Executive Summary

Source: RAP Bulletin of Biological Assessment: A Rapid Biological Assessment of the Lely and Nassau Plateaus, Suriname (with additional information on the Brownsberg Plateau): 17

Published By: Conservation International

URL: https://doi.org/10.1896/1-881173-98-4.17

Executive Summary

INTRODUCTION

The Lely and Nassau Plateaus are located in north-eastern Suriname and range in elevation from 500-700 m. They are covered mostly by high dryland rainforest on the plateaus and slopes and mountain savannah forest on the plateau. The Brownsberg Plateau is a third major plateau in this area, part of which is protected by the Brownsberg Nature Park (11,800 ha). The 2002 Guayana Shield Priority-Setting Workshop determined that these three plateaus are all important for biodiversity but that we lack essential biodiversity data, particularly for Lely and Nassau (Huber and Foster 2003). The plateaus provide many watershed services for local and coastal communities, as well as important sources of employment (principally small-scale gold mining), food, medicine and building materials for local communities. Lely and Nassau are still relatively intact owing to low human population density, which presents many unique opportunities for conservation over a relatively large landscape area. However, they all face a number of current and potential threats, including logging, hunting/poaching and small-scale (gold) and large-scale (bauxite and gold) mining.

Conservation International's Rapid Assessment Program (RAP)

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 56 terrestrial, freshwater aquatic (AquaRAP), and marine biodiversity surveys and have contributed to building local scientific capacity for scientists in 26 countries. Biological information from previous RAP surveys has resulted in 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.

Project Initiation

Alcoa, through its successful partnership with Conservation International (CI) conducting a RAP survey in Guinea, suggested to the Suralco/BHPB Joint Venture that a similar exercise would be worthwhile in Suriname. Thus in June 2005, BHP-Billiton Maatschappij Suriname (BMS) invited CI to present recommendations on how its Rapid Assessment Program (RAP) could contribute to a greater understanding of the fauna and flora of the Lely, Nassau and Brownsberg plateaus. Suriname Aluminium Company LLC (Suralco) holds mining concessions on these three plateaus and has formed a Mining Joint Venture with BMS. The joint venture divides the mining process between the two companies: BMS to first carry out exploration on the plateaus and then if sufficient bauxite is found, BMS is to do the mining and then Suralco will refine the bauxite.

CI proposed that a strategic partnership be formed with the Mining Joint Venture of BMS and Suralco. A central component of this partnership involves utilizing CI's Initial Biodiversity Assessment Planning (IBAP) methodology to both increase understanding of

these areas' ecosystems and socio-economic dynamics and provides recommendations for incorporating biodiversity considerations in the earliest stages of decision-making for Suriname's next generation of mines (see Chapter 2).

RAP Survey of the Lely and Nassau Plateaus

As part of the IBAP process, CI's RAP program organized a RAP team of 18 scientists, students and logistical support to undertake rapid biodiversity surveys of the Lely and Nassau Mountains. Prior to this RAP survey, very little biodiversity data had been collected for the Lely and Nassau plateaus. Many studies have been conducted in the Brownsberg Nature Park on the Brownsberg plateau so the RAP team did not include this plateau in their survey. However, the biodiversity of Brownsberg is summarized in this report (see Chapter 13) and comparisons between the three plateaus are made below. The few studies that had been done on the Lely and Nassau plateaus are also included in this report (see Chapters 3, 4, and 8).

The RAP team surveyed the Nassau and Lely plateaus from October 25 – November 6, 2005, focusing on the same areas studied during previous plant surveys (Bánki et al. 2003, ter Steege et al. 2004, 2005). The RAP team, composed of specialists in ants, birds, dung beetles, fishes, mammals, and reptiles and amphibians, collected data on these taxonomic groups, generated a set of overall conclusions of the regions' biodiversity, and made recommendations on how their ecosystems can be conserved.

Criteria generally considered during RAP surveys in order to identify priority areas for conservation across taxonomic groups include: species richness, species endemism, rare and/or threatened species, and habitat condition. Measurements of species richness can be used to compare the number of species between areas within a given region. Measurements of species endemism indicate the number of species endemic to some defined area and give an indication of both the uniqueness of the area and the species that will be threatened by alteration of that area's habitat (or conversely, the species that may be conserved through protected areas). Assessment of rare and/or threatened species (IUCN 2006) that are known or suspected to occur within a given area provides an indicator of the importance of the area for the conservation of global biodiversity. The confirmed presence or absence of such species also aids assessment of their conservation status. Many of the species on IUCN's Red List of Threatened Species carry increased legal protection thus giving greater importance and weight to conservation decisions. Describing the number of specific habitat types or subhabitats within an area identifies sparse or poorly known habitats within a region that contribute to habitat variety and therefore to species diversity.

RAP SURVEY AREAS

The Lely and Nassau Mountains are two isolated plateau areas in eastern Suriname along the border with French Guiana and east of the Brokopondo Reservoir (see Map). The defining feature of these plateaus is the presence of a solid and thick crust in the upper soil that is composed mainly of consolidated ferrite (Fe) and bauxite (Al). Although the RAP survey of both areas was conducted during the dry season, both areas received rainfall during the survey, with Lely receiving more rainfall (at times heavy) than Nassau. Rainfall generally occurred in the late afternoon or at night.

Lely Mountains

The Lely Plateau is located within the Marowijne River Basin and contains a series of plateaus with maximum altitude of approximately 700 meters. In the Lely Mountains, six main vegetation types occur namely: high dryland rainforest on laterite plateaus, high marsh forest on laterite plateaus, mountain savanna forest, mountain savanna moss forest, vegetation on and near rocky creek beds, and high dryland rainforest on slopes. In places were human disturbance has occurred, (low) secondary forest and open vegetation is found (e.g. near the airstrip).

The RAP base camp was established at N 4°16'13", W 54°44'18" (UTM N 04.27043, W 054.73815), at an altitude of 640 meters. Vegetation types surveyed by the RAP team included savannah forest with smaller areas of high forest, palm swamp and secondary growth from clearing areas for infrastructure. The Lely Mountains is still an intact area since access to the plateau is difficult and mostly restricted to small airplanes. The infrastructure found on the Lely plateau is considerably less developed than that of Nassau, with no known roads connecting it to other areas of the country.

At present the only human activities in Lely Mountains are related to three to five personnel of the Aviation Service (Sur. Luchtvaartdienst) at the airstrip on the plateau and several camps of small-scale gold miners in the western foot hills. The airstrip staff are stationed in a few huts near the airstrip and have cleared vegetation around two radio towers located adjacent to the airstrip. A number of footpaths are found in the survey area.

Nassau Mountains

The Nassau Plateau is comprised of four plateaus ranging from 500 - 570 meters. In the Nassau Mountains, six main vegetation types occur namely: high dryland rainforest on laterite plateaus, high marsh forest on laterite plateaus, mountain savanna forest, mountain savanna moss forest, vegetation on and near rocky creek beds, and high dryland rainforest on slopes. The mountain savanna (moss) forest is less extensive than on the Lely Plateau and has a higher stature. Open vegetation and secondary forest occur near the old airstrip and on places where bauxite exploration has taken place in the past.

The RAP base camp was established at N 4°49'13", W 54°35'20" (UTM N 04.82047, W 054.60572), at an altitude of 514 meters. Vegetation types surveyed in Nassau included primary and secondary high forest, mountain savanna forest, limited patches of palm swamp and some areas cleared for infrastructure such as roads and an overgrown airstrip.

Of the two plateaus surveyed, Nassau had the most widespread human impacts, with a number of unpaved roads, footpaths and a base camp to facilitate mining exploration by BHP-Billiton (BMS) personnel (it also housed the RAP survey teams). A relatively well-maintained unpaved road (connected to the paved road running along the coast) has a number of smaller, more poorly maintained roads and footpaths feeding off it. An airstrip was located near the mining base camp but has not been maintained and was currently unusable at the time of the RAP survey. At higher areas (> 400 m), the forest and streams of the Nassau Mountains are less impacted but many human activities are encroaching fast from the foothills, including shifting cultivation plots, logging, small-scale gold mining, and exploration for construction of a large goldmine (Newmont).

DATES OF THE RAP SURVEYS

The RAP team was divided into two smaller teams to facilitate transportation to these relatively inaccessible areas. Team 1 (consisting of specialists studying birds, fishes, ants and dung beetles) surveyed Lely from October 25 - 31, 2005 while Team 2 (consisting of specialists studying reptiles/amphibians and small mammals/bats/large mammals) surveyed Nassau. From November 2 - 6, 2005, Team 1 surveyed Nassau and Team 2 surveyed Lely.

OVERALL RAP RESULTS

The RAP survey of Lely and Nassau revealed a high diversity of species, at least 27 of which are endemic to the Guayana Shield region. Both sites contain many large mammals and large birds (e.g. parrots, guans), indicating that they still hold significant populations and may serve as a refuge for these larger species. For most taxa-plants (including orchids), mammals, ants, birds, and dung beetles-Lely appears to be more diverse than Nassau. This is likely due to a combination of factors, including the fact that the Lely Plateau is larger and reaches a higher elevation so that the extent of each forest type is greater. Lely also has a seasonal humidity created by rain clouds that touch the forest cover, which provides the appropriate conditions for Guayanan Highland elements to occur. The higher diversity of mammals and dung beetles at Lely may also be influenced by the more pristine condition of its habitats in comparison to Nassau, which has had more human disturbance and higher hunting pressure.

The pattern of higher diversity at Lely does not hold for the fishes of the high altitude streams, for which eight fish species were documented at Lely versus 11 species at Nassau. Nassau also seems to have higher endemism in fishes, the only taxa for which endemism can currently be established with some confidence. *Harttiella crassicauda,* a rare catfish endemic to the Nassau Plateau, was recorded for the first time since 1949, and a new species of *Guyanancistrus* ('big mouth') is also likely endemic.

At least 24 species new to science were recorded from both sites, indicating how little we know of these areas and the Guayana Shield region overall. Many of the new species are amphibians and fishes, which require clean, quality freshwater for their survival.

While still in fairly good condition, both sites are heavily threatened by human activities. Both sites currently show evidence of unregulated hunting activity, which is having a direct impact on larger species (particularly larger mammals and birds) as well as an indirect impact on the larger trophic chain (e.g. dung beetles). The Lely Mountains offer excellent conservation opportunities because of the relatively low human impact, low human population densities and relative lack of access. The Nassau Mountains have been more impacted by human activities, particularly with regards to hunting and habitat fragmentation resulting from access routes created to facilitate small-scale mining activities and exploration activities for large-scale mining. Better resource management, particularly with increased regulation of hunting and improved access control, could help improve ecosystem health.

RAP RESULTS BY TAXONOMIC GROUP

Ants

Thirty-six ant genera and 169 species were collected from 600 m^2 of leaf-litter samples. A total of 136 species (80.5%) were recorded at Lely and 97 species were recorded at Nassau (ca 58% of the total). The difference could be due to the fact that twice as many samples were taken at Lely, but the degree of disturbance seemed to be greater in Nassau than at Lely so that could also be affecting the ant fauna. The ant community of Lely differed somewhat from Nassau in ant species composition. The number of ant species on these plateaus is likely much higher; more sampling is needed.

The subfamily Myrmicinae was represented by 81 species followed by the Ponerinae with 25 species. The most speciose genus was *Pheidole* with 39 species followed by the genera *Hypoponera* (11 species), *Solenopsis* (10 species), *Pyramica* (9 species), and *Gnamptogenys* (8 species), the four genera accounting altogether for 21.9% of the total. With respect to the number of individuals collected, *Solenopsis* ranked first followed by the genera *Pheidole, Hypoponera,* and *Pyramica.*

Up to half of the ant species recorded constitute new records for Suriname; further species identifications are needed to confirm this. Members of the Dacetini tribe are good tools for biodiversity planning since they are relatively well known and are typical of closed forest understory. Four

Dacetine genera are now known from Suriname since the genus *Acanthognathus* was recorded for the first time in Suriname during this study. A possible new species of the genus *Pyramica* was also collected. The range of the recently described genus *Cryptomyrmex* Fernandez (Myrmicinae: Adelomyrmicini) known previously from only two species from Brazil and Paraguay, was extended to Suriname by this survey.

Dung Beetles

A total of 42 dung beetle species was recorded from both sites; 37 species at Lely and 27 species at Nassau. Comparing only standardized dung pitfall transects from primary forest between the two sites, Lely had 33 species and 21.2 individuals/trap, while Nassau had much lower richness and abundance with 24 species and 4.3 individuals/trap. Even though Lely contained more dung beetle species, the dung beetle species composition of primary forest at the two sites was fairly similar. The sites shared 18 species and showed a high Morisita-Horn similarity index of 0.93.

Both sites appeared to have hunting pressures that are likely to have negatively impacted dung beetle species richness and abundance, but Nassau appeared to have the strongest hunting pressure and the lowest beetle species richness and abundance. Dung beetle abundance at Nassau may also have been negatively affected by a large open cesspool near the basecamp. Both sites were characterized by hard, dry and rocky soils that may make it difficult for many dung beetle species to dig burrows for food and nesting, and may also increase larval mortality. This may be one reason why overall dung beetle abundance was much lower at both sites than for almost all other tropical forests previously sampled.

About 20-30% of the species collected may be undescribed. The genera *Anomiopus*, *Ateuchus*, *Canthidium* and *Uroxys* are likely to contain the most undescribed species. A few species appear to have wide geographical ranges and are also found in the southern Amazon, although most species probably have relatively restricted ranges. Much more information on dung beetle diversity is needed from these and nearby sites in order to make an evaluation of range sizes.

Birds

At Lely, 67 species of birds were positively identified by the RAP team. The team also located the remains of either a Harpy Eagle or Crested Eagle killed by local hunters. At Nassau, 79 bird species were positively identified. Thirty-four (34) species occurred at both sites. Hunting seemed to be having some impact on certain species, particularly on guans, curassows, parrots and raptors, the remains of which, along with discharged shotgun shells, were found in both sites. The species richness and diversity are believed to be typical for these habitats.

During a 14-day survey of Lely in 2003, Brian O'Shea recorded 152 bird species in a limited area around the airstrip. Because Lely is situated in a large region of unbroken forest, the mountain's avifauna is estimated to comprise at least 300 species. The avifauna of Lely appears to be representative of the lowland forest that covers the surrounding region, with the addition of several species that are primarily confined to plateaus in the country's interior. Cracids (guans and currassows) and parrots, two groups that are good indicators of human impact in tropical forest, are well represented at Lely. Scarlet Macaw, a CITES I species, was fairly common during the 2003 survey. Curassows were seen regularly as well, suggesting that hunting activity was not especially high at that time of the survey.

Contopus albogularis (White-throated Pewee) was observed at Lely by O'Shea. This species has one of the most restricted geographic ranges of any bird species in the Guayana Shield. *Phaethornis malaris* (Great-billed Hermit) also has a restricted range in the Guianas. Neither of these species has been recorded from adjacent Guyana. Sixteen species of Guayana Shield endemics, or approximately 40% of those occurring in Suriname, were seen during the 2003 study period.

Fishes

A total of 41 fish species were identified from the Lely and Nassau Mountains (4 and 11 sites, respectively). Of these, 26 were collected in a lowland stream in the foothills of the Nassau Mountains (altitude 106 m). The fish fauna of four high-altitude (plateau) streams in the Lely Mountains had 8 species. In four high-altitude streams in the Nassau Mountains we collected 11 fish species, including the endemic catfish *Harttiella crassicauda* known only from the headwaters of the Paramacca Creek in the Nassau Mountains. The small fish fauna of the Nassau Plateau included 6 species that are potentially new to science. The low number of fish species in the high-altitude streams of the Lely and Nassau Mountains was expected, but the high number of potentially new and possibly endemic species in the Nassau Mountains is exceptional. A striking aspect of the fish communities of the high-altitude streams at these sites is the large number of small-sized species, many of which can be considered dwarf species, such as *Lithoxus* spp., *Harttiella crassicauda*, and *Guyanancistrus* 'big mouth'.

The steep slopes bordering the Nassau Plateau apparently act as biogeographic barriers that prevent the dispersal of fishes from one high-altitude stream to the other streams on the plateau. For example, *Harttiella crassicauda* from the central branch of Paramacca Creek ('IJskreek') differed morphologically from *H. crassicauda* collected in the northern branch of Paramacca Creek. A new loricariid species (nicknamed 'big mouth') from the northern branch of Paramacca Creek was not collected in the central branch, notwithstanding extensive collection efforts at the latter site.

Reptiles and Amphibians

We observed a total of 49 species in 12 days of sampling but comparison of our data with other sites in the Guayana Shield indicate that our survey probably only sampled one-quarter to one-third of the total herpetofauna of the two mountains. During the RAP survery we recorded 36 species (19 amphibians, 16 reptiles) at Lely and 29 species (16

amphibians, 15 reptiles) at Nassau. Density of individuals was also higher at Lely.

Species composition differed between the two sites, with only 15/49 (31%) of all species occurring on both mountains. Forty-eight percent of the species at Nassau were unique to Nassau, whereas the percentage was 57% at Lely. Additional surveys by Ouboter et al. (Chapter 11) at Nassau in 2006 revealed 15 additional amphibian species, bringing the total known to 31 species. They also recorded 11 additional reptile species indicating that there are likely many more species to be found at both sites.

The species at the two sites represented a mix of widespread species that occur throughout lowland portions of much of the Amazon Basin, in addition to species known from lowland forest of the Guayana Shield. Five amphibian records are particularly noteworthy since they may represent species new to science (four species of *Eleutherodactylus* and one species of *Adenomera*).

Previous to the RAP survey, five species of *Eleutherodactylus* were known from Suriname; our work on the two mountains has almost doubled the representation of the genus in the country. Forest streams are important habitat for many species encountered during our surveys: about 50% of the species occurring at each site made use of forest streams, and 25% of the species encountered at Lely and about 30% of the species encountered at Nassau were only found in or along forest streams. Because stream-associated amphibians have experienced precipitous population declines in much of the Neotropics, the presence of an apparently intact, stream-associated amphibian fauna on the two mountains is of significant conservation value.

Mammals

Overall, 45 species of mammals from nine orders were recorded from the two study sites in Eastern Suriname: six orders and 28 species at Nassau; and eight orders and 30 species at Lely. Among the small mammals were one species of marsupial, three species of rodents, and 24 species of bats (mostly fruit-eating bats). Seventeen species of medium and large mammals were recorded at the two sites, with more species (13) at Lely than in Nassau (8). The most diverse groups were the primates and the carnivores, each with four species; including large (*Alouatta macconnelli*, *Ateles paniscus*, *Chiropotes chiropotes*) and small (*Saguinus midas*) monkeys, as well as two large (*Panthera onca*, *Puma concolor*) and one small (*Leopardus pardalis*) cat, plus one coati (*Nasua nasua*).

Our results indicate that the Lely Plateau may have higher taxonomic and ecological diversity and suggest that the forest at Nassau is less suitable for small non-volant mammal species, probably because of the alteration of primary forest. For instance, frugivorous bat were predominant at Nassau, as we would expect in secondary growth forest or forest borders. At Lely, we recorded a better representation of Phyllostominae bat species (which are omnivorous or insectivorous), indicating a more complex forest structure than at Nassau. Two bat species, *Lophostoma carrikeri* and *Artibeus obscurus* are listed as threatened (IUCN 2006). Most of the primates and carnivores are also listed as threatened at the global level and several are restricted to the Guiana region, so their global conservation depends largely on the status of these populations. The Brazilian tapir (*Tapirus terrestris*) is listed as Vulnerable because it is affected by hunting everywhere, and we found evidence that the same occurs in this region. The diversity and concentration of medium and large mammals suggest suitable habitats for these species, which usually require large extensions of less disturbed forest. The presence of ungulates may be the reason behind the presence of cougar and jaguar in the area.

RESULTS FROM OTHER BIODIVERSITY SURVEYS OF THE LELY, NASSAU AND BROWNSBERG PLATEAUS

Plants

Six main vegetation types occur on the Lely, Nassau and Brownsberg plateaus: high dryland rainforest on laterite plateaus, high marsh forest on laterite plateaus, mountain savanna forest, mountain savanna moss forest, vegetation on and near rocky creek beds, and high dryland rainforest on slopes. While on the Brownsberg plateau the forest height and vegetation type changes at very short distances forming a 'mosaic' forest, the vegetation types are more pronounced on the Lely Plateau, where large tracts of uniform vegetation types can be found. Open vegetation or open rock such as found on granite outcrops does not seem to occur on these plateaus.

The plot inventories of the bauxite plateaus show a highly diverse forest and form a distinct group within all inventoried plots of the Guianas. The plots found on Lely are currently among those with the highest average diversity for Suriname, which fits well with the general increase in tree alpha-diversity from western Guyana towards French Guiana. Although this difference is small and not significant, the bauxite plateaus and their surrounding forest have very high tree alpha-diversity compared to the other Surinamese forest areas for which data are available. The composition of the Eastern Suriname plots is best comparable with that of French Guiana on similar ferralitic soils. Plots close together are 'more similar' than plots at larger distance and share more species among them (compared to the lowlands) than can be attributed by chance.

The plant collection record for these bauxite plateaus and for Suriname and the Guianas in general is still very small and much more study is needed. In comparison to the Guayana Highlands with their very high endemicity, the vegetation of the lateritic and bauxitic plateaus on basic volcanic rocks is rather uniform and has low endemicity. We did not find proof in the current dataset for endemics specific to the Brownsberg, Lely, and Nassau plateaus.

Orchids

A separate survey of orchids was carried out on the three plateaus. A total of 190 species of orchids have been recorded from the Brownsberg, Nassau and Lely plateaus:

141 from Brownsberg, 70 from Nassau, and 96 from Lely; 16 % are known from all three ranges, and 31 % only from Brownsberg. The lower orchid richness figures for Lely and Nassau can be regarded as artifacts due to low collecting effort. Compared to other sites in the Guayana Shield region, Brownsberg has the second-highest recorded orchid species richness. The available information suggests that a number of orchid species that are very rare in the region occur in these three ranges, e.g. *Beloglottis costaricensis* (Brownsberg), *Cranichis diphylla* (Lely) and *Quekettia papillosa* (Nassau).

There were significant differences in the proportion of species assigned to different substrate classes. Lely, with 16% of its orchids growing on the ground or rocks, diverges from the other two plateaus, which each have 4-5% of their orchids on these substrates. A high proportion of highland orchid species (about 30-40 %) may be the characteristic that distinguishes these ranges with elevated plateaus from areas that are true lowlands, and may explain the high species richness. There may be a trend that highland orchids become more important as the height of the range's main plateau increases. Thus, Lely may be the most divergent, unique and species rich of the three ranges for orchids.

Orchid Bees

A total of 34 species of orchid bees was collected at the three plateaus: 13 at Brownsberg, 22 near Lely and 23 at Nassau. The frequency of bees with orchid pollinaria (pollen sacs) differed significantly between Nassau and a lowland location near Lely; at the first location, none of the bees carried pollinaria, at the second 13 %. More sampling needs to be done before a detailed comparison of the bee faunas of the three ranges can be made. The high frequency of orchid bees with pollinaria at Nassau is unusual and may be linked to the habitat in which most sampling took place, the low elevation cloud forest of the submontane plateau.

COMPARISONS BETWEEN THE LELY, NASSAU, AND BROWNSBERG PLATEAUS

Habitat Type and Current Status

Table 1 presents the current status of the three plateaus. All three plateaus contain six major vegetation types (see Chapter 3 and plant summary above). On the Brownsberg plateau, the forest height and vegetation type changes at very short distances forming a 'mosaic' forest, while the vegetation types are more pronounced on the Lely Plateau, where large tracts of uniform vegetation types can be found. Lely differs from Nassau and Brownsberg in the large extent of the mountain savanna forest. The increase in altitude (670 m asl compared to 550 m asl for the other plateaus) appears sufficient for the occurrence of several Guayana Highland elements, such as the Ericaceaous *Cavendishia*. In addition, the very low open forest on the highest slopes has an abundant moss flora (moss forest) with many Orchidaceae.

The natural habitats of the Brownsberg plateau are similar to those described from the interior of French Guiana by De Granville (1994) and also to those of the Nassau and Lely plateaus (De Dijn pers. comm., Chapter 3). The more unique habitats are those associated with the top of the plateaus, such as mountain savanna moss forest and habitats on heavily encrusted soil. These habitats are divergent in terms of soil and climatological conditions and also vegetation composition.

All three areas' ecosystems are relatively intact owing to low human population density, which presents many unique opportunities for conservation over a relatively large landscape area. However, each of these plateaus has had some impact from humans. Lely is in the most pristine shape, owing mainly to its remoteness and inaccessibility. There is some infrastructure at the Lely airstrip and the air strip work crew engages in hunting, with birds being of particular interest, to supplement their diet.

Nassau has a relatively extensive road network that is already fragmenting habitats and facilitating easy access to forest areas, particularly for small-scale gold miners, with subsequent impacts such as hunting. Infrastructure for mining operations at Nassau include a large open cesspool at Nassau and a small camp.

Over 11,600 ha of the Brownsberg plateau has been protected within the Brownsberg Nature Park (BNP) since 1970. However, a substantial part of the BNP has been disturbed by humans and is secondary forest, mainly along the main road across the range and at lower elevations, especially along creeks where miners are active. The lowest level of disturbance generally is found above 250 m, in the northwest corner of the range, and at some locations near Lake Brokopondo. Although it is a protected area, the BNP has also been impacted by tourism and faces challenges from unresolved conflicts over land rights and poverty, particularly with regards to Maroon communities.

All three plateaus face a number of current and potential threats, the greatest of which are hunting/poaching, logging, habitat fragmentation, and small-scale (gold) and large-scale (bauxite and gold) mining. Encroachment by illegal gold miners is the most imminent threat to all three areas. Considerable effects of human activities (e.g. siltation of streams and deforestation) can already be observed in the foothills of the Nassau and Brownsberg plateaus.

Species Richness

It is difficult to directly compare the three plateaus since there is much more information and greater research effort for Brownsberg compared to Lely and Nassau. However, we attempt here to make some general comparisons. Table 2 presents the species richness recorded at the three sites.

Surveys of plant diversity of the three plateau areas and surrounding areas indicate that all three areas have high diversity compared to most lowland forests plots sampled in western Suriname. The forest stature on the slopes of the plateaus is among the highest forest found in the Northern part of Suriname. While surveys showed Lely to have the highest plant diversity per plot of the three and Nassau the lowest, the differences are not great enough to distinguish any real

Table 1. Current status of the Brownsberg, Lely and Nassau Plateaus.

Site	Total Size	Elevation, Habitat type	Degree of habitat degradation	Evidence of Logging	Evidence of Hunting	Evidence of Mining	Taxonomic groups indicating good conditions or richness	Taxonomic groups indicating poor conditions or richness
Brownsberg	(11,800 ha park) [1] 27,500 total[1]	ca. 500 m Six main vegetation types. A mosaic forest of high dryland rainforest, mountain savanna (moss) forest. and liana forest.	5% of park destroyed by illegal gold miners, much secondary forest	moderate but high in northern parts	moderate but high outside of the park	Yes, legal and illegal gold mining	Monkeys, Trumpeters and Curassows, Large rodents, Tapir, Frogs, Tortoises, Rare orchids and other rare plant species (esp. species associated with submontane areas and encrusted soil)	Fruit bats, plant species that colonize large clearings (incl. invasive & pantropical weeds), human avoidance behavior with primates, low predation and dispersal of large seeds
Lely	32,000 ha[2]	640-700 m Six main vegetation types. Mostly high dryland rainforest and extensive mountain savanna (moss) forest with Guayana Highland elements.	low to moderate	low	moderate	Illegal gold mining nearby and at the base	Large mammals, Larger birds, Amphibians Phyllostomine bats, Dung Beetles Ants: *Wasmannia scrobifera, Thaumatomyrmex ferox*	Ant: *Wasmannia auropunctata*
Nassau	20,000 ha[2],[3]	500-550 m Six main vegetation types. Mostly high dryland rainforest and high marsh forest. Less extensive mountain savanna (moss) forest.	moderate	moderate	high	Yes Illegal gold mining, Legal bauxite exploration	Fishes (6 species new to science, endemic catfish), Large mammals, Larger birds	Stenodermatine (fruit eating) bats, Dung beetles, Ant: *Wasmannia auropunctat*a

[1]De Dijn et al. , Chapter 13
[2]Olaf Bánki and Hans ter Steege, pers. comm.
[3]The three major plateaus of Nassau have a total area of about 5000 ha if only the top of the plateaus and not the slopes are considered (Olaf Bánki and Hans ter Steege, pers. comm.).

differences in plant diversity between the three areas. Lely does differ from Nassau and Brownsberg in that it has a large extent of mountain savanna forest. Lely's plateau is at sufficiently higher elevation than the others such that several Guayana Highland elements are found there (see Chapter 3). The lower orchid richness figures for Lely and Nassau compared to Brownsberg are due to lower collecting effort. Compared to other sites in the Guayana Shield region, Brownsberg has the second-highest recorded orchid species richness.

There is no appreciable difference in the avifaunas of the Brownsberg, Lely, and Nassau plateaus. Differences in the quality and quantity of sampling among the three areas are responsible for differences in species lists. There isn't much of a "montane" avifauna in Suriname (Tafelberg being the exception); in fact structurally simplified habitats over ironstone/bauxite caps generally have relatively few bird species, none of which are restricted to those habitats, and slopes also seem to be depauperate. Tall forest on plateau tops, on the other hand, tends to be quite species-rich, but no more so than similar forest at lower elevations. The most important feature of Lely and Nassau from the bird perspective is the presence of good numbers of large birds such as parrots and guans. These birds are heavily hunted and captured for the pet trade, so their large numbers at these two sites is significant. Brownsberg also houses good populations of these birds, and functions as a wildlife refuge for game birds that tend to be much rarer in the surrounding lowlands. Ribot (2006) confirms that some larger birds (trumpeters, curassows and guans) have returned to Brownsberg after a period of heavy hunting during the internal wars.

Only one of the mammal species recorded at Lely and Nassau has not been recorded from Brownsberg (a spiny mouse, *Neacomys guianae*). The mammal fauna of all three areas is typical of Guayana Shield lowland rainforest and is fairly widely distributed across all three areas, which are very similar in origin but now have different degrees of habitat disturbance. Given that Brownsberg is not only a protected area, but also has a longer history of biological studies, it is likely that most of the mammal fauna has a wide distribution, which can help to keep their populations stable. However, Nassau is a more highly impacted area where local reductions or extinctions of some species populations are possible. Any inference about the status of the mammal fauna at both sites is still incomplete and far from accurate; a more extensive survey is required to determine real patterns of the mammalian assemblage. As noted for birds, the most important feature of these three sites may be the presence of good numbers of larger mammals, many of which are globally threatened and under heavy hunting pressure in other areas.

Besides butterflies, insects have not been systematically studied at Brownsberg, thus comparisons between the three areas cannot be made for ants or dung beetles. The species richness of these groups is high at Lely and Nassau and would be expected to also be high at Brownsberg. A number of rare butterflies have been documented at Brownsberg even though much more data are needed.

Table 2. Number of species documented on the Lely, Nassau, and Brownsberg plateaus.

	All RAP sites in this survey	Lely	Nassau	Brownsberg
Plants (including Orchids from botanical collections at Utrecht)	--	487[1]	694[1]	1060[1]
Orchids		96[2]	70[2]	141[2]
Ants	169	136	79	
Dung Beetles	42	37	27	12[3]
Orchid Bees	--	22[4]	32[5]	13[6]
Butterflies	--	--	--	137[7]
Fishes	41 (17)[8]	8[8]	35 (11)[8]	(3)[8]
Amphibians	27	20	16 (31)[9]	64[10]
Reptiles	22	16	13 (26)[9]	80[10]
Birds (RAP)	121	67	79	-
Birds		152		387[11]
Bats	24	14	19	54[12]
Small Mammals	4	3	1	21[12]
Medium and large mammals (including primates)	17	13	8	41[12]

[1]data from ter Steege et. al (Chapter 3 this volume). Lely based on 1097 specimens, Nassau on 1691 specimens, and Brownsberg on 2572 specimens).
[2] listing by Molgo, 11 Oct 2006, based on herbarium material and other reliable sources.
[3] listing by Hielkema, 2006, based on some material in his collection.
[4] no samples available from Lely sensu strictu; based on sample taken near Diitabiki.
[5] based on a modest sample obtained recently at Nassau plateau.
[6] based on museum specimens from Brownsberg present at NZCS in Suriname.
[7] based on listing by Hajo Gernaat, 2005; most unidentified species not included in count.
[8] number of species of high-altitude streams in parentheses (i.e. excluding 26 species from lowland stream in foot hills of Nassau Mountains); Brownsberg data from Jan Mol, unpublished data.
[9] ( ) with additional data from 2006 surveys by Ouboter et. al. (Chapter 11).
[10] based on various sources, 26 doubtful species not included in count.
[11] various sources, compiled by J.H. Ribot (http://www1.nhl.nl/~ribot/english/); some species removed from Ribot's list by O'Shea.
[12] based on Lim et al. 2005, but excluding 10 species not actually observed at Brownsberg.

Endemic Species

Species Endemic to the Lely, Nassau or Brownsberg Plateau

Given the limited biodiversity survey effort for Suriname and throughout the Guayana Shield, it is difficult to say if any of the species documented on the Lely, Nassau and Brownsberg plateaus are endemic to any of the plateaus proper. No species recorded at Brownsberg are known to be endemic to that area. More information is needed on all of the taxa both within and outside of this area to determine if any species are endemic to the plateaus.

The only local endemism possibly documented so far is for a few fish species at Nassau. The streams of the Nassau Plateau revealed six fish species that are new to science and are thus potentially endemic to the Nassau Plateau. No fish species appear to be endemic to the Lely Plateau so far. The reasons for this large difference in endemism are not clear and should be investigated in the future. Some species (e.g. *Harttiella crassicauda* and *Guyanancistrus* 'big mouth') from high-altitude streams of Nassau Mountains are apparently restricted to this small 20x20 km^2 area; but endemism of the other species remains to be established with future collection efforts. The distribution of some fish species could be restricted to a single stream (*H. crassicauda* in Paramacca Creek) or even a tributary of a stream (e.g. *Guyanancistrus*- 'big mouth' and the slender form of *H. crassicauda*). The steep slopes of the Nassau Mountains plateau probably are a biogeographic barrier preventing the dispersal of fishes throughout the mountains/plateau.

In the current plant data set there is no proof for endemics specific for the Brownsberg, Lely, or Nassau plateaus. However, some groups of plants, such as bryophytes, ferns and orchids are thought to show differences in species composition between lowland and mountainous areas. In

Table 3. Animal species recorded at Lely, Nassau and Brownsberg known to be endemic to the Guayana Shield.

Group	Species	Site
Mammals	Guyanan Red Howler, *Alouatta macconnelli*	Lely, Nassau
	Red-backed bearded Saki, *Chiropotes chiropotes*	Lely
	Linnaeus's Mouse opossum, *Marmosa murina*	Nassau
	Red-handed tamarin, *Saguinus midas*	Lely, Nassau
	Red-faced Black Spider monkey, *Ateles paniscus*	Lely, Brownsberg
	Dubost's Neacomys, *Neacomys dubosti*	Lely
	Guiana Neacomys, *Neacomys guianae*	Lely
	Guyenne Spiny Rat, *Proechimys guyannensis*	Lely
	White-faced saki, *Pithecia pithecia*	Brownsberg
	Black-tailed hairy dwarf porcupine, *Coendou melanurus*	Brownsberg
	Spiny mouse, *Neacomys paracou*	Brownsberg
	Auyantepui aboreal rice rat, *Oecomys auyantepui*	Brownsberg
	Red-legged short tailed opossum, *Monodelphis brevicaudata*	Brownsberg
	Warty Round-eared bat, *Lophostoma schulzi*	Brownsberg
Birds	Black Curassow, *Crax alector*	Lely, Nassau
	Marail Guan, *Penelope marail*	Lely, Nassau
	Caica Parrot, *Gypopsitta caica*	Lely
	Black Nunbird, *Monasa atra*	Lely
	Guianan Toucanet, *Selenidera piperivora*	Lely
	Green Aracari, *Pteroglossus viridis*	Lely
	Chestnut-rumped Woodcreeper, *Xiphorhynchus pardalotus*	Lely, Nassau
	Guianan Streaked-Antwren, *Myrmotherula surinamensis*	Lely
	Brown-bellied Antwren, *Myrmotherula gutturalis*	Lely
	Todd's Antwren, *Herpsilochmus stictocephalus*	Lely
	Black-headed Antbird, *Percnostola rufifrons*	Lely, Nassau
	Rufous-throated Antbird, *Gymnopithys rufigula*	Lely, Nassau
	White-throated Pewee, *Contopus albogularis*	Lely, Nassau

Group	Species	Site
	Guianan Cock-of-the-Rock, *Rupicola rupicola*	Lely
	Capuchinbird, *Perissocephalus tricolor*	Lely, Nassau
	White-throated Manakin, *Corapipo gutturalis*	Lely
	White-fronted Manakin, *Lepidothrix serena*	Lely
	Finsch's Euphonia, *Euphonia finschi*	Lely
	Golden-sided Euphonia, *Euphonia cayennensis*	Lely
	Blue-cheeked Parrot, *Amazona dufresniana*	Brownsberg
	Guianan Puffbird, *Notharchus macrorhynchos*	Brownsberg
	Golden-collared Woodpecker, *Veniliornis cassini*	Brownsberg
	McConnell's Spinetail, *Synallaxis macconnelli*	Brownsberg
	Black-throated Antshrike, *Frederickena viridis*	Brownsberg
	Band-tailed Antshrike, *Sakesphorus melanothorax*	Brownsberg
	Rufous-bellied Antwren, *Myrmotherula guttata*	Brownsberg
	Spot-tailed Antwren, *Herpsilochmus sticturus*	Brownsberg
	Dusky Purpletuft, *Iodopleura fusca*	Brownsberg
	Tiny Tyrant-Manakin, *Tyranneutes virescens*	Brownsberg
	Blue-backed Tanager, *Cyanicterus cyanicterus*	Brownsberg
	Red-and-black Grosbeak, *Periporphyrus erythromelas*	Brownsberg
Amphibians	*Colostethus beebei* (toad)	Lely
	Colostethus degranvillei (toad)	Lely, Nassau
	Eleutherodactylus chiastonotus (frog)	Nassau
	Eleutherodactylu zeuctotylu (frog)	Lely
	Chiasmocleis shudikarensis (frog)	Lely, Nassau
	Atelopus hoogmoedi (= *A. spumarius hoogmoedi*; toad)	Brownsberg
	Cochranella oyampiensis (frog)	Brownsberg
	Colostethus granti (frog)	Brownsberg
	Osteocephalus cabrerai (frog)	Brownsberg
	Scinax proboscideus (frog)	Brownsberg
	Eleutherodactylus inguinalis (frog)	Brownsberg
	Leptodactylus longirostris (frog)	Brownsberg
	Leptodactylus meyersi (frog)	Brownsberg
	Pipa aspera (frog)	Brownsberg
	Rhinatrema bivittatum (worm salamander)	Brownsberg
	Microcaecilia unicolor (worm salamander)	Brownsberg
Reptiles	*Gonatodes annularis* (gecko)	Lely
	Neusticurus rudis (lizard)	Lely, Nassau
	Atractus zidoki (snake)	Brownsberg
	Micrurus collaris (snake)	Brownsberg
	Leptotyphlops collaris (snake)	Brownsberg

the mountain savanna forest many yet unidentified Myrtaceae species occur, making it difficult to determine the conservation value of the forest type at this moment.

Species Endemic to Suriname

Three tree species, *Copaifera epunctata* (Fabaceae), *Phoradendron pulleanum* (Santalaceae), and *Sloanea gracilis* (Elaeocarpaceae) that are thought to be endemic to Suriname were collected at Brownsberg and Lely. However, these possible endemics for Suriname could also be the result of low collection efforts in the Guianas and the surrounding countries.

Species Endemic to the Guayana Shield

Eight mammal species recorded in Lely and Nassau are endemic to the Guayana Shield (Table 3). One of these species, *Ateles paniscus* (Red-faced black spider monkey) also occurs at Brownsberg. Brownsberg has an additional six species endemic to the Guayana Shield (Table 3). However, as noted above, further surveys are needed at Lely and Nassau to assess the presence and status of the mammal fauna.

Nineteen species of Guayana Shield bird endemics, or approximately 50% of those occurring in Suriname, were recorded at Lely and Nassau (Table 3). *Contopus albogularis* has one of the most restricted geographic ranges of any bird species in the Guayana Shield and *Phaethornis malaris* (Great-billed Hermit) also has a restricted range in the Guianas. Neither of these species has been recorded from adjacent Guyana. In addition to most of the aforementioned species, twelve additional Guayana Shield bird endemics have been recorded at Brownsberg (Table 3). Overall, the Lely-Nassau-Brownsberg region contains at least 75% of the Guayana Shield endemics that are known to occur in Suriname.

Of the known herpetofauna, six species of amphibians and two species of reptiles documented at Lely and Nassau are endemic to the Guayana Shield. An additional 15 species at Brownsberg are also known to be endemic to this region (Table 3).

In the current plant data set from the three bauxite plateaus, several species such as *Dicranopygium pygmaeum* (Cyclanthaceae), *Elaphoglossum latifolium* (Lomariopsidaceae), *Lonchitis hisuta* (Dennstaedtiaceae), *Thelypteris holodictya* (Thelypteridaceae), and *Thrichomanes membranaceum* (Hymwnophyllaceae) are found that are thought to be strictly endemic, at least in the Guianas, to the mountain savanna forest (moss forest) and rocky creek beds. At Lely some plant

Table 4. Threatened mammal species recorded at Lely, Nassau and Brownsberg.

Group	Species	Site
Bats	Carriker's Round-eared Bat, *Lophostoma carrikeri* (VU)	Lely
	Lophostoma schulzi (VU)	Brownsberg
	Dark Fruit-eating bat, *Artibeus obscurus* (LR/nt)	Lely, Nassau
	Brown Fruit-eating bat, *Koopmania concolor* (LR/nt)	Nassau
	Glyphonycteris daviesi (LR/nt)	Brownsberg
	Glyphonycteris sylvestris (LR/nt)	Brownsberg
	Phyllostomus latifolius (LR/nt)	Brownsberg
	Vampyressa brocki (LR/nt)	Brownsberg
Primates	Red-backed bearded Saki, *Chiropotes chiropotes* (DD)	Lely
	Guyanan Red Howler, *Alouatta macconnelli* (VU)	Nassau, Lely
Larger Mammals	Brazilian Tapir, *Tapirus terrestris* (VU)	Nassau, Lely
	Jaguar, *Panthera onca* (LR/nt)	Lely
	Cougar, *Puma concolor* (LR/nt)	Nassau
	Brocket Deer, *Mazama* sp. (DD)	Nassau, Lely, Brownsberg
	Giant Anteater, *Myrmecophaga tridactyla* (VU)	Lely
	Bush dog, *Speothos venaticus* (VU)	Brownsberg
	Oncilla, *Leopardus tigrinus* (LR/nt)	Brownsberg
	Giant armadillo, *Priodontes maximus* (EN)	Brownsberg
Small and Medium Size Mammals	Dubost's Neacomys, *Neocomys dubosti* (DD)	Lely
	Woolly opossum, *Caluromys philander* (LR/nt)	Brownsberg
	Delicate slender mouse opossum, *Marmosops parvidens* (LR/nt)	Brownsberg
	White-faced tree rat, *Echimys chrysurus* (VU)	Brownsberg

species, e.g. *Cavendishia callista* (Ericaceae) that belong to the Guayanan Highlands were also found in the mountain savanna forest.

Threatened Species

The IUCN Red List categorizes species based on the degree to which they are threatened (IUCN 2006). Categories, from less threatened to most threatened, include: Data Deficient (DD, not enough is known to make an assessment), Lower Risk (LR) which includes Conservation Dependent (cd), Near Threatened (nt), and Least Concern (lc, listed but not threatened), Vulnerable (VU), Endangered (EN), and Critically Endangered (CR) (IUCN 2006).

Ten tree species recorded on the three plateaus are listed by IUCN as threatened; the abundance of each species differs between the three plateaus. These species are: *Vouacapoua americana* (CR), *Apeiba intermedia* (DD), *Virola surinamensi* (EN), *Minquartia guianensis* (LR/nt), *Pouteria rodriguesiana* (LR/nt), *Copaifera epunctata* (VU), *Macrolobium amplexans* (VU), *Couratari guianensis* (VU), *Corythophora labriculata* (VU), and *Bertholletia excelsa* (VU). Five tree species recorded are protected under Surinamese law: *Bertholletia excelsa*, *Manilkara bidentata*, and species of *Dipteryx* and *Copaifera*.

All the mammal species recorded at Lely and Nassau are on the IUCN Red List of Threatened Species, but most are classified as Lower Risk -Least Concern (LR/lc). Eleven species are considered of significant conservation concern. An additional 13 mammal species recorded at Brownsberg are also threatened. Table 4 lists the threatened mammal species recorded at the three areas that are categorized above LR/lc. More information is needed on the mammals at Lely and Nassau to be able to say whether the species known from Brownsberg are also present at these two sites.

A diet based on algae, a low fecundity, sedentary habits and restricted distribution all make the rare catfish, *Harttiella crassicauda,* very vulnerable to increasing human activities on the Nassau Plateau. This species can be considered an endangered species and it should be included in the IUCN red list of endangered species. Efforts are underway to get this species on the IUCN red list.

Four of the bird species recorded at Brownsberg are of conservation concern: Harpy Eagle, *Harpia harpyua*; Olive-sided Flycatcher, *Contopus borealis*; Blue-cheeked Parrot, *Amazona dufresniana* and Scarlet Macaw, *Ara macao*. *Amazona dufresniana* is listed as LR/nt and is of conservation concern in the Guianas due to its value in the wildlife trade. No threatened bird species were recorded at Lely or Nassau, although a talon from a large raptor seen at Lely may be from a Harpy Eagle or Crested Eagle, both of which are threatened (LR/nt). Additional bird surveys of these two plateaus are needed to determine if any of these or other threatened bird species are present.

One frog species (*Atelopus hoogmoedi*) and the Yellow-footed tortoise (*Geochelone denticulata*) known from Brownsberg are listed as VU by IUCN. All of the amphibian and reptile species documented at Lely and Nassau have been evaluated by the IUCN Red List but none are categorized higher than Least Concern (LR/lc).

Species New to Science and Range Extensions

A high number (24) of species that are likely new to science was documented at Lely and Nassau during the RAP survey. These included five amphibian species, four fish species (and one new sub-species), 13 dung beetle species and at least one ant species (more new species are likely as species are analyzed). A new species of *Atelopus* was also found at Nassau in 2006 (see Chapter 11 and photo pages). New species of insects are common, but so many new species of amphibians and fishes indicates that this area has a very high overall diversity and likely harbors many more species yet to discover. No species new to science have been recorded at Brownsberg in recent years, but few studies have been conducted for these taxonomic groups. Thus new species and range extensions in these groups are also likely to be found at Brownsberg.

On the Nassau Plateau a recently new described plant species from French Guiana of Thymelaeaceae (*Daphnopsis granvillei*) was found abundantly at times in the undergrowth. In the Lely Mountains and surrounding area some plants have been found with a known or possible Amazonian distribution. At the base of Lely *Poulsenia armata* (Moraceae) was found in the inventory plots. This species had not been previously collected in Suriname, and has a more Amazonian distribution. Based on collections from the Lely Mountains and from the southern lowlands of Suriname and Northern Brazil, a new Annonaceae, *Guatteria anthracina* was described by Scharf et al. (2006). Plant collections from the Brownsberg Plateau might indicate a new species of *Danaea* (Marattiaceae; Christenhusz pers. comm.) and a new species of *Trigynaea* (Annonaceae; Maas pers. comm.), but further research is needed.

Many species of ants recorded at Lely and Nassau are new records for Suriname. Nine species are definite new records while up to 85 species (half of the 169 species documented) may also be new records for Suriname (pending further study). Two genera were recorded for the first time in Suriname and are represented by three species: *Acanthognathus lentus, Acanthognathus* cf. *ocellatus*, and *Cryptomyrmex* cf. *longinodus.*

CONSERVATION CONCLUSIONS AND RECOMMENDATIONS

(see also each chapter for detailed recommendations for each taxonomic group)

I. ALL THREE PLATEAUS, LELY, NASSAU AND BROWNSBERG, SHOULD RECEIVE INCREASED PROTECTION OF THEIR BIODIVERSITY. Each of these areas contains a high proportion of Suriname's biodiversity including both lowland and higher elevation species, many threatened species, and high numbers of spe-

cies endemic to the Guayana Shield. Worldwide amphibian declines have resulted in the loss of many higher elevation amphibian faunas, so the presence of abundant and diverse amphibian assemblages at Nassau and Lely is of significant global conservation value. The presence of many large mammals and larger birds at all three sites indicates their importance as a refuge for these species, which are heavily hunted in other areas. All three plateaus contain great habitat diversity that includes typical lowland forest habitats as well as more unique habitats at higher elevations (> 400 m) that are not widely found in the region.

1) Each of the three plateaus warrants protection for its own unique features:

a) **Lely** has high habitat and species richness for all taxonomic groups surveyed, as well as good forest conditions. Lely is relatively inaccessible and has not had many human impacts. It thus presents an excellent opportunity to protect a large area of high biodiversity, pristine dryland rainforest, and exceptional mountain savanna forest.

b) **Nassau** has been more heavily impacted, but still contains high biodiversity and good populations of large mammals and birds. Nassau also contains a rare and unique fish fauna. This area is particularly vulnerable to encroachment by illegal gold miners who are already active there. Action, especially to control access roads, must be taken immediately to protect Nassau from this threat.

c) **Brownsberg** contains a Nature Park that already provides some protection to the plateau, but threats still encroach upon the rest of the range and must be addressed. The biodiversity of Brownsberg has been fairly well studied, thus providing excellent opportunities for monitoring and assessment of protection efforts.

2) The mechanism for conservation of these sites should be developed through a collaborative approach between public and private institutions, including local communities, to address and halt the threats currently and potentially facing these sites. Some possible mechanisms include:

a) **Empower and fund the Nature Conservation Division** of the Suriname government to increase monitoring in all three areas, especially for hunting and illegal mining.

b) **Create a Nature Park on the Nassau Plateau** to protect the unique Paramacca Creek watershed. Urgent action is needed at Nassau due to the higher level of human pressures there.

c) **Engage the local people** including the traditional communities in the area, particularly the Paramaka Maroons (Nassau and Lely), Aukaner/Okanisi or Djuka Maroons (Lely), Saramaka Maroons (Brownsberg) and also the non-traditional communities such as the small-scale gold miners.

d) **Integrate the protection of key areas into any development plans for the plateaus (e.g. mining planning).** Key areas include the Paramacca watershed at Nassau, the pristine higher elevation forests of Lely, and the vegetation along creeks at Brownsberg. The Lely and Nassau Plateaus are concessions of the joint venture Suralco (Alcoa) and BHP-Billiton bauxite mining companies. Suralco is also involved in large-scale gold exploration by Newmont in the foothills of the Nassau and Brownsberg Mountains.

e) **Explore potential tourism opportunities in the two areas** as an alternative income for local communities to reduce their dependence on the bushmeat trade, logging, and gold mining.

II. INTEGRATE THE LELY, NASSAU AND BROWNSBERG PLATEAUS INTO A REGIONAL CONSERVATION STRATEGY. All three plateaus are key components of a broad international biodiversity protection plan for the Guayana Shield (Huber and Foster 2003).

1) **Conduct a study of the biological and socio-economic values of the Lely, Nassau and Brownsberg plateaus.** Based on that information, regional land use plans should be developed to guide decision-making on what activities can, or cannot, take place in certain areas. Without this type of planning, the areas will continue to be subject to haphazard and uncoordinated activities, leading to overall poor resource management and degradation of biological resources.

2) **Follow up on the IBAP Recommendations (Chapter 2)** by an inclusive group of stakeholders that includes government, universities, conservation groups, mining companies, and local communities.

III. HUNTING POSES A SIGNIFICANT THREAT TO THE LARGE MAMMALS, LARGER BIRDS AND DUNG BEETLES OF BOTH SITES AND MUST BE CONTROLLED. Hunting pressure is especially strong at Nassau but is also occurring in the Lely area. Healthy mammal and dung beetle communities are especially important for maintaining primary and secondary seed dispersal that may be essential for plant regeneration and forest dynamics. Many large birds (currassows and guans) were seen regularly at Lely in 2003 but the 2005 RAP team found much evidence of hunted birds and shotgun shells.

1) **Prevent access to hunters along roads**. Hunting pressure is particularly high at Nassau where a network of roads has facilitated entry by local hunters. These roads need to be minimized and controlled. A number of footpaths at Lely also apparently facilitate movement of hunters and small-scale gold miners as evinced by the large number of discharged shotgun shells and abandoned camps.

2) **Educate and supplement food for local workers.** Workers at the Lely airstrip engage in hunting to supplement their diet, with birds and primates being of particular interest, and there was evidence of hunting (discharged shotgun shells) around the Nassau exploration base camp, athough it could not be determined who was engaging in the activity. Provision of regular protein sources for the work crews, along with improved education and regulation of their hunting, should be promoted to lessen hunting pressure from local work crews in both sites. Incentives should be given to the workers to minimize hunting, especially of species that they are not killing for food.

3) **Make an alliance against hunting with all who have access to Lely and Nassau**, including airline companies, trucking companies, the Surinamese Airline Authorities, the Nature Conservation Division, and the mining companies (BHP-Billiton, Suralco, Newmont). This would help to control the distribution and sale of bushmeat from Lely and Nassau. The Nature Division of the Surinamese Forestry Service could also control the internal transport of bushmeat from the interior at Zorg en Hoop.

4) **Conduct research to determine** which larger mammal and bird species are targeted and most heavily impacted. The population sizes of key species that are most heavily hunted and most highly threatened in this area can then be determined and used to inform more specific recommendations on conserving key species threatened by hunting.

5) **Enforce hunting regulations, especially at Nassau**. Dung beetle communities at both sites are likely suffering from hunting since their food source, mammal dung, is decreased. The strongest hunting pressures seemed to be at Nassau, where unusually low dung beetle abundance was the observed. Stricter regulations and enforcement of hunting practices could make a big difference to dung beetles as well as mammals. Preventing what appears to be widespread hunting at Nassau should be a top priority.

IV. MAINTAIN THE INTEGRITY OF FOREST STREAMS. Streams in the Lely and Nassau Mountains typically have a sandy, gravel or rocky bottom and oxygen-rich, very clear water. The fishes are adapted to these environmental conditions. The amphibians and fishes found at Lely and Nassau, including the possible new species, depend on clean, quality water for their survival. Plants occurring down stream and their associated fish and invertebrate species are vulnerable to sedimentation. Suspended and deposited sediments can negatively affect fish reproduction and algae-based fish food. Our fish survey shows that the watersheds on the plateau are currently largely intact on both the Lely and Nassau plateaus. Three of the potentially new frog species are known only from forest streams, and two more potentially new species also utilized steam habitat, indicating that forested streams are key reservoirs of biodiversity on both mountains.

1) **Prevent sedimentation and runoff from mining, roads, and clearings**, which all have negative impacts on the water quality in the streams. On both the Lely and Nassau plateaus, human activities, including gold mining, logging, agriculture, hunting, and base camp construction currently threaten the integrity of the aquatic ecosystems. These impacts are particularly high in the foothills. Since we have identified streams as keystone habitat whose importance is disproportionate to their area, we recommend a forest buffer of at least 50 m on both sides of all creeks at the two sites.

2) **Protect upper catchment of Paramacca Creek at Nassau**. Based on our current knowledge, protection of the rare catfish *Harttiella crassicauda* from extinction is only possible by protecting its habitat in this creek. Control and restrict access to the Paramacca Creek catchment, especially with regard to small-scale gold miners, loggers and local people (shifting cultivation plots). Any development at Nassau should restrict water extraction from Paramacca Creek by utilizing rainwater collection facilities. Minimize pollution of Paramacca Creek by creating waste collection/treatment facilities and prohibiting bathing, washing and spilling of chemicals/materials in Paramacca Creek. Water quality, hydrology and catchment integrity should be monitored by government agencies.

   We recommend that an analysis be done of future impacts of the current Nassau mining base camp on the watershed, especially due to sedimentation from runoff and pollution from human habitation of the camp, to determine if there will be any long term impacts of the camp and whether the base camp should be moved further from the river.

3) **Initiate a water-quality monitoring program of the status of several key aquatic taxa** (including fishes, amphibians, plants, and selected invertebrate groups) as well as water quality and sedimentation to create a baseline and identify negative impacts to aquatic resources before they become irreversible. The creek at the Nassau basecamp is a 'keystone habitat', one that is essential to a wide variety of organisms, especially amphibians. Monitoring specific responses to certain indicators is essential. We recommend following standard aquatic monitoring protocols at regular intervals (at least twice a year, see Chapter 10 for more details).

V. MINIMIZE FRAGMENTATION OF THE NATURAL HABITAT AND CONTROL ACCESS ROUTES. This is particularly crucial at Nassau, where a relatively

extensive road network is already fragmenting habitats and facilitating easy access to forest areas. Many small organisms, including dung beetles and ants, are known to be especially sensitive to fragmentation. Even slight perturbations of the forest, such as the loss of plant diversity and changes in soil microclimate, are known to strongly affect these groups. Roads and other access routes provide access not only to humans but also to invasive species.

1) **Minimize the number of access routes.** The road network at Nassau should be blocked, reforested and monitored for illegal access. Footpaths and other access routes in all three areas should be minimized and regulated. Any future development in the three plateau areas must take great care to create a minimal access network, especially roads.

2) **Maintain large areas of forest**. Although deforestation is still not widespread at either site, it is important to keep large areas of primary forest to maintain intact communities of all taxa, especially mammals and dung beetles. Reptiles and amphibians need at least 1500 ha as the 'minimum critical area' necessary to protect a reasonably intact sample of the local fauna. We suggest that forest blocks of at least this size be preserved at Lely and Nassau.

3) **Monitor several key species or groups that depend on intact forest** to ensure healthy populations and to detect changes as early as possible to prevent serious declines. Target groups should include large and small mammals, amphibians, and several insect groups. Since small mammals are highly dependent on forest structure for their survival and constitute a key component of the diet of large animals, monitoring small mammal diversity and abundance is a good way to track the integrity of the forest ecosystem.

4) **Control logging**, which accelerates habitat fragmentation and degradation and has already begun to impact several groups, especially dung beetles, ants, and mammals.

VI. ENHANCE PROTECTION OF BROWNSBERG NATURE PARK AND OTHER PARTS OF THE PLATEAU.

1) **Protect the Brownsberg range** through i) effective law enforcement in and around the Park, ii) formal establishment and southward extension of the buffer zone, iii) a management plan for the larger area that includes the Park and the extended buffer zone, and iv) attempts to restore areas damaged by gold mining.

2) **Expand tourism activities** to i) the central and southern part of the Brownsberg range, ii) the Brokopondo lakeside area, and iii) the village of Brownsweg.

3) **Continue monitoring human activities, biodiversity and the environment**, including i) analyzing the data generated by STINASU in the course of the BNP Monitoring Program from 2002 to 2005, and ii) implementing a modified monitoring program (BMP) based on the results and recommendations of the data analysis.

4) **Make full use of the results of research and monitoring data,** meaning that i) the planning and management of the Park is guided by the results, and ii) the results are used as inputs for a variety of information products, as well as for public awareness and education activities in the Park and in the capital Paramaribo.

5) **Create a super-structure for the Brownsberg-Brownsweg area**, possibly linked to a MUMA (Multiple-Use Management Area), that would at least allow for i) conflict resolution between STINASU, the village of Brownsweg, and local miners and other operators, ii) a dialogue on land use with the stakeholders, and iii) conservation and development projects that benefit the local community.

VII. MONITOR TO DETECT THE PRESENCE OF THE CHYTRID FUNGUS, *BATRACHOCHYTRIUM DENDROBATIDIS* IN ADULT FROGS ALONG FOREST STREAMS

. This fungus has been linked to amphibian declines in many parts of the Neotropics. Global amphibian declines have resulted in the loss of many moderate- to high-elevation anurofaunas, so the presence of abundant, diverse, stream-associated amphibian assemblages at Nassau and Lely is of significant conservation value. The densities we observed at Nassau and Lely are comparable to pre-decline data from forest streams and adjacent forest in Panama, suggesting that the stream-associated fauna of Nassau and Lely have not experienced the dramatic declines that have occurred in other parts of the Neotropics. Although we are not aware of reports of amphibian declines from the Guianas, conditions favorable for the occurrence of *Batrachochytrium dendrobatidis* are predicted to occur in the vicinity of Nassau and Lely Mountains.

1) **Initiate an ongoing detection and monitoring project**. The presence of *B. dendrobatidis* can be detected via analysis of dermal swabs from live animals. We recommend collecting 300 swabs/visit (i.e., one swab per individual from the first 300 individuals encountered). To detect the presence of *B. dendobatidis*, analysis may be conducted on pooled samples of 10 swabs.

2) **Alert amphibian conservation biologists if the fungus is detected**. Individual analysis of all swabs will be necessary to identify infected species. Should *B. dendrobatidis* be detected, the Declining Amphibian Population Task Force (http://www.open.ac.uk/daptf/index.htm) should be contacted for recommended action.

ADDITIONAL RESEARCH PRIORITIES

I. Biodiversity surveys during the rainy season for all taxa are needed to compile a more complete inventory of species. As the RAP surveys were conducted at the height of the dry season, similar surveys in these areas during the rainy season are needed, particularly for groups that may be more active in the wet season, such as amphibians, and for groups that may flower (plants) or breed in the rainy season (birds).

II. Surveys of both lowland streams in the foot hills (especially Paramacca Creek) and high-altitude streams on the plateau of Nassau (and Lely) plateaus are needed to better understand (1) the ecology and evolution of the unique fish communities of the plateau and (2) diversity and endemism of Guayana Shield fish faunas in general.

III. Research on the biodiversity of the Paramacca Creek watershed, including conducting similar surveys during the rainy season.

IV. Research on the rare catfish *Harttiella crassicauda* should be initiated and stimulated by BHP Billiton and Suralco, conservation organizations, and the Surinamese government. Specific actions include:

a. More information about the occurrence of *H. crassicauda* in Paramacca Creek (and its tributary streams) at lower elevations and in two other streams draining Nassau Mountains (Anjumarakreek and an unnamed stream);

b. More information about the (reproductive/feeding) biology of *H. crassicauda* to better understand its ecology.

c. More information about the relationship of *H. crassicauda* with other catfishes of the subfamily Loricariinae (DNA analysis). When properly protected the unique fish *H. crassicauda* could become a symbol for good environmental management practices.

d. Immediate actions should be taken to initiate the process leading to inclusion of *H. crassicauda* on the IUCN/CITES red list of endangered species.

V. Research on the population sizes and viability of key species. Both Lely and Nassau are important for biodiversity conservation since they contain a high diversity of large mammals, as well as several new species of amphibians and dung beetles. Determining the IUCN red list status of the species new to science will depend on estimating the geographic range of these species, so special effort should be made to determine their area of occurrence. We recommended expanded surveys of streams on the two mountains and in adjacent lowlands in order to more accurately quantify abundance and extent of occurrence of stream-associated frogs, particularly new species whose distributions are unknown.

VI. Further plant inventories of Nassau and Lely, in which herbarium specimens are collected as well as live specimens, especially for plants that are associated with rocky creek beds and mountain savanna forest. These should include surveys to assess the presence of rare plant species and the habitats in which they occur, including orchids and plants associated with habitats with encrusted soil.

VII. Further research on the potentially new species for science observed on all three plateaus, especially for frogs and fishes. **Conduct additional inventories** for taxonomic groups for which we have very little information such as dung beetles, bees and ants, especially at Brownsberg. More orchid bee samples need to be obtained form all three ranges, and the relationship between orchids and orchid bees at these ranges should be investigated.

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