Conservation Planning in a Tropical Wilderness: Opportunities and Threats in the Guianan Ecoregion Complex

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Abstract—With increasingly limited resources, conservation planners are challenged to provide policymakers with conservation portfolios that: 1) are representative of all important biodiversity features, 2) incorporate socioeconomic data, 3) are flexible to change, 4) require less financial resources over the long term, 5) overcome substantial information gaps, and 6) are developed across disciplines to maximize efficiency and stakeholder buy-in. The practice of setting priorities for conservation in a largely undisturbed region differs greatly from methods commonly applied to highly disturbed, human-dominated regions. The resulting portfolio should include a spectrum of conservation tools including protected area and policy recommendations, trade-off mechanisms, buffer zones, and conservation incentives encouraging certain land uses. Here we present a method for developing a conservation biodiversity vision and action plan, based on lessons learned in a planning process for the Guianan Ecoregion Complex that combined the input of regional stakeholders and local experts with geographic information systems (GIS) and computer-assisted decision-support systems (DSS). We highlight how we addressed some of the challenges associated with conservation planning in a tropical wilderness and offer reflections on how our methods could be modified to suit other areas.

Why Plan for Wilderness?

Wilderness is a concept of the human mind. In many cases it's what is left—the pieces of nature that endure and give us hope and inspiration. Scales of time and space relevant to the observer and/or the question at hand determines the definition of wilderness. In the context of conservation planning, wilderness can be defined as a spatial extent large enough to conserve viable populations of species with large area-requirements, species migrations, and genetic diversity, ecological processes and ecosystem services. This definition is not without its problems and even more so in tropical areas where many species remain undescribed, many areas are entirely unexplored and very little is known about the species and areas that are described. Additionally, in many developing countries biodiversity planning is neither a priority nor a national concern as efforts are focused on more pressing needs such as drinking water, food and disease.

It would thus seem that any planning effort would be frivolous under these conditions; that perhaps we don't need to worry about these areas yet since they are currently still large and unfettered. It is further complicated when wilderness areas stretch across national boundaries, when policy and legal mechanisms become plural, and as is the case in the Guianas and elsewhere, where borders remain disputed. It is our experience that planning for conservation in tropical wilderness areas can provide a proactive tool for encouraging cooperation among development and conservation interests. Biodiversity goals, in addition to environmental services and development needs, can be met simultaneously when trade-off mechanisms are developed by regional stakeholders and experts. There is an intrinsic link between environmental and human health and we feel that proactive planning can also be a useful tool for creating future scenarios based on development objectives to explore potential impacts not only on the environment but on water quality, pollution, etc.

Conservation science has been termed a crisis discipline, and often reactive or even retroactive to immediate threats to species and landscapes. Crisis management can be very costly and is often a cause for conflict between development, industry and conservation interests. With limited time and money, proactive planning in tropical wilderness areas can be a means of engaging the stakeholders prior to a crisis, and can provide a framework for working towards a long-term multi-disciplinary "vision" for biodiversity while there are still options. We will define a biodiversity vision, in this case, on what we want the planning area to look like in say 50 years—ideally with its full complement of species and habitats. This also reinforces the need to take a "whole systems" approach to planning, that is to incorporate and integrate terrestrial, freshwater and even marine science into the analysis, recognizing the connectivity and flow between these realms.

For example, illegal gold mining is a terrestrial activity where pollutants primarily impact the freshwater environment. When conducted in the headwaters, mercury from gold mining operations can bioaccumulate in invertebrate and

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fish tissues progressively moving downstream, thus having an increasing impact moving up the food chain and down stream. Ultimately, the end consumers, for example, giant otter (*Pteronura brasiliensis*) and humans living along these rivers, suffer the most even though they are far removed from the source of the contaminant. There is a need to think about the whole system in the context of planning, and to use water as a planning template as it provides ecological connectivity from mountains to reefs.

In tropical America, as in many other areas, wilderness areas are rarely without a long history of human presence. In the Guianas and elsewhere, forest dwelling people have existed in the forests for thousands of years and are certainly part of the wilderness (fig. 1). However, increasingly these cultures are exploited by logging and mining companies, converted by missionaries, and are adopting modern lifestyles. What follows is loss of cultural and sustainable traditional practices, adaptation to permanent extractive settlements, increasing populations, use of firearms, and changes in worldview. Resulting from these changes, permanent forest villages are surrounded by so-called "empty forests" (Redford 1992). This is a further challenge to conservation and indigenous livelihoods, and reiterates the need to include indigenous peoples in the planning process as regional stakeholders and opportunities for conservation. These issues further complicate the definition of wilderness; however, in the planning sense wilderness remains a concept, a target of sorts.

Figure 1—A young Wayana girl from Apetina, Suriname, holds a brown capuchin (photo by J. Schipper).

Experts and Software

There is a growing body of literature describing systematic conservation planning versus ad hoc reserve design (Margules and Pressey 2000) and the need to involve experts and stakeholders at all stages of the planning process (Cowling and Pressey 2003). Software on the other hand incorporate reserve selection algorithms, which are mathematical tools for translating the "current state of knowledge" for a region into a systematic context from which data can be analyzed and iteratively modeled for representing biodiversity (Margules and others 2002; Pressey and Cowling 2001). Pearce and others (2001) describe a process for mapping vegetation with expert opinion, and readers are referred to Faith and others (2003), Ferrier (2002), and Pressey and others (1994, 1999, 2003) for further discussion on methods and examples of systematic conservation planning.

Software in this sense is simply a means to an end; it ensures that the planning process in question meets the representation and other goals set forth, is unbiased and yet uses expert knowledge to drive target setting, minimum areas requirements, etc. Setting the overall goals and specific site-selection targets and criteria, as well as developing the datasets, are the job of the experts. Stakeholders become involved as a steering mechanism for the process, determining feasibility, trade-offs and as a mechanism to link the science to policy. Software can provide insightful analysis and iterative scenarios based on information and can be a means of exploring relationships between development, policy and biodiversity conservation options. The information that goes into the software is derived first from the literature, but then relies entirely on the knowledge (data) and opinion (experience) of regional experts. From our experiences in the region we feel that it is critical to use both expert opinion and knowledge to fill data gaps and to drive the selection process.

It is beyond the scope of this article to present the results of the biodiversity vision and action plan discussed; these will be posted on the web site for WWF-Guianas (http://www.wwfguianas.org/) following peer-review. Following, we present a brief and simplified example of the software results using actual data and analysis in MARXAN software (http://www.ecology.uq.edu.au/marxan.htm) on a theoretical landscape to demonstrate the tools and process in a nutshell. In all maps presented below, the black areas represent protected areas, and shades of gray represent data and analysis results. Because a goal of this exercise is to develop a planning process that takes into account both conservation and development targets, we use a variety of data sets to map species distributions that are then reviewed and modified by experts. In order to ensure that the software selected important areas for giant otter (*Pteronura brasiliensis*)) and West Indian manatee (*Trichechus manatus*), for example, we drew upon expert knowledge to map critical areas as targets for conservation of these species (fig. 2).

Recognizing that not all areas are equally attainable or desirable in a conservation portfolio, we attempted to map the "cost" of the landscapes in terms of meeting the targets

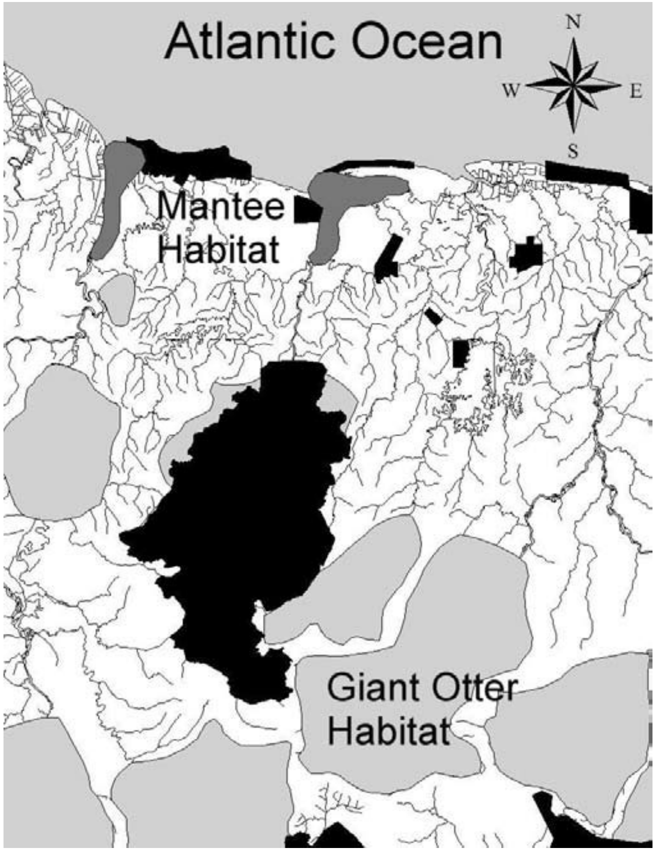

Figure 2—Two examples of species data used for demonstration analysis: areas along the coast are important manatee habitat (dark gray) and areas in the south are important otter populations (light gray).

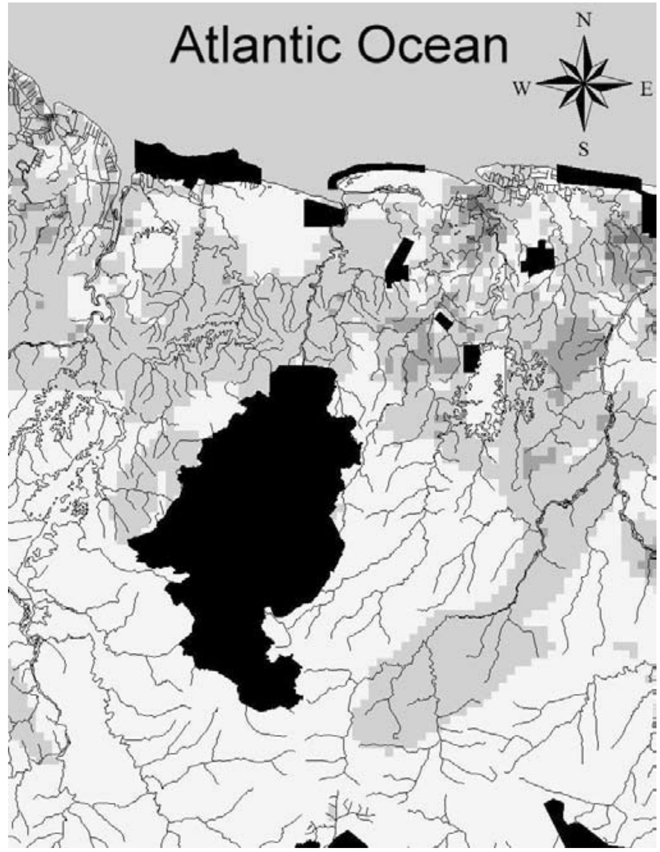

Figure 3—Cost surface: major cites (dark gray) and human populations along the coast and major river systems (light gray).

for biodiversity. In order to direct conservation targets away from regions important for development (and from cities, highways, etc.) we used a cost surface (fig. 3). In this sense the "cost" steers the software away from high conflict areas so that targets are first met in areas with less conflict to development (but ensures that they are still met). This cost map can be modified iteratively in the future as lands are developed or protected. As goals are met and opportunities are lost, the cost surface will provide new options and help us meet biodiversity conservation targets away from developed areas, and can help release conflict without compromising the vision.

Finally an "irreplaceability surface" is created that shows a given planning unit's relative importance for meeting targets. Highly irreplaceable planning units must always be selected to meet targets; they cannot be replaced. Only some planning units with lower irreplaceability values are needed to meet targets, hence there is more flexibility in these areas to meet targets (fig. 4). This final map depicts areas most necessary to meet the conservation targets. Notice how the selection for irreplaceable planning units steers away from high cost areas and attempts to connect current protected areas.

The importance of this process is its iterative and flexible nature; as targets are met, the software can be rerun to find the next best solution. In addition, by incorporating future development into the cost surface, we can predict the effect on optimal conservation areas for the future. In the Guianas, for example, we gave forestry and mining concessions, developed or not, an equal cost so that the software would first find conservation solutions away from areas already tied into economic development. It is important also to mention, however, that if solutions cannot be found elsewhere (in other words, the area in a mining concession is irreplaceable) the software will also make us aware of that. If this is the case, we must then use this information to explore trade-offs and approach the mining company to seek alternatives. These are just a few of the many uses of spatial decision-support systems such as MARXAN, C-Plan, SITES, SPOT, PANDA, etc.

Introduction to the Guiana Ecoregion Complex Planning Process

Systematic and expert driven planning for biodiversity conservation can be an important tool for conservation areas around the world, and is useful both in human dominated and wilderness areas. The planning process has useful results in terms of developing an action plan. In addition, the processes of gathering and curating data, consulting

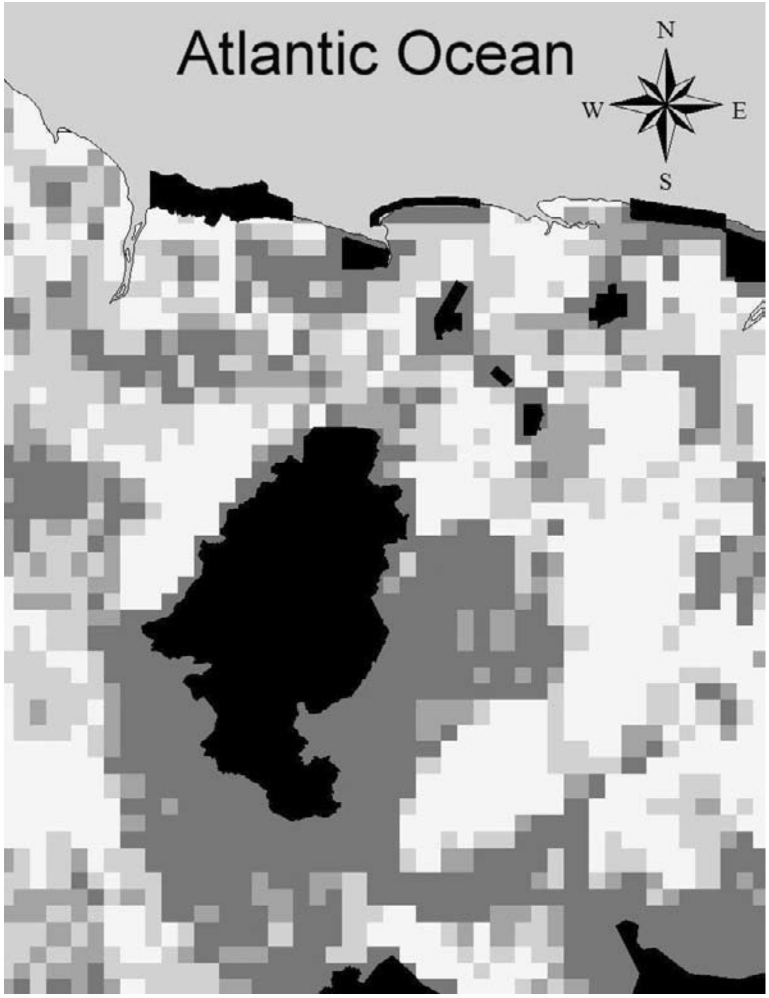

Figure 4—Irreplaceability surface: areas are selected to best meet the selection criteria (dark gray) while also providing alternative areas (light gray) based on the irreplaceability of the planning unit for meeting set targets.

and bringing together experts, and modeling and mapping ecosystems can have equally valuable side products. Below we discuss the process of developing a biodiversity vision and action plan for the Guianan Ecoregion Complex (GEC) in South America, present the decision criteria that resulted from numerous expert and stakeholder workshops, and suggest an approach based on lessons learned.

The need to begin a systematic conservation planning exercise was realized in the process of priority setting within the framework of the World Wildlife Fund (WWF)—Guianas Program in the region (Schipper 2005). Adding a systematic and data driven component to the planning process was voiced during an IUCN-CI (World Conservation Union-Conservation International) expert workshop held in Paramaribo, Suriname (Huber and Foster 2003). The area under analysis in this initial workshop spanned the entire northern Amazon, most of which was unexplored wilderness unknown even to the experts. Most experts knew some areas or taxa well but it was obvious that compiling these data was just a first step to achieving long term management options. Likewise, the priority areas resulting from this workshop were too large to be useful for on-the-ground action.

Although experts could drive the process of compiling and prioritizing the biodiversity in need of conservation, regional stakeholders would need to be included in the planning from the beginning so that there was participation and buy-in from corporations, organizations and the governments that could implement a plan when it was ready. With this in mind, a consortium of stakeholders was formed and began the process of developing a biodiversity vision and action plan within an ecoregional framework. This scale was chosen for several reasons: 1) both terrestrial and freshwater ecoregions had been delimited by regional experts, 2) ecoregions delimited for the area shared many of the species communities important for conservation, 3) the great diversity of ecosystems in the study area could best be represented by a complex of ecoregions containing both freshwater and terrestrial elements (for example, mangroves), and 4) encompassed areas of great species endemism (such as, tepuis, inselbergs, white-sand savannas).

The importance of including freshwater biodiversity and threats in the analysis was realized early on in the process, however, there are very few examples of where planning efforts have been able to incorporate these two systems effectively. Additionally, because the threats to both freshwater and terrestrial (and ultimately marine) systems are driven by socioeconomic factors, we felt it was urgent to document both the threats to biodiversity and opportunities for conservation as means of driving priorities for conservation action. The need for trade-offs is increasingly important when stakeholders are included from various interest groups—where mining and forestry interests need be reconciled with biodiversity conservation, for example.

The primary goals for the conservation of biodiversity were to identify a suite of sites, complementary to the existing protected areas, that would be 1) representative of some portion of all species and species surrogates (for example, vegetation types identified by experts), 2) large enough to retain populations and metapopulations of species requiring large areas, 3) with sufficient connectedness that ecological flows, species migrations and genetic diversity could be maintained, 4) that could be driven by expert knowledge in a systematic framework, and 5) in areas with the least conservation cost. However, because the results also need to be realistic and flexible around the needs of national development priorities, the analysis needed to be conducted and presented as a spatial decision-support system; in other words, one which industry, government agencies and non-government agencies could use as a tool for discussing trade-offs and scenarios for both conservation and development. Additionally, we wanted to create a system that could be iterative and easily adjusted as more data became available and as priorities and opportunities changed. Because of the lack of data in the area, experts were used to drive the information end of the analysis, with the goal of using this same process as a databank and repository for information on biodiversity in the planning area.

Guiana Ecoregion Complex

The study area considered in the planning exercises described herein consists of a "complex" of ecoregions. This approach was taken for a variety of reasons, though first and foremost so that the unique processes, interactions and ecotones between these ecoregions could be maintained over the long term. The GEC, as we have defined it, consists of six ecoregions, which together share many of the same species, some of which rely on more than one ecoregion for survival (fig. 5).

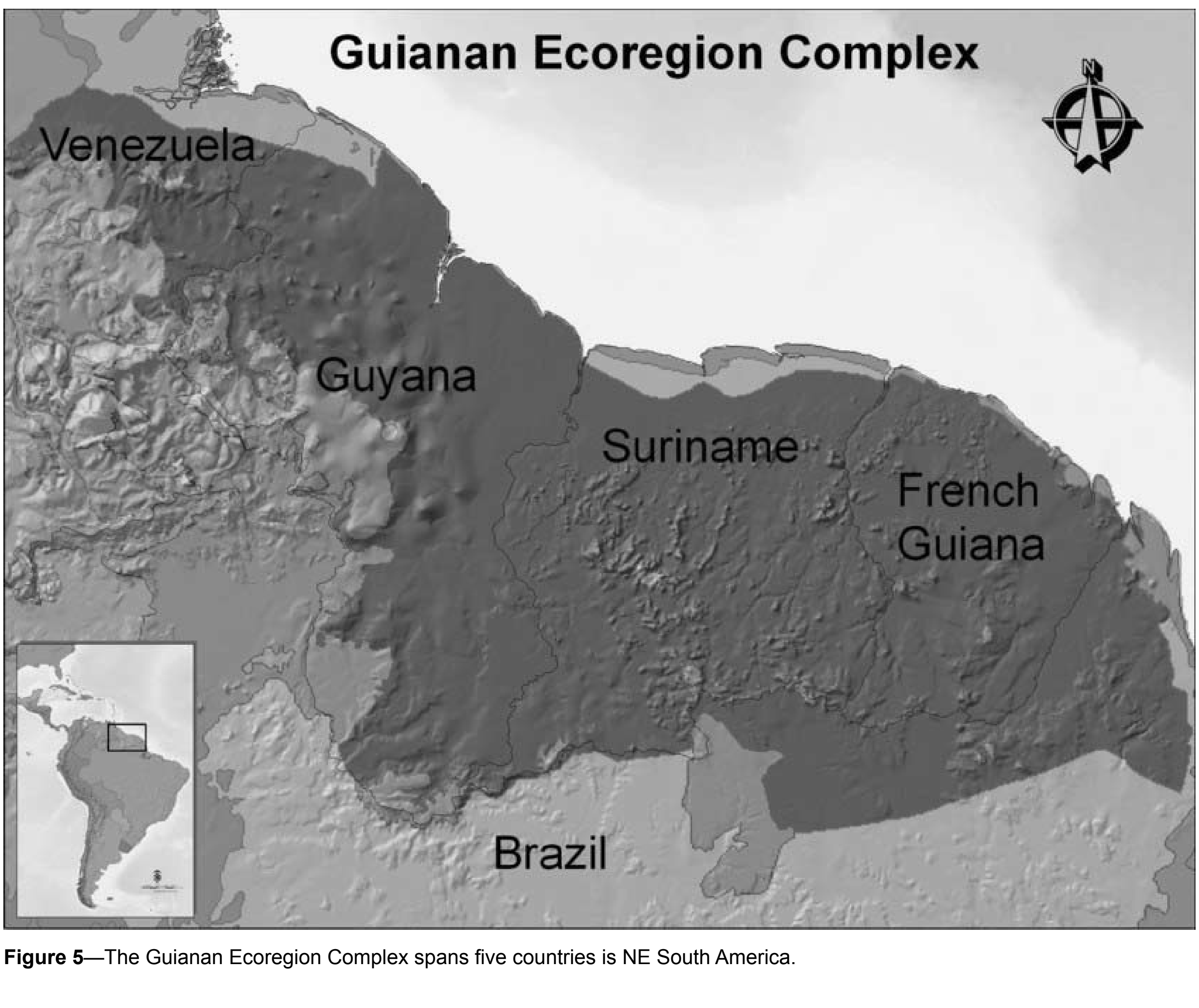

Figure 5—The Guianan Ecoregion Complex spans five countries is NE South America.

There are a number of unique geological and climatic features associated with the GEC (fig. 6). The ancient Precambrian Guianan Shield is the underlying geological formation in the northeastern portion of South America. Sandstone tabletop mountains (tepuis) in the eastern and central GEC, including Mt. Roraima and Mt. Ayanganna, rise above the surrounding area to heights of 2,810 meters (9,219 ft). Tafelberg Mountain in central Suriname (1,026 m/3,366 ft) is the easternmost outlier of the Pantepui ecoregion and, as with most tepuis, remains isolated from other formations and thus contains high levels of endemism. Along the southern GEC is a complex of large savannas that form along a transverse dry belt across northern Amazonia. Additionally, the inter-tropical convergence zone (ITCZ) transverses the northern portion of the study area, creating a complex set of climatic features. Also, in the northern portion there exists a savanna "belt" intermixed in a complex matrix of forest embedded with white sand savanna patches. These geological and climatic features are important determinants of forest type and species distributions both within and between ecoregions.

Freshwater biodiversity in the GEC is extremely diverse and has been included in the biodiversity vision and action plan from the beginning. Many free-flowing rivers still contain their full complement of biodiversity (fig. 7), and are extremely important for the livelihoods of the indigenous peoples in the region. From these rivers, forests peoples, such as the Wayana, derive food, water and transportation (fig. 8). The impact of upstream contamination on both the biodiversity and on the people who rely on these rivers is an important consideration for long-term sustainability, and reiterates the need to combine terrestrial and freshwater data in conservation planning efforts, especially in wilderness where systems are still intact.

What Are We Trying to Protect?

Because of the great variety of species that exist in the GEC, we found it helpful to derive a subset of species and species surrogates to focus on for biodiversity conservation. We refer to these as focal species, as they were eventually the focus of the analysis and thereby of conservation efforts. These species were defined by two broad criteria: 1) endemism (species found nowhere else outside of the GEC), and 2) threat (species globally threatened and/or listed under international treaties). Within these two criteria experts were asked to create a means of prioritizing the species via a weighted algorithm to direct the selection of planning units; however, the details of this process are beyond the scope of this report. Focal species were used in the analysis as site targets for representation (endemic species) and as area targets for viable populations (area-sensitive species).

There are a great number of species endemic to the Guianas, and using ecoregions to delimit the study area greatly facilitated inclusion of endemic species in the analysis in an area where very little data exists. Endemic species are

Figure 6—Kasikassima, a granitic protrusion known as an inselberg, rises above the Guianan moist forests of southern Suriname (photo by J. Schipper).

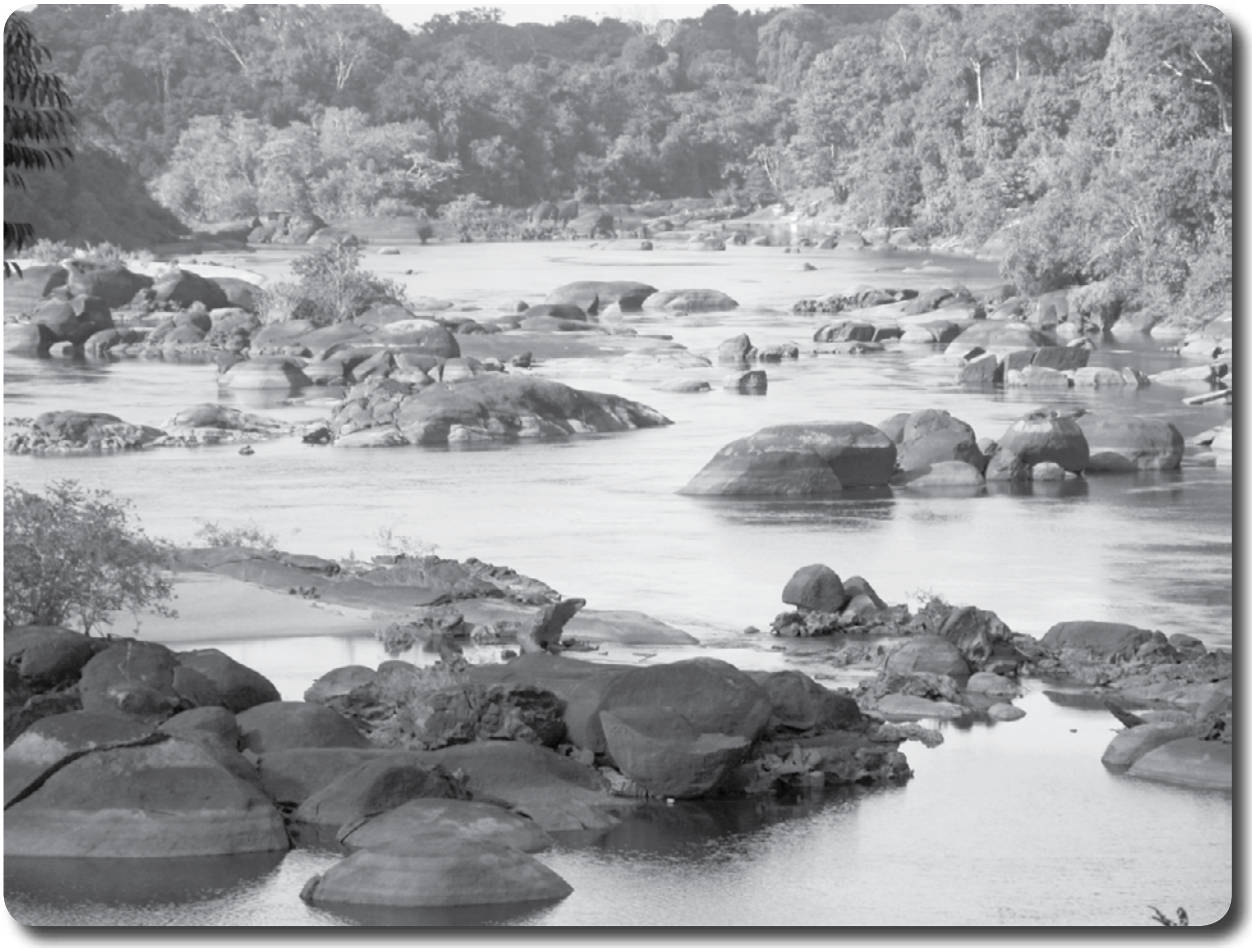

Figure 7—Many rivers, such as the Coopename pictured here, are extremely diverse and still intact (photo by J. Schipper).

Figure 8—The small village of Apetina, still derives food, water, and transportation from the Tapanahoni River (photo by J. Schipper).

high priorities for conservation if we acknowledge the goal of representing all biodiversity features. Knowing where these species are and how they are affected by development is useful in ensuring that species are adequately represented in the conservation plan.

Proactive planning provides an opportunity to develop a conservation portfolio with the requirement of individual species in mind. Keeping focal species in the conservation portfolio is thus essential in identifying spatial targets (sites) and specific actions for intervention. Flagship species such as Guianas cock-of-the-rock (*Rupicola rupicola*) and Guianan saki monkeys (*Pithecia pithecia*) are also important in drawing attention to the uniqueness of the area. Wilderness areas in the Guianas present a unique opportunity for the conservation of area-sensitive, globally threatened (http://www.redlist.org/) species such as harpy eagle (*Harpia haryja*-LR), jaguar (*Panthera onca*-NT), bush dog (*Speothus venaticus*-VU), bearded saki (*Chiropotes satanus*-EN) and giant otter (*Pteronura brasiliensis*-EN), which persist in the GEC but are otherwise imperiled over much of their range. However, basic research is needed even to obtain baseline data on populations of these species and their distributions (area of occupancy). These species were used in the planning process in three ways: 1) to identify important population segments (for example, giant otter), 2) to determine an endemic species total extent of occurrence, and 3) to define the minimum area of habitat blocks for species persistence. For example, based on the limited information available, experts determined that approximately 25,000 km^2/9,653 mi^2 was necessary to maintain a viable population of harpy eagle (with the hope that this would also provide an umbrella for jaguar and other threatened species). Thus in the analysis, the software was required to select at least three areas large enough for harpy eagle populations. Although somewhat arbitrary, the purpose of this restriction is that the software will first attempt to meet the planning targets in single large blocks of habitat, and in many cases will avoid the "salt and pepper" patterns of attempting to randomly meet all criteria with no spatial constraint for minimum size.

Lessons Learned

The process for planning for biodiversity conservation is almost always a work in progress. However, periodically results need to be presented to guide decision-making. Below we summarize a possible approach based on 4 years of workshops and planning exercises in the GEC. We have attempted to make the suggestions for this approach as broad as possible such that they can be applied elsewhere. Each of these suggestions may need to be revisited throughout the planning process, and workshops and subgroup meetings should be conducted throughout the process:

1. **Define the Area Under Consideration**: Ecoregions are a useful scale for large-scale conservation planning—and are an ideal scale in the context of wilderness as they, 1) share a large majority of their species, dynamics and environmental conditions, and 2) function together effectively as a conservation unit (Dinerstein et al. 1995). Efforts should be made early on to include all ecological flows and processes into the area of consideration—including terrestrial, freshwater and marine.

2. **Develop a Conceptual Model**: Once an area is defined, a conceptual model can help fine tune the linework for the spatial framework and can be useful in a general understanding of the system. A conceptual model can be an excellent exercise for an introductory experts' and/or stakeholders' workshop, where participants can be asked to draw a model of the ecological and human systems in place in the defined area (see Heemskerk and others (2003) for an example).

3. **Identify Stakeholders and Experts**: Identification and contact with the people and organizations that will make up the planning and review team is essential early on—recognizing of course that it will change over time. A clear description of the goals and objectives of the exercise and definitions of key terms can greatly improve the communication across disciplines and save much confusion. Additionally a statement of how this exercise will benefit the stakeholders is often very useful.

4. **Create a Databank**: It is important that all data collected be curated and maintained in one or more places for ease of access, inventorying data and as a point of reference (state of knowledge). It is sometimes best if one or more person has sole responsibility for data management, especially for spatial data for GIS, which might require a specialist to manage. Expert opinion as well as external data sources can only be used in systematic planning software if they are digitized and projected into a coordinate system for GIS analysis.

5. **Form Working Groups**: The diversity of expertise can best be taken advantage of by forming working groups around specific themes of the analysis. For example, a group of experts might form a team to identify focal species, while another might form a team to develop a seamless vegetation of ecosystems map, identify threats, etc.

6. **Define the Planning Objectives***:* Identifying targets for use in a software system can be done in working groups per taxa but should be discussed across all participants. It is often necessary to use multiple targets in an iterative fashion to "test" outputs and see what effect adjusting targets has on outputs. Ask yourself, "What do we want this area to look like in 50 years?"

7. **Identify Data Gaps**: This is most effectively done in working groups per taxa. Parallel to this is identifying existing data, collecting that data and determining how it will be used. Since software relies on spatially explicit data, maps of species ranges, important populations, habitat types, etc., are important data types.

8. **Communication**: Keeping an open dialog between scientists, policy makers and development interests is extremely important. There is a risk of losing trust between the stakeholders when communication fails or when interest groups are excluded or marginalized from the planning process. Transparency and communication can reinforce buy-in from developers and conservationists alike.

9. **Develop Biodiversity Vision**: A vision for the future of biodiversity is a product that can combine the knowledge of the experts, spatial and temporal requirements of the focal species populations into a format useful for discussing

and planning for further action. A vision defines the areas and processes necessary for ecological integrity and species persistence.

10. *Develop Action Plan*: The action plan defines how to implement the vision. Stakeholders interpret the biodiversity vision with socioeconomic priorities and can create trade-off mechanisms and options based on conservation and development scenarios explored in the vision. The action plan is the "how to" guide for the long-term persistence of the regions' biodiversity and ecosystem processes and services.

In conclusion, it is important to mention that this is an ongoing process by design. By creating and maintaining the data in a spatial decision-support system we hope to revisit the planning process as necessary and for measures of success and monitoring and evaluation. It is, in fact, the iterative nature of the planning process and flexibility to change that make it unique and palatable both to conservation and development interests. While working across five countries, and within five languages and political systems and perhaps 50 cultures, has been a challenge, we feel that thinking in an ecoregional context will be a benefit to all those involved in terms of thinking across political boundaries and perhaps some day using this perspective to engage in transboundary conservation.

Acknowledgments

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