Executive Summary

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INTRODUCTION

The Guiana Shield is a vast tropical wilderness covering over 2.2 million square kilometers and encompassing all or part of six South American countries (Hammond 2005). The numerous biomes of the Guiana Shield have fostered the evolution of an exceptionally rich flora and fauna with many endemic species. More than 20,000 species of vascular plants, 1,000 species of birds, and 1,100 species of freshwater fishes are known from the Guiana Shield (Huber and Foster 2003; Hollowell and Reynolds 2005; Vari et al. 2009). The region's tumultuous cultural history and general remoteness from large population centers have effectively limited environmental degradation on a large scale. As a result, much of the Guiana Shield remains forested, presenting an invaluable opportunity to set conservation goals and develop ecologically and socially responsible strategies for resource use (Huber and Foster 2003; Hammond 2005).

Suriname is entirely contained within the Guiana Shield region and is mostly covered by lowland rainforest. Although most of the human population lives on the coastal plain, many Maroon and Amerindian communities are found in the interior — the former mostly along rivers in the eastern half of the country, and the latter primarily in the far southern and western regions. Much of southern and western Suriname is sparsely populated, and wildlife is abundant.

However, the isolation that has protected Suriname's ecosystems, natural resources, and indigenous cultures is coming to an end, and the opportunity to take action to preserve these remarkable resources may soon be gone. Record high commodity prices have encouraged the spread of illegal gold miners from Brazil across the region, spurred potential major hydropower and mining investments, and provided the incentive to press ahead with road and dam projects.

One of the first steps needed to develop conservation and management plans for Suriname is to collect baseline biological and socio-economic data. Suriname currently lacks the scientific capacity to conduct multi-taxa biodiversity field surveys needed to make sound resource management decisions for the country. Increasing Suriname's scientific capacity is critical to ensuring long-term conservation of the country's biodiversity and promoting sustainable development for Suriname's people. This RAP survey was conducted to incorporate national scientific capacity and train local students, scientists and community members in biodiversity assessment and monitoring methods, as RAP has done before in previous surveys in Suriname (Alonso and Berrenstein 2006, Alonso and Mol 2007).

THE KWAMALASAMUTU REGION

The indigenous settlement of Kwamalasamutu (N 02.3561°, W 056.7945°) is situated on the north bank of the Sipaliwini River in southwest Suriname, approximately 10 kilometers upriver from the confluence of the Sipaliwini and Coeroeni Rivers, which together form the main eastern tributary of the Corantijn River flowing north to the Atlantic Ocean (see Map, page 13). The village of Kwamalasamutu was officially created in 1975. Different small nomadic tribes

that inhabited the vast forests of the surrounding region had already been brought together by missionaries in the late 1950s and early 1960s in settlements that were initially more upstream along the Sipaliwini River, but as more people came together in a more or less permanent settlement, the need for more water and better hunting lands eventually led them to their current location. Following establishment of the village, the population reached a maximum of more than 2,000 people before slowly decreasing to its present size of approximately 800 (Teunissen and Noordam 2003). The word 'Tareno' is used by the people themselves as a collective term for the different tribes who live together in Kwamalasamutu. The largest of these tribes is the Trio, and the Trio language is the lingua franca of the people. This document therefore uses 'Trio' to refer to the indigenous people of this region. Today, Kwamalasamutu is the political and cultural center for the Trio people of Suriname. Residents of Kwamalasamutu subsist primarily on fish, bushmeat, and a limited variety of food crops, especially cassava, that are cultivated in a large network of shifting plots surrounding the village (Teunissen and Noordam 2003).

The Kwamalasamutu Region is here considered to encompass the eastern portion of the upper Corantijn watershed, or an area extending from the village south to the Brazilian border, east to the Sipaliwini savanna, north to the Eilerts de Haan and Wilhelmina mountains, and west into the area between the Kutari and Upper Corantijn Rivers. This is one of the most remote areas of the Guiana Shield; the nearest roads are far to the south in Brazil, and all travel within the region is by boat or on foot. A wide, grassy airstrip in Kwamalasamutu serves as the principal connection between the region and the coast. The elevation of the region is mostly between 200–400 meters (higher in the south along the Brazilian border), but scattered granitic formations to the north and east of Kwamalasamutu approach 800 m. The region is entirely forested, with few permanent human settlements.

The Kwamalasamutu Region is situated within the Acarai-Tumucumac priority area located in Guyana, Suriname and Brazil, as defined by participants in a conservation priority-setting workshop held in Paramaribo in 2002, and co-sponsored by Conservation International, the Guiana Shield Initiative of the Netherlands Committee for the International Union for the Conservation of Nature (GSI/NC-IUCN), and the Caribbean sub-regional Resource Facility of the United Nations Development Program (Huber and Foster 2003). Participants ranked the Acarai-Tumucumac area of highest biological importance, citing the area's intact habitats and high ecological diversity, but acknowledged that insufficient data existed to inform conservation recommendations for particular taxonomic groups. To fill this knowledge gap, RAP surveys of the Acarai-Tumucumac area have since been undertaken in both Guyana (Alonso et al. 2008) and Brazil (Bernard 2008), but large areas remain unexplored. This is particularly true in Suriname, where previous biological surveys have been concentrated primarily in the eastern and central regions of the country.

The great forests of the Kwamalasamutu Region extend unbroken far into both Guyana and Brazil, and the region's lack of infrastructure ensures that there is little immediate threat of large-scale extractive activities or landscape conversion. However, this can be expected to change in coming decades as the countries of the Guiana Shield continue to expand their economic activities and develop road networks and other trade connections with one another. Of particular concern from a conservation perspective are the region's populations of large-bodied vertebrates, which are sensitive to over-exploitation and habitat alteration, and the integrity of the region's watercourses, which are vulnerable to sedimentation and contamination from small-scale mining activities.

CONSERVATION INTERNATIONAL'S RAPID ASSESSMENT PROGRAM (RAP)

Conservation International's (CI) Rapid Assessment Program (RAP) is a leading world expert in the collection of field data. RAP is an innovative biological inventory program designed to use scientific information to catalyze conservation action. RAP methods are designed to rapidly assess the biodiversity of highly diverse areas and to train local scientists in biodiversity survey techniques. Since 1990, RAP's teams of expert and host-country scientists have conducted 80 terrestrial, freshwater aquatic (AquaRAP), and marine biodiversity surveys and have contributed to building local scientific capacity for scientists in over 30 countries. Biological information from previous RAP surveys have supported the protection of millions of hectares of tropical forest, including the declaration of protected areas in Bolivia, Peru, Ecuador, and Brazil and the identification of biodiversity priorities in numerous countries. Visit https://learning.conservation.org/biosurvey/Pages/default.aspx for more information on RAP and its methodology.

Capacity Building

In 2008, CI's RAP and Suriname programs carried out two mini-training courses in rapid biodiversity assessment methods for 28 Surinamese students and eight international students. The courses were designed to promote interest in biodiversity conservation and provided students with an introduction to biodiversity assessment and its applications to conservation. Both courses were taught by taxonomic experts who covered field methods for assessing the diversity of plants, large mammals, birds, reptiles and amphibians, and a variety of terrestrial insect groups. Basic introduction to the taxonomy of each group was also presented and practiced. The course format included field projects and activities, lectures, and data analysis.

Project Initiation

In 2000, caves with more than 313 petroglyphs and shards of ancient pottery were discovered at Werehpai, near the village of Kwamalasamutu. At the time, Conservation

International-Suriname (CI-Suriname) was working with the people of Kwamalasamutu on a medicinal plant project that was coming to an end, and decided to explore the region and to support the development of eco-tourism. CI-Suriname first supported an archeological study of the petroglyphs by the Smithsonian Institution and the Suriname Museum (Sandoval 2005), which found evidence to show that the petroglyphs are over 3000 years old and that the caves had been used by humans for at least 5000 years. In 2006, CI-Suriname obtained funds to implement two projects to support protection of the petroglyphs and surrounding forest, and to help reduce poverty in Kwamalasamutu by establishing a community owned and operated eco-tourist facility. The first project, funded by the Global Conservation Fund, aimed to develop two sanctuaries or Indigenous Protected Areas (IPAs) around the petroglyphs (see Map 1, page 13), to identify an appropriate legal mechanism for establishing the areas as sanctuaries, and to build community capacity to manage existing protected areas. At the same time, a second project, funded by the Interamerican Development Bank / Japan Fund, established a community tourism lodge in the Iwana Samu protected area. The tourism lodge was created to generate funds required to sustain effective management of the protected areas, following the management plan that was created in the course of the GCF project.

The local foundation, Stichting Meu, was assigned responsibility by the *Pata Entu* (= chief) of Kwamalasamutu for development and management of protected areas. In 2007, the two separate sanctuaries (Iwana Samu and Werehpai) were joined into one protected area (Werehpai/Iwana Samu Protected Area) and placed under management of Stichting Meu. The total area is now ca. 18,000 ha (see Map 2, page 13). The reason given by the village council for joining the two separate areas into one large protected area was ease of management. One large protected area was easier to delineate than two smaller areas, and everyone on the ground could more easily understand the boundaries of a single sanctuary. Bushmeat hunting is prohibited in the Iwana Samu sanctuary to promote sustainable wildlife populations.

CI-Suriname drafted a report recommending that the Werehpai site be proclaimed a national heritage site, and that the government of Suriname apply to UNESCO for World Heritage Status for the site. The report was submitted to the Minister of Education (who is responsible for cultural sites) in early 2006 and again in 2007. The ministerial team promised further action, but nothing has been forthcoming, due in part to the complexity of indigenous land rights issues in Suriname. CI-Suriname has studied the possibility that Indigenous Protected Areas receive official protected status, and has discussed this complex matter with the government. CI-Suriname recommended that lands indicated as Indigenous Protected Areas be officially issued to the village council of Kwamalasamutu under the Forestry Act. The government installed a committee to study indigenous land rights and to make recommendations for amendments to existing laws or the drafting of new legislation. At the present time, a decision on the official status of the Indigenous Protected Areas established under this project has been postponed until the larger national issue of tribal lands is resolved.

The RAP survey of the Kwamalasamutu Region forms an integral part of CI-Suriname's ongoing efforts to assist the people of Kwamalasamutu to strengthen their capacity to manage the sanctuary and promote tourism on their lands.

The RAP survey in 2010 had two principal goals:

1) supply baseline data on the region's biodiversity and water quality to the Trio people of Kwamalasamutu, including recommendations for the management of game and fish populations for long-term viability and information to support eco-tourism
2) provide Surinamese students and young professionals with further training and opportunities to advance their interests in environmental biology. RAP and CI-Suriname are dedicated to continue to work with these and other students to build capacity for conservation within the university student population.

OVERVIEW OF THE RAP SURVEY

The scientific team included scientists from the Anton de Kom University of Suriname, Conservation International, Panthera, the Amazon Conservation Team, the Museum of Comparative Zoology at Harvard University, the Louisiana State University Museum of Natural Science, the Biodiversity Institute at the University of Kansas, the California State Collection of Arthropods, the Field Museum, the Royal Ontario Museum, and the National Herbarium of the Netherlands. The scientists were joined by seven students currently or formerly enrolled at the University of Suriname, many of whom participated on RAP training courses conducted by CI in Suriname in 2008. The RAP team collected data on water quality, plants, and the following groups of animals: ants, aquatic beetles, dung beetles, dragonflies and damselflies, katydids and grasshoppers, fishes, reptiles and amphibians, birds, small mammals, and large mammals.

Survey sites were chosen to maximize the diversity of sampled habitats, with a particular emphasis on areas most likely to be visited by tourist groups. All sites were easily accessible within one day's travel by boat from Kwamalasamutu.

DESCRIPTION OF THE RAP SURVEY SITES

The RAP team surveyed three sites in the Kwamalasamutu region. Only the coordinates of the base camps are given here; most sampling was done within 5–10 kilometers of these camps. Certain groups were sampled in other areas as well (e.g., along rivers between camps); please refer to individual chapters for sampling protocols and localities.

Site 1. Kutari River
N 02° 10'31", W 056° 47' 14"
18–24 August 2010
The first camp was situated on the east bank of the Kutari River, approximately 44 km by river from Kwamalasamutu. The Kutari flows north from its source along the Suriname-Brazil border and joins the Aramatau to form the Coeroeni River; at our camp, the Kutari formed a meandering channel approximately 40 meters wide. The habitat at this site was a mix of terra firme and seasonally inundated forest, with the latter more extensive here than at our other sites. Away from the river the terrain was quite hilly and supported tall terra firme forest; low-lying areas between hills were often swampy and dominated by palms (*Euterpe oleracea*). At least one large patch of tall bamboo (*Guadua* sp.) was found here as well. Approximately six km of trails were cut at this site, and most terrestrial sampling was done along these trails.

Site 2. Sipaliwini River
N 02° 17' 24", W 056° 36' 26"
27 August–2 September 2010
The second camp was situated on the north bank of the Sipaliwini River, approximately 27 km upriver from Kwamalasamutu. Here the Sipaliwini formed a broader, straighter channel than the Kutari, and contained numerous boulders and rapids. The habitat around this site was primarily tall terra firme forest, with fewer palm swamps and generally less seasonally flooded forest than the Kutari site. The understory contained many spiny palms (*Astrocaryum sciophilum*). In many places, particularly on hilltops, the soil layer was very thin and supported a shorter forest with fewer large-diameter trees. From this site, we were able to access a small granitic outcrop, or inselberg, situated approximately three km from the camp. Many creeks flowed into the Sipaliwini around this site; some of these creeks had steep banks and formed channels up to 15 meters across. At this site, we sampled primarily along the trail to the inselberg, and along a second trail that extended approximately three km northeast of the camp.

Site 3. Werehpai
N 02° 21' 47", W 056° 41' 52"
3–7 September 2010
The third camp was located on the north bank of the Sipaliwini River, approximately 16 km downriver from the second camp. The river here was slightly wider than at the previous site. The camp itself was situated on an abandoned farm, and the habitat immediately surrounding the camp was mostly second growth forest and bamboo with a dense, almost impenetrable understory. Farther away from the camp, the habitat consisted of tall primary terra firme forest, similar to the previous site. However, the soil was deeper and richer in some areas at this site, supporting more large-diameter trees. Most sampling occurred along the well-established 3.5-km trail to the Werehpai caves. No other trails were cut at this site. From this camp, some groups (primarily the fish and water quality specialists) surveyed Wioemi Creek, a small river that flows into the Sipaliwini approximately five km upriver from Werehpai. Wioemi Creek was much like the Kutari River in many respects, and supported substantial areas of seasonally flooded forest.

OVERVIEW OF RAP RESULTS—GENERAL IMPRESSIONS

The RAP survey team found the Kwamalasamutu region to be highly diverse and in near-pristine ecological condition. At least 1,316 species of plants and animals were identified by the RAP scientists, of which a minimum of 46 species—16 aquatic beetles, ~ten dung beetles, four dragonflies, seven katydids, eight fishes, and one frog—are new to science. Approximately 111 species were recorded for the first time from Suriname, underscoring the magnitude of the country's biodiversity and the need for additional surveys in other unexplored areas of the region.

Fifteen species listed on the IUCN Red List of Threatened Species (IUCN 2011) were encountered during the survey (Table 1). Many of these species play important roles in the forest ecosystem as top predators and dispersers of large seeds; they also include some of the most highly prized animals in the diet of the Trio people. More data are needed

Table 1. Species listed on the IUCN Red List of Threatened Species that were recorded during the Kwamalasamutu RAP survey. Species are listed in ascending order of threat level; those without English names are trees for which standardized English names do not exist. LR/NT: Lower Risk/Near Threatened; NT: Near Threatened; VU: Vulnerable; EN: Endangered; CR: Critically Endangered.

Scientific name	English name	IUCN Red List Status
Minquartia guianensis		LR/NT
Harpia harpyja	Harpy Eagle	NT
Tayassu pecari	White-lipped Peccary	NT
Panthera onca	Jaguar	NT
Cedrela odorata		VU
Corythophora labriculata		VU
Chelonoides denticulata	Yellow-footed Tortoise	VU
Ateles paniscus	Guianan Spider Monkey	VU
Priodontes maximus	Giant Armadillo	VU
Myrmecophaga tridactyla	Giant Anteater	VU
Tapirus terrestris	Brazilian Tapir	VU
Aniba rosaedora		EN
Trichilia surumuensis		EN
Pteronura brasiliensis	Giant Otter	EN
Vouacapoua americana		CR

to inform suitable hunting quotas for these species, but the RAP data provide some baseline information on species distribution and hunting intensity to inform a process to determine sustainable hunting levels.

RAP RESULTS BY TAXONOMIC GROUP

Water Quality

A total of 23 sites were sampled intensively in three major areas: the Kutari River, and two areas of the Sipaliwini River. We measured 13 physico-chemical parameters at each site: pH, dissolved oxygen, conductivity, temperature, alkalinity, total hardness, total phosphate, nitrate, chloride, tannin & lignin, ammonia, turbidity and secci depth. The oxygen content and pH of the Kutari River were lower than those of the Sipaliwini River, probably due to the lack of rapids and the input of organic material from the surrounding forest, particularly after heavy rains, which occurred frequently at the Kutari site. All sites had clear water except the Wioemi Creek, which was very turbid. The parameters measured in the field revealed undisturbed river ecosystems with few negative human impacts. However, high mercury levels were found in both sediment and piscivorous fishes from all sites. Further research is needed to clarify the origin of mercury in these river systems, and we recommend initiating a water quality monitoring program in Kwamalasamutu.

Plants

The RAP botanical team made 401 plant collections representing 62 families, 132 genera, and approximately 240 species. These collections were made in the nine vegetation types we distinguished: tall herbaceous swamp vegetation and swamp wood, seasonally flooded forest, (seasonal) palm swamp forest, high tropical rainforest on dryland (terra firme), tropical forest on laterite/granite hills, savannah (moss) forest, open rock (inselberg) vegetation, secondary vegetation, and bamboo forest. We found eight species previously unrecorded in Suriname, of which six were tree species and two were herbaceous species. We also found a substantial number of rare plant species for Suriname, including six tree species listed on the IUCN Red List and three tree species protected under Surinamese law. The three sampling sites each had a distinct species composition, and the forests along the Kutari River had one of the highest tree alpha diversity values ever recorded for Suriname. At the same time, the forests at Werehpai had relatively low tree alpha diversity values. The forests showed some floristic affinities with adjoining regions of Guyana and Brasil. Comparison of our results with data from forests in northern Suriname showed that forests in the Kwamalasamutu region overlap only partially in species composition. Based on these results we argue that the forests in the Kwamalasamutu region have a high natural value for Suriname, and appropriate conservation measures should be taken, including the establishment of additional community-managed protected areas, and exploration of agricultural methods that better incorporate standing forests.

Aquatic Beetles

We collected more than 4000 aquatic beetle specimens using both active and passive collecting techniques. We documented 144 species, representing 62 genera in nine families. Sixteen of these species have been confirmed as new, with an additional 10 likely to be new. Two of these new species, both in the family Hydrophilidae, are described here: *Oocyclus trio* Short & Kadosoe sp.n. and *Tobochares sipaliwini* Short & Kadosoe sp.n. Camps 1 (Kutari) and 3 (Werehpai) had comparatively high species diversity, with 91 and 93 species respectively—although only 48 of these species were shared between the two sites. Camp 2 (Sipaliwini) had the lowest number of species with 68. The fauna was typical of lowland Guianan forests. Some taxa, such as the genera *Siolus, Guyanobius, Fontidessus*, and *Globulosis* are either endemic or largely restricted to the Guiana Shield. The fauna was very similar to what is known from southern Venezuela (south of the Orinoco) and Guyana. The water beetle diversity was expected given the complement of aquatic habitats available at each camp. The relatively high number of genera and species, which cover a variety of ecological and habitat types, suggest the area is largely undisturbed.

Dung Beetles

Dung beetles are among the most cost-effective of all animal taxa for assessing biodiversity patterns, but relatively little is known about the dung beetle fauna of Suriname. I sampled dung beetles using baited pitfall traps and flight intercept traps in the Kwamalasamutu Region of southern Suriname. I collected 4,554 individuals represented by 94 species. Species composition and abundance varied quite strongly among sites. Dung beetle diversity correlated positively with large mammal species richness, and was highest at the most isolated site (Kutari), suggesting a possible cascading influence of hunting on dung beetles. Small-scale habitat disturbance also caused local dung beetle extinctions. The dung beetle fauna of the Kwamalasamutu region is very rich relative to other lowland forests of Suriname and the Guianas, and contains a mix of range restricted endemics, Guiana Shield endemics, and Amazonian species. I estimate that about 10–15% of the dung beetle species collected here are undescribed. While most species were coprophagous, 26 species were never attracted to dung; 4 of these were attracted exclusively to carrion or dead invertebrates and the other 22 were only captured in flight intercept traps. The abundance of several large-bodied dung beetle species in the region is indicative of the intact wilderness that remains. These species support healthy ecosystems through seed dispersal, parasite regulation and other processes. Maintaining continuous primary forest and regulating hunting (such as through hunting-restricted reserves) in the region will be essential for conserving dung beetle communities and the ecological processes they sustain.

Ants

At least 100 species of ants (Hymenoptera: Formicidae) were recorded around the Werehpai caves during the RAP survey. While ant data from the RAP survey are still being analyzed, a preliminary look at the ant fauna of the area indicates that the forests contain a diverse and abundant ant fauna. The presence of many dacetine species typical of closed-canopy rainforest indicate that the forests are in good condition. The ant fauna of Suriname is still very poorly known, with about 350 species documented, as few locations have been sampled for ants. Data on the ant fauna of the Kwamalasamutu area are valuable for eco-tourism since ants are easy to find and observe in the forest. Biological data for charismatic ant species will inform tourists about the hidden fauna of the rainforest and their important roles in ecosystem function and conservation. Habitat loss, fragmentation and the introduction of invasive ant species are the biggest threats to the ant fauna of the region.

Katydids

Seventy-eight species of katydids (Orthoptera: Tettigoniidae) were recorded during the RAP survey. At least seven species are new to science, and 29 species are recorded for the first time from Suriname, bringing the number of species of katydids known from this country up to 85. Of the three main camps, the Kutari site had the lowest number of both species (25) and specimens (64) collected, presumably because of the heavy rains that still affected the activity of katydids at the end of the rainy season, when the survey began. Werehpai had the highest number of species (54), followed by Sipaliwini (46). This RAP survey confirms that the katydid fauna of Suriname is exceptionally rich, yet still very poorly known. Although no specific conservation issues have been determined to affect the katydid fauna, habitat loss in Suriname due to logging and mining activities constitute the primary threat to the biota of this country.

Dragonflies and Damselflies

Ninety-four species of dragonflies and damselflies were recorded during the RAP survey, representing one-third of the species known from Suriname. Fifty-seven species were found at the Kutari River site, 52 at the Sipaliwini River site, and 65 at the Werehpai site. Fourteen species represent new records for Suriname, of which four, belonging to the genus *Argia*, are new to science; an additional five species represent first records at a new locality since their original descriptions, increasing considerably their known extent of occurrence. In terms of odonate community composition, the three sites shared between 1/2 and 2/3 of the species with each other, though relative abundance differed among sites. The diversity of odonate genera and species found in this study is characteristic of intact tropical lowland forest; most of the species found in the forest understory, creeks, and swamps would not be present if the forest were disturbed. Therefore it is recommended to designate a large and legally protected nature preserve to conserve the high diversity of odonate species found in this study. If forest cover and stream morphology are maintained in the area, the present odonate assemblages are expected to persist.

Fishes

We recorded 99 species of fishes from 43 sampling localities along the Sipaliwini and Kutari Rivers. This diversity is high compared to the rest of the world, but is typical for the Guiana Shield. We collected eight species of fishes potentially new to science, including a large catfish with spines along the body and a small catfish that lives in sand-bottomed creeks. Two species are new records for Suriname. We collected 57 species at the Kutari site, 60 species at the Sipaliwini site, and 63 species at the Werehpai site. This is remarkably consistent, with no significant difference in diversity among camps. However, we did not necessarily find the same species at each camp. Creek assemblages were similar among the three sites. Many young fishes were found in flooded forests, even if the adults lived in rivers or other habitats. Overall, large top-level predators were uncommon. The region is exhibiting the first stages of overfishing. Many fishes still occur in the Sipaliwini area, but there is a need to assess fishing pressure and implement management plans.

Reptiles and Amphibians

The RAP team found 42 species of amphibians and 36 species of reptiles, including a frog in the genus *Hypsiboas* that is new to science. The amphibian community was most similar to those of forests on bauxite plateaus in central Suriname. Several rare species were collected during the survey: *Osteocephalus cabrerai* is a rare tree frog from the western Amazon Basin and French Guiana and is reported from Suriname for the first time. *Scinax proboscideus* is a tree frog previously known from only two localities in the interior of Suriname and a few localities in French Guiana. *Microcaecilia taylori* was described, based on three specimens, from forest islands in the Sipaliwini savanna; the specimen collected by us is the fourth specimen known to science, and shows that this species is not restricted to the Sipaliwini savanna area. The snake *Xenodon werneri* is quite rare, and our record constitutes the third specimen for Suriname. The amphisbaenian *Amphisbaena slevini* was collected in Suriname for the first time. We also encountered *Chelonoides denticulata* (Yellow-footed Tortoise), listed as Vulnerable on the IUCN Red List. We discovered that certain expected species that are quite common in other areas in Suriname were either not found or found in very moderate numbers on the RAP survey. On the other hand, we found certain generally rare species to be quite common.

Birds

The RAP team recorded 327 species of birds: 294 species from the three RAP sites, 12 species observed in the area during the reconnaissance trip (3–8 May 2010) but not during the RAP survey, and 21 species observed only in the vicinity of Kwamalasamutu itself. The avifauna was typical

of lowland forests of the Guiana Shield, and included many species endemic to the region. Our observations represent the first published records for Suriname of *Crypturellus brevirostris* (Rusty Tinamou), *Dromococcyx pavoninus* (Pavonine Cuckoo), *Xiphocolaptes promeropirhynchus* (Strong-billed Woodcreeper), and *Ramphotrigon megacephalum* (Large-headed Flatbill). The overall species list was highest for the Sipaliwini camp (250 species), followed by Werehpai (221 species) and Kutari (216 species). 153 species, or approximately 52% of those encountered at the three sites, were observed at all sites. The Kutari site had the most distinctive avifauna of the three sites. We estimate that a minimum of 350 bird species, or roughly half of the number of species known to occur in Suriname, may be found in the Kwamalasamutu area. Although no species listed on the IUCN Red List were encountered during the RAP survey, at least one (*Harpia harpyja*, Harpy Eagle, Near-Threatened) is known to occur in the area. Maintenance of large tracts of intact forest is recommended to preserve the avian diversity of the Kwamalasamutu region.

Small Mammals

The RAP team documented 38 species of small mammals including 26 species of bats, 10 species of rats, and two species of opossums. The species diversity and relative abundance of rats and mice at the three survey sites were the highest recorded in 20 years of mammal surveys throughout Suriname and Guyana by the Royal Ontario Museum. The Kutari site had the highest capture rate of rats and mice, indicating a healthy source of prey species for predators such as cats, owls, and snakes. In contrast, Werehpai was the most successful site for bats, but this was attributable to the well-established trails at the site, which functioned as flyways that were more conducive to capture success compared to the other sites, where rudimentary trails were only recently cut. This indicates that bats are relatively tolerant to minor alternations to their habitat. Noteworthy records include two species endemic to the Guiana Shield, a water rat (*Neusticomys oyapocki*) and a brush-tailed rat (*Isothrix sinammariensis*), collected at Kutari that represent the first occurrences of these species in Suriname. The primary conservation recommendations arising from the small mammal survey of the Kwamalasamutu region are: 1) designation of the Kutari area as a nature reserve because of the high species diversity and relative abundance of rats and mice that are necessary to sustain healthy populations of top-level predators; and 2) minimal development of the Werehpai petroglyph site to ensure continued ecosystem services of the bat fauna including seed dispersal, flower pollination, and insect control.

Large Mammals

Twenty-nine species of medium- and large-bodied mammals were recorded through visual encounters and camera trapping. Large caviomorph rodents were the most frequently recorded animals in the camera trap images. The Kutari site was the richest in species, especially primates. The Brazilian Tapir (*Tapirus terrestris,* IUCN Vulnerable) was recorded by the camera traps at all three sites and was observed by several of the RAP scientists. Of the six species of cats known to occur in the Guiana Shield region, the Jaguar (*Panthera onca,* IUCN Near-Threatened), Puma (*Puma concolor*) and Ocelot (*Leopardus pardalis*) were found during the survey. The White-lipped Peccary (*Tayassu pecari,* IUCN Near-Threatened) was only photographed once by the camera traps in the Werehpai area and seems to be uncommon in the Kwamalasamutu region. In addition to the species mentioned above, four additional species listed on the IUCN Red List were encountered: *Ateles paniscus* (Guianan Spider Monkey, Vulnerable); *Myrmecophaga tridactyla* (Giant Anteater, Vulnerable); *Priodontes maximus* (Giant Armadillo, Vulnerable); and *Pteronura brasiliensis* (Giant Otter, Endangered). The number of mammal species found during this survey does not differ much from what was expected. The difference in number of species per site suggests that hunting pressure varies from one area to another. Our observations of many shy and sensitive mammal species indicate that hunting has not yet depleted game populations in the region. Nevertheless, hunting from Kwamalasamutu represents the most significant current threat to medium- and large-bodied mammals in the area. Recommended studies include more camera trapping and a sustainability evaluation of wild meat hunting.

SUMMARY OF CONSERVATION RECOMMENDATIONS

Conservation Action

Establish protected areas to maintain the intact ecological condition of the area's forests and rivers. Monitor and prevent illegal mining activity in the Kwamalasamutu region.

The results of the RAP survey indicate that the Kwamalasamutu region is in near-pristine ecological condition. The area supports high species diversity, including many species found only in extensive regions of undisturbed forest. We found no evidence of substantial anthropogenic impacts on water quality or forest structure away from the village itself. As the forested landscape of this area extends unbroken far beyond the borders of Suriname, the Kwamalasamutu region represents the nucleus of a vast biological treasure of global significance. Although not immediately threatened, effective conservation in the region will require active and continuous assessment of potential threats and international cooperation to adequately manage the region's resources.

We attribute much of the region's high species diversity to small-scale habitat heterogeneity and intact connections between habitats used by animals in different stages of their life cycles. Even within primary terra firme forest, most taxonomic groups showed surprisingly high species turnover between sites. This mosaic of diversity is typical of large, undisturbed regions of tropical forest, and can be impacted profoundly by human modification of the landscape. At a large spatial scale, road construction and resource extraction

(e.g., logging, mining) should be carefully controlled to avoid disrupting processes vital to maintenance of ecosystem integrity. At a smaller scale, guidelines should be developed for establishing protected areas that consider fine-scale environmental heterogeneity as well as the seasonal movement of animals among different habitats, particularly aquatic and terrestrial habitats.

Of particular concern is the continuing encroachment of small-scale gold miners in the region, which can be expected to accelerate with the construction of highways currently planned for interior Suriname and adjacent northern Brazil. The clean and abundant water flowing from the upper Corantijn watershed is an extremely valuable asset, both for the people who depend directly on the rivers for sustenance and for the people of coastal Suriname. Pollution of rivers by small-scale miners, a persistent problem elsewhere in the Guianas, has the potential to cause major ecological and social upheaval in the Kwamalasamutu area if miners gain access to the region. Already there are concerns among residents of Kwamalasamutu about gold mining activities in the upper reaches of the Aramatau River, and our data suggest that mercury pollution may already be affecting the region's watercourses (see Chapter 1, Water Quality). Aside from mercury contamination, any increase in mining activity would contribute to erosion and sedimentation, negatively impacting fish stocks upon which the people of the region depend. In addition, gold miners often hunt intensively and can severely deplete populations of terrestrial mammals that indigenous people, as well as healthy ecosystems, depend upon (see below).

Environmental Protection and Sustainable Harvesting

Develop and implement a plan to manage bush meat hunting and fishing in the Kwamalasamutu region.

Effective conservation in the Kwamalasamutu region will require active management of wildlife and their habitats to protect them from overexploitation. This is particularly important if the community desires to pursue ecotourism as a source of revenue (see below). Already there are signs that wildlife has been impacted, especially near the village. Our strongest evidence for this is the observation that large, predatory fishes, many of which are prized for food (e.g., *Hoplias aimara*, *Cichla ocellaris*), were generally scarce even at the most remote camp, and virtually absent in the vicinity of Kwamalasamutu. Although the camera traps and dung beetle surveys respectively provided direct and indirect evidence for a rich mammal fauna, the general scarcity and shyness of wildlife (particularly monkeys, peccaries, and curassows) at all sites was suggestive of hunting pressure. High mammal and dung beetle diversity at the most isolated site (Kutari) also suggests that hunting closer to the village is impacting local ecosystems. Populations of game animals in the region are probably sustained by dispersal through the vast and largely uninhabited forest matrix that surrounds the Kwamalasamutu region, where we presume wildlife is more abundant. However, this does not justify local depletion of wildlife, as many game animals and fishes play important roles as predators and seed dispersers in the ecosystem, and as such are vitally important for forest dynamics.

We suggest that a thorough assessment of bush meat hunting and fishing pressure be undertaken to promote establishment of, and adherence to, hunting and fishing quotas or seasons for particular species. Ideally, this would incorporate information on the ecology and reproductive habits of target species, already well known to many residents of the region. Alternatively, certain areas could be designated as non-hunting zones for at least a portion of each year, following the model of the Iwana Samu sanctuary set up by the people of Kwamalasamutu. However, the effectiveness of these protected areas depends on diligent local enforcement of activities within them. By either of these mechanisms, the regulation of bush meat hunting would benefit the residents of Kwamalasamutu by allowing wildlife populations to replenish themselves, thereby lessening the need for expensive hunting excursions far from the village. Chickens and other domestic animals also provide a good alternative protein source, and should be further encouraged in the village.

Ecotourism: Promotion & Implementation

Continue developing and upgrading the Iwana Samu ecotourism facilities, focusing on the region's cultural history.

Ecotourism has great potential to provide the village of Kwamalasamutu with much-needed income. To this end, the community should enhance the existing facilities at Iwana Samu and work to highlight the uniqueness of the area, manifested in the petroglyphs at Werehpai and elsewhere. Protection of wildlife (see above) would also help increase the area's appeal to tourists, many of whom will require some incentive to choose to visit Kwamalasamutu in lieu of less expensive destinations closer to Paramaribo. Protection of fish stocks could allow the development of sport fishing tourism. Adventure tourism (e.g. trekking) could also be promoted by taking advantage of the existing network of trails used by residents of the region to move between settlements. Effective advertisement and promotion of the site and facilities to tourists in the Netherlands, United States and other countries will also be key to the success of ecotourism here.

The data from this RAP survey are being incorporated into an educational/tourism booklet about the biodiversity of the Kwamalasamutu region that can be used by the people of Kwamalasamutu in their eco-tourism efforts. Charismatic species of birds, mammals, amphibians, dragonflies and other taxa—even ants!—have been identified and will be promoted as key attractions for tourists.

Scientific Capacity Building

Develop research facilities to promote the exchange of information between residents of Kwamalasamutu and scientists from Suriname and abroad. Develop and implement a water quality monitoring protocol.

The Kwamalasamutu community would benefit from the development of facilities for Surinamese and foreign researchers. The region supports a high diversity of aquatic and terrestrial habitats and is relatively free of large-scale anthropogenic degradation, rendering it highly suitable for ecological research. We consider the area to be particularly promising for research on the ecological role of humans in tropical lowland forest, given the region's long history of occupation by the Trio. To this end, researchers could employ and train residents of Kwamalasamutu in a mutually beneficial relationship, whereby researchers gain valuable field assistance and indigenous knowledge in exchange for site-specific recommendations for management of natural resources to promote long-term social and environmental stability. In particular, we recommend that residents of Kwamalasamutu be trained to implement a water quality monitoring program to empower them to detect and act upon the first signs of degradation of this vital resource. Residents could also be monitoring and recording wildlife observations and bushmeat and fish consumption patterns in order to gain better understanding of the long-term dynamics and sustainability of hunting and fishing.

One of the greatest potential threats to the region is the erosion of traditional knowledge among young people. We recommend creating educational materials—for example, picture guides to common species of birds, fishes, and mammals—to be translated into Trio and used in area schools. These guides could also be used by tourists visiting the region.

Further Studies

Conduct additional biodiversity surveys at different times of the year.

Although we found a high diversity of species in the Kwamalasamutu region, our survey was only the first step toward a thorough knowledge of the region's biodiversity. Beyond documenting species new to science, biodiversity surveys provide critical baseline information about the distribution, ecology, and habitat requirements of tropical organisms. Many tropical plants and animals are poorly known from a scientific perspective; this is particularly true for the species new to science that we encountered on this survey. We therefore recommend additional surveys, focusing on undersampled habitats (e.g. inselbergs), different seasons, and other sites within the region, to gain a better understanding of the biodiversity of the Kwamalasamutu region and southwest Suriname in general. We suspect that many undescribed species remain to be discovered.

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