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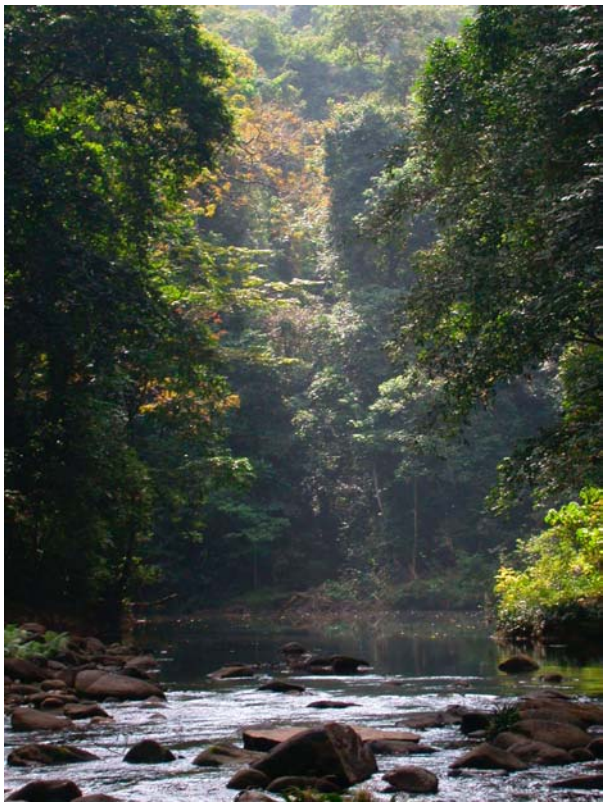
LM
Forest Resource Solutions Ltd.

Ecosystem-Based Natural Resource Management

In the Forests of Cross River State



Prepared for:

The Canadian International Development Agency (CIDA)

And

One Sky - Canadian Institute of Sustainable Living

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PROJECT SCOPE AND OBJECTIVES

GENESIS OF THE PROJECT

CIDA has had a bilateral program in Nigeria since 1998 with emphasis in two states – Borno and Cross River State (CRS). The program emphasizes environment, agriculture, and health. In 2003, CIDA contracted a Canadian NGO (One Sky) to deliver an environmental capacity building program. One Sky fostered six north-south partnerships that would further CIDA programming. One such alliance was that formed between Living Earth Nigeria Foundation (LENF) and LM Forest Resource Solutions Ltd. (LM) to develop a bioregional framework for sustainable resource use and ecosystem conservation. Both organizations (LENF and LM) work in forest resource management and conservation planning and, in the course of their discussions regarding CRS, noted that there had been no landscape level, strategic analysis of ecosystem resilience. They decided to collaborate to develop an ecosystem-based management plan for the state.

PURPOSE OF THE REPORT

The fundamental purpose of an ecosystem-based management plan is to provide organizations responsible for resource use planning with a strategic framework for resource use decisions that recognizes environmental risk and:

- identifies areas of critical ecological significance
- delineates core ecosystems
- outlines management goals and operating principles,
- outlines monitoring requirements and implementation considerations
- elucidates available data and information gaps making it easier for stakeholders to identify priorities for future work
- serves as a template for any future ecosystem-based analysis in CRS or other regions.

The plan is not meant to define land use rules but rather provide broad guidance on activities that will be ecologically appropriate.

It is expected that the plan will provide useful direction to senior government bureaucrats in the Forestry Commission, Ministry of Environment, and Parks Branch as well as industry planners, forest management committee leaders, and senior individuals within NGOs concerned with natural resource use and conservation. Examples of the kinds of broad zoning that might come out of the plan include the identification of extractive forest reserves, areas of conservation tourism, or areas of potential timber harvesting.

THE CONTEXT FOR ECOSYSTEM-BASED MANAGEMENT IN CROSS RIVER STATE

BIOLOGICAL CONTEXT

Tropical forests are among the most diverse natural environments on earth and their influence on climate, the gene pool, and global energy systems reaches far beyond local borders. The accelerating rate at which these forests are being destroyed around the world has garnered international attention and there is increasing commitment to stop the loss and ensure forest use is more sustainable. The process of forest loss is particularly well advanced in Nigeria where more than 90% of the original moist forest area has been cleared. Much of that remaining is within Cross River State. Approximately 35% of the total area within the state is forested (7610 km²) and, together with

similar adjacent areas in Cameroon, the existing forest is one of the best examples of contiguous, relatively undisturbed tropical moist forest in Africa. Forest management practices, however, are far from ideal. In a recent report (1999) commissioned by the Federal Department of Forestry it was concluded that:

- Forest management is practiced at a very basic level within the state.
- Forest management planning is virtually non-existent.
- High forests are being degraded and eradicated at an alarming rate.
- Forest resources are not being managed on a sustainable basis.
- Reinvestment in the resource is virtually non-existent.
- The current trend must be halted to avoid environmental disaster.

Cross River State is located between 4 1/2 degrees and 7 degrees north of the equator at the western edge of the Guinean-Congolian basin (2.8 million km^2). The state, covering 21,560 km^2 is bordered by Cameroon to the east, the Nigerian states of Benue, Enugu, Abia, and Akwa Ibom to the north and west, and by the Gulf of Guinea to the south.

The area was likely a refuge during past arid climate phases and was probably isolated during the Pleistocene. This fact combined with variable rainfall and a pronounced elevation gradient in some areas has resulted in an area of outstanding biological diversity with high endemism. It is estimated that 12% of the ~4000 plant species in the area are endemic and that wildlife species are diverse (e.g. over 1000 species of forest butterfly) with high levels of mammal, snake, and amphibian endemism.

Figure 1. Geographic location of Cross River State

Rainfall varies from 1800 to 4500 mm annually with the driest period (longer in the north than in the south) occurring from November to April. There is a general decrease in rainfall away from the coastal areas northwards and westwards. Peak flows in most rivers occur towards the end of the wet season in September or October and rivers can rise by as much as 2.5 m above dry season levels. Mean annual temperature is about 27 degrees.

Most of the state is rolling or flat with significant areas of mangrove along the coast and inland freshwater wetlands, particularly along the Cross River. Forested areas generally occur on rolling and mountainous topography rising to 1180m in the Oban Division of the National Park and 1820m in the Okwangwo Division.

Cross River soils are predominantly of five types. These are: (i) the steep, shallow, yellowish and red, gravely soils on the Oban and Obudu Hills; (ii) the deep, lateritic, fertile soils on the Cross River Plain; (iii) the dark clayey basaltic soils in Ikorn; (iv) the sandy, heavily leached, sandy soils on the older coastal plain; and (v) the swampy hydromorphic soils of the lower deltaic coastal plain that are usually flooded during the rains. Soils on the coastal plain are predominantly sands and silts with low cohesion values, high internal pore pressure and seepage forces, and low angle of internal friction making them highly susceptible to gully erosion. Because of the intensity of weathering (due to high rainfall levels), soils throughout the state are often deficient in weatherable minerals. Soils in forested areas can be generally characterized as acid, medium to coarse textured, with low cation exchange capacity, and leached of mineral elements. Conservation of organic matter is a vitally important aspect of maintaining soil fertility in these types of soils.

Although a variety of forest inventory work has been completed, no detailed classification maps have been produced for the state. The most detailed mapping comes from satellite imagery (Flasse, 2003) in which vegetation cover was broken down into the nine basic types listed in table one.

Table 1. Vegetation categories in Cross River State.

Tropical High Forest	29.71%
Open forest	5.60%
Swamp	2.40%
Mangrove	4.41%
Regenerating forest	0.07%
Oil Palm plantation	0.86%
Rubber plantations	0.62%
Gmelina plantation	0.47%

Tropical high forests (THF), largely uneven-aged, semi-deciduous or evergreen rainforests, represent almost 30% of the land base in CRS. Most of this is considered to be lowland rainforest.

Natural disturbance agents include pathogens and wind, with minor levels of disturbance from wildlife (e.g. elephants and primates). These agents typically create small forest gaps providing some opportunity for seral species to regenerate, however, much of the regeneration is under the canopy of mature trees and so most species in the tropical high forest are shade tolerant. A far more important source of disturbance is anthropogenic, including: slash and burn agriculture, logging, burning to enhance grazing opportunities for cattle, and establishment of exotic plantations. Across Nigeria, human activities have led to a 96% reduction in lowland rain forest.

The Cross River and numerous associated tributaries form the main water system in the state but there are also the Calabar, Kwa, Ebe, and Akpa-Yafe rivers draining the southeast part of the state. These rivers drain into an extensive area of mangrove. Delta formation is limited.

Within the many rivers, lakes, and wetlands in the state, about 230 fish species have been recorded, 104 of which occur in the Cross River which has the highest diversity index of all the rivers. In the upper Cross River there are ~ 90 fish species, at least four of which are endemic. One author felt that Cross River had more fish species than any other comparable west African river basin. Despite this, it is not considered to be particularly productive in terms of fish yield, with an estimated annual catch of 7,800 tonnes (~ 10 kg/ha/yr), 5000 of which come from the fresh water zone. Fishing has been found to contribute as much to the local consumption of protein and village economies as hunting in the region. Primary species caught include Tilapias, Clarias, Labeos, and Chrysichthys. Both finfish and shellfish are also important in the southeastern part of the state where many species are dependant on mangroves and their inland counterparts (swamps and mudflats). Fish stocks in the rivers are generally replenished from their adjacent floodplains after each flood season. Any phenomenon that disrupts the natural hydrological cycle of flooding or tidal flow is expected to affect fish species diversity and productivity, including in wetlands.

SOCIO-ECONOMIC CONTEXT

Human Intervention and Impacts

Nigeria is the most populous country in Africa (~ 140 people/km^2 versus 3/km^2 in Canada versus 6/km^2 in Gabon) and although Cross River is the least populous state it still has over 2 million people (1991 census data) in over 620 recognizable human settlements (65 people/km^2)[1]. If the parks are not considered part of the inhabitable area, population density is closer to 100 people/km^2. The vast majority of the population live in rural areas, in small nucleated settlements. Along the creeks and swamps of the lower Cross River valley, many of the small settlements consist of fishing camps which are occupied for only a few months in the year.

Population pressure of this magnitude is the primary reason for the depletion of tropical high forest in Nigeria and elsewhere. Forested areas are coming under increasing pressure from slash and burn agriculture, hunting, and industrial activities such as logging and plantation establishment. Farmland and plantations now occupy almost 60% of the land area in CRS.

Although significant tracts of land within CRS have protected area status, hunting continues virtually unabated in many areas, including the national park. Despite recent progress in protecting gorillas from hunting (no confirmed killing of gorillas in the park within the last 5 years), the bushmeat trade continues to be a major driver in depleting wildlife resources in Cross River State. A recent study highlighted that communities living near rain forest in Nigeria obtained as much as 84% of their total animal protein needs from bushmeat. Central Africans eat as much meat as most Europeans or North Americans, most of which comes from wildlife. Thirty million people eat 1.1 million tons of wildlife each year – the equivalent of 4 million cattle.

Habitat destruction from agricultural practices and improved access and transport (of meat) resulting from new road construction into forested areas for timber harvesting, are the main reasons for declining wildlife populations and even extirpation in some areas. Ecosystem functioning is dependant on the presence of all components of the system, including wildlife, which contributes to important processes like seed dispersal, forest disturbance and microclimate, nutrient cycling, population dynamics, and the gene pool. Destruction of habitat for agriculture will also disrupt natural ecological processes such as watershed hydrology, nutrient cycling, evapotranspiration, and terrain stability.

[1] Recent estimates of population are as much as 3 million people.

Figure 2. Products of the bush meat trade. CERCOPAN photo

Link Between Human Well-being and Environment

Human culture and economies are a subset of ecosystems and so human activities that compromise ecosystem integrity will eventually lead to decreased human well-being. Agriculture and forestry systems that work with nature, rather than against it are most likely to be sustainable.

The majority of people living in Cross River State live in a rural setting. Many of these communities are forest dependant; it is estimated that two thirds of people living in such communities depend on the forest for a wide range of goods and services including wild foods, clean water, forage or animal feed, fuelwood, medicines, building materials (homes, furniture), spiritual refuge, and sacred places. In one study in Cross River some 15 seeds, 3 oil seeds, 44 fruits, 5 vegetables, 13 spices, 25 mushrooms, and 69 medicinal plants were collected and used by forest dwelling communities. It is estimated that forest resources account for up to 78% of family income in rural Cross River State. Use of the forest can, however, become unsustainable. It is well documented that soil fertility experiences a rapid decline following removal of natural vegetation in tropical forests. Unlike temperate climates, there is little organic reserve (humus) in most upland tropical soils. Although farmers typically leave cultivated areas fallow for a number of years to compensate for this, growing population pressure has meant increased land use intensity and shorter fallow periods, resulting in new plots of land being cleared at greater distance from villages, deeper within the forest. In addition to a reduction in crop productivity following insufficient fallow periods, such practices can also lead to an increase in crop pests. The soil resource is a primary component of all terrestrial ecosystems, and any environmental stressor that alters the natural function of the soil has the potential to influence the vitality, species composition, and hydrology of forest ecosystems. Unfortunately, on the highly weathered soils of the Oban and Obudu hills and old coastal plain, population pressure has meant that vegetation litter as a source of nutrients can no longer be assured.

Increasing population pressure also means that non-timber forest products are also being harvested further and further afield. This is sometimes compounded by unsustainable practices such as, for example, the destruction of trees in pursuit of their fruits, pulling plants out by their roots, or stripping off an entire vine instead of the leaves only (Afang harvesting).

Although many rural residents understand the link between forest cover and soil fertility, their understanding of NTFP regeneration, fish stocks and recovery rates, and habitat needs and

reproduction rates of forest animals is not always as strong. Lack of data or understanding in such situations can lead to practices which are not sustainable and make regulation difficult. Compounding the problem are overt acts of environmental abuse such as the use of pesticides or natural poisons to kill fish in a stream during the spawning season, or completely emptying pond areas of water to harvest all the fish. Such practices lead to destruction of breeding capacity and damage to the flora and insect fauna important to the system.

The story is the same with hunting pressure and wildlife. Villagers often complain that animals are scarcer and one must go further to find them. Too many areas have become an "empty forest" with few animals and compromised ecological process that will eventually lead to major environmental degradation such as loss of forest cover, change in the forest structure and species, unstable terrain, increased erosion, and climate change. Finally, increased population pressure can also lead to water pollution, sickness, and decreased human productivity.

Building Socio-Economic Factors Into EBM

Any attempt at regulating forest use that does not recognize the needs of local communities who are accustomed to access to the forest is unlikely to succeed. Conservation goals and the need for a fully functional ecosystem must be balanced with the welfare of forest dependant communities. For EBM to be effective, resource use guidelines must be ecologically sustainable but also reflect social, cultural and economic considerations. In a practical sense, EBM can only be effective when there is a balance between conservation and development.

Innovative solutions will be required; for example, developing agro-forestry techniques that use cultivation-tolerant NTFPs (nutritive, utilitarian, or medicinal) in areas that are not critical to ecological functioning, domestication of selected wildlife species, allowing "extractive reserves" based on scientific evidence and local regulation, conservation tourism, and economic reward for the maintenance of forest goods and services important to others living away from the forest (e.g. clean air and water). This latter might include, for example, extending micro-credit and infrastructure funding to some villagers or village institutions in exchange for cooperation with resource management authorities. Another example might be ensuring that the value of mimosap oil (extracted without felling the tree) is known and considered before plans are made to fall such trees during timber harvesting operations.

DEVELOPING AN EBM PLAN FOR CROSS RIVER STATE

ECOSYSTEM-BASED MANAGEMENT – WHAT IS IT?

Ecosystem-based management is an adaptive approach to managing resource use that seeks to ensure the coexistence of healthy, fully functioning ecosystems and human communities. The intent is to maintain those spatial and temporal characteristics of ecosystems such that component species and ecological process can be sustained and human well-being supported and improved. Ecosystem-based planning at the landscape level (30,000 to 500,000 ha) aims to maintain overall ecological integrity in landscapes and watersheds with high conservation values, but allows a focus on economic development in landscapes and watersheds with greater economic values. The underlying assumption is that **it is not necessary to sustain all species and processes everywhere, all the time, to maintain ecological integrity**.

The process of designing an ecosystem-based management plan is closely aligned with conservation area design and usually involves identifying core reserves and connecting corridors, multiple use zones, and land use guidelines. This requires an understanding of ecosystem process and function - which areas are ecologically robust and which are sensitive. In Nigeria this is a long term endeavour

that will benefit from a great deal more knowledge. Yet it is imperative that, working with the best available information, and using adaptive management, a broad framework for management be developed and used. It was the intent of this project to use the best available information to develop an ecosystem-based management plan that will provide landscape-level strategies to minimize the risk of ecological degradation and its consequences on human well-being.

EBM PRINCIPLES

In North America, ecosystem-based management recognizes that people are a part of the ecosystems in which they live. Because of this, EBM plans normally go beyond protecting ecosystem integrity to include the well-being of human communities. This should include ensuring that people living within an ecosystem have a fair share of the benefits of that ecosystem. The corollary to this principle is that those who could potentially benefit from forest use must help find solutions for ensuring that its use is sustainable. Strong environmental protection, a strong economy, and a strong social fabric are directly linked.

EBM planning can take on many forms but there are several underlying principles involved:

*The precautionary principle***.** Avoid potentially harmful activities in the absence of scientific certainty about whether they are harmful. Approach resource use cautiously with the explicit intent of maintaining all parts of the system. Purposefully plan to learn from experience and actively test assumptions to achieve continuous improvement.

*Emulate natural disturbance regimes***.** Species are adapted to, and, therefore, more likely to persist, in the environment they have experienced historically. In ecosystem-based management one tries to emulate natural disturbance regimes to reduce the risk of disrupting ecosystem function. The more that managed forests resemble forests that were established from natural disturbances, the greater the probability that all native species and ecological processes will be maintained.

*Maintain ecosystem elements within the natural range of variation***.** In designing resource use, ensure that both ecosystem elements and processes are maintained within the natural range of variation.

Consider multiple scales (temporal and spatial). Maintenance of ecosystem function needs to occur at the landscape level as well as the regional and local level, in both the short term and long term.

*Use indicators and surrogates to deal with ecological complexity***.** Because ecosystems are so complex, especially in the Guinean-Congolian bioregion, we need to use some surrogate for measuring ecological integrity. An example would be whether there is sufficient habitat for certain focal species. An umbrella species is one that has broad habitat needs, generally over large areas. Ensuring adequate populations of these organisms will benefit many other species. An example might be elephants. Umbrella species would be used to assist in decisions about size, shape, and spatial distribution of habitat elements. A keystone species is one that plays a critical role in the ecosystem, enriching ecosystem function in a way that has bigger impact than numerical abundance might indicate. Hornbills for example, consume a quarter of all tree species in the THF and disperse seeds for up to 100km away. They play an important role in forest composition and structure.

Ensure planning and management are collaborative and supplement scientific/technical knowledge with local/indigenous knowledge and systems. In designing resource use, encourage broad participation in planning, respect the diverse values, traditions and aspirations of local communities, and incorporate the best of existing knowledge including traditional, local and scientific knowledge.

Provide for a diverse range of uses. Management for a single use is risky and invites disaster if some element of ecological functioning is overlooked. Ensuring a diversity of uses reduces economic or cultural consequences. If something goes wrong with one type of use, there may be others to fall back on.

In practice these strategies are implemented by establishing:

- *Protected areas* – relatively large undeveloped areas designated for protection by local peoples and/or government through specific authority or legislation. Protected areas may be established to:
    - protect representative samples of native ecosystems and seral stages, focusing on protecting examples of ecosystems that are rare or at-risk in the surrounding region
    - provide critical and seasonal habitat to sustain viable populations of all native species
    - protect regionally rare and/or unique landforms and biophysical features
    - protect culturally and socially significant areas and values, and
    - provide a benchmark for evaluating and comparing managed landscapes.
- *Landscape, watershed, and site reserves* - which are areas where no, or very little, extractive resource use takes place, but the land is not formally designated under legislation. Reserves are established to:
    - protect specific resource values or biophysical features (e.g. cultural heritage resources and features, unstable terrain, scenic areas, and recreation features), and
    - achieve objectives regarding maintenance of ecosystem representation, wildlife habitat, movement corridors, riparian forest, and other landscape design elements.
- *Site/stand **retention** and management:* in which individual trees, groups of trees, plant communities, wildlife habitats, or other features are retained or managed on the site to sustain ecological structures in the unprotected landscape (e.g. wildlife habitat, old forest structure). Site planning and management should focus on:
    - maintaining biological legacies (e.g., coarse woody debris, snags, understory plants)
    - maintaining connectivity between landscape and watershed reserves
    - providing for seasonal and critical wildlife habitat, and
    - protecting special ecological elements (e.g., animal dens, rare plants, small wetlands, waterfalls, karst features, etc.).

In British Columbia, Canada, a multi-stakeholder group that included the provincial government, the forest, fishing, and mining industries, native groups, and the environmental movement, produced an Ecosystem-Based Management Handbook recommending that EBM planning incorporate the following eight design elements:

1. **Representation of:**
   a) Ecosystems (plant communities) that are rare in the landscape;
   b) High value wildlife habitat including wildlife trees;
   c) High value fish habitat;
   d) Riparian ecosystems;
   e) Karst (limestone bedrock formation)
   f) Connectivity areas for focal species;
   g) Unstable slopes; and
   h) Other ecological values
2. **Rare and endangered plant communities** - Reserve 70 to 100% of rare plant and endangered plant communities.
3. **Stand level retention** – Maintain a minimum of 15% minimum of the tree canopy in logged areas..
4. **Maintenance of seral stages within the natural range of variation** - Maintain a variety of age classes)
5. **Estuaries (watershed scale) -** Maintain >90% of the natural riparian forest next to estuaries.
6. **Swamps and Gullies -** Maintain >50% of the natural riparian forest next to fans, forested swamps and small steep streams/gullies with unique microclimate.
7. **High Value Fish Habitat** - Reserve all wetlands, active floodplains, active fluvial units and high value fish habitat including buffers (hydroriparian buffers are equal to at least 1.5 times the height of the dominant trees). Examples of high value fish habitat include: a) where fish

congregate e.g. where clear water streams enter murky rivers and holding pools; b) critical spawning habitat (e.g. larger spawning beds and spawning beds that support threatened or endangered runs); c) critical rearing habitat (e.g. small streams, floodplains, and side channels used for rearing).

METHODS USED IN PRODUCING AN EBM PLAN FOR CROSS RIVER STATE

As stated earlier, the approach used in this project was to adapt North American concepts and methods for ecosystem-based planning to the Nigerian context. To start, a number of questions were posed:

- Do we know when ecosystems are fully functioning?
- Do we need to know the historic range of natural variation?
- What level of departure from historic conditions is acceptable?
- Which surrogates can we use for ecological functioning?
- How do we measure ecological degradation?
- Which areas are ecologically robust?
- What types of data are available?
- What is their reliability?
- Should we use focal species, which ones?
- Should the study include only forested areas in CRS, all of CRS, or adjacent areas in Nigeria and Cameroon?

The answer to these questions lay in knowing whether sufficient information was available to support the kinds of analysis implicit in these questions.

Available Inventory Products

Mapping and forest inventory information we were able to acquire included:

- Two types of broad vegetation classification maps (digital maps produced from satellite imagery with vector based mapping for the whole state, and hard copy maps from 1972 1:40,000 air photos for the southern half of the state).
- 2001 orthophotos at a scale of 1:10,000.
- Three sources of topographic maps at 1:50,000, 1:125,000, and 1:200,000 with contour intervals of 15m, 45m, and 40m respectively.
- Broad maps depicting observed areas of elephant and gorilla use.
- Two inventory databases from 1993 (165 plots) and 1997 (98 plots) with detailed forest mensuration data for each plot including tree information, limited information on NTFPs and plot locations.
- Three inventory reports from 1967 (based on 4000 prism plots), 1994 (based on 130 two ha temporary sample plots, and 1997 (based on 98 plots) detailing, for the areas surveyed, such elements as tree species present, diameter, height, volume, vegetation class, some topographic information. Potential annual allowable cuts were also specified.
- One preliminary evaluation of volume increment and sustainable timber yields for the Oban Division of the Park and for an area north of Oban called Cross River South.

Table 2 provides more detail on the data and mapping products we acquired. Further information on sources is provided under separate cover.

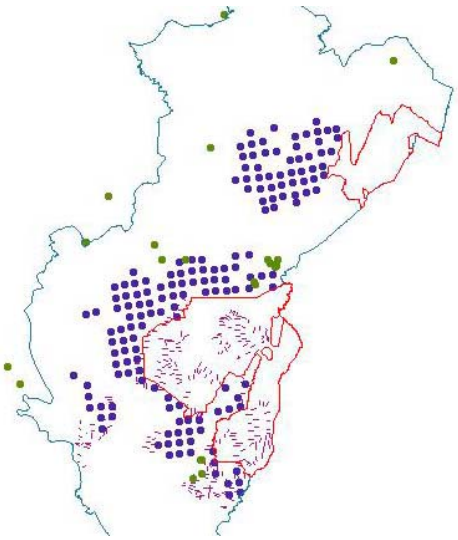

Figure 3. Plot distribution from three separate forest resource inventories.

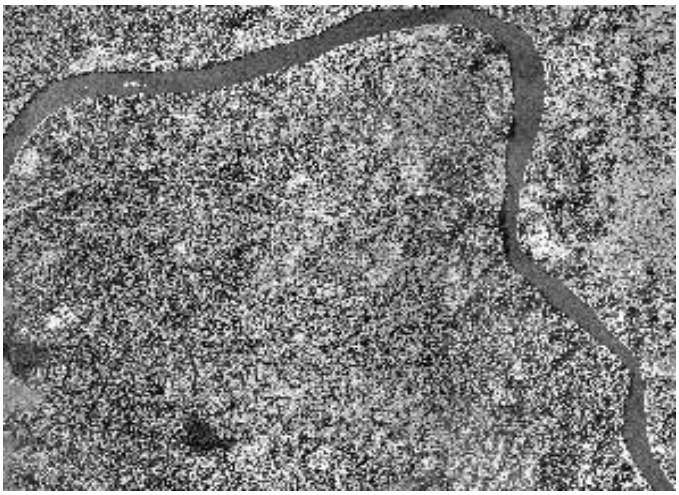

Figure 4. Example of an orthophoto.

Table 2. Data and Mapping Products Acquired for the Analysis

Mapping Products with Associated Database	
2002 Vegetation Map from Satellite Imagery	A digital vegetation map (ARC vectors) for the entire state showing 8 classes of vegetation and normal mapping features. Associated plot data (from 1993 forest inventory) includes: 165 total plots with information on species, form code, diam, and volume. An AAC calculation was provided for all tropical high forest.
1992 1:30,000 BW Air Photos (hard copy only)	Aerial photos are available through the Forestry Commission however, no flight line map could be found. The inventory associated with these photos may be the same as that noted for the satellite imagery.
Mapping Products without Database	
2000/01 1:10,000 Orthophotos	231 scenes (10 km^2 each) produced from aerial photos (TIFF format). Resolution is generally good (with fields, houses, roads, trails, water features, and forest canopy showing up very well) however many scenes with poor reproduction. Towns and rivers are labelled. Coverage for ~ 85% of the state.
1982 1:200,000 Topographic Maps	Scanned topographic maps (contour interval of 40m) produced by the Soviet Union. Four obtained covering the areas missing in the 1:50,000 maps.
1989 1:125,000 Land Use Maps of the Oban Hills	These are hard copy maps of the Southern half of CRS. Three maps: Land Units, Topography, and Land Use with roads, place names, water features shown on all of them. The land unit map shows, for some of the park and support zone only, lowland plains, dissected hills, hills, mountainous terrain and suitability for agriculture including agroforestry. The topography map shows contours (where available) with an interval of 150 feet. Contours missing for about half of the park. The land use map shows three broad categories of use:

	cultivated land, large plantations, and forest.
2002 1:1 million Maps of the Niger Basin	Very broadly defined areas considered to be important hydrological basins, wetlands, fish areas, bird areas, vertebrate areas and areas important for hydrological and ecological processes. Produced in ARC format. Some maps cover parts of Cross River State.
2004 Elephant and Gorilla Population Mapping	Cursory maps depicting observed areas of elephant and gorilla use were available from NGOs such as the Nigerian Conservation Foundation (NCF).
Inventory Data or Reports Without Maps	
1994 High Forest and Swamp Inventory Outside the Parks	130 two ha Temporary Sample Plots were established in 1991 outside the National Park (sample intensity = 1 plot per 20 km2 – 0.1%). 118 in HF and 12 in Swamp Forest. All trees greater than 10 cm and NTFPs were sampled. Statistically valid stem number estimates were made. A variety of boundaries (state, LGAs, forest reserves, park, support zone, vegetation types and areas of erosion risk) were digitized using Idrisi (map **not** available). Area classified as erosion prone if it was >6 degree slope. Growth rates stated in section 3 including diameter and volume increment and AAC by region is provided in appendices.
1967 Survey of Forest Resources in Uwet-Odot, Ekinta, and Oban	Line intercept survey used to establish 4,000 variable area plots. Plots spaced at 500 foot intervals. Circular sub-plots used for regeneration estimates. Trees >6 inches dbh were tallied by species. Heights measured as well as mid bole diameter with a relascope. Volume tables produced for 153 species from 8,000 sample trees. A map of plot locations shown. Forest cover types included ridge forest, high forest, low forest, disturbed forest, swamp forest, raphia swamp forest, and oxystigma swamp forest. Merchantable heights and volumes for developed species provided. Total areas and volumes for each forest type provided.
1997 Nigerian Reconnaissance Inventory of Forest Resources	This is a database for a 1997 forest cover inventory and classification of the country. Classifications in primary forest include: Lowland Rainforest (Dry), Lowland Rainforest (Moist), Riparian Forest, Forested Freshwater Swamp, Montane Forest, Mangrove Forest, Derived Savanna, Guinea Savanna, Sudan Savanna. No classifications were provided for plantations. In CRS there were only 17 clusters established, only 4 of which were in high forest, representing 98 total plots. 30 plots were rainforest and the rest were plantations. Total trees – 1834, of which 1307 are in a high forest cluster. Plot data in high forest includes: cluster lat and long, ecological type, management recommendation, density class (30, 60, >60% crown clos), disturbance class, terrain description (flat poorly drained, flat well drained, gully, lower slope, mid slope, upper slope, ridge, rock slide), slope class (<10, 111 – 30, > 30), altitude, soil texture, depth to seepage, hardpan, and watertable, soil colour, tree species, dbh, butt ht, stem ht, diameters at mid and top, bark thickness, bole quality. NTFP information in high forest includes: species, form, abundance, part used, and uses. NB: not all information that could be recorded is available for every plot!

1996 Geomatics Vegetation Classification Report for Formecu and the National Gov't	Produced a land classification map for the country that has 33 different classifications. The report is in several volumes. It was supported by CIDA. There are example maps in the report but we were unable to obtain the original files or hard copy maps. The land classifications are very broad.
2003 Lowe Report on Sustainable Timber Yield in Nigeria	Preliminary estimates were made of volume increments and sustained timber yields for localities sampled within five high forest reserves in different climatic/geographic regions of Nigeria (Oban Division of the Park was one and Cross River South was another). Two plots were established per square mile (2.59 km²). Data were recorded for all trees >5 cm DBH. Regeneration of exploitable trees >1 m tall were also sampled, and soil samples were taken for laboratory analysis. Volumes were calculated using Sutter's taper functions. Mean annual increments ranged from about 4.2 ±1.0 cu m/ha in Oban, to 5.0 ±0.5 cu m/ha in dryer types, and 6.5 ±1.3 cu m/ha in wetter forests. Standing bole volumes in the plots ranged from 110 to 340 cu m/ha and standing basal areas from 16 to 37 m²/ha

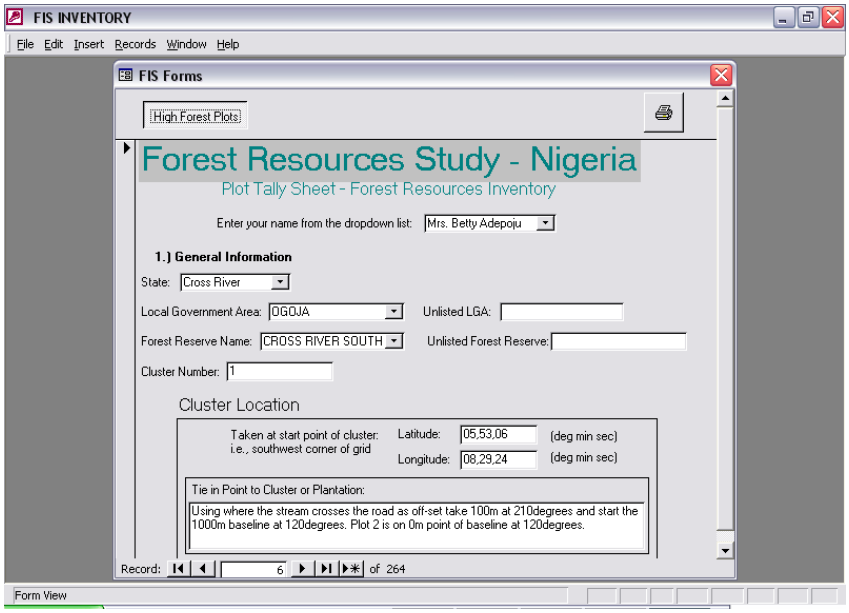

Figure 5. Example of an inventory database (Reimer 1997) without associated mapping.

Based on the information described above, we concluded that it would not be possible to undertake the level of ecosystem-based analysis commonly used in North America because:

- Some mapping products were not available.
- There was no database associated with some map products.
- Resolution of vegetation classes was too coarse.
- Habitat needs of most focal species have not been well defined.
- Budget was insufficient to establish a correlation between habitat and available aerial photography (orthophotos).

A broader approach was therefore used in which we:

1. Acquired and reviewed literature relevant to ecosystem functioning and management of tropical high forest.

2. Interviewed experts such as Richard Lowe (forest biometrician), Elizabeth Rogers (primate specialist), John Oates (professor of ecology), Stephane Flasse (remote sensing expert), and Daniel Otu (forestry specialist).
3. Identified, mapped, and evaluated level of disturbance in watersheds containing tropical high forest.
4. Identified and mapped areas of high stream density, wetlands, and mangrove forest (from orthophotos and existing hard copy maps).
5. Identified and mapped areas of potentially unstable or erosion prone terrain in areas with tropical high forest.
6. Identified and mapped potential habitat for two keystone species (gorilla and elephant) based on information from experts and literature on habitat requirements.
7. Identified core ecosystems and connecting corridors.
8. Developed management zones and resource use guideline recommendations.

Analysis Results

Literature and Expert Interviews

More than 250 documents were reviewed covering a wide range of topics including such things as Poverty and the Environment, The Conservation – Development Interface, Cross River State Forestry Strategic Management Plan, The Relative Effects of Hunting and Habitat Destruction on Elephant Population Dynamics over Time, Vegetation Change Analysis Study for Nigeria Between 1976 and 1995, Rain Forest Conservation and the Needs of Local People, Western Gorilla Diet – A Synthesis From Six Sites, Biodiversity Patterns and Conservation in the Gulf of Guinea Forests, and A Community Wildlife Management Model from Mount Cameroon.

Despite the somewhat lengthy bibliography, there is a paucity of information on most aspects of ecosystem-based planning as it relates to the forests of Cross River State. For this reason, a number of experts were consulted to augment our knowledge of ecosystem function in the area. Types of people interviewed included habitat specialists, growth and yield experts, ecologists from Nigeria, the United States, and the UK, remote sensing experts, a Canadian hydrologist, and various forestry specialists.

Preparation of a Base Map

Much of the analysis needed in this project was in the form of mapping of resource features. A base map was therefore prepared showing the state boundary, park boundaries, forested areas, and major rivers, roads, and settlements (see figure 6). The map was based on a forest cover mapping exercise conducted in 1994 by the state government using 1991 aerial photography, digitized using IDRISI. Precision and geo-location errors were rectified in 2002 by Stephane Flasse using Landsat 7 satellite imagery.

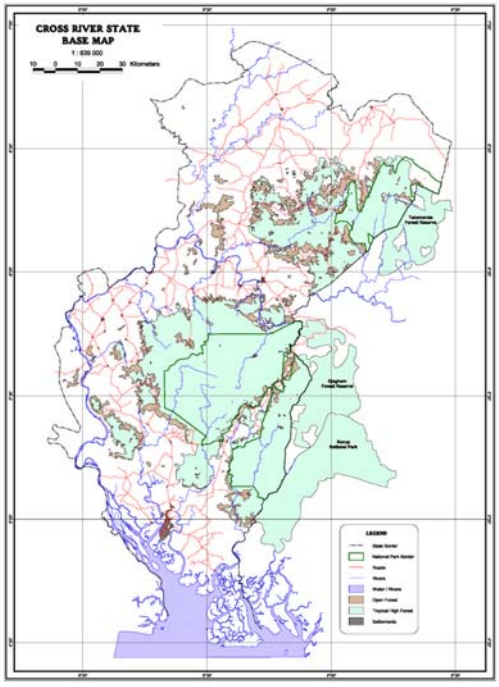

Figure 6. Base map. See Appendix B for larger-scale colour base map.

Analysis of Water Resources

Three types of landscape level analyses were performed: identification and mapping of wetlands, identification and mapping of areas with high stream density, and a watershed disturbance assessment. Wetland mapping produced by Flasse from satellite imagery was augmented using orthophotography. Additional areas were added only if they exceeded approximately 100 ha in size. Wetlands are unique and important habitats for many species, particularly bird life, juvenile fish, and herpefauna.

Areas of high stream density were identified and digitized from hard copies of British and Russian topographic maps. An area was considered to have high stream density if more than 2 streams per km^2 could be identifed. In a few cases orthophotos were used to augment stream locations shown on the topographic maps. Stream density is a good indicator of increased erosion potential, flooding, and increased sediment delivery as well as potential issues with access development and interruption of subsurface flow.

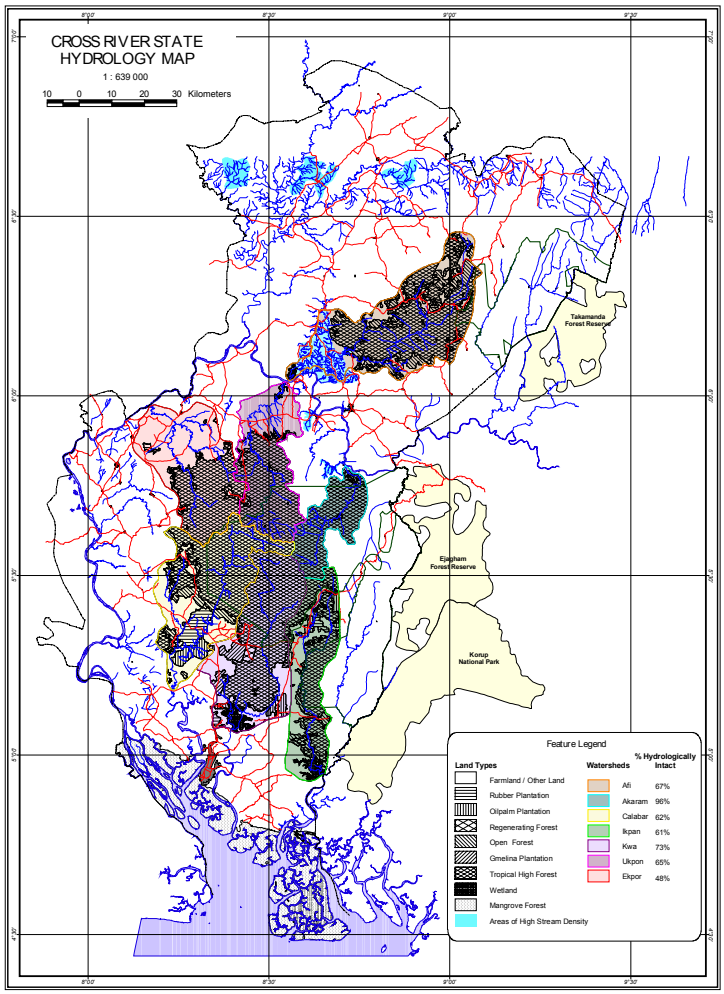

Figure 7. Map of state hydrology showing areas of high stream density, wetlands, and watersheds. See Appendix B for larger-scale colour hydrology map.

Watersheds (figure 7) were included in the disturbance analysis only if they encompassed forested areas and originated and ended in Cross River State. A coefficient of hydrologic integrity was developed for each of seven watersheds based on the degree to which natural conditions had been altered. For example, hydrological function in areas of undisturbed tropical high forest and wetlands were considered to be unaffected. Open forest and Gmelina forests were considered to be 70% hydrologically intact, regenerating forests were considered to be 50% intact, rubber plantations and oil palm plantation were considered to be 20% intact, and hydrologic function on farmland was considered to be 100% affected. The coefficient for each watershed was determined using GIS analysis to produce an area weighted rating based on the type of vegetation in it. Results are shown below. Based on this analysis, four of the seven watersheds are considered to be at risk for elevated peak flows and associated flooding, debris torrents, scouring and erosion, changes in water temperature budget, and ultimately infrastructure and habitat damage on lower reaches.

Table 3. Degree to which various watershed in the state are hydrologically intact.

Watershed	Area (ha)	Coefficient of Integrity
Afi	126,270	67
Akaram	39,609	96
Calabar	108,065	62
Ikpan	75,727	61
Kwa	105,490	73
Okpon	73,592	65
Okwo	88,773	48

Terrain Analysis

Potentially unstable or erosion prone terrain was delineated by measuring average slopes on hard copy topographic maps within forested areas. Although phenomenal gully erosion on gentle slopes (< 10%) is occurring in some areas of Cross River State (figure 8), it is restricted to the heavily leached silt and fine sand soils on the old coastal plain which has been deforested in favour of farmland and some commercial plantations. These areas were not mapped out. On the moderately hilly to steep, gravely soils in the Oban and Obudu Hills, where the majority of existing forested areas occur, the risk of erosion is less than on the coastal plains. However, the introduction of road construction and/or mechanized timber harvesting activities, will put these areas at high risk for various types of soil disturbance because of the heavy rainfall events experienced in the area and a complete lack of

Figure 8. Gully erosion near Calabar.

organic soil horizons in most areas. For this reason a slope limit of 30% was used to map high risk areas.

Habitat Analysis

A lack of detailed understanding of habitat needs, insufficient resolution of environmental data, and a lack of sufficient funding to undertake photo interpretation, prevented fine filter analysis of habitat needs for all but two keystone species (elephant and gorilla). Habitat needs of a third keystone species, hornbills, was also assessed but maps were not prepared because of insufficient inventory information. Maps of core habitats for gorilla and elephant were produced based on observed occurrence within the last five years (from a variety of sources). Connecting corridors were also identified. Connecting habitat for gorillas was mapped based on forest cover conditions, elevation, terrain, the juxtaposition of known groups, and proximity to human settlement.

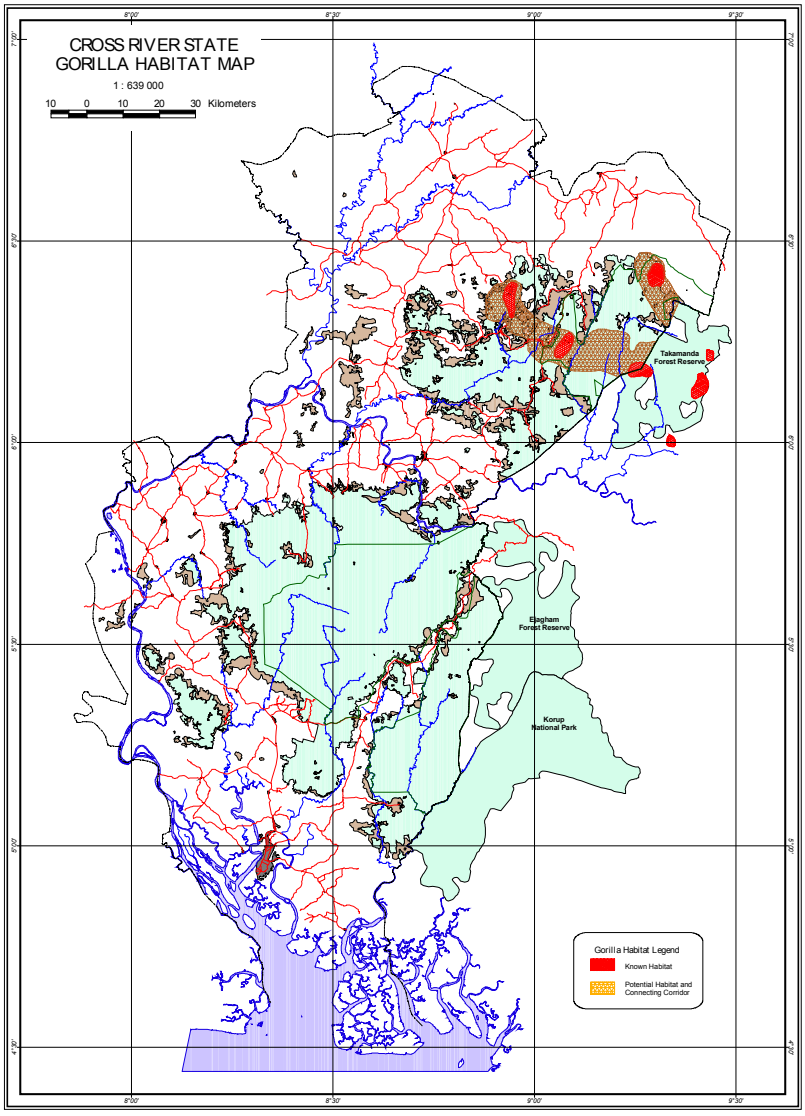

Figure 9. Gorilla habitat. See Appendix B for larger-scale colour gorilla habitat map.

Gorillas:

There are seven known groups of western gorilla in Cross River State and adjacent areas in the Takamanda reserve in Cameroon. Home range for these individuals varies from about 5 km^2 to 25 km^2 (all groups in CRS have home ranges from 20 to 25 km^2) with perhaps up to 40 individuals in a group. They will travel up to 4 km per day but movement is limited by large rivers and roads (lack of security cover) that form barriers. These groups seem to prefer highland areas (often greater than 500m elevation) and rugged complex terrain with steep valleys. They prefer primary forest conditions but in some areas may use open forest if fruit supply is abundant and human presence is low. Gorillas are frugivorous (in Gabon 65% of the diet is fruit) but they feed on most plant parts including leaves, shoots, stalks, epiphytes, vines, bark, and berries on as many as 150 plant species (adult males can eat up to 30 kg per day). They also forage in herbaceous patches and swamps. In Okwangwo, frequently used genera include Ficus, Cola, and Irvingia species. For this reason they are a keystone species in forested ecosystems where they influence the distribution and continued survival of many plant species. They are at risk because numbers are low, the population is fragmented, the gene pool is small, they have a late date of maturity and long breeding interval (slow reproduction), and they are highly susceptible to the Ebola

virus. It was thought during the 1980s that around 1,500 gorillas existed in the Cross River Region, however, as a result of the bush meat trade, habitat destruction, and, possibly, the Ebola virus, population today is much lower at only two or three hundred.

Elephants

At one time, elephants were known to occur throughout Cross River State. Today the only recent evidence of elephant occurrence is in a small area on the eastern side of the Okwangwo Division of the national park, adjacent to the Takamanda Forest Reserve in Cameroon. There was also a reported killing of seven elephants in 1989 in the Oban Division of the park (reported in Cross River National Park – Plan For Developing The Park and its Support Zone, 1989, by the British Overseas Development Natural Resources Institute).

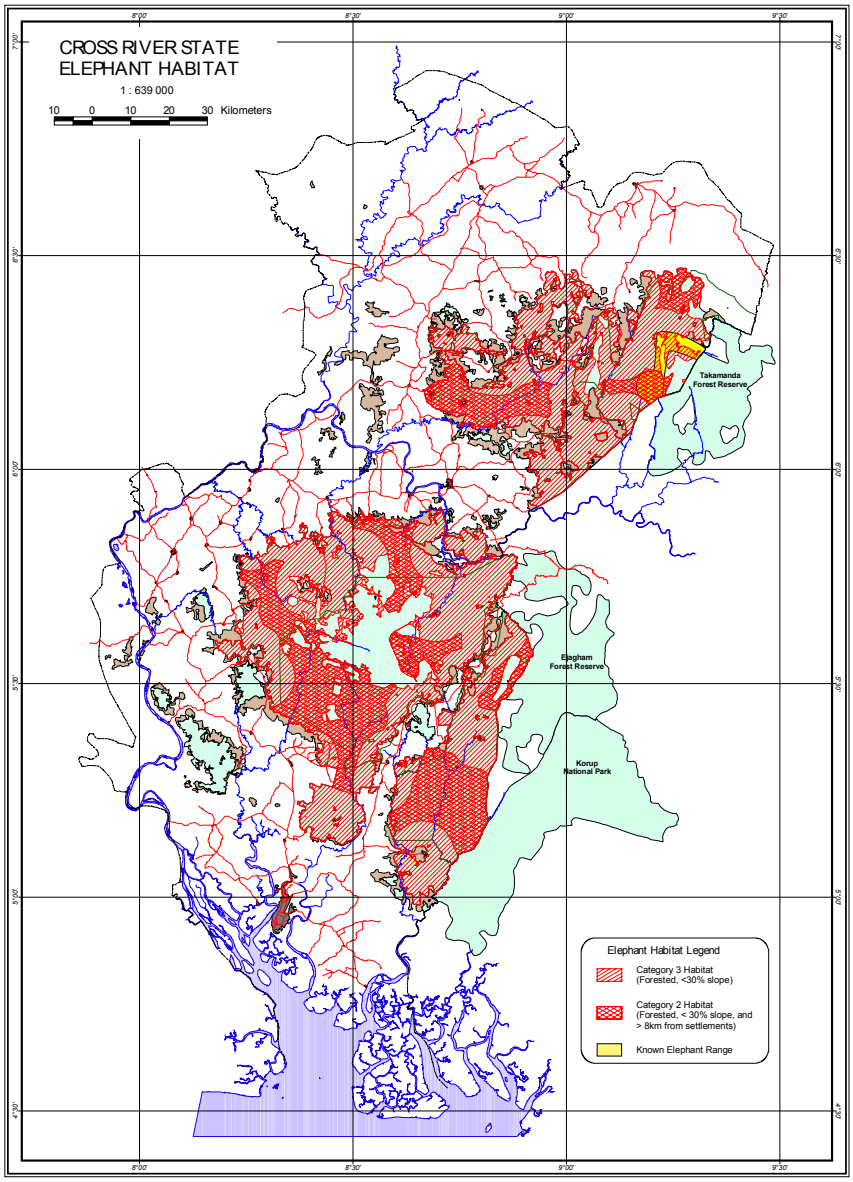

Figure 10. Elephant habitat. See Appendix B for larger-scale colour map of elephant habitat.

Elephants are highly adaptable and can survive in forest, bush, or savannah. In the Cross River area, during the dry season, they seem to have a preference for closed canopy forest conditions. They are wide ranging species however, sometimes traveling large distances in pursuit of food. They eat enormously (up to 1000 pounds of vegetation per day) and are destructive, uprooting and scattering as much as is eaten, often pushing over and breaking entire trees. Elephants eat almost anything green, but green grass, shoots, and buds of trees and shrubs are preferred. Because they can have large home ranges, they physically alter the habitat they use, and they spread seeds over wide areas in their dung, we have considered them to be a keystone species.

The three main drivers of population distribution are food availability, water availability, and distance from human activity. Terrain may also play a role. In a study in southwestern Cameroon, human activity had a greater effect on elephant density than vegetation type. Several studies have shown that elephant use of habitat (both in and outside the national parks) increases with distance from

villages for up to 20 km. Use of habitat by elephants within ten kilometres of villages is dramatically reduced.

Core elephant habitat in Cross River State was mapped (figure 10) based on findings from a population survey by Obot et al (1998) in the Okwangwo Division of Cross River National Park. There was no other documentation on recent evidence of use in other areas although this does not preclude the possibility that there are elephants in these other locations. Other areas of potential elephant habitat were identified and mapped based on whether primary forest cover was available, proximity to human settlement, and terrain (principally slope). The map shows three categories of habitat: known, category two, and category three. Known habitat was derived from maps produced in the Obot study. Category two includes all areas that are forested, less than 30% average slope, and greater than 8 km from a settlement and were derived using GIS tools. Category three includes all areas that are forested, and less than 30% slope.

Hornbills

A study in adjacent Cameroon showed that hornbills might also be very important in contributing to ecological function of tropical rainforest. In Cameroon, in the Dja Forest Reserve, three species of hornbill together consume the fruit of almost 60 species of tree and liana (the black casqued hornbill, white thighed hornbill, and the piping hornbill). Two of the hornbills show a preference for building nest cavities in large trees within areas of primary forest, making the conservation of areas with large trees important. The hornbills play an elemental role in the dispersal of tree species, flying 100 miles or more when foraging for ripening fruit, and dispersing seeds for almost a quarter of the tree flora in the area through their droppings. Many of the tree species were community dominants, economically important to humans, or both. Overlap in species utilized by elephants and gorillas was low meaning that there is little ecological redundancy between disperser groups. Given the propensity of humans to extirpate large mammals from areas of primary forest, the hornbills may become increasingly important in forest regeneration as seed dispersing mammals like gorillas and elephants diminish.

Core Ecosystems

Based on the analysis described above, core reserves and land use zoning and guidelines were developed for forested areas within Cross River State. Areas included in the core reserve were considered to be ecologically sensitive including: critical habitat for keystone species, regionally rare or unique features such as the cloud forest and grass lands around the Obudu Cattle Ranch, wetlands and mangrove forest, erosion or landslide prone terrain, some portions of watersheds at risk, and culturally significant sites. Their status with respect to park boundary was not necessarily considered. In addition to the core reserves, areas of representative habitat or natural connectivity were delineated as special management zones and, amongst other things, are meant to provide connecting corridors to ensure that core reserves are linked permitting genetic dispersal and energy flow (by organisms in the food chain and by water courses). The remaining forested matrix was considered to be an integrated resource use zone. (figure 11).

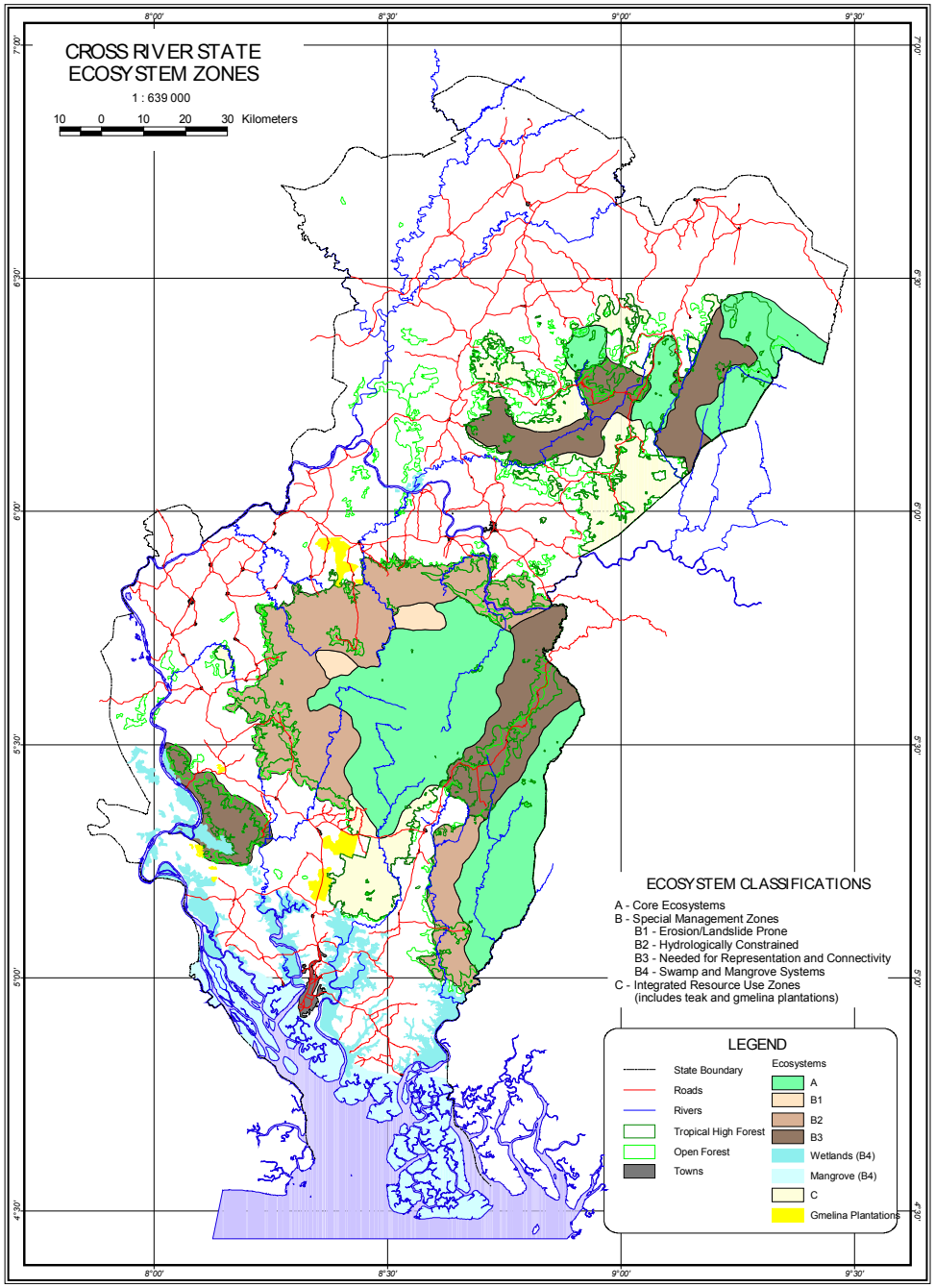

Figure 11. Ecosystem-based land use zones in Cross River State. See Appendix B for larger-scale colour map of land use zones.

MANAGEMENT GUIDELINES

MANAGEMENT INTENT AND RESOURCE USE GUIDELINES

Given that Nigeria has already lost most of its primary rainforest, it could be argued that all remaining undisturbed forest area is critical and should be delineated as core reserve. However this line of thinking ignores the historic dependency of proximal communities on forest resources as well as the inherent ecological characteristics of the area (some areas are ecologically robust and some are sensitive). Exploitation and development is occurring and will continue to occur. The intent of the support zones around the national park is to provide that very function. **It is of paramount importance for the long-term maintenance of ecological functioning, however, that only the right types of use occur, in appropriate locations, at the right intensity, and for an appropriate duration.** To help ensure that this occurs, this section of the plan identifies management intent and resource use guidelines for three categories of ecosystem-based land use zones: Core Ecosystems, Special Management Zones, and Integrated Resource Use Zones (table 4). The intent is to provide organizations responsible for resource use planning with a strategic framework for resource use decisions that recognizes environmental risk and provides guidance on activities that will be ecologically appropriate. It is **not** the intent of this plan to provide site level guidance on operational activities. Site level plans are based on a more careful and detailed land evaluation prior to the implementation of operations.

Table 4. Management intent by land use zone.

CORE ECOSYSTEMS	• The core ecosystem classification is intended to apply to areas that need to be protected because of their critical importance in ecosystem function. • No resource development or management intervention permitted • Non-consumptive recreational uses are permitted • Research and environmental monitoring allowed • Sustainable extraction of NTFP by adjacent forest dependant communities permitted in specified areas • Regulated hunting and fishing at sustainable levels by adjacent forest dependant communities for select species in • specified areas using traditional weapons only.

SPECIAL MGMT ZONES	**Erosion or Landslide Prone Areas**	• Any of the activities specified for Core ecosystems are permitted. • Must maintain a minimum area in old forest (i.e. mature forest with characteristics of primary forest that has reached a climax state) of 75% of the gross area of the zone at all times • No clear felling timber harvest regimes are permitted and retained basal area for trees must exceed 8 m^2 or 30% of original levels, whichever is more. • A terrain stability assessment (for erosion and mass movement) must be completed before any timber harvesting or road construction • In areas of low risk (based on the terrain stability assessment), road construction for timber harvesting is permitted to a standard specified in a road permit (maximum occupation by roads of the area as a percent of the gross area, maximum widths, construction and drainage standards, deactivation requirements, gating requirements, etc.) • A windfirm buffer of 100m must be conserved in its original state around all fish bearing streams, lakes, wetlands, or other water bodies • Regulated hunting and fishing at sustainable levels by adjacent forest dependant communities for select species in specified areas is permitted.

SPECIAL MGMT ZONES	**Hydrologically Constrained Areas**	• This zone represents watersheds that have been heavily altered from their natural state, especially on lower reaches. The intent is to limit further changes to hydrologic regime, promoting hydrologic recovery in disturbed areas, but allowing some further commercial resource use providing it does not further compromise ecosystem functioning. • Any of the activities specified for Core ecosystems are permitted. • Must maintain, within each watershed at all times, a minimum area in old forest (i.e. mature forest with characteristics of primary forest that has reached a climax state) of 50% of the gross area of the watershed, or 45% old forest plus an additional 10% or more of the area in fully stocked regenerating forest greater than 3m tall. • No clear felling timber harvest regimes are permitted and retained basal area for trees must exceed 8 m^2 or 30% of original levels, whichever is more. • Road construction for resource use is permitted to a standard specified in a road permit (in which early rehabilitation and maintenance of natural drainage patterns during construction and use is emphasized). • A windfirm buffer of 100m must be conserved in its original state around all streams, lakes, wetlands, or other water bodies. • Regulated hunting and fishing at sustainable levels is permitted.

SPECIAL MGMT ZONES	**Areas Needed for Representation and Connectivity**	• The intent in this zone is to provide large contiguous tracts of unaltered forest representing the full range of ecosystems occurring in the plan area and to ensure that there is connectivity between core ecosystems thus ensuring that habitats do not become isolated, migratory routes are not interrupted, and that gene dispersal continues to occur. Representation is a coarse filter analysis of biodiversity aimed at identifying and protecting target levels for different ecological communities (rather than targeting individual species) on the assumption that if ecological communities or ecosystems remain intact and well-distributed, so too will populations of species that depend on these communities. • Any of the activities specified for Core ecosystems are permitted. • Maintain a minimum area in old forest (i.e. mature forest with characteristics of primary forest that has reached a climax state) of 75% of the gross area of the zone at all times • No clear felling timber harvest regimes are permitted and retained basal area for trees must exceed 8 m^2 or 30% of original levels, whichever is more. • No more than 50% of the basal area of any given species may be harvested in a given harvest coupe (cutblock).

SPECIAL MGMT ZONES	**Wetlands and Mangrove Forests**	• Areas to be protected because of their critical importance in ecosystem function. • No commercial resource development or management intervention permitted. • Non-consumptive recreational uses permitted. • Research and environmental monitoring allowed. • Sustainable extraction of NTFP by adjacent forest dependant communities permitted in specified areas. • Regulated hunting and fishing at sustainable levels by adjacent forest dependant communities for select species in specified areas using traditional weapons only.
INTEGRATED RESOURCE USE ZONE		• The intent in this zone is to allow integrated resource use such as commercial forestry, mining, and oil and gas exploration and development as well as smaller scale and emergent activities such as tourism, commercial recreation, fishing and aquaculture, manufacturing, “green” energy production, and non-timber forest product harvesting in accordance with EBM principles. Within this zone the consumptive use of the natural resources is maintained within limits that can be sustained over the long-term, in accordance with EBM principles. The focus of resource development within the Integrated Resource Use Zone is to enhance community stability and individual well-being, to encourage economic diversification and innovation, and to increase local employment, economic development, revenue, cultural and environmental amenities and other benefits derived from resources. • It is envisioned that there will be a network of permanent roads in these areas built to an acceptable standard with some restrictions where required to address site-specific

	concerns. • A minimum area in old forest (i.e. mature forest with characteristics of primary forest that has reached a climax state) of 40% of the gross area of the watershed, or 35% old forest plus an additional 10% or more of the area in fully stocked regenerating forest greater than 3m tall, must be maintained within each watershed at all times. • Clear felling (clearcutting) must not exceed 20% of a gross cutblock area and individual openings cannot be more than 1 ha in size. Clear felling is only permitted where the species to be regenerated are ecologically suited to post harvest conditions. • In areas subject to partial cutting regimes, retained basal area for trees must exceed 8 m^2 or 30% of original levels, whichever is more. • A windfirm buffer of 100m must be conserved in its original state around all fish bearing streams, lakes, wetlands, or other water bodies. • Regulated hunting and fishing at sustainable levels is permitted.

RECOMMENDED MANAGEMENT PRACTICES/STRATEGIES

To help planners and resource use authorities design operations that are ecosystem-based and consistent with the landscape level management intent and guidelines outlined in the table above, some suggested practices and strategies have been provided for a range of topics including: biodiversity, riparian and aquatic ecosystems, fish and wildlife habitat, hunting and fishing, water, communities, access, tourism and recreation, non-timber forest products, and timber resources. Where these practices and strategies are specific to a particular zone, this has been indicated, otherwise they apply to all zones.

Terrestrial Biodiversity Conservation

- In partial cut timber harvest operations (selection systems), maintain the natural diversity of plant species and seral stages ensuring that the relative proportion of each species and age class will approximate natural conditions within a specified time.
- In the Integrated Resource Use zone, ensure that site level reserves are maintained on all sites (targeting 15% of gross cutblock area) and that biological legacies like animal dens, wildlife trees, dead trees, and coarse woody debris are represented post harvest.
- Protect rare ecosystems and the habitats of endangered, threatened, or rare species.
- Avoid the introduction of terrestrial exotic species.

Riparian and Aquatic Ecosystems

- Ensure that streamflow, channel characteristics, and water quality are not disrupted by resource use activities and are maintained within the range of natural variability.
- Ensure that the modification of water bodies does not eliminate or alter ecosystem types, condition, or pattern and does not prevent the persistence of habitats within them.
- Encourage forest resource users to identify, map and incorporate the protection of sensitive zones into development plans and approved operations.
- Increase the size of riparian buffers in areas of high windthrow hazard to minimize the risk of excessive blowdown.
- Maintain <10% deviation from natural riparian forest next to floodplains, fans, forested swamps, and small steep streams with distinctive microclimate.

- Mitigate and control the cumulative effects of material introduced into water sources resulting from resource uses.
- Conduct post-development monitoring to assess primary or cumulative effects of resource use on aquatic and riparian ecosystems.
- Set back roads from riparian areas or utilize alternative methods of harvesting to avoid building roads.
- Avoid building roads immediately above or adjacent to sensitive spawning or rearing areas.
- Provide greater riparian setback for areas which are prone to high natural erosion.
- Ensure that water pollutants are below levels that affect people or the ecosystem except where naturally induced contaminants are at levels above this.
- Avoid creating storage dams and out-of-stream diversions and/or operate so that in-stream flows remain within the natural range of variability.
- Avoid channelling and dikes except where the effect of prior development requires intervention to bring the flow within background range or where lives and valuable property necessitates intervention.
- Develop, implement, and ensure adequate government funding for appropriate water quality monitoring program.

Fish and Wildlife Habitat

- Identify and reserve key wildlife migration/movement corridors and known critical wildlife habitat features such as nesting and denning sites, feeding sites, and breeding habitats.
- Maintain sufficient undeveloped habitat (forage areas, security cover, resting habitat, breeding habitat, etc) to ensure population levels within the natural range of variability.
- Incorporate fish and fish habitat protection measures in community level planning.
- Avoid the introduction of alien species.
- Ensure consultation with local communities and consider local and traditional knowledge in managing fish and wildlife habitat.
- If a previously unidentified critical wildlife habitat feature is discovered during development, incorporate their management and protection.
- Minimize road induced displacement and mortality risk within or adjacent to critical habitats. This could include daily gating requirements for forest harvest roads and/or road deactivation following harvest.
- Avoid herbicide or pesticide use in areas containing critical wildlife habitat features.
- Minimize the impacts of commercial and non-commercial wildlife viewing, ensuring that user days are allocated in an equitable way.

Hunting and Fishing

- Forest resource use and management must not negatively impact fish and wildlife populations.
- The carrying capacity of forested areas and aquatic systems for umbrella and keystone species traditionally used by communities must be determined. This will include estimates of current populations/stock levels as well as estimates of fishing and hunting levels, using both modern inventory techniques and traditional knowledge.
- Maintain fish harvesting within the carrying capacity of the ecosystem and catch rates within the rate of renewal of the species of concern.
- Avoid the use of fish traps and pond evacuation techniques that result in indiscriminate catches leading to destruction of fish stocks.
- Do not use toxic chemicals to catch fish.
- Establish and maintain precautionary allocations for fish and wildlife use in consideration of the traditional needs of local communities for food, social, and ceremonial requirements.
- Ensure that local communities are involved in tenuring, permitting, and planning of fishing and hunting.

- Sustainable harvest practices must be encouraged through education programs and adoption of more environmentally friendly resource use practices and technologies.
- Control access on roads where hunting activity could compromise wildlife populations, in consultation with local communities.
- Ensure that adequate resources are made available to monitor hunting, trapping and fishing activities and to enforce legislation.
- Support local economic development and education initiatives that encourage the supply of alternative sources of protein (rather than bushmeat).[2]

Water

- Maintain forest cover within watersheds within the natural range of variation to avoid excessive peak flows and flooding damage.
- Maintain natural water quality for drinking water, fish and aquatic ecosystems, and recreational use.
- Surface water use should be authorized through a licence as defined in legislation.
- Improve water conservation through wise use, innovative technology, education, and water conservation programs.
- Water use applications for diversion, storage or use of water must minimize or avoid impacts to downstream users, riparian zones, aquatic ecosystems, and recreation.
- Apply management practices to land development activities to minimize or avoid impacts to water quality, quantity and timing of flows.
- Applications for development or uses on unstable slopes or within riparian areas should be accompanied by an assessment of terrain stability/erosion potential.
- Minimize and/or avoid the use of pesticides.
- Determine in-stream flow requirements for fish and fish habitat to establish water use limits for prospective water users.
- Manage the diversion, use and storage of water to maintain adequate in-stream flows for aquatic and riparian ecosystems.
- Maintain fish passage around new dams or any other waterworks (e.g. culverts on stream crossings on roads).
- To restore aquatic ecosystems, remove man-made obstructions, such as old dams, where possible, in an environmentally sensitive manner.
- Remove obstructions to increase aquatic habitat where appropriate.

Communities

- Build stable, resilient, well-serviced, and peaceful communities.
- Consult local communities in priorizing, designing, and implementing local resource use plans.
- Support local community research into cultural use of plants and trees.
- Develop a comprehensive research strategy to determine the state of terrestrial resources used by local communities for medicinal, food or social/ceremonial purposes.
- Undertake an educational needs assessment regarding knowledge of sustainable forest use and practices in forest dependant communities.
- Develop partnerships for educational programs between communities, public sector institutions, and developers.

[2] Although bushmeat and poverty are linked, increased economic welfare does not necessarily mean reduced consumption unless there is a supply of alternate sources of protein and people develop a taste for these substitutes.

- Ensure that educational programs include local history and culture to foster cross-cultural respect and understanding.
- Undertake a needs assessment to determine health services required for local communities.
- Provide access to traditional food and medicinal botanical sources.
- Help people develop the skills and opportunity to earn sufficient income to meet or exceed their basic needs.
- Provide support for current and future needs to existing businesses including resource manufacturing and processing facilities, that maximize benefits to communities in a sustainable way.
- Develop a diversified marketing program for forest resources that includes strategies and resources for implementation.
- Identify and plan for social, cultural, and volunteer programs that strengthen the community and region.
- Develop ways to return a portion of revenue collected from forest land to the local community and local governments.
- A percentage of tenures and licenses should be made available to local communities and governments for economic development.
- Develop effective public input process with balanced levels of representation from local communities, local governments, and other stakeholders.
- Identify long-term strategic needs for settlement sites.
- Identify environmentally appropriate settlement areas.
- Create a strong and diverse mix of businesses within communities.
- Create a strong and diverse mix of non-profit and voluntary organizations and a vibrant set of traditional, cultural, and non-market activities within communities.
- Ensure a fair distribution of benefits, costs, and risks across all parts of the area.

Access Management

- Establish local access management committees in forest dependant communities and prepare an access management plan prior to developing access into a forested area.
- In consultation with local communities and user groups, identify and evaluate environmental, recreational, and cultural heritage values that can be affected by development of roads and associated facilities.
- Ensure that development and use of current and planned access, including construction, maintenance, and deactivation activities, does not compromise environmental, recreational, and cultural heritage values.
- In cases where environmental, recreational, and cultural heritage values could potentially be compromised, ensure that adequate assessments are conducted and standards prepared and incorporated in a road permit.
- Control access where hunting or trapping are a concern to wildlife populations or in order to protect community assets or cultural values. This could include special gating requirements, early road deactivation, and/or patrolling roads.
- Ensure roads are adequately maintained to provide safe passage and to avoid road failures and associated environmental impacts.

Tourism and Recreation

- Where recreation or tourism values have been identified, develop comprehensive, strategic regional plans for sustainable tourism and recreation including direction on management, monitoring, enforcement, and conflict resolution.
- Consult with local communities prior to developing new tourism or recreation opportunities.

- Endeavor to create partnerships amongst government, developers, communities, and other stakeholders to assist in the monitoring, enforcement, management, and preservation of recreational values.
- Ensure that tourism and recreation development minimizes impacts to cultural and ecological values.
- Before approving new sites for wildlife viewing, determine potential area-wide impact on the subject species including potential habitat isolation, disruption of migration or travel corridors, impact on social behaviour and reproduction, and exposure to human born diseases or vice versa.
- Determine acceptable numbers of recreationists or tourists at recreation or tourist attractions based on ecological carrying capacity and public safety.

Non-Timber Forest Products

- Legislation and policy for a sustainable non-timber forest products industry should be developed.
- Options should be explored for the regulation of non-timber forest product harvesting to ensure sustainability.
- Promote the development of information systems, including inventories, for non-timber forest products (including maps).
- Sustainable harvesting of NTFPs by local communities should be maintained on all traditional use areas.
- A NTFP research program should be established and should include the cultivation of NTFPs.
- Create an educational awareness program for non-timber forest products.
- Conduct market research for non-timber forest products.

Timber

- Maintain a sustainable annual harvest and operationally feasible timber supply over the short and long term in a manner that is consistent with the principles of EBM and does not compromise ecosystem functionality.
- Conduct periodic timber supply reviews.
- Develop forest tenures and timber allocations based on the EBM zoning map and sustainable cut levels.
- Accommodate new tenure and existing holders in a fair and equitable manner.
- Ensure that local community issues and roles are addressed in forestry tenuring and allocation, permitting, policy and planning processes.
- Promote timely establishment of area based community forest tenures that are representative of a land base that will contribute to the long term economic and human well-being of local forest dependant people.
- Encourage the sorting, processing and marketing of forest products to extract the highest value from the forest resources.
- Encourage viable, diversified and profitable businesses in the timber and non-timber sectors.
- Review and adjust as necessary, timber harvesting utilization standards to enhance economic viability of EBM forestry operations while maintaining the full range of economic opportunities for future generations.
- Encourage diverse and innovative forest products that increase the employment, economic development, revenue, cultural and environmental amenities, and other benefits derived from forest resources.
- Ensure that the full cost of implementing EBM is adequately considered when timber harvesting fees and royalties are paid.
- Create incentive programs to encourage investment and innovations by the forest industry.

- Ensure that sufficient funding is allocated to reforest and manage areas in which harvesting has occurred.
- Ensure that reforestation involves a mix of ecologically appropriate tree species that reflects natural forest conditions.
- Enhance timber production through silviculture and management practices that increase stand yields and values.
- Allocate appropriate funding to effectively address research needs for implementation of EBM.
- Conserve soil productivity and maintain slope failures within natural rates.

IMPLEMENTATION AND MONITORING

EBM planning should engage people (local governments, senior governments, resource users, tenure holders, local communities, and local people) as necessary at all scales in a collaborative manner. Although ecosystem-based management is not a regulated requirement, it is foreseen that it would be implemented by all relevant government agencies in their own management activities and local strategic planning (e.g. land use plans and forest management plans), and also incorporated by them in any resource development permits or land or natural resource dispositions. Development plans and permits would need to be consistent with the zoning guidelines and principles and strategies outlined in this document. Conflict with existing plans or zoning, would need to be evaluated on a case-by-case basis to identify opportunities for modification that better reflect the principles of ecosystem-based planning.[3] Conversely, resource management zone guidelines and strategies in this plan will need to be amended in the future in accordance with the principles of adaptive management.

An often used approach in implementing broad use planning is to establish a coordinating body comprised of representatives from various stakeholder groups. This might include an overarching policy committee for the state with subordinate local resource use committees responsible for local implementation. The terms of reference for both these groups must be carefully designed, incorporating the principles of good governance, to ensure that self interest and single purpose conservation or development motives don't undermine the broader goals of environmental function and community well-being. With time, these groups would develop state policy and local procedures that foster and support collaboration amongst user groups, research, training, monitoring, and the use of best management practices.

A critical component of effective implementation of ecosystem-based management will be adequate training for those responsible for implementation. This will include a spectrum of topics from understanding ecosystems and their importance, to systems for good governance, and will be most effective if local communities, public agencies, and private organizations can be engaged in a partnership for the design and delivery of such programming.

Most modern land use plans will also have a monitoring requirement. Monitoring involves developing a program to determine:

- whether planning requirements are being implemented;
- whether implementation is achieving objectives; and

[3] For example, areas that are outside of Core reserves but still within the national park would still be treated as reserves subject to the constraints outlined in the development plan for the park (1989 - Developing the Park and its Support Zone – Oban Division report) in which different levels of allowable activity are identified for recuperation, public use, special use, intensive use, and traditional use areas.

- whether underlying assumptions and data used to design the program are valid.

A monitoring program would include:

- a collaboratively designed monitoring protocol;
- a series of indicators to be used to measure the degree to which objectives are being met;
- well defined roles and responsibilities for coordination, analysis, and reporting; and
- a communication protocol for sharing results of the evaluation and analyses.

While monitoring often requires quantitative measurements, it also can involve tracking less tangible indicators such as degree of satisfaction. Human well-being indicators in particular, need to go beyond simple measures of economic performance such as revenue or income, and the costs and benefits of economic development need to include long term social and ecosystem restoration/reparation impacts.

KNOWLEDGE GAPS AND FUTURE WORK

There are many gaps in knowledge and capacity to deliver natural resource management programs in Cross River State. New information that contributes to our understanding of how critical forest ecosystems can be maintained while meeting local social, cultural and economic requirements is of paramount importance. Some suggestions that would help inform public decision-making on conservation and development issues have been provided below. Suggestions fall into two broad categories: a) Scientific/technical and b) Socio-Economic information.

SCIENTIFIC/TECHNICAL

Resource use decisions must be based on sound science if they are to be sustainable. Too often donor groups and politicians want a quick fix without having the knowledge or data necessary to support their decisions. As a result, programs are not effective in either the short or long term. There is a reluctance to invest in data acquisition when there is no immediate gratification. Relatively little is known about many apparently sensitive ecosystems and their inhabitants. A great deal more research is needed in a number of areas. Some of the most important immediate requirements are listed below:

1. A detailed forest resource inventory is required which includes photo interpretation of forest cover. Because EBM seeks to incorporate the best of existing information including traditional, local, technical, and scientific knowledge, it is also advisable to review opportunities to integrate traditional ecological knowledge either during the inventory work or in a separate process. The inventory should be more detailed and available sooner in areas with near term potential for development. Outputs from such an inventory would include site level inventory polygons by species or genera group and, within each polygon, tree heights, diameter, volumes, stand structure, stocking class, and age class, NTFP occurrence and relative abundance, and soil and terrain conditions including an estimate of site productivity. This inventory could be based on existing aerial photography and plot data as well as new plot data in areas with poor information. It is suggested that an attempt be made to train experienced forest enumerators from within Cross River State to undertake the photo interpretation. Finally, because past experience in Cross River State has not always been very positive with respect to data archiving and subsequent use, a way must be found to go beyond conventional databases and maps so that such information can be effectively shared and used by a spectrum of users (eg. web based sharing).
2. A more comprehensive attempt at soliciting expert opinion on habitat requirements and biology of key focal species should be conducted. This would include identifying the best focal species candidates as well as acquiring relevant literature.

3. A habitat assessment, using the completed forest inventory described above for the focal species described above should be completed.
4. Much better information is needed on the silvics of indigenous tree species and their cultivation and establishment (including optimum stock types). This type of initiative is a long term endeavour but could be started with a literature review of the species of key economic, cultural, or habitat value based on the inventory described above, and would also include interviews with local and international experts.
5. Although some non-timber forest products research is being conducted (e.g. rattan and afang) little is known about the silvics of most species, the degree to which they can sustain exploitation, or potential for cultivation. In addition to fulfilling many needs within the community, some of these species may have significant commercial potential. For example, it is estimated that the sales value of Prunus africana (stinkwood), which occurs in the Okwangwo Division and is an important source for a drug used in the treatment of prostate cancer, is $150 to $220 million US per year. In the past Cameroon supplied up to 25% of the world demand for Prunus africana but over exploitation has led to declining supplies. This example underscores the need for much better information on these important forest resources.
6. More research is required on ecologically appropriate silviculture systems for the tropical high forests of Cross River. This would include a retrospective analysis of regeneration success in both clear felling and partial felling systems and such things as natural pre-harvest stocking of focal species (i.e. species that represent a broader group of species), post harvest stocking including regeneration delay, species mix, and growth rates as they relate to site conditions and harvest regime, and the effect of fill planting. It is likely that long term growth and yield monitoring plots will also need to be established.
7. Stocking standards for selection systems and clear felling systems need to be developed including number of desirable stems/ha, intertree spacing, acceptability criteria for naturals, fill planting requirements, and vegetation competition rules.
8. More effort is required to reforest areas that have been degraded and are not being used for agriculture. Because this activity does not generate short term income, donor support will be required.
9. Targets and indicators for sustainable forest management need to be developed and a monitoring program formulated and implemented.
10. It is extremely important that a successful ecosystem-based management project be initiated and nurtured as a source of inspiration for other communities and as a model that can be improved and used for experimentation and adaptive management. This type of project would need to be in a relatively small area that is ecologically robust, involving only one or two communities, with natural resources that provide a reasonable opportunity for economic development, and with community leaders that have vision and a history of good governance. The objective would be to develop a model forest that will be used to test and develop sustainable forest management regulations, plans, data management systems, and operational practices providing a range of services and products to the local population as well as markets further afield. It would require significant long term donor support but would eventually lead to a self sustaining unit.

SOCIO-ECONOMIC

1. Information and adaptive management are only useful if the people that need it receive and understand it. It is critically important that the kinds of research and results described above be extended to other groups grappling with similar issues. A substantial extension and training program is envisioned, likely delivered in a collaborative way by existing institutions, foreign consultants, NGOs and communities. The target audience for this type of training would

include government personnel responsible for forest management regulation, private sector and civil society personnel involved in resource use, and community groups and individuals like the forest management committees in affected communities. A spectrum of extension tools and techniques would be required because of the range of skills and interests of the target audience. The starting point for such a program would be teaching the principles of ecosystem-based management and fostering environmental awareness to change attitudes about both the environmental and commercial value of timber, NTFPs and fish and wildlife resources. The program would likely be most effective if a single coordinating agency such as a University was responsible for development and delivery with help from other stakeholders and support from donor agencies.

2. It was suggested that a different coordinating agency be formed to facilitate the design and delivery of ecosystem-based planning in the state. This would need to be an inter-agency management committee. It is suggested that a first step would be to explore the interest in such a group and develop potential terms of reference.
3. Another requirement will be to develop ways to integrate modern federal and state legislation and policy with customary or traditional law and political structure. This would include adequate land tenure reforms and mechanisms that would help change the culture of open access to land by virtue of clearing it.
4. Controlling illegal resource exploitation such as logging without permits and the bushmeat trade are often raised issues. Recommendations have recently been made for state level intervention and enforcement. However, in keeping with the principles of ecosystem-based management, further thought must be given to engaging and empowering local communities and institutions to undertake this work. Part of the solution will necessarily involve ensuring that communities understand the link between their own welfare and environmental function; however, poverty can narrow ones vision and elicit extreme behaviour, so extending micro-credit and infrastructure funding to some villagers or village institutions in exchange for cooperation with resource management authorities is of paramount importance, as is improving income generation.
5. Ways must also be developed to secure women's involvement in the formulation, planning, and execution of policy and to incorporate women's views, interests, and needs into resource management.
6. Finally, an important barrier to implementing many potential economic opportunities at the community level is lack of access to, and understanding of, both domestic and international markets. Substantial effort will be needed to change this. While there have been a number of market studies within Cross River State, they have largely been about timber or agriculture products and most are out of date. An unfortunate aspect of marketing, is that continual change in market forces means mechanisms for acquiring ongoing market intelligence must be developed. An initial step will be to undertake market research focussing on domestic and cross border markets for timber and non-timber forest products and eco-tourism. A second step would be to evaluate the potential for similar sales in Europe and the third step would be to develop mechanisms, such as a marketing cooperative, for gathering market intelligence over the long term.

BENEFITS OF THE PLAN

Ecosystem based management contemplates significant change to planning and practices associated with forest development. It relies on a high degree of cooperation among managers and proponents, ongoing learning and the methodical application of knowledge, data and science. EBM is a process that is implemented in stages as capacity and knowledge increases through an adaptive management approach. Applying the zoning, principles, practices, and strategies in this report will help natural

resource planners, conservationists, and developers ensure the forests of Cross River State continue to provide the goods and environmental services needed to sustain the people of the area in perpetuity.

As a result of this project a number of potentially useful planning tools have been provided:

- The report outlining: physical features of the area (ecology, climate, soils, geology, water resources, vegetation patterns, etc), the link between human well-being and the environment, EBM Principles and planning steps, data and mapping products available for EBM planning in Cross River State, analysis undertaken, analysis results (map preparation, analysis of water resources, terrain analysis, habitat analysis, and delineation of core ecosystems), management zones and resource use guidelines in each, recommended management practices and strategies, recommendations on implementation and monitoring, knowledge gaps and priorities for future work.
- Maps and associated ArcView files including: a base map, a watershed hydrology map, a terrain map, and maps of elephant and gorilla habitat).
- A powerpoint presentation summarizing key aspects of the ecosystem-based management plan.
- An annotated outline of inventory and database products available.
- An annotated bibliography.
- Orthophotos for the entire state (acquired from other sources).
- Digital photographs of environmental conditions in some areas of the state.

Key benefits of the project include:

- A regional framework that guides resource use planning and informs development and conservation decisions is now available to organizations involved in forest resource use.
- Available data and information gaps have been elucidated making it easier for stakeholders to identify priorities for future work.
- The guidelines will serve as a template for others hoping to undertake this type of analysis elsewhere.

It is hoped that, at the very least, the project will stimulate the interests of others, elicit dialogue among stakeholders, and encourage collaboration among the many groups using the forest resources of Cross River State.

APPENDIX A: PARTIALLY ANNOTATED BIBLIOGRAPHY

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A international journal of forestry published by FAO quarterly. The CD has all the quarterly publications from 1947 to 2000 and includes a catalogue and search function. To access more recent issues of the journal you need to go the FAO website. That's 58 years x 4 publications per year x say 8 articles per publication = 1856 articles! With the search function, if you know the title, author, or publication number you can link directly to an article. However, if you want to query for a subject, some of the words have to be in the title of the article or it won't show up. Out of 1856 articles, for example, querying on biodiversity only yielded 6 articles, querying on Nigeria yielded 0 articles, and ecosystem yielded only 4 articles. One of these "Tropical forest resources and biodiversity the risks of forest loss and degradation (1993, B.A. Wilcox) " is excellent. Many papers have excellent sources for further information in their literature cited section.

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Takamanda Forest Reserve (***chpt 1***): Basic info on rainfall, elevation, geomorphology, climate and temperature, and a summary of flora and fauna diversity. Hunting issues and information on fragmentation and how it affects gorillas also included. Pages 6 and 7 identify possible focal taxa.

Adaptive Management (***chpt 2***)

Vegetation Assessment (***chpt 3***): In addition to the 10 1 ha biodiversity plots in this study there were two one ha biodiversity plots established in Nigeria (one in Okwango and one in "CRS national park" – Comiskey et al, unpublished data.) A prelim land use change and veg map developed based on satellite imagery. The chapter provides descriptions of five forest types in TFR including average number of species, basal area, and some general comments on structure. Habitat types included lowland forest (including riverine forest), lowland ridge forest, mid elev forest , montane forest, and high altitude grassland.
Lowland forest (rainforest, riverine, secondary): Somewhat homogenous in structure and compostion. Has an upper & middle canopy and a shrub/herb layer. Large canopy trees for lowland forest listed on page 23. Riverine forest is that which is influenced by seasonal inundation and periodic flooding and is only somewhat distinct from terrestrial forest. In some areas pandanus palm and raffia are abundant and dominate. A bit about secondary forest on page 26. Land in the area that is not disturbed for 20 years after leaving it fallow regenerates well and forms dense secondary forest formations that grade easily into closed-canopy forest characterized by large trees. Antrocaryan micraster (timber species) regenerates well in canopy gaps.
Lowland ridge forests (300 to 500 m elev) are where the most trees with timber value occur (in combination with less understorey). There are many species found on ridge forests that aren't found in other forest types. Herbs and smaller shrubs are generally relatively sparse. Cola species are common.
Mid Elev Forest (500 to 800 m): A shorter canopy, a denser understorey, and increase in epiphytic vegetation. Less diverse than lowland forest. Contains both lowland and montane tree species. Some tree ferns.
Montane Forest (800 – 1500m): Short and often disjunct canopy, large numbers of trees with low basal area, and lower species richness. Epiphytic vegetation well developed.
High Altitude Grasslands: Large herbs and woody shrubs abundant. Also Pteridium aquilinum. Same as Obudu plateau.

The area is diverse and species richness decreases with altitude while tree density increases. Nigerian side of the border researched by Hall and Medler, 1975, and Keay 1979. Species of conservation priority are listed on pg 34 –most in lowland and ridge forest. Montane and grassland areas ecologically fragile however. Impacts of human practices briefly described on page 37.

Butterfly Fauna of TFR (***chpt 4***): 111 species found. Some species (listed pg 57) have a strong preference for dense wet forest conditions and some are good indicators of primary rain forest (4 listed on pg 58 that disappear at the first sign of disturbance).

Biodiversity Assessment of the Odonate Fauna of TFR (***chpt 5***): Dragonflies are excellent indicators of ecological health. Description (pg 73) of why the Nig/Cameroon border is so rich in biodiversity relative to drying periods during the Pleistocene era. In the lowlands there is a rich representation of dragonflies but a limited degree of endemism. Above 700 m tho there is a group that breed in the fast flowing rocky streams there is a suite of species which are susceptible to disturbance and opening of the canopy and have the potential to be used as indicators of forest quality (77) Page 80 lists habitat requirements.

Reptiles of TFR (***chpt 6***): 71 species. Some species of chameleon restricted to grassland and gallery forests. Three species of gecko are dependant on large old trees (decorticating bark) (pg 85).

Birds of the TFR (***chpt 7***): Endemism high (e.g. 24 species of bird restricted to the ridges corresponding to the Nigeria – Cameroon mountain chain. 313 species. One threatened and two vulnerable (one of which is Picathartes oreas). Area might be part of an EBA (endemic bird area) and is recommended to be an IBA (impt bird area). Submontane and montane important for avifauna. Middle altitude transition forest important cus it suffers most severe encroachment. Recommend that the highest elev receive full protection and a transborder conservation strategy.

Large Mammals (***chpt 8***): Very few animals in the reserve. There was evidence of forest elephant, giant forest hog, red river hog, forest buffalo, yellow backed duiker, red duiker, cross river gorilla, chimpanzee, drill, red eared guenon, mona monkey, putty nose guenon, crowned guenon, and Preuss's guenon. Population and hunting pressure resulting from it have led to unsustainable bushmeat harvesting however. Projections are that many species will be extirpated in the near future.

Surveys of the Cross River Gorilla and Chimpanzee Populations in the TFR (***chpt9***): Critically endangered and occur in only 4 isolated subpopulations. Population recovers slowly because of interbirth interval of ~ 4 years and late maturation. A new road between Takamand and Mbulu forests is thought to prevent gorilla movement between areas (pg 130). Gorillas and chimps both confined to highland areas (> 500 m). Gorilla population very fragmented and sign almost completely absent for the matrix of the lowland areas within which highlands embedded. Gorilla density low but ~ 20 times higher in the highlands than lowlands. Gorillas prefer steeper slopes and higher altitudes. Approx 15,000 people (43 villages) live in and around TFR. More human sign in the lowlands than highlands.

Fisheries in the Southern Border Zone (***chpt 10***): Fishing in the area was found to contribute as much as game hunting to local consumption and trade. PROFA (a GTZ sponsored project) produced a management plan for the area (2000 to 2003) that ensure biodiversity. Fish species caught on page 146. 54 species recorded in the rivers. In Okwangwo there were 31 species recorded. 3 o4 endemics. Teugels et al 1992, say the cross river has more fish species than any other comparable west African river. Some obvious recommendations made on page 50.

Distribution, Useage, and Sustainability of NTFPs (***chpt 11***): Definition (pg 162). Represent an average of 39% of household income. Bush mango and eru most important as source of income.

Also important are raffia, rattan, chewing stick, bush onion, cola, bush plum etc. Bush surveys yield data supporting the conclusion that NTFPs are being overharvested in some areas because of destructive harvesting practices or harvesting all mature individuals creating an age class gap or complete lack of seeds. Bush mango, bush onion, and bush pepper are less threatened because harvesting practices do not destroy the plant. Pg 167 lists the NTFPs that are being harvested unsustainably.

Land Change (***chpt 12***): Satellite image analysis (1986 and 2000 – Landsat, 30m resolution). Eight classes of vegetation were defined (lowland forest, ridge forest, mid elevation forest, montane forest, grassland/bare, secondary forest/farms, water, shadow) and one forest conversion class (forest to secondary forest or farms). Areas smaller than 0.5 ha filtered out. Map in photo gallery, area for each class on page 178. It was unclear how much regrowth had to occur before areas of secondary forest began to appear as primary forest again.

APPENDIX B: KEY MAPS

Cross River State Base Map

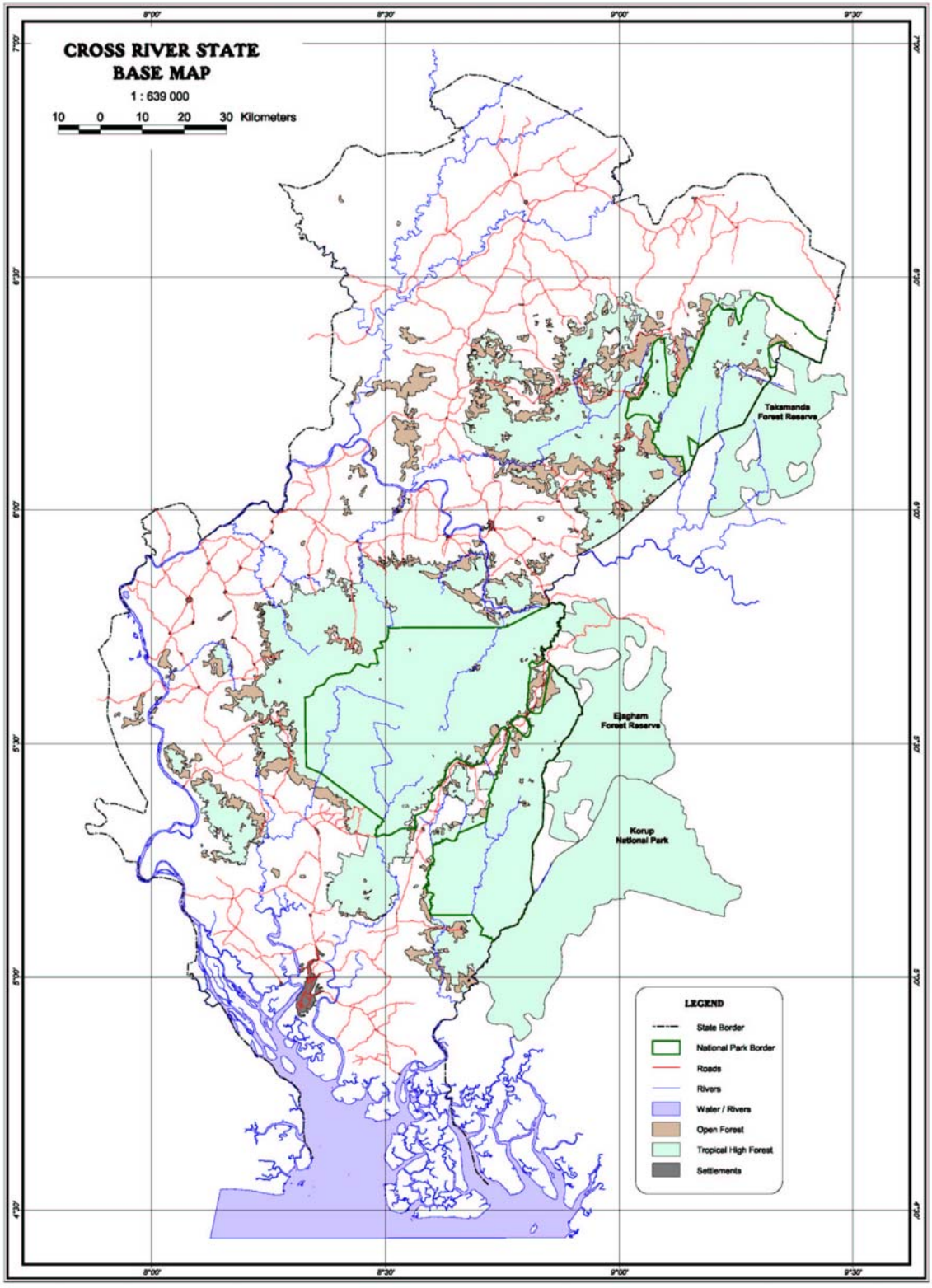
Cross River State Hydrology Map

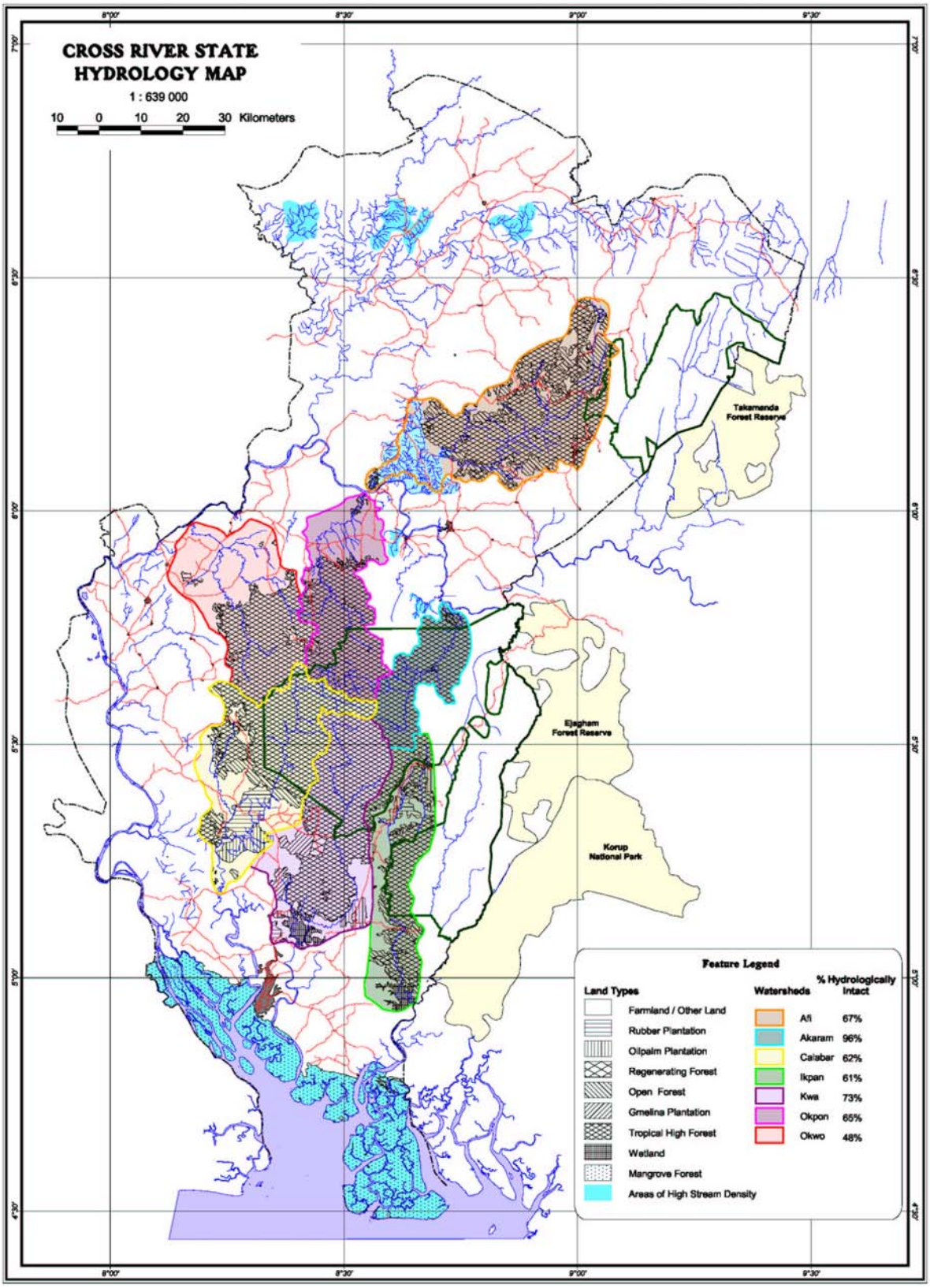
Cross River State Terrain Map

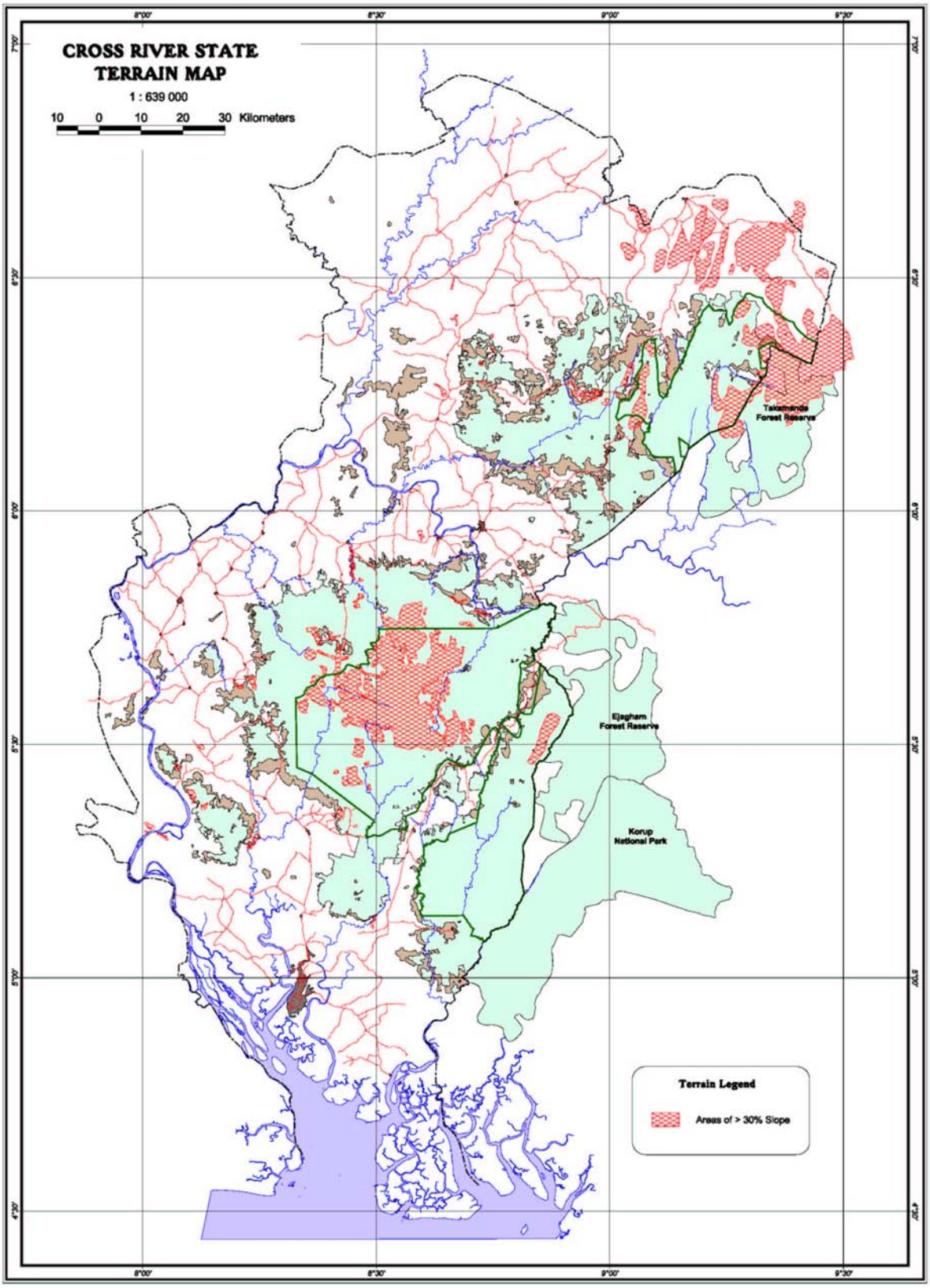
Cross River State Gorilla Habitat

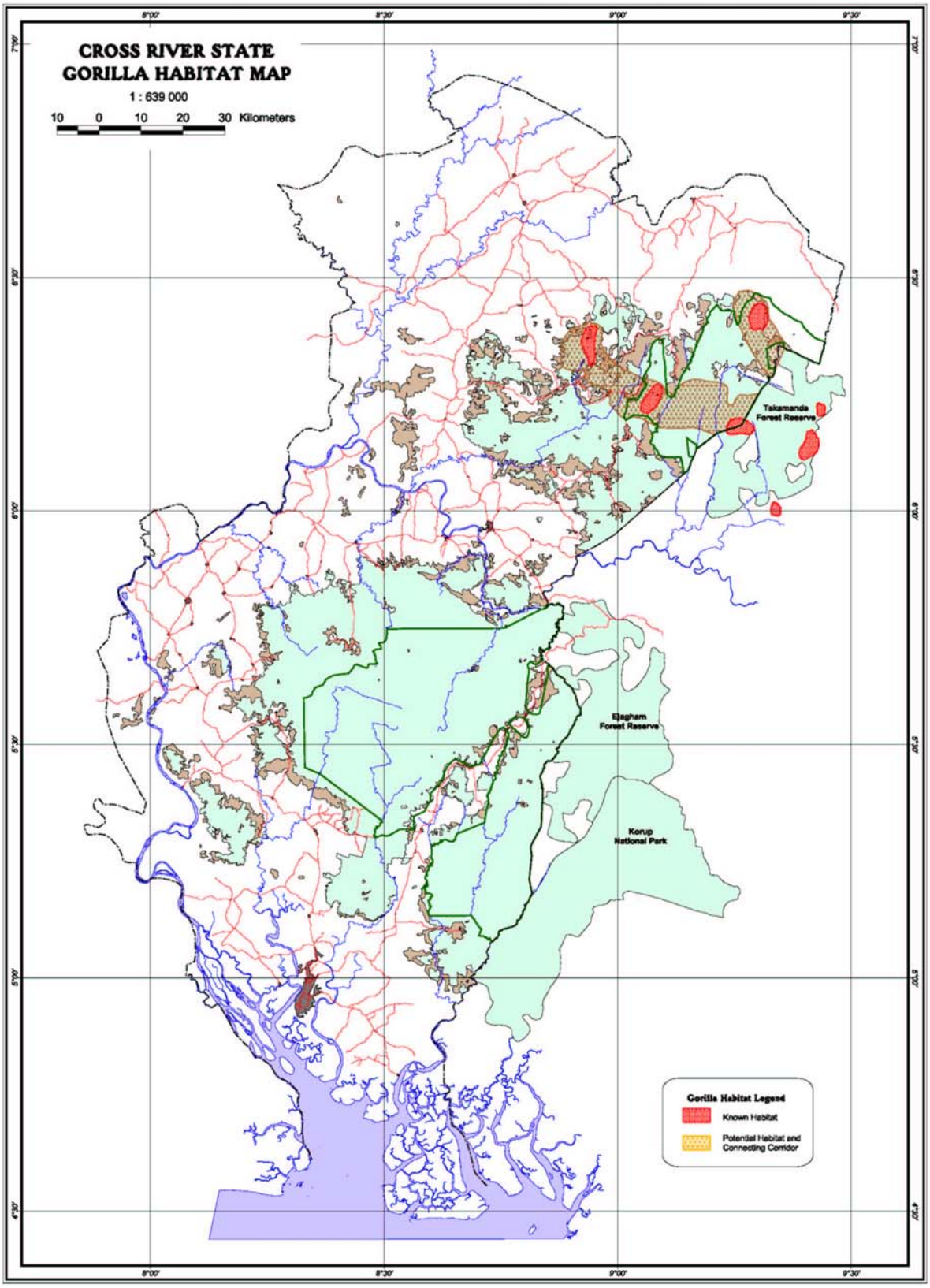
Cross River State Elephant Habitat

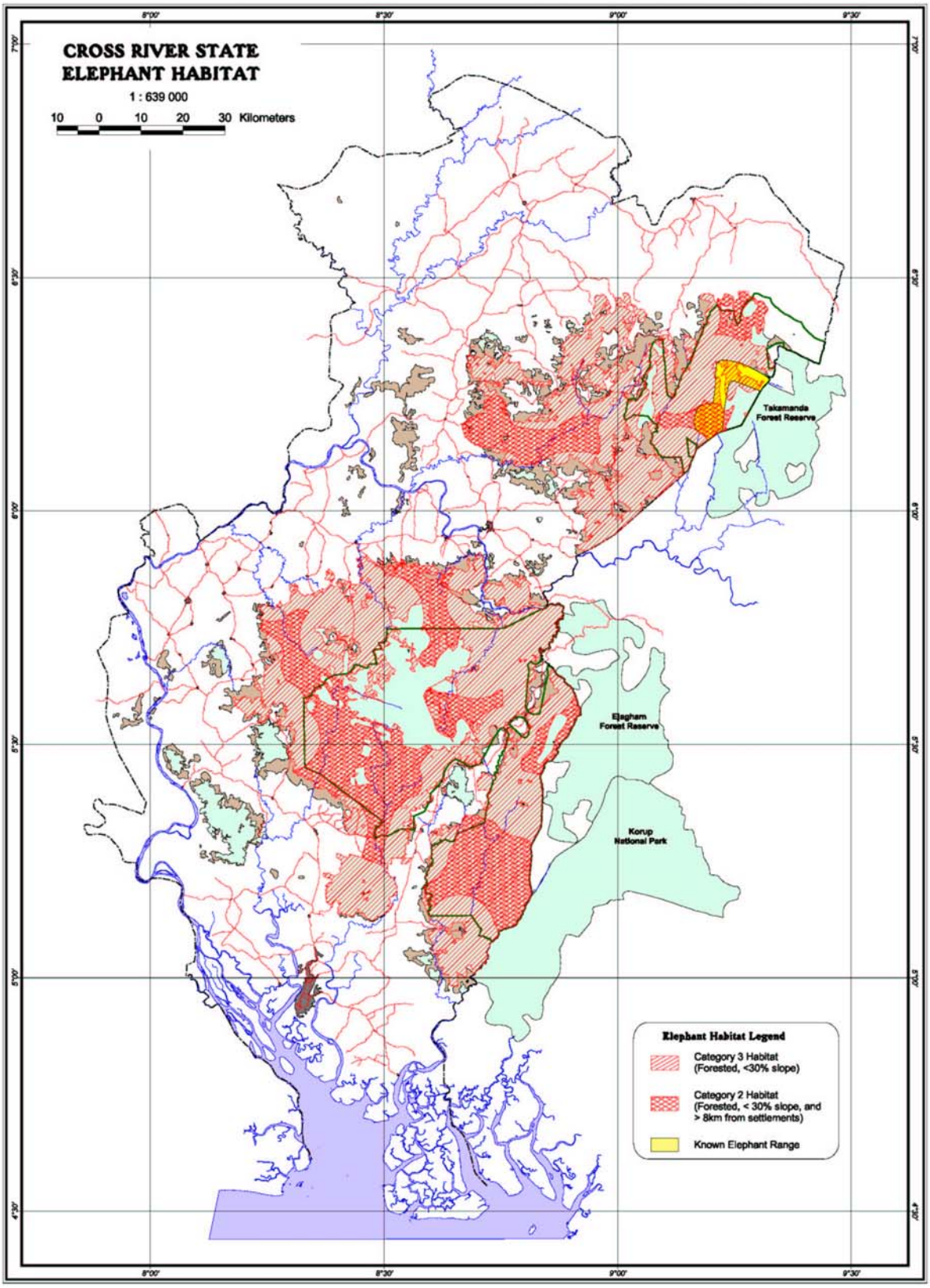
Cross River State Proposed Ecosystem Zones

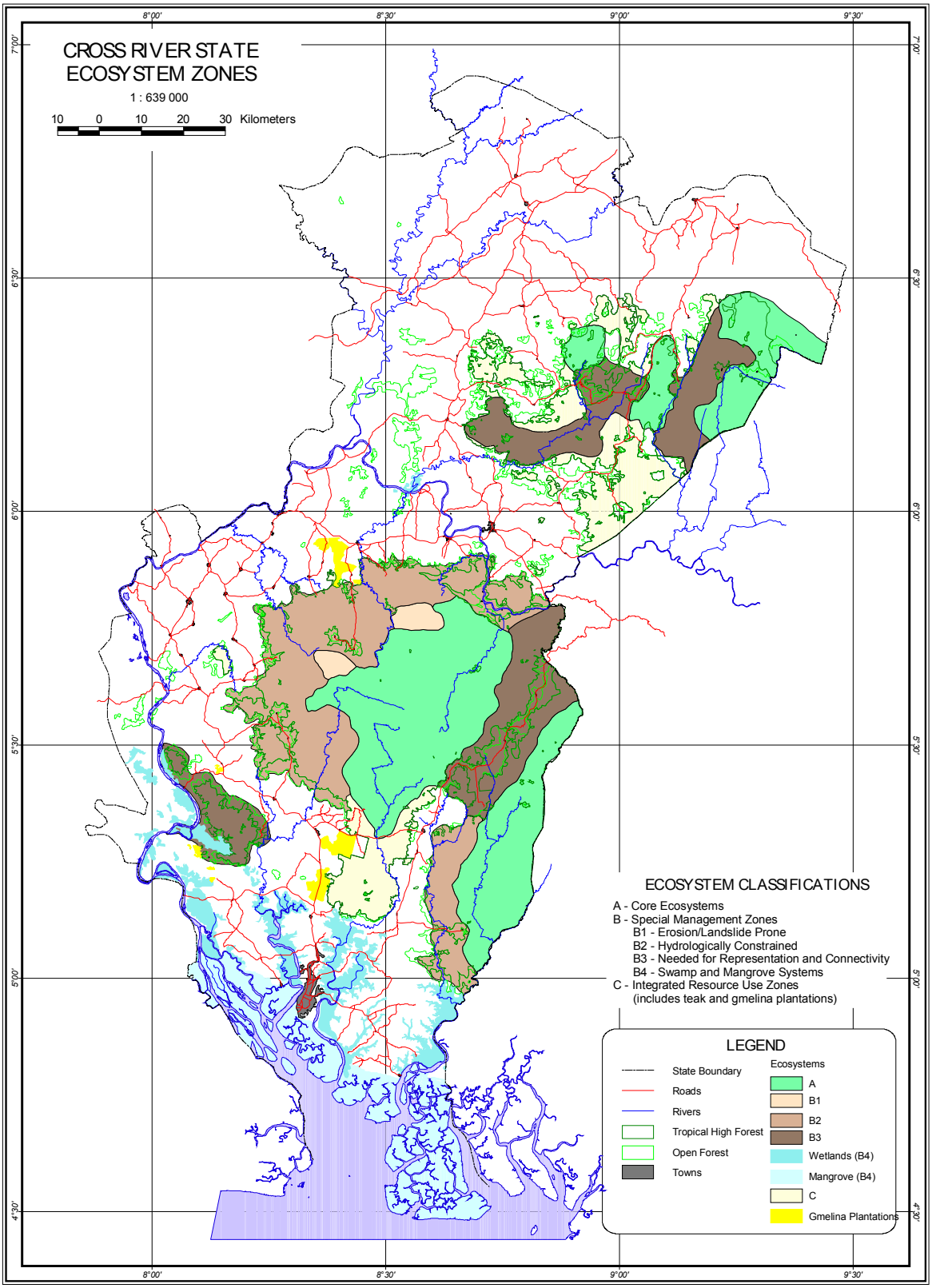

CROSS RIVER STATE
BASE MAP
1 : 639 000
10 0 10 20 30 Kilometers
8°00'
8°30'
9°00'
9°30'
7°00'
6°30'
6°00'
5°30'
5°00'
4°30'
Takamanda
Forest Reserve
Ejagham
Forest Reserve
Korup
National Park
LEGEND
State Border
National Park Border
Roads
Rivers
Water / Rivers
Open Forest
Tropical High Forest
Settlements


CROSS RIVER STATE
HYDROLOGY MAP
1 : 639 000
10 0 10 20 30 Kilometers
Takamanda
Forest Reserve
Ejagham
Forest Reserve
Korup
National Park
Feature Legend
Land Types
Farmland / Other Land
Rubber Plantation
Oilpalm Plantation
Regenerating Forest
Open Forest
Gmelina Plantation
Tropical High Forest
Wetland
Mangrove Forest
Areas of High Stream Density
Watersheds
% Hydrologically Intact
Afi 67%
Akaram 96%
Calabar 62%
Ikpan 61%
Kwa 73%
Okpon 65%
Okwo 48%


CROSS RIVER STATE
TERRAIN MAP
1 : 639 000
10 0 10 20 30 Kilometers
Takamanda Forest Reserve
Ejagham Forest Reserve
Korup National Park
Terrain Legend
Areas of > 30% Slope


CROSS RIVER STATE
GORILLA HABITAT MAP
1 : 639 000
10 0 10 20 30 Kilometers
Takamanda Forest Reserve
Ejagham Forest Reserve
Korup National Park
Gorilla Habitat Legend
Known Habitat
Potential Habitat and Connecting Corridor


CROSS RIVER STATE
ELEPHANT HABITAT
1 : 639 000
10 0 10 20 30 Kilometers
Takamanda Forest Reserve
Ejagham Forest Reserve
Korup National Park
Elephant Habitat Legend
Category 3 Habitat (Forested, <30% slope)
Category 2 Habitat (Forested, < 30% slope, and > 8km from settlements)
Known Elephant Range


CROSS RIVER STATE
ECOSYSTEM ZONES
1 : 639 000
10 0 10 20 30 Kilometers
8°00'
8°30'
9°00'
9°30'
7°00'
6°30'
6°00'
5°30'
5°00'
4°30'
ECOSYSTEM CLASSIFICATIONS
A - Core Ecosystems
B - Special Management Zones
B1 - Erosion/Landslide Prone
B2 - Hydrologically Constrained
B3 - Needed for Representation and Connectivity
B4 - Swamp and Mangrove Systems
C - Integrated Resource Use Zones
(includes teak and gmelina plantations)
LEGEND
State Boundary
Roads
Rivers
Tropical High Forest
Open Forest
Towns
Ecosystems
A
B1
B2
B3
Wetlands (B4)
Mangrove (B4)
C
Gmelina Plantations