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The Field Museum

The Field Museum is a collections-based research and educational institution devoted to natural and cultural diversity. Combining the fields of Anthropology, Botany, Geology, Zoology, and Conservation Biology, Museum scientists research issues in evolution, environmental biology, and cultural anthropology. Environmental and Conservation Programs (ECP) is the branch of the Museum dedicated to translating science into action that creates and supports lasting conservation. ECP collaborates with another branch, the Center for Cultural Understanding and Change, to ensure that local communities are involved in efforts for long-term protection of the lands on which they depend. With losses of natural diversity accelerating worldwide, ECP's mission is to direct the Museum's resources—scientific expertise, worldwide collections, innovative education programs—to the immediate needs of conservation at local, national, and international levels.

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Centro Oriental de Ecosistemas y Biodiversidad and Museo de Historia Natural "Tomás Romay"

The mission of the Centro Oriental de Ecosistemas y Biodiversidad (BIOECO) is to carry out specialized, interdisciplinary studies in the Eastern Region of Cuba that define and characterize the most important and interesting areas for the conservation of biodiversity. BIOECO also works to establish the means and methods for conservation of these areas and the wise use of their resources, as well as to contribute to the ecological recovery and the sustainable socioeconomic and cultural development of the region.

BIOECO has four Divisions:

- The Tomás Romay Museum of Natural History
- Botanical Gardens
- Natural Sciences
- Protected Areas

These Divisions conduct scientific studies, management of protected areas, ecological planning, in-situ and ex-situ conservation, environmental education, and community projects.

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Museo Nacional de Historia Natural de Cuba

The Museum's core mission is to collect, research, conserve, and exhibit natural objects to promote scientific knowledge and cultural appreciation of nature. It is an institution comparable, in structure and function, with the international model for this kind of museum; for that reason it includes the following among its fundamental objectives:

- Research on biogeography, paleogeography, and the biodiversity of Cuba and the Caribbean;
- Conservation of the collections of Cuban minerals, rocks, fossils, plants, and animals residing in the Museum, which are part of the National Heritage;
- Broadening of these collections so that they will be representative of Cuban nature, and systematic study of the collections and of the environment from which specimens were collected; and
- Creation of exhibits about nature, with emphasis on Cuban natural history, and the education of visitors and the general public in a culture of nature.

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Cornell Lab of Ornithology

The "Lab" is a nonprofit membership institution whose mission is to interpret and conserve the earth's biological diversity through research, education, and citizen science focused on birds. Our programs work with citizen scientists, government and nongovernment agencies across North America and beyond. We believe that bird enthusiasts of all ages and skill levels can and do make a difference. From backyards and city streets to remote forests, anyone who counts birds can contribute to the Lab's research. Data from the projects described below are used to monitor bird populations and outline conservation efforts.

The Lab's conservation work is based on sound science and draws extensively from the efforts of other Lab programs. Our conservation staff produces guidelines and manuals to help professional land managers and private landowners make informed, conservation-minded management decisions. Lab staff belong to a number of conservation alliances, including Partners in Flight and the International Whaling Commission, which work hard to affect broad-scale conservation policy.

Education is a vital component of the Lab's mission. We provide to the public a growing number of education projects and courses, and are committed to empowering educators with the tools they need to provide science-based programs to their students.

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The goal of rapid biological and social inventories is to catalyze effective action for conservation in threatened regions of high biological diversity and uniqueness.

Approach

During rapid biological inventories, scientific teams focus primarily on groups of organisms that indicate habitat type and condition and that can be surveyed quickly and accurately. These inventories do not attempt to produce an exhaustive list of species or higher taxa. Rather, the rapid surveys (1) identify the important biological communities in the site or region of interest and (2) determine whether these communities are of outstanding quality and significance in a regional or global context.

During social asset inventories, scientists and local communities collaborate to identify patterns of social organization and opportunities for capacity building. The teams use participant observation and semistructured interviews to evaluate quickly the assets of these communities that can serve as points of engagement for long-term participation in conservation.

In-country scientists are central to the field teams. The experience of local experts is crucial for understanding areas with little or no history of scientific exploration. After the inventories, protection of wild communities and engagement of social networks rely on initiatives from host-country scientists and conservationists.

Once these rapid inventories have been completed (typically within a month), the teams relay the survey information to local and international decision-makers who set priorities and guide conservation action in the host country.

REPORT AT A GLANCE	
Dates of fieldwork	February 1–10, 2004
Region	This inventory took place in La Bayamesa National Park, located in the central part of the Sierra Maestra Mountains, approximately 36 km directly south of the city of Bayamo (Fig. 1). It covers 241 km^2, of which 197 km^2 are located on the southern slope and only 44 km^2 on the northern slope. The highest point is Pico Bayamesa at 1,752 m.
Sites surveyed	During the rapid inventory, the biological team concentrated research efforts around two camps: Barrio Nuevo and El Zapato (Fig. 1B).
Organisms studied	Terrestrial vascular plants (ferns and fern relatives, and seed plants), terrestrial mollusks, spiders and other arachnids, aquatic insects, butterflies, hymenopterans (ants, bees, and wasps), amphibians, reptiles, and birds. We also studied the condition and distribution of the Park's vegetation types. Collaborators provided additional data from studies conducted previously in the area on liverworts, hornworts, and mosses.
Highlights of results	This mountainous park retains the majority of its original terrestrial habitats (Figs. 2, 3), including montane rainforest, natural pine forests, cloud scrub formations, cloud forest, and evergreen forests. Large portions of the Park that were disturbed mostly at the beginning of the twentieth century are now being regenerated by natural succession (see Main Threats in this section and Vegetation in the Technical Report). The Park is adjacent to Turquino National Park (Fig. 1B). From a biological point of view, this situation is very favorable because it creates a large block of continuous forest habitat that provides better, long-term protection for some organisms (such as birds) than would two parks at a distance from each other. Using the information we obtained during our fieldwork, supplemented with additional data from other collections, literature, and unpublished studies, we report the following highlights. **Birds:** We recorded 76 species in La Bayamesa National Park (55 species in Barrio Nuevo and 68 in El Zapato). Based on L. Melián's previous work in the area, we estimate that approximately 120 species inhabit the Park. We recorded 4 threatened species—Gundlach's Hawk (*Accipiter gundlachi*), Sharp-shinned Hawk (*A. striatus*), Gray-fronted Quail-Dove (*Geotrygon caniceps*), and Stygian Owl (*Asio stygius*)—and it is likely that the threatened Black-capped Petrel (*Pterodroma hasitata*; Fig. 7D) is also present.

Highlights of results (continued)

We found 11 species endemic to Cuba. The forests seem to harbor exceptional densities of two endemic resident species: Cuban Trogon (*Priotelus temnurus*; Fig. 7B), and Cuban Solitaire (*Myadestes elizabeth*; Fig. 7A). Most likely, they are more abundant here than in any other part of Cuba. The Park also harbors exceptionally high densities of wintering migrant birds, notably Black-throated Blue Warbler (*Dendroica caerulescens*; Fig. 7C), which occurs here in higher densities than in any other site in the Caribbean (possibly more than 50% of its world population winters here). A small population of a rare wintering migrant, Bicknell's Thrush (*Catharus bicknelli*), could be present as well.

Amphibians and reptiles: We recorded 16 amphibian and 20 reptile species (Fig. 6); we observed the Cuban boa (*Epicrates angulifer*) outside the area's borders, but rural farmers claim to have seen it within the Park. One amphibian (*Bufo peltacephalus*) and two reptiles (*Anolis noblei* and *A. guazuma*) are not included on our list, but they probably exist within the Park. With their inclusion, the total number of species increases to 39 (17 amphibians and 22 reptiles). We did not find species of the genera *Arrhyton*, *Amphisbaena*, or *Typhlops*, probably because their reclusive habits make them extremely difficult to detect.

Of all the species recorded, 15 amphibians and 17 reptiles (93.8% and 85.0%, respectively) are endemic to Cuba, and of those, 7 amphibians and 4 reptiles are endemic to Sierra Maestra. More significantly, 3 species inhabit only areas within the Park (Appendix 12), and 5 others are known to inhabit only this Park and adjacent Turquino National Park. Of the endemics, 10 amphibians (*Eleutherodactylus* spp.; Figs. 6A-C) and 2 reptiles, *Chamaeleolis chamaeleonides* (Fig. 6D) and *Epicrates angulifer*, are also considered threatened.

Mammals: We did not survey mammals in the Park.

Invertebrates: We observed 8 families, 11 genera, and 13 species of **terrestrial mollusks** in the Park (Figs. 5A-B). Species richness is high. All of the Park's montane rainforest species are endemic: 5 (38.5%) are endemic to Sierra Maestra, 6 (46.2%) are endemic to the Eastern Region, 1 (7.7%) is endemic to both the Central and Eastern Regions, and 1 is endemic to Cuba in general.

There are 65 species of **spiders**, grouped in 54 genera and 24 families. Of these, 21 species and 3 families were new records for the Park. Best-represented families included Araneidae, Theridiidae, Salticidae, and Tetragnathidae. We found 17 of Cuba's endemic species (including 3 that are restricted to the Sierra Maesta), which represents 6.9% of the country's endemic species. Of the Park's endemics, *Argyrodes cubensis* is only known to exist from its populations in two localities in the Eastern Region.

We observed 6 species (all endemic to Cuba) belonging to 6 genera, 4 families, and 3 orders of **other arachnids** (scorpions, amblypygids, and schizomids). Our inventory was the first effort to study these groups in the zone. The most interesting record was a new species of *Cubazomus*. This is the second known species of this genus in the Order Schizomida within Sierra Maestra, and recorded at a high altitude: 1,100 m (the other species lives below 300 m).

We collected 2,033 individual **aquatic insects** assignable to 65 species, 35 families, and 7 orders. Compared to other Cuban data, the number of aquatic insects in the Park is high: its 65 species represent 31.1% of all known Sierra Maestra species and 12.7% of those known for Cuba. We found 26 species endemic to Cuba (40% of all the species found), of which 3 are local endemics: *Hagenulus sextus* (Ephemeroptera, Leptophlebiidae), *Campsiophora mulata* (Trichoptera, Glossosomatidae), and *Paltostoma palominoi* (Diptera, Blephariceridae). The Orders Ephemeroptera, Odonata, and Trichoptera were especially rich in endemic species.

We observed 23 **butterfly** species and predict that 35 occur in the Park. Four are endemic to Cuba, and 2 (*Anetia briarea* and *A. cubana*) are considered near threatened globally.

The Park harbors a significant diversity of **hymenopterans** (ants, bees, and wasps). We found 200 species belonging to 10 families and estimate that the number of species easily surpasses 400. We registered 6 genera of the Family Ichneumonidae (*Clistopyga*, *Eruga*, *Exenterus*, *Protichneumon*, *Symplecis*, *Zatypota*) and one Braconidae (*Macrostomion*) that are new records for Cuba (Fig. 5D)—most of these probably represent species new to science as well. We predict that endemism could be significant for some hymenopterans in the Park because of its altitude, good state of conservation, and relative isolation; rates are close to 40% for the hymenopteran families for which there are data available in Cuba. Results from this inventory suggest that La Bayamesa National Park is a "hot spot" for groups of parasitic wasps, and without a doubt, the area is the most important for the Ichneumonidae in the country.

Nonvascular plants: Many Cuban and foreign botanists have visited the Sierra Maestra. Despite their efforts, each additional visit brings new finds, showing that research on its flora is far from complete. The Sierra del Turquino, in which La Bayamesa National Park is found, is one of the most important areas for nonvascular species richness and endemism. There are 172 species of **liverworts and related plants**, belonging to 63 genera and 19 families, which is a significant portion of the hepaticological flora recorded for the country. Six endemic species occur in the Park, which represent 26% of all the Cuban

Highlights of results (continued)

endemics and 46% of those endemic to Sierra Maestra. Twelve species are globally threatened: 8 Endangered and 4 Vulnerable.

The **moss** flora is represented by 142 infrageneric taxa belonging to 78 genera and 32 families (Fig. 4A). Based on the highest numbers of infrageneric taxa, the following genera are best-represented: *Fissidens*, *Campylopus*, *Leucobryum, Macromitrium*, and *Syrrhopodon*. Two taxa are endemic: *Dicranella hioramii* var. *hioramii* and *Syrrhopodon elongatus* var. *elongatus*, and 22 taxa are threatened globally.

Vascular plants: The Park harbors a rich pteridoflora (**ferns and fern relatives;** Fig. 4B). We registered 346 species, 74 genera, and 25 families, representing 53% of all Cuban fern species. We found 2 species that are possibly new to science (*Pityrogramma* and *Pteris*), two new records for Cuba (*Ophioglossum harrissii* and *Danaea urbanii*), and 6 new records for the Park. There are 21 endemic and 4 possibly endemic species, for an endemism rate of 7.2%; of these, 3 are found only in the Park, an additional 7 are endemic to Sierra Maestra, and 12 are endemic to eastern Cuba. We recorded 44 species categorized or listed as candidates for categorization as threatened; of these, 10 are found in Cuba only in the studied area. There are 3 naturalized, highly invasive species.

We recorded 553 taxa of **spermatophytes** (seed-bearing plants; Figs. 4C-D) belonging to 315 genera and 103 families, of which 6 or 7 are new records for the Park, Sierra Maestra, or Cuba. We estimate that approximately 700 species exist in the area. Of those recorded for the Park, 6 are considered globally threatened. The families with the most species are Asteraceae (38), Orchidaceae (37), Rubiaceae (32), Poaceae (29), and Fabaceae (28). The percentage of native species is probably over 90%. There are 37 known introduced species; when compared to other protected areas where we have conducted similar inventories, this number is high, probably because human settlements within and around the Park facilitated their introduction and dispersal.

We identified 6 **native vegetation** types in the Park (Figs. 2, 3): cloud forest (above 1,500 m), cloud scrub (over 1,700 m), montane rainforest (between 800 and 1,400 m), natural pine forest (the most extensive found between 700 and 1,100 m), mesophyll evergreen forest, and gallery grassland. Montane rainforest covers the largest surface area within the Park. There are also areas of anthropogenic vegetation, including plantations of *Pinus cubensis* and *P. caribaea* that are not native to the Park.

Main threats

01 **Native habitat destruction and alteration.** During the rapid inventory, we observed some areas (mostly in the western portion) where forest cover had been eliminated sometime in the early twentieth century by settlements, logging, and the creation of pasture and cropland (Fig. 2). Because of this, vegetation in many areas is regenerating via natural succession (Fig. 8A). However, in some areas along the Park's periphery, and in some lower elevation valleys, forest is being fragmented or degraded by human activities—despite the fact that it is formally protected. We did not detect any significant contamination in rivers or streams.

Subtle fragmentation of fragile habitats (covering a small area of the Park), such as cloud forests and natural cloud scrub above 1,400 m, is of particular concern. This fragmentation threatens flora and fauna because it creates habitat "islands," separating species from one another and isolating populations. New roads and trails, unless carefully planned, could increase human presence in susceptible habitats in upper altitudes.

02 **Introduced plants.** The presence of exotic species that displace native vegetation represents a significant potential threat. Some introduced plants of concern include eucalyptus (*Eucalyptus* spp.), cypress (*Cupressus* spp.), "marabú" (*Dichrostachys cinerea*), and rose apple ("pomarrosa," *Syzygium jambos*). Although these species are not dominant or extensive at present (as they have become in some other parks and ecological reserves in Cuba), it is not clear whether or not they will continue to behave as good citizens—that is, they may displace native vegetation over extensive areas in the future unless they are eliminated or actively managed. There are also many plantations of *Pinus cubensis* and *P. caribaea,* which are not native to the area. These species reproduce naturally in the area and easily hybridize with *P. maestrensis*, the Park's native species, thereby altering its genetic makeup.

03 **Introduced animals.** Predation by introduced animals, such as feral dogs (*Canis familiaris*) and cats (*Felis catus*), can affect bird and other faunal communities. At this time, these mammals' impact on native fauna is unknown. Reforestation may represent a threat to the Park's entirely endemic malacofauna because non-native mollusks can be introduced in the process.

Current status

La Bayamesa is a National Park, which is a Category II strictly protected area according to IUCN categorization.

REPORT AT A GLANCE

Principal recommendations for protection and management

01 **Reduce or eliminate deforestation or degradation of forested habitats and promote regeneration of large patches of rainforest and natural pine forest.** Protect undisturbed or relatively undisturbed native forests. Increase patrols and control within the Park to stop unregulated agriculture and unauthorized logging.

02 **Reduce or eradicate exotic species, focusing on the most damaging first.** Eliminate, or at least reduce, exotic plant populations in the Park and prevent the introduction of harmful animals.

03 **Control access to fragile habitats.** The cloud forest is especially vulnerable. Expert biologists should be consulted if new roads are built, or existing roads are rebuilt or widened, or when trails are built for tourists, so as to reduce subsequent erosion, disturbances, and habitat fragmentation.

04 **Consolidate park management, providing additional resources and training for personnel.** Elaborate the Park's Management Plan, using information from this and future inventories and other research, and strengthen human resources.

Why La Bayamesa National Park?

More than one thousand species of plants and an even larger number of animals find refuge in the rough and beautiful landscape of La Bayamesa National Park. Although the Park comprises only 0.2% of the area of Cuba, it is protected by its difficult access. Mostly covered by native forests in a good state of conservation, the Park encompasses the largest contiguous area above 1,200 m altitude in Cuba. Intact cloud forests mantle its tallest mountain peaks, which are named after heroes in the nation's struggle for independence.

Together with the adjacent Turquino National Park, this area is the principal nucleus of biodiversity in the Sierra Maestra and, unquestionably, one of the principal nuclei within all the Caribbean islands. Many species restricted to the Sierra Maestra, including amphibians, insects, mollusks, ferns, and spiders, are found in Parque Nacional La Bayamesa. Eleven species of birds endemic to Cuba are present, often in significant numbers (such as Cuban Trogon and Cuban Solitaire). The Park also shelters hugely important populations of North American migrant birds, especially Black-throated Blue Warbler, and populations of many globally threatened plants and animals.

These natural treasures of La Bayamesa deserve to be studied and appreciated in their full magnitude. But, it is one of the least studied national parks in Cuba, even though the information from such studies is crucial for the evaluation of conservation targets and for the development of effective management plans.

Conservation in the Park

CURRENT STATUS

La Bayamesa National Park is located in the central part of Sierra Maestra, approximately 36 km directly south of the city of Bayamo. It covers 241 km^2, of which 197 km^2 are located on the southern slope and only 44 km^2 on the northern slope. The highest point is Pico Bayamesa at 1,752 m. La Bayamesa National Park is a strictly protected area (Category II, IUCN). Together with Turquino National Park, which is adjacent, it forms the largest mountainous block above 1,200 m in Cuba. These two national parks harbor the greatest biological diversity in Sierra Maestra and contain some of the richest flora and fauna in Cuba. The fact that these protected areas are contiguous not only facilitates management actions but also provides a unique opportunity to safeguard important conservation targets.

CONSERVATION TARGETS

Conservation targets are the elements of physiographic, biological, or cultural diversity that we want to persist in the landscape. We used the following criteria to choose these targets:

C1 Wild vegetation types or aquatic habitats that are the foundations of native biodiversity

C2 Vegetation types or aquatic habitats that are especially species rich, diverse, or threatened

C3 Wild communities/assemblages that are especially species rich, diverse, or abundant in comparison to those of other landscapes in the country or region

C4 Species, subspecies, or communities/assemblages that are endemic to the country, to the region, or to the locality

C5 Species, subspecies, or communities/assemblages that are rare, threatened, endangered, vulnerable, or declining (including species of economic importance)

C6 Species or subspecies under such intense local harvesting pressure that their populations may be in jeopardy (sufficient information is lacking)

(Codes continued on next page)

We identified the following conservation targets for the Park during the rapid inventory. Site managers and planners should continue research on these targets to refine our selections. Codes in parentheses refer to the criteria in the sidebar to the left. Detailed lists of conservation targets are provided at the beginning of each group's chapter in the Technical Report.

Physiographic Features	▪ Clean, uncontaminated rivers and streams, free of human-produced toxins and sediments that damage native amphibians, fish, and aquatic insects (C10)
Terrestrial Vegetation Types	▪ Montane rainforest and its successional stages, cloud forest, cloud scrub, natural pine forest, and gallery forest, all of which harbor thousands of endemic and native plant, invertebrate, and vertebrate species (C1, C4)
Nonvascular Plants	▪ Two endemic, threatened **liverwort** species (*Nowellia wrightii* and *Radula pocsii*) (C4, C5), 10 additional threatened species (C5), and 4 endemic species (C4) ▪ Twenty-two threatened **moss** species, including *Eurhynchium clinocarpum* and *Hookeriopsis luteo-rufescens*, which are categorized as globally Critically Endangered (C5)
Vascular Plants	▪ Forty-four species of **ferns** categorized as or listed as candidates for categorization as threatened; 10 of these species are found in Cuba only within the Park (for example, *Asplenium alatum* and *Blechnum gracile*) (C5) ▪ Twenty-five endemic or possibly endemic ferns, 3 of which are found only within the Park, 7 of which are endemic to the Sierra Maestra, and 12 to eastern Cuba (C4)

C7 Concentrated populations of migratory species (either as passage migrants or as seasonal residents) that may be vulnerable through their dependence on the landscape's resources C8 Institutions, social assets (including human resources), or built structures that are significant for the diversity of the landscape, especially if threatened C9 Human land uses and social/ecological practices that apparently support or are compatible with biodiversity conservation C10 Physiographic features of the landscape that harbor significant native biodiversity and are at risk	Vascular Plants (continued)	▪ One endemic **spermatophyte** (a seed-bearing plant) considered globally Endangered, *Lyonia elliptica* (Ericaceae); 5 species considered globally Vulnerable, *Begonia cubensis* (Begoniaceae), *Tabebuia hypoleuca* (Bignoniaceae), *Juniperus barbadensis* var. *lucayana* (Cupressaceae), *Licaria cubensis* (Lauraceae), and *Sideroxylon jubila* (Sapotaceae) (C4, except *Juniperus*, and C5); 1 subspecies categorized as Undetermined (C5); and 1 species restricted to small populations along the Peladero River and its tributary, the Nuevo Mundo, *Marathrum utile* (Podostemaceae) (C5)
	Mollusks	▪ Five species endemic to the Sierra Maestra Subregion and 6 endemic to the Eastern Region: *Helicina subglobulosa leoni*, *Troschelvindex arangianum turquinensis, Cysticopsis lessavillei*, *Obeliscus* (*Stenogyra*) *clavus flavus*, *Veronicella* sp. nov., *Alcadia* (*Idesa*) *spectabilis, Emoda p. pulcherrima, Zachrysia* (*Chrysias*) *bayamensis*, *Coryda lindoni*, *Cysticopsis pemphigodes,* and *Obeliscus (Pseudobalea) latus* (C4, C5)
	Arachnids	▪ Populations of 17 endemic **spider** species in the Park, especially *Argyrodes cubensis*, which is known from only two localities in the Eastern Region, and *Leucauge spiculosa, Modisimus pavidus*, and *Hibana turquinensis*, which are only known for a few localities within the Sierra Maestra (C4) ▪ The population of a **schizomid**, *Cubazomus* sp. nov. (Hubbardiidae), the second known species of this genus endemic to Sierra Maestra (C4)

Conservation Targets (continued)

	Insects	▪ Communities of **aquatic insects**, especially 26 endemic species, of which 3 are particularly important because they are Park endemics: *Hagenulus sextus* (Ephemeroptera), *Campsiophora mulata* (Trichoptera), and *Paltostoma palominoi* (Diptera) (C4) ▪ Four **butterfly** species endemic to Cuba (*Calisto sibylla, Anetia cubana*, *Greta cubana,* and *Parides gundlachianus*) (C4) ▪ Communities of **hymenopterans** (wasps, bees, and ants), especially groups of parasitic wasps that are more diverse and abundant here than in any other place in the country, including genera that in Cuba have only been found in this region (*Clistopyga, Eruga, Exenterus, Macrostomion, Protichneumon, Symplecis, Zatypota*) (C3, C4) ▪ Endemic ant species (*Camponotus gilviventris*, endemic to Cuban mountainous zones, and *Leptothorax bruneri*, a regional endemic) (C4)
	Amphibians and Reptiles	▪ Twelve species considered threatened (*Eleutherodactylus albipes, E. cubanus, E. glamyrus, E. gundlachi, E. intermedius, E. ionthus, E. jaumei, E. melacara, E. ricordii, E. turquinensis*, *Chamaeleolis chamaeleonides*, and *Epicrates angulifer*), which are also endemic to Cuba (C5, C4) ▪ Ten species whose ranges are restricted to the Sierra Maestra forests (*Eleutherodactylus albipes*, *E. cubanus*, *E. glamyrus*, *E. jaumei*, *E. melacara*, *E. turquinensis*, *Eleutherodactylus* sp. nov., *Anolis clivicola*, *A. altitudinalis*, and *Diploglossus garridoi*) (C4)

Conservation Targets (continued)

	Birds	▪ Four or five threatened species: Gundlach's Hawk (*Accipiter gundlachi*), Sharp-shinned Hawk (*A. striatus*), Gray-fronted Quail-Dove (*Geotrygon caniceps*), Stygian Owl (*Asio stygius*), and, if its presence is confirmed, Black-capped Petrel (*Pterodroma hasitata*) (C5) ▪ Eleven Cuban endemics (C4) ▪ Terrestrial migrant birds from North America, including Bicknell's Thrush (*Catharus bicknelli*) (C7)
	Mammals and Human Communities	We did not survey mammals or evaluate the human communities within and around the Park.

THREATS

DESTRUCTION AND ALTERATION OF NATIVE HABITATS

Terrestrial habitats

During the rapid inventory, we observed some areas (mostly in the western portion; Fig. 2) where forest cover had been eliminated sometime in the early twentieth century by settlements, logging, pasture, and cropland. Because of this, vegetation in many areas is regenerating via natural succession. However, in some areas along the Park's periphery, and in some lower elevation valleys, forest continues to be fragmented or degraded by human activities—despite formal protection of the Park. For example, habitat loss is extensive in the La Mula, Guayabo, La Plata, and La Bruja River Basins.

Many native species depend entirely on very specific microhabitats for survival. Deforestation not only affects the timber species that are cut out of the forests, but also different groups associated with these forests. For example, most liverworts living in the understory or on other plants need microhabitats of a certain age, and specific pH, shade, and humidity to grow and reproduce. Likewise, many mollusks, arachnids, insects, amphibians, and reptiles are also extremely sensitive to localized habitat loss or destruction.

Subtle fragmentation of fragile habitats is of particular concern. This fragmentation threatens flora and fauna because it creates habitat islands, which separate populations of the same species from each other. High-altitude habitats (those above 1,400 m, including cloud forest and cloud scrub) face the highest risk of degradation. Historic patterns of degradation of the Park's montane rainforests and mesophyll evergreen forests in lower altitudes have created isolated patches of some native plants and animals, which are now threatened with disappearance from the Park.

Roads and trails

There are very few roads within the Park, but the potential for new roads and trails is cause for concern. Increased vehicular traffic could alter the structure of the bird communities by introducing new species to the area, and it could change the structure and distribution of vegetation. Subsequent increased hunting pressure may also stress certain bird species.

New roads and trails, unless carefully planned and implemented, could also increase human presence in fragile, high-altitude habitats. High-altitude vegetation covers a small surface area in the Park and is vulnerable to excessive collection of plant material and human presence. Current projects designed to facilitate access to these areas represent an immediate threat.

Aquatic habitats

Fortunately, we did not detect any significant sources of contamination, such as dumping in rivers and creeks, which are typically the biggest threats to lotic ecosystems. As long as natural resource use remains as it is now, freshwater macroinvertebrate communities are not at risk.

We did see many ruts along the roads caused by fluvial erosion. Soil loss from erosion along these roads or any other construction area on steep slopes in the Park would have a negative local effect on some aquatic organisms.

EXOTIC, INVASIVE SPECIES

Plants

Another significant potential threat is the existence of exotic plants that displace native vegetation in some areas in the Park. For example, several intentionally planted species in the Park include eucalyptus (*Eucalyptus* spp.) and cypress (*Cupressus* spp.). Several other non-natives escaped cultivation and have invaded the forests, such as "marabú" (*Dichrostachys cinerea*, Fabaceae) and rose apple (*Syzygium jambos*, Myrtaceae). While these exotic species are not as pervasive or extensive as some in other parks or ecological reserves in Cuba, it is not clear whether or not they will behave as good citizens within La Bayamesa National Park in the future. That is, these species have the potential to displace large areas of native species if they are not eliminated or managed now, while they are still controllable.

Finally, there are several plantations of *Pinus cubensis* and *P. caribaea,* which are not native to the area. These species naturally reproduce in the Park and easily hybridize (especially the first) with native *P. maestrensis*, thereby altering its genetic makeup.

Animals

Predation by introduced species, such as feral dogs (*Canis familiaris*) and cats (*Felis catus*), could be affecting bird and herpetological fauna communities. The level of impact on native fauna is unknown.

A threat to the Park's entirely endemic malacofauna is deforestation and subsequent reforestation, which could introduce non-native mollusks.

OTHER POTENTIAL THREATS

Amphibian declines and extinctions have not been documented in Cuba, but the possibility exists, especially in high-altitude, forested areas (La Bayamesa, for example). Most species in decline in Latin America live above 500 m altitude (Lips et al. 2003). The lack of baseline studies or previous data in Cuba may be masking the magnitude of amphibian declines on the island.

West Nile virus is a potential threat, but we do not have sufficient information regarding its possible occurrence among resident and migrant species populations of birds.

RECOMMENDATIONS

Based on the Park's conservation targets and threats, we offer the following recommendations, including specific notes on protection and management, and additional scientific research (inventories, research, and monitoring). Collaboration among local communities, scientists, park managers, and local governments will provide deeper and broader content for our goals and strategies. For more detailed, organism-specific recommendations, see the Technical Report.

Protection and management

01 **Reduce or eliminate deforestation and degradation of native habitats.**

- Protect native forests (rainforest, cloud forest, evergreen forests) and scrub.
- Increase vigilance and enforcement within the Park to eliminate unregulated agriculture and unauthorized logging, thereby protecting remnant stands of natural forest.

02 **Reduce or eradicate exotic species, focusing on the most harmful first.**

- Eliminate (or at least reduce) exotic plant populations (eucalyptus, cypress, *Dichrostachys*, rose apple, and others) from the Park.
- Prevent harmful animals from entering the forests (for example, feral dogs and cats, and non-endemic mollusks).

03 **Control access to fragile habitats.** Strictly limit (to small groups only) and control access to the cloud forest ecosystem (which is especially vulnerable), and strictly control excessive botanic and zoological collections. Restrict access (only permitting scientific research) to Pico Botella, Pico Maceo, and La Bayamesa's second peak, the natural pine forests at María Tomasa (Colón) and La Francia, as well as other places where endemic, rare, and/or threatened communities are concentrated.

04 **Carefully plan any new road or improvement project.**

- Consult biologists with expertise regarding vegetation, herpetology, birds, and aquatic environments if new roads are built, or existing roads are rebuilt or widened, or when trails are built for tourists, to help determine how best to reduce subsequent erosion, disturbances, and habitat fragmentation.
- Consider the indirect effects of new roads and increased access by humans; for example, the potential for increase in illegal logging or unauthorized collection of Park fauna.

05 **Maintain water quality, preventing sedimentation and contamination of aquatic habitats.** Implement erosion control along ruts and control water flow along roads and other areas where it causes damage.

RECOMMENDATIONS

Protection and management (continued)

06 **Promote regeneration of large rainforest and natural pine forest patches.**

- Reforest pasture areas within rainforests using passive and active processes and native species (appropriate to altitude) in the Park (especially areas in and around Pata de la Mesa).
- Prevent human-caused fires in the pine forests.

07 **Consolidate park management, providing additional resources and personnel training.**

- Elaborate the Park's Management Plan using information from this and future inventories and research to protect ecosystem integrity and indigenous species.
- Strengthen human resource capacities.
- Consider self-financing strategies for the Park's long-term maintenance and conservation.
- Develop "sustainable use" areas in La Bruja and in Marverde (disturbed and populated areas), that is, promote development that is compatible with the conservation of indigenous species and communities.

08 **Raise awareness of the Park's value and benefits.** Increase environmental education programs in nearby communities to establish conservation awareness.

Additional inventories

Gather more information on native species and their distribution in the Park. Here we present a sampling of the specific recommendations detailed in the Technical Report.

01 Continue biological inventories in other locations, during dry and rainy seasons.

02 Conduct additional, detailed inventories of the pteridoflora, which are lacking for many areas, especially La Sierrita (or "Maestrica") de los Libertadores.

03 Carry out more inventories of the area's entirely endemic mollusk community, which are needed to understand its composition.

04 Survey aquatic insects in different rivers and streams during the rainy and dry seasons to increase the total number of known species, and (most likely) find species new to Cuba and to science.

05 Devise an annual collection plan of hymenopterans in different areas in the Park. This will reveal the true magnitude of the Park's hymenopteran biodiversity and most likely will lead to finding many species new to Cuba and to science.

Additional inventories (continued)	**06** Conduct additional studies of the herpetofauna of the southeastern area of the Park (called "Maestrica de los Libertadores"), which is poorly known due to difficult access. **07** Monitor the presence and level of West Nile virus in populations of resident and migratory birds.
Research	**01 Investigate active and passive regeneration methods for disturbed and damaged forests.** ▪ Study the various successional stages, especially in the montane rainforest (Appendix 1), to understand and actively facilitate succession, if passive methods do not work. ▪ Study how to replace *Pinus cubensis* planted in the area. It is a major threat to *Pinus maestrensis* (because they can easily hybridize). Study how gradually to remove *Pinus caribaea* plantations from the Park, focusing first on regeneration around roads and other open areas. **02 Study the effects of introduced, exotic species on native biodiversity.** Determine which exotic species cause the most damage and then study their population biology in the Park. Using results from these studies, design management actions that address these threats. For example, understand and quantify the effects of feral dogs and cats on amphibians and reptiles in the Park to develop better control and eradication strategies. Also determine the effects of other feral or introduced animals on the survivorship of ground-nesting birds and on the health of understory vegetation. **03 Increase studies on the distribution, ecology, and phenology of threatened and endemic plant and animal species.** ▪ Research why ichneumon wasps are so abundant and diverse in the Park. ▪ Study the breeding biology and behavioral ecology of endemic birds in various sites. Factors driving high densities of some endemic species at sites we visited are unknown. **04 Study the ecological roles of migratory birds.** Carry out banding, point and transect counts, visual counts of daytime migrants, audio monitoring of nocturnal migrants, winter surveys of migrant populations, and winter survivorship studies. **05 Resolve the mysteries surrounding certain native bird species in the Park.** ▪ Observe Black-capped Petrel over the sea, close to the coast, and flying over

RECOMMENDATIONS

Research (continued)

inland territory at night to determine whether or not this species reproduces in the Sierra Maestra. Since nesting colonies for the area have not been confirmed, surveys of appropriate, potential nesting habitats are needed.

- Conduct additional studies to learn about the biology of Bicknell's Thrush. Such studies should include active "playback" techniques, area searches, and point and transect counts to determine the species distribution and abundance in the Park, especially near the highest peaks (over 1,400 m).
- Determine the requirements for secondary-cavity nesting species in the Park. Questions to consider include: What is the relationship between woodpecker abundance and other species that require secondary cavities for nesting? Is cavity availability a limiting factor for distribution and abundance of certain species in the Park? Is this why no Cuban Parrots (*Amazona leucocephala*) are found in the Park?

06 Complete vertebrate inventories and conduct population studies.

- Survey mammals in the Park while actively considering the possibility of finding the almiquí (*Solenodon cubanus*), whose last report for Sierra Maestra came from an area within the Park.
- Develop population studies of rare and threatened species, such as the frogs *Eleutherodactylus albipes*, *E. cubanus*, and *E. turquinensis*, which inhabit isolated areas or fragmented habitats.

Monitoring and surveillance

01 In general, site managers should give special attention to endemic species categorized as Critically Endangered, Endangered, and Vulnerable (see the list of Conservation Targets). Monitoring strategies for these species should be established, analyzing potential threats and estimating their distribution in the area. These actions will help to develop measures for maintaining their populations in the Park over the long term.

02 Exotic species identified as potential threats to native species should be monitored. For example, monitor cypress (*Cupressus*), "marabú" (*Dichrostachys cinerea*), and rose apple (*Syzygium jambos*) to determine if their populations are growing at an accelerated rate.

03 Aquatic insect communities have been used as water-quality indicators in various countries. The data collected during this inventory and presented in this report can serve as a baseline for monitoring water quality in the Park. Changes in water quality because of contamination or deteriorating ecosystems can be detected using these baseline data.

SITES VISITED

During the rapid inventory, the biological team concentrated survey efforts around two camps: Barrio Nuevo and El Zapato (Fig. 1B). As is noted in the individual chapters of this report, we collected data during this inventory from in and around the camps and from many locations within one day's walk from the camps. We also include data collected from additional sites during a BIOECO expedition in 2003 and from other previous visits by us or our collaborators. More information is provided in individual chapters.

Barrio Nuevo (20°01.545'N, 76°41.749'W, ca. 1,293 m altitude)

Half of the biological team worked in the area around this camp from February 1 to 10, 2004. The camp was located in montane rainforest along the dirt road running down to the southern coast. From this camp, we explored cloud forests on Pico Botella, Naranjal's evergreen forests, gallery forest along the Nigua River, and other habitats.

There are approximately 12 km between the two camps. Walking from one to the other, we passed (1) the intersection of the road running from Barrio Nuevo to San Pablo de Yao Arriba with a mule trail heading towards El Zapato at 20°03.560'N, 76°41.688'W, ca. 1,322 m altitude, (2) the abandoned town of El Manguito at 20°03.297'N, 76°41.274'W, ca. 1,205 m altitude, and (3) the intersection of the trails to El Manguito, El Zapato, and Pino del Agua Arriba at 20°03.501'N, 76°39.274'W, ca. 1,247 m altitude.

El Zapato (20°02.550'N, 76°39.657'W, 840-860 m altitude)

The other half of the biological team worked in this area from February 2 to 9, 2004. It is located in a gallery forest along the banks of Arroyo El Manguito (El Manguito Stream), at its intersection with the Nuevo Mundo River (downriver, it is called the Peladero River). From this camp, we worked in the basins of the streams Arroyo El Maguito, Arroyo Nuevo Mundo, Arroyo Hondo, and the headwaters of the Peladero River to the old barracks at Pino del Agua Arriba (20°03.890'N, 76°37.190'W, 1,276 m altitude). We also explored natural and planted pine forests, and old coffee plantations abandoned 20 years ago.

PHYSIOGRAPHIC CHARACTERISTICS

Participant/Author: Nicasio Viña Bayés

La Bayamesa National Park is located in the central part of the Sierra Maestra, approximately 36 km directly south of the city of Bayamo. It covers 241 km^2, of which 197 km^2 are located on the southern slope and only 44 km^2 on the northern slope. The highest point is Pico Bayamesa at 1,752 m.

GEOLOGY

The area's geology is characterized principally by the presence of the undifferentiated El Cobre Group, of the Paleocene-Eocene Period. The most abundant rocks include andesites and tufas, mixed with volcanic breccias (*lavas brechas*) and agglomerates of mid-acidic composition. There are granodiorite elements, some of which present hydrothermal alteration, and also small particles of porphyritic diorites.

RELIEF

Relief is defined by a tectonically rising terrain, characteristic of the Sierra Maestra, which has led to the drainage network's intense action. Rivers have excavated deep valleys that separate crests with steep slopes. Taken together, these give the territory a very complex character and create strong erosive processes. The few areas of moderate relief are confined to the Park's southern zones (Fig. 1A).

Of the Park's 241 km^2 total surface area, 178 km^2 are at altitudes greater than 800 m and 68 km^2 are at altitudes greater than 1,200 m. This is very significant, since this portion of the Park represents the largest surface area above 1,200 m in Cuba.

In addition to Pico Bayamesa, six of the highest peaks in Cuba are found within the Park: Martí (1,722 m), Maceo (1,720 m), Máximo Gómez (1,680 m), Céspedes (1,424 m), Calixto García (1,335 m), and Pico Botella (1,557 m). The first five peaks plus Bayamesa Peak are known as the "Maestrica de los Libertadores."

HYDROLOGY

The Park's northern slope forms part of the headwaters of the Bayamo River (Fig. 1B). Most of the Park's hydrological network drains into the Peladero River, whose basin covers 28% of the Park's surface. The eastern portion drains into Bayamita River, which emerges in this area on the flanks of Pico Bayamesa. The western portion drains into La Mula River, whose headwaters are located on the slopes of Pico Botella. Several rivers drain toward the south, including La Bruja, La Uvita, Las Agujas, Avispero, Uvero, and Las Bijas (Fig. 1B), all characterized by short courses and fairly small flows that become mountain torrents during heavy rainfall.

CLIMATE

The climate is fairly constant throughout, although there are some differences between the northern part of the Park and the southern border. There is only one season in the area closest to Sierra Maestra's principal ridges (where altitudes mostly exceed 1,200 m) and the portion on the northern slope, with rainy, "wintery" conditions year-round. Relative humidity is between 87 and 92% in the morning (7:00 am) and between 75 and 80% in the afternoon (1:00 pm) (Montenegro 1991). Precipitation is elevated, oscillating between 1,800 and 2,300 mm per year. The rainiest period is between April and October, with values between 1,200 and 1,400 mm (more than 170 mm per month). May, September, and October are the rainiest months. During the drier period, precipitation fluctuates between 700 and 900 mm.

At the same time, average annual evaporation is low. Most days are cloudy and cool, with more than 230 days of fog and low clouds; more than 160 days have dense fog. The months with the densest, foggiest days are October to May (15 days or more per month), while June to September have the least, with 10 days or less per month of thick fog (Montenegro 1991).

In areas below 800 m altitude on the southern slope, the difference between the rainy season and the dry season is more marked. There is less overall rainfall; annual precipitation fluctuates between 1,100 and 1,400 mm.

In the northern part, the trade winds from the northeast predominate. The strongest winds (from November to April) are also found here. In contrast, the southern portions are subject to the Föhn effect and are affected during the day by sea breezes from the southeast (Montenegro 1991). In valleys or basins where air tends to get trapped because of poor drainage, cold air descends and accumulates at night, which results in extreme minimum temperatures just before dawn. This is a common occurrence in the Peladero River Valley.

Average annual temperature varies between 16 and 20ºC. January average temperatures fluctuate between 14 and 18ºC, and July temperatures between 18 and 22ºC. In the highest altitudes, above 1,200 m, minimum average temperatures vary between 12 and 16°C, average absolute maximum temperatures are between 26 and 30ºC, and average absolute minimum temperatures are between 4 and 8ºC. Below 1,200 m, average absolute maximum temperatures range from 28 to 32ºC, and average absolute minimum temperatures range from 8 to 12ºC. Minimum temperatures drop 0.6°C for every 100 m climb in altitude on the southern slope.

SOILS

There are three types of soil in the Park (Renda et al. 1981). Soil characteristics are detailed below.

Suelo Ferralítico Lixiviado

(sensu Hernández et al. 1994)

Ferralítico Rojo Lixiviado Soil is the most extensive soil type in the territory. Generally it is found on a ferralitic weathered crust. Depth varies from shallow to very deep. The soil is poor and acidic, with very little organic material. (Ferralitico Amarillento Lixiviado soil predominates in cloud forest and cloud scrub—see Vegetation, below.)

Suelo Pardo Sin Carbonato

This soil dominates the Park's southernmost portions. Its formation is related to tufas. On average, it reaches 45 cm in depth. Surface runoff is regular and absorption is moderate. Frequently, there are gravelly portions and rocky outcroppings.

Suelo Esquelético

This "skeletal" soil type is dispersed throughout the Park. It is rocky and appears on steep slopes and in the higher altitudes of some crests. Generally, it is not more than 10 cm deep.

VEGETATION

Participants/Authors: Orlando J. Reyes and Félix Acosta Cantillo

Conservation targets: Montane rainforest and its successional stages, cloud forest, native cloud scrub formations, and native pine forests

INTRODUCTION

La Bayamesa National Park is in the central part of the Sierra Maestra Occidental (the Western Range), in the most elevated mesoblock (Hernández 1989). It has the best-conserved vegetation and is the most valuable landscape in this mountainous massif. It is also the massif's most important biodiversity refuge. Certain parts of the Park's forests were exploited for timber, mostly for *Pinus maestrensis* (Pinaceae) and other zones were cultivated. However, almost all these activities came to an end more than 35 years ago, and now various, distinct phases of vegetative development via natural succession are evident.

METHODS

In this study, we conducted direct mapping of the vegetation using 1:50,000 maps. To do so, we surveyed the area and recorded some points using a GPS (Magellan 10). We analyzed vegetation types (Reyes, in press), their structure and successional stages, and we described the characteristics and floristic composition of each stratus, as well as the humus layers.

VEGETATION TYPES

The diversity of vegetation in the Park (Figs. 2, 3) is a result of varied ecological conditions, primarily due to differences in altitude, but sometimes also because of soil conditions. The Park's different vegetation types include:

- Cloud forest
- Cloud scrub
- Montane rainforest
- Natural pine forests
- Mesophyll evergreen forest
- Gallery grassland
- Anthropogenic vegetation

Cloud forest (*bosque nublado*)

Cloud forest (sensu Samek, unpublished; Reyes, unpublished) appears around 1,500 m altitude and extends to Pico La Bayamesa (1,752 m). It generally grows over abrupt topographic formations (Fig. 3D).

Predominantly, the soil is Ferralítico Amarillento Lixiviado (Hernández et al. 1994), which is typical above 1,500 m. According to Renda et al. (1981) and Renda (1989), pH of the upper horizons is acidic to very acidic (reaching values of 4.5 to 5.3 in water). Assimable nitrogen varies between 0.80 and 11.08 mg/100 g and tends to diminish abruptly with depth. Phosphorus is absent or found only in trace amounts. Assimilable potassium fluctuates between 3.0 and 10 mg/100 g. The sum of basic cations (CCB [S]) is very low, generally between 1.44 and 5.02 mEq/100 g, and the cation exchange capacity (CCC [T]) is from 2.5 to 18.75 mEq/100 g. This demonstrates low cation saturation and the complex is cation-poor, due to the intense weathering processes. In the cloud forest's altitudinal range, average temperature fluctuates between 15.2°C (on the north slope) and 15.5°C (on the south slope) at 1,500 m, to 14°C at 1,750 m (Montenegro 1991).

The arboreal layer reaches between 10 and 15 m and has coverage of 80 to 100%. Constant and abundant species include *Cyrilla racemiflora* (Cyrillaceae), *Magnolia cubensis* subsp. *cubensis* (Magnoliaceae), *Clusia grisebachiana* (Clusiaceae), and *Alsophila major* (Cyatheaceae); additional constant species include *Ditta myricoides* (Euphorbiaceae), *Myrsine coriacea* (Myrsinaceae), *Ixora ferrea* (Rubiaceae), *Chionanthus domingensis* (Oleaceae), *Brunellia comocladifolia* (Brunelliaceae), and *Weinmannia pinnata* (Cunoniaceae). Less frequent species include *Cyathea furfuracea* (Cyatheaceae), *Clethra cubensis* (Clethraceae), *Henriettea ekmanii* (Melastomataceae), and *Ternstroemia peduncularis* (Theaceae). The shrub layer covers between 40 and 70%, and the most conspicuous species is *Graffenrieda rufescens* (Melastomataceae); other constant species include *Palicourea alpina* (Rubiaceae), *Cyathea parvula* (Cyatheaceae), *Ilex macfadyenii* (Aquifoliaceae), *Viburnum villosum* (Caprifoliaceae), *Lyonia elliptica* (Ericaceae), *Eugenia laeteviridis* (Myrtaceae), and *Purdiaea stenopetala* (Cyrillaceae). The herbaceous layer usually covers between 50 and 60%, occasionally more or less. The most frequent species include *Hedyosmum grisebachii* (Chloranthaceae) and *Lisianthius glandulosus* (Gentianaceae) (both abundant), *Scleria lithosperma* (Cyperaceae), *Zeugites americana* (Poaceae), *Ocotea spathulata* (Lauraceae), a species of *Ilex* (Aquifoliaceae), *Callicarpa ferruginea* (Verbenaceae), and the following ferns: *Odontosoria scandens* (Lindsaeaceae), *Sticherus bifidus* (Gleicheniaceae), and *Trichomanes robustum* (Hymenophyllaceae). Also observed, albeit more dispersed, are *Sapium erythrospermum* (Euphorbiaceae), *Phaius tankervilliae* (Orchidaceae), *Campyloneurum phyllitidis* (Polypodiaceae), *Peperomia tenella* (Piperaceae), and a moss of the genus *Polytrichum* (Polytrichaceae). This forest is very liana-poor (some ferns with this character are mentioned in the herbaceous layer, above), yet very rich in epiphytes: we observed *Isochilus linearis* (Orchidaceae), *Psychotria guadalupensis* (Rubiaceae), *Guzmania monostachya*, a species of *Catopsis* (Bromeliaceae), *Polybotrya osmundacea* (Dryopteridaceae), *Microgramma lycopodioides* (Polypodiaceae), *Hymenophyllum polyanthos* (Hymenophyllaceae), and a large number

of hepatics and mosses that are locally found in great abundance.

One characteristic of this forest is that the humus layers are very well defined (sensu Herrera and Rodríguez 1988). The L horizon reaches 2 cm, with some variation. The F layer varies between 1 and 2 cm, and the H layer constitutes a well-developed root mat, embedded in a humus matrix with fine roots and rootlets where this ecosystem's nutrient cycle is concentrated. Its poor and acidic soil does not play a vital role in plant nutrition (actually, the soil barely contributes), but rather it serves as the physical medium supporting plants and their thick roots.

Cloud scrub (*matorral nublado*)

This cloud scrub is located next to the summit of dual-peaked Pico Bayamesa, close to 1,700 m. It is found on the northeastern exposure, the portion most affected by trade winds. The soil is the same as that previously described for the cloud forest. The shrub layer is very dispersed, covering 30%, and reaching 2.0 to 2.5 m in height (on exception, certain individuals may reach 3 m). Species present are *Cyrilla racemiflora* (abundant), *Lyonia elliptica*, *Ilex macfadyenii*, *Vaccinium cubense* (Ericaceae), *Hedyosmum grisebachii*, *Myrsine coriacea*, *Brunellia comocladifolia*, and *Ageratina paucibracteata* (Asteraceae). In contrast, the herbaceous layer is dense (100% coverage). A compact mass of the fern *Dicranopteris flexuosa* (Gleicheniaceae) forms the layer, making walking difficult. Covering the soil is a mass of dead plant parts (same species) approximately 30 cm thick, full of rhizoids. In addition to *Dicranopteris flexuosa*, we observed *Lycopodiella cernua* (abundant, Lycopodiaceae), *Pteridium aquilinum* var. *arachnoideum* (Dennstaedtiaceae), *Scleria lithosperma*, *Lisianthius glandulosus*, and *Cyathea parvula*.

Anthropogenic cloud scrub formation (*matorral nublado antrópico*)

Anthropogenic cloud scrub is found on Pico Bayamesa, at 1,752 m. It used to be cloud forest, but it was cleared in 1962 for a "triangulation" to precisely measure the position and height of the peak. At present, it is considered in a "Fiera I" successional stage in the system put forth in Budowski (1985), Valdes-Lafont (1986), and Capote et al. (1988). Its soil, Ferralítico Amarillento Lixiviado, is severely eroded and develops on tufas and sandy tufas.

This scrub has no stratification and reaches between 2 and 3 m in height. Some zones have 100% coverage. The central area, which is visited by people, has dispersed plants. The most abundant species are *Ageratina paucibracteata*, *Cyrilla racemiflora*, *Vaccinium cubense*, *Zeugites americana*, *Coccocypselum herbaceum* (Rubiaceae), and *Lycopodium clavatum* (Lycopodiaceae). Moderately abundant species are *Pteridium aquilinum* var. *arachnoideum*, *Sticherus bifidus*, *Panicum glutinosum* (Poaceae), *Cyathea parvula*, and *Alsophila major*. Other species can also be found, such as *Lyonia elliptica*, *Purdiaea stenopetala*, *Myrica punctata* and *M. cacuminis* (Myricaceae), *Myrsine coriacea* (Myrsinaceae), *Weinmannia pinnata*, *Ilex macfadyenii*, *Brunellia comocladifolia*, *Garrya fadyena* (Garryaceae), *Clusia grisebachiana* (Clusiaceae), *Hypericum hypericoides* (Hypericaceae), *Clethra cubensis*, *Viburnum villosum*, *Hedyosmum grisebachii*, *Scleria lithosperma*, and *Blechnum lineatum* (Blechnaceae). Its poor recovery over the last 40 years demonstrates the fragility of the cloud forest and the slow speed at which the restoration process occurs.

Montane rainforest (*pluvisilva montana*)

The montane rainforest (sensu Capote and Berazain 1984; Borhidi 1996, 1998; Reyes, in press) predominates between 800 and 1,400 m and covers the most surface area within the Park (Figs. 2, 3B). At higher altitudes it is transitional with cloud forest, and in lower areas with mesophyll evergreen forest. Relief is abrupt, and 30-degree slopes are frequent. It grows on very poor and acidic Ferralíticos Rojo Lixiviado soils (Renda et al. 1980), on tufas, sandy tufas, and granitoid derivatives. Humus layers are important for this vegetation type's development. The L layer is between 1.5 and 3.0 cm thick and the F layer varies between 2.0 and 2.5 cm.

The root mat fluctuates between 6 and 13 cm, sometimes reaching 20 cm in small depressions. This mat is made up of roots and rootlets embedded in a humus matrix and its main function in this ecosystem is nutrient recycling. This explains how such a poor soil can support such exuberant vegetation. Condensation of atmospheric humidity occurs at this altitude—sufficient amounts to produce a favorable water balance—and as a result, fog and low clouds are present most days. Average temperature fluctuates between 20°C at the lowest altitudes and 16.2° C in the highest altitudes of this vegetation type (Montenegro 1991).

Its arboreal layer normally reaches 18 to 20 m, but it can also reach or has emergents that reach 25 m. Coverage varies between 90 and 100%. The most frequent species include *Magnolia cubensis* subsp. *cubensis*, *Matayba apetala* (Sapindaceae), *Chionanthus domingensis*, *Prunus occidentalis* (Rosaceae), *Ocotea leucoxylon*, *Persea anomala*, *Cinnamomum elongatum* (Lauraceae), *Ixora ferrea*, *Guatteria moralesii* (Annonaceae), *Miconia pteroclada* (Melastomataceae), and *Clusia grisebachiana*. The shrub layer normally covers between 40 and 60%, but can fluctuate either way. The most abundant species in this layer are *Meriania leucantha* var. *nana* and *Graffenrieda rufescens* (Melastomataceae), *Palicourea alpina*, and *Psychotria grandis* (Rubiaceae), and other frequent species include *Eugenia laeteviridis* and *Alsophila major*. The herbaceous layer is dense, covering between 50 and 80%. The most abundant species vary locally and include *Zeugites americana* and *Arthrostylidium multispicatum* (Poaceae), *Peperomia hernandiifolia* (Piperaceae), *Diplasium unilobum* (Dryopteridaceae), a species of *Antirhea* (Rubiaceae), *Danaea elliptica* (Marattiaceae), *Hedyosmum grisebachii*, and *Elaphoglossum chartaceum* (Lomariopsidaceae). This vegetation type is liana-poor; the most often observed liana species include *Odontosoria aculeata* and *Arthrostylidium multispicatum*. Among the epiphytes, a species of *Guzmania*, *Tillandsia fasciculata* (Bromeliaceae), *Isochilus linearis*, *Polybotrya osmundacea* (Dryopteridaceae), and various species of *Hymenophyllum* are most common; other ferns, mosses, and liverworts are also found.

Successional stages in montane rainforest (*estadios sucesionales en la pluvisilva montana*)

In areas where humans altered and later abandoned montane rainforest, vegetation is regenerating and changes in structure and floristic composition are evident. We estimate that 25% of the Park's rainforest has been altered in this way. Once rainforest is converted to pasture land or land for crops (both land uses represent the most frequent and intense conversions, and have the largest spatial magnitude), then abandoned, plant communities develop and are subsequently replaced until a new relative equilibrium is established. That is, ecological succession occurs, in which structural complexity, number of microhabitats, biodiversity, and relative stability all gradually increase. We present a more thorough discussion of La Bayamesa National Park's montane rainforest's successional stages and their relationships in Appendix 1.

Natural pine forests (*pinares naturales*)

In the Sierra Maestra, pine forests only develop naturally on areas that have suffered landslides, on soils derived from granodiorites or very gravelly soils, and along very steep and rocky ridges. These soils are very poor and incapable of supporting broadleaf species.

The most extensive pine forests are in the northeastern and southeastern portions of the Park. The pine forests of the location known as "La Francia" occupy the Park's extreme southeastern portion and its buffer zone, between 700 and 1,100 m altitude. Soils are Ferralíticos Amarillentos, sandy (sometimes even gravelly), and very poor, derived from a granodiorite block that intruded through the rocks of the El Cobre Group. Topography is generally abrupt; slopes are between 30 and 45 degrees. Because of structural conditions, it is hard to find flat areas, and large eroded trenches or ruts form close to one another, some of which are more than 1 m deep.

Its arboreal layer reaches heights of 12 to 20 m and is composed of *Pinus maestrensis*, with coverage between 50 and 70%. The shrub layer fluctuates between 10 and 60%, but mostly between 15 and 30%. Frequent species include *Ageratina paucibracteata* (abundant), *Critonia dalea* (Asteraceae), *Myrsine coriacea*, *Cyathea parvula*, *Myrica cerifera* (Myricaceae), *Viburnum villosum*, *Clusia tetrastigma*, *Ilex macfadyenii*, and *Cytharexylum caudatum* (Verbenaceae). Less common species present are *Cyrilla racemiflora*, *Garrya fadyena*, and *Tabebuia brooksiana* (Bignoniaceae), among others. The herbaceous layer is usually made up of thick mats of *Dicranopteris flexuosa*. Other constant species are *Scleria lithosperma*, *Callicarpa ferruginea*, a species of *Eupatorium* s.l. (Asteraceae), *Panicum glutinosum*, and in isolated patches *Gesneria viridiflora* var. *obovata* (Gesneriaceae), a *Panicum* species (Poaceae), *Psilochilus macrophyllus* (Orchidaceae), *Pteridium aquilinum* var. *caudatum*, *Clethra cubensis*, and *Agave underwoodii* (Agavaceae). Occasionally, *Coccocypselum herbaceum*, *Trema lamarckiana* (Ulmaceae), *Clusia rosea* (Clusiaceae), *Panicum pilosum* (Poaceae), *Guettarda valenzuelana* (Rubiaceae), *Myrica cacuminis*, *Begonia cubensis* (Begoniaceae), a species of *Blechnum* (Blechnaceae), *Psychotria brevistipula* (Rubiaceae), *Andropogon bicornis* (Poaceae), and a species of *Vernonia* (Asteraceae) are also found. Frequently observed lianas include *Odontosoria aculeata*, *Mikania alba* (Asteraceae), and *Cynanchum ephedroides* (Asclepiadaceae). Occasional species include *Cissampelos pareira* (Menispermaceae), *Vanilla bicolor* (Orchidaceae), *Stigmaphyllon sagreanum* (Malpighiaceae), and *Cissus verticillata* (Vitaceae). Constant epiphytes are *Catopsis floribunda* and *Tillandsia fasciculata*; and sometimes *T. valenzuelana*, *T. balbisiana*, and *Hohenbergia penduliflora* (Bromeliaceae) are present.

Pine forest successional stages
(estadios sucesionales en los pinares)

Succession in these pine forests is different from that of the montane rainforest. When there is a landslide, which is common in Sierra Maestra, the soil takes all the vegetation with it. Only the exposed crust and altered rocks remain—an open area where only pioneer and heliophilous plants can develop. The pine is found among these pioneers. The first closed canopy stage is made up of *Pinus maestrensis*, which continues to grow (about one meter per year), and is not replaced by broadleaf species at this stage. Competition from broadleaf species is restricted to the layers below the pine canopy. As pine groves form, their roots and fallen needles begin to improve soil conditions. In advanced successional stages, however, rainforest species begin to close the arboreal layer, preventing pine germination. In the end, only isolated pine trees are observed. Those too eventually disappear, leaving a closed canopy broadleaf forest with characteristic climatic conditions. Succession in pine forest areas also is discussed in greater detail in Appendix 1.

Mesophyll evergreen forests
(*bosques siempreverdes mesófilos*)

Mesophyll evergreen (mesophytic) forests occupy the submontane zone of the Park, between the mesophyll semideciduous forest and montane rainforest. León (1946) called these evergreen forests "manacales" and Samek (1974) called them "canelones." They grow on soils derived from rocks of the El Cobre Group (mostly andesites), which are principally Pardos Sialíticos, reasonably moist, and shallow to very shallow, at times with rocks on the surface. The climate is relatively cool. Average annual temperature fluctuates between 22 and 23°C in the lower altitudes, and approximately 20°C in the higher altitudes. Rainfall is approximately 1,200 mm per year (Montenegro 1991). The L leaf litter horizon is well developed and is between 2 and 3 cm thick. The F humus horizon is approximately 1 cm, and there is no H horizon. In very small depressions, humus accumulates with roots and rootlets.

Three layers are distinguishable. The arboreal layer reaches heights between 16 and 25 m and coverage is 100%. It is very rich in species. Constant and abundant species are *Guarea guidonia* (Meliaceae), *Cinnamomum elongatum*, *Dendropanax arboreus* (Araliaceae), *Pseudolmedia spuria* (Moraceae), and *Ocotea leucoxylon*. Other constant species include *Ocotea globosa*

(Lauraceae), *Zanthoxylum martinicense* (Rutaceae), *Cupania americana* (Sapindaceae), *Chrysophyllum oliviforme* (Sapotaceae), *Trophis racemosa* (Moraceae), *Prunus occidentalis* and *P. myrtifolia* (Rosaceae), *Chionanthus domingensis*, *Beilschmiedia pendula* (Lauraceae), *Roystonea regia* (Arecaceae), *Sapium jamaicense* (Euphorbiaceae), and *Talauma orbiculata* (Magnoliaceae). Locally, *Drypetes alba* (Euphorbiaceae) is abundant, and many other species are scattered. The shrub layer covers between 20 and 30% and is made up of mostly arboreal species, including *Clusia rosea* and *Wallenia laurifolia* (Myrsinaceae), among others. The herbaceous layer has 30% coverage, and constant species include *Blechnum occidentale* (abundant), *Campyloneurum phyllitidis*, *Oplismenus setarius* (Poaceae), *Oeceoclades maculata*, *Lophiaris* (*Oncidium*) *lurida* (Orchidaceae), a species of *Hyperbaena* (Menispermaceae), *Psychotria uliginosa* and another species of *Psychotria* (Rubiaceae), *Pavonia spinifex* (Malvaceae), *Elephantopus scaber* (Asteraceae), and *Lithachne pauciflora* (Poaceae). Among the lianas, *Vitis tiliaefolia* (Vitaceae), *Pisonia aculeata* (Nyctaginaceae), *Gouania lupuloides* (Rhamnaceae), and *Lygodium volubile* (Schizaeaceae) are constant, but *Trichostigma octandrum* (Phytolacaceae), *Davilla rugosa* (or *D. nitida*?, Dilleniaceae), and *Smilax havanensis* (Smilacaceae) are also frequently observed. *Hippocratea volubilis* (Hippocrataceae), *Cissampelos pareira* (Menispermaceae), and *Passiflora sexflora* (Passifloraceae) are occasionally found. In general, this forest type has very few epiphytes. The most commonly observed species include *Lophiaris* (*Oncidium*) *lurida* and *Campyloneurum phyllitidis*.

Gallery grassland (*herbazal de galería*)

This low, gallery grassland, with isolated sub-shrubs and shrubs, is found in flooded riparian terraces along mountainous rivers of the montane rainforests. In the upper part of the western branch of the La Plata River and the Nuevo Mundo River, typical grasslands form. The only layer is the herbaceous layer, and it has two clearly distinguishable sublayers. The upper sublayer reaches 80 to 100 cm in height with dispersed plants and has between 5 and 10% coverage. The lower sublayer reaches 20 to 30 cm, and unlike the upper layer, it is extremely dense, with 100% coverage of *Cyperus lanceolatus* var. *compositus* (Cyperaceae), on which one can walk. Other dispersed and constant species in this sublayer are *Nephrolepis biserrata*, *Phaius tankervilliae*, *Hypericum hypericoides*, and *Asclepias nivea* (Asclepiadaceae). In both sublayers, *Cyrilla racemiflora*, *Cyathea parvula*, *Andropogon bicornis*, *Piper aduncum* (Piperaceae), *Clidemia umbellata* (Melastomataceae), and *Urena lobata* (Malvaceae) can be found. Locally, *Myrsine coriacea*, *Sticherus bifidus*, *Tibouchina longifolia* (Melastomataceae), *Lycopodium clavatum*, *Stachytarpheta cayennensis* (Verbenaceae), *Miconia dodecandra* (Melastomataceae), *Palicourea alpina*, *Solanum torvum* (Solanaceae), *Begonia cubensis*, *Plantago major* (Plantaginaceae), and *Spermacoce laevis* (Rubiaceae) are also observed.

In areas with human disturbance and intermittent flooding from the Nuevo Mundo, Manguito, and Peladero Rivers, the grasslands are covered with *Cyperus lanceolatus* var. *compositus*, as in the typical formation, but the composition of accompanying vegetation is different. Here, constant species include *Cuphea hyssopifolia* (Lythraceae), *Sporobolus indicus* (Poaceae), *Hypericum nitidum* (Hypericaceae), *Ludwigia octovalvis* (Onagraceae), *Sida rhombifolia* (Malvaceae), and *Pennisetum purpureum* (Poaceae). Occasionally present are *Arundo donax* (Poaceae), *Psidium guajava* (Myrtaceae), and *Emilia sonchifolia* (Asteraceae).

Anthropogenic vegetation (*vegetación antrópica*)

There are several types of anthropogenic vegetation (Fig. 2). There are secondary grasslands found in significant portions of the Park (mostly in the northern, western, and southwestern parts). These areas were (or are) pastures of *Panicum maximum* (Poaceae) and/or another species of *Panicum* at the early stages the successional process (or "syngenetic evolution"). There

are also approximately 35-year-old pine plantations (*Pinus caribaea*, *P. cubensis,* and *P. maestrensis*) in advanced successional stages (Fiera II). And, in the area called El Zapato (in the central part of the Park) and in the La Mula River Basin, remains of coffee plantations exist.

THREATS

- Exotic plants, including eucalyptus (*Eucalyptus* spp.), cypress (*Cupressus* spp.), and others planted in El Manguito, Barrio Nuevo, and other places, may threaten native vegetation.
- Plantations of *Pinus cubensis* and *P. caribaea*, which are not indigenous to the Park, can naturally reproduce in the area. *Pinus cubensis* hybridizes easily with *P. maestrensis*.
- Natural habitats have been lost in large areas altered by humans in the La Mula, Guayabo, La Plata, and La Bruja River Basins (Fig. 2).
- Long, eroded ruts along roads, caused by water flowing for long distances, lose significant amount of soil due to erosion.
- Rigorous conservation measures are absent in the cloud forests, cloud scrub, and natural pine forests, which are locally and regionally endemic plant communities.

RECOMMENDATIONS

Protection and management

- Eliminate eucalyptus, cypress, "marabú" (*Dichrostachys cinerea*), rose apple, and other exotic plants.
- Reforest areas around Pata de la Mesa using native species appropriate for the altitude.
- Develop "sustainable development" areas in La Bruja and Marverde (disturbed and populated areas). That is, promote development that is compatible with the conservation of native species and communities of indigenous plants and animals.
- Implement erosion control actions along the ruts and control water flow along roads and other areas where it causes damage.
- Restrict access (permitting scientific access only) to Pico Botella, Pico Maceo, La Bayamesa's second peak, and the pine forests at María Tomasa (Colón) and La Francia, and other areas where endemic, rare, and/or threatened species or communities are concentrated.

Research

Study the various successional stages, especially in the montane rainforest (see Appendix 1), in order to better understand and actively facilitate that process if passive methods do not work.

LIVERWORTS AND HORNWORTS

Author: Kesia Mustelier Martínez

Conservation targets: Endemic and threatened liverworts (*Nowellia wrightii, Radula pocsii*); threatened liverworts (*Anastrophyllum donianum, A. gradsteinii, A. piligerum, Crossotolejeunea prionocalyx, Frullania josephina, Jubula pensilvanica, Lepidolejeunea spongia, Leptoscyphus amphibolius, Plagiochila adiantoides, Radula evansii*); and endemic liverworts (*Aphanolejeunea evansii, Radula cubensis* and *R. wrightii*, and *Riccardia reyesiana*)

INTRODUCTION

Sierra Maestra's massif has been visited over the years by various Cuban and foreign botanists. To date, 383 liverworts and hornworts are recorded for the area, representing 77% of those present in Cuba (Mustelier 2001). Despite this impressive number of identified species, each collection trip results in new finds, demonstrating that research on this group is far from complete.

Sierra del Turquino, in which La Bayamesa National Park is located (at the second elevation block), is one of the most important areas of this massif because of its species richness and endemism. Throughout the Park, hepatics abound in several different forested ecosystem types.

RESULTS

After reviewing the Herbarium at the Centro Oriental de Ecosistemas y Biodiversidad (BSC)—whose Bryophyte Section includes 740 plant samples collected from La Bayamesa National Park—and conducting a corresponding literature review, I developed a list for the Park, which includes 172 species belonging to 63 genera and 19 families (Appendix 2). This figure represents a significant percentage of the entire liverwort flora recorded for the country and for the Sierra Maestra.

The family with the most diversity and abundance is Lejeuneaceae (as is the case throughout the Neotropics), representing 32% of the samples collected in the Park and 40% of all species present. The Metzgeriaceae and Geocalycaceae follow it in abundance, and Jubulaceae, Radulaceae, and Lepidoziaceae in diversity.

In the Park, there are six endemic species (*Aphanolejeunea evansii*, *Nowellia wrightii*, *Radula cubensis*, *R. pocsii*, *R. wrightii*, and *Riccardia reyesiana*), which represent 26% of liverwort endemism in Cuba and 46% of the endemism of the Sierra Maestra.

Liverworts are most abundant in humid forests, mostly in the rainforests, which have the highest species richness and endemism. The most abundant species include *Drepanolejeunea orthophylla* and *Diplasiolejeunea brunnea* (among the epiphytes); *Lophocolea bidentata*, *Marchesinia brachiata*, and *Metzgeria elliottii* (on tree trunks); species of *Micropterigium* and *Trichocolea* (growing on fallen, decomposing trunks); and *Monoclea gottschei* and the species of *Symphyogyna* (growing on soil and rocks).

Following the methodology described in Hallingbäck et al. (1996), there are 12 threatened species in the Park: 8 Endangered (*Anastrophyllum donianum*, *A. gradsteinii*, *A. piligerum*, *Crossotolejeunea prionocalyx*, *Jubula pensilvanica*, *Nowellia wrightii*, *Plagiochila adiantoides*, and *Radula evansii*); and 4 Vulnerable (*Frullania josephinae*, *Leptoscyphus amphibolius*, *Lepidolejeunea spongia*, and *Radula pocsii*).

THREATS

Forest destruction is by far the biggest threat to the Park's liverworts, since hepatics living in the understory or as epiphytes on certain forest species are also lost owing to habitat deterioration and fragmentation.

RECOMMENDATIONS

Protection and management

Protect rainforests, evergreen forests, and gallery forest with little or no human disturbance. The quantity and variety of the hepatics diminish notably in disturbed environments, and it is very probable that many species can only survive in primary forests (Richards 1984).

Research

Systematic and taxonomic studies are needed in order to update the list of taxa present in the Park as well as population studies for this plant group, which have not been properly inventoried.

Additional inventories

Collect during different periods of the year for phenological and taxonomic studies.

MOSSES

Authors: Ángel Motito Marín and María Elena Potrony Hechavarría

Conservation targets: 22 threatened species

INTRODUCTION

Cuban mosses are typically montane. Notable expeditions have been conducted in La Bayamesa National Park because of the biotic and abiotic characteristics known in several different locations. These characteristics form ideal ecological conditions for growth and exceptional diversity of mosses because of their autecology and their relationships with other plants in the forest. High moss diversity—both quantitatively and qualitatively—is present in cloud forests, for example (López et al. 1994), because of this forest type's optimum

conditions, including light levels, humidity, and the presence of all substrate types, even uncommon ones such as epiphytic and lignicolous (woody) substrates.

Another thing to keep in mind is that the Sierra Maestra is a crossroads of principal floristic migration and exchange routes, and a refuge of long-emergent land (Reyes et al. 1991).

Of all the moss collections conducted in Sierra Maestra, 30.3% have been from the Park. The most notable collections began in 1941 when J. Acuña and C. V. Morton visited the area (between Turquino and La Bayamesa). During the beginning of the 1950s, Morton intensified explorations. And, in 1987, A. Motito conducted the first moss inventory for La Bayamesa and visited several locations.

Principal locations visited include Pino del Agua, Nuevo Mundo, Pico Bayamesa, Pico Botella, María Tomasa, Pico Martí, and Pico Maceo.

METHODS

We obtained data for this inventory in two ways. First, we reviewed the samples collected from the zone and deposited in the Bryophytes Section of the Herbarium in Santiago de Cuba (BSC). Second, we collected from the Park along roadsides and roadbanks, creek edges and banks, and from the forest interior, keeping microhabitat preferences in mind at all times. The process was uncomplicated and followed conventional methods.

We followed the taxonomy of Gradstein et al. (2001), and the updates found in Buck (1998) and Zander (1993), for the pleurocarpic mosses and representatives of the Pottiaceae family, respectively. To identify samples, we used three moss keys: Churchill and Linares (1995), Duarte (1997), and Gradstein et al. (2001).

To determine threatened species, we followed the general considerations published in the Conservation Assessment and Management Plan for Select Cuban Plants Species (CAMP 1998) and IUCN methodology, modified by Hallingbäck et al. (1996, 1998).

Table 1. Moss taxa present in La Bayamesa National Park, Sierra Maestra, and Cuba

	Families	Genera	Infrageneric taxa
La Bayamesa National Park	32	78	142
Sierra Maestra	48	145	330
Cuba	49	164	410

RESULTS

Richness and endemism

There are 142 infrageneric moss taxa in La Bayamesa National Park belonging to 78 genera and 32 families (Appendix 3 and Fig. 4A). In Table 1, we compare the number of taxa present in the Park with the number present in the Sierra Maestra and Cuba.

In the Park, the families with largest number of species include Dicranaceae (with 20), Pilotrichaceae (16), Sematophyllaceae (11), and Fissidentaceae (10). All of these families have extensive global distributions. Genera most often represented, according to total numbers of infrageneric taxa, include *Fissidens* (with 10 species), *Campylopus* (7), and *Leucobryum, Macromitrium*, and *Syrrhopodon* (with 6 species each). There are two endemic infrageneric taxa: *Dicranella hioramii* var. *hioramii* and *Syrrhopodon elongatus* var. *elongatus*.

Threatened species

There are 22 threatened infrageneric taxa in the Park: 2 are Critically Endangered, 13 are Endangered, and 7 are Vulnerable (Appendix 3). Each species occupies extensions less than 10 km^2 in the Park. The IUCN Criteria are those published in Hallingbäck et al. (1996, 1998). Our analysis of the Park's threatened species follows.

Critically Endangered species

Each of these two species occupies less than 100 km^2 worldwide.

Eurhynchium clinocarpum (Brachytheciaceae): This species was collected only once, from Loma Subida Albear, close to Pico Bayamesa; it grows on moist rocks

in rainforest vegetation between 1,300 and 1,400 m; Criteria B1a and 2a.

Hookeriopsis luteo-rufescens (Pilotrichaceae): Reported by Welch (1969) for Lomas de Oro, La Bayamesa, at 1,725 m; it has not been collected since; Criteria B1a and 2a.

Endangered species

Except for *Thamniopsis undata*, each of these species occupies an area between 101 and 5,000 km^2 worldwide.

Aongstroemia jamaicensis (Dicranaceae): Collections were obtained on Pico Bayamesa and the highest altitudes in Sierra Maestra; it grows on moist soil and is typical of rainforests and cloud forests between 1,000 and 1,500 m; Criterion B1a.

Breutelia jamaicensis (Batramiaceae): Collected in Nuevo Mundo, Pino del Agua, and between Pico 1555 and Arroyo 26; it grows on leaf litter and humid soil along road and creek banks, in rainforest vegetation between 1,000 and 1,450 m; Criteria B1a and 2a.

Breutelia scoparia (Batramiaceae): Collected from Pico Bayamesa and between Pico 1555 and Arroyo 26; it grows profusely over decomposing organic material, mostly on leaf litter and along roadsides, in rainforests and cloud forests between 1,400 and 1,750 m; Criteria B1a and 2a.

Cyclodictyon subtortifolium (Pilotrichaceae): This species was collected from Loma Subida Albear, near Pico Bayamesa; it grows on moist rocks in rainforests between 1,300 and 1,400 m; Criteria B1a and 2a.

Daltonia longifolia (Daltoniaceae): Collected from Loma Subida Albear, close to Pico Bayamesa; it is an epiphyte growing on the trunks and branches of trees and shrubs in rainforests between 1,300 and 1,400 m; Criteria B1a and 2a.

Ditrichum rufescens (Ditrichaceae): Collected along the road to Pico Bayamesa, growing on moist soil along trail banks and edges in slightly exposed areas in rainforests between 1,300 and 1,500 m; Criteria B1a and 2a.

Fissidens inaequalis (Fissidentaceae): Collected from Pico Bayamesa, growing on moist soil in shady and protected places in rainforests between 1,200 and 1,300 m; Criteria B1a and 2a.

Leskeodon cubensis (Daltoniaceae): This plant was collected at Subida Albear, close to Pico Bayamesa; it grows on humid rocks in rainforests between 1,300 and 1,400 m; Criteria B1a, b and 2a, b.

Leucoloma mariei (Dicranaceae): This species was collected along the route to Pico Bayamesa; it grows as an epiphyte on the base of tree and shrub trunks in rainforests between 1,300 and 1,500 m; Criteria B1a and 2a.

Leucoloma schwaneckeanum (Dicranaceae): Collected at the summit of Pico Bayamesa; it grows as an epiphyte on tree trunks (on old and rough trunks), in cloud forest between 1,700 and 1,750 m; Criteria B1a, b and 2a, b.

Pohlia papillosa (Bryaceae): This species was collected on the route to Pico Bayamesa; it can grow on humid soil and rocks along roadsides and roadbanks, in protected rainforest sites between 1,300 and 1,500 m; Criteria B1a and 2a.

Thamniopsis undata (Pilotrichaceae): Global range is less than 100 km^2. Welch (1969) recorded this species, and it was collected by Ekman at Pico Bayamesa at 1,600 m; Criteria B1a and 2a.

Thamnobryum fasciculatum (Neckeraceae): Collected on Loma Subida Albear, close to Pico Bayamesa; it can grow on moist rocks along roadsides and roadbanks in protected sites within rainforests between 1,300 and 1,500 m; Criteria B1a and 2a.

Vulnerable species

Each Vulnerable species occupies an area between 101 and 5,000 km^2 worldwide.

Aptychella proligera (Sematophyllaceae): Collected along the road between La Bayamesa and El Nueve, growing on the soil on the roadsides and roadbanks, in rainforests between 1,372 and 1,400 m; Criteria B1a, b.

Atrichum androgynum (Polytrichaceae): This species was collected in Pino del Agua, Pico Bayamesa, El Nueve, and Loma El Rajao; it grows on decomposing organic material, especially leaf litter, and on soil along roadsides and exposed banks (with a certain level of human disturbance) in rainforests between 800 and 1,450 m; Criteria B1a, b.

Atrichum angustatum (Polytrichaceae): Collected at Pinalón, Nuevo Mundo, and Pico Bayamesa; it prefers slightly acidic soils, and it grows on soil along the roadsides and roadbanks, in disturbed sites, and occasionally between pine needles; the plants are most abundant in rainforests between 900 and 1,372 m; Criteria B1a, b.

Macromitrium harrisii (Macromitriaceae): Collected on Loma Subida Albear, close to Pico Bayamesa; it grows on tree and shrub trunks and it can grow up to 2 m above ground; in rainforests between 1,300 and 1,400 m; Criteria B1a and 2a.

Macromitrium microstomum (Macromitriaceae): Collected on Loma Subida Albear, close to Pico Bayamesa, and along the road to Pico Bayamesa; it can grow on moist rocks found along the roadsides and banks and on tree and shrub trunks; it can grow up to 2 m above the ground; it grows in rainforests between 1,300 and 1,500 m; Criteria B1a and 2a.

Philonotis uncinata (Bartramiaceae): This species has been collected on Loma Subida Albear, close to Pico Bayamesa, and along the road to Pico Bayamesa; it can grow on soil and moist rocks on roadsides and banks in protected sites within rainforests between 1,300 and 1,500 m; Criteria B1a, b and 2a, b.

Porotrichum mutabile (Neckeraceae): Collected on Loma Subida Albear, close to Pico Bayamesa; it grows on the bases of tree and shrub trunks in rainforest vegetation types between 1,300 and 1,500 m; Criteria B1a and 2a.

THREATS

Moss infrageneric taxa recorded in the Park depend on complex ecosystem relationships for survival. Habitat loss and fragmentation caused by timber harvest represent the biggest threats to the mosses. Mosses can also be affected by droughts, hurricanes, and fires.

RECOMMENDATIONS

Protection and management

The two vegetation types with the most moss diversity and the highest number of threatened species are the rainforests and cloud forests. In order to conserve threatened species, we recommend caring for, protecting, and properly managing these forest types and the phanerogamous flora growing within these ecosystems.

Research

- Increase the number of studies of the distribution, ecology, and phenology of threatened and endemic moss species.
- Research the taxonomy of certain groups, especially those groups that have received very little scientific attention thus far and for which such research has the potential to increase the number of known taxa, including species not before reported and even species new to science.

Additional inventories

Continue bryological inventories in other location during the rainy and dry seasons. Future inventories should focus on finding species that are known only from bibliographic references, including *Hookeriopsis luteo-rufescens* and *Thamniopsis undata*. Study of *Eurhynchium clinocarpum* should continue because it was reported for the first time in this inventory and its population status is unknown.

FERNS AND FERN RELATIVES
(Pteridophyta)

Participants/Authors: Manuel G. Caluff and Gustavo Shelton

Conservation targets: Cloud forests, montane rainforests, gallery forests, and regenerating secondary evergreen forests; tree ferns and other threatened species; and endemic species

METHODS

To carry out this inventory, we worked out of two camps. One was located in Barrio Nuevo, at 1,300 m in montane rainforest. From there we were able to access the cloud forest at Pico Botella (1,567 m), evergreen forests at Naranjal (800 m), and gallery forests (along La Nigua River). The other camp was located at El Zapato (860 m), in a gallery forest along Arroyo El Manguito (approximately 12 km from the other camp). From that camp we worked in the basins of Arroyo El Manguito, Arroyo Nuevo Mundo, Arroyo Hondo, and the headwaters of Peladero River, as well as in natural and plantation pines and in coffee plantations abandoned 20 years ago.

From these camps, we used existing trails and old mountain roads to reach different vegetation types present in the area. We identified species in the field. The most interesting and unknown species were collected for identification and will be incorporated in the Pteridophyta Section at the Herbarium of The Centro Oriental de Ecosistemas y Biodiversidad (BSC), found in the Fern Garden (*Jardín de los Helechos*). We took digital photographs of most species.

We also include results of previous visits to different sections of the Park and data gathered from the collections at the national herbariums HAC and HAJB.

RESULTS

Pteridoflora analysis

We registered 346 species belonging to 74 genera and 25 families in La Bayamesa National Park (Appendix 4 and Fig. 4B), which represent 53% of Cuba's 650 (estimated) fern species (Caluff et al. 1994).

Endemism

There are 21 endemic and 4 possibly endemic species (under study). The endemic species represent 7.2% of the total number of the Park's ferns, which is low compared to Cuba's overall endemism rate, estimated at 12% (Caluff et al. 1994).

Of these endemics, 3 are known only from the Park (*Diplazium* sp., *Pityrogramma* sp., and *Nephrolepis multiflora* f. nov.), an additional 7 are endemic to Sierra Maestra (*Alsophila* x *boytelii*, *Asplenium erosum* x *A. serra*, *Arachniodes formosa*, *Arachniodes* sp., *Elaphoglossum* sp. 1, *Hymenophyllum turquinense*, and *Sticherus* x *leonis*), 12 are endemic to eastern Cuba, and the rest have larger distributions within Cuba. Eight of these endemic species are also threatened.

Threatened species

We recorded 44 threatened species in total, 19 already categorized as such and 25 species that are candidates for listing (Sánchez and Caluff 1997). Of the threatened species, 10 are found in Cuba only in the study area (*Asplenium alatum* and *A. rhomboidale*, *Blechnum gracile* and *B. polypodioides, Diplazium* sp., *Lomagramma guianense, Nephrolepis multiflora* f. nov., *Pityrogramma* sp., and *Thelypteris cheilanthoides* and *T. linkiana*). The majority of these species are known from less than three collections.

Naturalized species

In the Park, we located three naturalized, highly invasive species. *Nephrolepis multiflora* is found in all locations, situations, ecosystems, and sampled sites. *Macrothelypteris torresiana* and *Thelypteris dentata* are occasional, but where they are found they have dense populations like *N. multiflora*. All of these are Asian species that have escaped cultivation, originally introduced to America as ornamentals. We believe that airborne spores from the southern United States were blown to Cuba and then became established. The presence or absence of these species is an indication of ecosystem health, since they do not proliferate in pristine ecosystems.

Uses

Regional use of the pteridoflora is very poor. Ferns in general are called "Penquitas" and very few have specific common names. People call some invasive species "Cucaracha" (cockroach in English), especially the invasives species of *Pteridium* and *Adiantum*. The fern tree *Cyathea arborea* is called "Camarón" (shrimp).

They use several species medicinally: "Doradilla," *Polypodium polypodioides* (to treat liver disease), "Polipol," *Phlebodium aureum* (used as an anti-inflammatory and to treat hypertension), and "Culantrillo de Pozo," *Adiantum tenerum* (as a cold medicine and to dissolve kidney stones).

Ten species are considered weeds because of their proliferation, especially in disturbed ecosystems. The most invasive species are *Nephrolepis multiflora, Cyathea parvula, Blechnum lineatum*, and the species of Gleicheniaceae.

Regional use of ferns as ornamentals is practically nonexistent. We detected only one horticultural variety in cultivation, *Nephrolepis exaltata*, called "Aliento de Angel."

Abundance

Of the Park's recorded species, we could not relocate 49 species, and we saw or collected 87 species fewer than three times. As a result, these 136 species (39% of the total) are considered less frequent. Some species, such as *Botrychium jenmanii, Adiantum lunulatum*, and *Lomagramma guianense,* have not been collected in many years. Of the remaining species, we consider that 126 are sporadic, 56 are frequent, and only 27 are common.

Analysis by vegetation type

Cloud forest

Cloud forest pteridoflora is characterized by low endemism and a large number of species found only here, especially small epiphytes. These reach even the forest floor, which itself is covered by a thick layer of humus and bryophytes. *Hymenophyllum axillare* and *Trichomanes robustum* carpet the cloud forest floor. Some terrestrial species of the cloud forest include *Arachniodes denticulata* and *Paesia glandulosa.* Well-represented groups at the summit of Pico Botella are, for example, *Elaphoglossum* (9 species), *Grammitis* s.l. (11), and Hymenophyllaceae (12).

Montane rainforest

The pteridoflora of this forest type is composed of a group of dominant, very frequent species, and others less frequent, including some threatened and endemic species. Epiphytism is not noteworthy, and many epiphytes grow close to the ground. Well-represented groups include Cyatheaceae, such as *Alsophila balanocarpa* and *A. cubensis*, *Diplazium* (especially *D. unilobum* and *D. striatum*), and several species of *Thelypteris* (especially *T. deltoidea*).

Gallery forest

Most of the Park's pteridoflora is found in gallery forests. Some elements of the cloud forest and montane rainforest seem to appear at lower altitudes in this vegetation type. Several families abound, including Selaginellaceae, Lycopodiaceae, Vittariaceae, Thelypteridaceae, and many Polypodiaceae s. str. Epiphytism is common and epiphytes are found growing several meters up in the trees. Many species inhabit the banks and rocky outcroppings along the watercourses. A gradual species substitution is seen as the gallery forest transitions from montane rainforest to evergreen forest. Pteridological composition in this vegetation type varies with illumination, in which heliophytes and some rheophytes* dominate in sunny areas, such as *Selaginella heterodonta*, *S. serpens*, *Thelypteris sancta*, *T. resinifera*, and *T. angustifolia*.

Evergreen forest

In the study area, vegetation of this type is mostly secondary because its fertile soils were converted to agriculture years ago. The pteridoflora is poor and for the most part is made up of common and naturalized species.

* Rheophytes are plants that live at the interface of land and water, usually on rocks, and are frequently covered by water or are constantly splashed or sprayed by water.

Species of the following genera are abundant: *Adiantum*, *Asplenium*, *Bolbitis*, *Campyloneurum*, *Dennstaedtia*, and *Thelypteris* subgenera *Goniopteris* and *Cyclosorus*.

Pine forest

Pine forests are not suitable habitat for most ferns, and only a few species survive in this vegetation type. One local endemic species, *Pityrogramma* sp., is found in the pines at María Tomasa. Another endemic species, *Odontosoria wrightiana*, and the threatened *Cyathea microdonta* are known in eastern Cuba only from the Park's pine forests. On this expedition, we recorded epiphytic ferns in pine forests for the first time in Cuba. The species observed were *Nephrolepis pectinata, Polypodium squamatum*, and *Pleopeltis macrocarpa*.

Secondary vegetation

Most secondary vegetation is found along roads and in areas opened up by anthropogenic intervention. Secondary vegetation growing in the old coffee plantations that were abandoned approximately 20 years ago is called "segetal vegetation" and is discussed in the next section.

The most invasive heliophytes are found in secondary vegetation types. Above 800 m altitude, some emergents stand out, including *Cyathea armata, C. parvula, Alsophila balanocarpa*, and *A. cubensis*. In their shade, species of *Thelypteris*, such as *T. rudis, T. malangae*, and *T. resinifera,* proliferate. Species of Gleicheniaceae colonize wide-open areas, especially *Pteridiun aquilinum* var. *arachnoideum* and *Lycopodiella cernua*. *Lycopodium clavatum* colonizes the surface of the ground and *Huperzia reflexa* colonizes sunny banks. Some uncommon species occasionally seen in this vegetation type are *Alsophila major, Blechnum polypodioides, Lycopodiella curvata, Marattia alata*, and *Thelypteris pteroidea*. Below 800 m, dominant species include *Blechnum occidentale*, *Cyathea arborea, Lycopodiella cernua*, and *Nephrolepis multiflora*.

"Segetal" vegetation of fields and croplands

This vegetation type is composed mostly of very common species. Synantropic species abound and many naturalized species are present. Many abandoned coffee plantations show high regeneration rates as proven by the presence of some montane rainforest species and evergreen forest species like *Polybotrya osmundaceae*, *Didymochlaena truncatula, Ophioglossum palmatum*, and many tree ferns already several meters in height.

"Ruderal" vegetation of roadsides and open, disturbed ground

There are very few human settlements in the zone. In areas abandoned by the original inhabitants and now used as the Park's administrative centers, ruderal vegetation proliferates—mostly synantropic species and many naturalized species. Common species include *Macrothelypteris torresiana, Nephrolepis multiflora, Thelypteris dentata*, and *T. kunthii*.

In 1997, in Barrio Nuevo, a herbarium sample was collected of a feathery and ornamental natural mutation of *Nephrolepis multiflora*. In fact, one of our objectives during this inventory trip was to locate these plants and take several individuals to the Fern Garden in Santiago de Cuba, but we did not successfully locate them. The original specimen is in the Herbarium of Cuba's National Botanical Garden (HAJB).

Notable finds

- Two possibly new species: *Pityrogramma* sp., in the pines at La Francia and María Tomasa, and *Pteris* sp., in the evergreen forest at El Naranjal.
- Two new records for Cuba: *Ophioglossum harrissii,* collected at Pino del Agua, and *Danaea urbanii*, collected around Barrio Nuevo and from Pico Bayamesa.
- A new record for eastern Cuba: *Alsophila* x *medinae*, collected along El Manguito River. Previously, it was known to exist only in central Cuba.
- Six new records for the Park: *Asplenium pteropus*, *Huperzia acerosa*, *H. serrata, Pityrogramma trifoliata*, *Thelypteris hispidula*, and *T. pteroidea*.
- Ten unknown species, in the process of being identified.

THREATS

The rarest species and those with the smallest ranges are found in the most sensitive areas above 1,400 m, especially in cloud forests. This vegetation type occupies a very small surface area, and its species are vulnerable to overcollection and excessive human presence. This is why the Park's current management projects aimed at creating access facilities to these areas represent a threat.

RECOMMENDATIONS

Protection and management

For the especially vulnerable cloud-forest ecosystem, we propose strictly limited and controlled access by small groups only, and strict controls on human activities, including excessive botanic and zoological collections.

For pteridoflora conservation in the Park in general, we propose letting nature take its course and give the ecosystems time to regenerate.

Additional inventories

The pteridoflora has been carefully studied in very few zones within the Park, and the understudied zones should receive attention, especially La Sierra (La Maestrica) de los Libertadores.

SEED PLANTS
(Spermatophyta)

Participants/Authors: Eddy Martínez Quesada, William S. Alverson, Robin B. Foster, and Corine Vriesendorp, with collaborators María del C. Fagilde Espinosa, Ramona Oviedo Prieto, Orlando J. Reyes, and Félix Acosta Cantillo

Conservation targets: One endemic species considered globally Endangered, *Lyonia elliptica* (Ericaceae); five species considered globally Vulnerable, *Begonia cubensis* (Begoniaceae), *Tabebuia hypoleuca* (Bignoniaceae), *Juniperus barbadensis* var. *lucayana* (Cupressaceae), *Licaria cubensis* (Lauraceae), and *Sideroxylon jubila* (Sapotaceae); a subspecies categorized as Undetermined, *Brunellia comocladifolia* subsp. *domingensis* (Brunelliaceae); and a species, *Marathrum utile* (Podostemaceae), whose range is restricted to a few populations along the Peladero River and its tributary, the Nuevo Mundo

INTRODUCTION

Several studies of flora and vegetation have been carried out in specific locations in La Bayamesa National Park that contribute to our knowledge of the Park's biological diversity. However, most of these studies have not been published. Reyes et al. (1997) contains information on the Park's flora and vegetation, and Martínez and Fagilde (2004) includes a floristic study of the rainforests of Alto de La Bayamesa and other locations. It is clear that the Park is extremely important because it contains various habitats with considerable species richness, especially the montane rainforest.

METHODS

During the inventory's eight days, we surveyed accessible habitats and we collected botanical material for species in which we had interest or uncertainty, or were unable to identify. The rest of the species were identified and noted in the field. The first author also consulted collections in the Herbarium of the Centro Oriental de Ecosistemas y Biodiversidad (BSC) and compared them with collected material. To determine species' threat levels, we used IUCN's categories and guidance (IUCN 2004). We also took photographs that will be available on our website (*www.fmnh.org/rbi*).

RESULTS

Species richness and endemism

We recorded 553 infrageneric taxa belonging to 315 genera and 103 families (Appendix 5 and Figs. 4C-D). Of those, 114 were only identified to genus. In addition, 25 species belonging to 16 families have yet to be identified, and 14 are unknown to us. We estimate that in total, there are 700 species of spermatophytes in the area.

The families with the largest number of species are Asteraceae (38), Orchidaceae (37), Rubiaceae (32), Poaceae (29), and Fabaceae (28).

Endemism

We have identified with certainty 69 endemic species, and another 6 need to be confirmed (together representing

12.5 to 13.6% of all the spermatophytes inventoried). We are certain that the area harbors additional endemic species, since many of those identified to the genus level are likely endemics.

The only family with significant endemism is Euphorbiaceae (9 of 21 species, 42.9%). The rest of the families with significant number of species have low endemism rates. Several families, such as Magnoliaceae and Myricaceae, have proportionately high endemism (100% and 75%, respectively) but few species in the Park.

Native and introduced species

There are 393 native species (including the endemics and non-endemic natives) and 83 possibly native species. Therefore, the actual number of native species in the Park is probably over 90%.

There are 37 introduced species (6.7% of the total), mostly fruit trees (including 6 species of *Citrus*) and ornamentals. When compared to other protected areas where similar inventories have been conducted, such as the Pico Mogote and Siboney-Juticí Ecological Reserves, we observe more introduced species in La Bayamesa. This is probably because human settlements within and around the Park facilitated their introduction and development. The introduced species have adapted well to these ecosystems, but they do not seem to significantly affect the ecosystem at present. However, we suggest giving immediate attention to *Cupressus* (Cupressaceae), since individuals can easily propagate and spread.

New records

While we were in the process of identifying collected material, we found six or seven new records for the Park, Sierra Maestra, or Cuba.

The three new species for the Park (and El Zapato) are *Senna lisgustrina* var. *turquinae* (Fabaceae-Caesalpinioideae), *Pavonia schiedeana* (Malvaceae), and *Citharexylum discolor* (Verbenaceae). Also, if we confirm that the species identified as *Callicarpa* cf. *floccosa* (Verbenaceae) is properly classified, then it too is a new Park record.

Two new records for the Park and for Sierra Maestra are *Purdiaea stenopetala* (Cyrillaceae) and *Lunania subcoriacea* (Flacourtiaceae).

A new record for Cuba is *Vicia sativa* subsp. *nigra* (Fabaceae-Faboideae), which was collected in its natural state on Pico Bayamesa. Until now, the species was known only from cultivation in Cuba.

The aquatic plant, *Marathrum utile* (Podostemaceae), is a new record for the El Zapato locality. This species has a range restricted in the Park to small populations along the Peladero River and its tributary, the Nuevo Mundo. Urquiola and Novo (2000) reported that this species was found in Alto de Valenzuela (another place in Cuba). Our record is significant because it is only the second time in more than a century that it has been collected in Cuba (Ramona Oviedo, pers. comm.).

THREATS AND RECOMMENDATIONS

We did not identify significant threats to the spermatophyte flora of the Park. In general, the introduced species do not seem to impact the habitats where they occur and their populations do not seem to occupy large extensions within the study area. However, we recommend establishing monitoring of several species:

- *Cupressus* sp., which may spread within the Park
- "Marabú" (*Dichrostachys cinerea*)
- Rose apple ("pomarrosa," *Syzygium jambos*)

We also recommend a quantitative inventory of the seven species of global concern (categorized as Endangered, Vulnerable, or Undetermined; see Conservation Targets at the beginning of this section), and mapping their distributions, in order to determine whether or not these species need active management to ensure their survival in the Park. Individuals of *Vicia sativa* subsp. *nigra* in the area need to be monitored to determine if it is an adventitious, casual taxon or a naturalized species.

TERRESTRIAL MOLLUSKS

Participant/Author: David Maceira F.

Conservation targets: Five species endemic to the Sierra Maestra Subregion and six species endemic to the Eastern Region: *Helicina subglobulosa leoni, Troschelvindex arangianum turquinensis, Cysticopsis lessavillei, Obeliscus* (*Stenogyra*) *clavus flavus, Veronicella* sp. nov., *Alcadia* (*Idesa*) *spectabilis, Emoda p. pulcherrima, Zachrysia* (*Chrysias*) *bayamensis, Coryda lindoni, Cysticopsis pemphigodes,* and *Obeliscus* (*Pseudobalea*) *latus*

INTRODUCTION

Throughout most of Cuba, most of the original vegetation has been lost—except for the Eastern Region, which harbors Cuba's most significant rainforests because of its mountainous relief. These forests are distributed principally in the Sierra Maestra and the Sagua-Baracoa Subregions. Even though terrestrial malacological studies have been conducted in vegetation types of both subregions, including rainforests (Maceira 1998, 2000, 2001), there are no publications dealing with this vegetation type. In this section, terrestrial malacofauna of La Bayamesa National Park's montane rainforest is characterized.

METHODS

I studied the montane rainforest at Pico Bayamesa (in June 2003) and El Zapato (in February 2004), both located in Granma Province. For terrestrial snails, I combined quantitative and qualitative methods. For tree-dwelling snails, I set up 10 plots (each 4 x 4 m), totaling 160 m^2. For ground snails, I searched six plots (0.5 x 0.5 m) totaling 1.5 m^2. I employed open search methods, looking in all possible biotopes, and recorded location, date, habitats, and microhabitats for each individual found. Relative abundance is described using this classification: uncommon, common, and abundant.

RESULTS

Species richness

I observed 13 terrestrial mollusk species belonging to 8 families and 11 genera (Appendix 6 and Figs. 5A-B). There are 8 species (61.5%) belonging to Subclass Pulmonata, 4 (30.8%) Prosobranchia, and 1 (7.7%) Gymnomorpha. Species richness in this vegetation type is high. Similar values were obtained in montane rainforest sites in Pico Turquino (12) and in Gran Piedra (11), both located in Santiago de Cuba Province. In a lowland submontane rainforest at Piedra La Vela, Yateras, Guantánamo (in the Sagua-Baracoa Subregion) I recorded 13 species (Maceira, in press).

Endemic and introduced species

All of the species recorded in the montane rainforests at Pico Bayamesa and El Zapato are endemic to Cuba or restricted areas within Cuba. One species is a Cuban endemic (7.7%), one is endemic to both the Central and Eastern Regions (7.7%), six are endemic to the Eastern Region (46.2%), and five are endemic to the Sierra Maestra (38.5%).

Cuban rainforests are characterized by high endemism of terrestrial malacofauna. Endemism for Pico Turquino is 88.2%, and in Gran Piedra it is 100%. Endemism in Piedra La Vela's lowland submontane rainforest is 83.3%, in the submontane rainforest on poorly drained soil of Pico El Toldo (Moa, Holguín) it is 87.5%, and in the Altiplanicie de Monte Iberia it is 100%. Endemism is 100% in La Melba's lowland rainforest over metamorphic rocks, in the lowland submontane rainforest on ophiolites in Cupeyal del Norte and La China, and in Sierra del Cristal (Maceira, in press). This 100% rate is close to the 96.1% cited for Cuba by Espinosa and Ortea (1999) and the 95.6% cited for Cuba's Eastern Region (Maceira 2001).

Microhabitats, habitats, ecology, and abundance

The terrestrial snails were found in two microhabitats: six species were found on the ground (46.2%) and seven species in trees (53.8%).

Of those inhabiting the ground, I found one terrestrial snail new to science, *Veronicella* sp. nov., which is also the only representative of Subclass Gymnomorpha in the montane rainforest. It lives under rocks and leaf litter. *Obeliscus latus* and *O. clavus flavus*

(the most abundant ground-dwelling mollusks) live in leaf litter and roots and under rocks, where their translucent colors provide camouflage, making them hard to distinguish from the substrate. I also found *Oleacina solidula* and *Haplotrema paucispira*, two carnivorous species that feed on other mollusks. Their presence indicates that the ground mollusk community is well developed. The last species found on the ground was *Cysticopsis pemphigodes*, which lives under rocks and in leaf litter; its shell is a brown color similar to its habitat, providing excellent camouflage.

Among the tree-dwelling mollusks, I recorded the small and brightly colored *Helicina subglobulosa leoni* and *Troschelvindex arangiana turquinensis*. The second species is often found hanging from a fine thread of mucus from the reverse side of leaves, and at the slightest contact it falls.

Emoda p. pulcherrima is medium-sized and is found on shrubs and trees. *Zachrysia bayamensis* is a larger-sized, chestnut-brown-colored snail. *Cysticopsis lessavillei* (the most abundant tree-dweller), *Coryda lindoni* (the second most abundant tree-dweller), and *Alcadia spectabilis* are the most colorful. The shell of the first is entirely green and blends in with surrounding vegetation. The second one's shell has yellow, red, and black stripes. It is often confused with the famous *Polymita* snails. And, unlike other species in Subclass Prosobranchia whose shells are not usually colorful, the shells of the small *A. spectabilis* are yellow, red, orange, green, and blue.

Other notable records

The existence of a new species of *Veronicella* is especially important. In addition, records from the Park increase the distributional ranges for all species inventoried. Also, the shell coloring adaptations seen in the species of *Cysticopsis* are notable. As such, *C. lessavillei* with its green shell is adapted to live in the trees and *C. pemphigodes* with its brown shell is adapted to live among the leaf litter. The presence of predator species, *Oleacina solidula* and *Haplotrema paucispira*, is significant. Two species in the *Obeliscus* genus are also notable because *O. latus* opens to the left and *O. clavus flavus* opens to the right.

THREATS AND RECOMMENDATIONS

Threats

Deforestation and subsequent reforestation efforts, which introduce non-endemic mollusks to this entirely endemic mollusk community, are the biggest threats to La Bayamesa National Park's terrestrial malacofauna.

Recommendations

Protection and management

Initiate environmental education activities in the communities to raise awareness about the completely endemic malacofauna inhabiting the Park.

Additional inventories

Additional inventories are needed in the area in order to understand the mollusk community's composition more completely.

Monitoring

Population densities of two species, *Cysticopsis lessavillei* and *Coryda lindoni*, should be monitored. These tree-dwelling snails have specific humidity and vegetation density requirements and can serve as indicators of changes in the ecosystem.

SPIDERS

Participants/Authors: Alexander Sánchez-Ruiz and Giraldo Alayón García

Conservation targets: Populations of 17 endemic species present in La Bayamesa National Park, especially *Argyrodes cubensis*, which is known from only a few localities in the Eastern Region of Cuba, and *Leucauge spiculosa, Modisimus pavidus*, and *Hibana turquinensis*, known from only a few locations within the Sierra Maestra

Table 2. Spider taxa represented in La Bayamesa National Park.

Taxa category	Number in Cuba (Alayón 2000)	% of Cuban taxa in Park	Number in Sierra Maestra (Sánchez-Ruiz 2000)	% of Sierra Maestra taxa in Park
Species	568	11.4	230	28.3
Genera	243	22.2	130	41.5
Families	53	45.3	38	63.2

INTRODUCTION

Spiders are the second richest arachnid group in Cuba, after the Order Acari. In the Cuban archipelago, 568 species belonging to 53 families have been recorded (Alayón 2000). Of these, almost half (45.1%) are endemic to the country.

Unlike other protected areas in Sierra Maestra (such as Turquino National Park, Siboney-Juticí Ecological Reserve, and Gran Piedra National Protected Landscape), no previous arachnid studies have been conducted in La Bayamesa National Park, but some isolated collections have been made. P. J. Darlington made the largest collections near the Park in 1936 when he visited several places in Cuba's Eastern Region. From these collections, E. B. Bryant (1940) described 25 new species for Sierra del Turquino, most from Pico Turquino and from the coast at the foot of this mountain and to the south.

This report is the first effort to describe the spider fauna of the area that is today protected in La Bayamesa National Park.

METHODS

During the rapid inventory, we conducted diurnal and nocturnal collections in principal habitats only (semideciduous forest, evergreen forest, pine forest, and secondary vegetation) because of time constraints. We observed and/or collected all spiders found, especially from vegetation, under rocks, on the ground, on leaf litter, on fallen trunks, under bark, and on buildings.

To develop the species list, we considered previous records in the region (Alayón 2000; Bryant 1936, 1940; Exline and Levi 1962; Franganillo 1930, 1936; Platnick 2004), material deposited in the arachnological collection of the Centro Oriental de Ecosistemas y Biodiversidad, and specimens collected during a 4-day visit to Pico La Bayamesa in June 2003, when the first author worked in the cloud forest and montane rainforest.

RESULTS

Species richness and endemism

During the rapid inventory, we examined 198 specimens. We were able to identify 171 (86.4%) to the species level. There are 65 spider species of 24 families and 54 genera in the Park (Appendix 7). Despite several factors such as its relatively small surface area compared to the Sierra Maestra or Cuba in general, a lack of data available from the literature, and the short period of time for sampling, the percentage of spider species, genera, and family richness is significant (Table 2). Best-represented families include Araneidae, Theridiidae, Salticidae, and Tetragnathidae (Table 3).

Of Cuba's 247 endemic species (Alayón 2000), we found 17 in the Park (13 are distributed throughout Cuba, 1 has distribution restricted to Cuba's Eastern Region, and 3 are restricted to the Sierra Maestra), which represents 6.9% of the endemic species recorded in Cuba and 18.7% of the 91 endemic species recorded in Sierra Maestra. Of the endemic species present in the Park, *Argyrodes cubensis* is known only from populations in two localities in the Eastern Region: Pico La Bayamesa, Guisa, Granma (the type locality), and La Melba, Moa, Holguín. Three other species (*Leucauge spiculosa, Modisimus pavidus*, and *Hibana turquinensis*) are known only from very few localities in the Sierra Maestra.

Table 3. The most species-rich spider families in La Bayamesa National Park

Family	Number of species	% endemism (relative to the number of endemics in the Park)
Araneidae	14	11.8
Theridiidae	7	11.8
Salticidae	6	17.6
Tetragnathidae	6	5.9

Notable finds

In this inventory, we found 21 new records for the Park and 3 new families: (1) Hahniidae, for which we collected four adult females; (2) Deinopidae, represented by four *Deinopis lamia* individuals (collected in the pine forest close to the camp) and two *Deinopis* sp. individuals (collected in the camp); and (3) Anyphaenidae, represented by one *Hibana turquinensis* specimen, which was known only from the holotype and paratype from Pico Turquino, Guamá, Santiago de Cuba. Our specimen is the third collected for this species.

Our record of *Ctenus brevitarsus* (Ctenidae) also stands out, since this species is known in only a few localities in the Central and Eastern Regions of Cuba (Alayón 2000). We found it during the rapid inventory in leaf litter in montane rainforest near Nuevo Mundo, Guisa, Granma.

Another interesting find is *Agobardus prominens* (Salticidae), which was known only in the province of Cienfuegos in Cuba's Central Region. We located it on Pico La Bayamesa, Guisa, Granma, which increases its known distribution to Eastern Cuba.

THREATS

Populations with small ranges are the most fragile since they will be the first to disappear if habitat loss intensifies. Because of this, the three species endemic to Sierra Maestra and known from the Park deserve special attention: *Modisimus pavidus* (Pholcidae), *Leucauge spiculosa* (Tetragnathidae), and *Hibana turquinensis* (Anyphaenidae). These species are considered rare since they have been collected only a few times in over 50 years.

RECOMMENDATIONS

Research

Carry out population studies of the three range-restricted species in the Park to determine their actual distributions within the Park and their habitat requirements.

Additional inventories

Continue biological inventories during different times of the year in more habitats within La Bayamesa National Park and in other national parks within the Sierra Maestra. An inventory covering the other national parks (for example, Turquino or Desembarco del Granma) would help increase understanding of spider distributions and level of protection throughout this mountain range. Particularly, an inventory in Parque Nacional Turquino would help locate 20 species that are known only from type localities within this protected area.

OTHER ARACHNIDS

(Orders Scorpiones, Amblypygi, and Schizomida)

Participant/Author: Rolando Teruel

Conservation targets: The population of *Cubazomus* sp. nov., found in broadleaf rainforest and pine forest at El Zapato, between 1,000 and 1,100 m altitude

INTRODUCTION

Among the arthropods, the arachnids are an ecologically important group because of the sheer number of species and their typically predatory lifestyle. Consequently, they are one of the elements most susceptible to the effects of anthropogenic actions. This risk is further increased by two other, equally important factors: the relatively small geographic distributions of most species, and the fact that high rates of endemism and species richness are concentrated in arid and coastal vegetation zones, which are ecologically fragile ecosystems. As a result, studies of this group's biological diversity are significant. No previous studies of these orders exist for La Bayamesa National Park.

Table 4. Arachnids (except spiders) in the Sierra Maestra and in La Bayamesa National Park.

	Sierra Maestra				La Bayamesa National Park			
Order	Families	Genera	Species	Cuban endemic species	Families	Genera	Species	Cuban endemic species
Scorpiones	2	5	22	20	2	3	3	3
Amblypygi	2	3	7	4	1	2	2	2
Schizomida	1	5	13	12	1	1	1	1
TOTALS	**5**	**13**	**42**	**36**	**4**	**6**	**6**	**6**

METHODS

I inventoried arachnids through direct visual observation and by turning over rocks and fallen trunks, peeling bark off dead trunks and branches, as well as looking inside epiphytic bromeliads. I captured small specimens (less than 5 mm long) using a brush soaked in 80% ethanol, and larger specimens using entomological tweezers appropriate to the specimen's size and exoskeletal hardness. I preserved all species in 80% ethanol and deposited them, properly labeled, in BIOECO's collections.

RESULTS

Species richness and endemism

I captured six species, belonging to three orders, four families, and six genera (Appendix 8). These values may seem to indicate a paucity of diversity, but Cuban mountains are characterized precisely by drastic reduction in these groups with increasing altitude (Armas 1984, 1988; Teruel 1997, 2000a, 2000b, 2001). Therefore, the number of species recorded concurs with the expected number of species, even though it is low. In the upper part of the Peladero River (at altitudes greater than 500 m), I did not catch any individuals from these orders even though altitude and vegetation conditions are appropriate in the area. (This may be because I was unable to use ultraviolet light for nocturnal detection. The method cannot be used during a full moon, which we had during the inventory.) It is possible, therefore, that these organisms do occur in that area.

Table 4 presents a comparison of the Park's arachnid fauna (this study) with that of Sierra Maestra (Teruel 2000b, 2001). Species representations (by order) in the Park compared to those present in the Sierra Maestra are as follows: amblypygids (29%), scorpions (14%), and schizomids (8%). The Park covers less than 1% of Cuba's national territory, yet representation of the arachnid fauna is notable. All of the Park's species are endemic to Cuba.

New and significant records

The most interesting find is a new *Cubazomus* species. This is the second species of this genus of schizomid endemic to the Sierra Maestra. It also represents the highest altitude record for the genus: 1,100 m. The other *Cubazomus* species lives below 300 m.

THREATS

During this inventory, I did not identify specific threats to these arachnids in the sampled areas of the Park. However, in general, small population sizes of most species make them vulnerable to changes in their habitats. In particular, a potential threat is indiscriminate forest clearing that destroys vegetative cover and its corresponding leaf litter (which drastically alters essential microclimatic parameters needed for the survival of these species, such as humidity and the level of soil insolation).

RECOMMENDATIONS

Protection and management

Prevent local deforestation and protect remaining rainforests and pine forests that harbor these species, including the species proposed as a conservation target.

FRESHWATER INSECTS

Participants/Authors: Pedro López del Castillo, Carlos Naranjo López, José L. Fernández Triana, José Pérez Osoria, Dany González Lazo, and Adrián Trapero Quintana

Conservation targets: Aquatic insect communities, especially the 26 endemic species found, three species in particular: *Hagenulus* (*Borinquena*) *sextus* (Ephemeroptera, Leptophlebiidae), *Campsiophora mulata* (Trichoptera, Glossosomatidae), and *Paltostoma palominoi* (Diptera, Blephariceridae), which are endemic to the Park

INTRODUCTION

Benthic macroinvertebrates are sensitive to many environmental biotic and abiotic factors, which makes them excellent indicators of water quality. Insect larvae are dominant organisms in rivers, streams, and lakes and are extremely useful in monitoring and inventory studies (Armitage et al. 1983; Rosenberg and Resh 1993).

There are many permanent and seasonal bodies of water (rivers and streams) in La Bayamesa National Park. Here we provide data on the Park's aquatic insects, including information for seven orders (Coleoptera, Diptera, Ephemeroptera, Hemiptera, Lepidoptera, Odonata, and Trichoptera).

METHODS

During the week long rapid inventory in February 2004 (dry season), we collected from 16 sites, spanning altitudes from 750 m to 1,750 m in the Park's rivers and streams: (1) lower Nuevo Mundo River, (2) Campamento La Mesa, (3) Grumay, (4) La Pangola, (5) right branch of La Plata River, (6) Arroyo de Pancho, (7) headwaters of Arroyo Veinte y Seis, (8) El Camino, (9) El Oro de Guisa, (10) La Plata de Guisa, (11) El Zapato, (12) Manguito River, (13) Nuevo Mundo River, (14) Arroyo Veinte y Seis, (15) lower Peladero River, and (16) Arroyo Hondo.

We collected all material using soft entomological brushes and pinchers and preserved samples in 90% alcohol. We employed four basic methodologies:

- Flipping rocks—We inspected 25 rocks in each station, extracting adhered larvae.
- Netting against current—We dragged an entomological net against the current in both pools and areas with rapid current. Two people participated: one person removed riverbed substrates while the other dragged the net along the bottom.
- Netting along the edge—We used the same entomological net, but it was dragged for 5 m along the edge in an attempt to sample insects on roots, trunks, rocks, and debris.
- Capture of flying adult insects—We used an aerial entomological net.

We deposited all reference material in the Biology Department at the Universidad de Oriente. We supplemented our results with data collected during a weeklong trip to La Bayamesa in June 2003 (rainy season). We identified all individuals to the species or genus level.

RESULTS

Species diversity and endemism

We collected 2,033 individuals belonging to 65 species, 35 families, and 7 orders in the Class Insecta (Appendix 9). We found the highest species richness at the Nuevo Mundo River and El Zapato, with values of 31 and 30 respectively. In general, the average number of species per locality was greater during the dry season (23.7) than the rainy season (11.3). This is because during the rainy season, current speeds and water volume are higher, creating a scouring effect on the riverbeds.

The number of aquatic species present in the Park is high compared to other sites in Cuba. López (2001) found 61 species for the basin of the Yara River, located in the northwestern portion of the Sierra Maestra. Sampling effort there was much greater since each of the 13 sites were sampled in the dry and rainy season. Naranjo and Trapero (2000) recorded 59 species in La Gran Piedra (Santiago de Cuba Province), in an area much more intensely sampled than La Bayamesa. Outside of the Sierra Maestra, data from Universidad de Oriente inventories in the Nipe-Sagua-Baracoa

Mountains also demonstrate lower numbers than those reported for La Bayamesa.

In Cuba, 512 infrageneric taxa are known of aquatic insects, 209 of which are known from the Sierra Maestra. The 65 species found in La Bayamesa National Park represent 12.7% and 31.1% of these values, respectively. In other words, one out of eight species in Cuba and almost one out of three species in Sierra Maestra are found in the Park. We recorded 26 species endemic to Cuba (40% of all the species found in the Park), three of which are local endemics to the study area: *Hagenulus sextus* (Ephemeroptera, Leptophlebiidae), *Campsiophora mulata* (Trichoptera, Glossosomatidae), and *Paltostoma palominoi* (Diptera, Blephariceridae). The orders Ephemeroptera, Odonata, and Trichoptera were especially rich in endemic species.

The amount of time we put forth for collections in the Park cannot be considered exhaustive, and the number of rivers studied and area covered do not constitute an exhaustive spatial effort. Similar research (e.g., Naranjo and Trapero 2000; López 2001) suggests that the number of species will increase if each sampling site is measured during the dry and rainy seasons. Taking research results from other Cuban sites into account, we estimate that La Bayamesa harbors at least 50% of the species present in the Sierra Maestra and approximately 20% of all the species present in Cuba. Habitat diversity and their pristine state of conservation, altitudinal differences, and the large number of rivers and streams in the Park explain the high numbers of aquatic insects. It is probable that the Park is a "hot spot" for aquatic insect biodiversity in Cuba.

New and significant records

We identified larvae of *Dixella* (Diptera, Dixidae) in pools of three different sites, which are the first records of this family in the country (López et al. 2004). Other new records for Cuba are the following genera: *Cleptelmis* (Coleoptera, Elmidae) and *Petrophila* (Lepidoptera, Pyralidae) (López et al. 2004).

In the headwaters of Arroyo Veinte y Seis, we captured two *Cubanoptila cubana* larvae (Trichoptera, Glossosomatidae) in the rapids. Until now, this species was known to exist only in western Cuba (Botosaneanu 1979, 1980), and this Park record makes it the first record for eastern Cuba. Other interesting results include finding, for the second time, two extremely rare and local Ephemeroptera species: *Hagenulus* (*Careospina*) *evanescens* and *H.* (*Borinquena*) *sextus*; and we collected the largest ephemeropteran in Cuba, *Euthyplocia inaccessibile*, which is only the third time this species has been collected.

Habitats

Of all the individuals collected, we found 1,273 (62.6%) in rapids and only 760 (37.4%) in pools, which is characteristic of mountain streams where rapids dominate and most taxa present are adapted to these conditions. Nineteen species (29.2%) inhabited only rapids, while five (7.7%) were found only in pools. The remaining 41 species (63.1%) were collected in both microhabitats, but 10 of them were found most frequently in rapids, suggesting that they are typical in rapids and only occasional in pools.

THREATS

Because of difficult access and altitude, La Bayamesa National Park is naturally protected. Sources of contamination or substances draining into the rivers that normally threaten lotic ecosystems are not present in the Park. As long as current levels of resource use in the Park remain low, freshwater macroinvertebrates are not at risk.

RECOMMENDATIONS

Research

We recommend additional sampling of aquatic insects in different rivers and streams during the rainy and dry season in order to increase the total number of known species, and possibly find new records for the Park or even new to science.

Monitoring

Aquatic insect communities have been used as water quality indicators in various countries (Armitage et al. 1983; Rosenberg and Resh 1993). The data collected during this inventory and presented in this report can serve as baseline data for water monitoring in the Park. Changes in water quality because of contamination or deteriorating ecosystems can be detected using these baseline data.

BUTTERFLIES

Participant/Author: Jorge L. Fontenla Rizo

Conservation targets: Four endemic species, *Calisto sibylla, Anetia cubana, Greta cubana*, and *Parides gundlachianus*

METHODS

I made observations between February 1 and 9, 2004, in different sites between 1,200 and 1,500 m altitude in La Bayamesa National Park. There is very little rain during February and temperatures are relatively low.

RESULTS

I observed 23 species (Appendix 10). Most likely, species richness is closer to 35 species. The area stands out because of its endemic species, including a very colorful endemic restricted to the mountains of the Eastern Region of Cuba, *Anetia cubana*. Other species worth noting because they are both endemic and charismatic are "mariposa de cristal" (*Greta cubana*) and "mariposa de Gundlach" (*Parides gundlachianus*). Another colorful species with a regional distribution is *Anetia briarea*. IUCN categorizes this species and *A. cubana* as Near Threatened (IUCN 2004).

THREATS, OPPORTUNITIES, AND RECOMMENDATIONS

Deforestation is the main threat. Rare species and habitat specialists, such as *Calisto sibylla*, *Anetia cubana*, and *Greta cubana,* should be monitored and protected.

HYMENOPTERANS

Participants/Authors: José L. Fernández Triana, Jorge L. Fontenla Rizo, Eduardo Portuondo Ferrer, and Julio A. Genaro Artola

Conservation targets: Communities of hymenopterans, especially parasitic wasps (for example, Ichneumonidae: Cryptinae, Pimplinae, and Ichneumoninae; Braconidae: Microgastrinae) that are the most diverse and abundant in the country; endemic ant species (*Camponotus gilviventris*, endemic to Cuba's mountainous zones, and *Leptothorax bruneri*, a regional endemic); and genera (*Clistopyga, Eruga, Exenterus, Macrostomion, Protichneumon, Symplecis, Zatypota*) that have only been found in this region of Cuba

INTRODUCTION

Despite the World Conservation Union's 1991 resolution regarding invertebrate protection, insects are usually underestimated and many times ignored in conservation efforts. Several factors have led to this unfortunate situation: (1) the extraordinary diversity that makes species identification difficult, (2) the number of techniques needed for their collection, and (3) the erroneous but widespread perception that their small size makes them insignificant. In reality, these insects perform extraordinary services and occupy central roles in most terrestrial ecosystems. For example, they are important decomposers of organic matter and recyclers of nutrients. They also pollinate plants, disperse seeds, comprise a large percentage of the biomass in many ecosystems, and regulate many food chains (via complex plant-herbivore-predator/parasite-hyperparasite relationships).

Unlike other taxonomic groups for which some preliminary information exists, La Bayamesa National Park's insects are almost completely unknown. There are not even many specimens available at the national level, and entomological collections from the Park are practically nonexistent. In this report, we provide data on the Order Hymenoptera (bees, wasps, and ants) in the Park.

METHODS

We studied six vegetation types: cloud forests, evergreen forests, rainforests, pine forests, coffee plantations, and secondary vegetation. We used three methods:

- Direct collection—This was the most varied collection method and it incorporates several techniques. Using an entomological net, we collected insects we saw flying or feeding on flowers, or we swept herbaceous and shrub vegetation with the net. We also overturned rocks and lifted tree bark (live and decomposing), capturing insects with entomological pinchers and brushes.
- Yellow plates—We used six to eight plates for each sample site, placing them along a transect in the studied ecosystem with at least 3 m between each plate. We placed these traps between 8:00 a.m. and 2:00 p.m., although for logistical reasons the schedule varied slightly at times.
- Malaise traps—We used the model modified by Townes (1972), and we captured during 24-hour periods or more, since diurnal and nocturnal collections are possible with this method.

We deposited collected reference material in the Zoological Department of BIOECO (Santiago de Cuba) and in the Museo Nacional de Historia Natural (La Habana). We complemented our field results with data from a weeklong expedition conducted in June 2003 (rainy season) in La Bayamesa National Park, and with data collected from studying BIOECO's entomological collection. Most individuals were identified to the species or genus level.

RESULTS

Species diversity and endemism

We collected more than 200 species of Hymenoptera, of which we have identified approximately 100 to the species or genus level (Appendix 11 and Fig. 5D). If an inventory plan is implemented in an area with ecosystem and landscape diversity as well as altitudinal differences of more than 1,000 m, we estimate that the actual number of hymenopteran species will exceed 400. It is likely that many of the new records for the country of genera found during this inventory will turn out to be species new to science, especially in the case of the family Ichneumonidae.

Almost 1,200 species of the Order Hymenoptera have been reported in Cuba (Portuondo and Fernández 2003), and 644 in the Sierra Maestra (Portuondo and Fernández 2004). Diversity in the Park is significant, especially considering that it covers only 0.2% of national territory and 5% of the Sierra Maestra, yet harbors approximately one-sixth and one-third, respectively, of the hymenopteran species.

Endemism rates are close to 40% for the families for which current data are available (Fontenla 1994, 2000; Genaro and Tejuca 2000; Genaro 2002; Portuondo and Fernández 2003; Fernández 2005). We predict that endemism could be significant for some hymenopteran groups in the Park because of its altitude, excellent state of conservation, and relative isolation.

Notable finds

We found six Ichneumonidae genera (*Clistopyga*, *Eruga*, *Exenterus*, *Protichneumon*, *Symplecis*, *Zatypota*) and one Braconidae (*Macrostomion*) that are new records for Cuba (Appendix 11, Fig. 5D, and Portuondo and Fernández 2004).

We did not find any individuals of *Exenterus* (Ichneumonidae) during the expeditions, but the first author of this report studied one specimen collected in 1999 and deposited in BIOECO. This specimen emerged from the larva of a hymenopteran pest, *Neodiprion maestrensi* (Diprionidae), in a pine forest outside of but bordering the Park (to the north), which makes its presence in La Bayamesa very probable because the pines extend into the Park. This is the first report in the country of an Ichneumonidae parasitizing a Diprionidae, and even more important, it is the first time the genus has been found in the Neotropics. It is also probably a new species to science that would extend the known distribution range of the genus, which previously was Holarctic and Oriental (Yu and Horstman 1997). Geographically, the closest species are

Nearctic, found in Northern Mexico and in the United States. Interestingly, species of Cuban Diprionidae (the host insects) are closer phylogenetically to the Nearctic species rather than the Neotropical ones (Portuondo and Fernández 2003), suggesting that a co-speciation phenomenon could exist between these wasps and their Nearctic ancestors.

We found an elevated number of Ichneumonidae individuals and species. Thus far, we have identified 34 species (Appendix 11), but the final figure is probably closer to 100. This is extraordinary given that only 200 species of this family are known in Cuba (Portuondo and Fernández 2003; Fernández, unpublished data), and the total number of Cuban species is estimated to be between 400 and 600 (Fernández et al., in press). The Park, with 0.2% of the national territory, harbors approximately 40% of the known Ichneumonidae species and between 15 and 25% of the predicted number of species. Several genera are known to exist only in the Park, leading us to believe that local endemism is high. This phenomenon requires additional study, but current data clearly demonstrate the region's importance.

Habitats

The vegetation types harboring the most species diversity of the Order Hymenoptera were rainforests, cloud forests, and secondary vegetation. Coffee plantations that conserve part of the natural rainforest vegetation are also an interesting vegetation type because we found elevated hymenopteran diversity and abundance. However, data from both expeditions are not all-inclusive, especially for insect groups whose populations fluctuate greatly from year to year (for example, Buskirk and Buskirk 1976; Wolda 1978; Smythe 1985; Janzen 1993; Kato et al. 1995; Shapiro and Pickering 2000). Perfecto and Snelling (1994) observed this same phenomenon in Costa Rican coffee plantations, at least for one hymenopteran group: the ants.

There were fewer Aculeatae (stinging bees, ants, and wasps) found in the Park than are normally found in low-altitude and/or sunny areas, according to previous data and inventories from other parts of the country (Portuondo 1998, 2000, 2001; Fernández et al. 2002; Genaro 2002; Portuondo and Fernández 2004; Fernández and Portuondo, in press). Notable exceptions were ants (Formicidae). We found 25 ant species, more than recorded during the Pico Mogote rapid inventory (Maceira et al., in press), although they were less abundant in comparison with what is usually seen in lower altitudes. Species of *Polistes* and *Mischocyttarus*, particularly the latter, were numerous in all sampled ecosystems, especially in those disturbed by man (pine forests, coffee plantations, and secondary vegetation).

In general, the low diversity of Aculeatae in the Park is due to high precipitation and the prevailing relative humidity in its predominant vegetation types (especially rainforests), which seems to hinder many bees' and sphecid wasps' nest building (they require drier conditions).

Yet, for various groups of parasitic wasps that generally avoid sunny, hot, and dry places, these ecosystems are probably preferred by a greater number of species. In Cuba, families cited as the most abundant in forest types include Ichneumonidae, Scelionidae, Diapridae, some genera of Braconidae, and some groups of Chalcidoidea (Portuondo and Fernández 2003, 2004); the rainforests are the most significant of the forest types (Fernández and Portuondo, in press). The best-represented subfamily of parasitic wasps is Microgastrinae (Braconidae), with many species in various genera.

THREATS

Although data are still inconclusive, it appears that the area covering La Bayamesa and Turquino National Parks harbors the highest levels of species richness for some wasp groups, especially the ichneumonids, in Cuba. This could be because of the area's altitudinal range (from 0 to 1,972 m) and the fact that this is the only place in the country where the altitude surpasses 1,500 m and cloud forests, which harbor significant parasitic wasp diversity, are found.

The rainforests seem to be one of the last strongholds for the hymenopterans that are more

abundant in cool and humid ecosystems (Fernández and Portuondo, in press). Habitat destruction is the principal threat to these wasp communities. Another potential threat is fragmentation, because many ecosystems persist as "skullcaps" (*casquetes*)—little islands of remnant native vegetation, perched atop the highest and most inaccessible mountains.

RECOMMENDATIONS

Protection and management

Results from this inventory suggest that La Bayamesa National Park is a "hot spot" for parasitic wasps. Without a doubt, it is the most important site in the country for species of Ichneumonidae. Protecting remnant cloud forests is the most important step for preserving these hymenopterans.

These wasps should also be included in the Park's management plans as one of the distinctive and characteristic fauna groups. We recognize that this suggestion will be difficult to achieve because invertebrate conservation is not customary.

Research

Research why the ichneumons are so abundant and diverse in the Park (possible explanations include altitude, climate, or biogeographic reasons). Metapopulation dynamics of insects and their influence on conservation have never been studied in Cuba, but it is extremely important in a group like the hymenopterans, with parthenogenetic reproduction mechanisms (Hanson and Gauld 1995) and occurrence—especially parasitic species—in low population densities (LaSalle and Gauld 1994).

Additional inventories

We recommend an annual collection plan, using Malaise traps, in different areas in the Park. This will reveal the true magnitude of the Park's hymenopteran biodiversity and will most likely lead to finding species new to Cuba and to science.

AMPHIBIANS AND REPTILES

Participants/Authors: Luis M. Díaz, Ansel Fong G., Nicasio Viña Dávila, and Guillermo Knell

Conservation targets: Ten species whose ranges are restricted to the Sierra Maestra forests (*Eleutherodactylus albipes, E. cubanus, E. glamyrus, E. jaumei, E. melacara, E. turquinensis, E.* sp. nov., *Anolis clivicola, A. altitudinalis*, and *Diploglossus garridoi*), and 12 threatened species (*Eleutherodactylus albipes, E. cubanus, E. glamyrus, E. gundlachi, E. intermedius, E. ionthus, E. jaumei, E. melacara, E. ricordii, E. turquinensis, Chamaeleolis chamaeleonides*, and *Epicrates angulifer*), which are also endemic to Cuba

INTRODUCTION

La Bayamesa National Park is found in one of the most biological diverse and highly endemic areas in the Sierra Maestra and Cuba. Herpetological studies clearly demonstrate this. The first species for the zone were described at the beginning of the twentieth century (Barbour and Shreve 1937) and new species were still being found during the 1990s (Estrada and Hedges 1997). Despite this, an overall analysis uniting all available herpetological data on the Park did not exist, and aspects such as geographic distribution and species ecology have not yet been published.

With this report, we try to close this information gap by presenting the Park's amphibian and reptile list, providing some comments on the habitats and microhabitats used, and giving our considerations regarding their conservation.

METHODS

We sampled 19 sites in the provinces of Granma and Santiago de Cuba during this inventory and two other expeditions in November 2002 and June 2003 (Table 5). We collected amphibians and reptiles during diurnal and nocturnal searches of bromeliads, leaf litter, rocks, different vegetation strata, and on dry *Agave* plants. We collected larvae using nets, and we taped audio vocalizations using different professional equipment.

Each species' threat category was determined using previous publications on amphibians (IUCN et al.

Table 5. Locations of amphibian and reptile collection sites during and before the rapid inventory.

Location	Coordinates	Altitude (m)
Guamá Municipality, Santiago de Cuba Province		
Close to El Naranjal (Park's southern limit)	19º58'10"N, 76º42'16"W	750
Buey Arriba Municipality, Granma Province		
La Mesa	20º05'68"N, 76º61'62"W	–
Barrio Nuevo and surroundings	20º01'36"N, 76º41'47"W	1,300
Alto de Rondón, road to Barrio Nuevo	–	–
Pico Botella	20º02'09"N, 76º41'28"W	1,557
El Manguito	20º03'19"N, 76º41'09"W	1,200
Nuevo Mundo	20º03'27"N, 76º37'59"W	980–1,000
Alto del Zapato	20º02'29"N, 76º39'31"W	1,200
Guisa Municipality, Granma Province		
Oro River tributary	20º04'44"N, 76º37'08"W	900
El Nueve (also known as Grimau)	20º03'16"N, 76º36'05"W	1,300–1,400
Road to Pinalón	20º03'55"N, 76º35'52"W	1,200
Pico La Bayamesa and surroundings	20º03'18"N, 76º36'13"W	1,000–1,752
Pico Maceo	20º02'42"N, 76º37'38"W	1,440
Pico Corea	20º04'03"N, 76º32'54"W	1,373
Between Brazo del Palmar and Pinar del Millón	20º03'53"N, 76º33'07"W	1,459
Pedro Guyo, climbing towards Pinar del Millón	20º04'15"N, 76º32'20"W	1,050
La Lechuza	20º04'24"N, 76º31'16"W	850
María Tomasa and surrounding areas	20º03'43"N, 76º31'15"W	683
Pinar del Millón and surroundings	20º04'08"N, 76º32'34"W, 20º04'14"N, 76º32'39"W, and 20º04'15"N, 76º32'20"W	1,109–1,307

2004) and Cuba's reptiles (Vales et al. 1998), as well as referring to IUCN's Red List of Globally Threatened Species (IUCN 2004).

RESULTS

Species richness and endemism

We found 16 amphibian and 20 reptile species in La Bayamesa National Park (Appendix 12 and Fig. 6). During our surveys, we observed all but one within the Park, the Cuban boa (*Epicrates angulifer*). We found this snake outside of the Park's limits (around the town of Las Piñas), but rural farmers from La Mesa (within the Park) assure us that they have seen the species there.

One amphibian and two reptiles are not included on our list, but their presence in the Park is very probable, and brings the total species list to 39 (17 amphibians and 22 reptiles). These include:

- *Bufo peltacephalus*—We saw individual toads along the coastal zone of Las Piñas and at the mouth of the Peladero River, making it very likely that the species reaches the Park's southern border.
- *Anolis noblei*—We observed several individuals around Las Piñas, and the rural farmers of El Naranjal confirm that it exists there, allowing us to assume that it is within Park borders as well.
- *Anolis guazuma*—This hard-to-find anole is probably within the Park, and future inventories should dedicate special efforts to search for it.

Individuals of the genera *Arrhyton*, *Amphisbaena*, and *Typhlops* were not found either. These reptiles have reclusive habits and are difficult to find, which makes it entirely possible that they went undetected during the inventory even though present.

Of these species, 15 amphibians and 17 reptiles (93.8% and 85.0%, respectively) are endemic to Cuba, and of those endemics, 7 amphibians and 4 reptiles are endemic to the Sierra Maestra. Especially important are the 3 species that only inhabit areas within the Park (Appendix 12), and another 5 that only inhabit areas within this Park and adjacent Turquino National Park.

New and significant records

Among the most notable finds is the new species of *Eleutherodactylus* currently being described (Díaz, in press). The inventories also allowed us to record new localities for three species that are restricted to the Sierra Maestra, *Eleutherodactylus cubanus*, *E. albipes*, and *E. turquinensis* (Figs. 6A-C). These have been considered rare but we encountered them with relative abundance.

Another important find was *Diploglossus garridoi*, a species previously known only from the holotype, an adult female collected at El Manguito. In the area of María Tomasa, we collected an adult male and two juveniles (now these specimens are deposited at the Museo Nacional de Historia Natural de Cuba and at the Museo de Historia Natural of Holguín, Cuba).

In Pinar del Millón, under a dense accumulation of pine needles, we found a female *Sphaerodactylus*, possibly *S. cricoderus*, previously known for two localities: one 2.8 km north of Uvero and the other 1.5 km west-southwest of La Tabla, Santiago de Cuba Province. This species is considered relatively rare because it is only known from these few specimens that were used to describe it. Our specimen is being studied and we prefer to consider it as related to *S. cricoderus* until further conclusions are made.

We collected some *Tropidophis* individuals, possibly of the species *T. pilsbryi*, in Barrio Nuevo and surroundings, which if confirmed would increase this species' range to the western Sierra Maestra, although additional specimens are needed for verification.

We found a chameleon, "chipojo ceniciento" (*Chamaeleolis chamaeleonides*; Fig. 6D) on our climb to Barrio Nuevo (Alto de Rondón), in a transition zone between evergreen and rainforest at 850 m. This species could be considered rare. It is very difficult to detect as it blends in perfectly with the trunks and branches where it lives. *Anolis loysianus* is also rare because of difficult detection, making our capture of a juvenile an interesting addition to this herpetological inventory.

It was very interesting to find both *Anolis isolepis* and *A. altitudinalis* in the Park because the latter had been considered a subspecies of the first until just recently. We observed the two color variations of *A. isolepis* (with and without a supralabial stripe) around María Tomasa (Fig. 6E), and *A. altitudinalis* was found in Pico Bayamesa's cloud forest and in the pine forests at El Nueve.

Ecological observations

Of the amphibians recorded, 56% inhabit the ground, 19% inhabit riparian areas, and the remaining 24% are divided equally between tree-dwelling, semi-tree-dwelling, and bromeliad-dwelling species (Appendix 12). Among the most common terrestrial species in the rainforest's leaf litter are *Eleutherodactylus gundlachi*, *E. dimidiatus*, and *E. cubanus*. At night, *E. glamyrus* was frequent on vegetation, although it can also be found on the leaf litter during the day. *E. turquinensis* was only found in some areas along rocky streams above 1,000 m altitude.

The rainforest harbored the most amphibian species richness, followed by evergreen forest (Appendix 12). *Eleutherodactylus albipes* was only found in cloud forest at La Bayamesa Peak. *E. cubanus*, *E. glamyrus*, and *E. melacara* appeared above 800 m altitude, where the rainforest begins. *E. jaumei* was found in evergreen forest, and was common between 900 and 1,000 m. While around 800-900 m, the rainforest is typically very humid, the evergreen forest (around 700 m) has a marked dry season. Several frog species, including *Eleutherodactylus jaumei*, *E. dimidiatus*, and *E. cuneatus*, had their highest densities in humid leaf litter in a minimum-flow creek, where conditions are apparently most favorable. *Eleutherodactylus ionthus* was the only bromeliad-dwelling frog of the genus that we could detect here, while in the rainforest near Barrio Nuevo, it was *E. melacara*,

proving that both species overlap in the transition between these vegetation types at Alto de Rondón (road to Barrio Nuevo). In the rainforest near Nuevo Mundo these two species were also sympatric.

The frog "rana platanera" (*Osteopilus septentrionalis*) was common. Its larvae were abundant in rivers and puddles. It was mating season for the species in Barrio Nuevo and El Manguito, and we made observations, audio recordings, and filmed their reproductive behavior at the first site.

Overall, there were few amphibian vocalizations heard during the inventory compared to the amount during the rainy season (April to October). *Osteopilus septentrionalis* was only heard during the height of its breeding season (five days) while we were at Barrio Nuevo. Approximately 100-120 individuals gathered in an artificial pool, 5 m in diameter, but the number of individuals and vocal activity begin gradually diminishing after three to four days. During the day and the first few hours at night, abundant vocalizations of the species *Eleutherodactylus cubanus* were heard. We also heard *E. gundlachi*, usually around dusk. *E. auriculatus* vocalized at sunset, but its calls were brief and did not last long. *E. cuneatus*, *E. glamyrus*, and *E. melacara* sporadically called from nightfall to the first morning hours, although *E. melacara* and *E. ionthus* were also periodically heard during the day. It should be noted that *E. auriculatus* and *E. glamyrus* are very difficult to identify if their calls are unknown, because they are sympatric at Barrio Nuevo. Night-time temperature during the inventory fluctuated between 7 and 19°C.

Among the reptiles, we observed *Anolis homolechis*, *A. sagrei*, *A. porcatus*, *A. clivicola*, *A. alutaceus*, and *Leiocephalus cubensis* most frequently. In the evergreen forest (at approximately 700 m) common species included *Anolis allogus* and *A. argenteolus*. These same species were not found above 900 m altitude. Like the amphibians, most reptile species were located in the rainforest and evergreen forest, but we only found tree-dwelling species (60% of total), ground-dwelling species (35%), and one that was associated with rivers and creeks (Appendix 12).

Threatened species

Of the Park amphibians, 68.8% are listed as threatened to some degree (IUCN et al. 2004), and most of these are within the priority categories, elevating their conservation importance. There are four species listed as Critically Endangered and five listed as Endangered (Appendix 12).

Unlike the amphibians, only 20% of the Park's reptiles are considered threatened (Appendix 12). The National Biodiversity Study lists all of them as "Vulnerable" (Vales et al. 1998). Of these, only one species (*Epicrates angulifer*) has been included on IUCN's Red List (IUCN 2004).

THREATS

Habitat destruction seems to be the biggest threat to the survival of the Park's amphibians and reptiles, especially those with restricted ranges. Ecosystem fragmentation also seems to be a threat since it creates "islands" of habitat and the attendant separation of small populations. Principally, deforestation results from land conversion to agricultural uses and logging of timber species.

Introduced species, such as feral dogs (*Canis familiaris*) and cats (*Felis catus*), can affect herpetofauna by predation. However, at this point, it is not known how these mammals impact the Park's native fauna.

Amphibian declines and extinctions have not been documented in Cuba, but the possibility cannot be rejected, especially in high-altitude, forested areas (La Bayamesa, for example), as it has been shown that most species in decline in Latin America live above 500 m altitude (Lips et al. 2003). The lack of baseline studies or previous data in Cuba could be masking the magnitude of amphibian declines on the island.

RECOMMENDATIONS

Protection and management

- Increase vigilance and control within the Park to eradicate unregulated agriculture and unauthorized or excessive logging, thereby protecting its natural forest remnants.

- Start developing plans to control introduced and established non-native species.
- Increase environmental education programs in nearby communities as a way to stop environmentally damaging practices that harm Park species and to raise conservation awareness.

Research

- Study habitat requirements of endemic species in the Park and adjacent Turquino National Park in order to detail the conditions present in their range, which would be useful for the species conservation and management.
- Understand and quantify effects of introduced fauna on amphibians and reptiles to use as a basis for implementing control and eradication strategies.

Additional inventories

We recommend additional studies of the herpetofauna in the southeastern area of the Park (called "Maestrica de los Libertadores"), which is poorly known due to difficult access.

Ecological monitoring

Amphibian monitoring programs should be established in different parts of the Park in order to detect early signs of species declines or extinctions and carry out necessary actions before it's too late.

BIRDS

Participants/Authors: Andrew Farnsworth, Douglas Stotz, and Luis Omar Melián

Conservation targets: The four or five threatened species, namely Gundlach's Hawk (*Accipiter gundlachi*), Sharp-shinned Hawk (*A. striatus*), Gray-fronted Quail-Dove (*Geotrygon caniceps*), Stygian Owl (*Asio stygius*), and, if present in the Park, Black-capped Petrel (*Pterodroma hasitata*); 11 Cuban endemics present in the Park (Appendix 13); and migrant landbirds from North America, especially winter populations of Bicknell's Thrush (*Catharus bicknelli*)

INTRODUCTION

Much of eastern Cuba is mountainous. The tallest of the ranges, the Sierra Maestra, straddles the city of Santiago de Cuba and extends west along the south coast of Cuba. It forms the border between the provinces of Granma and Santiago de Cuba along the narrow western extension of Santiago de Cuba. It contains the highest peak in Cuba, Pico Turquino, at an altitude of 1,972 m. It also contains several other peaks that surpass 1,700 m in elevation, including Pico Bayamesa at 1,752 m. Few bird surveys have occurred in the national park created around Pico Bayamesa until this inventory. One of us (Melián, unpublished) has surveyed the region irregularly on brief trips since the 1970s.

METHODS

From 2 to 10 February 2004, we surveyed the area around two camps, Barrio Nuevo (Farnsworth) at 1,350 m (with coverage ranging from 800 to 1,575 m) and El Zapato (Melián and Stotz) at 850 m (with coverage up to 1,350 m). The areas covered were in Granma Province, except for a small part of the road surveyed by Farnsworth south of the Barrio Nuevo camp, which was in Santiago de Cuba Province. The entire area consists of steep hills covered with disturbed broadleaf evergreen forest with scattered, native *Pinus maestrensis* and second growth, plus areas of mostly planted *Pinus caribeus*, which is introduced from western Cuba. Under most of the pines, which are concentrated between 1,000 and 1,250 m, a dense broadleaf second growth grew to 4 to 6 m in height. Some open grassy areas or areas with a dense growth of ferns were scattered through the site. There were a few dwellings and small areas of agriculture, mainly in stream valleys below 1,150 m.

We used the following techniques to assess the presence and abundance of species in the area:

- 8-minute and 10-minute point-count observations, from a fixed location with unlimited detection distance and 200 m between each fixed observation point, with approximately 10 points per morning on three different mornings
- 15-minute transect counts, with unlimited detection distance and pishing to attract birds in the initial 2 minutes of every period, and between minutes 10 and 11, with 15 counts per morning on two different mornings
- Area searches, with no time or distance limits, using pishing to attract birds within a fixed area usually delimited by topographic or anthropogenic boundary (e.g., steep ridges, road cuts)
- Playback to determine the presence and to assess the abundance of some species, especially during nocturnal surveys of owls and caprimulgids, and diurnal surveys for Bicknell's Thrush (*Catharus bicknelli*)

RESULTS

Species richness and endemism

We recorded data for 69 points in cloud forest, evergreen forest, and road cuts, and covered over 7.2 km during 9 hours and 45 minutes. We also recorded 30 counts on two road cut transects, covering over 7.5 km during 7.5 hours. We recorded a total of 76 species at Bayamesa including 11 endemic species. Farnsworth found 55 species at Barrio Nuevo, while Stotz and Melián recorded 68 at El Zapato (Appendix 13). Melián has conducted bird surveys in the region off and on since the 1970s. During this work, he recorded 72 species, including an additional six species not seen during the current survey: White-winged Dove (*Zenaida asiatica*), Key West Quail-Dove (*Geotrygon chrysia*), Yellow-billed Cuckoo (*Coccyzus americanus*), Common Nighthawk (*Chordeiles minor*), Blackburnian Warbler (*Dendroica fusca*), and Summer Tanager (*Piranga rubra*). Based on previous work in these areas, we estimate roughly 120 species to occur. Most species not recorded during our surveys are either seasonal migrants or occur in habitats not visited in 2004.

Although most endemic birds occur widely across Cuba and most endemics are apparently common where they occur, the forests of La Bayamesa National Park appear to support exceptional densities of resident endemic species, such as Cuban Trogon (*Priotelus temnurus*; Fig. 7B), and Cuban Solitaire (*Myadestes elizabeth*; Fig. 7A). These species likely occur in higher numbers in this area than in any other part of Cuba. Additionally, this area supports exceptional densities of wintering migrants, especially Black-throated Blue Warbler (*Dendroica caerulescens*; Fig. 7C), which occurs in densities higher than in any other Caribbean location.

Threatened species

Gundlach's Hawk (*Accipiter gundlachi*)

Small populations of this Cuban endemic appear to exist in the Park, but we did not observe this species above altitudes of 1,100 m. We observed this species on a few occasions in, or flying over, patches of broadleaf forest. It is possible that the small number of columbids at higher elevations of the Park limits this species' elevational range.

Sharp-shinned Hawk (*Accipiter striatus*)

Parties at both camps observed the resident subspecies of Sharp-shinned Hawk, which is apparently rare throughout Cuba, and is considered to be threatened (Garrido and Kirkconnell 2000). The resident race differs substantially in plumage, and identifying residents from migrants is straightforward. Additional surveys of the higher peaks in the Park could document a small population of this species. Pine plantations and natural pine forests within the Park could be important to this species, as they are for Sharp-shinned Hawk in the United States.

Stygian Owl (*Asio stygius*)

We found at least three pairs of Stygian Owl in the area near the camp at Barrio Nuevo. These birds appeared to be highly territorial and we believe they all had nests in the area during our survey period. Given that we found so many individuals in such a small area, we suggest that the Park may harbor a substantial population of Stygian Owl. The apparent abundance of Stygian Owl follows the pattern of other owls in the park, though the reasons for such large owl populations are not known.

Black-capped Petrel (*Pterodroma hasitata;* Fig. 7D)

This species probably nests on the higher peaks in the park that contain suitable nesting sites. We observed these petrels on two occasions just outside the Park (so it is not included in our list in Appendix 13). We found this species in near-shore coastal waters (25 birds on 9 February 2004, and 46 birds on 23 February 2004), and on one occasion we recorded birds vocalizing and flying inland. Pico Turquino may support a small breeding population (Garrido 1985). Pico Bayamesa also may support a small population of petrels, but further research is necessary to confirm this. Lee and Viña (1993) suggest that the records at sea in this area refer only to foraging birds and that evidence that the species breeds in the Sierra Maestra is weak. The only known breeding colonies for this species are in the mountains of Hispaniola, mainly in Haiti (Collar et al. 1992), although the species may still breed in the mountains of the Dominican Republic. Given the tremendous human pressures on the landscape in Haiti, populations of this petrel breeding in the Sierra Maestra would be important to its long-term survival. Ascertaining the distribution and size of breeding populations in the Park should be a high priority.

Gray-fronted Quail-Dove (*Geotrygon caniceps*)

Melián observed one bird near the Zapato Camp at an altitude of approximately 1,100 m. This is a higher elevation than most populations in Cuba. Gray-fronted Quail-Dove is rare away from its stronghold in the Zapata Peninsula and a survey should focus on this species in the La Bayamesa National Park and adjacent areas.

Rare migrants

Ruby-crowned Kinglet (*Regulus calendula*)

On 2 February 2004, Farnsworth found a Ruby-crowned Kinglet in a flock of Oriente Warblers at the summit of Pico Botella, at approximately 1,450 m. This record is only the third for Cuba. The previous records included one near Havana in October 1964 (Garrido and Kirkconnell 2000), and one at Zapata in February 2002 (Craves and Hall 2003).

Bicknell's Thrush (*Catharus bicknelli*)

On 2 February 2004 at approximately 1,400 m, Farnsworth heard several vocalizations of a single Bicknell's Thrush at the base of Pico Botella. This record is significant because the only known wintering populations of this species in Cuba are near the summit of Pico Turquino (Garrido and Kirkconnell 2000). This observation suggests that a small wintering population might be present in other appropriate habitat in the Bayamesa region. The wintering areas for much of this species' population are not known. Currently, the vast majority of the population is thought to winter at high elevations on Hispaniola (AOU 1998), but cursory examination of the available habitat on peaks in La Bayamesa National Park suggests that this area, along with the area around Pico Turquino, might support a reasonably large wintering population of this species.

Philadelphia Vireo (*Vireo philadelphicus*)

Stotz found one individual in a mixed species flock on 8 February 2004. This species is rare in Cuba (Garrido and Kirkconnell 2000), and usually found as a migrant. This is the first record of the species for eastern Cuba (Melián, unpublished).

Chipping Sparrow (*Spizella passerina*)

Stotz and Melián observed a single Chipping Sparrow above the Zapato camp on 6 and 7 February 2004, in open pine woods with a grassy understory at an altitude

of ca. 1,150 m. There are only four previous records from Cuba (Garrido and Kirkconnell 2000) with only one from eastern Cuba. Those with specific dates were in November, so this is the first winter record for this species in Cuba.

Ecological interactions

The importance of the Oriente Warbler

The endemic Oriente Warbler (*Teretistris fornsi*) appears to be the major nuclear species of mixed-species foraging flocks in the montane forests of eastern Cuba. On numerous occasions, we observed up to eight species of wintering Neotropical migrants in mixed-species flocks led by *Teretistris*. This species has all the hallmarks of a typical nuclear flock-species, including alarm calls, high abundance, and multiple foraging strategies. The importance of this species to the survivorship of overwintering and transient Neotropical migrant birds is not known, but this probably warrants further study. Based on our observations, we believe that *Teretistris* is an essential element of Neotropical migrant mixed-species flock ecology in eastern Cuba. In western Cuba, another member of this genus probably plays a similar role in flocking, potentially a very important resource for overwintering or transient migrants. In areas without *Teretistris*, we found that mixed species flocks were small and transitory (i.e., we found evidence only of small aggregations of wintering migrants with no endemics).

Sexual differences in habitat usage by Neotropical migrants

Our observations agree with recent research suggesting that wintering male and female migrants exhibit a marked difference in their preferences of habitat and elevation. Therefore, different habitats are critically important for the winter ecology of different species and of populations of the same species. If habitats are not available for both of the sexes, the balance between distribution of males and females of a species would be upset, with unknown consequences.

Stopover ecology

What are the roles of the Park in the migration ecology of Neotropical migrants that winter in Cuba or occur only as transients? Based on our data, we believe the Park is critical for various populations of wintering warblers, especially for populations of males and females of the same species choosing different sites and different elevations. Our results suggest that during the migration season this area is critical for migrant refueling. This area harbors a huge wintering population of Black-throated Blue Warbler (*Dendroica caerulescens*; Fig. 7C), possibly representing greater than 50% of the world population.

An assessment of the length of time that birds spend in different locations, how much weight they gain, and mortality factors at different locations is not available but is needed to assess the importance of these areas.

Niches of Caribbean migrants and Neotropical migrants

Wintering migrants from North America occupy a wide breadth of ecological niches in Cuba. We do not know what fills these niches when these migrants depart in the spring. Are Caribbean migrants occupying these niches or are resident species filling them? Understanding the dynamics of this situation would offer a unique view of the ecology of migrant species and how they fit into a resident community composed of many generalist species, as well as an understanding of the patterns of resource and habitat partitioning among Neotropical migrants, Caribbean migrants, and resident Cuban species.

Birds and fruit

Many regions of the tropics exhibit relationships between birds and fruit. Cuba appears to be no exception: we observed many resident and migrant species feeding on fruit, especially small fruits such as those of *Miconia* (Melastomataceae). The importance of this resource for the local avifauna requires further study, including research on the seasonal pattern of fruit use relative to seasonal patterns of movements, the degree to which migrant species use fruit resources, and a quantitative assessment of the importance of fruit in

local birds' diets. However, our observations clearly indicate that many species are using these resources heavily during the winter.

THREATS

- The effects of roads and increased travel are a concern. Increasing vehicular traffic could alter the structure of the avian community by introducing new species to the area, change the vegetation structure, and increase stress from hunting pressures.
- West Nile virus is a potential threat but we do not have enough information about its occurrence in populations of resident and migrant bird species.

RECOMMENDATIONS

Research

- What are the effects of pigs, goats, and other feral or exotic animals on the survivorship of ground-nesting birds and the health of the understory vegetation community?
- The factors driving high densities of endemic species at the sites we visited are unknown. Further studies of the breeding biology, behavioral ecology, and habitat productivity from multiple sites are necessary. There exist many opportunities for researchers at the graduate and professional level to study populations, to monitor trends, to study behavior, and to gain a better understanding of ecological and biological interactions that define the ranges of species.
- Several studies are needed to clarify the ecological roles of migrants and residents in the Park, and should include banding, point and transect counts, counts of visual migration of birds during morning flight, acoustic monitoring of nocturnal migrants, winter surveys of migrant populations, and winter survivorship.
- Determine the requirements for secondary-cavity nesting species in the Park. What is the relationship between woodpecker abundance and other cavity-nesting species? Are cavities a limiting factor for the distribution and abundance of certain species in the Bayamesa area? For example, is the absence of appropriate cavities the reason why the Cuban Parrot is not present in the Park?
- Carry out a thorough assessment of community knowledge and a full review of any previous research activities in the Park to determine the historical patterns of occurrence of bird species in the Park.
- Observe Black-capped Petrel at sea near the coast, and flying inland at night, to determine if this species breeds in the Sierra Maestra. No nesting colonies have been confirmed, and surveys of the appropriate breeding habitat for colonies are needed.
- Further research the biology of Bicknell's Thrush, including active playback studies, area searches, and point and transect counts, to determine the distribution and abundance of this species in the park, especially in the higher peaks (e.g., above 1,400 m).
- Determine how tolerant resident and migrant species are to different land use practices, especially light use, and potential ecotourism development.

Additional inventory

Survey the presence and extent of West Nile virus in resident and migrant bird populations.