

A jungle kept for study



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Barro Colorado Island in Panama has been a biological reserve since 1923 and now enjoys permanent protection. The long-term, continuous investigations that such status allows are transforming our understanding of the ecology of tropical forests

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From 1 October, 1979, a new treaty between the United States and Panama changed the effective sovereignty over the Canal Zone, which the US had administered since 1903; the attention of the world was focused on the future of the Panama Canal. But international biologists were equally worried about the future of the Barro Colorado Island, 1600 hectares in the middle of Gatun Lake, the reservoir that supplies the water for the canal. Were their fears well founded?

Fortunately, the negotiators of the treaty took decisive and imaginative action to ensure the island's protection and accessibility. In a separate agreement annexed to the treaty, they declared Barro Colorado Island a "nature monument" under the terms of the Western Hemisphere Convention of 1940 on Nature Protection and Wildlife Preservation. The Smithsonian Institution of Washington DC was designated as its custodian.

Barro Colorado has been a biological reserve and scientific research station since 1923. It is a reliable, comfortable and accessible area of moist tropical forest which thousands of scientists have used as a field laboratory; in 1979 1180 biologists came from 32 countries. Recently demand has increased exponentially, and now researchers have to be turned away.

The island is one of the few truly protected natural areas of neotropical forest, which means that many animals may be seen here which, in other ecologically similar areas, have become too shy or too rare. It also has one of the best tropical biological libraries in the world, with more than 500 journals and 18 000 volumes, including the recently published *Flora of Barro Colorado*, an important advance. Barro Colorado also has a resident staff and fellows supported by institutes.

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Biologists have always been intrigued by the diversity of organisms in tropical forests, and have proposed various theories to account for it. One holds that the permanent superabundance of food, resulting from the benign environment, is the main factor. But studies at Barro Colorado in the late 1960s were among the first to contradict this view and show that an important ecological characteristic of this forest is a season of deprivation of unpredictable severity. Since then, a long-term study of seasonal and other temporal changes has been looking at the effects on all the living things of changes in climate, number of predators, and of food. We keep records of climatological phenomena such as the rainfall and sunlight. The phenology (that is, the repeated pattern of growth, especially as influenced by climate), of leaf, flower and fruit of several hundred individual trees has been recorded for nearly 10 years, as have fluctuations in the numbers of night-flying (phototropic) insects.

The data recorded by staff scientists, supplemented by those from the studies of visiting researchers, are forming a bank of baseline information that will help us to understand this complex system. The monitoring programme demonstrates one of the great advantages of this type of biological research station: of long-term studies that seldom yield spectacular results but, without which, we would remain ignorant of the basic functioning of an ecosystem. Such insights can never be gained through sporadic visits, nor through studying unprotected forests.

Since 1946 the Smithsonian Institution has been responsible for the scientific management and protection of the island through the Smithsonian Tropical Research Institute (STRI). This was authorised, and the budget appropriated, by the US Congress. The resulting stability has helped to make Barro Colorado one of the best known areas of tropical wilderness in the world; it is comparatively small but the fauna and flora are typical of more remote areas. The 366 species of birds, 170 of which nest on the island,

include several such as the crested guan (*Penelope purpurascens*) that are heavily hunted elsewhere. Unfortunately, the three species of macaws natural to the area all fell victims to the pet trade before the reserve was established. Mammals are also abundant, with tapirs (*Tapirus bairdii*) and red spider monkeys (*Ateles geoffroyi*), both on the IUCN Red Data Book of endangered species, moving about with apparent indifference to the human observer. Unfortunately the island is too small for resident jaguars (*Felis onca*) or pumas (*Felis concolor*). Both used to visit but, as the surrounding areas became progressively more disturbed, their visits became less frequent until it is now by no means certain that these big cats still occur. Among the 90-odd species of mammals recorded on the island are three other cats, five primates and 46 bats.

The fauna is still changing. Species that are adapted to second growth conditions that occur in more open spaces move away as the forest gets older. Some deep-forest

examining the role of natural gaps in the canopy, in the process of forest regeneration. A team of biologists, led by Stephen Hubbel from the University of Iowa, is mapping a 50-hectare area of forest in order to identify every tree in the area and to learn about the diversity of forest species and dispersal of propagules (that is, seeds, buds or other parts that break off to form new plants).

Some pioneering biological field studies were done at Barro Colorado. C. R. Carpenter's study of the behavioural ecology of howler monkeys in 1934 was one of the first with truly objective observations, and has long stood as a model for students. Theodore Schneirla spent 35 years studying the ecology and behaviour of army ants (*Eciton* spp.) at Barro Colorado; his description of the social behaviour of army ants published in 1935 is a field biology classic. Frank Chapman first visited the island in 1925: his primary interest was in ornithology and he wrote 32 books and articles about the birds, and other aspects of the forest.

Technological advances have stimulated other studies on the island. Recently, Merlin Tuttle used light-enhancing, night vision devices and high-speed photography, triggered photoelectronically, to study the ability of bats to find and devour calling frogs in the nearly total darkness of the forest floor. Others have used tiny transmitters to study the movements of animals as small as bats, or radio tracking to study sloths and monkeys.

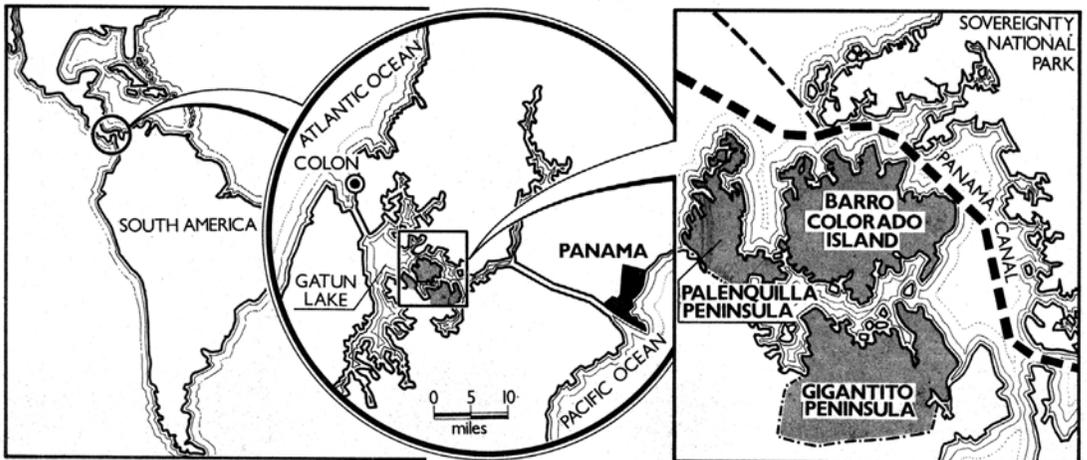
Because the island is too small to support resident

populations of some organisms, and because mainland forests are being destroyed and there is a steadily increasing demand for research space on the island, the Smithsonian applied for land-use licences for some peninsulas adjacent to Barro Colorado. In 1978 they were given three peninsulas on the east bank: Bohio, Buena Vista and Frijoles. Much of the land of these areas was farmed until then: the forests are considerably younger, and the fauna was impoverished because of hunting. The forest will eventually regenerate, but meanwhile researchers can carry out projects that are not feasible on the island, for example on the white-tailed deer (*Odocoileu virginianus*). Such species are adapted to the secondary growth that occurs in clearings and around young trees, and so no longer thrive on Barro Colorado. Clearings of a controlled size and known age of the peninsulas of the east bank will encourage such species without detracting from the health of the biological community.

The 1979 Panama Canal treaty assured the continued use of these peninsulas and also designated a similar buffer zone for the west bank. The Panama Canal Authority now leases two areas known as Palenquilla and Gigantito (see Figure), to the Smithsonian. Although they are not, as yet, completely inventoried or surveyed, we know that they include some types of habitat such as swamp forest that are not available on Barro Colorado.

The additional 3800 ha of mainland area on both sides of the canal presented the STRI with new problems; primarily that of protection. Although destruction along the banks was prohibited, enforcement was practically non-existent. In addition, small slash-and-burn areas had steadily spread, farmed by the people who were generally employed elsewhere and who would be in the area only when actually cutting, burning, planting or harvesting.

Hunters have been attracted to the area by the belief



Barro Colorado Island and Palenquilla and Gigantito, leased to the Smithsonian since 1979

species that normally live in dispersed populations have apparently been unable to sustain reproduction. There are no more white-lipped peccaries (*Tayassu pecari*): the island is probably too small to support even one of the large bands in which they live. On the other hand, capybara (*Hydrochaeris*), the world's largest rodent, have arrived within the past 10 years.

There is a similar variety of amphibians (32 species) and reptiles (28 species). Several species of anurans—frogs and toads—have been the subject of studies into systems of communication and partitioning of ecological niches. The largest reptile in the area is the endangered yellow crocodile (*Crocodylus acutus*) which is still fairly common around the island although it is hunted in other parts of Gatun Lake. Iguanas (*Iguana iguana*) have also been persecuted to the point of rarity or extinction throughout much of their range. They spend most of their adult lives in the treetops and are difficult to census, but they are abundant on Barro Colorado and probably occur there in approximately their natural density. They have a traditional, communal nesting site, which has been extensively studied.

Non-insect invertebrates include several species of freshwater crab, a lobster-sized shrimp, several species of scorpion, peripatus (*Onychophora*)—a strange, primitive creature half-way between a segmented worm and an arthropod—and various spiders including a large tarantula (*Sericopelma*). As for insects, there are at least 100 species of ant and 60 of termite. Henk Wolda of the STRI has found 1100 species of Homoptera (the cicada group), about a quarter of which are new to science.

The availability of a comprehensive flora has encouraged other investigations. A number of researchers have been



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Howler monkeys—objects of C. R. Carpenter's classic studies

that game animals must be plentiful if an area is protected. The lack of enforced hunting laws and the widespread use of dogs have completely extinguished the most popular species over a large part of otherwise suitable habitat. Those who hunt for sport are relatively easy to control because they are few and tend to be both conspicuous and more respectful of the law. Those who hunt for the pot or the market are more difficult to control. The length of broken coastline makes it easy for poachers to conceal their canoes, and because the trees deaden sound so effectively, gunshots can be heard only for a few hundred metres.

As soon as they had agreed on the west bank additions, the Smithsonian put up signs warning that entry is restricted. They cut 11 kilometres of trail along the Palenquilla and Gigantito boundaries, and put up a barbed wire fence along the entire length to keep out cattle from some of the adjacent farmed areas. The number of patrol wardens was increased from 7 to 15 and members of the Panamanian National Guard began to help out on a temporary basis. The wardens conduct foot and boat patrols

24 hours a day and seven days a week; they also conduct aerial patrols, particularly in the dry season.

Because the nature monument extends over a considerable part of the adjacent waters of Gatun Lake, the Smithsonian has bought large patrol boats. Vast areas of the lake are inaccessible to motor craft because of the tree trunks submerged when the Chagres River was dammed to form the lake in 1914, and so a zone of restricted entry, of about one to two hundred metres off shore, has been established. Anyone found within this zone in possession of firearms or dead game animals can be arrested and charged with poaching.

Once the boundaries and legal status of the nature monument were settled, the Smithsonian began to develop a management plan for the additional areas. Many researchers want a programme of clearing selected areas periodically so as to maintain samples of all stages of



Ocelot



Merlin Tuttle photographed this fringe-lipped bat, *Trachops cirrhosus*, as it emerged from its roost in a large hollow tree in Panama (above). The bat is attracted by the mating calls of frogs and swoops down to make a successful catch (right). To escape attack, frogs often sing from the protection of thorn bushes or noisy waterfalls

Some more of the denizens of Barro Colorado (below). The vine snake is one of 28 species of reptile; the tree frog, one of 32 species of amphibian. The spiders are quite simply astonishing and there are few areas where the endangered red spider monkey, *Ateles geoffroyi*, moves with such indifference to man



Two species of *Morpho* feed on *Gustavia*



Vine snake on *Heliconia*

Agalychnis tree frogs with eggs

forest regeneration. One proposed project would attempt to short-cut the lengthy process of natural regeneration by planting a mixture of late second growth and climax species on what was recently a rice-growing area; that is, planting species that normally would encroach only after several generations of pioneer species and other quick-growing types had come and gone. Another proposal is to try to find a native tree that will successfully compete with *Panicum maxima*, a fire-resistant, soil-debilitating African grass that has become a plague in much of the neotropical region.

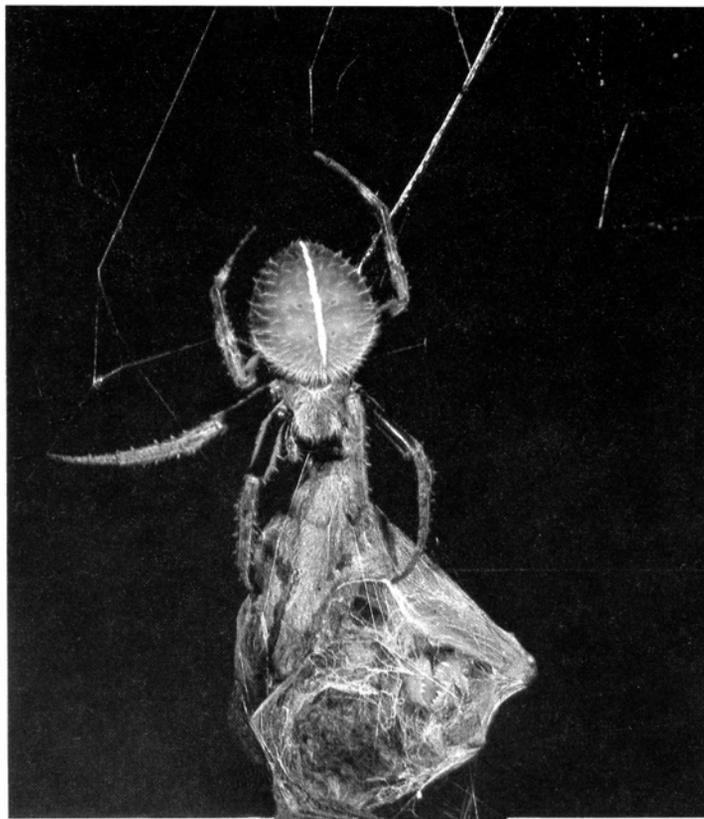
President Royo gave biological research in Panama an important boost when he decreed that the Republic's National Directorate of Renewable Resources (RENARE) should set aside 22 000 ha of forest in the former canal zone to be known as Sovereignty National Park. It includes the experimental Summit Gardens and the Pipeline Road Reservation, an area of some of the finest forest in central Panama, protected for many years because of a pipeline built during the Second World War. The new national park is contiguous with the nature monument and together they constitute over 40 per cent of the remaining forest in the watershed basin of the Panama Canal. We hope that the areas will allow for some of the larger rare species of birds and mammal, such as macaws, harpy eagles and jaguars, to be preserved. The prohibition of hunting, though still not entirely effective, has already resulted in a noticeable increase in some of the game species.

The nature monument and the national park are important components in the canal watershed. As such they govern, to some extent, the water supply for the canal and the country's two largest population centres. Because of their close proximity to the cities there will undoubtedly be pressure to use the Barro Colorado for recreation or agriculture.

Nevertheless Panama is now firmly committed to protect these unique resources and the decision to forgo small and short-term economic benefits will be offset by the area's future value as comparable regions of tropical moist forest disappear; several recent studies indicate that 50 per cent of existing tropical moist forests will have been destroyed by the year 2000.

With its new legal status and the continued encouragement of the US and Panamanian governments, Barro Colorado should serve as a model to catalyse the establishment and support of similar reserves elsewhere. □

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A spider catches a bat



A youthful red spider monkey

Photos by N. Smythe