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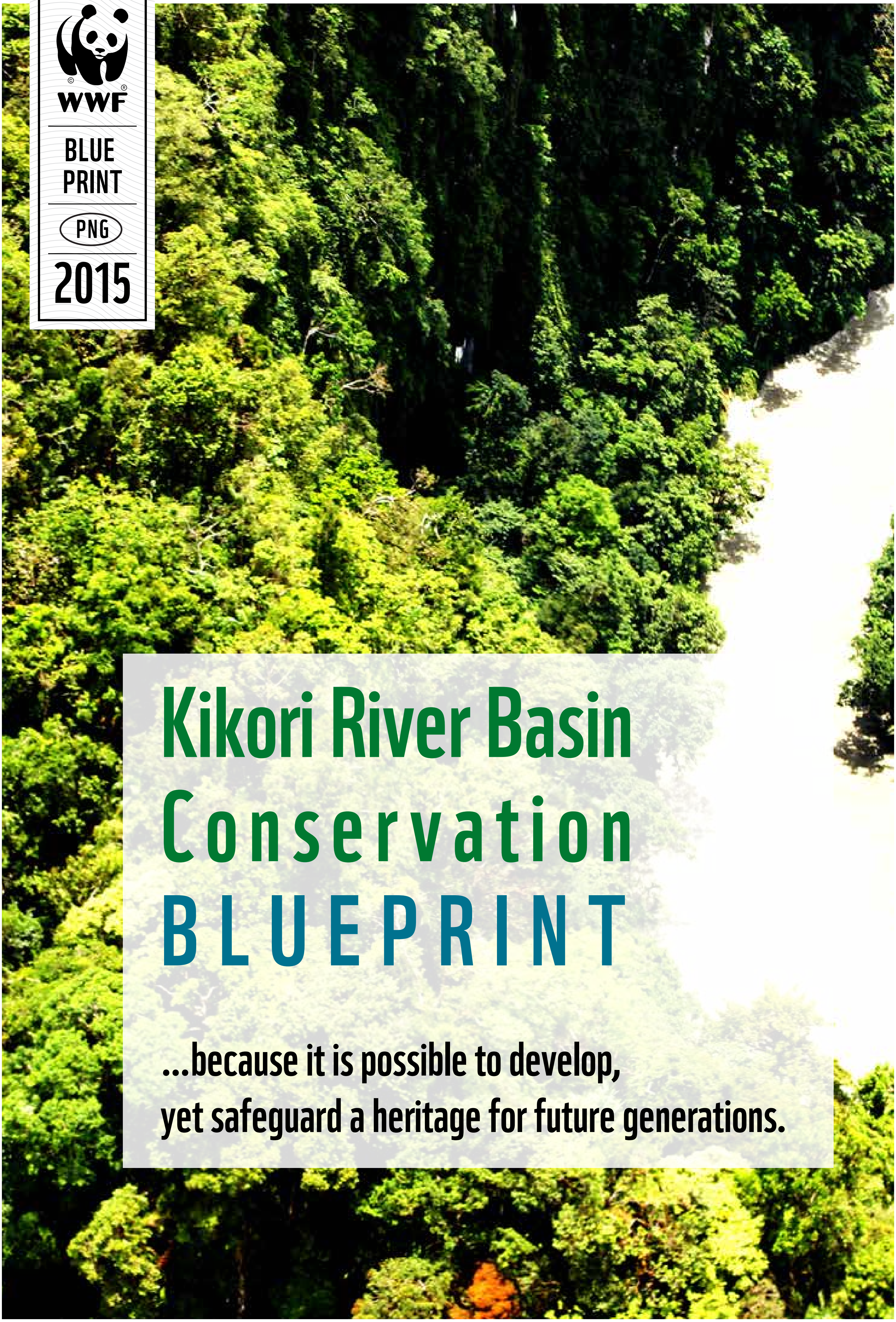

Kikori River Basin Conservation BLUEPRINT

...because it is possible to develop,
yet safeguard a heritage for future generations.

WWF is one of the world's largest and most experienced independent conservation organizations, with over 5 million supporters and a global network active in more than 100 countries. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

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Front cover: Aerial view of the Kikori River Basin
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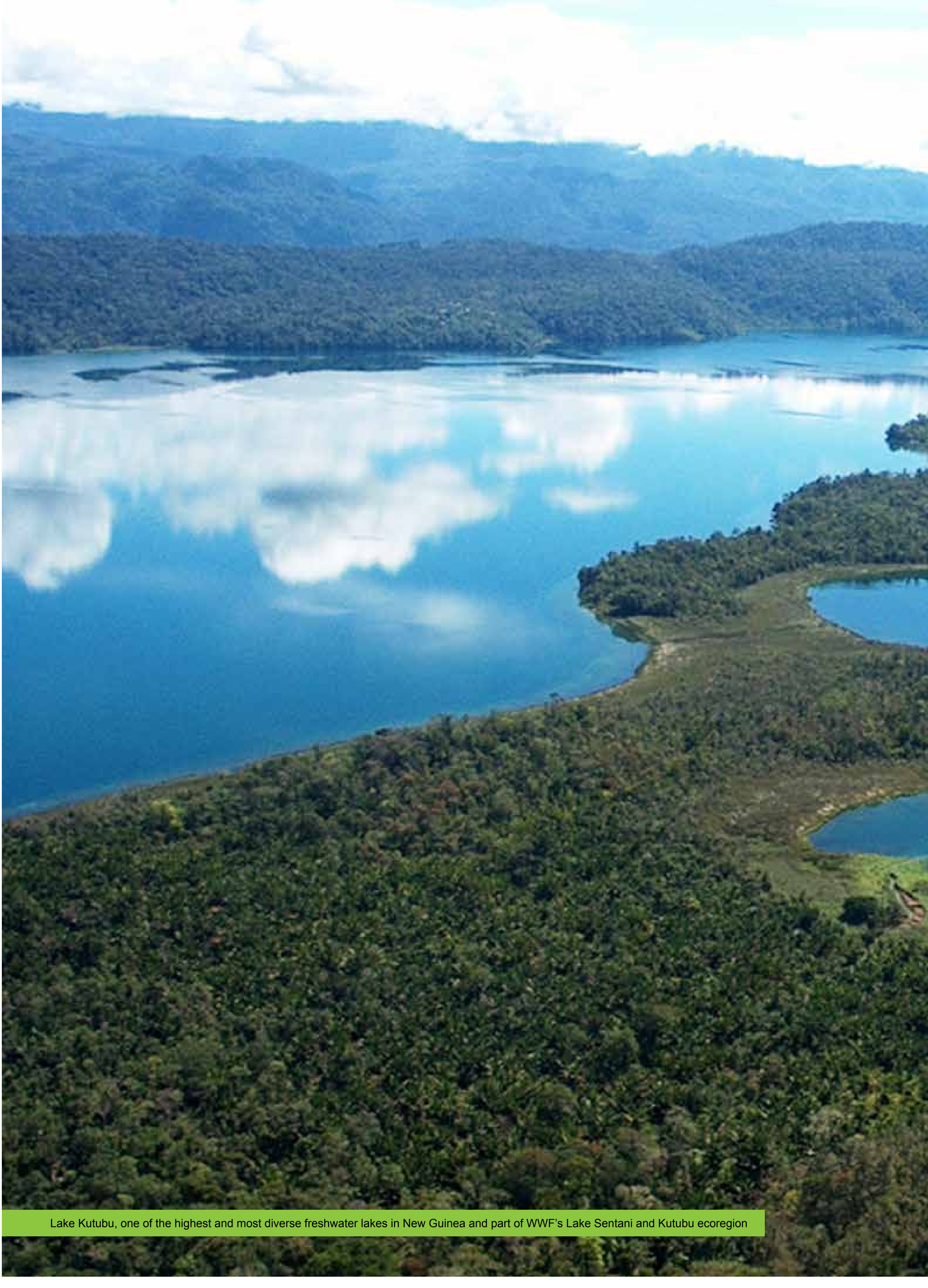

Lake Kutubu, one of the highest and most diverse freshwater lakes in New Guinea and part of WWF's Lake Sentani and Kutubu ecoregion

ACKNOWLEDGEMENT

Those who helped us in this 15-year journey…

The drafting of the Conservation Blueprint for the Kikori River Basin was made possible through generous funding support by WWF Netherlands, a Swiss private donor, the Indo-Pacific Cetacean Research and Management Funds and the former WWF Western Melanesian Programme Office (WMPO). The Kikori River Conservation Blueprint is based on the results of the Kikori Conservation Blueprint Workshops which were held in November and December 2011 and represents the culmination of more than 15 years' work and a synthesis of the expertise, knowledge and views of communities of the Kikori area, the provincial and local level governments, scientific experts, NGOs and authorities. We thank all those present at the workshops and who provided invaluable contributions to the development of the Conservation Blueprint for Kikori River Basin. Thanks also to Oala Iuda, Kafuri Yaro, Ted Mamu, Zola Sangga, Raymond Bure, Vagi Vali, Joy Herea, Avosa Oeri, and the facilitator Stuart Sheppard for their support and contributions to this report.

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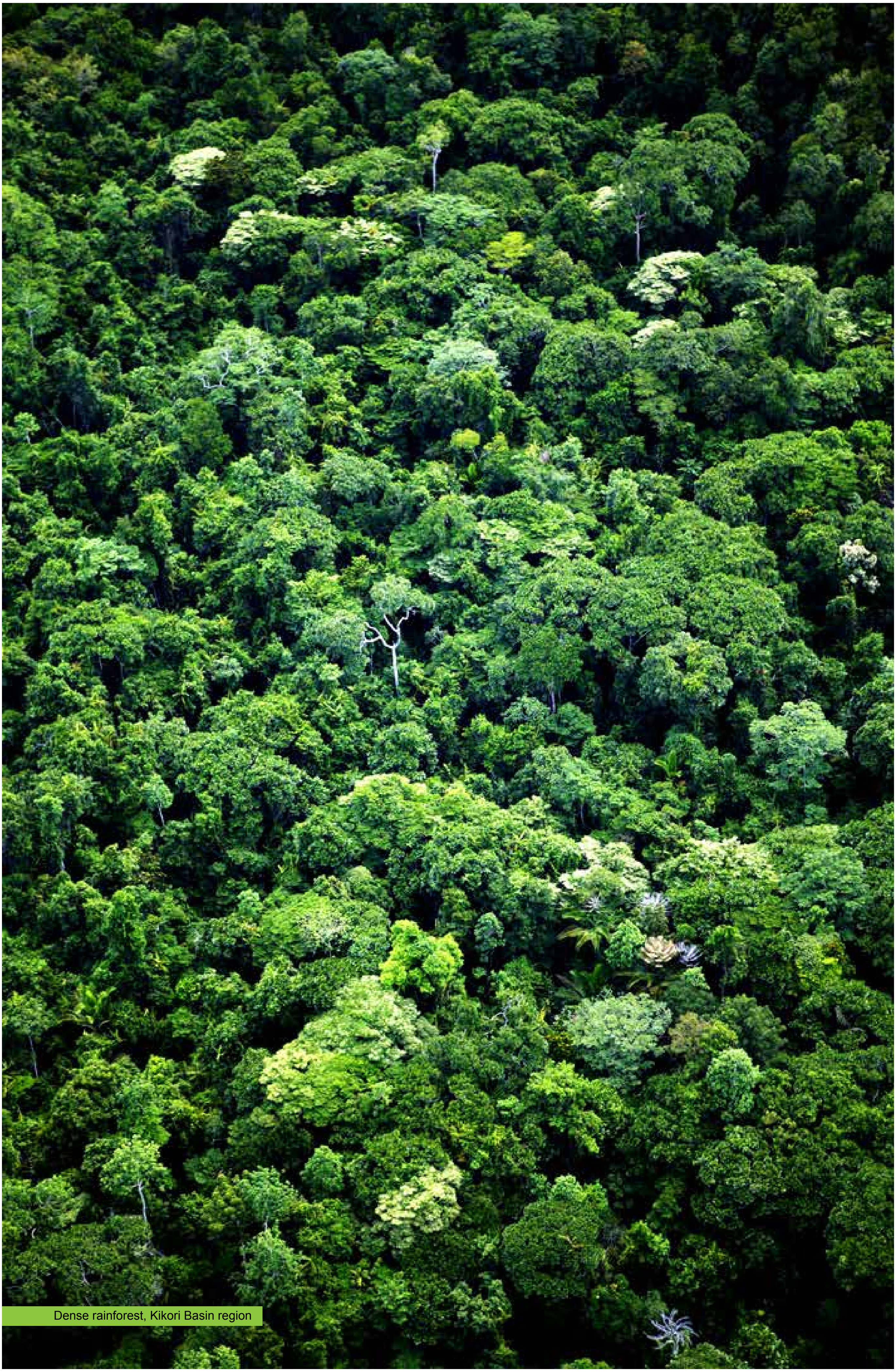

Dense rainforest, Kikori Basin region

INTRODUCTION

A starting-point for present and future generations.

This is the year, 2015, that the world is gathering to formulate and endorse the Sustainable Development Goals (SDGs) as a way forward for the future of the planet and humanity. It is fitting, therefore, that the Kikori River Basin Conservation Blueprint makes its way into the world as part of that process.

The term, 'sustainable development' entered global lexicon in *Our Common Future*, published by the World Commission on Environment and Development in 1987. Known as the "Brundtland Report", it included the "classic" definition of sustainable development: "Development which meets the needs of the present without compromising the ability of future generations to meet their own needs."

To communities in Papua New Guinea, communities across the Pacific, and to indigenous peoples across the world, this has been, and continues to be, a cultural reality – because without the 'people', without 'clan', without 'tribe' there is no existence. For centuries, indigenous communities have learned, known and transmitted their world down bloodlines through sustainable practice. For this reason, most of the world's most pristine and biodiverse regions belong to indigenous peoples.

Many, however, have forgotten, or are rapidly forgetting this part of their history. The challenge for Papua New Guinea, as for most indigenous nations and communities, is how best to protect their legacy while participating and benefiting from the global economy.

This document is a way forward.

The Kikori River Basin Conservation Blueprint provides the necessary guidance that visionary communities, tribes, provincial and national government, and anyone for that matter, may use to plan development without harming the most valuable areas of biodiversity of critical importance locally and globally. It gives us an indication of the value of biodiversity present and how best to plan development that guarantees a worthwhile future for coming generations.

As the world gathers to set goals toward the 'Sustainable Development Agenda', it is a feat that in Papua New Guinea, the Kikori River Basin Conservation Blueprint is being released to set another benchmark – that of providing a model as to exactly how people and governments may put this global agenda into practice. This document is extended in the hope that it enhances the protection of this almost uniquely valuable landscape through protected area network management, sustainable land use practice where the vegetation is to be altered, and best practice where there is to be construction.

This is a starting point.

What this Blueprint is not.

This Blueprint does not claim to have all the answers.

This Blueprint does not tell you exactly what to do or not do.

What this Blueprint is.

This Blueprint is a guide, a living document that will require use, implementation, analyses, and will evolve with lessons learned. It is a tool to empower you to manage your landscape and your inheritance for your benefit, and for the benefit of your future generations.

It has been born of good science that mapped the biodiversity of the Kikori River Basin. It tells the story of the Kikori River, its basin, and the associated emergence and spread of species that support human life. It can continue to do so if development in and around it, is planned with sound information.

This Blueprint provides information to permit wisdom in development.

It shows degrees and levels of biodiversity, the location of endemic and flagship species, the most vulnerable areas, the most valuable, and it must be interpreted to glean where community or infrastructure development may, or may not, be advisable to take place.

This Blueprint provides guidance.

What this Blueprint is for.

This Blueprint is useful for land-use planning. It is useful for the identifying and prioritising of areas that deserve special consideration for conservation.

This Blueprint is useful for planning of development and infrastructure. It is not here to stop development, it is here to make sure it is in the right place.

Whom this Blueprint is for.

This Blueprint is useful to provincial and local level government (LLG) entities, including district authorities that work in, and with communities who customarily own the land.
It is useful to communities, and in fact, anyone interested in the Kikori River Basin, and its associated natural and cultural heritage.

How to use this Blueprint.

- This Blueprint comprises a set of detailed maps with notes. To make full use of this, ensure that you are reading the map with its corresponding notes.

- Read the table of contents to see the various themes and subject areas covered.

- Read the introductory section to get a summary of what you will find inside.

- If you are a local level government (LLG), provincial, or national government representative, this Blueprint is a guide to the rich natural heritage and associated cultural or human features of the Kikori River Basin and will help you serve the communities of the Kikori, and your people of Papua New Guinea, better. It will help you provide well-informed guidance in the communities you work in, and to the people you serve.

- If you are from the Kikori River Basin and call it home, this Blueprint provides a map of your rich natural heritage and allows you to safeguard your legacy while planning development.

- If you cannot read maps, please find a friend or family member who can help you. You can also contact your LLG or provincial office to assist you. Use it as a group. Share it widely.

- For any further enquiries, you may contact the WWF- Pacific PNG office.

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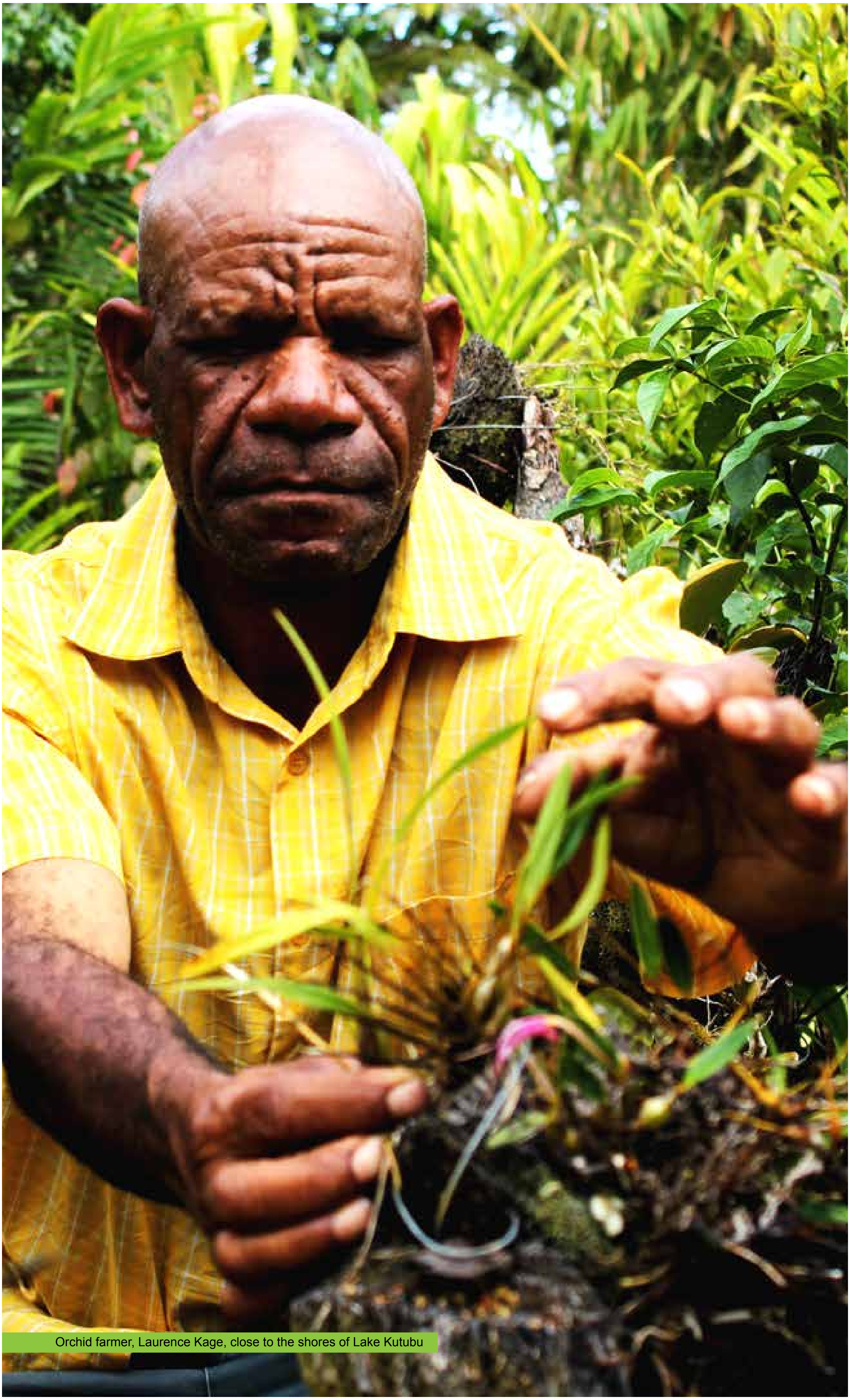

Orchid farmer, Laurence Kage, close to the shores of Lake Kutubu

CONTENTS

ACRONYMS

BLM	- Boundary Length Modifier
CA	- Conservation Area
DEC	- Department of Environment and Conservation
ERA	- Eco Regional Assessment
GIS	- Geographic Information System
JCU	- James Cook University
LLG	- Local Level Government
LNG	- Liquefied Natural Gas
MARXAN	- Marine Reserve Design using Spatially Explicit Annealing
NGO	- Non-Government Organization
PA	- Protected Area
PNG	- Papua New Guinea
PNGFA	- PNG Forest Authority
SRTM	- Shuttle Radar Topography Mission
TNC	- The Nature Conservancy
UNESCO	- United Nations Educational, Scientific and Cultural Organization
UPNG	- University of Papua New Guinea
WHRC	- Wood Hole Research Center
WMA	- Wildlife Management Area
WMPO	- Western Melanesia Programme Office (Now WWF-Pacific PNG)
WWF	- World Wide Fund for Nature
CITES	- Convention on International Trade in Endangered Species

DEC: As of 2015 now CEPA: Conservation and Environment Protection Authority.

A Guide to the Blueprint

The following section of the Blueprint outlines the process taken to develop six maps – all included in this report - identifying the most important areas of biodiversity and cultural significance in the Kikori Basin. Each map is simply one different option towards the objective of coming up with the best solution – a network of high value conservation areas which could be agreed upon when developing land use plans for the region.

The Blueprint used MARXAN which is the most widely used systematic reserve planning software in the world, and has been used to create the marine reserve network on the Great Barrier Reef, in Queensland, Australia, the largest marine protected area in the world. It has also been used for many other reserve planning applications, including the Galapagos Islands, Baltic Sea and Gulf of Mexico.

Put simply, MARXAN, comes up with its options by calculating the known biodiversity of a region, from highest to lowest, through a set of biodiversity targets. It compares these with the potential costs of a network of conservation areas, the potential boundaries – is it going to be single large system or a several small systems - and the positives, such as the presence of particular flagship species like tree kangaroos or a proposed Wildlife Management Area, with the negatives, such as oil pipelines or roads.

The maps included in this report are scaled from red through shades of green and yellow. Red marks out the most critical High Conservation Value Areas.

TECHNICAL INTRODUCTION

This report provides a concise summary of the processes and outcomes for planning and development of the conservation Blueprint for the Kikori River Basin landscape. The planning and development exercise was concluded in December 2011 providing the most complete data analysis on available conservation and biodiversity information for the provincial land-use plans in the Kikori River Basin landscape for the local level governments and provincial governments of Gulf, Southern Highlands, Hela and Enga.

The Blueprint describes the planning process and methodology used in its drafting, and clarifies that the network of areas of biodiversity significance should “ensure the maintenance of the region’s biodiversity”. Because the Kikori River Basin environment is still relatively intact compared to many areas in PNG and in other countries, there is a wide range of options for the design (location, size, and configuration) of Conservation Areas (CAs) that could potentially meet the set conservation goals. As there are also complex and important resource developments, resource-use and cultural issues to be considered in the selection and management of conservation areas, an interactive process of weighing conservation priorities against a wide range of other resource-management priorities is required to develop a network of conservation areas that best meets the Kikori River Basin’s objectives. It could also feed into the discussions related to the biodiversity offsets as required under the LNG project agreement.

This report also provides several scenarios taking into account 27 biodiversity targets, agreed conservation goals for each of the 27 targets; a cost layer (incorporating existing or proposed site for conservation, cultural or tourism status, steepness, presence of karst, presence of infrastructure, cash crops, proposed developments or proposed palm oil plantations); and a geographic zonation of three regions (developed from stratification units including rivers and altitudinal variation). From these data, the six reserve design scenario maps were developed that display the spatial distribution of conservation targets within the region’s planning units, with a colour-scaling to indicate the irreplaceability of the local-scale planning units. The six scenarios all achieved or exceeded the predetermined conservation goals for the 27 targets, although scenario 1b (developed using unconstrained unit selection in relation to existing or proposed conservation status and with low unit clustering) was determined to be the “most efficient”, in having a marginally lower total “cost” across the planning units.

The scenario maps have been accepted by the experts involved in their development as indicative of the areas that they consider important for protection and management, and by community and government representatives as useful for guiding drafting of land-use planning and promoting discussion about local concerns and potential designation of conservation areas.

OBJECTIVE OF THE KIKORI RIVER BASIN CONSERVATION BLUEPRINT

The primary aim of the Conservation Blueprint for the Kikori River Basin is to present the most current biodiversity information, useful for the planning and implementation of a river basin-wide network of conservation areas for the Kikori River Basin. The Conservation Blueprint will provide a number of scenarios that presents options for cross-section of targeted areas to be included in the network of conservation areas to meet the agreed biodiversity conservation goals.

Secondly, the scenarios presented herein may become useful for community consultations and discussions at the provincial and local level government (LLG) levels to help progress dialogue for conservation areas and government land-use planning to ensure long term sustainability and effective management of natural resources from different land uses including the large scale development projects within the vicinity of Kikori River Basin.

Although there are already some conservation areas of various types in the Kikori River Basin, including the locally managed Wildlife Management Areas (WMAs) established under the Fauna (Protection and Control) Act 1996 and the protected wetland areas known as Ramsar sites under the 1971 Convention on Wetlands of International Importance (Ramsar Convention). Most of these sites have been established primarily for natural resource management purposes or responses to an immediate threat of biodiversity loss and/or to managing a very specific element of biodiversity. However, to date there has been little consideration to developing a comprehensive, representative and ecologically coherent network of conservation areas where all elements of biodiversity are effectively considered for the entire Kikori River Basin landscape to be included in their provincial land-use plans.

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Dendrobiumspec tabile: One of a number of new species of orchid discovered by WWF in the Kikori/Kitubu region.

The Kikori River Basin Conservation Blueprint will assist the LLG and provincial governments to develop a land-use plan that incorporates a network of conservation areas, which builds on the existing suite of conservation areas. This will lead to the development of a conservation areas network that meets the dual objectives of protecting the Kikori River Basin landscape's terrestrial and freshwater biodiversity and supporting the sustainable management of the provinces' natural resources. This report provides a starting point for discussions between the LLG, provincial governments, (potential) developers, and last but not least the resource owners to progress these dual objectives and to include the recommendations in the discussions during the drafting of the provincial land-use plans.

At the same time there are significant development challenges facing the Kikori River Basin landscape, particularly along the Kikori River, where a new road along the LNG pipeline is opening the Kikori River Basin for easier access and development opportunities. Information on areas that are important for biodiversity protection and management will help to guide land-use planning to ensure that development is sensitive to the terrestrial and freshwater environments of the Kikori River Basin landscape.

Dorsal fin of what could be a new sub-species of the Australian snub-fin dolphin *(Orcaella heinsohni)*. Kikori Delta.

OVERVIEW OF THE BASIN'S BIODIVERSITY VALUES

The landscape of the Kikori River Basin has unique ecological, cultural, and economic significance that connects with the vast intact rainforests in the region and many unique cultures and customs. The basin also contain many newly described and undescribed species.

The basin is recognised as one of the most important areas of forest and wetlands biodiversity in the Asia/Pacific region. Within the basin is the exceptional Ramsar site of Lake Kutubu. In addition, the Kikori River Basin and the Great Papuan Plateau are currently under consideration as the proposed World Heritage site by UNESCO ("Papua New Guinea", 2006).

The Kikori basin hosts 24 of the 38 "Birds of Paradise" species, the world's only poisonous bird, the Pitohui, the world's rarest underground roosting bird *(Melampitta gigantean)*, and the New Guinea flightless rail *(Megacrex inepta)*, one of PNG's rarest birds. In addition, the area contains three rodent species which are new to science, and a recently discovered blossom bat which is not yet described by scientists. Its freshwater systems are home to at least 15 endemic freshwater fish of which three are new to science, and 28 undescribed frog species of which four have been recently confirmed as new species. The flora of the region is no less impressive, with 20 undescribed orchid species recorded around Lake Kutubu area alone, and two as yet undescribed species of palm (WWF unpublished report, 2005).

Last but not least, the Kikori River Basin landscape, is the home of three of WWF's flagship species, including the pig-nosed turtle, tree-kangaroo, and inshore dolphin. The latter was the focus of a joint WWF – JCU research project led by Dr Isabel Beasley, to establish the identity of the species and the extent of the species distribution.

Tree Kangaroo, Daga Village, Kutubu Region.

THE CONSERVATION BLUEPRINT DRAFTING METHODOLOGY

The methodology of the drafting of the Kikori River Basin Conservation Blueprint followed the process which was used in 2007 while developing a "Blueprint" for Palau's national Protected Areas Network (Hinchley et al., 2007). A general description of the planning process, initially developed by TNC, referred to as Eco Regional Assessment (ERA), is provided by Groves et al. (2000). The methodology uses the following steps:

1. Identification of biodiversity targets (species, communities and ecosystems that represent the biodiversity of the region),

2. Mapping of the occurrences/distribution of biodiversity targets, together with a database of information related to each target using the best available data,

3. Identification of conservation goals for each biodiversity target (i.e. what is needed to ensure that each biodiversity target is conserved in the future - considering area needed for viability, scale, and ecosystem function),

4. Identification of areas of high biodiversity value (e.g. areas that support multiple targets, rare species, and those that are important to maintain ecological processes),

5. Analysis of threats and causes of threats to high biodiversity areas and targets,

6. Conduct a series of specialist and community consultative meetings to verify the results of the MARXAN analysis.

© M. Pauza

Pig-nosed turtle *(Carettochelys insculpta).* Almost entirely aquatic, it only comes ashore to breed. Kikori Delta.

The ultimate goal of this planning effort is the identification of a network of areas of biodiversity significance that collectively, if conserved or managed sustainably, will ensure the maintenance of the regions' biodiversity. Groves et al. (2000) identified six principles that are required for an effective design:

1. The portfolio of conservation and managed sites represents all system targets.

2. Multiple examples of all biodiversity targets should be represented across the diversity of environmental gradients in the eco-region.

3. Priority is given to system targets during the site selection process as these areas are likely to contain multiple species targets.

4. Areas that contain high-quality examples from multiple environments (marine, aquatic and terrestrial) are also given priority.

5. Areas of biodiversity significance should be functional – maintain size, condition and landscape/seascape context - within the natural range of variability of the biodiversity targets.

6. The assemblage of areas of biodiversity significance should capture all targets.

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Cuscus. Kutubu Region

MARXAN

MARXAN is a widely-adopted tool for development of reserve scenarios and was used also in the preceding “Blueprint” development for the Palau national protected area network (Hinchley et al. 2007). Figure 5 and concerns expressed in the Kikori Blueprint demonstrate some of the limitations of Marxan, particularly those relating to scale of analysis versus application, the importance of the data layers underlying the development of reserve scenarios, and its use as a tool in discussions rather than a driver of the planning process.

Since ownership and control of natural resources in PNG, and thus in the Kikori River Basin, operates at the community level, it is acknowledged that any final decisions would be subject to extensive discussion and negotiation, and made at the community level. Therefore, in order to best consider all of the landscape’s biodiversity and natural resource issues, all factors including stakeholders, various types and management regimes of Kikori River Basin-wide Network of Conservation Areas would be required.

For the development of the Kikori River Basin Conservation Blueprint, two expert workshops were held in November 2011 to: (1) develop an agreed set of conservation areas network design principles, stratification units, biodiversity targets and goals, cost layer and (2) to provide a range of conservation areas scenarios for review by workshop participants. The workshops were attended by representatives of the main science and resource management agencies in PNG as well as representatives from communities and the national government. The first workshop focused on expert and stakeholder review and refinement of available biodiversity and socio-economic spatial information.

At the second workshop, the design principles for guiding decisions about the most suitable areas for inclusion in conservation areas network were also discussed.

Stratification units were used within MARXAN to ensure the sampling of the full range of environmental and geographic space when meeting conservation goals. It also ensures that representation goals are met in accordance with the design principles. Stratification forces MARXAN to select planning units from each stratum when meeting conservation goals. The stratification units therefore need to define meaningful and different ecological units across the Kikori River Basin.

Biodiversity “targets” were derived from the best available data gathered from all sources, including PNG Forestry Authority (PNGFA), National Museum and Art Gallery of PNG, Department of Environment and Conservation (DEC), local experts and published literature. Prior to the consultative expert workshops, all spatial data were compiled and produced as maps for review by the experts.

Conservation goals are an expression of how much (e.g. area or number of viable occurrences) spatial configuration of each biodiversity target is required to ensure the long-term viability of that target.

The goals in this assessment represent an initial estimate of percentages necessary to maintain the biodiversity of Kikori River Basin and contribute to the survival of species across their range. These goals should be considered as first approximations that will need to be reviewed and refined as more information becomes available.

The cost layer represents the relative influence (both positive and negative) of factors that are likely to affect the long-term ecological integrity of a protected area. Each factor was rated on a scale from -10 to +10. Negative ratings represented factors considered likely to have a negative effect on a protected area (i.e. the more negative, the less suitable for inclusion). Positive ratings represent factors considered likely to have a positive effect on a protected area (i.e. the more positive, the more suitable for inclusion).

Information obtained in the first workshop was digitized and compiled for analysis using MARXAN (Ball and Possingham 2000), a conservation planning tool developed to aid in the design of conservation areas options.

During the second workshop, three scenarios, each with two clustering values, were presented and discussed (Table 1). The Boundary Length Modifier (BLM) medium clustering option provide scenarios that are more clustered compared to the BLM low clustering option. The BLM High clustering option was not used because it resulted in scenarios that were too clustered.

Table 1: Description of the Six MARXAN scenarios

Scenarios			Description
##	Scenario name	Clustering	
1a	Unconstrained	BLM medium	Highlights the most important areas to achieve the conservation goals and the least important areas. This scenario aims to meet the targets in the smallest area possible (within the constraints of the boundary conditions and cost layer) while clumping planning units into contiguous areas as much as possible. Two clustering options were used (BLM 1 and 0.5)
1b		BLM low	
2a	Locking in of existing protected areas and traditional areas	BLM medium	This scenario "locks in" all existing protected areas and also traditional areas and then allows MARXAN to search for additional areas to fully meet conservation goals. Two clustering options were used (BLM 1 and 0.5)
2b		BLM low	
3a	Locking in of existing protected areas, traditional areas and proposed areas (including Ramsar river site)	BLM medium	This scenario is the same as scenario 2a & 2b except that it also locks in proposed protected areas. Two clustering options were used (BLM 1 and 0.5)
3b		BLM low	

RESULTS

Stratification

Stratification units were identified by MARXAN and the full range of environmental and geographic space met the conservation goals. Further, using these stratification units, different ecological units across the Kikori River Basin were defined.

Participants in Workshop 1 reviewed a number of landscape stratification options, using rivers, altitude boundaries, among others, for delineation of the different strata in the Kikori River Basin landscape. The final stratification has three distinct areas in which the conservation goals should be achieved. The final stratification is shown in Figure 1.

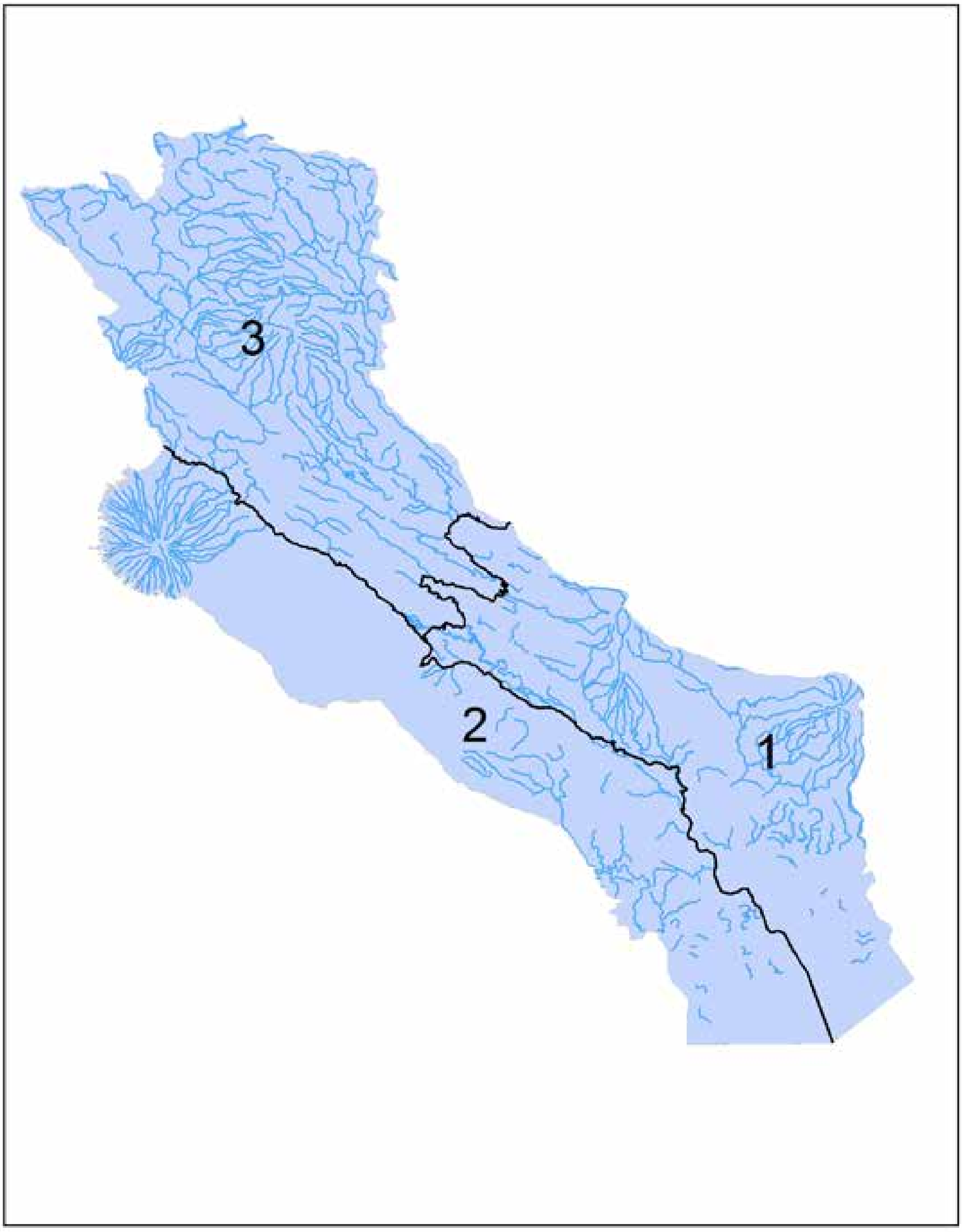


Figure 1: Stratification

Biodiversity Targets

Twenty seven biodiversity targets (Table 2) were derived from expert opinion and published literature. All 27 targets were used in the analysis. Of these, one was a coastal system, 17 were terrestrial systems, seven were freshwater aquatic, and two were focal areas for individual species (Pig-nosed Turtles and Inshore Dolphins). For a complete description of each target see the following pages.

Table 2. Biodiversity Targets and Conservation Goals (%)

Biodiversity targets	Agreed Goal (%)
1. Pig-nosed turtle nesting areas	100%
2. Pig-nosed turtle feeding areas	50%
3. Inshore dolphin habitat	80%
4. Coastal mangroves	30%
5. Riverine successions dominated by grass	20%
6. Mixed swamp forest	20%
7. Swamp woodland	25%
8. Peat swamp forest	90%
9. Swamp grassland	25%
10. Open forest (below 400m)	20%
11. Open forest (400m – 1,000m)	20%
12. Large crowned forest (400m – 1,000m)	30%
13. Large to medium crowned forest (below 400m)	50%
14. Medium crowned forest (below 400m)	25%
15. Medium crowned forest (400m – 1,000m)	25%
16. Small crowned forest (below 400m)	25%
17. Small crowned forest (400m – 1,000m)	25%
18. Small crowned forest (above 1,000m)	25%
19. Small crowned forest on Karst (400m – 1,000m)	25%
20. Small crowned forest with *Nothofagus* (400m – 1,000m)	50%
21. Small crowned forest with *Nothofagus* (above 1,000m)	50%
22. Small crowned forest with Conifers (above 1,000m)	50%
23. Very small crowned forest (above 1,000m)	60%
24. Sub-alpine grassland (above 1,000m)	45%
25. Alpine grassland (above 1,000m)	60%
26. Lakes	100%
27. Rivers	75%

Biodiversity targets	Agreed Goal (%)	Description
Pig-nosed turtle nesting areas	100%	*Carettochelys insculpta* also known as the Pitted-shelled turtle, Fly River turtle or New Guinea Plate-less turtle (IUCN, 2012). A large, freshwater *chelonian*, found in Southern New Guinea, West Papua, Indonesia and the Northern Territory, Australia. The Pig-nosed turtle is almost entirely aquatic, with only the female ever leaving the water to nest. The species inhabits rivers and streams, as well as lakes, swamps, lagoons and water holes, usually in water up to 7 metres deep. It can also tolerate brackish water to an extent, and is sometimes found in estuaries and river deltas. Female Pig-nosed turtles mature at around 25 years of age. In Kikori, they nest late in the dry season from September to December in the coastal areas and from November to March in riverine areas (Georges et al., 2012) and are larger than those nesting in Australia. The nest is built at night, and the female excavating a shallow chamber in sand or mud close to water covering them over to conceal them for protection, into which are laid around 4 to 39 white, spherical eggs in the sandy river banks, above water (Georges et al., 2008).
Pig-nosed turtle feeding areas	50%	The Pig-nosed turtle is mostly an underwater grazer and in PNG its diet primarily consists of unripe fruit, leaves, stems of mangroves and upstream species of *Sonneratia, Xylocarpus Canarium indicum* and *Artocarpus incisa, Nypa fruiticans, Saccharum robustum, molluscs; Batissa violacea, Nerita sp. and Centhidea sp.*, and the crustacean; *Scylla serrata* (Georges et al., 2008). In Australia, its diet primarily consists of ribbon weed, leaves, fig flowers, bush apple, eucalyptus, fresh-water aquatic plants' fruits, aquatic invertebrates, their larvae, insects and mollusks (Groombridge, 1982 and Arthur Georges et al., 1993).
Inshore dolphin habitat	80%	There are six species that live in river systems and call this special habitat home and have very different histories. Some oceanic dolphins live in fluvial environments, such as the Irrawaddy dolphin, but are not classified as river dolphins. The largest inshore dolphins usually grow up to 2.4 meters (8 feet) long, but most are smaller. Dolphins may be white, pink, yellow, brown, gray, or black.
Coastal mangroves	30%	Mangroves are various kinds of trees up to medium height and shrubs that grow in saline coastal sediment habitats in the tropics and subtropics – mainly between latitudes 25° N and 25° S. The remaining mangrove forest areas of the world in 2000 was 53,190 square miles (137,760 km²) spanning 118 countries and territories. The mangrove biome is a distinct saline woodland or shrub land habitat characterised by depositional coastal environments, where fine sediments collect in areas protected from high-energy wave action. Mangroves dominate three-quarters of tropical coastlines. The saline conditions tolerated by various mangrove species range from brackish water, through pure seawater (30 to 40 ppt), to water concentrated by evaporation to over twice the salinity of ocean seawater (up to 90 ppt). Mangrove cover in PNG is 574 867hectares fringing relatively sheltered and shallow coastlines. Most coastal provinces have mangroves with 66% in Western Province (Shearman et al., 2008)
Riverine successions dominated by grass	20%	This community is tall grassland found in low altitudes areas on scroll bars and in the scroll arches of meandering rivers, and sand-bars in braided rivers. Site conditions vary from frequently flooded to permanently swampy. Thus, on frequently flooded sites, *Sacchrum robustum* is the dominant species. On swampier sites *Phragmites karka, Coix lachrymal-jobi* and *Typha sp.*, grade into a permanent swamp containing the species described above under swamp grassland. Inclusion of forest and woodland are common on the less frequently flooded higher scroll bars (Harmmermaster & Saunders,1995).

Biodiversity targets	Agreed Goal (%)	Description
Mixed swamp forest	20%	This is the most common type of swamp forest in the Kikori Area. It generally has an open but occasionally dense canopy. Some of the more common trees include *Campnosperma spp, Terminalia canaliculata, Nauclea coadunata, Syzygium sp, Aistonia scholaris, Biscofia javanica* and *Palaquium sp.*(Orsborne, ….?).
Swamp woodland	25%	Swamp woodland (Wsw): The woodland consists of an open to fairly dense upper layer of sago palms or pandanus, with scattered trees, over a ground layer of tall sedges and ferns or *Phragmites* grass, or bare ground. Where trees occur, the species are similar to those of swamp forest. Swamp woodland with *Melaleuca leucandendron* (WswMl): This woodland is a very open variant of swamp forest with *Melaleuca*. The upper layer of very open *Melaleuca leucandendron* can attain a height of 20m over a dense ground layer of grasses and sedges (Harmmermaster & Saunders,1995).
Peat swamp forest	90%	Peat swamp forests are tropical moist forests where water-logged soil prevent dead leaves and wood from fully decomposing, which over time creates a thick layer of acidic peat. Peat swamp forests are typically surrounded by lowland rain forests on better-drained soils, and by brackish or salt-water mangrove forests near the coast. Peat lands occupy mostly on low altitude coastal and sub-coastal situations and extend inland for distances of more than 100km along river valleys and across watersheds. At altitudes from sea level to about 50m above mean sea level (amsl). They are most fully developed on the coasts of East Sumatra, Kalimantan (Central, East, South and West Kalimantan provinces), West Papua, Papua New Guinea, Brunei, Peninsular Malaya, Sabah, Sarawak, Southeast Thailand and the Philippines. The special characteristic of lowland tropical peat land is peat swamp forest (part of the rainforest formation) growing on top of and contributing to the accumulation of a thick surficial layer of peat.
Swamp grassland	25%	On low altitude plains, in permanent to intermittently dry swamps, the community is dominated by *Phragmites karka, Saccharum robustum* and *Coix lachrym-jobi.* In permanent swamps the main species are *Leersia hexandra, Oryza spp.*, and *Hymenachne acutigluma.* In lower montane zone, on the swampy valley floors, the commonly occurring species are *Phragmites karka, Agrostis reinwardtii, Arundinella furva, Monostachya oreodoloides* and *Leersia*, together with sedges (Harmmermaster & Saunders,1995).
Open forest (below 400m)	20%	Low altitude forest on plains and fans. Forest has an uneven canopy up to 30 m in height with many, often large, gaps revealing a lower tree stratum. Large crowned (>15m diameter) emergents often reach 40m, rising above a canopy comprising medium (8-15m) to small (<8m) crowns. The floristic composition is very similar to the “large to medium crowned forest” (Caracala, 2010).
Open forest (400m – 1,000m)	20%	Description same as above
Large crowned forest (400m – 1,000m)	30%	Low altitude forest on uplands. This forest type has an uneven canopy 30-35m in height with a 60-80% closure. Emergents can reach 40m in height. Large stem diameters (70-89cm) predominant. In both structure and floristic content it is very similar to the “Large to medium crowned forest” on plains and fans (Caracala, 2010).
Large to medium crowned forest (below 400m)	50%	Low altitude forest on plains and fans. Crown diameter >8m. Canopy is generally 30–35m high and irregular in both height and closure. Stem diameters generally range from large (70-89cm) to small (30-49cm) but very large stems (90+ cm) are not uncommon. The floristic composition is very mixed with no single-species dominance (Caracala, 2010) .

Biodiversity targets	Agreed Goal (%)	Description
Medium Crowned Forest (below 400m)	25%	Low altitude forest on uplands. The canopy of this forest type is 25-30m in height, is generally only slightly uneven and has a 60-80% crown closure. Except for Araucaria emergents rarely exceed 40m in height. Very large stem diameters (90cm+) are rare except for Araucaria. Floristically the forest is very mixed (Caracala, 2010).
Medium Crowned Forest (400 – 1,000m.)	25%	Low altitude forest on uplands below 1000 m.
Small Crowned Forest (below 400m)	25%	Low altitude forest on plains and fans. This forest type has a dense even canopy of small crowns (<8m) 25-30m in height with no emergents. Stem diameters are generally small (30-49 cm) to very small (<30 cm) (Caracala, 2010)
Small Crowned Forest (400 – 1,000m)	25%	Low altitude forest on uplands. This forest has a relatively even canopy 20-30m in height, with a 60-80% closure and no emergents. Large stem diameters (90cm+) are rare, the majority of trees falling into the medium (50-69cm) to small (30-49cm) classes. The forest may be either a mixed forest which is poorly developed due to adverse site or climatic conditions, or a forest win which a small crowned (<8m) trees predominates in the canopy (Caracala, 2010).
Small Crowned Forest (above 1,000m)	25%	Lower montane forest (above 1000m). This forest has an even to slightly undulating canopy 20-30m in height. Canopy closure varies from dense to slightly open. The canopy height decreases with increasing altitude. Stem diameters are generally medium (50-69cm) to small (30-49cm). The forest occurs throughout the mountain ranges in the 1,400-3,400m altitude range (Caracala, 2010)
Small Crowned Forest on Karst (400 – 1,000m)	25%	Lower montane forest (above 1000m). This forest has an even to slightly undulating canopy 20-30m in height. Canopy closure varies from dense to slightly open. The canopy height decreases with increasing altitude. Stem diameters are generally medium (50-69cm) to small (30-49cm). The forest occurs throughout the mountain ranges in the 1,400-3,400m altitude range (Caracala, 2010) and growing on a Karst substrate
Small Crowned Forest with Nothofagus (400 – 1,000m)	50%	Lower montane forest above 1000 m (Rogers, 2008). This forest has an almost closed, even to slightly undulating canopy 20-30m height. Emergents are rare to absent. Nothofagus sp. Is the dominant species of the canopy. The forest occurs throughout the mainland in the altitude range 1600-2400m, and on the Nakanai Range (ENBP) at lower altitude, down to 1000m. Where it occurs with a complex with small crowned forest (L/LN or LN/L), the Nothofagus is generally confined to the ridges crest and upper slopes. However, on the higher parts of Nakanai Range the ridges are dominated by *N. starkenborghii* and the depressions by *N.resimosa* (Clunie 1976) (Harmmermaster & Saunders, May 1995).
Small Crowned Forest with Nothofagus (above 1,000m)	50%	Lower montane forest above 1000 m (Rogers, 2008). The forest has an almost closed canopy composed of small to very small crowns 15-25m in height. Emergent trees are the cornifers; *Libocedrus, Phyllocladus, Dacrycarpus* and *Podocarpus spp*.,. These species also form the canopy with the broad leaf genera *Ascarina, Claoxylon, Euodia, Halfordia, Ilex, Pygeum, Quintinia, Timonius, Weinmannia, Xanthomyrtus,* and *Xanthoxylum*. The canopy signature is characteristics by the conical crowns and its dark tone. It occurs throughout the ranges of the mainland above 2400m altitude. The height of the forest decreases with increase in altitude (Harmmermaster & Saunders, May 1995).

Biodiversity targets	Agreed Goal (%)	Description
Small crowned forest with Conifers (above 1,000m)	50%	This forest has a canopy 15-25m in height with emergent conifers. Crowns are small (<8m) to very small. Although the stems of the associated broadleaf species are generally small (30-49cm) in diameter, the coniferous stems often exceed 50cm in diameter. The forest occurs in many places in the mountain ranges above 2400m altitude (Caracala, 2010).
Very small crowned forest (above 1,000m)	60%	This forest has a dark-toned, dense to almost closed, even canopy 5-15m in height. Emergents are high and may be coni-fers or, if the emergents are very low light-toned, *Pandanus spp*. The forest generally occurs on the higher ranges of the mainland above 2400m, and at lower altitudes on exposed ridge crests and upper slopes. Species composition similar to that of the small crowned forest with cornifers, but with fewer coniferous trees (Harmmermaster & Saunders, 1995).
Subalpine grassland (above 1,000m)	45%	This grassland occurs above 2500m and below 3200m altitude, generally in valleys subject to cold air drainage and frost. It is typically surrounded by *Agrostis reinwardtii, Dichelacne novoguinensis, Deyeuxia spp., Anthoxanthum augustum* and *Arundinella furva* are commonly present. Often, the presence of the tree-fern *Cyathea* gives the grassland the appearance of a savannah. This type of grassland is occasionally subject to fire (Harmmermaster & Saunders,1995).
Alpine grassland (above 1,000m)	60%	This grassland occurs above the tree-line at 3200m approximately. The tussock grasses *Deschampsia, Danthonia, Hierochloe* and *Poa*, together with *Festuca* are commonly present with herbs and sedges. It is present on the higher ranges (Harmmermaster & Saunders,1995).
Lakes	100%	A lake is a body of relatively still water of considerable size, localized in a basin, which is surrounded by land apart from a river, stream, or other form of moving water that serves to feed or drain the lake. Lakes are inland and not part of the ocean and therefore are distinct from lagoon, and are larger and deeper than ponds. Lakes can be contrasted with rivers or streams, which are usually flowing. However most lakes are fed and drained by rivers and streams.
Rivers	75%	A river is a natural watercourse usually freshwater, flowing towards an ocean, a lake, a sea, or another river. In a few cases, a river simply flows into the ground or dries up completely before reaching another body of water. Small rivers may also be called by several other names, including stream, creek, brook, rivulet, run, tributary and rill. There are no official definitions for generic terms, such as river, as applied to geographic features, although in some countries or communities a stream may be defined by its size.

Conservation Goals

The local experts at Workshop 1 developed a conservation goal for each biodiversity target (Table 2).

GIS data layers were produced for each of the biodiversity target. Elevation values from SRTM (elevation zones) were used to draft GIS data layers for targets that transcend across several elevation zones and that required separation along the elevation zones. These biodiversity targets included Open Forests and the different types of Crowned Forests.

Table 3. Workshop meeting positive and negative factors used to calculate the workshop Cost Layer

(See Figure 2 below)

No	Name	Agreed Conservation Rating (1 to 10)
Positive Factors		
1	Existing protected areas	10
2	Ramsar sites	10
3	Traditional, cultural, archaeological & sacred sites	10
4	Slope above 30 degrees	10
5	Extreme karst	10
6	Proposed protected areas	5
7	Proposed Ramsar sites	5
8	Proposed World Heritage Sites	5
9	Tourism/promotional sites	4
No	**Name**	**Agreed Conservation Rating (-1 to -10)**
Negative Factors		
1	Highland - Coast road +5km	-10
2	Towns and villagers	-10 — -5
3	Commercial logging	-10
4	Small scale logging	-9
5	Industrial camp sites	-8
6	Jetties & wharfs	-8
7	Waste disposal sites	-7
8	Proposed Palm Oil (SABLs)	-6
9	Proposed Development PPLs	-5
10	Other roads	-5
	Airports/airstrips	-5
	Oil & Gas pipeline	-4
	Well /drill sites	-4
	Cash Crops (Coffee, rice etc)	-2

Cost Layer

Nine positive factors (e.g. existing protected areas, Ramsar sites, tourism promotion sites, cultural and historical sites, etc.) and 14 negative factors (e.g. highland-coast road, logging areas, oil and gas pipeline wells/drill sites, waste disposal sites, etc.) were considered in developing the cost layer (Table 3 and Figure 2). In addition, the calculated cost layer was combined with the Woods Hole Research Centre (WHRC) carbon data to ensure that high value carbon areas are considered as a positive cost factor (Figure 3). WHRC was selected over the NASA data set as it provides better data for mangroves, although it had more range over mountains and valleys. The final, combined cost layer is detailed in Figure 4

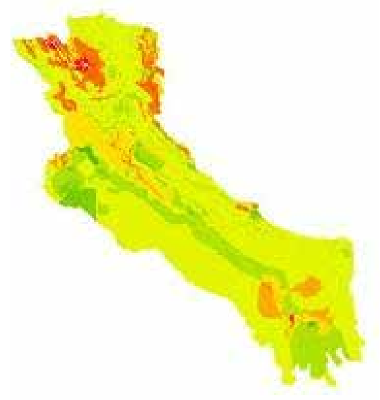


Figure 2: Workshop meeting Cost Layer (see table above)

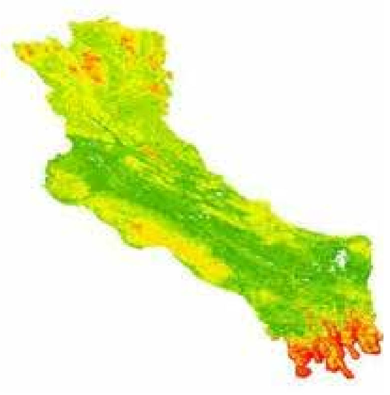


Figure 3: Total Biomass Carbon (WHRC)

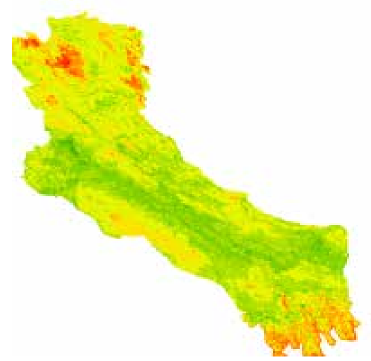
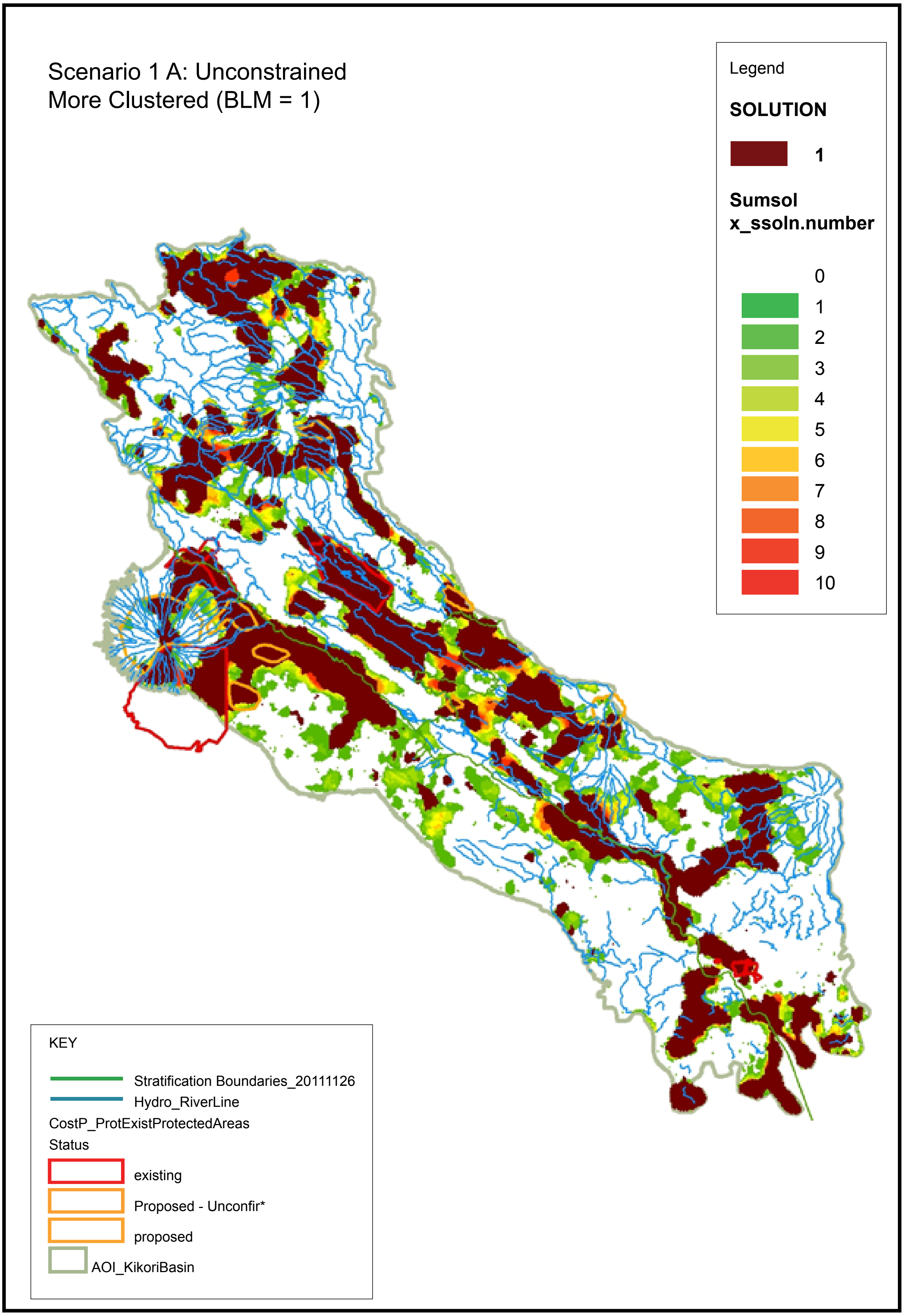


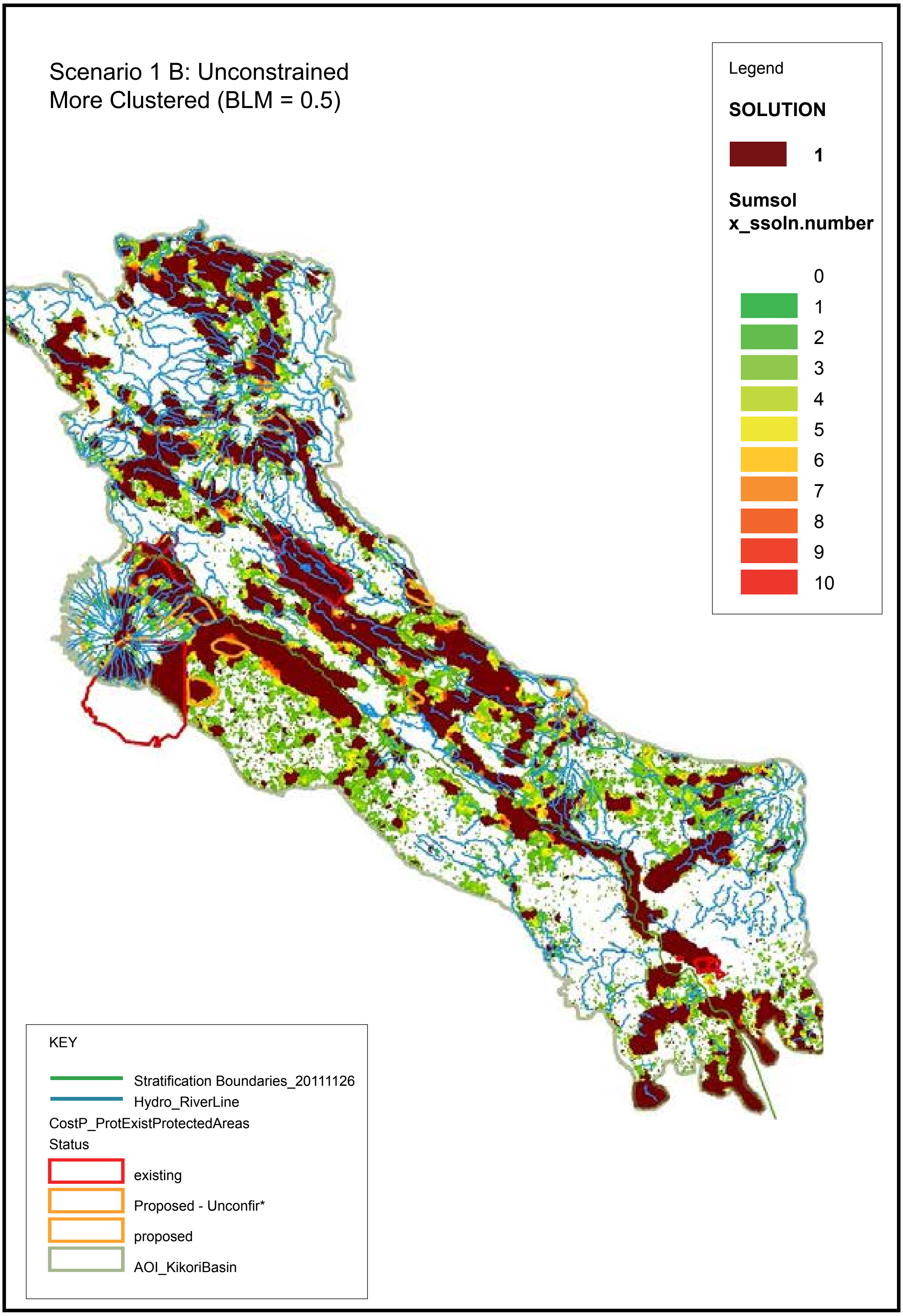
Figure 4: Total, combined cost layer used in analysis

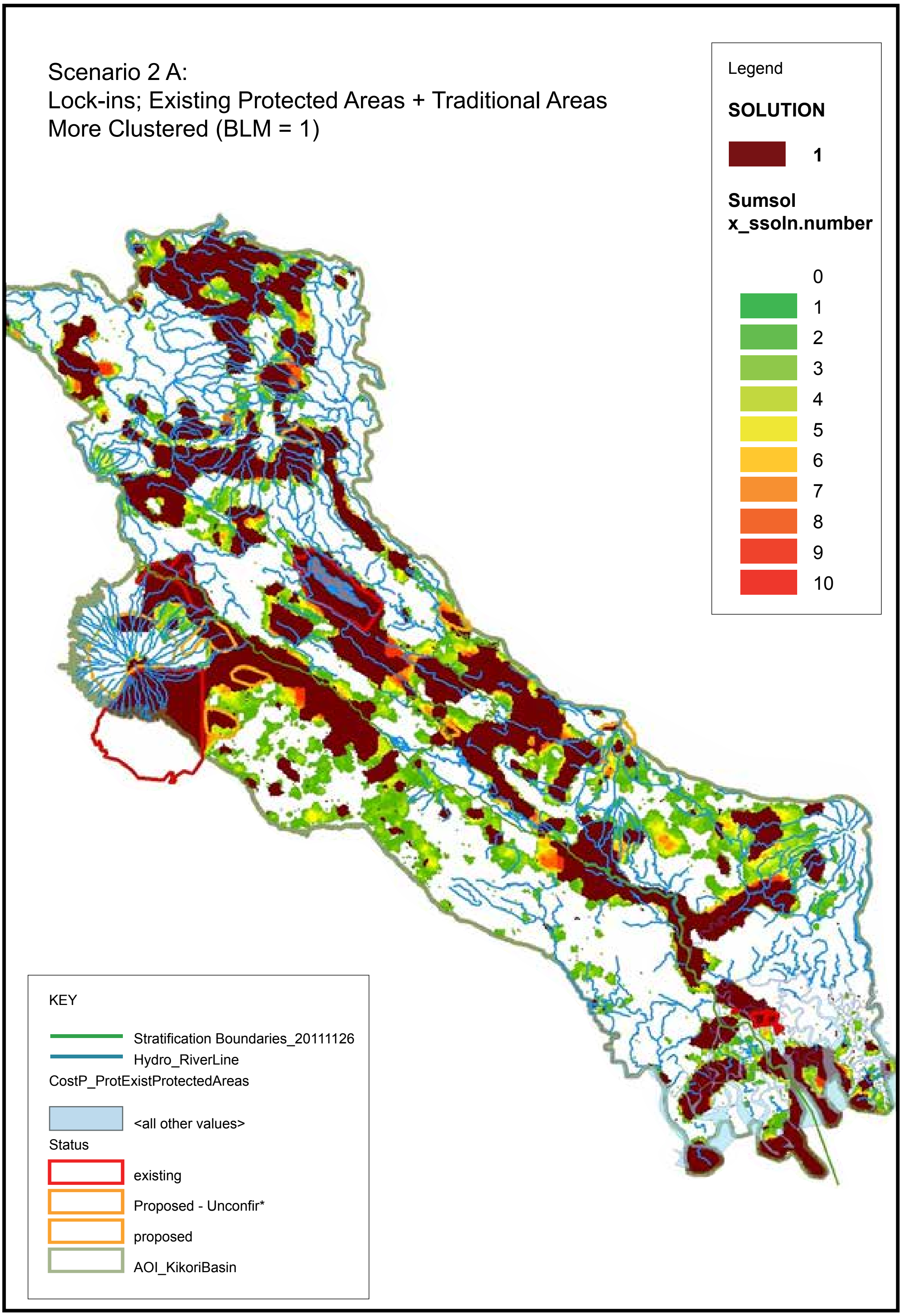
MARXAN Scenarios

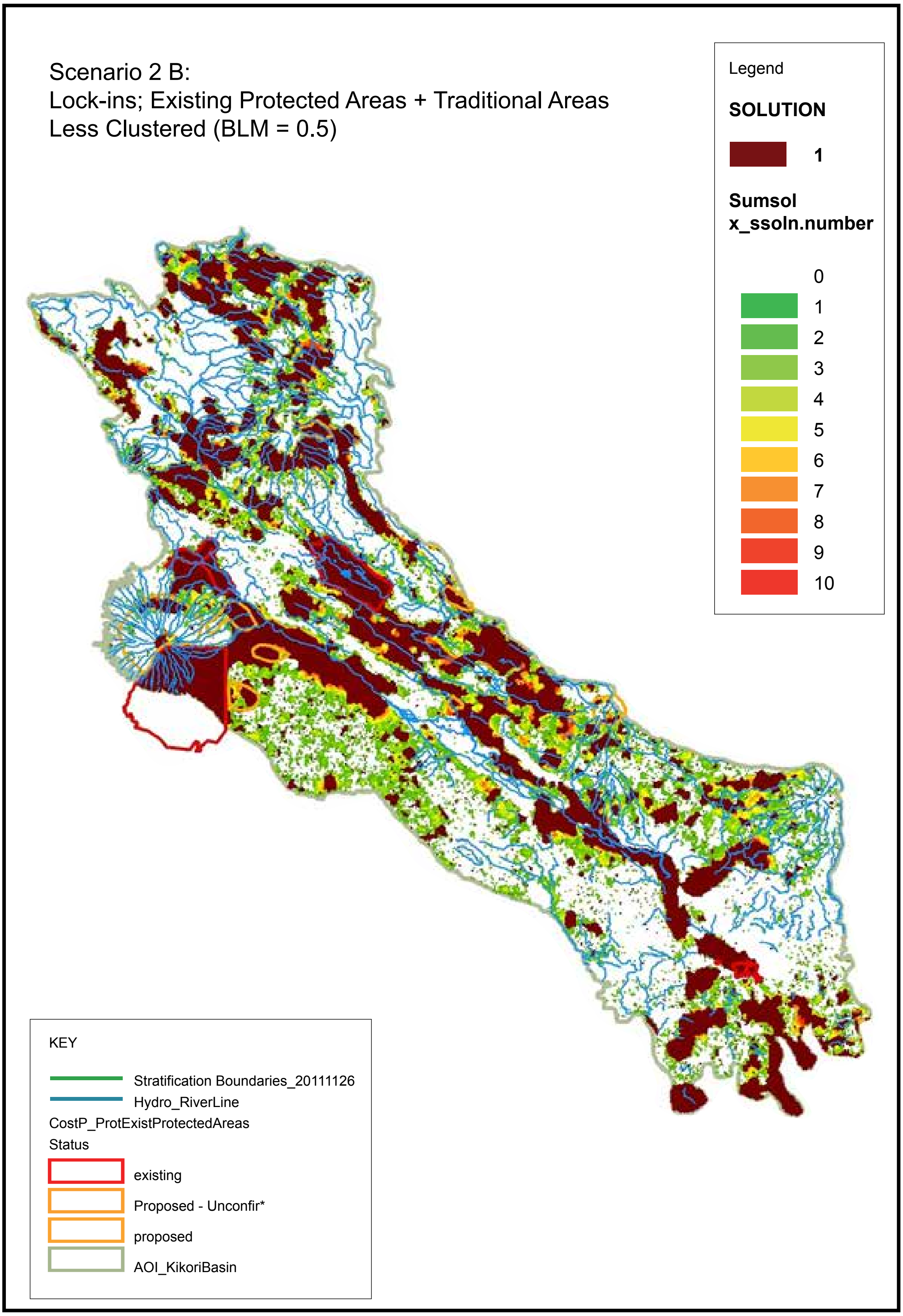
The scenario maps (Figure 5) show the relative importance of areas for inclusion in potential network of conservation areas. Each scenario map represents the sum of 100 possible protected area network designs. The red areas represent those planning units which were present in 100 of 100 possible protected area network designs. These are the planning units for which there are few or no options available. That is, if we are to meet our conservation goals, then these planning units must be included in the protected area design. Conversely, the light green areas occur in fewer than 10 of 100 possible protected area network designs. These are planning units for which there are many options available to meet the conservation goals. The yellow and green areas are least important for protection, that is there is much greater flexibility to achieve our conservation goals. These areas often contain widespread conservation values where options for protection are enormous.

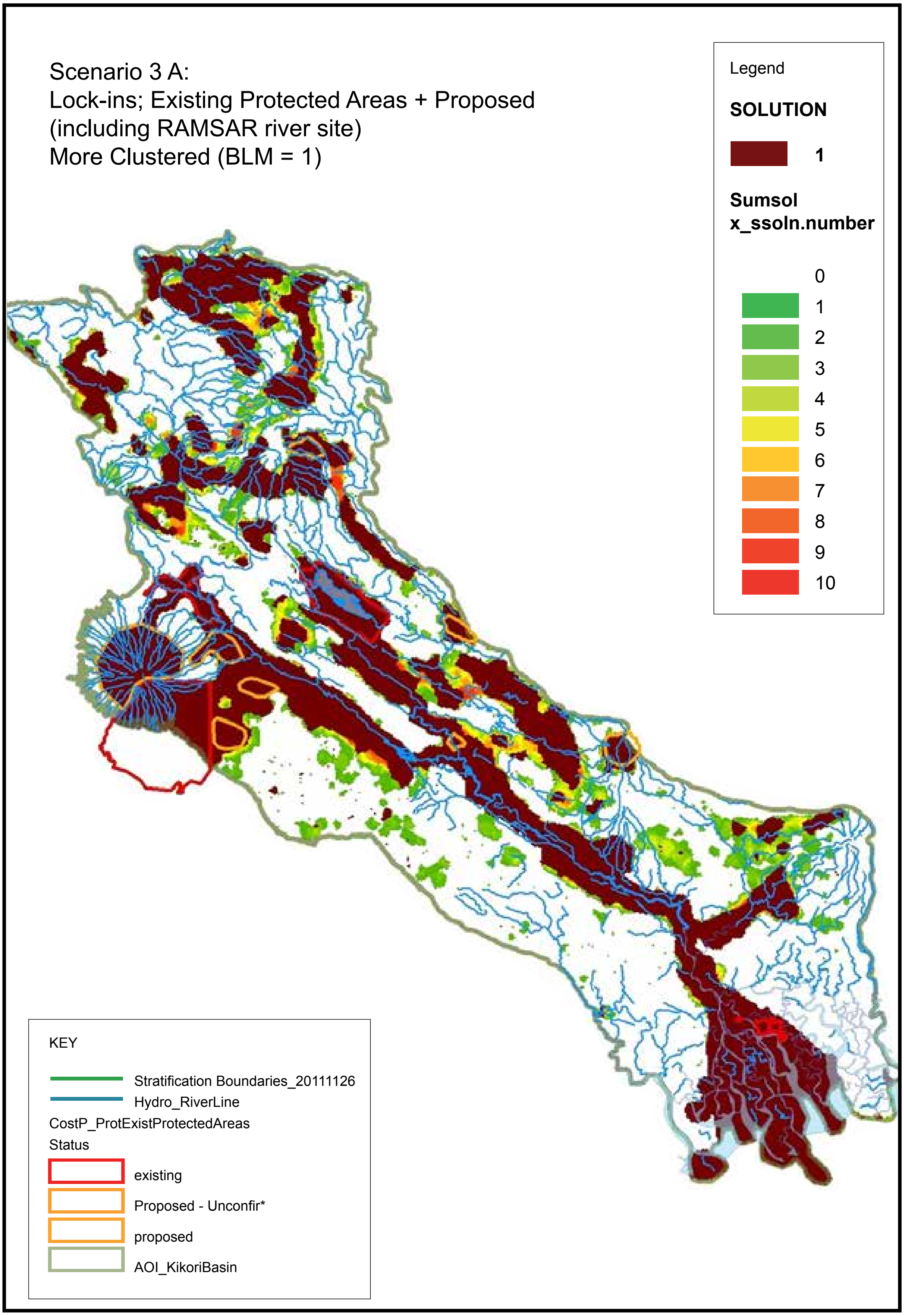
Rain clouds form a mist over River Kikori as it flows south

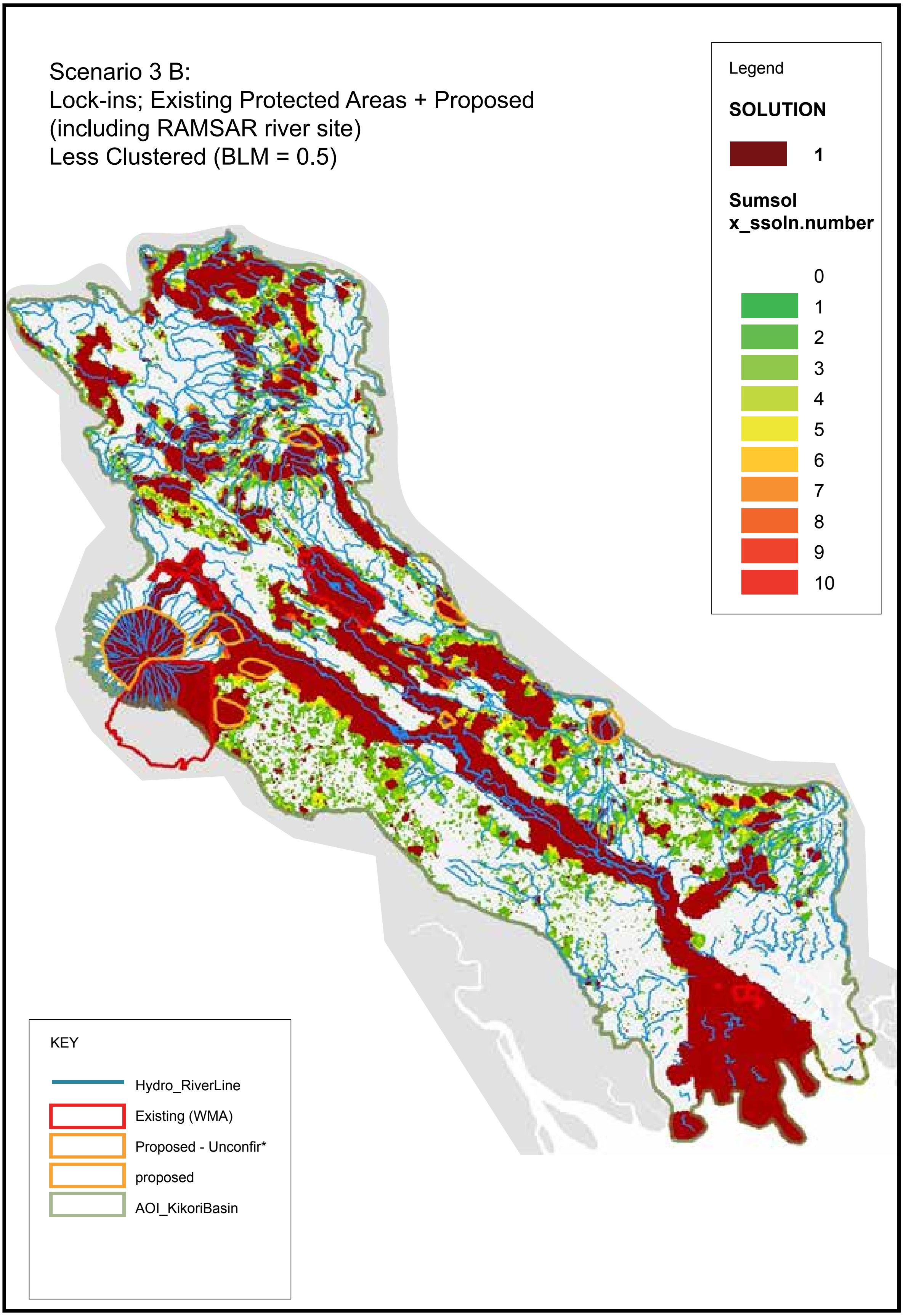

Scenario 1 A: Unconstrained
More Clustered (BLM = 1)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Stratification Boundaries_20111126
Hydro_RiverLine
CostP_ProtExistProtectedAreas
Status
existing
Proposed - Unconfir*
proposed
AOI_KikoriBasin


Scenario 1 B: Unconstrained
More Clustered (BLM = 0.5)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Stratification Boundaries_20111126
Hydro_RiverLine
CostP_ProtExistProtectedAreas
Status
existing
Proposed - Unconfir*
proposed
AOI_KikoriBasin


Scenario 2 A:
Lock-ins; Existing Protected Areas + Traditional Areas
More Clustered (BLM = 1)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Stratification Boundaries_20111126
Hydro_RiverLine
CostP_ProtExistProtectedAreas
<all other values>
Status
existing
Proposed - Unconfir*
proposed
AOI_KikoriBasin


Scenario 2 B:
Lock-ins; Existing Protected Areas + Traditional Areas
Less Clustered (BLM = 0.5)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Stratification Boundaries_20111126
Hydro_RiverLine
CostP_ProtExistProtectedAreas
Status
existing
Proposed - Unconfir*
proposed
AOI_KikoriBasin


Scenario 3 A:
Lock-ins; Existing Protected Areas + Proposed
(including RAMSAR river site)
More Clustered (BLM = 1)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Stratification Boundaries_20111126
Hydro_RiverLine
CostP_ProtExistProtectedAreas
Status
existing
Proposed - Unconfir*
proposed
AOI_KikoriBasin



Scenario 3 B:
Lock-ins; Existing Protected Areas + Proposed
(including RAMSAR river site)
Less Clustered (BLM = 0.5)
Legend
SOLUTION
1
Sumsol
x_ssoln.number
0
1
2
3
4
5
6
7
8
9
10
KEY
Hydro_RiverLine
Existing (WMA)
Proposed - Unconfir*
proposed
AOI_KikoriBasin

DISCUSSION

SCENARIOS

All scenarios were able to meet or exceed conservation goals for all of the biodiversity targets because the natural environment of the Kikori River Basin is still relatively intact. ScenarioS 2a & 2b show locked-in conservation areas and traditional areas. Scenarios 3a & 3b show locked-in conservation areas, traditional areas, and also highlight potential additional areas that could be protected or managed to conserve the Kikori River Basin's biodiversity (including Ramsar river site). Table 3 summarises the detailed results of all three scenarios for each of the BLM options.

Taking into consideration that all three scenarios for each of the two BLM clustering options meet or exceed conservation goals for all of the biodiversity targets, it is desirable to identify the MARXAN scenario that scores best for efficiency.

The MARXAN Score is calculated using the "objective function":

(∑Cost) + (BLM * ∑Boundary) + [(∑CFPF) x Penalty]

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Table 3: Scenario Summary

Species_ Sample	Species_ Sample_Desc	Goal	1 A		1 B		2A		2B		3A		3B	
			% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured
30	Pig-nosed turtle nesting	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
31	Pig-nosed turtle breeding	50%	119%	60%	116%	58%	118%	59%	115%	57%	175%	88%	174%	87%
32	Dolphins	80%	100%	80%	100%	80%	100%	80%	100%	80%	107%	86%	107%	86%
100	Coastal mangroves	30%	123%	37%	125%	37%	125%	38%	125%	37%	203%	61%	203%	61%
200	Riverine succesions dominated by grass	20%	124%	25%	119%	24%	329%	66%	318%	64%	417%	83%	417%	83%
300	Mixed swamped forest	20%	100%	20%	100%	20%	100%	20%	100%	20%	122%	24%	123%	25%
400	Swamped woodland	25%	113%	28%	113%	28%	113%	28%	113%	28%	134%	33%	113%	33%
500	Peat swamped forest	90%	101%	91%	101%	91%	101%	91%	100%	90%	104%	93%	104%	93%
600	Swamped grassland	25%	101%	25%	101%	25%	101%	25%	101%	25%	104%	26%	104%	26%
801	Open forest (below 400m)	20%	100%	20%	100%	20%	100%	20%	100%	20%	348%	70%	340%	68%
802	Open forest (400-1000m)	20%	122%	24%	100%	20%	105%	21%	100%	20%	215%	43%	210%	42%
902	Large crowned forest (400-1000m)	30%	100%	30%	100%	30%	100%	30%	100%	30%	144%	43%	144%	43%

Species_ Sample	Species_ Sample_Desc	Goal	1 A		1 B		2A		2B		3A		3B	
			% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured
1001	Large medium crowned forest (below 400m)	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%
1101	Small crowned forest (below 400m)	25%	100%	25%	100%	25%	100%	25%	100%	25%	105%	26%	105%	26%
1102	Medium crowned forest (400-1000m)	25%	100%	25%	100%	25%	100%	25%	100%	25%	112%	28%	112%	28%
1201	Small crowned forest (below 400m)	25%	103%	26%	102%	25%	103%	26%	102%	25%	117%	29%	116%	29%
1202	Small crowned forest (400-1000m)	25%	101%	25%	101%	25%	101%	25%	101%	25%	101%	25%	101%	25%
1203	Small crowned forest (above 1000m)	25%	100%	25%	100%	25%	104%	26%	104%	26%	122%	30%	122%	30%
1302	Small crowned forest on Karst (400-1000m)	25%	100%	25%	100%	25%	100%	25%	100%	25%	100%	25%	100%	25%

Species_ Simple	Species_ Simple_Desc	Goal	1 A		1 B		2A		2B		3A		3B	
			% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured	% of Goal Captured	% Captured
1402	Small crowned forest with *Nothofagus* (400 - 1000m)	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%
1403	Small crowned forest with *Nothofagus* (above 1000m)	50%	100%	50%	100%	50%	100%	50%	100%	50%	104%	50%	104%	52%
1503	Small crowned forest with Conifers (above 1000m)	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%	100%	50%
1603	Very small forest (above 1000m)	60%	100%	60%	100%	60%	100%	60%	100%	60%	101%	61%	101%	60%
1703	Sub-alpine grassland (above 1000m)	45%	100%	45%	100%	45%	100%	45%	100%	45%	100%	45%	100%	45%
1803	Alpine grass-land (above 1000m)	60%	100%	60%	100%	60%	100%	60%	100%	60%	100%	60%	100%	60%
1902	Lake	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
99999	River	75%	100%	75%	100%	75%	100%	75%	100%	75%	133%	100%	133%	100%

The 'objective function' is simply a product of (total cost of all planning units (PU) included) + (how clustered they are) + (penalty for unmet goals). The Cost is calculated by total of the cost value assigned to each PU. The PUs show the number of planning units selected for that result. Fewer planning units selected means that portfolio is a smaller area and therefore the costs for conservation lower. Table 4 shows how MARXAN scored the results of the 3 scenarios, each with two clustering options. Preliminary results scored scenario 1b as the best for efficiency.

Table 4: MARXAN scores of efficiency

	Score	Cost	PUs
1a	5,992,829	4,865,240	26,728
1b	5,781,163	4,771,090	26,679
2a	6,170,420	4,911,325	26,910
2b	5,935,840	4,841,690	26,860
3a	6,917,520	5,882,155	31,378
3b	6,681,333	5,818,430	31,335

LOCAL EXPERT COMMENTS

The second workshop was used to obtain expert views of the scenarios and to examine the use of MARXAN and the scenarios as a tool to assist and guide the LLGs and provincial governments with the development of provincial land-use plans for the Kikori River Basin landscape to include conservation recommendations from the Kikori River Basin Conservation Blueprint into their land-use plans.

The overall view from the workshop participants was that the areas defined in the MARXAN scenarios agreed with and reinforced their expert opinions of which areas are important for protection and management.

There was agreement that the products from MARXAN and the language and interpretation of these products are crucial to the success or failure of the Kikori River Basin Conservation Blueprint drafting approach. Considerable thought needs to be given to the delivery, interpretation and explanation of MARXAN products for use in the communities, LLGs and provinces, or with other audiences, to avoid misinterpretation of the outputs from MARXAN – e.g. through misunderstanding limitations of the input data, or using the outputs/blueprint as prescriptive rather than as providing a starting point for review and discussion. It was also recognised that MARXAN could be used as a tool to periodically evaluate progress towards biodiversity conservation of the Kikori River Basin landscape.

Most concerns about the scenario outputs related to the development of the cost grid and related land management issues. For example, there were some concerns about the large area identified as potential "conservation areas" as these often encompass several different levels or types of management. Although some of these areas are conserved under a management plan, the cost surface did not include delineation of the specific zonings and types of management within a protected area, that is, the delineation of "effectively managed areas". Also, traditionally managed areas were not fully included within the scenarios. There was recognition that many areas have already been managed traditionally through closed seasons or other means for hundreds of years and as yet these are not effectively captured in the existing data. There were also concerns regarding the relative weightings within the cost surface and how that might influence the inclusion and/or exclusion of sites.

INITIAL COMMUNITY AND GOVERNANCE REVIEW

The draft results of the MARXAN scenarios were presented to the different communities and representatives of LLGs and provincial governments in the Kikori River Basin landscape. The results of the workshops and the MARXAN approach were well received. The communities, LLGs and provincial governments' representatives indicated they felt the results were extremely useful to guide, provide input, and assist the provincial governments of the Kikori River Basin with the drafting of their land-use plans.

Daga Village girl at the Kutubu Kunde Festival 2013

CONCLUSIONS AND NEXT STEPS

The Kikori River Basin Conservation Blueprint has successfully identified the critical areas of highest conservation value across 2.2million hectares of one the most important remaining areas of biodiversity and extant rainforest globally – the first time this has ever been done.

The Blueprint provides the most complete data analysis of conservation and biodiversity information currently available at the time of development for provincial land use and development plans for the entire region.

The critical next steps from 2015 to 2020 are to:

- Ensure that the key areas of highest conservation value are endorsed and formally recognised in ongoing land use planning by the four provincial governments in the Kikori Basin – Gulf, Southern Highlands, Hela and Enga.
- Engage with and ensure that key government agencies, particularly the PNG Forestry Authority (PNGFA), Conservation and Environment Protection Authority (CEPA) and Office for Climate Change and Development (OCCD) endorse and recognise the critical high conservation value areas in forestry planning, forthcoming protected areas policy and REDD+ policy.
- Engage with and reach agreement with key development stakeholders in the Kikori Basin, with particular emphasis on oil and gas corporates and logging companies, to recognise the critical conservation areas identified by the Blueprint and to make use of it in their development and exploration planning.
- Engage with and raise awareness among Kikori Basin communities, district authorities and at Local Level Government, of the availability of the Blueprint and how it could be used.
- Fund ongoing GIS analysis to update and further improve the biodiversity knowledge base and mapping of the Kikori Basin.
- Fund and support sustainable livelihood efforts of and for the Kikori River basin communities in support the protection of the region's ecological integrity through sustainable use of their forest and cultural assets.

GIS mapping and MARXAN analysis will need to be ongoing as the process of consultation and discussion within each stakeholder is undertaken and realistic boundaries of potential conservation areas are developed. As areas are identified and designated they can be "locked in" to a future MARXAN analysis and used to refine the network and track progress towards the conservation goals.

To improve the MARXAN analysis, and the quality and detail of the outputs produced, there are some data gaps that need to be filled. These include, among others, more detailed vegetation maps and mapping of historical/traditional sites. A more detailed understanding of critical habitat areas for flagship species is also necessary, as information is limited.

However, as the network of conservation areas continues to evolve and develop, and as long as the implementation of the provincial land-use plans is underway, there will be time to refine the selection of areas for inclusion in the network by including improved information as it becomes available.

RECOMMENDATIONS FOR IMPROVED PROCESS AND REFINED OUTCOMES

The Conservation Blueprint of Kikori contains 27 conservation targets, and provides the best option of doing conservation in the Kikori River Basin. We do not expect everyone to agree with all of them. Our hope is that everyone concerned with the future of Kikori River Basin will act on those recommendations they do agree with. We acknowledge that new technology and newer and more refined data-sets will emerge and have emerged, and these will need to be brought into a multi stakeholder consultation process as basis to review and improve the current outcomes.

Successful implementation of the Blueprint will require the active collaboration of conservation organizations, community groups, land/resource owners, resource development agencies (including agricultural organizations, oil and gas, forestry, etc), local level and provincial governments, and individuals. Roles and responsibilities for implementing recommended strategies and action in the coming years will need to be agreed.

It should be noted that while this report is the first ever analysis and detailed mapping of critical biodiversity areas in the Kikori Basin, it is not perfect and needs further refining and collaboration if the best data is to be available for its continued development. In order to properly refine the priority areas already identified as the best options of undertaking conservation in the Kikori River Basin, work need to be done to:

1. Improve the resolution of the maps to scale them for use at a more local level. The maps presented in this Blueprint are regional, covering a huge area. Individual proposed conservation areas need to be identified and the accuracy and precision of the target data sets need to be discussed. Comments from some managers who have used MARXAN in reserve design scenario development in Australia have been that the technique is too coarse for local planning given the mismatch between scales of data sets, analysis and on-ground application. This is evident that "the cost surface did not include delineation of the specific zonings and types of management within a protected area" and did not fully include traditionally managed areas.

2. Incorporate key stakeholders in the planning process going forward which will be critical to implementation of planning objectives. One approach would be to incorporate a data layer in the analysis relating to the existing use of land management techniques that maintain biodiversity values, including designation of conservation areas or minimal use areas, or low impact land use practices.

3. Compile a more complete regional database of all relevant biological, ecological and socio-cultural knowledge relevant to each identified area, as well as its distribution, status and threats. This would provide an extremely useful background resource for future assessments such as IUCN Red Listing and CITES monitoring as well as aiding with protected areas policy for government organizations such as CEPA .

4. Further analyse overlay data layers of other conservation targets to assess spatial overlap with the 27 targets and the appropriateness of the 27 targets as overall biodiversity surrogates. This would assist achievement of the stated objective of the Blueprint "to synthesise the most current biodiversity knowledge".

5. Carry out a comprehensive (inclusive) assessment of regional biodiversity values, their distribution and variability across the region, and status (i.e. stable, declining, threats) would be useful to address biodiversity comprehensiveness, adequacy and representativeness (CAR principles; JANIS 1997). Guiding conservation principles and protected area design principles should be articulated within the Blueprint, and aligned with the regional conservation goals and objectives. They can be used also to guide discussions and reserve development, particularly given the landscape-scale conservation imperative exacerbated by rapid development and global warming which has highlighted the importance of landscape connectivity and the maintenance of ecological processes.

6. Align the Blueprint strategy with the regional, national and international policies and legislation relating to biodiversity conservation and ecologically sustainable development. The Millenium Ecosystem Framework recognition of the interdependence of biological and human socio-economic and cultural welfare is also relevant, particularly given the high level of community land ownership in PNG and intimate dependence on and interaction with natural resources.

7. Carry out further work to acknowledge the prevalence of community land ownership and management, traditional usage of and interdependence on natural resources, and ongoing community needs and development opportunities, particularly where communities may perceive advantages from short-term financial developments (e.g. logging) or longer-term developments (e.g. broad-scale palm oil plantation establishment) that are counter to ecologically sustainable development and maintenance of the region's natural values. Ongoing use and involvement of communities in land management is particularly pertinent in PNG. It forms a necessary part of increasing awareness and adoption of conservation objectives and practices, and the development of local strategies that address socio-economic and cultural, as well as ecological, welfare. It may also be worthwhile to highlight communities whose land use is sustaining conservation values, in respect and recognition of their actions, to facilitate and sustain such actions, and as a guide to potential management strategies and discussions in other areas.

8. Update known data on current forest extent and condition (Shearman et al., 2008), rather than using older data, so that the chances of including recently deforested or degraded land in the proposed protected areas are avoided (Moore et al., 2009).

9. Improve the land use constraints layer via MARXAN to clearly identify areas suitable for industries such as forestry, oil palm, petroleum (oil and gas), mining, etc. would reduce the chance of conflict between allocations to protected area management and allocations for commercial development.

10. Update social and cultural data from relevant institutions.

11. Start developing a PNG wide payment of ecosystem services (PES) model to enable the effective consideration of opportunities for the network of the conservation areas to best safeguard the unique biodiversity of the Kikori River Basin.

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Patience and persistence by staff, pulling together the report from drafts, to tracking and checking with people who were directly involved, to cross checking information, literature search to unlocking data and maps on hard drives that moved from Port Moresby to Madang to Fiji, staff who were not directly involved with the planning workshops nor with the project, was nurtured by the vision and memory of high elevation water body that is Lake Kutubu, the colorful Melanesian kinsmen of the region and the calm evoked by the endless forest in the awe inspiring Kikori landscape. This region is a gift of Nature. Every action to safeguard its integrity is an act of reverence.

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Chopping sago, a staple part of diet in the Kutubu Region

GLOSSARY

Biodiversity	The variability among living organisms from all sources, inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part, this includes diversity within species, between species and of ecosystems (Glowka et al., 1994).
Conservation Area	Land under community or other ownership that is managed by a community committee for conservation protection. The Prime Minister declares a Conservation Area on recommendation of the Minister for Environment and the landowners.
Conservation Blueprint	The assessment of the natural health of Kikori River Basin and the possible recommendations for the next generation of conservation of the natural and cultural resources of the basin.
Ecoregion	An area defined by environmental conditions and natural features; a region defined by its ecology. www.dictionary.com. Landscape planning units for WWF, modified version for PNG – Conservation Planning Region (CPR) of the DEC. The DEC is using CPR as a base tool to analyse future conservation initiatives (e.g. DEC vegetation change assessment – intersected CPR + PNGFA FIMS Vegetation Types dataset).
MARXAN	A software designed to aid systematic reserve design and conservation planning. Marxan is freely available conservation planning software that provides decision support to a range of conservation planning problems, including: the design of new reserve systems, reporting on the performance of existing reserve systems, and developing multiple-use zoning plans for natural resource management. Marxan is commonly used worldwide and it is maintained by the University of Queensland in Australia. (www.uq.edu.au)
Protected Area	An area declared by the Minister for Environment to protect only those animals declared as protected. [Fauna (Protection and Control) Act 1966].
Ramsar Site	A wetland which fulfils the criteria set forth within the Convention of Wetlands (Sander van den Ende).
Shuttle Radar Topography Mission (SRTM)	An international research effort that obtained digital elevation models on a near-global scale from 56° S to 60° N to generate the most complete high-resolution digital topographic database of Earth prior to the release of the ASTER GDEM in 2009. SRTM consisted of a specially modified radar system that flew on board the Space Shuttle Endeavour during the 11-day STS-99 mission in February 2000, based on the older Spaceborne Imaging Radar-C/X-band Synthetic Aperture Radar (SIR-C/X-SAR), previously used on the Shuttle in 1994 (http://en.wikipedia.org/wiki).
Wildlife Management Area	It is one of the simplest form of protected area and one that gives full power to the land/resource owners to manage their land/resources established/declared under the Fauna (Protection and Control) Act 1996.
World Heritage Site	A place (such as a forest, mountain, lake, desert, monument, building, complex or city) that is listed by UNSECO as of special cultural or physical significance

REFERENCES

Ball, I. and Possingham,H. 2000. *MARXAN (v1.8.2) Marine Reserve Design using Spatially Explicit Annealing – A Manual prepared for the Great Barrier Reef Marine Park Authority*. Retrieved from http://www.ecology.uq.edu.au/index.html?page=27710

Chatterton, P., Higgins-Zogib, L., Yamuna, R. and Duguman, J. (in prep). 2005. *PNG National Rapid Assessment and Prioritisation for Priority Protected Areas Management (RAPPAM).*

Groves, C., Valutis, L., Vosick, D., Neely, B., Wheaton, B., Touval, J. and Runnels, B. 2000. *Designing a Geography of Hope: A Practitioner's Handbook for Ecoregional Conservation Planning*. The Nature Conservancy, Arlington, VA.

HCVF Technical Committee. 2005. *High Conservation Value Forest Toolkit for Papua New Guinea: A national guide for identifying, managing and monitoring High Conservation Value Forest.* First Edition. PNG Forest Stewardship Council Incorporated.

Hammermaster, E.T. and Saunders, J,C. 1995. Forest Resources and Vegetation Mapping of Papua New Guinea. In: *PNGRIS Publication,* No. 4, Australian Agency for International Development, Canberra, Australia. 2601pp.

Hinchley, D., Lipsett-Moore, G., Sheppard, S., Sengebau, F.U., Verheij, E. and Austin S. 2007. Biodiversity Planning for Palau's Protected Areas Network: An Ecoregional Assessment. In: *TNC Pacific Island Countries Report* No. 1/07. The Nature Conservancy, Indo-Pacific Resource Centre, Brisbane, Australia.

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

JANIS (Joint ANZECC/ MCFFA National Forest Policy Statement Implementation Subcommittee). 1997. *Nationally agreed criteria for the establishment of a comprehensive, adequate and representative reserve system for forests in Australia.* Commonwealth of Australia, Canberra, Australia.

Moore, G. L., Game. E., Peterson, N., Saxon, E., Sheppard, S., Allison, A., Michael, J., Singadan, R., Sabi, J., Kula, G and Gwaibo, R. 2009. Interim National Terrestrial Gap Analysis for Papua New Guinea: Planning for Climate Change. *PNG PoWPA Gap Analysis Report.* Unpublished report for DEC.

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.* University of Papua New Guinea, Port Moresby, Papua New Guinea.

Watson, J.E.M., Evans, M.C., Carwardine, J., Fuller, R.A., Joseph, L.N., Segan, D.B., Taylor, M.F.J., Fensham, R.J. and Possingham, H.P. 2011. The capacity of Australia's protected-area system to represent threatened species. In : *Conservation Biology,* 25(2):pp 324–332.

WWF (2006). Nomination of the Kikori River Basin and Great Papuan Plateau for World Heritage Site/UNESCO. http://whc.unesco.org/en/statesparties/pg

WWF Kikori Technical Reports:

1. Rogers, H. 2008. *Forestry Impact Assessment for the PNG LNG Project For Coffey Natural Systems*, CNS801_Forestry, Booyong Forest Science Pty Ltd.

2. Wilkie, M.L, 2010. Global Forest Resources Assessment 2010, In: *Papua New Guinea, Country Report*, FAO Forestry Department, Viale delle Terme di Caracalla, Rome 00153, Italy.

3. Rieley, J.O. Tropical Peatland - The Amazing Dual Ecosystem: Coexistance and Mutual Benefit, School of Geography, University of Nottingham, Nottingham, NG72RD, UK,. Retrieved from: http://www.geog.le.ac.uk/carbopeat/media/pdf/yogya papers/p41.pdf

Georges, A. 2012. *The Piku Project: Community-led Conservation (The Pig-nosed Turtle, Carettochelys insculpta*). Final report prepared by the Institute for Applied Ecology, University of Canberra, for the Kikori community, Gulf Province Papua New Guinea. Institute for Applied Ecology, University of Canberra ACT 2601, Australia.

Asian Turtle Trade Working Group 2000. 2011. The IUCN Red List of Threatened Species. Retrieved from: http://www.iucnredlist.org/apps/redlist/details/3898/0

Georges, A., Doody, J.S., Eisemberg, C., Alacs, E.A. and Rose, M. 2008. Carettochelys insculpta Ramsay1886 – Pig-Nosed Turtle, Fly River Turtle. In: Rhodin, A.G.J., Pritchard, P.C.H., van Dijk, P.P., Saumure, R.A., Buhlmann, K.A. and Iverson, J.B. (Eds), *Conservation Biology of Freshwater Turtles and Tortoises*. Chelonian Research Monographs 5. Chelonian Research Foundation.

Georges, A., and Rose, M. 1993. *Conservation Biology of the Pig-nosed Turtle, Carettochelys insculpta*. Applied Ecology Research Group and the Wildlife Trust. Chelonian Research Foundation.

Eisemberg, C. 2010. *Nesting Ecology, Harvest and Conservation of the Pig-nosed Turtle (Carettochelys insculpta) in the Kikori region*, Papua New Guinea. Institute for Applied Ecology, University ofCanberra, Australia. A thesis submitted in fulfillment of the requirements of the Degree of Doctor of Philosophy at the University of Canberra, Australia.

The inner back cover pocket holds A3 Scenario Maps 1A & 1B (enlargement of maps on pages 24 & 25).It is intended to be pulled out and used against topographical or other maps during planning, so as to accurately demarcate areas for protection. Maps 1A & 1B represent collation of features and scenarios in maps 2A & 2B and maps 3A& 3B

What We Do

Who are we?

WWF is an international conservation organization. Its mission is to stop the degradation of the planet's natural environment and build a future in which humans live in harmony with nature.

Where we work?

Madang Province
and the Kikori Basin

Building Partnerships

We welcome approaches from government, community groups and other NGOs to work on initiatives to improve livelihoods and the environment.

Community Support

We can work with your community on better ways to manage your forests and fisheries, to defend against the impact of climate change or look after threatened species and your customary land rights.

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