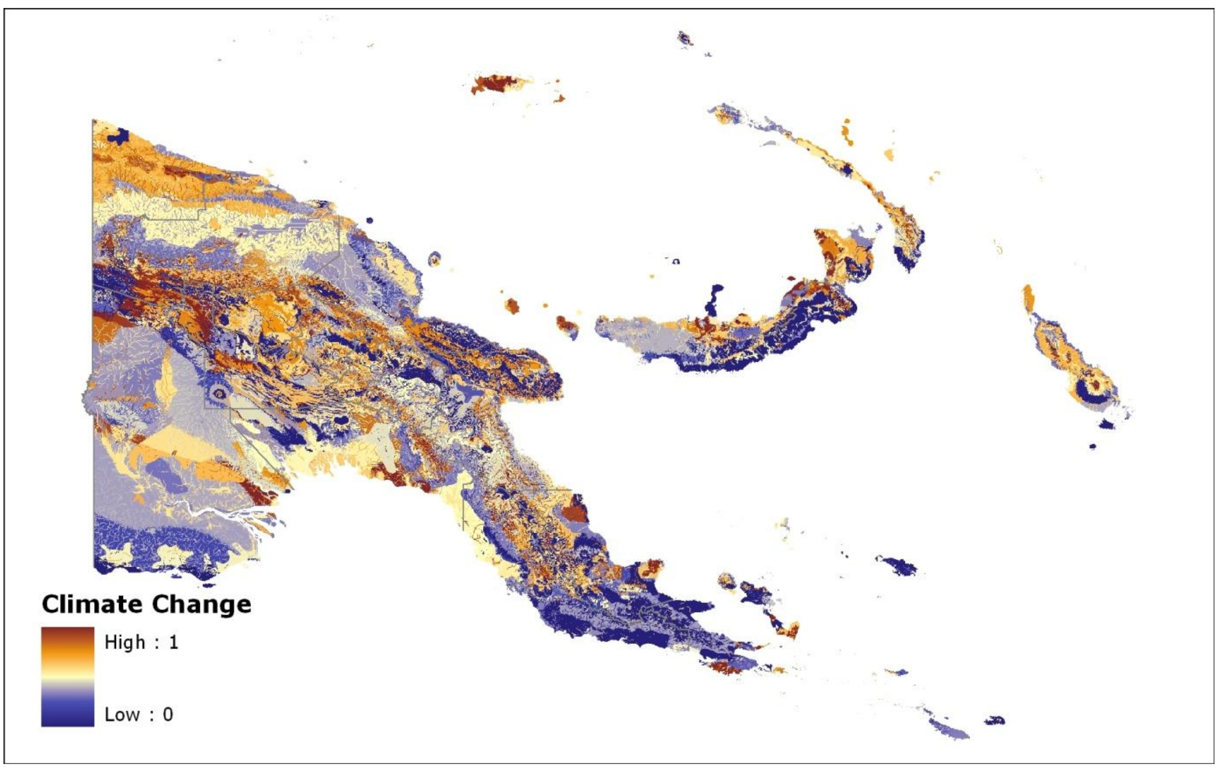

Figure 15: Climate change model

5.2.6 Cost Surface

The cost surface layer was derived from the 2000 population census data for Papua New Guinea. Each population census point was summed to provide a total population value for each hexagon (Figure 16). This provides the appropriate gradient for Marxan to work with, from populous areas where it is expensive to create and manage protected areas, to less populous areas where it is less expensive to create and manage protected areas and where human threats tend to be lower.

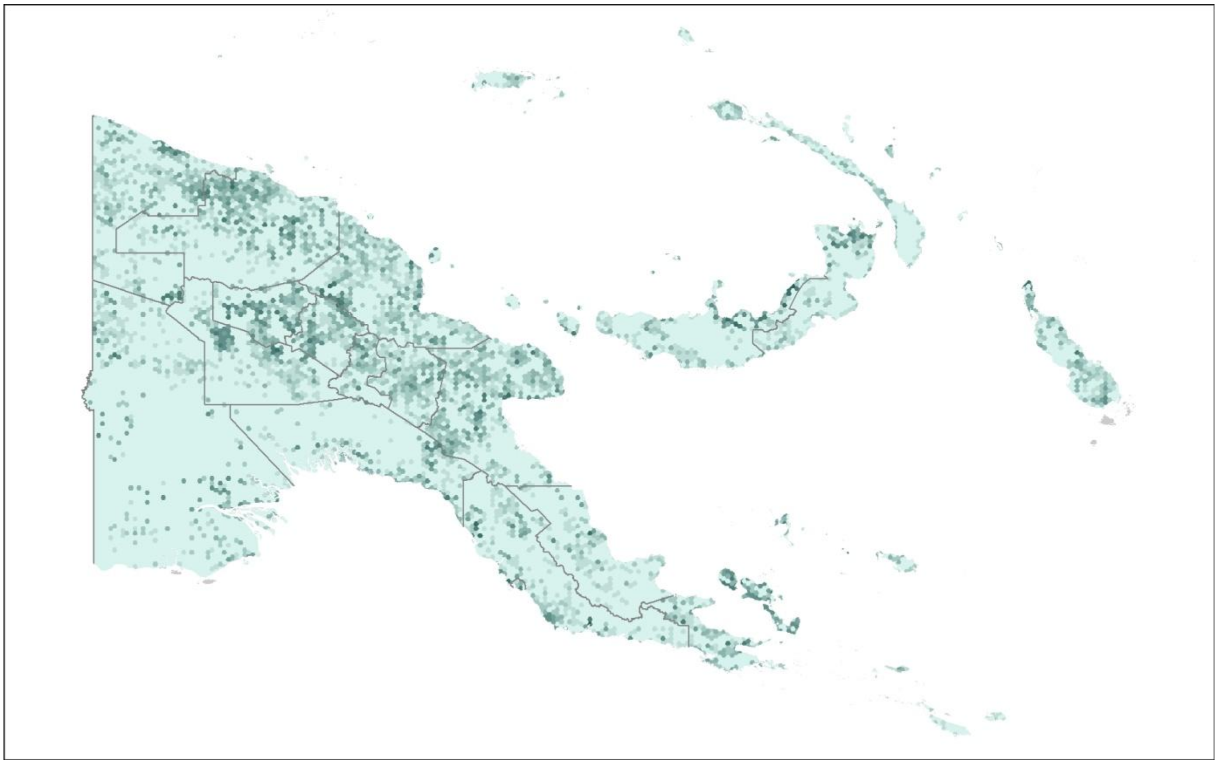

Figure 16: Cost surface. Darker shades have higher populations

5.2.7 Options

Numerous biodiversity priority options are possible. The draft criteria outlined in Section 3 provide the overarching guidance. Given available data and criteria, a range options were developed to enable the exploration and comparison of: (1) the different available surrogates for biodiversity, (2) different targets (10% and 20%), the (3) validity and contribution of existing protected areas and (4) the contribution of climate change (Table 4).

5.2.8 Marxan - Decision support

Planning units are the fundamental unit of selection. Protected Areas planning requires the consideration and comparison of an enormous number of potential planning units. Protected areas design requires the selection of those planning units that satisfy a number of ecological, social and economic criteria (in this case our biodiversity targets, goals for each target layer, design principles and the effective consideration of the cost layer which incorporates socio-economic considerations). Marxan is designed to help synthesize and automate the selection process so that many different scenarios can be developed and explored. One way of dealing with often conflicting biodiversity and socio-economic criteria is to have well defined goals for all of the conservation targets and well defined measures of the likely economic impact of the reserve system. The conservation goals are then sought in a way that the protected areas network results in minimal impact on community interests. The selection process uses an objective function whereby any collection of planning units is given a score. The simulated annealing procedure then attempts to find protected areas networks (i.e. collections of planning units) which have the lowest scores (socio-economic cost) and highest biodiversity benefit. This means that the scenarios produced try to meet the most conservation goals while simultaneously having the least impact on socio-economic values (Ball and Possingham 2000).

Calibration of the Boundary Length modifier, initial systems testing and running of Marxan was performed within Zonae Cogito (ZC) (Watts et al. 2009)

5.2.9 Key Marxan Inputs

The key inputs used in the Marxan runs were:

- Total planning units = 10,693
- Each planning unit = 5,000 ha (note that coastal units are less because they were clipped)
- For option exploration = 10 runs, where the "Best" run was chosen for inclusion
- 100 runs = sum solutions for final runs
- Number of iteration/run = 10,000,000 iterations
- Boundary Length Modifier = 0.7 - 1.8 (With testing between 0.01 - 2.5)
- Penalty Cost = 5 (Set equally across all conservation targets) which means all targets were weighted equally
- Temperature decreases 10,000
- Adaptive annealing "on"
- Using simulated annealing

For a complete description on the use of Marxan see (Game and Grantham 2008).

5.3 Results

5.3.1 Opportunities for filling the gaps

Marxan generated options for filling the remaining representation gaps were explored (see **Error! Reference source not found.**). Five major parameters were compared: (1) 3 different surrogates (2) with and without protected areas, (3) with and without climate change and (4) 10% and 20% targets and (5) adjustments in the Boundary Length Modifier (BLM). These preliminary results are described below. Parameters 1, 2, and 3 were explored using the 10% option. Parameter 5 was explored for both the 10 and 20% final options.

Surrogates

Three biodiversity surrogates were explored, including: Land Systems, FIM and Restricted Range Endemics. Each surrogate samples different components of biodiversity. FIM was consistently the most space demanding surrogate accounting for 22.5-29.1% of PNG (10% Target) compared with 10.6-13.5% for Land Systems (10% Target) and 4.0-10.6% for 50% RRE's (Table 4). Equally, each surrogate sampled different geographic space (see Figure 17, Figure 18, Figure 19).

With and without Protected Areas

Developing options where protected areas were locked in, that is, targets were first met within existing protected areas and then the remaining target sought in the remaining landscape, consistently resulted in more space demanding options. Using protected areas as locked in required between 2.4 and 6.5% extra land (see Table 4, Figure 17, Figure 18, Figure 19).

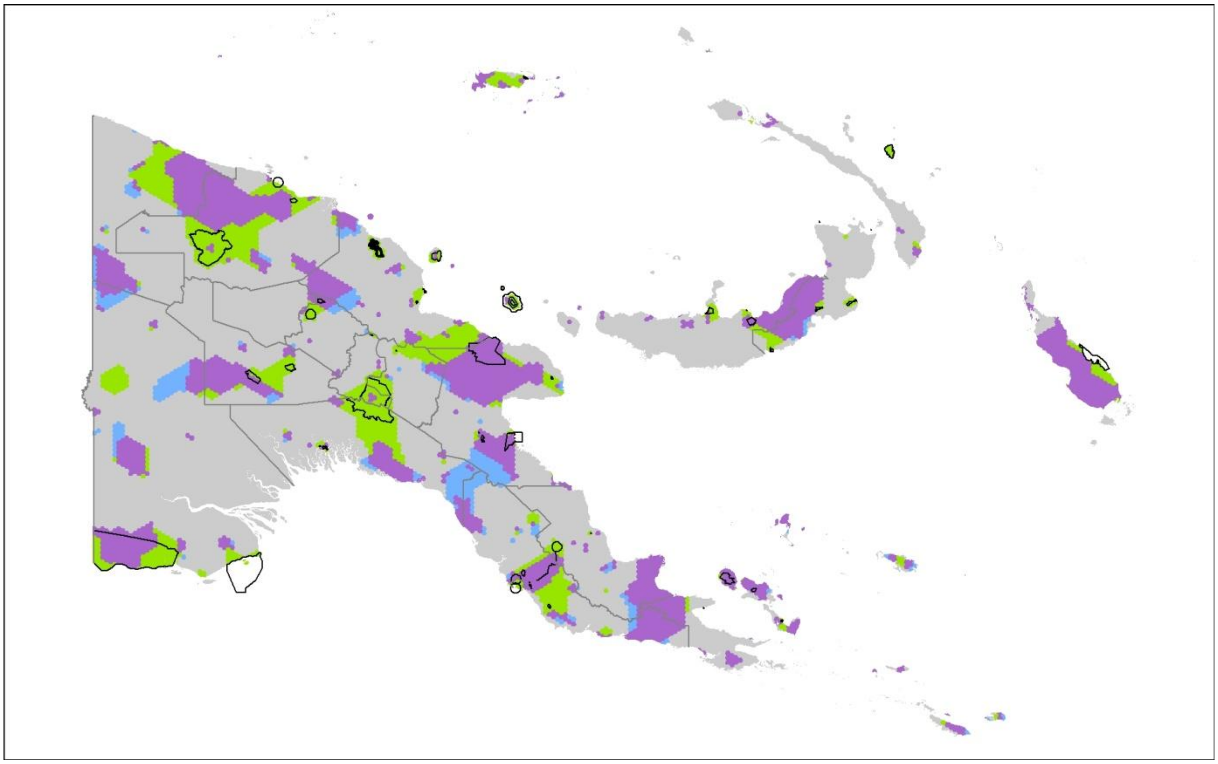

Figure 17: 10% Target for FIM only. Marxan run without protected areas in blue, with protected areas in green, common to both in purple. Protected areas in black outline.

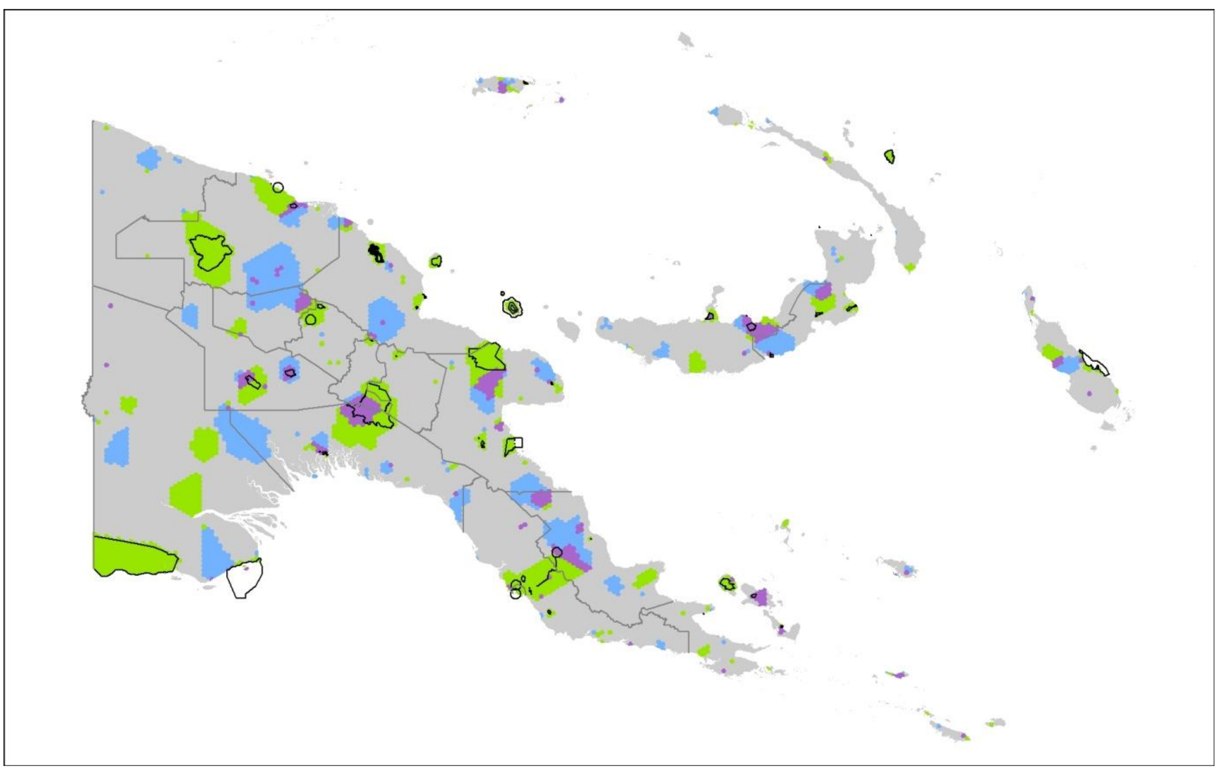

Figure 18: 10% Target for Land Systems only. Marxan run without protected areas in blue, with protected areas in green, common to both in purple. Protected areas in black outline.

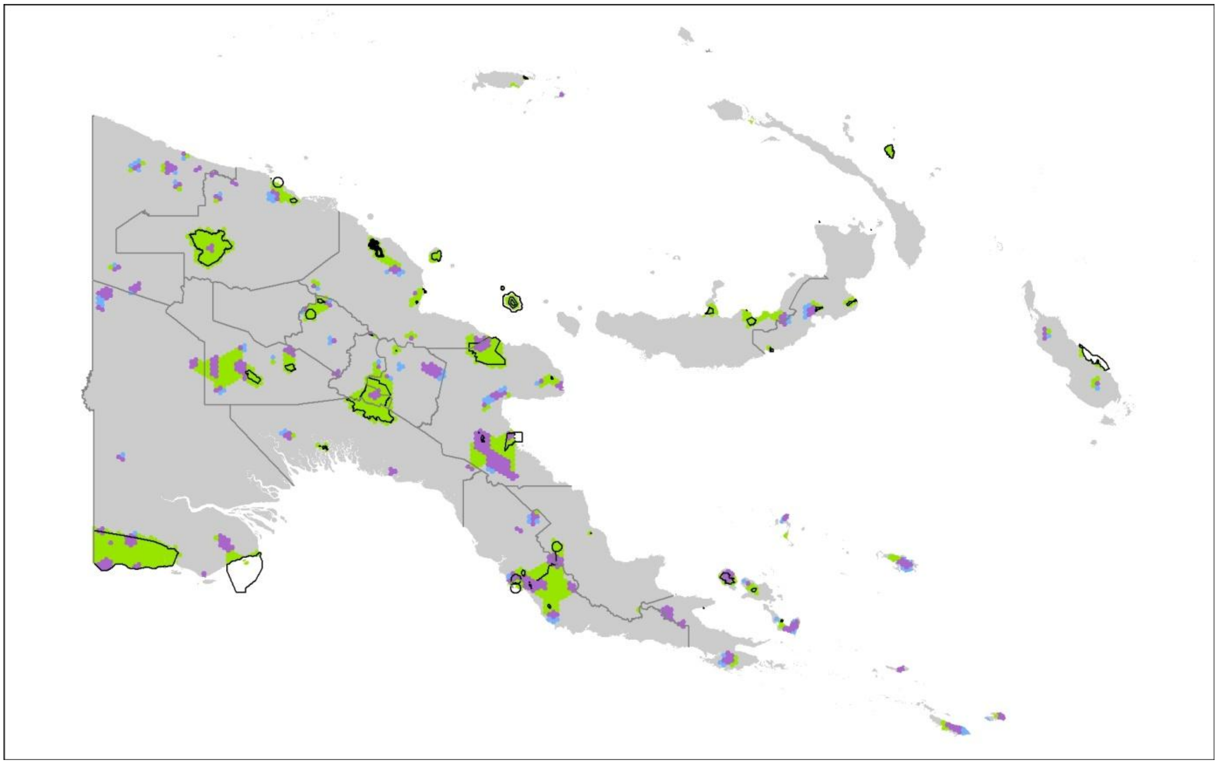

Figure 19: 50% Target for Rare and Restricted Range Endemics only. Marxan run without protected areas in blue, with protected areas in green, common to both in purple. Protected areas in black outline.

With and without Climate Change

Incorporating climate change probability within an option resulted in slightly larger areas for each option across all three surrogates, ranging from 0.5 to 2.8% (see Table 4). Of greater significance, although the area demands of considering climate change were relatively small, the geographic distributions differed markedly between surrogates. There was significant spatial overlap for FIM with and without climate change (Figure 20). In contrast there was dramatic separation of areas with and without climate change for Land Systems (Figure 21) and an entirely different outcome again for Restricted Range Endemics, where the climate change option attempted to connect some groups across gradients (Figure 22).

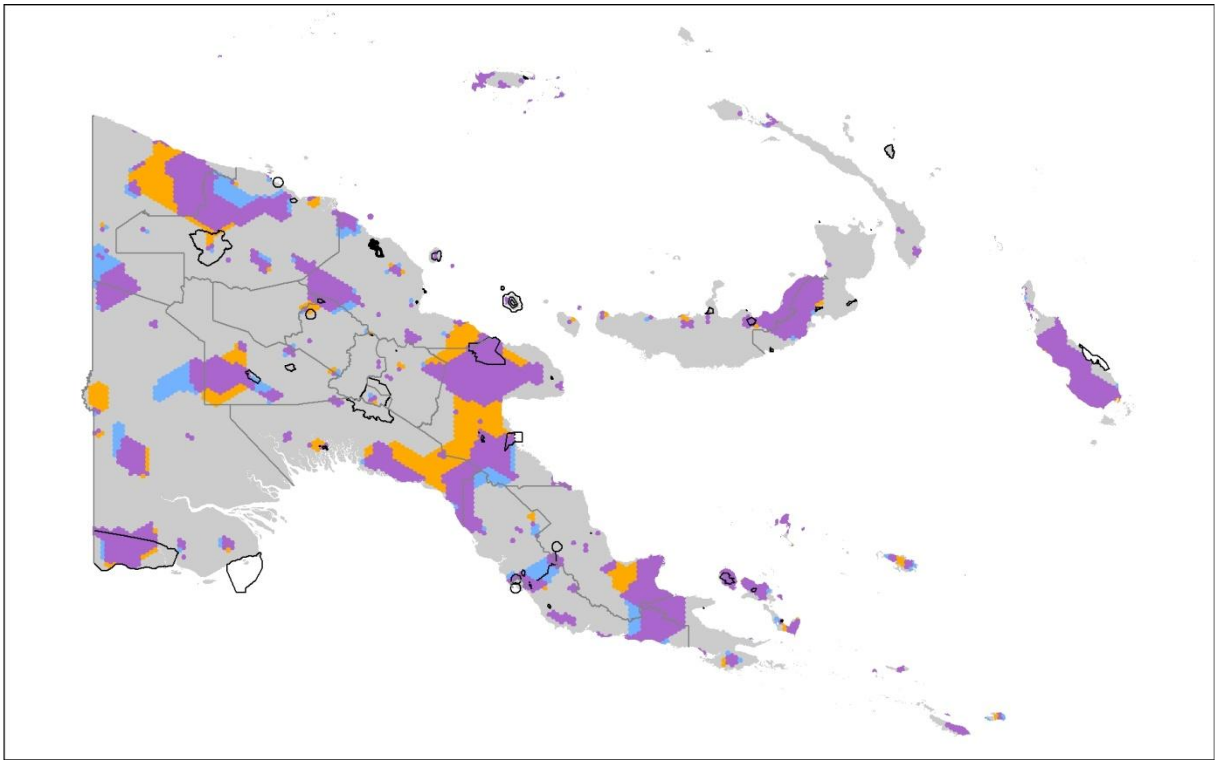

Figure 20: 10% Target for FIMs without protected areas. Marxan run without climate change in blue, with climate change in orange, common to both in purple. Protected areas in black outline.

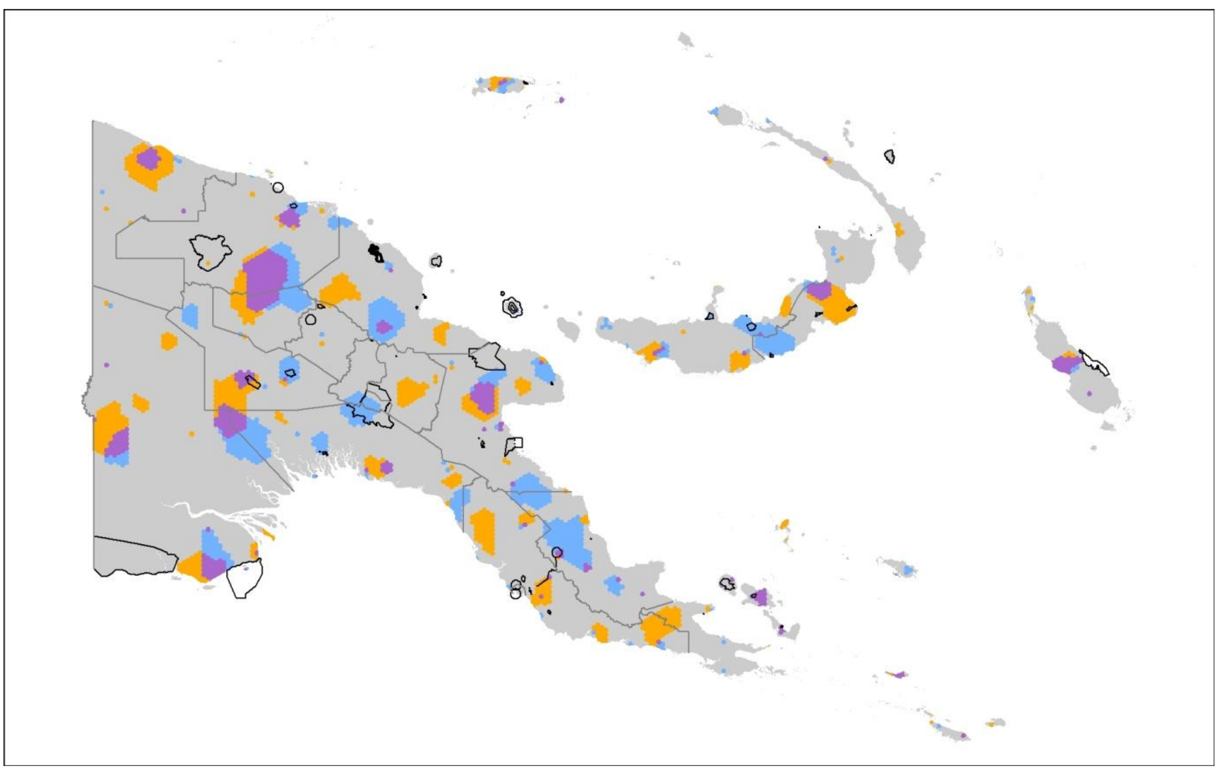

Figure 21: 10% Target for Land Systems without protected areas. Marxan run without climate change in blue, with climate change in orange, common to both in purple. Protected areas in black outline.

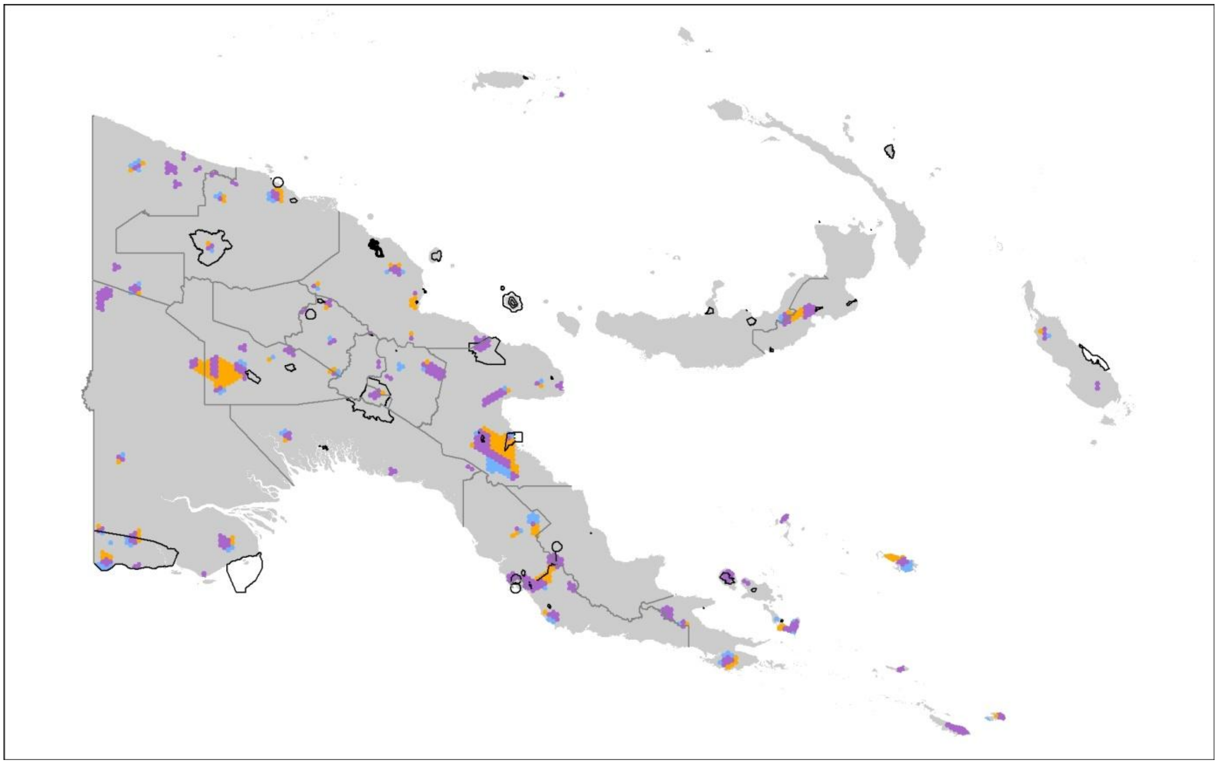

Figure 22: 50% Target for Rare and Restricted Range Endemics without protected areas. Marxan run without climate change in blue, with climate change in orange, common to both in purple. Protected areas in black outline.

All surrogates combined

When all three surrogates were combined (FIM, Land Systems and RRE), as might be expected, the spatial requirements in order to effectively meet all targets also increased (see Table 4). The final options to meet 10% and 20% targets for all conservation features without including existing protected areas and including climate change probability required 22% and 32% of the land base respectively (Figure 23, Figure 24, Table 6). What is also interesting is that the climate change version required slightly less area than the non climate change version (-1.7% and -2.7% respectively).

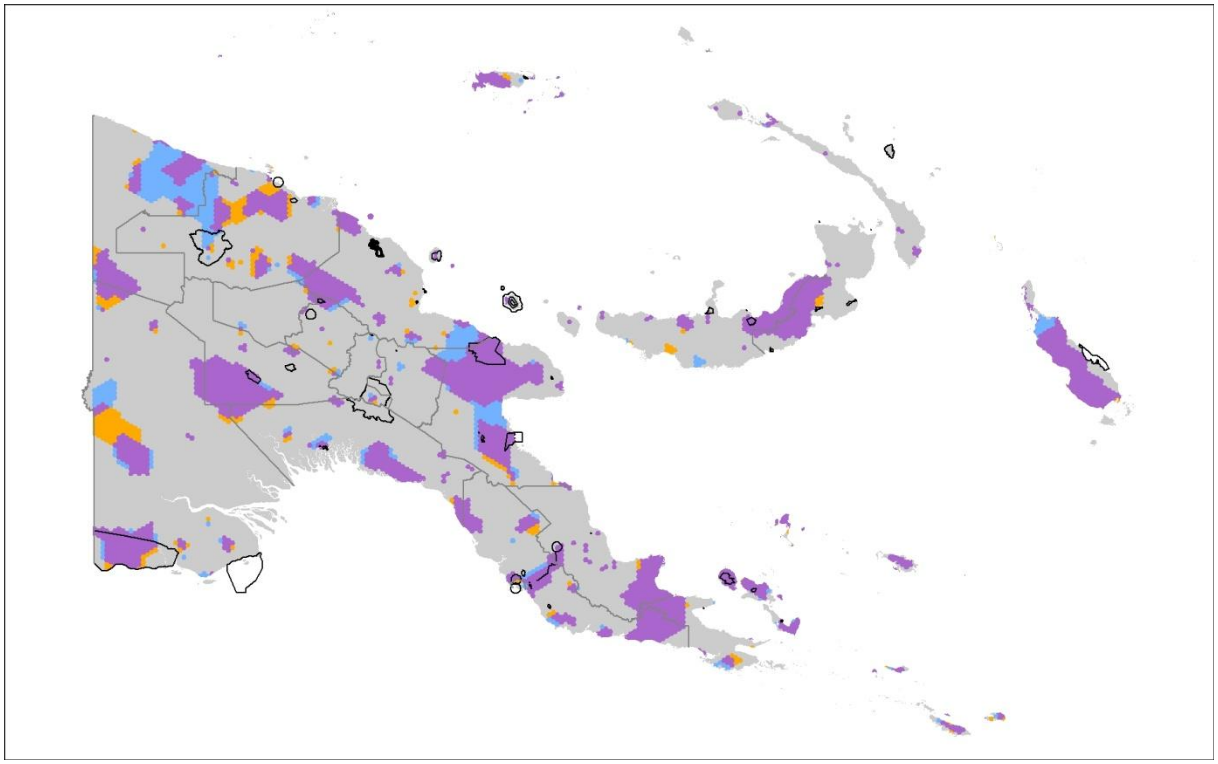

Figure 23: 10% Target for Land Systems & FIMS, 50% Target for Rare and Restricted Range Endemics, without protected areas. Marxan run without climate change in blue, with climate change in orange, common to both in purple. Protected areas in black outline.

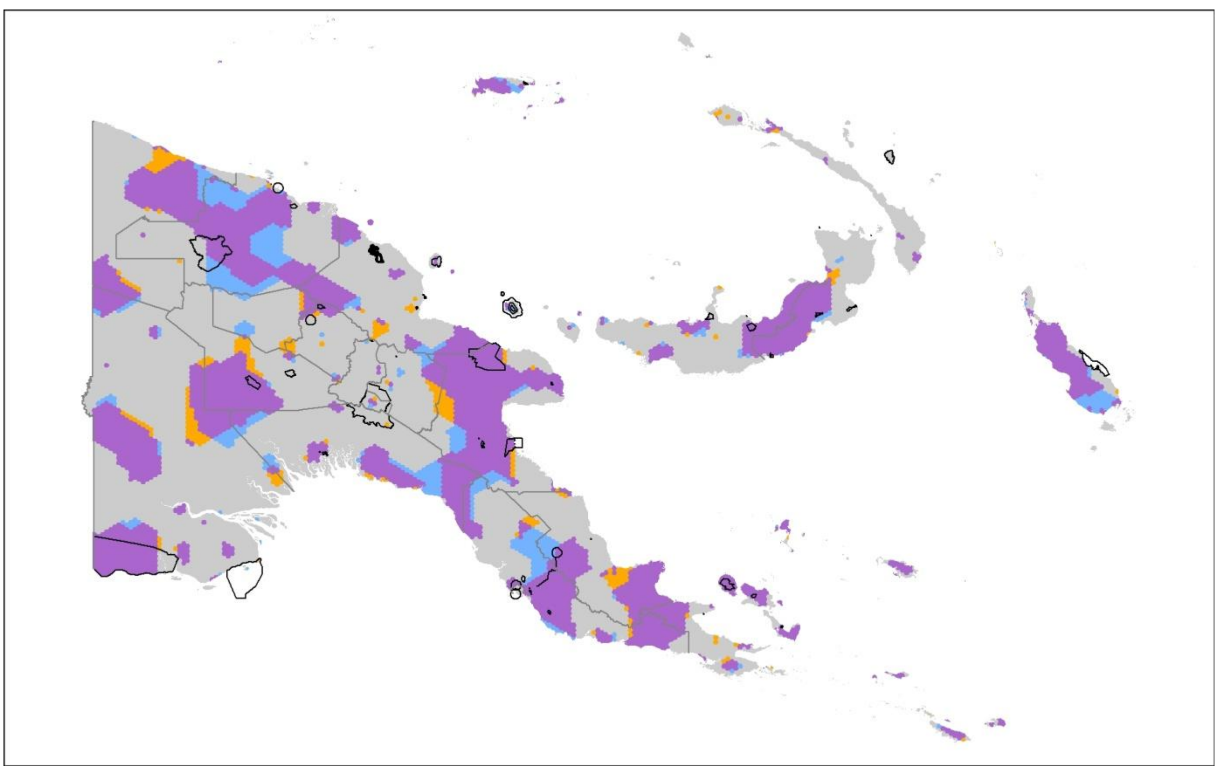

Figure 24: 20% Target for Land Systems & FIMS, 50% Target for Rare and Restricted Range Endemics, without protected areas. Marxan run without climate change in blue, with climate change in orange, common to both in purple. Protected areas in black outline.

Adjusted BLM

Finally, we consistently used a BLM of 1.5-1.8 throughout the analyses based on initial calibration runs within ZC. This tended to provide options with larger more cohesive conservation priority areas that spanned large altitudinal gradients and also ensured better connectivity. While a BLM that produces large cohesive areas with good connectivity which helps achieve climate change and biodiversity criteria, it may not meet the social and political expectations of PNG. In order to demonstrate a more socially, politically acceptable set of options, we also re-ran the combined surrogates with a BLM of 0.5. As expected this resulted in a larger number of smaller conservation priority areas. More importantly, it required significantly less land area to meet the conservation targets 16.5% of the land area for the 10% option and 25.3% of the land area for the 20% option (Table 4, Figure 25 and Figure 26).

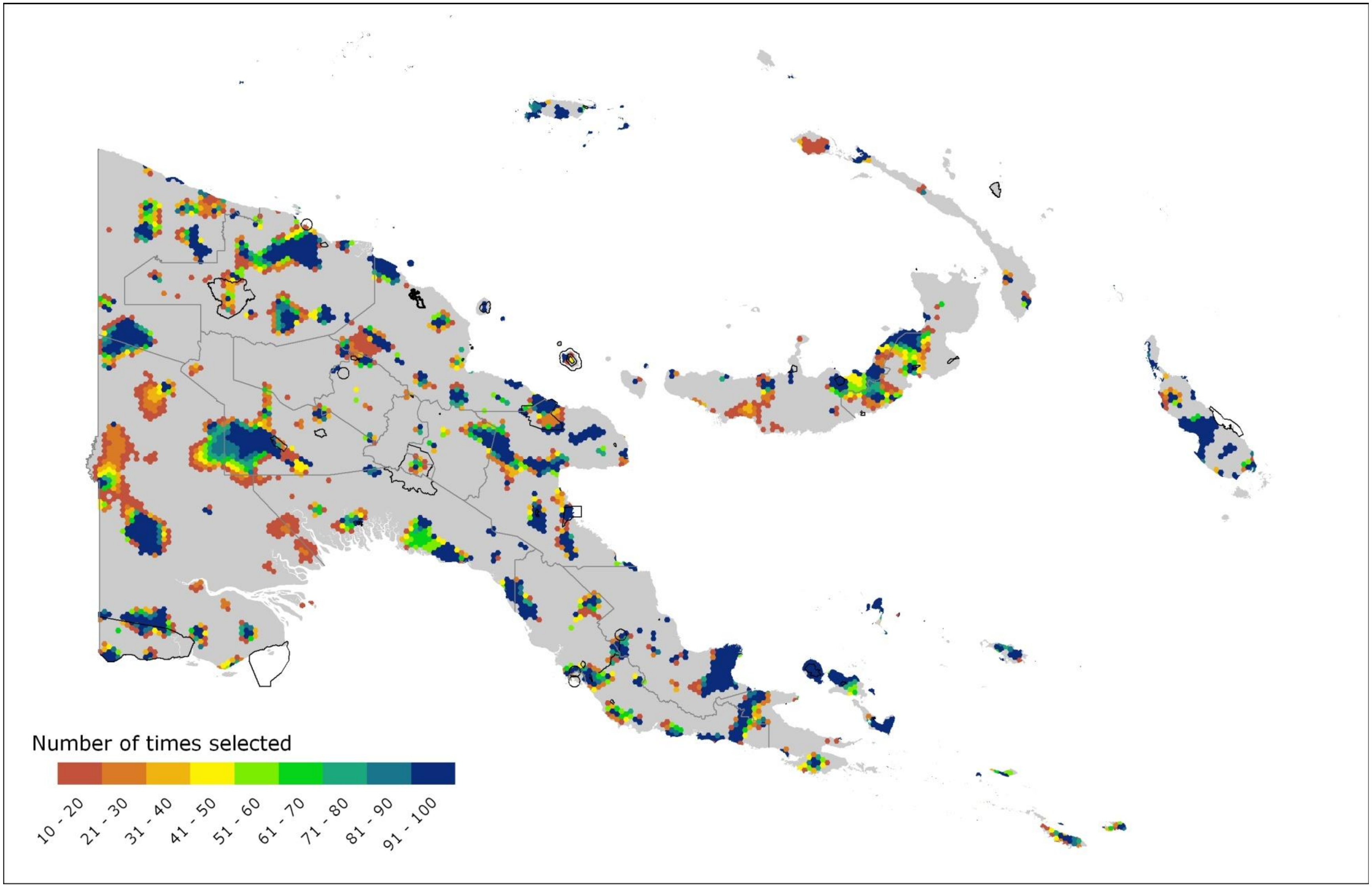

Figure 25: Sum solution. 10% Target for Land Systems & FIMs, 50% for Rare and Restricted Range Endemics, without protected areas, with climate change, BLM = 0.5. Protected areas in black outline.

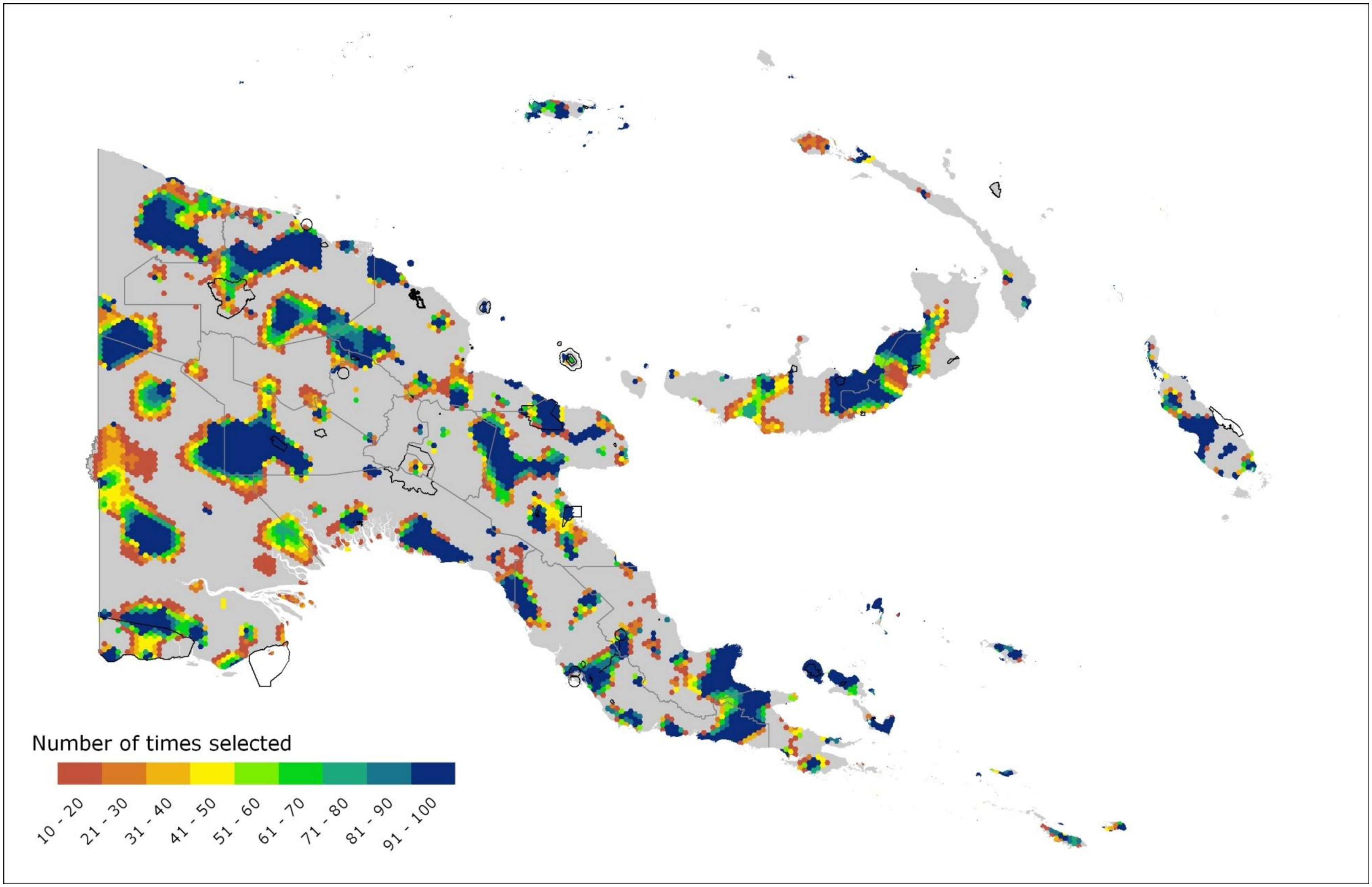

Figure 26: Sum solution. 20% Target for Land Systems & FIMs, 50% for Rare and Restricted Range Endemics, without protected areas, with climate change, BLM = 0.5. Protected areas in black outline.

Table 4: Marxan Scenarios

Percent/Surrogates	Number of Planning Units (Best Run)	Area (ha)	% of PNG	Add'l % with PAs	Add'l % with CC	Figure Number
Individual Surrogates with/without PAs						
10% FIM without PAs	2409	12,045,000	22.53			17
10% FIM with PAs	3112	15,560,000	29.10	6.57		
10% LS without PAs	1141	5,705,000	10.67			18
10% LS with PAs	1405	7,025,000	13.14	2.47		
50% RRE without PAs	429	2,145,000	4.01			19
50% RRE with PAs	1128	5,640,000	10.55	6.54		
Individual Surrogates with/without CC						
10% FIM without PAs	2409	12,045,000	22.53			20
10% FIM without PAs with CC	2641	13,205,000	24.70		2.17	
10% LS without PAs	1141	5,705,000	10.67			21
10% LS without PAs with CC	1447	7,235,000	13.53		2.86	
50% RRE without PAs	429	2,145,000	4.01			22
50% RRE without PAs with CC	490	2,450,000	4.58		0.57	
Combined LS+FIM+RRE50% surrogates with/without CC (BLM =1.5)						
10% LS 10% FIM 50% RRE without PAs	2548	12,740,000	23.83			23
10% LS 10% FIM 50% RRE without PAs w/CC	2359	11,795,000	22.06		-1.77	
20% LS 20% FIM 50% RRE without PAs	3762	18,810,000	35.18			24
20% LS 20% FIM 50% RRE without PAs w/ CC	3472	17,360,000	32.47		-2.71	
Combined LS+FIM+RRE50% surrogates with CC (BLM = 0.5)						
10% LS 20% FIM 50% RRE without PAs w/ CC BLM 0.5	1763	8,815,000	16.49			25
20% LS 20% FIM 50% RRE without PAs w/ CC BLM 0.5	2706	13,530,000	25.31			26

5.4 Discussion

5.4.1 Conservation Priority Areas (CPAs)

The PNG Department of Environment and Conservation has twin responsibilities with respect to the nation's biodiversity: (1) a role, minimizing impacts on biodiversity arising from national development; and (2) a role, protecting a comprehensive, adequate and representative and resilient system of the country's ecosystems, species and genetic diversity for future generations.

The conservation priority areas (CPAs) developed in this study serve both purposes. They allow DEC to quickly identify areas where nationally significant development proposals must be subject to careful assessment of impacts on identified conservation targets and specific measures to attenuate and offset those impacts if the development takes place. They also allow DEC to quickly identify opportunities to strengthen the national protected areas system, for example by designating all or part of a conservation priority area (CPA) as a protected area.

The CPAs have been identified through the use of explicit decision rules, readily available computer software, and distribution maps of the occurrence and condition of conservation targets. As better data come to hand the processing can be repeated and the delineation of CPAs can be further improved and refined.

Five different sets of conservation targets were analyzed: existing protected areas; projected future climate refugia; Land Systems; Forest Inventory Mapping (FIM); and, known occurrences of Restricted Range Endemic fauna species (RREs). In theory, CPAs derived from these five data sets could be combined in 3,125 different ways. After examining the preliminary results, we developed a decision tree to simplify the selection of relevant criteria for delineating CPAs (Figure 27).

First, we developed CPAs based on Land Systems, FIM and RREs individually. Then we developed CPAs starting with all existing protected areas and adding only additional areas needed to complete a representative set for Land Systems, FIM or RREs. These proved to be substantially larger than the CPAs based on Land Systems, FIM or RREs only. They frequently turned out to be in different locations as well. We conclude that requiring CPAs to include all existing protected areas would impose unnecessary inefficiency (i.e. a much larger protected area system) on any CPA network system as a whole.

Next we examined the effect of a rule giving preference, all else being equal, to those planning units projected to be least affected by climate change, hence most likely to provide refugia for biodiversity, allowing time and space for ecosystems to adapt. CPAs assembled under this additional rule were found to be very slightly larger than those that ignored climate impacts but spatially different. We conclude that requiring CPAs to consider the potential impacts of climate change strengthens the CPA network system as a whole.

Finally we compared the extent and locations of CPAs generated by Land Systems, FIM and RREs on their own and in various combinations. CPAs for RRE only occupies the smallest total area because restricted range endemic species occupy narrow geographic and climate ranges and are widely scattered occurring on discrete mountain tops of valleys or unique geographies such as Karst systems (Allison pers. comm.). CPAs for FIM proved to require large amounts of land to compensate for the degraded condition of many forest types. CPAs for LS, which did not consider current forest condition, required no additional areas, i.e. representing 10% of each land system results in a CPA system occupying 10% of the country.

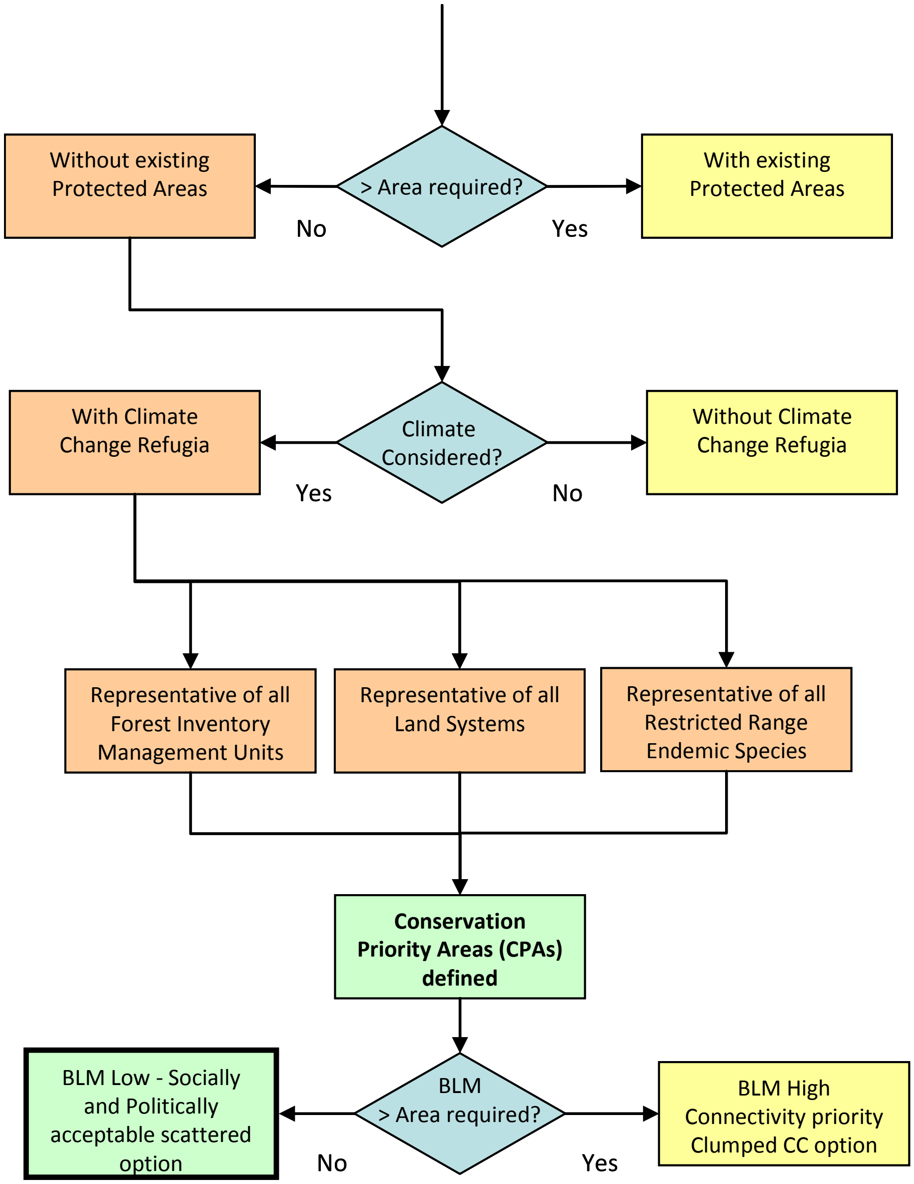

Figure 27: Decision trees for the selection of final options

Given that the distribution of much of PNG's biodiversity is presently poorly understood and its responses to climate change are unpredictable, the CPA network designed to capture 20% of LS, FIM and 50% RREs without protected areas with provision for climate refugia, offers the best available guide to priority areas for minimizing impacts on biodiversity arising from national development and priority areas for protecting a comprehensive, adequate, representative and resilient system of the country's ecosystems, species and genetic diversity (Figure 26).

5.4.2 Data Limitations

The gap analysis conducted represents a preliminary analysis based on a subset of best available data. There are a number of caveats associated with these data including:

- **Coarse biodiversity surrogate data -** both Land Systems and FIM are older, coarse data sets (1996). We have little understanding of how these surrogates perform sampling the full range of biodiversity in PNG. In addition, we included all vegetation types with the exception of anthropogenic grasslands. It may be that classes such as grassland with some forest and grassland reverting to forest may also be anthropogenic habitats and therefore inappropriate for inclusion in the analysis. All CPAs will require detailed validation and assessment to determine their relevance for inclusion in the CARR protected area system.

- **Current Forest Extent** - In the absence of current forest extent data (Shearman et al 2008), we made assumptions to enable the discounting of existing forests data (FIM 1996) to approximate current forest condition. We focused specifically on logged areas and did not consider forest loss and degradation from cash crops, subsistence land use, oil palm conversion and other conversion and degradation processes. PNG Forests are being degraded at a rate of 1.41%/year. For the period from 1972 to 2002, 48.2% of forest change was due to logging (0.9 million ha deforested; 2.9 million ha degraded) and 45.6% (3.6 million ha) was cleared for subsistence agriculture (Shearman et al 2008). The current forest extent estimates is this study therefore greatly under estimate forest conversion and degradation. This means that any areas identified in this desktop study as a priority for protection and management would require further validation using recent high resolution satellite data and/or field checking to ensure that areas selected for protection are relevant to the protected area system as a whole.

- **Extreme and serious constraints** - we assumed that land in extreme and serious constraints would be subject to less conversion and degradation, as this is a requirement under the PNG Forest Logging Code of Practice (1996). We conducted a brief validation exercise to test this assumption and it was evident that this was not the case. Many of the areas within extreme and serious constraints were logged and converted, particularly areas of West New Britain.

- **Existing protected areas** – This assessment assumes that the existing protected areas are effectively protected. Unfortunately, in the recent management effectiveness review of PNG's protected areas, it was found that very few of the protected areas assessed were effectively managed (RAPPAM 2009). In addition, for 34 protected areas across PNG, 38,926 ha were cleared for subsistence activities and 11,951 ha were further degraded by logging activities (Shearman et al 2008).

- **Species data -** For this assessment we only included a small subset of the species data available for PNG, notably restricted range endemic reptiles, amphibians and mammals, those species most vulnerable to the impacts of climate change for which we had robust verified data. The analysis would clearly benefit from the inclusion of other priority species data (both fauna and flora), as identified in the Section 4 - Criteria, in particularly:
    - The special needs of rare, vulnerable or endangered species; A major limitation of this study was the lack of consideration of Red Listed Species, which include: 36 critically endangered, 49 endangered, 365 vulnerable, 288 near threatened, species.
    - Special groups of organisms, for example species with complex habitat requirements, or migratory or mobile species;

  - Areas of high species diversity, those species whose distributions and habitat requirements are not well correlated with any particular ecosystem

  The use of species data would require the development of robust species models (GLM or GAM) to avoid the inherent sampling biases associated with species data.

- **Climate data** – Different combinations of greenhouse gas emission scenarios and global circulation models could give different projections for future refugia, but the most significant shortcoming of any century-scale model is that it does not capture increased climate variability or greater frequency and severity of extreme weather events, such as droughts. Therefore increased area representation is an essential precaution.

- **Past Assessments** - Past biodiversity assessments have been completed for PNG including: (1) The Conservation Needs Assessment (CNA) (1993) and (2) BIORAP (2001). Neither CNA nor BIORAP outcomes were considered in this assessment. This assessment may have benefited from the inclusion of CNA and BIORAP priorities as individual conservation features and with targets.

5.4.3 Opportunities for filling gaps

There are significant opportunities to fill the gaps in the existing protected areas network in PNG. The 10% and 20% options outlined in this report allow us to: (1) represent a broad range of biodiversity by sampling two different sets of major habitat types: FIM a biotic surrogate and Land Systems an abiotic surrogate, (2) capture the most climate vulnerable elements of biodiversity (a subset of restricted range endemic species) and (3) ensure the effective inclusion of climate refugia, by incorporating those areas with the least probability of change. By combining three surrogates of biodiversity we avoid the failure of any one surrogate in capturing and representing biodiversity. By including the consideration of change refugia, we provide the greatest chance of survival for vulnerable climate change elements to retreat to or expand from. Finally, by providing a 20% option we again reduce risking the loss of biodiversity by increasing the adequacy of the CARR protected area system. This recognizes the uncertainty around habitat loss from anticipated increased frequency and intensity of drought and fire from climate change.

Climate change will rapidly alter the abiotic environment of many localities leading to significant losses of biodiversity unable to adapt quickly. However, local extirpation will be least likely where environmental change is slowest. Such locations will offer refugia for species with narrow environmental ranges, provide persistent sources of colonists, offer transitory homes for dispersers and serve as platform sites on which new community assemblages develop (Saxon 2008). Consequently, networks of protected areas that include such climate refugia sites will be of great benefit to the persistence of biodiversity (Saxon 2008; Loarie et. al. 2008).

This study includes the magnitude and pace of climate change as part of the analyses. In this way we consider the full spectrum, from sites likely to change most to those likely to change least, in addition to the conventional stratification techniques for protected area site selection. We found that optimal solutions that considered climate change tended to be more dispersed (scattered) than options developed in the absence of climate change, implying that only some parts of existing large intact areas will remain environmentally stable under rapid climate change. Fortunately, the development of more and smaller protected areas also has the benefit of spreading the risks of failure of any one protected area due to non-climate related causes. A well-distributed network of relatively small protected areas may also be more appropriate in the PNG context from a social and political perspective.

The threat of climate change is of particular importance to restricted range endemic species, those constrained to a narrow geographic and often climatic range. These are particularly vulnerable to impacts of climate change as there are often few or no options regarding future habitat. Projected percent extinctions for endemic biota in biodiversity hotspots ranged from 1 to 43% (average 11.6%) (Malcolm et al. 2006). In the case of restricted range endemics living on mountain tops, as warming proceeds, the abiotic range will contract until it no longer exists, resulting in the extinction of these particularly vulnerable species.

There is a uncertainly about both the possible future state of the environment and how species are likely to respond, consequently, it is not possible to analyze the needs of individual species under the full range of possible futures. Instead, protecting those areas likely to change least (climate change refugia), maintaining appropriate connectivity among these areas and spreading risk by securing multiple sites offer promising approaches to slowing the pace of species loss and fostering natural adaptation responses to rapid climate change and increased climate variability.

6 Recommendations

This gap analysis was developed to provide DEC with a clear picture regarding progress towards its commitment under the CBD and NBSAP (i.e. 10% of terrestrial areas Protected Areas by 2010) and to provide options regarding CPAs required to complete a National CARR terrestrial protected area system for PNG. This analysis was also developed to provide DEC with a tool that could readily be used and updated by DEC staff to inform decisions as well as provide an effective means for stakeholder consultation regarding protected areas development.

This analysis is by no means perfect. It uses the best available data given the limited timeframe available for its completion. As far as better defining priority areas in PNG, this analysis could be improved by addressing the limitations identified in section 6.4.2. Most importantly, this analysis and its products provide DEC with a blueprint for strategic action. Immediate steps that need to be taken include:

1. Address the backlog of protected area proposals to determine those proposals that correspond to CPAs where customary landowners are supportive. This will allow DEC to take immediate steps to strengthen the establishment of the National CARR protected area system.

2. Where existing industry proposals coincide with and conflict with CPAs, reinforce the need for biodiversity offsets. In the case of new proposals, careful consideration would be required and only approved where not net harm can ensured.

3. Recognize that PoWPA Phase I (this study) is the first phase of a process for the establishment and effective management of a CARR National Protected Area system. DEC needs to take steps to commence PoWPA Phase II: the validation of CPAs regarding their suitability for inclusion in the CARR National Protected Area System, social mapping and assessment of customary ownership, and options for payments for ecosystem services to support CPAs.

4. Finally, DEC needs to develop an efficient and effective process for the legal establishment and gazettal of the National CARR Protected Area System, but also reinforce the effective management of the existing protected areas. Steps taken regarding the development of effective processes with the Kokoda Project should assist with this.

7 References

Alcorn, J. B. (ed), 1993. Papua New Guinea Conservation Needs Assessment Vol. 1. Biodiversity Support Program, Government of Papua New Guinea, Department of Environment and Conservation. Corporate Press Inc., Landover, Maryland.

Anderson, M., and C. Ferree. 2010. Conserving the Stage: climate change and the geophysical underpinnings of species diversity. PLoS One in press.

Ball, I. R. and H. P. Possingham, 2000. MARXAN (V1.8.2): Marine Reserve Design Using Spatially Explicit Annealing, a Manual pdf (267KB)

Beehler, B. M. (ed), 1993. Papua New Guinea Conservation Needs Assessment Vol. 2. Biodiversity Support Program, Government of Papua New Guinea, Department of Environment and Conservation. Corporate Press Inc., Landover, Maryland.

Bellamy, J. A. and J. R. McAlpine. 1995. Papua New Guinea: inventory of natural resources, population distribution and land use handbook. 2nd edition. Papua New Guinea Resource Information System (PNGRIS) Publication 6. Australian Agency for International Development (AusAID): Canberra, Australia.

Chatterton, P., Yamuna, R., Higgins-Zogib, L., Mitchell, N., Hall, M., Sabi, J., Jano, W., Duguman, J., Mogina, J., Mowbray, D., Melick, D. and Leggett, M. (2009) An assessment of the effectiveness of Papua New Guinea's Protected Areas using WWF's RAPPAM Methodology. WWF.

Christian, C. S., and G. A. Stewart. 1953. General report on survey of Katherine-Darwin Region, 1946. Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Land Research Service 1. Commonwealth Scientific and Industrial Research Organisation (CSIRO): Canberra, Australia

Climate Change 2007: *Impacts, Adaptation and Vulnerability*. IPCC Summary for Policymakers. (2007)

Commonwealth of Australia (1997) Nationally Agreed Criteria for the Establishment of a Comprehensive, Adequate and Representative Reserve System for Forests in Australia.

Dudley, N. Stolten, S. Belokurov, A. Krueger L. Lopoukhine N., MacKinnon K, Sandwith T. and Sekhran N (eds) (2010); Natural Solutions: Protected Areas helping people cope with climate change, IUCN-WCPA, TNC, UNDP, WCS, the World Bank and WWF, Gland Switzerland, Washington DC and New York, USA.

Ervin, J., J. Mulongoy, K. Lawrence, E. T. Game, D. Sheppard, P. Bridgewater, G. Bennet, S. Gidda, and P. Bos. 2009. Making Protected Areas Relevant: A guide to integrating protected areas within wider landscapes, seascapes and sectoral plans and strategies. CBD Technical Series. Secretariat of the Convention on Biological Diversity, Montreal.

Faith, D. P., Walker, P. A., Ive, J. R. and Belbin, L., 1994. Integrating conservation and forestry production: effective trade-offs between biodiversity and production in regional land-use assessment. In: *Conserving biological diversity in temperate forest ecosystems - towards sustainable management* pp. 74-75.

Faith, D. P. and Walker, P. A., 1996a. DIVERSITY - TD. In: *BioRap*, *rapid assessment of biodiversity. Volume three*, *tools for assessing biodiversity priority areas* (ed. D. P. Faith and A. O. Nicholls), pp. 63-74.

Faith, D. P. and Walker, P. A., 1996b. Integrating conservation and development: effective trade-offs between biodiversity and cost in the selection of protected areas. *Biodiversity and Conservation* 5, 417-429.

Faith, D. P., Margules, C. R., Walker, P. A., Hutchinson, M. and Nix, H. A., 1999. Biodiversity conservation planning and implementation. *in* Papua New Guinea: from targets and trade-offs to environmental levies and carbon-offsets ed anon. Pacific Science Congress, Sydney.

Faith, D. P., Walker, P. A., Margules, C. R., Stein, J. and Natera, G., 2001a. Practical application of biodiversity surrogates and percentage targets for conservation in Papua New Guinea. *Pacific Conservation Biology*.

Faith, D. P., Margules, C. R. and Walker, P. A., 2001b. A Biodiversity conservation plan for Papua New Guinea based on biodiversity trade-offs analysis. *Pacific Conservation Biology.*

Faith, D. P., Walker, P. A. and Margules, C. R., 2001c. Some future prospects for systematic biodiversity planning in Papua New Guinea - and for biodiversity planning in general. *Pacific Conservation Biology.*

Farr, T. G., et al. (2007), The Shuttle Radar Topography Mission, Rev. Geophys., 45, RG2004, doi:10.1029/2005RG000183.

Game, E. T., C. Groves, M. Anderson, M. Cross, C. Enquist, Z. Ferdaña, E. Girvetz, A. Gondor, K. Hall, J. Higgins, R. Marshall, K. Popper, S. Schill, and S. L. Shafer (2009) Incorporating climate change adaptation into regional conservation assessments. The Nature Conservancy. Arlington, Virginia.

Game, E. T., Watts, M. Wooldridge, S., and Possingham, H. 2008. Planning for persistence in marine reserves: a question of catastrophic importance. Ecological Applications 18:670-680.

Game, E. T. and Grantham, H. S.. 2008. Marxan user manual; for Marxan version 1.8.10. The University of Queensland and Pacific Marine Analysis and Research Association Brisbane.

Game, E.T. and Segan, D. (2009) - PNG PoWPA Marxan Manual

Gonzales, P. Neilson R.P., and Drapek R.J (2005) Climate change vegetation shifts across global ecoregions. Ecological Society of Ammerica Annual Meeting Abstracts 90: 228

Gordon, C.; Cooper, C., Senior, C.A., Banks, H., Gregory, J.M., Johns, T.C., Mitchell, J.F.B., and Wood, R.A. (2000). "The simulation of SST, sea ice extents and ocean heat transports in a version of the Hadley Centre coupled model without flux adjustments". *Climate Dynamics* 16**:** 147–168.

Hammermaster, E. T. and Saunders, J.C. (1995) Forest Resources and Vegetation Mapping of Papua new Guinea. PNGRIS Publication No 4. (Ausaid: Canberra.) 294 pp, 1 mapsheet

Hunnam P. (1992) Papua New Guinea Protected Areas Program: Register of Protected Areas. WWF South Pacific Program, Port Moresby.

Hutchinson, M. F., Belbin, L., Nicholls, A.O., Nix, H. A., McMahon, J. P. and Ord, K. D, 1996. *BioRap. Volume Two. Spatial Modeling Tools*, The Australian BioRap Consortium, Canberra, 142 pp.

IUCN, 1999: Threats to Forest Protected Areas, Research Report for World Bank/WWF Forest Alliance,IUCN, Available from http://iucn.org/themes/wcpa/themes/wcpa.

Lakau, A.A.L. "Land and Churches in Melanesia: An Overview" in M. Rynkiewich (eds), *Land and Churches in Melanesia : Issues and Contexts*, (hereafter Land & Churches) (TMI. Sat Prachar Press, Indore, 2001), 24 -29, at 26; Haynes C., (1981) 1&2 "Succession to Land in Papua New Guinea" *Melanesian Law Journal*, 74, at 75.

Lewis, M. Paul (ed.), 2009. Ethnologue: Languages of the World, Sixteenth edition. Dallas, Tex.: SIL International. Online version: http://www.ethnologue.com/.

Loarie SR, Carter BE, Hayhoe K, McMahon S, Moe R, et al. (2008) Climate Change and the Future of California's Endemic Flora. PLoS ONE 3(6): e2502. doi:10.1371/journal.pone.0002502

Malcolm, J R., Liu, C, Neilson, R. P. Hansen, L, Hannah, L. (2006). Global warming and extinctions of endemic species from biodiversity hotspots. Conservation Biology. 20(2): 538-548.

Margules, C.R., Pressey, R.L. (2000). Systematic conservation planning. Nature. 405: 243-253.

Margules, C. R., Redhead, T. D., Faith, D. P. and Hutchinson, M. F., 1995. *Guidelines for Using the BioRap Methodology and Tools*. CSIRO Australia, 70 pp.

McAlpine J.R, and Quigley J. (1998) Forest Resources of Papua New Guinea - Summary Statistics from the Forest Inventory Mapping (FIM) System. Prepared by Coffey MPW Pty Ltd for the Australian Agency for International Development and the Papua New Guinea National Forest Service.

McAlpine J.R. and Freyne D.F. (2003) Land Use Change and Intensification in Papua New Guinea 1975–1996 Asia Pacific Viewpoint Volume 42 Issue 2&3, Pages 209 - 218

McNeely J.A., and Miller K.R. (1984) National Parks, Conservation and Development: The role of protected areas in sustaining society. Proceedings of the World Congress on National Parks held on 11-22 October 1982 in Bali, Indonesia. Smithsonian Institution Press, Washington, DC.

Mittermeier, R.A., Myers N., Thomsen J.B., da Fonseca, G.A.B. and Olivieri, S. (1998) Biodiversity Hotspots and Major Tropical Wilderness Areas: Approaches to Setting Conservation Priorities. *Conservation Biology*, Vol. 12(3):516-520

Nakicenovic, N., and R. Swart, (eds.). 2000. Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios. Cambridge University Press: Cambridge, United Kingdom.

Norman Myers, N., Russell A. Mittermeier R.A., Cristina G. Mittermeier C.G., da Fonseca G.A.B and Kent J (24 February 2000) Biodiversity hotspots for conservation priorities *Nature* 403, 853-858

Noss, R.F., (2001) Beyond Kyoto: Forest management in a time of rapid climate change. *Conservation Biology*, Vol. 15(3):578-590.

Olson, D.M, Dinerstein, E, Wikramanayake E.D., Burgess N.D. , Powell, G.V.N, Emma C. Underwood, Jennifer A. D'amico, Illanga Itoua, Holly E. Strand, John C. Morrison, Colby J. Loucks, Thomas F. Allnutt, Taylor H. Ricketts, Yumiko Kura, John F. Lamoreux, Wesley W. Wettengel, Prashant Hedao, and Kenneth R. Kassem (2001) Terrestrial Ecoregions of the World: A New Map of Life on Earth BioScience 933 Vol. 51 (11) 933-938

Papua New Guinea Government (1996) Papua New Guinea Logging Code of Practice: First Edition. Papua New Guinea Forest Authority and the Department of Environment and Conservation.

Papua New Guinea Government (2009). Supporting Country Action on the Convention on Biodiversity (CBD) Program of Work. Department of Environment and Conservation.

Saxon E.C. (2008) Noah's Parks: A partial antidote to the Anthropocene extinction event Biodiversity 9.3-9.4) 5-10

Saxon, E. C., Baker, B., Hargrove, W., Hoffman, F. and Zganjar, C. (2005). Mapping environments at risk under different global climate change scenarios. Ecology Letters 8: 53–60.

Sheppard, S., and Saxon E. C. 2008. Land Systems of the New Guinea Archipelago. ESRI Map Book **23**. Redlands, California: ESRI Press. Available on line at http://conserveonline.org/workspaces/NG_LandSystems.

Shearman, P. L., Bryan, J. E, Ash, J., Hunnam, P., Mackey, B., and Lokes, B. (2008). The state of the forests in PNG: Mapping and condition of forest cover and measuring the drivers of forest change in the period 1972-2002. Port Moresby: University of Papua New Guinea

Vié, J.-C., Hilton-Taylor, C. and Stuart, S.N. (eds.) (2009). *Wildlife in a Changing World – An Analysis of the 2008 IUCN Red List of Threatened Species*. Gland, Switzerland: IUCN. 180 pp. http://data.iucn.org/dbtw-wpd/edocs/RL-2009-001.pdf

Watts, M.E., R.R. Stewart, D. Segan, L. Kircher, and H.P. Possingham: Using the Zonae Cogito Decision Support System, a Manual.

World Statistics Pocketbook Small Island Developing States Department of Economic Series V No. 24/SIDS and Social Affairs Special Issue Statistics Division Preliminary -2007 update.

8 Appendicies

Appendix 1: IUCN Categories and PNG Protected Areas

Within the PNG context, the following categories apply. For a full description of the IUCN Categories see Appendix 1 below.

IUCN Categories I-IV

- **National Parks (Act),** (includes National Heritage - see Box 1)
  - Acquisition of land, gazetted
  - Private ownership - gift to the Nation
  - Ministerial declaration
- Lands Act

IUCN Categories V and VI (multiple use)

- **Conservation Areas Act** (everything other than species - all Natural Heritage)
  - Conservation Areas
- **Fauna Protection Control Act (species specific)**
  - WMA’s (including: RAMSAR, World Heritage Areas)
  - Protected Areas
  - Sanctuaries
- **Environment Protection Act**
  - Buffer Zones (under codes of practice)
  - Beneficial Values including (water etc.)
  - Customary protection (Tambu Areas) - to be evaluated under the permitting process

- **Other forms of Protection and Management that contribute to a National Network of Protected and Managed areas (that can enforced). DEC Recognize:**
  - Protected Areas established under the Organic Law (OLPLLG) includes marine (LMMA's - Locally Managed Marine Areas) terrestrial (CMA's - Community Managed Areas)
  - Voluntary agreements (Conservation Deed - private arrangement under contract law)

Category	Definition
I - Strict nature reserve/ wilderness area	Protected area managed mainly for science or wilderness protection. These areas possess some outstanding ecosystems, features and/or species of flora and fauna of national scientific importance, or they are representative of particular natural areas. They often contain fragile ecosystems or life forms, areas of important biological or geological diversity, or areas of particular importance to the conservation of genetic resources. Public access is generally not permitted. Natural processes are allowed to take place in the absence of any direct human interference, tourism and recreation. Ecological processes may include natural acts that alter the ecological system or physiographic features, such as naturally occurring fires, natural succession, insect or disease outbreaks, storms, earthquakes and the like, but necessarily excluding man-induced disturbances.
II - National park	Protected area managed mainly for ecosystem protection and recreation. National parks are relatively large areas, which contain representative samples of major natural regions, features or scenery, where plant and animal species, geomorphological sites, and habitats are of special scientific, educational and recreational interest. The area is managed and developed so as to sustain recreation and educational activities on a controlled basis. The area and visitors' use are managed at a level which maintains the area in a natural or semi-natural state.
III – Natural monument	Protected area managed mainly for conservation of specific natural features. This category normally contains one or more natural features of outstanding national interest being protected because of their uniqueness or rarity. Size is not of great importance. The areas should be managed to remain relatively free of human disturbance, although they may have recreational and touristic value.
IV - Habitat/species management area	Protected area managed mainly for conservation through management intervention. The areas covered may consist of nesting areas of colonial bird species, marshes or lakes, estuaries, forest or grassland habitats, or fish spawning or seagrass feeding beds for marine animals. The production of harvestable renewable resources may play a secondary role in the management of the area. The area may require habitat manipulation (mowing, sheep or cattle grazing, etc.).
V – Protected landscape/seascape	Protected areas managed mainly for landscape/seascape conservation and recreation. The diversity of areas falling into this category is very large. They include those whose landscapes possess special aesthetic qualities which are a result of the interaction of man and land or water, traditional practices associated with agriculture, grazing and fishing being dominant; and those that are primarily natural areas, such as coastline, lake or river shores, hilly or mountainous terrains, managed intensively by man for recreation and tourism.
VI – Managed resource protection area	Protected area managed for the sustainable use of natural ecosystems. Normally covers extensive and relatively isolated and uninhabited areas having difficult access, or regions that are relatively sparsely populated but are under considerable pressure for colonization or greater utilization.

Source: McNeely and Miller 1984.

Appendix 2: Target Table for FIM Vegetation Types and Land Systems

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
Ecoregion: Northeastern Island (10,000)								
10,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	17%	34%	101,693	42,563	
10,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	16%	32%	103,252	44,536	
10,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	11%	22%	3,413	2,917	
10,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	16%	32%	66,056	24,307	
10,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	13%	26%	2,661,403	1,141,320	
10,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	278,459	145,285	
10,120	Forest	Small crowned forest with an even canopy	Low Altitude Forest on Uplands - below 1000 m	12%	24%	34,261	6,761	
10,130	Forest	Small crowned forest with Nothofagus	Low Altitude Forest on Uplands - below 1000 m	95%	95%	2,667	-	
10,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	270,581	208,002	
10,160	Forest	Small crowned forest with conifers	Lower Montane Forest - above 1000 m	95%	95%	812	-	
10,170	Forest	Small crowned forest with Nothofagus	Lower Montane Forest - above 1000 m	10%	20%	42,665	22,857	
10,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	76,028	45,627	
10,200	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	60,270	31,564	
10,230	Forest	Mixed forest	Littoral Forest	95%	95%	3,398	1,392	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
10,240	Forest	Forest with Casuarina equisetifolia	Littoral Forest	95%	95%	172	102	
10,260	Forest	Riverine mixed successions	Seral Forest	95%	95%	3,026	3,007	
10,280	Forest	Riverine successions with Eucalyptus deglupta	Seral Forest	15%	30%	30,035	11,267	
10,290	Forest	Riverine mixed successions with Eucalyptus deglupta	Seral Forest	95%	95%	215	10	
10,300	Forest	Riverine mixed successions with Terminalia brassi	Seral Forest	95%	95%	3,470	665	
10,320	Forest	Volcanic successions	Seral Forest	95%	95%	6,988	2,706	
10,330	Forest	Mixed swamp forest	Swamp Forest	13%	26%	38,453	23,015	
10,350	Woodland	Woodland		17%	34%	13,718	6,818	
10,360	Woodland	Riverine successions dominated by woodland		95%	95%	2,290	907	
10,380	Woodland	Swamp woodland		12%	24%	41,067	22,906	
10,400	Woodland	Volcanic successions dominated by woodland		95%	95%	1,769	1,101	
10,440	Scrub	Scrub		11%	22%	19,491	3,558	
10,460	Scrub	Volcanic successions dominated by scrub		12%	24%	17,634	6,069	
10,470	Grassland And Herbland	Grassland		0%	0%	13,462	818	
10,490	Grassland And Herbland	Grassland with some forest		95%	95%	4,216	415	
10,510	Grassland And Herbland	Grassland reverting to forest		95%	95%	147	147	
10,530	Grassland And Herbland	Riverine successions dominated by grass		95%	95%	319	255	
10,550	Grassland And Herbland	Swamp grassland		95%	95%	4,532	2,593	
10,560	Grassland And Herbland	Volcanic successions dominated by grass		95%	95%	1,107	738	
10,570	Grassland And Herbland	Herbaceous swamp		95%	95%	8,302	4,499	
10,580	Estuarine Communities	Mangrove		10%	20%	36,594	18,796	
10,590	Non Veg And Dominated By Land Use	Lakes and large rivers		10%	20%	12,917	12,001	
110,011	Landsystems	Mangroves Flats		10%	20%	-	-	42,604
110,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	403,746
110,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	2,522
110,021	Landsystems	Wetlands with Back swamps		10%	20%	-	-	27,911
110,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	22,249
110,032	Landsystems	Levee plain River Valleys		10%	20%	-	-	32,951
110,041	Landsystems	Undifferentiated Alluvial Plains		10%	20%	-	-	9,247

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
110,042	Landsystems	Composite Alluvial Plains		10%	20%	-	-	180,520
110,044	Landsystems	Terrace Alluvial Plains		10%	20%	-	-	3,138
110,045	Landsystems	Bar Alluvial Plains		10%	20%	-	-	23,529
110,054	Landsystems	Coastal plains with Long-term inundated		10%	20%	-	-	3,552
110,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	375,429
110,073	Landsystems	Other Ridges with Slope 5 - 10		10%	20%	-	-	4,765
110,074	Landsystems	Other Ridges with Slope 10 - 20		10%	20%	-	-	38,227
110,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	11,256
110,081	Landsystems	Limestone Ridges with Slope < 2		10%	20%	-	-	1,421
110,082	Landsystems	Limestone Ridges with Slope 2 - 5		10%	20%	-	-	51,266
110,083	Landsystems	Limestone Ridges with Slope 5 - 10		10%	20%	-	-	139,321
110,084	Landsystems	Limestone Ridges with Slope 10 - 20		10%	20%	-	-	202,206
110,085	Landsystems	Limestone Ridges with Slope > 20		10%	20%	-	-	102,993
110,093	Landsystems	Acid Igneous Ridges with Slope 5 - 10		10%	20%	-	-	503
110,094	Landsystems	Acid Igneous Ridges with Slope 10 - 20		10%	20%	-	-	4,979
110,095	Landsystems	Acid Igneous Ridges with Slope > 20		10%	20%	-	-	3,091
110,111	Landsystems	Volcanic Ridges with Slope < 2		10%	20%	-	-	1,965
110,112	Landsystems	Volcanic Ridges with Slope 2 - 5		10%	20%	-	-	4,438
110,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	51,548
110,114	Landsystems	Volcanic Ridges with Slope 10 - 20		10%	20%	-	-	281,448
110,115	Landsystems	Volcanic Ridges with Slope > 20		10%	20%	-	-	287,207
110,140	Landsystems	Lakes		10%	20%	-	-	11,523
110,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	5,188
110,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	98,244
110,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	152,846
110,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	83,754
110,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	12,580
110,681	Landsystems	Limestone Foothills with Slope < 20		10%	20%	-	-	30,284
110,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	181,528
110,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	238,123
110,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	192,388
110,685	Landsystems	Limestone Foothills with Slope > 20		10%	20%	-	-	36,233

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
110,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	356
110,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	2,430
110,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	8,575
110,695	Landsystems	Acid Igneous Foothills with Slope > 20		10%	20%	-	-	2,147
116,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	58,541
116,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	236,135
116,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	421,482
116,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	515,580
116,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	97,806
Ecoregion: Northern New Guinea (20,000)								
20,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	14%	28%	284,443	142,112	
20,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	12%	24%	629,387	497,775	
20,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	15%	30%	498,459	190,595	
20,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	16%	32%	69,361	19,734	
20,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	13%	26%	1,868,183	1,033,017	
20,060	Forest	Medium crowned forest with Araucaria common	Low Altitude Forest on Uplands - below 1000 m	14%	28%	24,849	11,871	
20,070	Forest	Medium crowned forest with depauperate/damaged forest	Low Altitude Forest on Uplands - below 1000 m	13%	26%	677,771	479,350	
20,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	37,425	27,508	
20,110	Forest	Small crowned forest with Casuarina papuana	Low Altitude Forest on Uplands - below 1000 m	11%	22%	21,039	3,061	
20,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	11%	22%	529,497	483,979	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
20,160	Forest	Small crowned forest with conifers	Lower Montane Forest - above 1000 m	10%	20%	73,912	6,973	
20,170	Forest	Small crowned forest with Nothofagus	Lower Montane Forest - above 1000 m	10%	20%	69,627	34,309	
20,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	23,749	23,749	
20,200	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	95%	95%	6,006	6,006	
20,210	Forest	Very small crowned forest	Montane Forest - above 3000 m	10%	20%	29,680	28,043	
20,230	Forest	Mixed forest	Littoral Forest	95%	95%	4,813	2,996	
20,240	Forest	Forest with Casuarina equisetifolia	Littoral Forest	95%	95%	823	489	
20,260	Forest	Riverine mixed successions	Seral Forest	10%	20%	42,892	41,338	
20,270	Forest	Riverine successions with Casuarina grandis	Seral Forest	95%	95%	2,726	2,652	
20,320	Forest	Volcanic successions	Seral Forest	95%	95%	1,175	1,175	
20,330	Forest	Mixed swamp forest	Swamp Forest	11%	22%	587,172	475,899	
20,360	Woodland	Riverine successions dominated by woodland		11%	22%	17,556	15,138	
20,370	Woodland	Riverine successions with Casuarina grandis woodland		20%	40%	665	-	
20,380	Woodland	Swamp woodland		11%	22%	847,359	591,539	
20,440	Scrub	Scrub		95%	95%	5,417	-	
20,460	Scrub	Volcanic successions dominated by scrub		95%	95%	467	-	
20,470	Grassland And Herbland	Grassland		0%	0%	194,021	46,778	
20,480	Grassland And Herbland	Alpine grassland		10%	20%	14,960	14,960	
20,490	Grassland And Herbland	Grassland with some forest		85%	95%	430,613	49,576	
20,500	Grassland And Herbland	Subalpine grassland		95%	95%	7,913	4,319	
20,510	Grassland And Herbland	Grassland reverting to forest		18%	36%	29,917	12,392	
20,530	Grassland And Herbland	Riverine successions dominated by grass		11%	22%	118,540	106,059	
20,550	Grassland And Herbland	Swamp grassland		10%	20%	320,480	277,197	
20,560	Grassland And Herbland	Volcanic successions dominated by grass		95%	95%	868	868	
20,570	Grassland And Herbland	Herbaceous swamp		10%	20%	78,825	59,814	
20,580	Estuarine Communities	Mangrove		10%	20%	33,996	32,533	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
20,590	Non Veg And Dominated By Land Use	Lakes and large rivers		11%	22%	16,119	14,207	
120,011	Landsystems	Mangroves Flats		10%	20%	-	-	46,881
120,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	107,585
120,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	37,282
120,014	Landsystems	Coastal Estuarine Flats		10%	20%	-	-	52,121
120,021	Landsystems	Wetlands with Back swamps		10%	20%	-	-	1,769,939
120,023	Landsystems	Wetlands with Swampy depressions		10%	20%	-	-	8,520
120,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	8,010
120,031	Landsystems	Braided or bar plain River Valleys		10%	20%	-	-	43,523
120,032	Landsystems	Levee plain River Valleys		10%	20%	-	-	80,359
120,033	Landsystems	Meander floodplain River Valleys		10%	20%	-	-	553,628
120,041	Landsystems	Undifferentiated Alluvial Plains		10%	20%	-	-	2,433
120,042	Landsystems	Composite Alluvial Plains		10%	20%	-	-	955,737
120,043	Landsystems	Alluvial Back Plains		10%	20%	-	-	63,368
120,044	Landsystems	Terrace Alluvial Plains		10%	20%	-	-	188,772
120,045	Landsystems	Bar Alluvial Plains		10%	20%	-	-	50,337
120,052	Landsystems	Permanently inundated Coastal Plains		10%	20%	-	-	5,500
120,054	Landsystems	Coastal plains with Long-term inundated		10%	20%	-	-	180,964
120,055	Landsystems	Coastal plains with Periodic brief flooding		10%	20%	-	-	24,865
120,056	Landsystems	Waterlogged Coastal plains		10%	20%	-	-	304,428
120,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	1,715,636
120,071	Landsystems	Other Ridges with Slope < 2		10%	20%	-	-	199
120,072	Landsystems	Other Ridges with Slope 2 - 5		10%	20%	-	-	3,088
120,073	Landsystems	Other Ridges with Slope 5 - 10		10%	20%	-	-	25,938
120,074	Landsystems	Other Ridges with Slope 10 - 20		10%	20%	-	-	253,843
120,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	373,598
120,082	Landsystems	Limestone Ridges with Slope 2 - 5		10%	20%	-	-	3,267
120,083	Landsystems	Limestone Ridges with Slope 5 - 10		10%	20%	-	-	49,272
120,084	Landsystems	Limestone Ridges with Slope 10 - 20		10%	20%	-	-	148,145
120,085	Landsystems	Limestone Ridges with Slope > 20		10%	20%	-	-	336,786
120,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	3,911

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
120,114	Landsystems	Volcanic Ridges with Slope 10 - 20		10%	20%	-	-	106,200
120,115	Landsystems	Volcanic Ridges with Slope > 20		10%	20%	-	-	277,016
120,123	Landsystems	Alpine Peaks with Slope 5 - 10		10%	20%	-	-	4,728
120,124	Landsystems	Alpine Peaks with Slope 10 - 20		10%	20%	-	-	28,323
120,125	Landsystems	Alpine Peaks with Slope > 20		10%	20%	-	-	98,133
120,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	17,783
120,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	235,523
120,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	418,217
120,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	321,167
120,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	25,804
120,681	Landsystems	Limestone Foothills with Slope < 20		10%	20%	-	-	2,525
120,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	28,254
120,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	116,770
120,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	138,654
120,685	Landsystems	Limestone Foothills with Slope > 20		10%	20%	-	-	34,686
120,691	Landsystems	Acid Igneous Foothills with Slope < 2		10%	20%	-	-	1,211
120,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	2,646
120,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	2,400
120,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	3,346
120,695	Landsystems	Acid Igneous Foothills with Slope > 20		10%	20%	-	-	2,175
126,102	Landsystems	Ultrabasic Foothills with Slope 2 - 5		10%	20%	-	-	86
126,103	Landsystems	Ultrabasic Foothills with Slope 5 - 10		10%	20%	-	-	7
126,104	Landsystems	Ultrabasic Foothills with Slope 10 - 20		10%	20%	-	-	3,419
126,105	Landsystems	Ultrabasic Foothills with Slope > 20		10%	20%	-	-	545
126,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	84,343
126,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	15,075
126,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	30,154
126,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	58,654
126,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	26,277
Ecoregion: Central Range (30,000)								

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
30,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	95%	95%	8,782	4,659	
30,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	13%	26%	80,042	34,355	
30,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	14%	28%	80,653	28,895	
30,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	47,702	40,067	
30,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	3,457,618	2,343,765	
30,060	Forest	Medium crowned forest with Araucaria common	Low Altitude Forest on Uplands - below 1000 m	11%	22%	89,694	62,637	
30,070	Forest	Medium crowned forest with depauperate/damaged forest	Low Altitude Forest on Uplands - below 1000 m	95%	95%	6,207	5,398	
30,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	423,200	198,982	
30,110	Forest	Small crowned forest with Casuarina papuana	Low Altitude Forest on Uplands - below 1000 m	10%	20%	13,743	13,728	
30,130	Forest	Small crowned forest with Nothofagus	Low Altitude Forest on Uplands - below 1000 m	10%	20%	38,902	36,572	
30,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	11%	22%	2,120,423	1,931,781	
30,160	Forest	Small crowned forest with conifers	Lower Montane Forest - above 1000 m	10%	20%	189,911	147,916	
30,170	Forest	Small crowned forest with Nothofagus	Lower Montane Forest - above 1000 m	10%	20%	1,452,466	1,302,244	
30,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	252,359	234,345	
30,190	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	17,664	17,499	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
30,200	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	11%	22%	180,582	133,519	
30,210	Forest	Very small crowned forest	Montane Forest - above 3000 m	10%	20%	90,746	89,628	
30,220	Forest	Dry evergreen forest	Dry Seasonal Forest	95%	95%	57	45	
30,230	Forest	Mixed forest	Littoral Forest	95%	95%	5	-	
30,260	Forest	Riverine mixed successions	Seral Forest	95%	95%	154	128	
30,270	Forest	Riverine successions with Casuarina grandis	Seral Forest	95%	95%	4	4	
30,330	Forest	Mixed swamp forest	Swamp Forest	12%	24%	63,294	24,350	
30,370	Woodland	Riverine successions with Casuarina grandis woodland		95%	95%	71	-	
30,380	Woodland	Swamp woodland		12%	24%	28,533	11,790	
30,440	Scrub	Scrub		11%	22%	30,640	8,791	
30,470	Grassland And Herbland	Grassland		0%	0%	128,188	57,215	
30,480	Grassland And Herbland	Alpine grassland		10%	20%	59,847	47,837	
30,490	Grassland And Herbland	Grassland with some forest		80%	95%	86,959	10,862	
30,500	Grassland And Herbland	Subalpine grassland		10%	20%	62,723	58,561	
30,510	Grassland And Herbland	Grassland reverting to forest		95%	95%	20	20	
30,530	Grassland And Herbland	Riverine successions dominated by grass		95%	95%	2,094	1,831	
30,550	Grassland And Herbland	Swamp grassland		10%	20%	39,721	34,628	
30,570	Grassland And Herbland	Herbaceous swamp		95%	95%	933	397	
30,580	Estuarine Communities	Mangrove		95%	95%	140	57	
30,590	Non Veg And Dominated By Land Use	Lakes and large rivers		13%	26%	12,295	7,382	
130,071	Landsystems	Other Ridges with Slope < 2		10%	20%	-	-	61,799
130,072	Landsystems	Other Ridges with Slope 2 - 5		10%	20%	-	-	109,790
130,073	Landsystems	Other Ridges with Slope 5 - 10		10%	20%	-	-	308,312
130,074	Landsystems	Other Ridges with Slope 10 - 20		10%	20%	-	-	1,402,906
130,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	2,333,369
130,081	Landsystems	Limestone Ridges with Slope < 2		10%	20%	-	-	3,737
130,082	Landsystems	Limestone Ridges with Slope 2 - 5		10%	20%	-	-	131,726
130,083	Landsystems	Limestone Ridges with Slope 5 - 10		10%	20%	-	-	278,327
130,084	Landsystems	Limestone Ridges with Slope 10 - 20		10%	20%	-	-	915,933

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
130,085	Landsystems	Limestone Ridges with Slope > 20		10%	20%	-	-	700,261
130,091	Landsystems	Acid Igneous Ridges with Slope < 2		10%	20%	-	-	118
130,092	Landsystems	Acid Igneous Ridges with Slope 2 - 5		10%	20%	-	-	1,746
130,093	Landsystems	Acid Igneous Ridges with Slope 5 - 10		10%	20%	-	-	5,711
130,094	Landsystems	Acid Igneous Ridges with Slope 10 - 20		10%	20%	-	-	46,282
130,095	Landsystems	Acid Igneous Ridges with Slope > 20		10%	20%	-	-	194,927
130,103	Landsystems	Ultrabasic Ridges with Slope 5 - 10		10%	20%	-	-	1,196
130,104	Landsystems	Ultrabasic Ridges with Slope 10 - 20		10%	20%	-	-	14,276
130,105	Landsystems	Ultrabasic Ridges with Slope > 20		10%	20%	-	-	65,261
130,111	Landsystems	Volcanic Ridges with Slope < 2		10%	20%	-	-	22,869
130,112	Landsystems	Volcanic Ridges with Slope 2 - 5		10%	20%	-	-	152,518
130,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	362,304
130,114	Landsystems	Volcanic Ridges with Slope 10 - 20		10%	20%	-	-	545,655
130,115	Landsystems	Volcanic Ridges with Slope > 20		10%	20%	-	-	514,661
130,121	Landsystems	Alpine Peaks with Slope < 2		10%	20%	-	-	381
130,122	Landsystems	Alpine Peaks with Slope 2 - 5		10%	20%	-	-	8,969
130,123	Landsystems	Alpine Peaks with Slope 5 - 10		10%	20%	-	-	91,478
130,124	Landsystems	Alpine Peaks with Slope 10 - 20		10%	20%	-	-	362,332
130,125	Landsystems	Alpine Peaks with Slope > 20		10%	20%	-	-	298,740
130,131	Landsystems	Montane Wetlands		10%	20%	-	-	16,227
130,132	Landsystems	Alpine Wetlands		10%	20%	-	-	1,305
130,140	Landsystems	Lakes		10%	20%	-	-	27,024
130,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	63,538
130,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	226,957
130,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	493,144
130,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	749,510
130,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	272,960
130,681	Landsystems	Limestone Foothills with Slope < 20		10%	20%	-	-	215,685
130,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	292,348
130,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	144,058
130,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	81,371
130,685	Landsystems	Limestone Foothills with Slope > 20		10%	20%	-	-	24,617

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
130,691	Landsystems	Acid Igneous Foothills with Slope < 2		10%	20%	-	-	573
130,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	1,147
130,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	7,884
130,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	23,178
130,695	Landsystems	Acid Igneous Foothills with Slope > 20		10%	20%	-	-	10,441
136,101	Landsystems	Ultrabasic Foothills with Slope < 2		10%	20%	-	-	729
136,102	Landsystems	Ultrabasic Foothills with Slope 2 - 5		10%	20%	-	-	464
136,103	Landsystems	Ultrabasic Foothills with Slope 5 - 10		10%	20%	-	-	9,157
136,104	Landsystems	Ultrabasic Foothills with Slope 10 - 20		10%	20%	-	-	44,357
136,105	Landsystems	Ultrabasic Foothills with Slope > 20		10%	20%	-	-	16,739
136,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	7,070
136,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	4,651
136,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	21,476
136,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	91,912
136,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	37,188
Ecoregion: Southeast Peninsula (40,000)								
40,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	15%	30%	271,339	141,444	
40,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	13%	26%	110,393	72,319	
40,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	17%	34%	118,952	41,632	
40,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	72,741	64,196	
40,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	1,529,644	1,040,020	
40,070	Forest	Medium crowned forest with depauperate/damaged forest	Low Altitude Forest on Uplands - below 1000 m	12%	24%	22,369	15,472	
40,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	898,992	642,370	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
40,100	Forest	Small crowned forest with Castanopsis	Low Altitude Forest on Uplands - below 1000 m	95%	95%	1,743	1,743	
40,110	Forest	Small crowned forest with Casuarina papuana	Low Altitude Forest on Uplands - below 1000 m	95%	95%	4,041	834	
40,140	Forest	Small crowned forest with Rhus taitensis	Low Altitude Forest on Uplands - below 1000 m	95%	95%	203	131	
40,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	890,752	793,867	
40,160	Forest	Small crowned forest with conifers	Lower Montane Forest - above 1000 m	10%	20%	133,014	29,036	
40,170	Forest	Small crowned forest with Nothofagus	Lower Montane Forest - above 1000 m	10%	20%	649,592	607,165	
40,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	182,339	181,409	
40,190	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	95%	95%	583	-	
40,200	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	16,755	15,399	
40,210	Forest	Very small crowned forest	Montane Forest - above 3000 m	10%	20%	55,216	54,759	
40,230	Forest	Mixed forest	Littoral Forest	95%	95%	5,692	2,636	
40,250	Forest	Forest with Melaleuca leucadendron	Littoral Forest	95%	95%	8,930	955	
40,260	Forest	Riverine mixed successions	Seral Forest	95%	95%	7,503	5,989	
40,270	Forest	Riverine successions with Casuarina grandis	Seral Forest	11%	22%	14,498	12,472	
40,320	Forest	Volcanic successions	Seral Forest	95%	95%	3,590	3,590	
40,330	Forest	Mixed swamp forest	Swamp Forest	13%	26%	19,377	6,743	
40,350	Woodland	Woodland		11%	22%	40,577	24,541	
40,360	Woodland	Riverine successions dominated by woodland		95%	95%	3,720	788	
40,370	Woodland	Riverine successions with Casuarina grandis woodland		95%	95%	8,160	4,941	
40,380	Woodland	Swamp woodland		11%	22%	215,702	126,152	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
40,390	Woodland	Swamp woodland with Melaleuca leucadendron		95%	95%	2,289	1,242	
40,400	Woodland	Volcanic successions dominated by woodland		95%	95%	1,381	-	
40,410	Savanna	Savanna		11%	22%	152,322	104,385	
40,420	Savanna	Savanna with galley forest		11%	22%	54,775	46,675	
40,440	Scrub	Scrub		11%	22%	38,183	16,040	
40,460	Scrub	Volcanic successions dominated by scrub		95%	95%	1,239	687	
40,470	Grassland And Herbland	Grassland		0%	0%	153,522	32,673	
40,480	Grassland And Herbland	Alpine grassland		10%	20%	31,680	29,863	
40,490	Grassland And Herbland	Grassland with some forest		88%	95%	99,476	11,036	
40,500	Grassland And Herbland	Subalpine grassland		10%	20%	37,441	33,892	
40,510	Grassland And Herbland	Grassland reverting to forest		95%	95%	96	96	
40,520	Grassland And Herbland	Grassland reverting to forest with some forest		95%	95%	2,129	-	
40,530	Grassland And Herbland	Riverine successions dominated by grass		95%	95%	9,990	5,438	
40,550	Grassland And Herbland	Swamp grassland		11%	22%	13,559	8,604	
40,570	Grassland And Herbland	Herbaceous swamp		12%	24%	63,797	41,903	
40,580	Estuarine Communities	Mangrove		10%	20%	88,516	63,080	
40,590	Non Veg And Dominated By Land Use	Lakes and large rivers		11%	22%	8,613	7,195	
140,011	Landsystems	Mangroves Flats		10%	20%	-	-	171,692
140,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	10,023
140,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	49,576
140,021	Landsystems	Wetlands with Back swamps		10%	20%	-	-	176,789
140,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	73,822
140,031	Landsystems	Braided or bar plain River Valleys		10%	20%	-	-	12,267
140,032	Landsystems	Levee plain River Valleys		10%	20%	-	-	86,412
140,033	Landsystems	Meander floodplain River Valleys		10%	20%	-	-	54,564
140,041	Landsystems	Undifferentiated Alluvial Plains		10%	20%	-	-	6,743
140,042	Landsystems	Composite Alluvial Plains		10%	20%	-	-	355,406
140,043	Landsystems	Alluvial Back Plains		10%	20%	-	-	52,271
140,044	Landsystems	Terrace Alluvial Plains		10%	20%	-	-	1,794
140,054	Landsystems	Coastal plains with Long-term inundated		10%	20%	-	-	18,161

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
140,055	Landsystems	Coastal plains with Periodic brief flooding		10%	20%	-	-	34,268
140,056	Landsystems	Waterlogged Coastal plains		10%	20%	-	-	21,314
140,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	499,663
140,071	Landsystems	Other Ridges with Slope < 2		10%	20%	-	-	1,300
140,072	Landsystems	Other Ridges with Slope 2 - 5		10%	20%	-	-	11,257
140,073	Landsystems	Other Ridges with Slope 5 - 10		10%	20%	-	-	67,255
140,074	Landsystems	Other Ridges with Slope 10 - 20		10%	20%	-	-	439,730
140,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	1,461,546
140,084	Landsystems	Limestone Ridges with Slope 10 - 20		10%	20%	-	-	11,835
140,085	Landsystems	Limestone Ridges with Slope > 20		10%	20%	-	-	10,769
140,093	Landsystems	Acid Igneous Ridges with Slope 5 - 10		10%	20%	-	-	5,850
140,094	Landsystems	Acid Igneous Ridges with Slope 10 - 20		10%	20%	-	-	57,911
140,095	Landsystems	Acid Igneous Ridges with Slope > 20		10%	20%	-	-	76,645
140,102	Landsystems	Ultrabasic Ridges with Slope 2 - 5		10%	20%	-	-	4
140,103	Landsystems	Ultrabasic Ridges with Slope 5 - 10		10%	20%	-	-	10,720
140,104	Landsystems	Ultrabasic Ridges with Slope 10 - 20		10%	20%	-	-	77,316
140,105	Landsystems	Ultrabasic Ridges with Slope > 20		10%	20%	-	-	167,260
140,111	Landsystems	Volcanic Ridges with Slope < 2		10%	20%	-	-	541
140,112	Landsystems	Volcanic Ridges with Slope 2 - 5		10%	20%	-	-	24,453
140,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	67,822
140,114	Landsystems	Volcanic Ridges with Slope 10 - 20		10%	20%	-	-	383,505
140,115	Landsystems	Volcanic Ridges with Slope > 20		10%	20%	-	-	475,550
140,121	Landsystems	Alpine Peaks with Slope < 2		10%	20%	-	-	109
140,123	Landsystems	Alpine Peaks with Slope 5 - 10		10%	20%	-	-	8,543
140,124	Landsystems	Alpine Peaks with Slope 10 - 20		10%	20%	-	-	75,236
140,125	Landsystems	Alpine Peaks with Slope > 20		10%	20%	-	-	127,275
140,132	Landsystems	Alpine Wetlands		10%	20%	-	-	277
140,140	Landsystems	Lakes		10%	20%	-	-	4,234
140,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	5,126
140,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	42,539
140,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	209,180

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
140,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	358,049
140,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	118,921
140,681	Landsystems	Limestone Foothills with Slope < 20		10%	20%	-	-	7,604
140,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	26,995
140,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	39,592
140,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	52,525
140,685	Landsystems	Limestone Foothills with Slope > 20		10%	20%	-	-	7,028
140,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	13
140,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	1,644
140,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	10,323
140,695	Landsystems	Acid Igneous Foothills with Slope > 20		10%	20%	-	-	4,098
146,101	Landsystems	Ultrabasic Foothills with Slope < 2		10%	20%	-	-	18
146,102	Landsystems	Ultrabasic Foothills with Slope 2 - 5		10%	20%	-	-	731
146,103	Landsystems	Ultrabasic Foothills with Slope 5 - 10		10%	20%	-	-	4,754
146,104	Landsystems	Ultrabasic Foothills with Slope 10 - 20		10%	20%	-	-	14,465
146,105	Landsystems	Ultrabasic Foothills with Slope > 20		10%	20%	-	-	12,558
146,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	176,208
146,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	199,263
146,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	290,331
146,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	517,674
146,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	165,657
Ecoregion: Southeastern Islands (50,000)								
50,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	11%	22%	665	619	
50,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	95%	95%	307	109	
50,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	10%	20%	92,480	90,314	
50,230	Forest	Mixed forest	Littoral Forest	95%	95%	484	484	
50,350	Woodland	Woodland		10%	20%	1,792	1,792	
50,410	Savanna	Savanna		95%	95%	258	-	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
50,440	Scrub	Scrub		95%	95%	173	173	
50,470	Grassland And Herbland	Grassland		0%	0%	10,294	890	
50,490	Grassland And Herbland	Grassland with some forest		24%	48%	1,008	425	
50,580	Estuarine Communities	Mangrove		10%	20%	8,044	7,793	
50,590	Non Veg And Dominated By Land Use	Lakes and large rivers		95%	95%	107	107	
150,011	Landsystems	Mangroves Flats		10%	20%	-	-	9,017
150,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	7,738
150,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	46,011
150,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	1,200
150,112	Landsystems	Volcanic Ridges with Slope 2 - 5		10%	20%	-	-	397
150,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	381
150,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	859
150,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	18,384
150,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	29,007
150,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	23,776
150,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	8,636
150,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	42
150,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	608
150,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	1,385
156,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	1,409
156,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	4,863
156,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	16,062
156,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	11,354
156,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	266
Ecoregion: Southern New Guinea (60,000)								
60,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	14%	28%	61,213	28,789	
60,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	13%	26%	394,580	202,315	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
60,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	11%	22%	70,540	61,532	
60,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	13%	26%	43,700	24,221	
60,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	15%	30%	2,457,808	928,573	
60,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	857,436	494,584	
60,110	Forest	Small crowned forest with Casuarina papuana	Low Altitude Forest on Uplands - below 1000 m	95%	95%	1,470	673	
60,130	Forest	Small crowned forest with Nothofagus	Low Altitude Forest on Uplands - below 1000 m	95%	95%	1,546	1,537	
60,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	95%	95%	809	-	
60,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	95%	95%	435	217	
60,220	Forest	Dry evergreen forest	Dry Seasonal Forest	11%	22%	1,051,475	788,043	
60,230	Forest	Mixed forest	Littoral Forest	38%	76%	2,611	33	
60,250	Forest	Forest with Melaleuca leucadendron	Littoral Forest	10%	20%	36,806	34,155	
60,260	Forest	Riverine mixed successions	Seral Forest	10%	20%	22,293	18,540	
60,310	Forest	Swamp forest with Melaleuca leucadendron	Seral Forest	10%	20%	219,652	166,700	
60,330	Forest	Mixed swamp forest	Swamp Forest	11%	22%	1,263,016	678,800	
60,350	Woodland	Woodland		11%	22%	584,717	321,345	
60,360	Woodland	Riverine successions dominated by woodland		10%	20%	10,079	3,341	
60,380	Woodland	Swamp woodland		10%	20%	503,139	321,188	
60,390	Woodland	Swamp woodland with Melaleuca leucadendron		10%	20%	231,723	130,002	
60,410	Savanna	Savanna		11%	22%	647,500	379,086	
60,420	Savanna	Savanna with galley forest		103%	95%	31,039	3,025	
60,430	Savanna	Savanna with Melaleuca leucadendron		10%	20%	269,690	137,845	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
60,440	Scrub	Scrub		10%	20%	440,055	276,215	
60,470	Grassland And Herbland	Grassland		0%	0%	56,815	16,674	
60,490	Grassland And Herbland	Grassland with some forest		86%	95%	41,680	4,846	
60,510	Grassland And Herbland	Grassland reverting to forest		10%	20%	8,942	8,654	
60,530	Grassland And Herbland	Riverine successions dominated by grass		95%	95%	7,398	4,744	
60,540	Grassland And Herbland	Swamp grassland		10%	20%	28,807	28,807	
60,550	Grassland And Herbland	Swamp grassland		10%	20%	409,900	323,429	
60,570	Grassland And Herbland	Herbaceous swamp		10%	20%	262,493	146,052	
60,580	Estuarine Communities	Mangrove		10%	20%	382,577	336,189	
60,590	Non Veg And Dominated By Land Use	Lakes and large rivers		10%	20%	207,798	190,057	
160,011	Landsystems	Mangroves Flats		10%	20%	-	-	422,018
160,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	83,920
160,014	Landsystems	Coastal Estuarine Flats		10%	20%	-	-	116,436
160,021	Landsystems	Wetlands with Back swamps		10%	20%	-	-	706,462
160,022	Landsystems	Flooded valley wetlands		10%	20%	-	-	705,035
160,023	Landsystems	Wetlands with Swampy depressions		10%	20%	-	-	2,507,386
160,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	42,689
160,032	Landsystems	Levee plain River Valleys		10%	20%	-	-	1,083,421
160,033	Landsystems	Meander floodplain River Valleys		10%	20%	-	-	497,981
160,042	Landsystems	Composite Alluvial Plains		10%	20%	-	-	201,621
160,043	Landsystems	Alluvial Back Plains		10%	20%	-	-	68,632
160,044	Landsystems	Terrace Alluvial Plains		10%	20%	-	-	1,121
160,051	Landsystems	Near-permanently Inundated Coastal Plains		10%	20%	-	-	1,895
160,052	Landsystems	Permanently inundated Coastal Plains		10%	20%	-	-	3,482,228
160,053	Landsystems	Seasonaly inundated Coastal Plains		10%	20%	-	-	14,425
160,054	Landsystems	Coastal plains with Long-term inundated		10%	20%	-	-	4,215
160,055	Landsystems	Coastal plains with Periodic brief flooding		10%	20%	-	-	96,553
160,056	Landsystems	Waterlogged Coastal plains		10%	20%	-	-	1,503
160,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	354,364
160,140	Landsystems	Lakes		10%	20%	-	-	78,012

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
160,691	Landsystems	Acid Igneous Foothills with Slope < 2		10%	20%	-	-	918
166,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	184,296
166,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	221,560
166,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	149,731
166,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	27,352
166,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	200
Ecoregion: Admiralty Islands (70,000)								
70,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	10%	20%	1,290	1,290	
70,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	22%	44%	78,303	17,923	
70,080	Forest	Medium crowned forest with an even canopy	Low Altitude Forest on Uplands - below 1000 m	14%	28%	46,366	31,769	
70,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	37%	74%	739	198	
70,230	Forest	Mixed forest	Littoral Forest	10%	20%	1,502	1,502	
70,350	Woodland	Woodland		11%	22%	6,644	5,795	
70,380	Woodland	Swamp woodland		12%	24%	16,321	12,548	
70,440	Scrub	Scrub		11%	22%	3,105	66	
70,470	Grassland And Herbland	Grassland		0%	0%	131	-	
70,570	Grassland And Herbland	Herbaceous swamp		11%	22%	1,514	585	
70,580	Estuarine Communities	Mangrove		12%	24%	7,160	4,377	
70,590	Non Veg And Dominated By Land Use	Lakes and large rivers		95%	95%	241	218	
170,011	Landsystems	Mangroves Flats		10%	20%	-	-	11,642
170,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	16,911
170,014	Landsystems	Coastal Estuarine Flats		10%	20%	-	-	4,951
170,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	8,402
170,042	Landsystems	Composite Alluvial Plains		10%	20%	-	-	4,550
170,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	42,341
170,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	255
170,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	3,426

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
170,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	2,369
170,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	5,518
170,691	Landsystems	Acid Igneous Foothills with Slope < 2		10%	20%	-	-	47
170,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	2,025
170,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	4,505
170,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	5,826
176,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	6,883
176,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	44,219
176,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	40,613
176,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	4,022
Ecoregion: Trobiand Islands (80,000)								
80,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	95%	95%	109	95	
80,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	11%	22%	2,105	1,874	
80,030	Forest	Small crowned forest	Low Altitude forest on Plains and Fans - below 1000m	13%	26%	44,655	28,083	
80,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	17,755	1,620	
80,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	11%	22%	126,068	106,314	
80,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	19,127	17,670	
80,230	Forest	Mixed forest	Littoral Forest	11%	22%	2,734	2,592	
80,330	Forest	Mixed swamp forest	Swamp Forest	95%	95%	601	-	
80,350	Woodland	Woodland		95%	95%	193	166	
80,380	Woodland	Swamp woodland		12%	24%	4,285	2,980	
80,440	Scrub	Scrub		12%	24%	2,860	2,042	
80,470	Grassland And Herbland	Grassland		0%	0%	11,226	1,651	
80,490	Grassland And Herbland	Grassland with some forest		73%	95%	8,389	1,144	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
80,570	Grassland And Herbland	Herbaceous swamp		11%	22%	3,277	2,708	
80,580	Estuarine Communities	Mangrove		10%	20%	11,771	7,894	
80,590	Non Veg And Dominated By Land Use	Lakes and large rivers		95%	95%	556	264	
180,011	Landsystems	Mangroves Flats		10%	20%	-	-	16,162
180,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	117,527
180,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	1,461
180,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	3,448
180,032	Landsystems	Levee plain River Valleys		10%	20%	-	-	18,751
180,041	Landsystems	Undifferentiated Alluvial Plains		10%	20%	-	-	933
180,055	Landsystems	Coastal plains with Periodic brief flooding		10%	20%	-	-	875
180,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	22,625
180,072	Landsystems	Other Ridges with Slope 2 - 5		10%	20%	-	-	10
180,073	Landsystems	Other Ridges with Slope 5 - 10		10%	20%	-	-	254
180,074	Landsystems	Other Ridges with Slope 10 - 20		10%	20%	-	-	3,591
180,075	Landsystems	Other Ridges with Slope > 20		10%	20%	-	-	63,234
180,105	Landsystems	Ultrabasic Ridges with Slope > 20		10%	20%	-	-	1,140
180,671	Landsystems	Other Foothills with Slope < 2		10%	20%	-	-	358
180,672	Landsystems	Other Foothills with Slope 2 - 5		10%	20%	-	-	2,963
180,673	Landsystems	Other Foothills with Slope 5 - 10		10%	20%	-	-	8,350
180,674	Landsystems	Other Foothills with Slope 10 - 20		10%	20%	-	-	34,608
180,675	Landsystems	Other Foothills with Slope > 20		10%	20%	-	-	42,164
180,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	179
180,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	556
180,691	Landsystems	Acid Igneous Foothills with Slope < 2		10%	20%	-	-	88
180,692	Landsystems	Acid Igneous Foothills with Slope 2 - 5		10%	20%	-	-	46
180,693	Landsystems	Acid Igneous Foothills with Slope 5 - 10		10%	20%	-	-	1,269
180,694	Landsystems	Acid Igneous Foothills with Slope 10 - 20		10%	20%	-	-	10,977
180,695	Landsystems	Acid Igneous Foothills with Slope > 20		10%	20%	-	-	3,800
186,101	Landsystems	Ultrabasic Foothills with Slope < 2		10%	20%	-	-	11

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
186,102	Landsystems	Ultrabasic Foothills with Slope 2 - 5		10%	20%	-	-	513
186,103	Landsystems	Ultrabasic Foothills with Slope 5 - 10		10%	20%	-	-	1,995
186,104	Landsystems	Ultrabasic Foothills with Slope 10 - 20		10%	20%	-	-	4,920
186,105	Landsystems	Ultrabasic Foothills with Slope > 20		10%	20%	-	-	1,861
186,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	6,199
186,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	10,069
186,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	24,417
186,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	25,786
186,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	1,549
Ecoregion: Bougainville (90,000)								
90,010	Forest	Large to medium crowned forest	Low Altitude forest on Plains and Fans - below 1000m	95%	95%	1,853	1,363	
90,020	Forest	Open forest	Low Altitude forest on Plains and Fans - below 1000m	17%	34%	170,244	98,302	
90,040	Forest	Large crowned forest	Low Altitude Forest on Uplands - below 1000 m	16%	32%	6,620	4,113	
90,050	Forest	Medium crowned forest	Low Altitude Forest on Uplands - below 1000 m	18%	36%	336,254	185,997	
90,090	Forest	Small crowned forest	Low Altitude Forest on Uplands - below 1000 m	13%	26%	38,222	9,424	
90,150	Forest	Small crowned forest	Lower Montane Forest - above 1000 m	17%	34%	139,399	74,725	
90,180	Forest	Very small crowned forest	Lower Montane Forest - above 1000 m	10%	20%	13,105	13,105	
90,230	Forest	Mixed forest	Littoral Forest	12%	24%	3,912	3,401	
90,240	Forest	Forest with Casuarina equisetifolia	Littoral Forest	14%	28%	4,238	2,736	
90,260	Forest	Riverine mixed successions	Seral Forest	95%	95%	1,926	971	
90,300	Forest	Riverine mixed successions with Terminalia brassi	Seral Forest	12%	24%	2,746	2,278	
90,320	Forest	Volcanic successions	Seral Forest	10%	20%	13,435	12,899	
90,330	Forest	Mixed swamp forest	Swamp Forest	11%	22%	10,305	5,414	
90,340	Forest	Swamp forest with Terminalia brassi	Swamp Forest	13%	26%	42,166	28,855	

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
90,350	Woodland	Woodland		95%	95%	579	571	
90,360	Woodland	Riverine successions dominated by woodland		95%	95%	741	-	
90,380	Woodland	Swamp woodland		11%	22%	29,534	18,491	
90,440	Scrub	Scrub		95%	95%	1,965	1,965	
90,450	Scrub	Scrub with Bambusa and Cyathea		13%	26%	20,607	11,484	
90,460	Scrub	Volcanic successions dominated by scrub		10%	20%	11,088	2,864	
90,470	Grassland And Herbland	Grassland		0%	0%	3,751	7	
90,530	Grassland And Herbland	Riverine successions dominated by grass		95%	95%	1,301	662	
90,550	Grassland And Herbland	Swamp grassland		95%	95%	9,167	5,639	
90,560	Grassland And Herbland	Volcanic successions dominated by grass		95%	95%	4,159	2,564	
90,580	Estuarine Communities	Mangrove		95%	95%	4,989	3,804	
190,011	Landsystems	Mangroves Flats		10%	20%	-	-	6,072
190,012	Landsystems	Coastal Beach Sand Flats		10%	20%	-	-	74,072
190,013	Landsystems	Coastal Coral Flats		10%	20%	-	-	20,082
190,024	Landsystems	Undifferentiated Wetlands		10%	20%	-	-	68,485
190,057	Landsystems	Coastal plains with No flooding or inundation		10%	20%	-	-	321
190,083	Landsystems	Limestone Ridges with Slope 5 - 10		10%	20%	-	-	3,479
190,084	Landsystems	Limestone Ridges with Slope 10 - 20		10%	20%	-	-	5,800
190,085	Landsystems	Limestone Ridges with Slope > 20		10%	20%	-	-	2,986
190,112	Landsystems	Volcanic Ridges with Slope 2 - 5		10%	20%	-	-	189
190,113	Landsystems	Volcanic Ridges with Slope 5 - 10		10%	20%	-	-	15,910
190,114	Landsystems	Volcanic Ridges with Slope 10 - 20		10%	20%	-	-	87,766
190,115	Landsystems	Volcanic Ridges with Slope > 20		10%	20%	-	-	105,895
190,681	Landsystems	Limestone Foothills with Slope < 20		10%	20%	-	-	155
190,682	Landsystems	Limestone Foothills with Slope 2 - 5		10%	20%	-	-	129
190,683	Landsystems	Limestone Foothills with Slope 5 - 10		10%	20%	-	-	4,792
190,684	Landsystems	Limestone Foothills with Slope 10 - 20		10%	20%	-	-	6,060
190,685	Landsystems	Limestone Foothills with Slope > 20		10%	20%	-	-	4,375
196,111	Landsystems	Volcanic Foothills with Slope < 2		10%	20%	-	-	156,543
196,112	Landsystems	Volcanic Foothills with Slope 2 - 5		10%	20%	-	-	105,242
196,113	Landsystems	Volcanic Foothills with Slope 5 - 10		10%	20%	-	-	120,586

SP_ID	Grouping	Name / Description	FIM Structure Class	10% Target	20% Target	Hectares		
						Veg 1975	Veg 2009	Land Systems
196,114	Landsystems	Volcanic Foothills with Slope 10 - 20		10%	20%	-	-	129,471
196,115	Landsystems	Volcanic Foothills with Slope > 20		10%	20%	-	-	20,727

Appendix 3: Target Table for Restricted Range Endemic Fauna

Fauna - sources: (1) RRE reptiles and amphibians and mammals (Allen Allison - Bishop Museum)

SP_ID	Fauna	Scientific Name	Count	Hectares
		Herps		
1,100	Herps	Albericus exclamitans	1	17,471
1,110	Herps	Albericus fafniri	2	19,361
1,120	Herps	Albericus gudrunae	3	17,549
1,130	Herps	Albericus rhenaurum	4	17,539
1,140	Herps	Albericus sanguinopictus	5	17,871
1,150	Herps	Albericus siegfriedi	6	17,509
1,160	Herps	Albericus swanhildae	7	35,041
1,170	Herps	Antaresia maculosa	8	17,436
1,180	Herps	Aphantophryne minuta	9	34,818
1,190	Herps	Aphantophryne pansa	10	77,946
1,200	Herps	Aphantophryne sabini	11	17,392
1,210	Herps	Austrochaperina archboldi	12	17,507
1,220	Herps	Austrochaperina brevipes	13	31,485
1,230	Herps	Austrochaperina polysticta	14	17,410
1,240	Herps	Barygenys cheesmanae	15	17,416
1,250	Herps	Barygenys flavigularis	16	17,497
1,260	Herps	Barygenys maculata	17	17,353
1,270	Herps	Barygenys parvula	18	38,567
1,280	Herps	Batrachylodes gigas	19	17,499
1,290	Herps	Callulops eremnosphax	20	17,454
1,300	Herps	Callulops glandulosus	21	17,759
1,310	Herps	Callulops marmoratus	22	18,088
1,320	Herps	Callulops omnistriatus	23	17,504
1,330	Herps	Callulops sagittatus	24	17,710
1,340	Herps	Choerophryne allisoni	25	18,828
1,350	Herps	Choerophryne burtoni	26	69,964
1,360	Herps	Cophixalus aimbensis	27	12,908
1,370	Herps	Cophixalus ateles	28	17,628
1,380	Herps	Cophixalus bewaniensis	29	17,833
1,390	Herps	Cophixalus cryptotympanum	30	19,130
1,400	Herps	Cophixalus cupricarenus	31	29,473
1,410	Herps	Cophixalus daymani	32	17,814
1,420	Herps	Cophixalus interruptus	33	17,493
1,430	Herps	Cophixalus iovaorum	34	17,374
1,440	Herps	Cophixalus kaindiensis	35	17,928
1,450	Herps	Cophixalus kethuk	36	29,473
1,460	Herps	Cophixalus linnaeus	37	15,517
1,470	Herps	Cophixalus melanops	38	81,371

SP_ID	Fauna	Scientific Name	Count	Hectares
1,480	Herps	Cophixalus misimae	39	21,272
1,490	Herps	Cophixalus nubicola	40	13,519
1,500	Herps	Cophixalus phaeobalius	41	17,472
1,510	Herps	Cophixalus pulchellus	42	18,018
1,520	Herps	Cophixalus sisyphus	43	32,552
1,530	Herps	Cophixalus sphagnicola	44	57,226
1,540	Herps	Cophixalus tagulensis	45	24,284
1,550	Herps	Cophixalus timidus	46	17,330
1,560	Herps	Cophixalus tomaiodactylus	47	57,182
1,570	Herps	Cophixalus verecundus	48	17,852
1,580	Herps	Copiula pipiens	49	18,038
1,590	Herps	Cryptoblepharus furvus	50	88,488
1,600	Herps	Cryptoblepharus richardsi	51	21,272
1,610	Herps	Ctenotus robustus	52	17,413
1,620	Herps	Ctenotus spaldingi	53	44,683
1,630	Herps	Cyrtodactylus capreoloides	54	17,505
1,640	Herps	Cyrtodactylus derongo	55	17,534
1,650	Herps	Cyrtodactylus klugei	56	81,371
1,660	Herps	Cyrtodactylus louisiadensis	57	81,344
1,670	Herps	Cyrtodactylus murua	58	90,072
1,680	Herps	Cyrtodactylus robustus	59	29,473
1,690	Herps	Cyrtodactylus tripartitus	60	21,272
1,700	Herps	Diporiphora bilineata	61	34,830
1,710	Herps	Hylophorbus picoides	62	20,601
1,720	Herps	Hylophorbus proekes	63	17,580
1,730	Herps	Hylophorbus rainerguentheri	64	91,540
1,740	Herps	Hylophorbus richardsi	65	20,602
1,750	Herps	Hypsilurus ornatus	66	33,933
1,760	Herps	Hypsilurus schoedei	67	9,891
1,770	Herps	Leiopython bennetti	68	67,810
1,780	Herps	Leiopython huonensis	69	17,493
1,790	Herps	Liophryne magnitympanum	70	17,377
1,800	Herps	Liophryne similis	71	18,079
1,810	Herps	Lipinia albodorsalis	72	17,573
1,820	Herps	Litoria albolabris	73	11,849
1,830	Herps	Litoria becki	74	36,670
1,840	Herps	Litoria bulmeri	75	76,945
1,850	Herps	Litoria chrisdahli	76	70,220
1,860	Herps	Litoria contrastens	77	97,891
1,870	Herps	Litoria dorsivena	78	18,255
1,880	Herps	Litoria eschata	79	29,473
1,890	Herps	Litoria flavescens	80	88,488
1,900	Herps	Litoria hilli	81	81,371
1,910	Herps	Litoria huntorum	82	17,562

SP_ID	Fauna	Scientific Name	Count	Hectares
1,920	Herps	Litoria majikthise	83	50,600
1,930	Herps	Litoria mucro	84	17,980
1,940	Herps	Litoria oenicolen	85	17,993
1,950	Herps	Litoria ollauro	86	17,809
1,960	Herps	Litoria robinsorae	87	17,454
1,970	Herps	Litoria rubrops	88	81,127
1,980	Herps	Litoria singadanae	89	17,980
1,990	Herps	Mantophryne axanthogaster	90	81,371
2,000	Herps	Mantophryne infulata	91	39,366
2,010	Herps	Mantophryne louisiadensis	92	29,475
2,020	Herps	Mixophyes hihihorlo	93	17,971
2,030	Herps	Nactus acutus	94	11,473
2,040	Herps	Nactus pelagicus	95	3,336
2,050	Herps	Nyctimystes avocalis	96	70,747
2,060	Herps	Nyctimystes daymani	97	28,850
2,070	Herps	Nyctimystes kuduki	98	17,504
2,080	Herps	Nyctimystes obsoletus	99	14,870
2,090	Herps	Nyctimystes tyleri	100	17,907
2,100	Herps	Nyctimystes zweifeli	101	26,723
2,110	Herps	Oreophryne geminus	102	17,522
2,120	Herps	Oreophryne kampeni	103	17,835
2,130	Herps	Oreophryne terrestris	104	17,522
2,140	Herps	Oxydactyla coggeri	105	36,229
2,150	Herps	Pherohapsis menziesi	106	13,795
2,160	Herps	Platymantis bufonulus	107	70,054
2,170	Herps	Platymantis caesiops	108	17,533
2,180	Herps	Platymantis macrops	109	28,687
2,190	Herps	Platymantis mamusiorum	110	17,530
2,200	Herps	Platymantis nakanaiorum	111	65,911
2,210	Herps	Platymantis sulcatus	112	70,062
2,220	Herps	Sphenomorphus louisiadensis	113	29,472
2,230	Herps	Sphenomorphus microtympanus	114	90,364
2,240	Herps	Sphenomorphus transversus	115	16,716
2,250	Herps	Toxicocalamus holopelturus	116	29,473
2,260	Herps	Toxicocalamus misimae	117	21,269
2,270	Herps	Typhlops fredparkeri	118	57,342
2,280	Herps	Typhlops hades	119	29,473
2,290	Herps	Typhlops mcdowelli	120	80,996
2,300	Herps	Varanus telenesetes	121	29,473
2,310	Herps	Xenobatrachus huon	122	17,960
2,320	Herps	Xenobatrachus subcroceus	123	17,954
Mammals				
2,400	Mammals	Aproteles bulmerae	1	52,959
2,410	Mammals	Conilurus penicillatus	2	71,533

SP_ID	Fauna	Scientific Name	Count	Hectares
2,420	Mammals	Dactylopsila tatei	3	14,487
2,430	Mammals	Dorcopsis atrata	4	8,325
2,440	Mammals	Echymipera davidi	5	27,831
2,450	Mammals	Echymipera echinista	6	63,116
2,460	Mammals	Hydromys ziegleri	7	17,668
2,470	Mammals	Leptomys signatus	8	76,447
2,480	Mammals	Melomys arcium	9	29,453
2,490	Mammals	Microhydromys musseri	10	54,326
2,500	Mammals	Myoictis leucura	11	40,899
2,510	Mammals	Myoictis wavicus	12	10,873
2,520	Mammals	Myotis macropus	13	20,377
2,530	Mammals	Nyctophilus bifax	14	3,183
2,540	Mammals	Otomops papuensis	15	22,284
2,550	Mammals	Otomops secundus	16	52,638
2,560	Mammals	Petaurus abidi	17	17,679
2,570	Mammals	Phalanger lullulae	18	88,137
2,580	Mammals	Phalanger matanim	19	15,314
2,590	Mammals	Pharotis imogene	20	53,726
2,600	Mammals	Pogonomys championi	21	22,067
2,610	Mammals	Pteropus scapulatus	22	23,594
2,620	Mammals	Saccolaimus flaviventris	23	17,270
2,630	Mammals	Taphozous australis	24	22,566
2,700	Mammals	Xeromys myoides	25	78,316