Tropical Resources Institute

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Message From a Faculty Member

We have been bombarded lately with analyses of and proposed solutions to biological, ecological, economic, and sociological problems wrought by climatic warming. However, to develop effective solutions, it is necessary to see global warming in its environmental context. Greenhouse gases are but one aspect of a more general deterioration of the global atmosphere. Acid rain, a mixture of pollutants, now falls on substantial portions of North America, Europe, and Asia and may affect lakes, forests, and structures. A synoptic study of the chemistry of clouds and fog that impinge on North American vegetation found heavy contamination by acid rain. The stratospheric ozone layer is thought to be thinning due to chloroflourocarbon pollutants, and decreases in the ozone layer may permit biologically destructive UV-B radiation to reach Earth's surface. Ozone resulting from man-made air pollution is increasing at air-land interfaces and can cause major damage to crop plants and to natural vegetation. As chemical analytical ability improves, we are finding more evidence of long-range transport of pollutants; for example, pesticides sprayed in Alabama are now found in Lake Superior. Chernobyl dramatically brought home the fact that there is no such thing as local contamination of the atmosphere.

Contents

To gain focus on this bewildering array of environmental insults, we can borrow from economics. In the United States, the 1980s was an age of trade and budget deficits. We were deeply concerned about borrowing from the future and the effect of that deficit on the stability of global economics. But there is another deficit, deeper and longer lasting: the global environmental deficit. This deficit results from the collective and often unanticipated impact of our alteration of the earth's atmosphere, water, soil, biota, ecological systems, and entire landscapes. The social and economic costs to human welfare are ultimately greater than the shorter term benefits that flow from this activity. Anthropogenic alteration of global life-support systems produces not only climate change, but also loss of species, global loss of soil, forest destruction, desertification, and toxification of air, water, and land. Judging by indicators such as the net flow of greenhouse gases to the atmosphere or estimates of global erosion rates, the global environmental deficit is growing at an alarming rate. Like its economic counterpart, the planetary environmental deficit borrows from the future but is even more difficult to reverse and its implications are far greater.

The global environmental deficit demonstrates the magnitude of environmental problems and warns against proposed solutions that concentrate on global warming alone. The deficit is not caused simply by the generation of greenhouse gases, sulfur dioxide, or soil erosion, but rather by the growth in human population and the use and abuse of natural resources. To stop the growth of the deficit or eventually to reduce it, society must reevaluate economic systems that glorify growth and design social systems that seek human dignity, equity, and ecological and economic stability.

Growth and development of the world will continue as human populations move toward the eight billion mark in the 2020s and as governments strive to raise material standards of living. Thus we cannot expect the deficit to decline or even level off for decades to come. Our first objective should be to reduce the deficit's rate of growth. All sectors of society--from the individual to industry and government, from less-developed countries to developed countries, from nongovernmental organizations to the United Nations--should give the highest priority to developing lifestyles and policies designed to reduce global population growth rates and to use more efficiently resources such as energy, metals, soils, and forests.

F. Herbert Bormann
Oastler Professor of Forest Ecology
Director of Ecosystem Research
Yale School of Forestry and Environmental Studies

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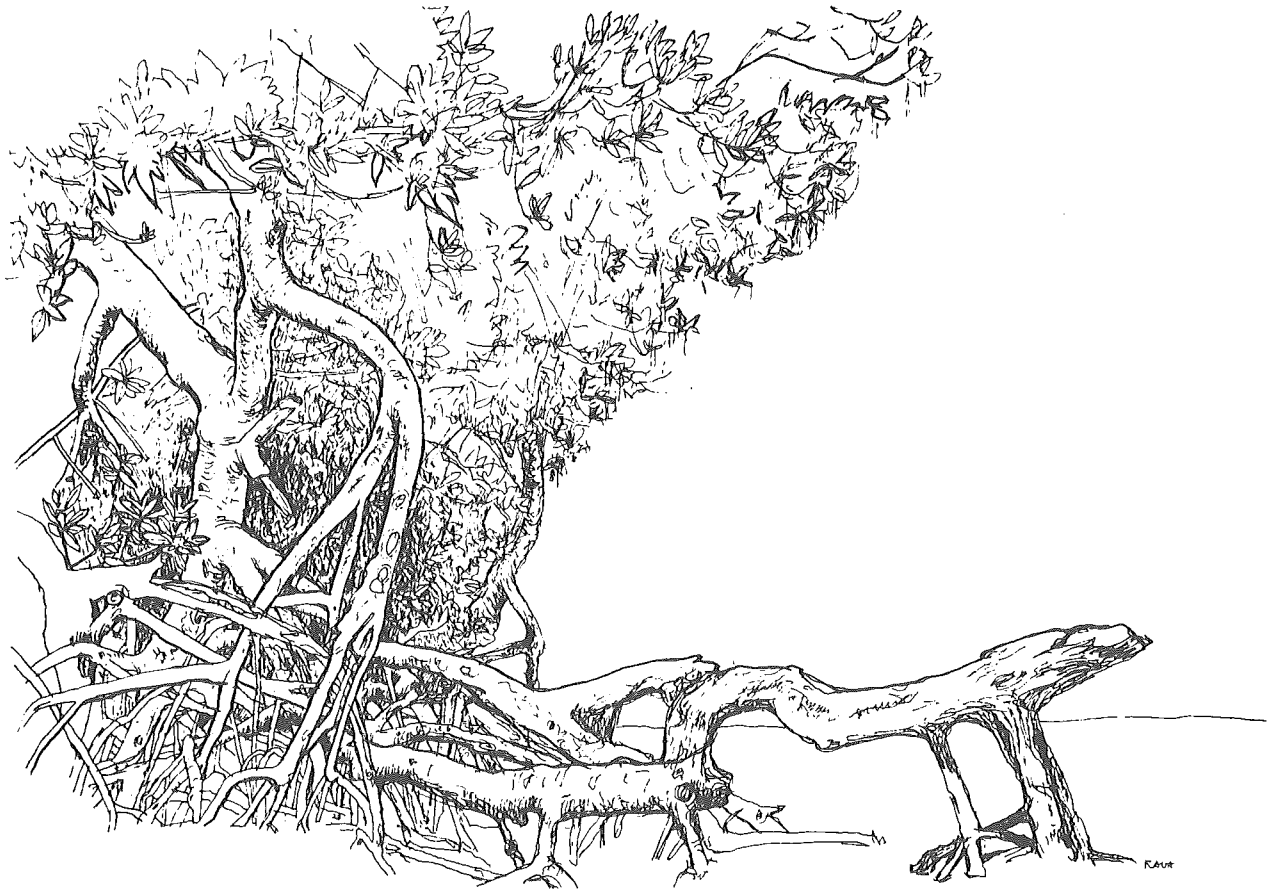

RESEARCH PROFILES

THE AYE-AYE LEMUR OF MADAGASCAR:
Feeding ecology, social behavior, and microhabitat

Eleanor Sterling, PhD Candidate
Betsy Carlson, MFS '89

Four hundred kilometers off the southeast coast of Africa lies the isolated island continent of Madagascar. Having separated from the African mainland at least 200 million years ago, Madagascar appears to have been in its present relative position for the last 120 million years (Rabinowitz *et al.* 1983). It is unlikely that plants or terrestrial animals have crossed the channel between Madagascar and Africa for at least 40 million years. This long isolation from the mainland along with the wide diversity of available habitats on Madagascar have resulted in the survival and radiation of ancient genetic lineages. Ninety-three percent of the island's primates and 80% of its flowering plant species are found nowhere else in the world (Jenkins 1987). Tragically, forest habitat on this unique island is fast disappearing, even before some of the most preliminary of field studies can be completed. At least 14 lemur species have become extinct since humans arrived about 1500 years ago (Dewar 1984), with approximately 24 species remaining on the island. All but the four smallest living species are listed as threatened in the IUCN Red Data Book (IUCN 1980-1985).

One such species is the aye-aye *(Daubentonia madagascariensis)*, the only living member of the primate family Daubentoniidae. An animal of great taxonomic interest, the aye-aye displays a suite of morphological features which distinguish it from all others. Once described as being made from "the spare parts of other animals," the aye-aye's peculiar morphology includes bat-like ears, rodent-like continuously growing incisors, claws on all digits but the first toe, a fox-like tail, a foreshortened face, and a filiform middle finger. It is about the size of a house cat and weighs 2.5 kilograms. This combination of features resulted in arguments over the aye-aye's taxonomic position for nearly a century following its discovery by scientists in 1780. Owen's (1863) anatomical study finally placed the aye-aye in the Order Primates.

As a consequence of its taxonomic uniqueness and endangered status, conservationists consider the protection of the aye-aye one of the highest conservation priorities in the world. This profile describes an on-going two-part study based on the PhD thesis work of Eleanor Sterling. It combines a study of aye-aye feeding behavior and ecology with a botanical evaluation of its microhabitat preferences.

The study area is the Special Reserve of Nosy Mangabe, an island located in the Bay of Antongil off the northeast coast of Madagascar. This 520-hectare reserve was set aside in 1965 as an enclave of natural habitat for the aye-aye, then thought to be verging on extinction. In 1967, nine aye-ayes captured in forests on the mainland were released on the island by Dr. Jean-Jaques Petter and colleagues. The island supports a moderately high forest canopy (30-35 meters), and evidence collected from this study thus far suggests that the founder population has thrived. The rain forest is characterized by steep slopes, boulder-strewn ravines, and thick liana tangles. Many tree species in this diverse flora are from such families as Lauraceae, Burseraceae *(Canarium)*, Clusiaceae *(Garcinia)*, Sapindaceae, Sapotaceae, Rubiaceae, and Ebenaceae (20 or more species of ebony, *Diopyros*). A variety of mammals shares the forest habitat with the aye-aye, including four other primate species.

Despite the aye-aye's endangered status and unique morphology, no long-term study has been undertaken of this animal in the wild. The main objective of this work is to investigate the behavioral ecology and social system of the aye-aye over a period of eighteen months. Eleanor Sterling is focusing on the role of the aye-aye's digits and dentition in food acquisition, its diet in the wild, and its social interactions. In collaboration with Betsy Carlson (MFS '89), microhabitat preferences and population density of aye-aye are being assessed on Nosy Mangabe, as well as in nearby forested regions on the mainland of Madagascar. This study will contribute to our understanding of four general issues in primate ecology: 1) the interaction between morphological and ecological specialization; 2) the relationship between body size and diet; 3) the degree of sociality in nocturnal primates; and 4) seasonal patterns of fruiting and flowering in tropical plants. Data collected will also be useful for developing a conservation management plan for this endangered species.

To assess aye-aye ecology and feeding behavior, Sterling and two field assistants conduct all-night focal animal samplings of radio-collared individuals. So far, five animals have been captured and affixed with collars, and the trapping effort continues. Ethological data are recorded on the minute at five minute intervals. Size,

Daubentonia madagascariensis

height and nature of supports are noted to determine patterns of substrate use. The researchers then retrace their steps during the day in order to plot activity ranges and confirm identification of food sources. As many animals as possible are tracked each day to their nest sites to aid in determination of home ranges and sleeping associations. Samples of all food sources are being collected for identification and subsequent nutritional analysis.

A series of 10x10 m plots are being surveyed to evaluate the forest structure. One set of plots is being placed at aye-aye nesting and feeding sites, and the other set is being placed randomly within the study area. The availability of different microhabitat types will be assessed using the latter, and will be expressed as a proportion of total forested area on the island. Plots established around feeding and sleeping sites will be compared to these estimates of microhabitat availability in order to determine microhabitat selectivity by aye-ayes. Within the plots, each tree over 10 cm dbh (diameter at breast height) is identified, mapped, and measured for height, crown diameter, and dbh. Forest structure is described by combining these measurements with an inventory of seedlings, small trees, dead trees, lianas, and epiphytes. A comparison will be made with neighboring mainland forests using similar methods.

Phenology—time of leaf formation, flowering and fruit formation— is a major determinant of food availability. This aspect of the botanical study focuses on tree species already known to be important to other lemurs on Nosy Managabe, particularly *Varecia variagata variagata.* A permanent phenology trial has been established by marking individuals of these and other common species. Food sources utilized by aye-aye are added to the study as they are discovered by Sterling. Flowering, fruiting and leaf-flush times are recorded monthly to provide a general picture of seasonality and insight into possible keystone food species of this tropical forest. This information is supplemented by plant materials collected every two weeks from fruit traps placed throughout the study area. The construction of the trials and collection of first year phenological data have been done in collaboration with Dr. George Schatz of the Missouri Botanical Garden, who is currently working on a flora of Nosy Mangabe.

One of the most important forest trees found on Nosy Mangabe is *Canarium* (Burseraceae). This tree is used extensively by humans and by a variety of wildlife. Local people cut boles for the construction of dugout canoes and process sap to make a glue for patching wooden boats. The fruits are heavily consumed by humans, lemurs, and wild boars. The branches provide sleeping sites for some lemurs. Because of *Canarium*'s value as a food source, Carlson is taking a closer look at the fruit production of this species. Thus far, the understanding of *Canarium* in Madagascar is poor; its taxonomy needs revision and its phenology is unrecorded.

The analysis of forest structure and phenology will facilitate the estimation of the distribution and relative abundance in space and time of different food sources, as well as the availability of different microhabitat types. Together, these data and observations of the behavior of the animals themselves will be used to answer basic questions about aye-aye ecology and to identify variables important in the selection of habitat by aye-ayes. This information is also important as it can be used in developing potential translocation schemes for individuals threatened by hunting or habitat destruction on the mainland.

Eleanor Sterling is a candidate for a joint PhD in Anthropology and Forestry and Environmental Studies. Her work is being supervised by Profs. Alison Richard and Steven Beissinger. She has received grants from the following: National Science Foundation (with Dr. Richard), National Geographic Society, Wenner Gren Foundation for Anthropological Research, World Wildlife Fund, Fulbright Program, and Enders Fund. Betsy Carlson received her Master of Forest Science degree from Yale F&ES. She is supported by the Royal Botanical Gardens, Kew.

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PROBLEMS OF MONTEZUMA PINE SEEDLING ESTABLISHMENT IN CENTRAL MEXICO: The need for renewing the pine forest

Francisco Becerra-Luna, Doctor of Forestry Candidate

INTRODUCTION

Of the 79 varieties, forms, and types of pines found in Mexico, *Pinus montezumae* is one of the most important. Taxonomically complex, genetically variable, and of outstanding economic importance, it is one of the most naturally widespread commercial trees. Its distribution is discontinuous and includes five main populations in Mexico existing in a wide range of environmental conditions (Jasso 1989).

In the central region of Mexico, Montezuma pine's primary habitat is the Sierra Nevada mountain range, where the tree has long dominated the ecology and economy of local communities. Today, however, natural regeneration of Montezuma pine is threatened by adverse ecological pressures. Young seedlings require shade or protective cover for successful establishment. Heavy logging and thinning have exposed seedlings, causing increased mortality from low nocturnal temperatures, extended periods of drought, and direct sunlight. Young seedlings also die due to pests, diseases, frequent fires, predation, grazing, and browsing (Musalem 1984). When mature stands are thinned, invasion by grasses, *Salix* spp., *Alnus* spp., *Pinus ayacahuite*, and *Abies religiosa*, is common (May 1971). These problems often have been responsible for the failure of natural regeneration of Montezuma pine in recent years.

Central Mexico's dense human population, the result of rapid population growth during the last three decades, is having a severe impact on the forests and associated resources of the region. Land use has undergone rapid change. Environmental pollution and water scarcity are increasingly problematic. Large domestic sheep herds are causing severe soil compaction, preventing establishment of new forest seedlings while encouraging grass to invade forest soil. The frequent use of fire every dry season by shepherds to increase forage yields is also destroying pine seedlings which emerged during the previous rainy

season. These fires also encourage grasses that thrive on disturbed sites. Grasses present a serious problem for pine seedlings which cannot compete with these hardy invaders.

Despite the economic importance of Montezuma pine, there is inadequate understanding of the silvicultural behavior of the species or of other important pines in Mexico. This has become a matter of concern in the last two decades as forest clearing has increased and regeneration failures have become evident (Musalem 1984).

Until recently, pine stands in central Mexico (including Montezuma pine) had long been subjected to commercial harvesting based on the selection method. Mexican law required adherence to a forest management system called "Método Mexicano de Ordenación de Montes," or Mexican Method of Forest Management. This system, which allowed felling only of large trees that met commercial needs, often amounted to high-grading and seldom made provision for establishment of new seedlings. During most of the last two decades, however, more deliberate methods (seed trees, shelterwood, and heavy thinning from below) have been applied according to the technique of the "Método de Desarrollo Silvícola." This new Method of Forest Development has permitted extraction of increased volumes of timber from the pine forests while heeding conditions for natural regeneration.

Increased logging in combination with grazing has resulted in *Pinus montezumae* growing in low-density stands throughout the area. These stands typically consist of an overstory of old trees ranging in age from 80 to 120 years. The amount of overstory pine is constantly diminished as a result of logging and natural mortality. A medium stratum of suppressed pines and other hardwoods such as *Quercus* spp. and *Alnus* spp. invades openings. The understory is composed of coarse clustered grasses (chiefly *Muhlenbergia macroura*) and other herbaceous plants that display a competitive advantage over the pine seedlings that will regenerate the forest (May 1971). Bunch-grass is fire-resistant and becomes thickly established as a result of the cycles of cutting, burning, and grazing widely practiced in the pine forests.

It is thought that throughout the evolutionary history of Montezuma pine, fires have been instrumental for the maintenance of characteristically pure, even-aged stands. However, unlike the frequent fires set by herdsmen, these were hot fires ignited naturally and fueled by years of litter buildup in the forest. Such fires may have provided a favorable seedbed of mineral soil and controlled competing vegetation. Exposure of the mineral soil and removal of litter, grass, and other vegetation are still required to prevent early competition. Now, however, yearly fires set by herdsmen are no longer beneficial to pine. Under present conditions, the exclusion of fire has seemed necessary to minimize the invasion of competitive grasses.

To investigate key microenvironmental factors affecting Montezuma pine seedling establishment, I have set up an experiment in a mountainous area of the central Mexican state of Tlaxcala. The Tlaxcalteca people graze sheep in formerly thick Montezuma pine forests and plant maize in forest clearings. With gradual declines in crop yields, the Tlaxcaltecas are realizing that their fields and forests are threatened. Mountain-dwellers in the states of Puebla and Hidalgo are faced with the same problem and have expressed concern about regeneration of the pine forests.

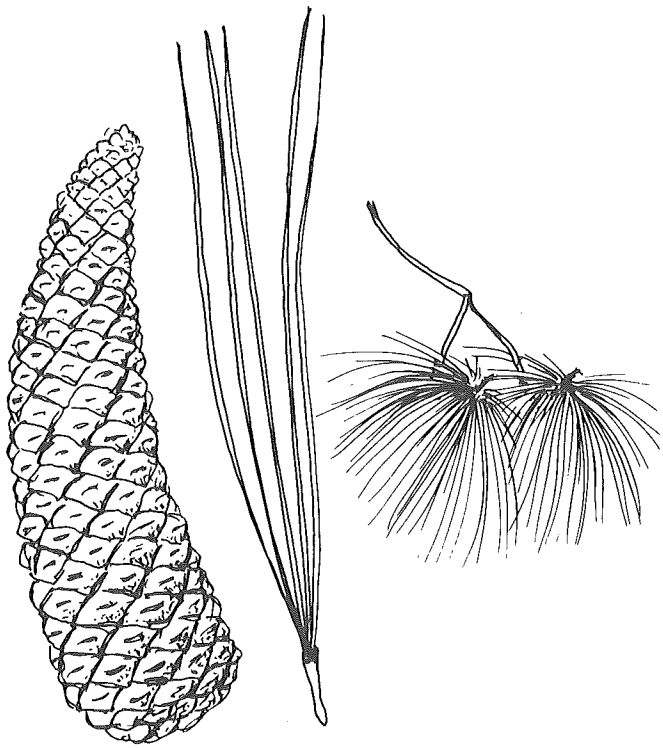
I have chosen the present experiment to test the hypothesis that even with the exclusion of fires and grazing, root competition from invading grass represents one of the most important factors preventing early establishment of Montezuma pine seedlings.

FIELD METHODS

In May, 1989, circular plots containing concentric circles of planted Montezuma pine seedlings were tested using four different treatments for grass. These were replicated three times under different pine and grass densities. Prescribed burning, herbicide application, and total grass removal by plowing were used to determine the rate at which grass roots reinvade the available growing space after treatments. The experiment includes untreated controls.

Records are kept of all vegetation surrounding each treated plot in an area of 36 square meters. Moisture, pH, temperature, and light incidence are measured within the plots. Soil core samples are collected to determine the density and rate of spread of grass roots as they develop from the edge towards the center of each plot. Some of the planted pine seedlings in the three circles have been removed to measure root development and biomass, the major seedling growth parameters at this time. Removal of seedlings has also allowed grass roots to invade the plot without competition. Remaining pine seedlings form concentric "barriers" which have an effect on the invasion rate of grass roots toward the center of the plot.

The study also involves an investigation of the anatomy, morphology, and ecological behavior of three different growth forms of *Pinus montezumae* seedlings. Some geographical races have seedlings that resprout after the tops are damaged. Others exhibit a grass stage in which seedlings do not grow in height for several years. This experiment is testing the hypothesis that these adaptations



Pinus montezumae

allow seedling roots to grow large and deep before height growth begins. It is possible that this phenomenon is an adaptation to grass competition.

RESULTS AND CONCLUSIONS

A preliminary statistical analysis of the first experiment showed that plowing produced the lowest grass root density. Herbicide and burn treatments also resulted in lower grass root density than the control. However, there was a large difference in effect between the herbicide and burn treatments in comparison to plowing. Plots with herbicide and burn treatments had at least seven times as much grass root regrowth than those with plowing.

The practical implications of these results are important. Many residents of the pine forest region are capable of cultivating small plots to reestablish pine stands. The costs of the most effective treatment-- plowing--are lower than the costs of herbicide treatment. Plowing of small plots appears to provide a means for reestablishment of pine which is within financial reach of the communal forest owners of the area.

Without accurate knowledge of the theoretical principles of silviculture, efforts to regenerate Montezuma pine in central Mexico may be unsuccessful and forest stands throughout the region would eventually disappear. It is most important that forest researchers understand this and recognize their role in resolving the problems facing mountain communities. Unless forest technicians receive further scientific training and the Mexican government imposes regulations to curb population growth in the central states, all inhabitants will continue to suffer a shortage of clean air and water, outdoor recreation sites, and timber. Most importantly, people living in rural and marginal areas will no longer have access to forest for timber and fuelwood or to productive agricultural and grazing fields. Only degraded land will remain.

ACKNOWLEDGEMENTS

Academic advisors for this study are Dr. David M. Smith, Dr. Graeme P. Berlyn, Dr. Kristiina A. Vogt, and Dr. Bruce C. Larson. Institutional and financial support for the project has been provided by Mexico's National Institute for Research on Forestry, Agriculture and Animal Husbandry (INIFAP) through the Research Center in the State of Mexico. Special thanks are given to three collegues from this center for their support: M.C. Francisco Moreno-Sánchez, Dr. Carlos Rodríguez-Franco (Yale F&ES '88), and M.C. Gil Vera-Castillo. I also thank Dr. Graeme Berlyn for the use of his facilities in Greeley Memorial Laboratory. Most of the background research on Montezuma pine underpinning this investigation has also been supported to some extent by INIFAP.

Francisco Becerra-Luna has served as Professor of Silvicultural Systems in the Department of Forest Science at the Universidad Autonoma Chapingo in Mexico and is Researcher of Silviculture at INIFAP.

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MASTER'S PROFILES

TAPPING ANCIENT WISDOM FOR MODERN CURES:
The undervalued role of native healers in U.S. medicinal plant research

Patricia Shanley, MES '90

The rapid loss of indigenous botanical knowledge and the proliferation of human suffering call for an urgent and cooperative international effort in the search for new plant-derived drugs. Historically, the US has lagged far behind the rest of the world in plant-based drug research. Rapid gains in synthetic chemistry quickly outstripped medical interest in cures from the plant kingdom. Yet revolutionary medical breakthroughs of the last half century made possible by reserpine, cortisone, and cytotoxins, all of vegetal origin, are causing a number of pharmaceutical firms and research institutions to leave the lab for the forest.

Plants and traditional healers quietly attend to the illnesses of 80% of the world's population. The rest of the people on earth seek their medicines not in the forest but in the drug store. One quarter of the synthetic medicines they buy contain natural compounds. Some are used to combat illnesses such as childhood leukemia, Parkinson's and heart disease. Traditional healers, not synthetic chemists, are responsible for initially discovering the uses of 74% of these drugs.

Perhaps briefer and more fragile than the life-span of the flora is that of the traditional healer. While ecological research describes the number, geographical distribution, reproductive capacity, and extinction rates of economically significant plant species, no such information exists on traditional healers. The tradition of natural healing is not being passed on, and so the ancient knowledge of natural medicine is vanishing.

The staggering medical importance of tropical plant species, plus the recent and irrevocable loss of these species, is impetus for an immediate plant collection and conservation effort. By the year 2000, 10-15% of the estimated 250-500,000 plant species on earth will become extinct. Of these, only a few percent have been tested for pharmacological activity.

The National Cancer Institute (NCI) has been the forerunner of plant-based drug development in the US. Between 1960 and 1980, and again in 1986, NCI funded an ambitious plant collection program designed to explore plants as sources of agents with anti-tumor activity. During the summer of 1989, as part of this effort, I worked as an intern for the New York Botanical Garden (NYBG) collecting samples within the lowland tropical rainforest of the Peruvian Amazon. Undercollected, yet rich in endemic species and traditional botanical knowledge, the Peruvian rainforest rates high in terms of site selection criteria.

PLANT SELECTION CRITERIA

For the purpose of drug development there are three methods of plant selection: chemotaxonomic, in which plant families with a high probability of active compounds are targeted; ethnobotanic, in which traditional knowledge is used to select species; and random, in which no selection criteria are used. Historically, NCI has funded random searches. Given the vastness of the plant kingdom, random searches are costly and time consuming. Researchers tested approximately 40,000 plants for 25 years and failed to identify a single agent of general use in the treatment of cancer. Program officers at NCI have called for an increase in ethnobotanical collections.

In Peru I worked with a NYBG ecologist, a local botanist, and a medical doctor who has compiled a list of over 100 plants used medicinally in the Iquitos area. Lacking a nearby forest in which to collect plants, urban dwellers obtain medicinal plants from open air markets. Piles of green herbs, textured barks, and colored tinctures are all for sale there. Particular species are reputed as useful against fevers, coughs, stomachaches and skin afflictions. Others are reported to give *buena suerte*, good luck, when added to bath water. Clearly, not all plants indicated as medicinal within one culture will prove cross-culturally effective. However, the narrowing of research focus made possible by carefully recorded ethnographic data has the potential to save research and development costs, lab time, and lives.

After obtaining the list of medicinal plants, we traveled by boat to rainforests up to two days away. In the forests, local villagers aided our efforts by scaling tall trees and scanning the canopy for fruits or flowers. Fertile specimens (those in fruit or flower) are necessary to ensure correct identification of the plant material to be screened in NCI's laboratories. When we discovered fertile trees, we prepared voucher specimens, then gathered and labeled wood, bark, and root samples.

KEYS TO SUCCESS

The majority of US plant-based drug research efforts

in the past have failed, not due to insurmountable obstacles or lack of promise within the plant kingdom, but rather to uncertainty of lab techniques, poorly documented plant collections, and lack of interdisciplinary team work. The only notable success of a large-scale US screening effort was that undertaken by a natural products chemist and his two high school graduate helpers for Eli Lilly Co. Instead of taking a random sample from the 500,000-odd plant species in the world, chemist Gordon Svoboda chose to look through many books to find plants with interesting folkloric uses. He selected 400 plants to screen. The 40th, *Catharanthus roseus*, the Madagascar periwinkle, showed remarkable antitumor activity. This small flower has yielded two anticancer agents of supreme importance, leurocristine and vincaleucoblastine.

In the Lilly case, folklore and teamwork paid off. Only five years after a crude antitumor extract was discovered, vincristine was marketed in the US and patent protection was secured. In 1985, profit for Eli Lilly Co. was 88% of the domestic and international sales, which reached $100 million. The market value for plant-based drugs within OECD countries is estimated to have been $43 billion in 1985. Given the current and potential value of plant-based drugs, the hesitancy of US industries to more actively fund ethnopharmacological research is unwarranted.

For ethnobotanical field work to be successful, the weak botanical infrastructure of US universities and pharmaceutical industries needs strengthening and expansion. Fortunately, rich repositories of traditional botanical knowledge survive in the developing world. Medicinal plant research is given high priority and respect in China, in the Ayurvedic tradition in India, the Unani Tibb in Pakistan, National Traditional Healers Association in Africa, and in the Latin American shamanistic tradition.

The plants and people who directly benefit from ethnobotanical research are described by economists as those with the "weakest ownership." Ailing citizens, aged shamans, and threatened trees are unable to rise up and insist on plant protection. Profit, the motivating force that may move large organizations into action, looks highly promising for ethnobotanical work. The unlikely pairing of the shaman leading the research chemist in the forest offers the best odds in curing people and saving plants.

LEATHERBACK TURTLE CONSERVATION ON CULEBRA ISLAND, PUERTO RICO

Vicki Nichols, MES '90

INTRODUCTION

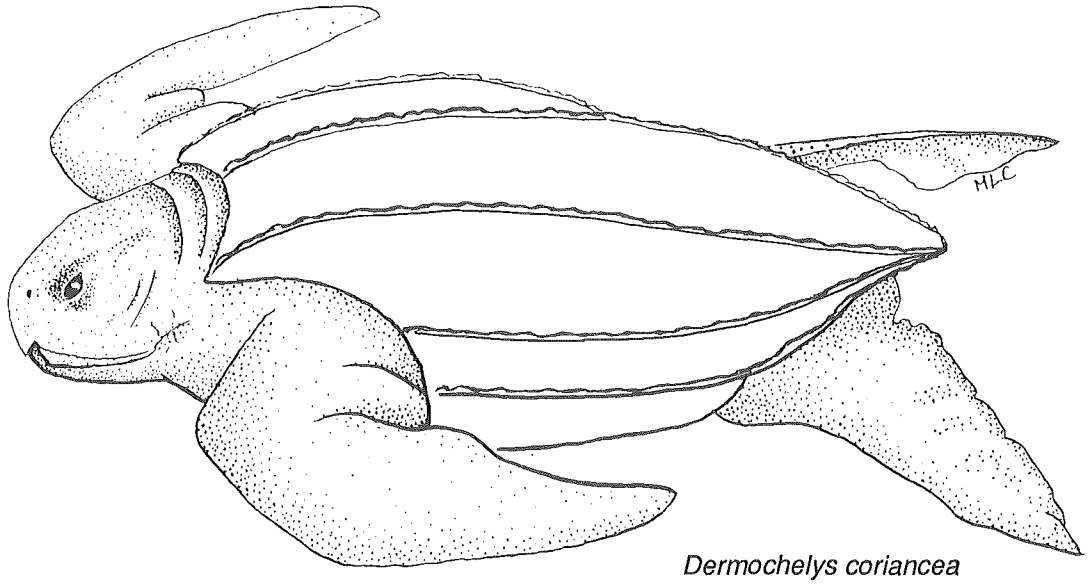
Hiking down a steep mountain slope, while battling thick forest to discover a beautiful starlit beach: this was to become a ritual for local citizens, the U. S. Fish and Wildlife Service (F&WS) staff, and Earthwatch volunteers involved in the Leatherback Turtle Project on the small island of Culebra, Puerto Rico.

Research on the nesting biology of the leatherback turtle has been an important project on Culebra since 1984. In 1976 and 1977, the U.S. F&WS sought to determine whether turtles nest on the island's isolated beaches. It was discovered that they did, primarily on two beaches, Brava and Resaca. Restrictions were placed on these beaches in 1982 to limit human use during the nesting season. In 1984, a tagging program and nightly patrols on Brava and Resaca began with the assistance of locals and Earthwatch volunteers. This project has yielded important information on the only two major leatherback nesting areas in the United States.

It is estimated that the world's population of female leatherbacks exceeds 115,000 individuals. Because males never return to land, it is impossible to guess their numbers. Many people question the endangered species status for leatherbacks with such high numbers, yet because the species faces numerous threats, full protection is justified.

LEATHERBACK TURTLE BIOLOGY

The leatherback (*Dermochelys coriacea)* is the largest marine turtle in the world, weighing up to 590 kg (1,300 lbs) with a maximum length of 2.4 meters (8 feet). It is distinct from other marine turtles in that it does not have a hard carapace, or shell; instead it is covered with a layer of tough, rubbery skin. Unlike other marine turtles, leatherbacks lack jaws with crushing plates, and can feed only on soft-bodied invertebrates like jellyfish. The front flippers are very long and allow the turtle to "fly" through the water. With superior propulsion abilities leatherbacks can travel great distances; individuals have been sited from New Zealand to the Arctic Circle. Because of their migratory abilities, great size, feeding habits, and unique anatomy, the leatherback has been classified in its own taxonomic family, Dermochelyidae. The remaining six marine turtles are in the Testudines family.



Dermochelys coriancea

Leatherbacks live in the ocean their entire lives except for the short period of time females spend nesting on the beaches and the brief journey hatchlings make from the nest to the water's edge.

Egg Laying

A few weeks after copulation, females make their way onto the sandy beach. It is a stressful time for a large turtle because in the ocean her weight is supported by the water. The journey from the waters edge to a nesting spot on the beach requires great strength and determination. As she moves, large tracks are carved into the beach surface, providing researchers with population estimates of the species.

No one is sure how a female chooses a particular beach or nest site. Theories suggest that an imprint occurs as the hatchlings venture down the beach slope, drawing the females back to the site when it is time to lay eggs. How she decides where on the beach to dig the nest remains a mystery; how far she moves away from the encroaching ocean and whether she avoids potentially intruding roots determine the success of the brood.

Every night during the nesting season in Culebra, we climbed the mountain and walked down the slope to the isolated beach. Once there, we broke into teams of two, switching off between reconaissance and sleep. We were looking for tracks or a nesting turtle. When a leatherback is finally found, it is an astounding spectacle — a 900 pound turtle digging a nest in the sand is not a mundane sight.

When a leatherback was spotted, we snuck up from behind, gently pulled a flipper to one side, and counted the number of eggs being laid. Carapace measurements were taken, and tags were connected to the flippers if there were none attached. Baseline data was collected on nest distance from the ocean and beach vegetation.

Results from these studies revealed that over the last two years, 33 leatherback turtles have nested on Culebra. It is estimated that one out of 1000 hatchlings will reach maturity. The Culebra beaches, it is anticipated, will produce about 11 mature leatherback turtles per season. Yet, we have no idea how many will be reproducing females.

Hatchling Emergence

About 65 days after the eggs are laid, 9 cm (3.5 in) leatherback hatchlings emerge and head toward the ocean. Birds, crabs, lizards, and mammals all pose a fatal threat, as do sand obstacles such as footprints or vehicle tracks. In order to determine hatchling success, it is necessary to examine the contents of the nest and cross reference the number of eggs and deceased hatchlings with earlier data. Unhatched eggs are opened to determine fertility and the developmental stage of the embryos.

Upon reaching the ocean, hatchlings encounter a whole new set of predators including fish, sharks, and diving birds. Researchers have found that to reach the surf, hatchlings orient themselves toward the reflection by the stars and moon on the ocean. Artificial lights coming from developed regions disorient the hatchlings, and they never make it to the sea.

In the sea, hatchlings are at the mercy of the currents. They draw nutrients from a residual yolk attached to their abdominal region until they reach a 'raft' of debris. The

rafts accumulate a variety of sea grasses, seaweeds, fish, jellyfish, larva from benthic invertebrates, and floating debris, providing food and concealment for the hatchlings.

LEATHERBACK THREATS

Egg poaching is the primary threat to leatherback turtles. High in vitamin A, eggs are a good source of protein and are eaten by many islanders. Eggs are also sought for their aphrodisiac powers. Nesting turtles are easily seen on the beach, and it takes little effort to collect freshly laid eggs, particularly in unprotected areas. In some parts of the world, a night's work can yield a poacher $200 to $300.

Another serious threat to leatherbacks is the ocean disposal of plastics. Leatherbacks consume plastics because the debris resembles jellyfish, their main food source. Plastics can get caught in the throats of turtles, blocking the passage of food and causing starvation. If indigestible plastics end up in the stomach, they impact the gut, killing the animal.

Finally, incidental catches from commercial shrimp trawls are one of the greatest threats to sea turtles.The National Marine Fisheries Service estimated that 48,000 sea turtles are captured and more than 11,000 drown per year. Of these, 9,250 are a combination of green, leatherback, and Kemp's ridley turtles.

CONSERVATION EFFORTS

To conserve any marine species, careful management procedures must be adopted to protect breeding stocks and to preserve appropriate habitat. For the past 20 years, various efforts have been initiated to expand our knowledge about marine turtles and to implement conservation programs. The three most common conservation practices on Culebra include tagging, beach protection, and community education.

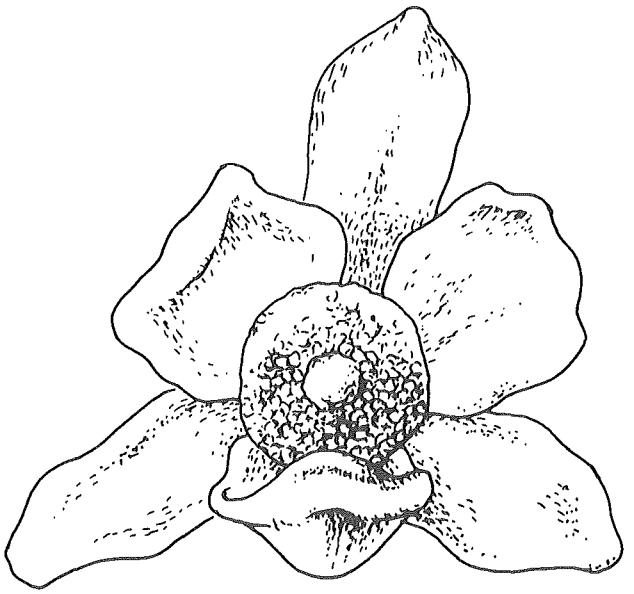
Tagging is commonly used to identify the individual turtle and to extrapolate information over a long period of time. Tagged turtles can yield information on migratory routes and geographic ranges, seasonal and lifetime breeding frequencies, location of nest sites, longevity, growth rates, and estimated population sizes. The problem with tags is that they fall off. It is hard to determine the longevity of a turtle when it carries a tag for only three years. Scars may remain after the tags fall off, but these are unreliable for determining specific information.

During the nesting season, Culebra residents and Earthwatch volunteers are stationed on the beach to deter poachers. Volunteers also relocate nests which appear threatened by intruding roots or water. However, a majority of nests are left in place. It has been found that in many cases when eggs are moved, the hatching percentage drops from 90% to 50-70%. As a result of beach patrols and camouflaged nest sites, poaching on Culebra has dropped to less than 5% compared with 1983 estimates of more than 85%.

CONCLUSION

Ultimately the most important component of a conservation effort is the active participation of the local people in the project. Education is a primary mechanism for community involvement, and has been essential in the success of the leatherback project.

Teresa Tallevast, project coordinator for the Culebra Leatherback Turtle Project, has been active in initiating community involvement. She believes that it is important to "provide incentives for local residents to become involved in their own island's natural resource conservation." In 1988, she employed islanders to assist with beach patrols and data collection, inspiring teachers, school children, summer camp groups, and families to assist in the effort. Tallevast's recognition of the importance of local involvement and her ability to encourage the community to work with the leatherbacks has made the program successful. As of June 1989, 227 local and off-island volunteers have contributed 2,979 hours to the leatherback project. The project on Culebra has worked in large part because the community has come to care about the animals. This part of conservation cannot be downplayed. It is essential to the success of a program and is the key to making conservation an international activity.



Fusaca longifolia

COOPERATOR PROFILE

THE NEW YORK BOTANICAL GARDEN - Institute of Economic Botany

In the heart of the Bronx, New York, a small unique group of professionals from the fields of botany, anthropology, forestry, ecology, nutrition, molecular biology, and economics join efforts in the study of the relationships between plants and people. They are scientists at the New York Botanical Garden's Institute of Economic Botany (IEB). Together they are striving to find, collect, and document valuable plants before overexploitation and habitat destruction eliminate these resources forever. Since the IEB's founding in 1981, the staff has carried out projects in Haiti, Belize, Honduras, Peru, Brazil, Colombia, Venezuela, Ecuador, and Indonesia.

In Haiti, where only 1% of the original forests remain, the IEB embarked on a project to save the world's rarest palm, *Attalea crassipheha*. When the project first began, there were only 3 or 4 individual palms of this species known to exist on the island. Seed collecting and the search for fertile palms had to be linked with conservation education if the palm was to be saved. Dr. Andrew Henderson, a specialist on palm taxonomy at the IEB, led several trips to Haiti. He and his colleagues found two dozen palms, of which 3 or 4 were seed-producing. Over 500 seeds were collected and distributed to individuals, tropical botanical gardens, and institutions all over the world. In addition, NYBG scientists and staff members worked with Haitian NGOs to encourage use of the palm in reforestation efforts. Thus the Institute has played an important role in saving this rare species from extinction.

The efforts of the IEB in Honduras have focused on high density plantings of various palm species for the production of palm hearts. Vast populations of wild species of the genus *Euterpe* have been destroyed for their hearts, a delicacy enjoyed in gourmet restaurants abroad. Since palms have a single meristem, they fail to resprout once they are cut down. Through trials using high density stands with up to 20,000 trees per hectare, the Institute has assisted in the development of a more sustainable alternative to forest destruction.

The IEB strongly believes in collaborating with local institutions or assisting in their development. In Belize, the IEB helped to create a small embryonic center known as the Ix-Chel Tropical Research Center Ltd. The center, named after Ix-Chel, the Mayan Goddess of Medicine, is devoted to ethnobotanical study, plant collecting, regional education, herbalism, natural healing, and other activities. Working with numerous herbal healers, the project is taking inventory of local plants used as food, fiber, construction materials, medicine, and other purposes. This effort, known as "The Belize Ethnobotany Project," is a long-term study of the utility of local forest plant species. It focuses on collecting, documenting, and preserving local knowledge about plant lore and use by the various cultures in Belize—Maya, East Indian, Mennonite, Creole, Garifuna, and Ladino (of Spanish descent). Approximately 750 plant species have been collected and catalogued for study. A primary goal is to test a broad variety of Belizean medicinal plants for possible therapeutic action against cancer and AIDS. In search of plants that can be developed into potential therapies, the Center's staff works with over a dozen *curanderos*, indigenous healers, collecting ethnopharmacopia used locally to treat various illnesses.

"A precursor to conservation is knowledge of what exists."

Most people of Belize have access to and seem to prefer the attractions of modern medicine. Because of this, medical practices and botanical wisdom held by the *curanderos* are dying out, with no one left to inherit the tradition. The ethnobotanists at the IEB represent a last opportunity to discover the knowledge of the healers of Belize, now 80 and 90 years of age. The directors of Ix-Chel hope the Belize Ethnobotany Project will provide an impetus for the preservation of indigenous cultures and knowledge as well as the tropical forest areas they inhabit, all of which are rapidly disappearing.

A precursor to conservation is knowledge of what exists. Certainly the job of those in the New York Botanical Garden's Systematics and Economic Botany programs is to inventory biological diversity in order to determine utility, management and conservation priorities for the world's vanishing forest resources. Through the collaboration of scientists and professionals from diverse disciplines, the Institute of Economic Botany of the NYBG is a prime example of the interdisciplinary, interactive effort needed for resource conservation, planning and utilization.

Alicia Grimes, Editor

COOPERATOR NOTES

The Caribbean Natural Resources Institute (formerly ECNAMP) has been assisting in the formation of a consortium of Caribbean universities with an interest in natural resource management. Fourteen universities have been divided into four groups according to language (Spanish, French, English, Dutch). The effort was initiated based on the premise that demand for specialized training is too small at each university to justify curriculum innovations. By pooling educational resources, however, specialized training can be offered to students in the region through traveling courses, visiting lectures, and short-term formal training.

The Caribbean Natural Resources Institute is a regional non-governmental organization involved in research, training, and development. The institute is currently focusing on four different areas: tertiary education, the management of natural parks and reserves, nature tourism, and community-based resource management. The Institute operates out of two main offices in St Croix and St. Lucia. For more information contact: *Mr. Yves Renard, Director-St. Lucia Office, Vieux Fort, St. Lucia, W.I.*

Nutrition gardens serving 150 families have been established in five neighborhoods in the village of Maun, Botswana by the **Botswana Biointensive Nutrition Project (BBIN).** The project, initiated by the Near East Foundation of New York, NY, offers assistance in establishing community gardens near public water taps. A villager trained in nutrition and horticulture oversees the project. The community receives hand tools and seeds to maintain the garden. Up to 12 additional gardens are planned which will use endemic perennials as fruit trees, vines, and living fences. The Near East Foundation co-funds and operates development projects in the Near East as well as in West and Southern Africa. For more information on the BBIN project contact: *Gaeage Moetse Maher, Co-Director, Botswana Biointensive Nutrition Project, P.O. Box 162, Maun, Botswana.*

In 1991 the **RARE Center for Tropical Bird Conservation** will repeat a study at Monteverde Cloud Forest Reserve in Costa Rica on the habitat needs of the resplendent Quetzal (*Pharomachrus mocinno*). The irridescent green and red bird, considered a deity by the ancient Aztec and Maya, inhabits the cloud forests of Central America. Last year, RARE Center used radio telemetry to determine whether established reserves do in fact protect this species. Dr. George Powell and Robin Bjork, assisted by Latin American biologists, attached tiny radio transmitters to track the birds to determine habitat ranges. The study yielded some surprising results: the birds crossed the continental divide and descended the Atlantic slope to an altitudinal zone not previously considered important to the Quetzal. **Carlos Guindon** (F&ES PhD Candidate), a biologist on the research team, contributed information on fruit availability which was directly correlated with Quetzal migrations. These findings indicate that montane reserves in Central America must be expanded to include lower altitudes in order to protect the Quetzal. A grant of $20,000 from the Burgoon Foundation enabled RARE Center to assist the **Monteverde Conservation League's** effort to acquire land adjacent to the Monteverde Cloud Forest Reserve. For more information contact: *RARE Center, 19th & the Parkway, Philadelphia, PA 19103.*

Bat Conservation International (BCI), based in Austin, Texas, hosted an international conference on the conservation of Pacific Island flying foxes (large bats). The meeting, attended by representatives from 14 island nations and states, was designed to inform islanders about the importance of flying foxes. Commercial hunting has caused a high incidence of bat mortality in the Pacific where between 15,000 and 25,000 flying foxes are eaten annually as a delicacy. BCI is now planning a bat conservation and education plan for the Pacific Region. As part of this effort, F&ES Master's student **Lili Sheeline** will assist by helping the people of Guam establish a public awareness and conservation campaign for bats. For more information contact: *Bat Conservation International Inc., P.O. Box 162603, Austin, Texas 78716-9721.*

The **Insitute for Tropical Rainforest Studies (ITRS)** in Queensland, Australia held a 'rainforest workshop' on May 4-6. The workshop focused on the research needs for conservation and management of tropical forests. Five priority programs for research were selected by the ITRS: the establishment of decision support systems, the reconstruction and rehabilitation of TRF ecosystems, the economics of rainforest conservation, the people/forest interface, and the sustainability of timber production. The ITRS operates out of the department of Geography at James Cook University in Townsville. *For more information contact: Dr. Mike Bonell, Director, ITRS, Dept. of Geography, James Cook University, Townsville Q 4811.*

*The **TRI** News welcomes any articles, news, and comments from our cooperators, friends and readers.*

TRI NOTES

GUEST LECTURES

On March 5th, IRG/ISTF brought **Roland Bunch**, World Neighbors Area Representative for Central America, Mexico, and Haiti, and author of *Two Ears of Corn*, to Yale F&ES for a day-long visit. After meeting with individual students, Mr. Bunch led a seminar on "Practical Approaches to Agricultural Improvement: What Limits Expansion?" He ended with a public address entitled "Scaling Up! Farmer-Led Agricultural Improvement in Central America." In both sessions he discussed the success of World Neighbors and appropriate and effective large-scale expansion of grassroots development projects. World Neighbors is an international grassroots organization that assists villagers in developing nations to raise food, plan their families, maintain and improve their health and start small industries using locally available resources.

Yale F&ES and IRG/ISTF invited **Enrique Bucher,** of the Center of Applied Zoology, Cordoba, Argentina, to the school on March 2nd for a talk about the notion of ranching parrots as a conservation strategy. Dr. Bucher believes that the destruction and overexploitation of the forest in Argentina can be mitigated by the sale of "approved birds" that are raised sustainably. Parrots became a fashion rage in the US and Europe in the 1980s; Argentina became a departure point for that lucrative trade. About 100,000-150,000 parrots are exported from Argentina annually. The present collection rates, not only in Argentina but other South American countries, are reducing parrot populations. Bucher's vision of parrot farming offers a sustainable alternative.

FACULTY & STAFF

Dean John Gordon traveled with William Bentley (chair), Thomas Geary (US Forest Service) and Dr. Sadikin (Winrock International, Indonesia) to Indonesia late last January; Carol Stoney, a Yale F&ES graduate, now working in agroforestry in Indonesia, also worked with the team. They were invited by the Minister of Forestry of Indonesia, under the auspices of the Winrock International/USAID F/FRED program. The purpose of the visit was to see if present and future employees of the Ministry might need or utilize graduate education. The team advocated graduate education opportunities for at least 500 Ministry employees over the next ten years. The goal is to enhance the skills of people doing natural resource management and environmental work. The team's work is part of a broader FAO study of Ministry personnel needs.

Professor William R. Burch, Jr., Prinicpal Investigator of the Nepal Institute of Forestry Project which Yale F&ES is conducting for USAID, has returned from Nepal after serving as the Project's interim senior advisor. Professor Burch helped push project activities forward during his four months in Nepal. Dr. Michael A. Rechlin, former Head of the Forestry Division of Paul Smith's College, assumed the post of senior advisor in March 1990. (Refer to issue #7 of *TRI News* for a more detailed description of the project.)

Betsy McGean, MES '86, has left after an excellent performance as Assistant to the Director of TRI to work with Seva Mandir, an NGO in India. There she is working with women and children in small villages on social and community forestry. She is also assisting the Ford Foundation evaluate their forestry and reforestation programs in India. Her address is: Betsy McGean, c/o Seva Mandir, Fatehpura, Udaipur 313001, Rajasthan, India. We anxiously await further news from her.

Dr. Brian Boom, visiting professor from the New York Botanical Garden (NYBG), took his Yale F&ES Plant Systematics class to Puerto Rico to make plant collections in the various ecosystems of the island. The students gained hands-on experience in identifying, collecting and mounting botanical specimens, some of which will be catalogued at the NYBG herbarium.

STUDENT NOTES

Yance deFretes, a first-year MFS student at Yale F&ES and graduate of Cenderawasih University in Indonesia, spoke and showed slides on Janurary 30th. He described his work with the World Wildlife Fund on the preparation and implementation of a management plan for the Irian Jaya Conservation Area in Indonesia.

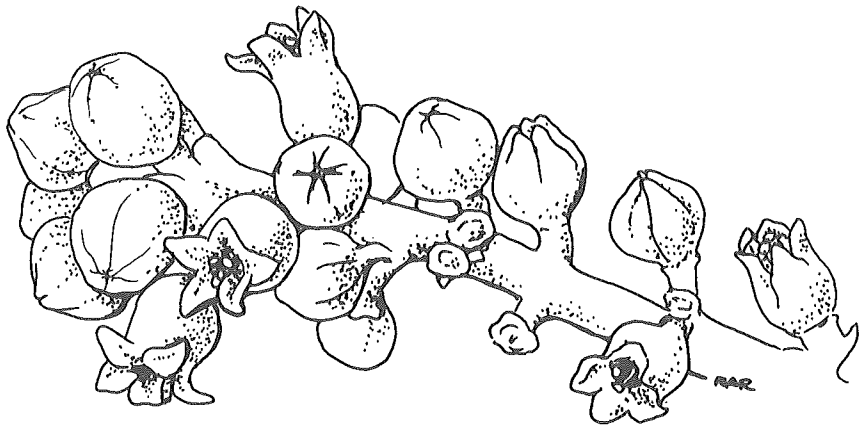
Second-year MFS student **Linda Lind** showed slides and served Fijian bevarages as part of her discussion of reforestation on Fiji Feburary 27th. During her three and half years of work for the Fiji Pine Commission, Linda designed a successful program in private plantation development which is still in use today.

Richard Carrol, a Yale F&ES DF candidate, lectured on April 25th about his work conducting a census of forest elephants (a subspecies of the savannah elephant) and lowland gorillas in the Central African Republic (CAR). Although his doctoral thesis is on the feeding ecology of lowland gorillas, Carrol has been sidetracked by the need to inventory the forest before it disappears. He has worked in CAR for 14 years, originally as a Peace Corps Volunteer. In 1983, he was asked by the Minister of the Interior of the CAR to survey the forest for wildlife and other natural resources. This led to the World Wildlife Fund-USA and CAR's funding of his present work. His talk was punctuated by many slides of the people and animals in the southeast reserve where he works.

CONFERENCES

"Environment and the Quality of Life: Lessons from the Third World" was the theme of a one-day workshop organized by student members of IRG/ISTF and held at the Yale School of Organization and Management on April 6. Led by distinguished professionals from abroad and the US, the workshop examined innovative approaches to environmental issues from the Third World, where socioeconomic and ecological problems are increasingly regarded and treated as an integrated whole rather than as separate issues. In the United States, where natural resources are becoming ever more thinly spread, and poverty and homelessness are on the rise, the time is ripe for new approaches to the concept of "environment," which include social factors affecting the quality of life. The challenge presented to workshop participants was how to best use the experience of colleagues in the Third World.

Three keynote speakers were joined by six leaders in community development, which headed working groups that discussed a wide range of environmental issues with a focus on solutions at the community level. The speakers included **Margarita Marino de Botero**, president of the Green College, a Colombian environmental advocacy organization, and member of the United Nations Bruntland Commission; **Chuck Matthei**, executive director of the Institute for Community Economics in Greenfield, Massachusetts; and **Yves Renard**, director of the St. Lucia office of the Caribbean Natural Resources Institute. Other working group leaders included **Mollie Beattie**, deputy secretary of the Vermont Agency of Natural Resources; **Foster Brown**, geochemist at the Woods Hole Research Center; **Emilio LaTorre**, sociologist at the Universidad del Valle, Cali, Colombia; **Deborah Schimberg**, executive director of the Southside Community Land Trust in Providence, Rhode Island; **Mike Wells**, economist in the Environmental Department at the World Bank; and **Ted Smith**, executive director of the Consultative Group on Biological Diversity. **Vernita Fort**, economist in the Bureau for Latin America and the Caribbean, AID in Washington, DC, moderated the workshop. Yale F&ES Master's students Helmut Gieben, Gary Helseth, Leslie Hudson, Marco Lowenstein, Sally Pick, and Juan Pablo Ruiz comprised the working committee that conceived and organized the workshop.



Licania spp.

The Tropical Resources Institute
Yale School of Forestry and Environmental Studies
205 Prospect Street
New Haven, CT. 06511
(203) 432-5117

For more information about the Tropical Resources Institute contact:

William R. Burch, Jr., Director
The Tropical Resources Institute
(203)432-5119

or

John C. Gordon, Dean
Yale School of Forestry and Environmental Studies
(203)432-5109

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