TRI NEWS

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THE FUTURE OF THE TROPICAL RESOURCES INSTITUTE

John C. Gordon, Dean

The current state and future of the Tropical Resources Institute (TRI) in our School and University is enviable in this era of academic retrenchment and uncertainty. Endowment now provides funds for internships, the Directorship, and related scholarships. We have an excellent leader; Dr. Florencia Montagnini, John M. Musser Director of the Tropical Resources Institute, is building a dynamic program on the solid and pioneering foundation built by Dr. William Burch, the founding director, and Dr. William Bentley, TRI's second director.

But what lies ahead? John Gardner is said to have remarked that if universities built cars, they would build Edsels (the Edsel was intended to be an avant garde automobile, but failed miserably in the market place). I think he meant that universities are particularly prone to create things out of their own musings, and that these may not fit what the society around them needs or wants. What evidence is there that TRI is not, or will not become, an Edsel?

Foremost, the answer must be external acceptance. Do students, other institutions, alumni, and (yes) donors continue to find TRI interesting and useful? Currently, we cooperate with over thirty other institutions, and student and alumni interest remain high. Several foundations and private individuals have recently provided major support. Things look positive now, but what of the future?

It seems to me that if TRI is to continue to receive external approval, and to help provide the people and knowledge to support tropical resources around the world, we must continue to change and enlarge our intellectual menu. Natural forest management, ecotourism, agroforestry and institution building will continue to be important. But it seems that we will, in the future, need to place greater emphasis on producing people and knowledge that effectively address human population problems. We are currently designing, with the Department of Epidemiology and Public Health, and the Yale Center for International and Areas Studies, a program that links human health, de- and reforestation, population movements and government policies. But this should only be the beginning.

It is possible to view most tropical (and other) resource depletion and management problems as caused by human population size and distribution problems. This perspective should be addressed, in the near future, by the Tropical Resources Institute and its cooperators. The future of TRI lies increasingly in the study of people in relation to resources, in truly integrated ways.

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A MESSAGE FROM THE DIRECTOR

Florencia Montagnini, Director

In the last issue of TRI NEWS (Fall 1991) we briefly stated the Tropical Resources Institute's present mission, goals and programs. TRI was originally supported by two three-year grants from the A.W. Mellon Foundation in 1983. Most recently, it has been endowed with a gift of $1,000,000 from the Musser Fellowship Fund as a program within the School. To date, TRI has succeeded in establishing six major programs to carry out its mission. These include: research, internships, field trips, publications and reference center, outreach, and the Tropical Studies Curriculum. The scope of its efforts has allowed TRI to expand operations into three regions: Latin America/Caribbean, Asia/Pacific, and most recently Africa. In this issue we are expanding on TRI's Tropical Studies Curriculum Program.

Over the past decade, the School has made earnest efforts to strengthen its tropical studies curriculum. Foremost in this endeavor has been the introduction of new faculty members whose research is relevant to tropical studies. These faculty include: Mark Ashton (silviculture), Steven R. Beissinger (wildlife ecology and conservation biology), William R. Bentley (forest resource management and economics), Kristiina Vogt (ecosystem ecology), and myself (tropical forest ecology and agroforestry). They join an already existing group of researchers with strong involvement in tropical as well as temperate ecosystems including Graeme P. Berlyn (anatomy and physiology of trees), F. Herbert Bormann (forest ecology), William R. Burch (natural resource management), Stephen R. Kellert (social ecology), Robert O. Mendelsohn (forest policy and economics), and Thomas G. Siccama (forest ecology). Visiting faculty such as Russell Barbour (African agronomy), Brian Boom (plant systematics), Art Johnson (soil science), Michael Balick (tropical botany), have supplemented the School's focus on the tropics.

In the last year, the Tropical Studies Committee has designed Science and Policy concentrations in Tropical Studies which offer 35 related courses. The curriculum is enhanced with course offerings from other departments such as Biology, International and Area Studies, Anthropology, and Economics. TRI also regularly sponsors lectures by visiting scholars. Some recent lectures include: "Agroforestry Extension and Education," given by Susan Huke of the International Programs and Forestry Support Program, U.S. Department of Agriculture and U.S. Forest Service; "Environmental Accounting: An Economic Approach Towards Integrating Environmental Impact Assessment in Natural Resources Management in the Tropics," given by Dr. Carsten Stahmer of the Federal Statistical Office in Wiesbaden, Germany; "Multidisciplinary Approach to Making Forest Management More Sustainable in Latin America," given by Robert Buschbacher, Director of the World Wildlife Fund's Tropical Forestry Program; and "Light Variability Within a Tropical Rainforest and Its Effects on Plant Growth," given by Dr. Robin Chazdon, Department of Ecology and Evolutionary Biology, University of Connecticut. Students in Tropical Studies have also organized conferences including "Planning for Amazonia: Incorporating Indigenous Peoples' Knowledge Into Land Use" which featured Davi Kopenawa, leader of the Yanomami people in Brazil. Students are currently planning a conference on the Himalayan region.

Increasing student interest in tropical and international studies is markedly evident. A 1985 grant from the Tinker Foundation provided the basis for cooperative student exchanges between Centro Agronomico Tropical de Investigacion y Ensenanza (CATIE) in Turrialba, Costa Rica, and Universidad Nacional Agraria (UNA), La Molina, Peru. TRI has also served as an umbrella for sponsoring foreign students under a variety of fellowships. In recent years, TRI has welcomed students from Nepal, Bangladesh, Puerto Rico, the U.S. Virgin Islands, and Chile, each supported by organizations such as the Ford Foundation, the Organization of American States, the Inter-American Foundation, the World Bank, the U.S. Agency for International Development, the MacArthur Foundation, and the Underhill Foundation. TRI has also administered funds from the Sequoia Foundation, the Tinker Foundation, and the MacArthur Foundation, to help send students on summer internships in the tropics.

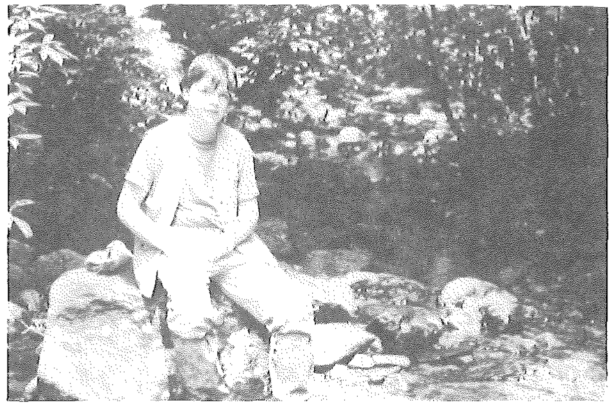
Students continue to conduct original research in the tropics. At the recent Eighth Annual Doctoral Student Conference held at the School, ten of twenty-four research abstracts presented were directly related to the tropics. Some abstract titles include, "Decay Rate and Substrate Quality of Fine Roots and Foliage of Two Tropical Tree Species in Puerto Rico," "Assessing and Managing Livestock Impacts on Wild Caprid Populations in Himalaya," "Behavioral Ecology of the Aye-Aye on Nosy Mangabe," and "The Political Ecology of Rural Development Forestry Land Use Decisions and Species Choices in Tribal Regions of Gujarat, India."

We will continue to expand on other TRI Programs in upcoming issues.

FACULTY PROFILES

Mark Ashton, Assistant Professor of Silviculture
Yale School of Forestry and Environmental Studies

Mark Ashton has been appointed Assistant Professor of Silviculture at the School of Forestry and Environmental Studies. His research is currently located in three complex forest regions; 1) Asian tropical wet-evergreen forest (angiospermous mixed-dipterocarp) concentrating in southwest Sri Lanka; 2) American temperate moist deciduous forest (angiospermous oak-hickory) concentrating in southern New England, USA and; 3) American temperate moist evergreen (gymnospermous cedar-hemlock) concentrating in the Adams Lake region of interior British Columbia, Canada.



Dr. Ashton in the field, Sri Lanka

His work is focused toward investigating seed germination and seedling establishment, and in particular, understanding physiological and morphological adaptations that allow individuals of closely related canopy-tree species to co-occur within the same forest. Comparisons are also being made between co-generic assemblages that have evolved within one forest region, and between assemblages that have evolved within different forest regions. Findings have theoretical implications toward understanding ecosystem processes that maintain tree species diversity within a forest. This work also has direct and immediate application in silviculture for the development or refinement of regeneration methods for complex natural forests.

In the tropics, Mark is working on several research projects in collaboration with Sri Lankan colleagues from the University of Sri Jayewardenapura, and the University of Peradeniya, Sri Lanka. For the last six years they have been investigating the germination and establishment patterns of the genera *Mesua* (Clusiaceae), *Shorea*, and *Dipterocarpus* (Dipterocarpaceae). These studies are continuing. However, enough information has been generated on the germination and establishment of canopy trees, and on the flowering and fruiting biology obtained by other investigators within this group, to test silvicultural manipulations that are focused toward sustainable management of this forest type. Studies are now being started to develop shelterwood methods for establishing natural regeneration, and for the testing and evaluation of enrichment planting guidelines of plant species that provide non-timber forest products.

ESTIMATING NITROGEN FIXATION BY TREES IN PUERTO RICO

Dwight Baker, Ph.D., John A. Parrotta, Ph.D., and Maurice Fried, Ph.D.

Since 1988, a project arising out of the Yale School of Forestry and Environmental Studies Program for Forest Microbiology has been attempting to estimate biomass productivity and nitrogen fixation of two important tropical trees, *Casuarina equisetifolia* and *Leucaena leucocephala*. The project is a collaboration between Dr. Dwight D. Baker, Lecturer and Associate Research Scientist at YF&ES, Dr. John A. Parrotta (Ph.D. '87), University of Puerto Rico and Institute of Tropical Forestry, USDA Forest Service, Puerto Rico, and Dr. Maurice Fried, National Research Council, Washington, DC. The project is sited at the University of Puerto Rico's Toa Baja Experimental Farm just west of San Jose on the northern coast of Puerto Rico.

The two species, *C. equisetifolia* and *L. leucocoephala*, were chosen because they are fast growing, are believed to fix high amounts of atmospheric nitrogen and are widely exploited around the world for reforestation, agroforestry and fuelwood. Nitrogen fixation by tree species is considered to be a desirable trait because such trees can grow in soils of poor fertility (low nitrogen). Actually the tree itself does not fix nitrogen, symbiotic bacteria living in root nodules on the tree perform the biochemical functions on behalf of the trees. Soils of low fertility are found widely in the tropics because of rapid litter decomposition and leaching, and thus utilization of nitrogen fixing trees can result in greater forest productivity or improved soil fertility. In addition to these two species, *Eucalyptus*

Sanjay Surange, Dwight Baker and John Parrotta (left to right) during plantation establishment

robusta is also included in the study as a "reference" species. It is also a fast growing species and is widely used all over the world.

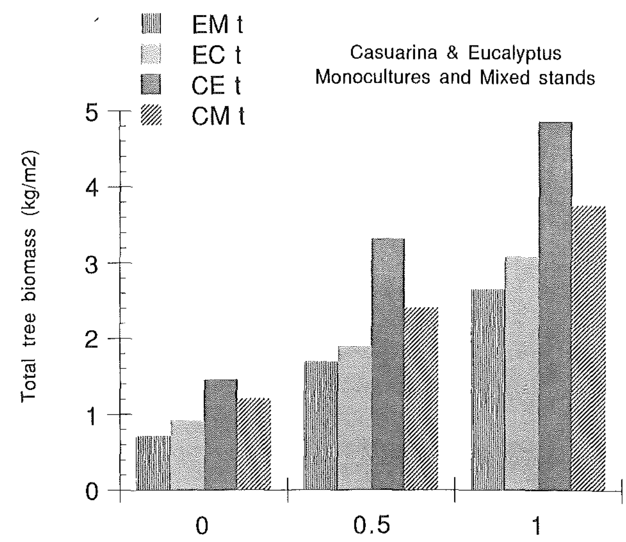
There are two major objectives of this project. The first is to determine whether mixtures of nitrogen fixing trees with Eucalyptus produce greater amounts of biomass than do monocultures of either species. Some preliminary work in Hawaii by the USDA Forest Service indicated that such mixtures can produce greater biomass. The second objective is to determine whether stable isotope methodologies can be used to estimate the amount of nitrogen fixed by the trees. Stable isotope methods are routinely applied to agricultural legume crops to estimate nitrogen fixation and it was believed that such a technique, if modified for the special problems of trees, could more accurately estimate nitrogen fixation than other more tedious methods.

View of the plantation after one year of growth

The concept behind stable isotopic estimation is elegant yet simple. The majority (99.6337%) of nitrogen in the earth's atmosphere exists in the isotopic form bearing a molecular weight of 14. However, a very small amount (0.3663%) has a molecular weight of 15, is stable (does not decompose into another isotope and is not radioactive) and can be distinguished from the smaller isotope by a mass spectrometer. If a non-nitrogen fixing tree is planted in a soil containing a higher amount of nitrogen-15 than that of the atmosphere, the nitrogen found in its leaves, stem and other tissues will contain the amount of nitrogen-15 as that of the soil. On the other hand, a nitrogen fixing tree planted in the same soil will get some of its nitrogen from the atmosphere and some from the soil so that the amount of nitrogen-15 in its tissue will be less than that of the non-fixing tree. This reduction in nitrogen-15 as a result of nitrogen fixation is called nitrogen-15 dilution. By mathematically comparing the amount of nitrogen-15 in the fixing and non-fixing tree, one can determine how much of the nitrogen was obtained from the atmosphere.

Although this seems simple to do in theory, conducting an experiment in practice with trees is difficult because trees are very large and have the capability of storing large amounts of nitrogen. One could overcome any problems by digging up entire plants, extracting all the nitrogen and analyzing for nitrogen-15, which is exactly what is done for small agricultural plants, however, this is impractical for trees. In addition, over many years trees start to recycle nitrogen from within their tissues, or from

Biomass harvesting operation at one year; John Parrotta in center



that lost through litterfall. This complicates the estimation of nitrogen fixation by nitrogen-15 dilution. By carefully following this tree plantation in Puerto Rico over 3-4 years, a correction method will be devised to alleviate the problem of any recycled nitrogen.

After two years of growth, the trees have achieved heights of about 4-7 meters, a dramatic demonstration of the potential of fast-growing trees to produce biomass. Figure 1 illustrates the biomass accumulation after just one year for Casuarina and Eucalyptus. Even at this early stand age, mixed stands performed better than monocultures.

Using the nitrogen-15 dilution calculations, we determined that both Casuarina and Leucaena were fixing approximately 60% of the nitrogen in the tissues of the tree over the first two years of growth. In reality, what may have happened is that the trees fixed much less nitrogen (perhaps as low as 25-30%) when they were young and their nitrogen demand did not exceed soil nitrogen availability by much, and fixed almost all of their nitrogen (perhaps as much as 90-95%) during the latter part of growth, when soil nitrogen availability was limited. It is difficult to know whether the average of 60% can be dramatically influenced by environmental factors until we start looking at fluctuations in nitrogen fixation over time. To assess such fluctuations we must apply the mathematical corrections for recycled nitrogen, a procedure which we are just beginning to do. We hope that within the next year, we can identify the contribution that nitrogen fixation makes to tree nutrition and to predict how much of that fixed nitrogen can result in improvements in soil fertility. We expect that from our results we will be able to design more ecologically sound forest plantations for the tropics.

SUSTAINABLE HARVESTING AND THE CONSERVATION OF PARROTS

Steven R. Beissinger, Associate Professor of Wildlife Ecology
Yale School of Forestry and Environmental Studies

New World parrots are widely prized for their colorful plumage and some species' ability to mimic speech. From 1982 to 1988, more than 1.8 million parrots were legally exported from Latin American countries to the United States (80%), the European Common Market countries (15%), and Japan (3%) (Beissinger & Bucher, 1992). Estimates of parrot mortality before exportation and the magnitude of illegal smuggling indicate that two to three times as many birds were actually removed from the wild. As a consequence of the "unsustainable harvesting" of wild birds for the pet trade and the systematic destruction of their forest habitats, up to one-third of the 140 parrot species found in the western hemisphere are nearing extinction and the populations of non-threatened species are declining (Yale, 1992).

To conserve endangered parrot species and their forest habitat, Steven R. Beissinger, associate professor of wildlife ecology at the Yale School of Forestry and Environmental Studies, has been studying the possibility of establishing parrot "ranches." Parrot ranches in tropical forests would provide a new 'crop' that, in addition to fruits, rubber, exotic plants, spices, and pharmaceuticals, could contribute to making forests more economically valuable when left standing than when harvested for timber or for cattle production.

Dr. Beissinger is working with Enrique H. Bucher, the director of the Center for Applied Zoology at the University of Cordoba in Argentina, to develop a model to guide sustainable harvesting when biological data on the affected population is incomplete. Applying this model to parrots indicates that a population managing to increase the number of nestlings could have those nestlings sustainably harvested over time. It is advantageous to harvest nestlings both because they make better pets and have relatively low survival rates in the wild. Field experiments in Venezuela involving green-rumped parrotlets (*Forpus passerinus*) reveal that the number of nestlings can be increased through the creation of artificial nesting sites.

Such parrot ranches could be economically viable and each would be licensed and regulated. Modest financing from international conservation organizations could help organize the political structure and train the necessary field biologists in parrot biology. Similar ranching approaches have been used successfully to raise alligators in Venezuela, butterflies and crocodiles in Papua New Guinea, game in Africa, and iguana in Central America. By preventing the exploitation of parrot populations and preserving their forest habitat, parrot ranching could break the dual causal chains shown in Figure 1 that have led to disturbing reductions in the populations of New World parrots.

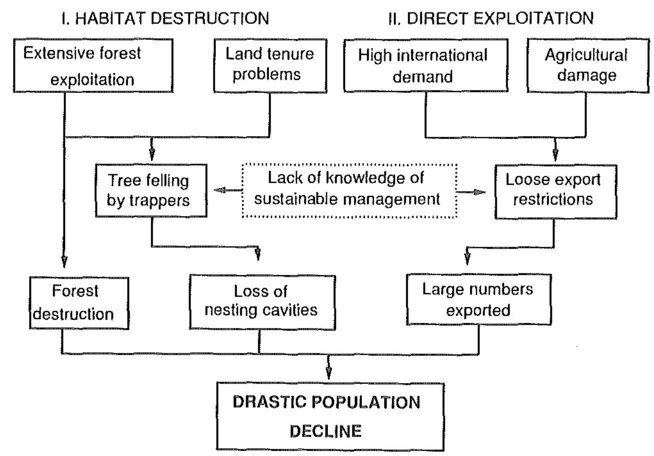


Figure 1. The dual, separate causal chains that have led to drastic population declines of neotropical parrots through habitat destruction and exploitation for the pet industry. The proximate causes of the demise of parrots toward the bottom of the figure are driven by the ultimate factors at the top. A poor understanding of sustainable practices connects both chains. Both chains must be broken if conservation efforts are to be successful. (After Bucher in press.)

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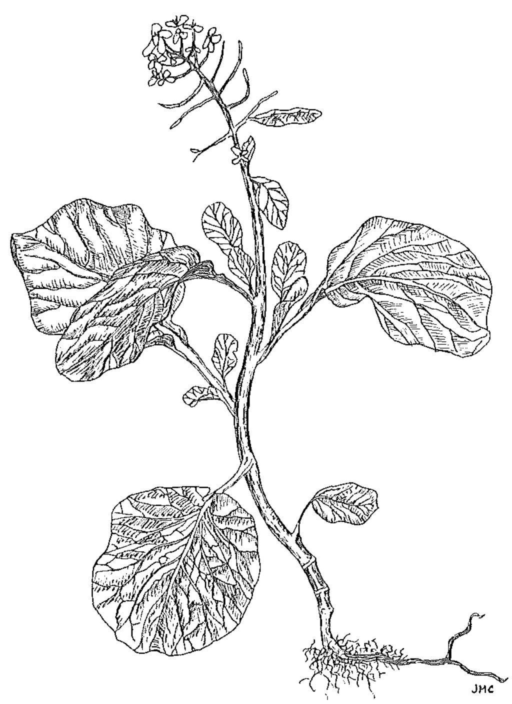
MANAGEMENT LESSONS FROM TROPICAL FORESTRY

William R. Bentley, Director, Weyerhaeuser Center in Forest Resource Management and Policy
Yale School of Forestry & Environmental Studies

While we still talk a lot about North/South transfers of technology and institutional designs, the time has come for the developed nations to absorb ideas that have developed in tropical contexts. Forestry in both the tropics and the West has common Germanic roots, generally focused on management of trees and stands on public or industrial estates. Many forces have stimulated major rethinking about what forest resources are and how to manage these resources for multiple purposes in the wide variety of tropical and temperate contexts. The basic ideas have evolved considerably over the past century. Rapid population growth, a multitude of economic changes, and inadequate definition of property and tenure rights have been critical social forces in most tropical nations. Exploitative harvesting, conversion of land to crops and pastures, and degradation of massive areas are the obvious overt symptoms. The causes of these symptoms still are not fully understood. Understanding these causes are the first important lessons to be learned. The second set of lessons will broaden our perception of management problems. Forest resources are not just commercial timber or even the concrete goods and services of multiple-use forests. They include all the forest ecosystem, its diversity and its soils, and they potentially include all the lands that could be covered with woody plants and associated perennials. The current definition and perspective of forestry as a set of applied disciplines and what the professional forester is concerned with in terms of resources is too narrow. Perhaps the most dramatic lessons to learn are in the realm of relationships between forests and people. The dramatic downward spirals of resource productivity observed during deforestation, while overtly biophysical in character, more fundamentally are caused by social mechanisms. Interventions based on technology alone will not work and often exacerbate the symptoms.

Institutional changes are necessary, especially in the definition and enforcement of use rights and in the creative development of markets. However, the most critical institutional change is the involvement of local people in the planning and management of forest resources. This is a difficult change for forestry organizations and their professional staffs to master—as the USDA Forest Service well knows. Local participation is necessary for several interrelated reasons. Protection of forest reserves for purposes of biodiversity requires protection by the people surrounding the reserves. Only with their involvement can agroforestry technologies and social forestry management systems be developed that will provide adequate food, fuelwood, fodder, and other flows necessary for local livelihoods. Without livelihoods for the poor, biodiversity is a lost cause. Some environmental advocates may gloat over the demise of foresters as timber estate managers. They, too, will give up power as the definition of forestry includes biodiversity and management, including protection, shifts towards open, participatory processes. Forest resources, however defined, cannot be protected by soldiers and guns. They can be protected and managed by local people, who fairly share in the net benefits of productive and sustainable systems. The most important reason is that much of the world's future forest will be on private property, mainly farms, or on public or commonlands, but with long-term tree or land tenure for village-level organizations. For all these reasons, forestry agencies will shift from an estate focus to roles as advisers and facilitators to work on-farm in research and extension. Foresters will have far less control than they traditionally have assumed, and most resource management units will be small rather than large. The interpretation of lessons to new contexts always requires creative insight. Tropical villagers could teach American public agencies some lessons in how to involve local poor people, who often are illiterate and non-verbal, in forest planning. Winrock International is adapting some of the lessons of social forestry and agroforestry overseas to rural Arkansas, and Yale's Urban Resources Initiative demonstrates the power of participatory forestry to inner city contexts. Learning these kinds of lessons is critical to the future of forest management in both the temperate and tropical regions.



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RESEARCH PROFILES

SOCIAL DIMENSIONS OF AGROFORESTRY AND PARTICIPATORY FORESTRY EXTENSION FOR RESOURCE-POOR PEOPLE: EXAMPLES FROM GUJARAT, INDIA

Sarah T. Warren, D.F. Candidate
Yale School of Forestry and Environmental Studies

Most people are predisposed to learn and to teach. This characteristic propels all extension work, for at the heart of all such programs is the desire to share knowledge. Agroforestry extension is motivated by the perceived need to expand our knowledge of an old system and extend its use to new frontiers in order to improve the quality of life for both individuals and society at large. The transmission of participatory and agroforestry techniques and technology is the result of three factors: 1) expressed needs of producers/beneficiaries (e.g., for higher productivity and income); 2) new ideas or discoveries (e.g., of hybrids or varieties); 3) collective goals (e.g., state policies intended to increase productivity and efficiency).

Within traditional viewpoints the mechanisms by which these are transmitted are simple. Extension links the researcher (or producer of new techniques and technologies) with the farmer (or producer of goods and services) in a triangular system with balanced flows of information and feedback (figure 1). Some formalized extension systems, however, have been criticized for collapsing this triangular model into a unidirectional linear one, where feedback loops are weakened or disappear entirely (figure 2).

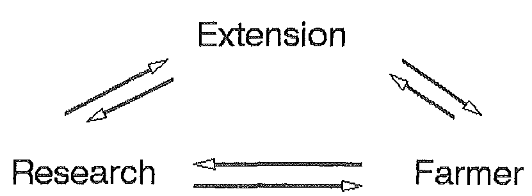

Figure 1. Multidirectional extension with feedback opportunities

Agroforestry and participatory forestry are complex systems. The recognition of site-specificity, inherent in any good agroforestry plan or design, favors a "splitting" rather than a "lumping" approach. Splitting enables us to look at multiple variables, carefully assess existing conditions and options, and then reassemble components into clusters designed to satisfy reasonable social and biophysical criteria. The re-weaving process reinforces the integrative approaches that are preconditions for optimal agroforestry and participatory forestry.

Figure 2. Collapsed extension model with weakened feedback loops

Extension must also reflect these complexities, but it can be impeded by defining conditions and options as "either/or" situations. Rather, viewing these conditions and options as moveable points on a continuum allows us to consider changes over time. Points on a land capability continuum are allied with other points on a tenure/usufruct continuum. Both may be related to climate zonation (figure 3).

Social descriptors of the beneficiaries or "target" popula-

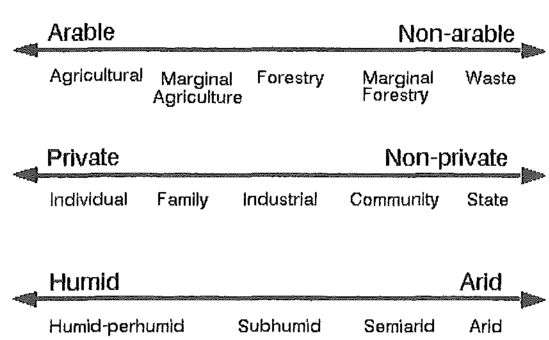

Figure 3. Land-use patterns showing capability, tenure/usufruct, and rainfall continua

tions of extension are frequently placed on continua. "Adopter" classifications (figure 4) have unfortunately prejudiced many extension specialists. As we move to the right on this line, we encounter increasingly pejorative designations. It may be more practical, and certainly more beneficial, to split this into several other continua that offer potential solutions to extension difficulties. For example, literacy conditions, which may additionally have a gender variance, will affect the choice of options for agroforestry and participatory forestry extension methods, whereas infrastructural conditions such as roads may affect the frequency of extension visits or placement of extension specialists (figure 5).

High adopters ⟵⟶ Low adopters

Innovators | Early Adopters | Early Majority | Late Majority | Laggards

Figure 4. A biased set of beneficiary classifications

Literate ⟵⟶ Non-literate

Male and female | Male only | Female only | Male and female

Developed roads ⟵⟶ Undeveloped roads

Highways | Metalled roads | Dirt roads | Cart tracks | Footpaths

Figure 5. Alternate beneficiary classification examples: male and female literacy; transportation

Traditional extension systems, founded on the belief that investment "at the margin" is inefficient, often ignore distant sites and distant people. In countries such as India, where the quantity of so-called marginal or waste land and the persistence of poverty among marginal people—low resource farmers, the landless, women, tribals—are significant, the location of the margin must shift. Agroforestry and participatory forestry, which benefit from long time horizons and inherently multipurpose objectives, can profitably function at sites "marginal" for agriculture.

In the eastern districts of Gujarat, India, where teak and dry mixed deciduous forests once covered hills inhabited by tribal people *(adivasis)*, several innovative agroforestry and participatory forestry programs have been initiated.

The Sadguru Water and Development Foundation (SWDF) is a non-governmental organization (NGO) based in the Panch Mahals district. It focuses on three objectives: 1) the conversion of privately owned, degraded land that is hilly and uneven to tree crops in order to create self-sufficiency in fuel and other wood requirements; 2) the improvement of economic conditions by providing sources of regular income, especially to decrease seasonal out-migration; 3) and the improvement of village environments where fast-growing tree species and fruit trees are planted in blocks, strips, and along water-courses.

Operating in such farm forestry activities since 1982, SWDF has focused on expansion and motivation rather than on traditional technical extension. Success within neighbor's farms or neighboring villages, for example, the construction of new houses or sale of trees during drought, serves as demonstration of utility. This is reinforced by the easy availability of seedlings grown in decentralized nurseries under the management of local women. Expansion of the number of participants is further aided by the use of folk theatricals, the exchange of visits between villages, and the insertion of tree consciousness messages into other SWDF activities such as health care, lift-irrigation cooperatives, etc.

Working in Bharuch district since 1985, the Aga Khan Rural Support Programme (India) (AKRSPI) is an NGO that until about 1990 concentrated its forestry activities on public lands. Arranging for the usufruct of revenue department lands and voluntarily protecting forest department lands, three reforestation strategies have been adopted: planting nursery-raised seedlings in blocks; protecting natural regeneration of forest trees; and enrichment planting within sparse natural regeneration. AKRSPI's objectives are 1) to better utilize public and private wastelands; 2) encourage self-reliance among tribal people and enable their village institutions to maintain long-term responsibility; and 3) ensure that benefits reach the poorer sections of the community through wage employment.

AKRSPI depends on the establishment of a village institution to channel its extension activities. These bodies identify land, choose species to plant, identify beneficiaries for employment in nurseries and site preparation from among poorer households, and administer membership and savings/credit schemes. Certain members are selected by these village institutions to become extension volunteers. They are trained and motivated to strengthen not only their own technical capability but also the village institution's sense of group accountability. These extension volunteers assist in the recently adopted participatory appraisal process, which is one of the most successful motivation tools to ensure that AKRSPI programs match local needs and knowledge.

The Surat Working Circle (SWC), in the territorial division of the Gujarat Forest Department, has little responsibility for agroforestry or farm forestry; it is restricted to gazetted forest land in south Gujarat, much of which is no longer productive because of over-exploitation. Throughout the early and mid-1980s, hostile interactions between *adivasis* and forest officers were common, and a new strategy of participatory forest management had to be developed.

The SWC drew on local village leaders, youth groups, and members of other civic groups. It organized a series of travelling rallies throughout the most hostile forest areas, and has used village meetings, films, environmental song and dance festivals, and tree planting programs to recapture people's support and interest. It has encouraged and assisted the formation of village institutions to focus on forest protection and replantation. These bodies bring social pressure on offenders and reinforce social fencing; they assist GFD staff in identifying persons who need employment; and maintain linkages with other village institutions. In attempting to go beyond traditional "scientific management," the objectives of the SWC have become: (1) to create awareness and educate people in prudent forest use; (2) to find alternatives for forest products to reduce forest pressure; and (3) to return to the forests of 50 years ago. Motivation thus depends on education, village organization for forest protection, with occasional opportunities for employment in reforestation. At present SWC and NGOs such as AKRSPI have begun to collaborate through overlapping village institutions.

These three organizations have consciously targeted people and lands on the margins—the NGOs by choice and the SWC by default. Through their encouragement and support of local leadership and village institutions, they are shifting the position of *adivasis* beyond the constraints suggested in figures 4 and 5 towards a more fully participatory mode. Each institution has found a source of change agents from within; collectively they widen the three-cornered traditional view of extension (figure 1) into a multidimensional, multidirectional model that necessarily incorporates a wider spectrum of components (figure 6).

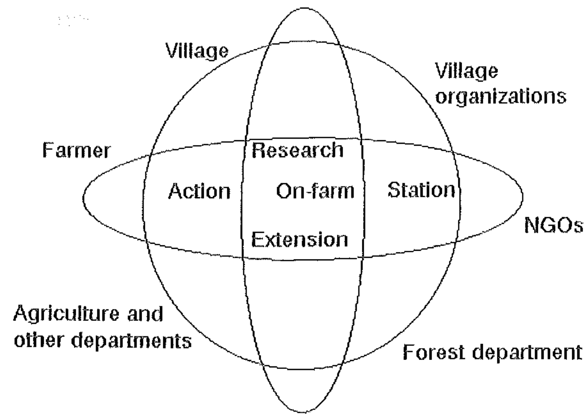

Figure 6. Multidimensional, multidirectional extension model

This is an abbreviated and revised version of a chapter entitled "Social dimensions of agroforestry extension for resource-poor people," in *Agroforestry in South Asia: problems and applied research perspectives*, W. R. Bentley, P. K. Khosla, and K. Seckler (eds.), Oxford and I. B. H. Publishing, New Delhi, 1992. The author is indebted to the Sadguru Water and Development Foundation, the Aga Khan Rural Support Programme (India), and the Gujarat Forest Department for their cooperation and assistance. Field work was supported by the Winrock International Institute for Agricultural Development.

AGROFORESTRY IN SOUTHERN CHINA: THE SHARE HOLDING INTEGRATED FORESTRY TENURE (SHIFT) SYSTEM

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INTRODUCTION

The history and tradition of agroforestry in China can be traced back more than 2,000 years. Agroforestry has always been important to the country's economic and social development. However, with rapid population growth, a decrease in arable land, and an increase in food and energy shortages, there is a need for development and implementation of more efficient land-use management systems for agriculture and forestry production.

In the last decade, agroforestry production in southern China has increasingly improved under the Share Holding Integrated Forestry Tenure (SHIFT) management system. The SHIFT system is a way of organizing communities, villages, and households to effectively manage the land for agriculture, forestry, animal husbandry, and fishery. It has helped to increase land-use productivity, efficiency, and sustainability (Wang, 1989).

The lack of research and education on the SHIFT management system is a concern for China's future development. Thus, the Yale School of Forestry and Environmental Studies in conjunction with the Yale-China Association has proposed the support of a Yale-China Forestry Training Institute in Sanming (Fujian Province). With funding from the Tropical Resources Institute, we conducted research on the social, economic, and ecological aspects of the SHIFT management system. The success of the Chi-Ho agroforestry farm under the SHIFT system will be discussed in this paper.

BACKGROUND

The Sanming region is located in the heart of the Southern Community Forest Reform Zone in China. Located in the subtropical belt, Sanming experiences a warm humid climate year round with annual temperatures between 20°C and 26°C. The greatest amount of rainfall occurs in the summer months (1,500 - 2,000 mm). The region is characterized by vast expanses of sloping hills and steep mountains. Soil erosion and nutrient loss are major problems for farmers. The total forest area in the Sanming region is 1,884,000 ha (1985 Secondary-Level Forest Resource Inventory Survey). Managing this land are the 1,768 villages within the area. Over 76% are managed by the SHIFT system. There are 118 village tenure tree farms (VTTF), 78 state joined tree farms (SJTF), and 546 women reforestation and afforestation teams (WRAT).

THE SHIFT MANAGEMENT SYSTEM

In 1980, the Chinese government implemented a commune program by tenuring forest land to farms, villages, and households for the purpose of afforestation. In southern China, however, tenuring forests proved to be unsuccessful. The tenure program resulted in premature mass harvest, reduced timber output, massive soil erosion, and depletion of natural resources. After analyzing the problems associated with this commune system, an effort was made to recollect the forest resources under a more

Chinese fir (*Cunninghamia lanceolata*), intercropped with medicinal shrub *Amomum villsoum*, is harvested and transported to the nearby lumber yard by local villagers.

effective land management system that would provide an infrastructure for forestry production, management, and distribution utilizing the incentives and resources of individual villagers.

The SHIFT management system was initiated in early 1983 and accepted by the majority of the post-commune villagers in the Sanming region. The SHIFT system integrates a share holding (SH) system with a forest tenure (FT) arrangement. In the SH system, people obtain shares which form the capital for production costs and purchase land. Villagers hold shares to the forest land, but are not sole owners. The amount of revenue received from the sale of forest products depends on the number of shares one owns. Under the FT system, villagers are contracted to tenure the land. The forest tenures are responsible for planting, maintaining, harvesting, and marketing the trees. The contracting of forest tenures is under the supervision of the SHIFT board of directors. The board is comprised of share holders which manage all aspects of forest production as well as overseeing both the share holders and the forest tenures. The SHIFT system has eliminated the need for government control and regulation. The government mainly provides guidance, program design, and technical assistance to the SHIFT board.

The SHIFT system has been successful because it capitalizes on the skills, knowledge, incentives, and resources of local, community, and regional farmers to improve agroforestry systems. Anyone is allowed to participate in the SHIFT system by contributing shares in the form of land, labor, technical skill, or money. The increase in participation from individuals results in greater motivation to better protect and preserve the natural resources of the land. Since the SHIFT system was implemented nine years ago, a total area of 345,990 ha has been afforested. The afforestation rate in Sanming has risen from 58% in early 1980s to 65.6% by 1990 (Zhang, 1989).

The Chi-Ho agroforestry farm is made up of many components utilizing the natural resources of a mountain watershed. Chinese fir is grown on the upland slopes which buffer lowland fish ponds against run-off and erosion.

THE CHI-HO AGROFORESTRY FARM

The Chi-Ho agroforestry farm in Shaowu County has been operating successfully as a pilot SHIFT program for the past six years. Since forestry is a long-term commodity, short-term cash crops are grown on adjacent land while making full use of the natural resources within the mountain watershed. Furthermore, by incorporating agronomy, silviculture, animal husbandry, and fish-breeding into a sustainable productive system, a balance between economic benefit, ecological security, and social service is achieved (Hsiung *et al.*, 1985). Table 1 shows the input and output of resources from the Chi-Ho farm.

Table 1: Total production (1990) of the Chi-Ho agroforestry farm under the SHIFT management system.

Total area: 7,046 ha — Total Income: 156,300 Yuan
Labor Force: 297 people

OUTPUT		INPUTS	
Chinese fir:	4190 ha	—	—
Amomum:	2000 ha	1,333 kg	0.67kg/ha
Fruit trees:	851 ha	460,000 kg	541 kg/ha
Rice patties:	2 ha	8400 kg	31 kg/ha
Fish ponds:	2 ha	5000 kg	2500 kg/ha
Duck ponds:	2 ha	3000 ducks	1500 ducks/ha
Pig farm:	1 ha	1000 pigs	1000 pigs/ha

Villagers have adapted to farming on the steep slopes and uneven contours of the surrounding mountains. Teamwork is an important aspect of the SHIFT system. Each family specializes in taking care of one of the components of the farm.

The major tree plantation species is Chinese fir (*Cunninghamia lanceolata*), which is indigenous to southern China. *Cunninghamia lanceolata* is grown on the top of the mountain slopes. It grows favorably in high humidity with a sufficient supply of water. In addition to its ecological importance, it is also grown for its economical and social value. The natural dark red coloration of the wood makes it very attractive for doors, window frames, and furniture. Chinese fir takes 20 years to mature before it can be harvested. After harvest, the land is cleared by burning away the brush and stumps before farmers can replant the area with cuttings. Eight years later, the plantation is selectively thinned by removing 30% of the trees. *Cunninghamia lanceolata* is sold on the market for US \$190 per m^2. Overall economic returns have been favorable. However, the biomass and quality of the wood diminishes with subsequent yields due to the depletion of soil nutrients.

Improving soil nutrient retention is a major concern among farmers. Intercropping *Cunninghamia lanceolata* on the high mountain slopes with economic crops such as *Amomum (Amomum villsoum)* have been an effective means of preventing erosion and protecting large areas of forested lands under which it is grown. The preference of shade (70%) by *Amomum villsoum* makes it suitable for the understory (Saint-Pierre, 1991). *Amomum villsoum* is an annual plant that is highly prized for its medicinal properties. Oil extracted from its leaves and fruit is sold as a remedy for stomach pain. *Amomum* rhizomes are planted under *Cunninghamia lanceolata* after the trees have been thinned and the undergrowth plants have been cleared. After three years, a thick layer of stalks and leaves is formed, two meters high with 20 to 30 stalks per m^2. Flowering occurs at the end of the dry season (approximately June). It takes three months after pollination for the fruit to ripen. Fruit production is typically 300 kg per ha per year. A study by Lin *et al.* (1981) has shown that artificial cross-pollination increases the annual fruiting yield by 82.1% over natural pollination. Thus, villagers have been trained to pollinate the flowers by hand: first removing the petals, then smearing the pollen from one flower onto the pistil of another. The fruit of *Amomum villsoum* can fetch a price of US $25 per kg.

To make efficient use of space, each component of the farm is positioned vertically along the mountain slope (figure 1). Cash crops such as oranges are grown on the terrace below the fir/amomum plantation. Precipitation inputs are drained into the base of the mountain where ponds have been dug to intercept the water. Each successive pond is used to raise geese, ducks, carp, and rice. Pigs are raised in stalls at the base of the mountain where they are easily transported to market.

CONCLUSIONS

The SHIFT system in southern China remains in the early stages of development. Over the last nine years, improvements to the social, economic, and ecological progress are evident. The Chi-Ho agroforestry farm is a key pilot project that has been successful in organizing the community, village, and household to cooperatively manage the watershed for sustainable agroforestry production. The long-term benefits of the SHIFT system are not known due to the lack of systematic research. The complicated topography and natural conditions of Fujian have resulted in different farming practices used under a SHIFT management system. The continued effort to study the multi-levelled and multi-purpose agroforestry farms using the SHIFT system will be of great interest, not just for China's growth, but to other countries in the sub-tropics with similar geographical restrictions.

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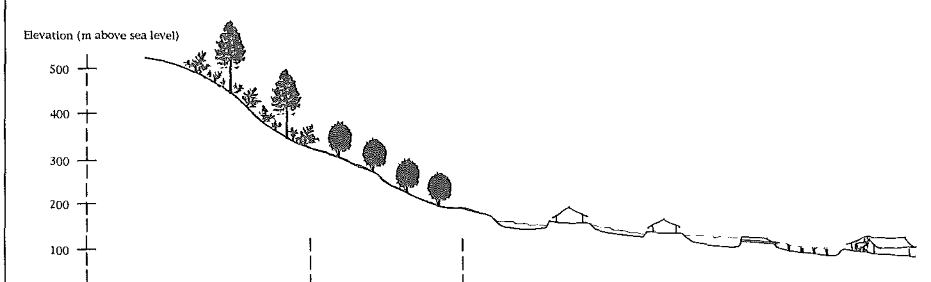

LAND TYPE	Upland	Midland	Lowland				
SOIL	Red pedalfer soils Orthic & Ferric acrisols acidic, pH = 4-6 Nutrients easily leached low nutrients low humus						
CLIMATE	Humid subtropical Precipitation: 1,500-2,000 mm Temperature: 20°C-26°C Humidity: 80% Annual Average PET: 950 mm Drought stress: 110 mm Frost free growing season: 240-300 days						
CROPS & TREES	Chinese fir (*Cunninghamia lanceolata*) *Amomum villosum*	Mandarin oranges				Rice (2 times/year)	
LIVESTOCK & FISH			geese	ducks	carp		pigs chicken
MANAGEMENT	Chinese fir intercropped with Amomum. Chinese fir: plant cuttings, thin after 8 yrs. Amomum rhizomes planted. Artificial finger pollination of Amomum	Ferilization with pig manure and chemicals			Aeration	Water from fish pond	
PROBLEMS	Shallow soil, erosion soil fertility	Erosion, runoff of fertilizer			Occasional flooding	"	

Figure 1. Transect of the Chi-Ho watershed and its characteristics

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DETECTION OF LEAD CONTENT IN TREES, SOILS AND CROPS IN THE MEXICO CITY BASIN

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INTRODUCTION

For most people, the "tropics" conjure up images of beautiful forests threatened with destruction. However, the increased population in tropical countries has led to rapid urbanization. Hand in hand with this urbanization process have come a range of social and environmental problems. Mexico City is one of the largest urban centers in the world. Its increasing urbanization, together with the topographical and climatological characteristics of the metropolitan zone of Mexico City (MCMZ), have resulted in high levels of pollution in that area. Lead, in particular, is a pollutant of great concern because of its detrimental effects to human health and the environment (Needleman, 1988).

Located in a mountain basin at 19º N, 99º W, and an altitude of 2,240 m above sea level, the metropolitan zone of Mexico City experiences frequent thermal inversions during the winter period when the cold temperatures prevent the ventilation of emissions from the city. Thermal inversions concentrate pollutants in the lower atmosphere, sometimes reaching contamination levels harmful to both human and plant health.

Airborne lead is progressively removed from the atmosphere by wet and dry deposition causing contamination of soil vegetation and water. In order to study the effect of lead on vegetation, I collected and analyzed soil samples, along with leaf and twig tissue of Jacaranda (*Jacaranda accutifolia*) and Eucalyptus (*Eucalyptus* sp.) from 17 busy streets in the Mexico City area. Soil, lettuce and radish samples were also collected and analyzed from two agricultural sites that are close to Mexico City: Xochimilco and Valle del Mezquital.

BACKGROUND

Lead is an extremely poisonous heavy metal. In humans, high concentrations of lead in the blood cause mental disorders. Children are the most likely to be affected, especially in their first two years of life when concentrations of as low as 10 g/dl can impair mental development (Rotenberg *et al.*, 1989). Chronic lead poisoning, "saturnismo," can cause neurotoxicity, adverse impacts on growth, and perceptual changes (Nava Dolores *et al.*,1985; Needleman, 1989).

Because of its high toxicity, lead is a pollutant of great public and scientific concern. The standard for lead concentration in air both in the U.S. and Mexico is 1.5 g/m^3 (Bravo, 1987). In 1991 lead air concentration in Mexico City, between the months of February and July, averaged 0.95 g/m^3 (SEDUE, pers. comm.). However, in the northeast part of Mexico, Xalostoc, the lead concentration reached up to 4.64 g/m^3 during March—more than three times the permissible standard.

The Secretariat of Urban Development and Ecology (Secretaria de Desarrollo Urbano y Ecologia, SEDUE) estimated that motor vehicles are responsible for 85% of all atmospheric pollutants in Mexico City (SEDUE, 1986). Air quality in Mexico City is degraded because of the tremendous number of vehicles, the poor maintenance of cars, and most importantly, because approximately 80% of the automobiles in MCMZ use leaded "Nova" gasoline (Bravo, 1987). In 1979, according to the Secretariat of Budget and Programming (Secretaria de Programacion y Presupuesto, (SPP)), 2.5 million automobiles were driven, and 17 million liters of hydrocarbons were consumed in the Federal District alone (Bravo, 1987). The number of vehicles in the Federal District accounts for almost 50% of the total number of vehicles in the whole country.

Until 1990, "Nova" gasoline was used by all vehicles, except diesel-powered buses. This resulted in a deposition of about 34 tons of lead in the atmosphere per day in the city (Bravo, 1987). As a result of the high atmospheric lead concentrations, Petroleos Mexicanos (PEMEX), the Mexican government-owned oil refiner, introduced a new gasoline in 1990. "Magna Sin" contains only 0.1 ml of lead per gallon, compared to 0.5 ml/gal in "Nova." However, this new gasoline requires that cars be equipped with a catalytic convertor. Only cars built after 1990 are so equipped and can burn the new gasoline blend. Eighty percent of the 2.5 million cars in Mexico City are 1980 models or older. Nevertheless, the introduction of "Magna sin" is an important measure for controlling future lead pollution.

Other projects to study the impact of lead on human health in Mexico are currently underway (Lauria, 1990). Still, not much is known about the flux and phytotoxicity thresholds of lead in the MCMZ. Furthermore, there is very little information about how high levels of lead affect crop production in the vicinity of Mexico City.

High concentrations of lead in the atmosphere may eventually affect trees in the urban areas (Smith, 1972). The flux of lead from the atmosphere to the forest floor in temperate zones varies from 0.01 to 1000 kg/ha per year (Smith, 1990).

Measurable lead retention in trees varies depending on the season, the species, and the part of the tree being sampled. Work done on temperate species (Smith *et al.*, 1977) shows lead concentrations increasing through the spring and early summer, resulting in very high levels of particulate loads late in the growing season. Twigs and leaves of urban sugar maple (*Acer saccharum*) had lead concentrations of approximately 120 ppm (unwashed, dry weight sample) (Smith, 1972). In terms of lead retention in different species, conifers generally intercept more particles than deciduous species. Lead concentration in different parts of the leaf also vary.

Lead deposition on the leaf surface eventually reaches the soil floor through the rinsing action of the rain or through decomposition. Harrison *et al.* suggest that 30-50% of lead deposited on the plant is removed by rainfall. Baseline lead is about 10-20 g(Pb)/g of dry soil, which is almost the same concentration as the earth's core (Smith, 1990). According to William Smith, YF&ES professor, the phytotoxicity threshold for lead concentrations in soil can be as low as 600 g(Pb)/g.

Because soils have a very high affinity for heavy metals, considerable quantities of lead accumulate in the soil. Lead and copper appear to be bound mostly to the organic fraction (Davies *et al.*, 1987). Thus, most of lead deposited to the soil from the atmosphere is accumulated in the upper soil horizon.

METHODS

During the summer of 1991, I collected twigs and leaves of *Jacaranda acutifolia* and *Eucalyptus* sp. on a busy street close to each of the sixteen monitoring stations of the "Red Manual de Muestreo Atmosferico." These stations are run by SEDUE and monitor lead concentrations once a week throughout the year. Leaves and twigs were collected from the lower canopy facing the road and facing the sidewalk. The top 5 cm of soil under each species sampled was collected.

In order to measure lead influence on crops grown below and above ground, lettuce and radishes of Xochimilco and Valle del Mezquital were collected. Xochimilco is a county south of Mexico City which receives high concentrations of air pollution due to prevailing winds coming from the north. Xochimilco has been an important agricultural region since Columbian times. A large percentage of produce consumed by Mexico City residents come from the Xochimilco county (Rosas *et al.*, 1984).

Although Valle del Mezquital is located about 300 km from MCMZ. This valley is one of the most important agricultural areas supplying crops to Mexico City. It is irrigated with sewage water collected from the City and carries a high lead content from atmospheric deposition. Eighty percent of the crops grown in the Mezquital valley are transported to Mexico City markets (Castaneda, pers. comm.).

In order to distinguish between external and internal tissue contamination, samples of eucalyptus and jacaranda at four sites were washed for 60 seconds with 1% hexadecyltrimethylammonium bromide (detergent) followed by a rinse in metal-free water. In order to find whether or not lead contamination was a health hazard, some lettuce and radish samples were washed with water. No detergent was used, as the washing was intended to mimic the household washing procedure for vegetables before they are consumed.

All samples were dried and brought back to Yale School of Forestry & Environmental Studies where they were analyzed by atomic absorption spectrophotometry.

RESULTS

Jacaranda leaf and twig tissue contain, on average, more lead (25 $\pm$ 3ppm) than eucalyptus (19 $\pm$ 4 ppm). No statistical difference was found between leaf and twig tissue, collected at different sites (facing road and facing sidewalk), and washed with 1% hexadecyltrimethyl-ammonium bromide. The average soil lead concentration under jacaranda trees was higher (760 $\pm$ 192 ppm) than that under euclapytus trees (341 $\pm$ 50 ppm).

In Xochimilco, lettuce (10 ppm) contained more lead concentrations than radishes (4 ppm). Soil lead concentration averaged 46 $\pm$ 1.6 ppm. In Valle del Mezquital, lettuce (5 ppm) contained more lead than radishes (3 ppm). Soil lead concentrations have averaged 20 $\pm$ 0.1 ppm (Table 1). No difference in lead concentration was found by washing the crop tissue with water for 5 minutes.

Table 1: Lead content (ppm) in unwashed lettuce, radish, soils and tree tissue of sites around the Metropolitan zone of Mexico City collected during the summer of 1991.

Tissue	ppm	Tissue	ppm
Jacaranda:		Xochimilco:	
Tissue	25±3	Lettuce	9.96*
Soil	760±192	Radish	3.70*
Eucalyptus:		Soil	46±1.6
Tissue	19±4	Mezquital:	
Soil	341±50	Lettuce	4.99*
		Radish	2.47*
		Soil	20±0.1

* because of low sampling number, no statistical analysis was performed.

CONCLUSIONS

Most of the lead pollution in the MCMZ is due to mobile sources, however, other sources of lead contamination in Mexico City are important. These sources include paints, water, canned food, and pottery. Paints containing lead can be dangerous because children can ingest them. Street painting can be dissolved in the water due to acid rain, thus contaminating the water system which is then used for irrigation of agricultural crops. Water can also be contaminated from plumbing, since lead is used to seal water pipes. The human ingestion of lead from canned foods is a serious problem. Some cans containing pickled peppers or fruit juices, which tend to be acidic, are still sealed with lead, thus introducing lead dissolved from the can. Pottery is widely used for cooking, storing water, and for dishes. Pottery which is not cooked at high temperatures or is varnished, may have a higher lead content. These sources of contamination should not be neglected.

There was great variation in the results. Collection of two soils (one under jacaranda and one under eucalyptus) along the same street, on the same day, gave very different concentrations of lead. Tree tissue and soil collected in the same street under jacaranda were much more contaminated than that of eucalyptus.

By far, the most contaminated environment was the soil. High soil lead content was probably due to atmospheric deposition and due to deposition from the tree from rinsing or leaf decomposition.

Leaf and twig tissue were low in lead contamination, compared to studies of New Haven, CT in the 1970s when atmospheric lead concentrations were comparable to those of Mexico City at the present time. Low levels of lead content in tree tissue were probably due to the differences in collection times during the year, or due to acid rain washing lead deposited on the leaf and twig tissue to the soil.

Lead concentrations of soils and crop tissue in agricultural sites were much lower, probably because the soils are plowed and they are located away from the City and from main roads. However, lettuce and radish of both Xochimilco and Valle del Mezquital contained enough lead to be considered a human health hazard.

In order to draw firm conclusions of which zones are more contaminated by lead, on how rain affects lead concentration of leaf and twig tissue, or whether lead contamination of crops is due to irrigation on atmospheric deposition, more samples need to be collected.

The removal of lead from gasoline in the United States has resulted in a 99% decrease in the amount of alkyl lead released into the atmosphere. This indicates how imperative it is that we move to eliminate the use of leaded gasoline in the Mexico City area, and eventually throughout Mexico. Hopefully this study will serve as a point of comparison for later studies of lead contamination in the Mexico City area, particularly once lead is no longer added to gasoline in Mexico.

ACKNOWLEDGEMENTS

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BEHAVIORAL ECOLOGY COMPLEMENTS CONSERVATION BIOLOGY IN STUDIES OF GREEN-RUMPED PARROTLETS (*FORPUS PASSERINUS*)

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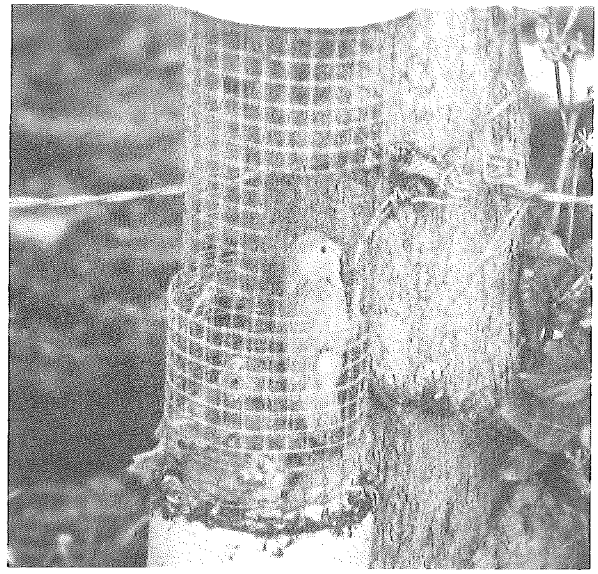
INTRODUCTION

Parrots are one of the least studied groups of neotropical birds, even though they are among the most endangered. At least 30% of the 140 New World parrot species are now threatened with extinction, and most of the remaining species are thought to be declining in numbers (Collar and Juniper, 1992). The major reasons for contemporary declines are collection for the pet trade, habitat destruction, and shooting for food or to protect crops (Beissinger and Snyder, 1992).

With the assistance of the Tropical Resources Institute, Smithsonian Institution, and National Geographic Society, I participated in an ongoing investigation of the behavioral ecology of a small savanna-dwelling parrot, the Green-rumped Parrotlet (*Forpus passerinus*). Dr. Steven Beissinger of the Yale School of Forestry and Environmental Studies began the parrotlet study five years ago at a private cattle ranch in the central savanna (los llanos) of Venezuela. The goals of the study are to collect baseline demographic information about the parrotlets, understand their life-history strategies, and create a model for sustainable nestling harvest programs. Our work has been greatly facilitated because the parrotlets adopted artificial nest boxes that were constructed to supplement the sparsely occurring natural cavities parrotlets normally use. The annual productivity of the population has increased 1.5- to 15-times as a result of the addition of new nest sites.

Green-rumped Parrotlets have two unusual reproductive behaviors that make them particularly interesting to study. First, the parrotlets lay an average of seven eggs, and sometimes as many as 11 eggs, in contrast to the two to three eggs typical of other tropical birds (Lack, 1968). Second, baby parrotlets hatch so asychronously that an interval of as much as two weeks may elapse between the hatching of the first and last chicks. This is extremely long relative to most other temperate and tropical birds (Clark and Wilson, 1981). Scott Stoleson (Ph.D. candidate YF&ES), Jim Waltman (MFS, '90), and Dr. Beissinger have been conducting studies to illuminate the reasons for the large clutches and prolonged hatching interval, while Dr. Beissinger and I have spent two years researching parrotlet mass change patterns and strategies.


Green-rumped parrotlet nestlings in artificial nest box

BACKGROUND: MASS CHANGE IN BIRDS

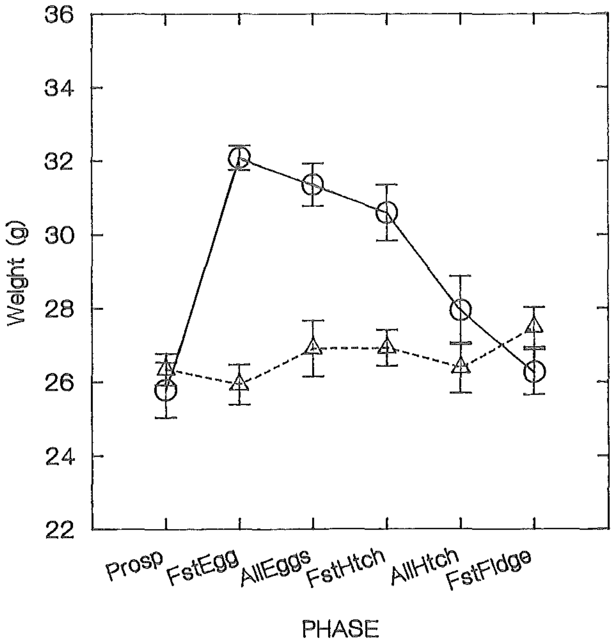
Mass change in breeding birds has been viewed as an index of how much a parent invests, or has to invest, in its offspring. This investment in young appears to differ markedly among bird species, but two patterns of weight change are typical (Moreno, 1989). When a female bird begins nesting it typically undergoes a weight increase of 7% to 30% by the time the first egg is laid. This increase is generally followed by a drop in weight during egg laying. At the time of incubation, two different strategies emerge. Some species maintain or even increase mass during incubation and only lose weight after the onset of hatching. Other bird species continue to lose weight during incubation and complete weight loss by the time of hatching. Delayed weight loss is typical for smaller birds that raise dependent young. Females with delayed weight loss usually also either share incubation duties with males and/or obtain food from the male (Moreno, 1989). Birds that lose weight during incubation are usually larger species in which only the female incubates, there is little male assistance, and the young develop quickly (Moreno, 1989).

Five hypotheses have been formulated to explain these different patterns of weight loss. The first, and most traditional explanation, is that females lose weight during the nestling-provisioning period due to the stress of parenting (Drent and Daan, 1980). A second hypothesis also assumes stress is the reason for weight loss, but posits that weight loss should occur earlier if females are unable to leave the nest and are dependent upon male provisioning while incubating and brooding (Andersson and Norberg, 1981). A third hypothesis conversely views weight loss as a way for the female to lose weight before she begins feeding nestlings, because lighter females use less energy for flight (Freed, 1981; Norberg, 1981). A fourth hypothesis predicts that staggered hatching prolongs the brooding period and reduces female weight loss, since asynchrony allows females to gain assistance from males for a longer proportion of the breeding cycle and delays their participation in the work of parenting (Slagsvold and Lifjeld, 1989). Finally, a fifth hypothesis suggests much of the weight lost by females is simply due to regression of the reproductive organs (Ricklefs, 1974), which usually occurs by the end of incubation (Peterson, 1955).

STUDY OBJECTIVES AND METHODS

To determine which pattern of weight loss occurs in Green-rumped parrotlets, unmanipulated "trend" females were weighed during courtship, at the beginning of egg laying, at the completion of laying, at the first egg hatch, at the end of hatching, and at the first fledging. To test the predictions of the five mass change hypotheses and illuminate the mechanisms of weight loss, I experimentally manipulated parental investment by altering hatch spread (in 1990) and brood size (in 1991). The hypotheses predict different outcomes from parents with contrasting demands. For instance, the brood starvation hypothesis predicts that females that have to spend more time brooding a staggered clutch will lose more weight than females with a same-age clutch; whereas, the regression hypothesis predicts there will be no difference between the two females because weight loss is due to organ regression, not different parenting stresses.

Weights of male and female parrotlets were taken as they entered their nest boxes. I used a tared perch resting on a digital electronic balance that was connected by cable to a portable computer display terminal. The perch and base



Graph 1. Weights of trend males and females for the following phases: Prosp = prospecting, FstEgg = first egg laid, AllEggs = all eggs laid, FstHtch = first hatch, AllHtch = all eggs hatched, FstFldge = first nestling fledged. Female weights were significantly different by nesting phase (p=.000), but male weights were not (p=.728) (One-way ANOVA, Tukey Means Separation). Female and male weights differed significantly (p .01) at the time of FstEgg, AllEggs, and FstHtch (Mann-Whitney U-Test). Sample sizes for males ranged from 5 to 9. Female samples ranged from 6 to 11.

were camouflaged to mimic the usual stationary perch at the mouth of the nest box entrance. This proved to be a time-consuming procedure since the bird had to accept the substitute perch and maintain a stable position to get a reliable reading, but it allowed recurrent weight sessions without causing nest desertion from excessive handling.

Data from the unmanipulated trend nests, the two experimental groups, and behavioral observations of male and female provisioning are currently being analyzed.

PRELIMINARY RESULTS

The pattern of weight change in female *F. passerinus* conforms to the strategy predicted from mass change theory. Since parrotlets are small, have very dependent young, and males provide food to incubating females, we expected females to maintain weight gains throughout incubation. This was what we found (Graph 1). Our data show there was a steep increase in female weight from prospecting through the beginning of egg laying, followed by either a leveling off or a slight increase or decrease in weight by the time all eggs were laid. Females lost some weight at the beginning of the hatching period, but weight loss was not significant until all eggs were hatched. Some additional weight loss occurred between the end of hatching and the date the first nestling fledged. Male parrotlets are similar to other non-incubating birds in that they experienced no significant increase or decrease in weight during breeding (Graph 1).

Preliminary analyses indicate a strong correlation between the weight of a female at the onset of egg laying and how many eggs she eventually laid. Weights of females predicted clutch size or total egg mass better than body-size adjusted weights and female mass was not significantly correlated with body size. Therefore, the heavier females that laid larger, heavier clutches were not simply larger birds. The frequency of male feeding visits to egg-laying females may also be significantly correlated with clutch size and mass, though male feeding was not significantly correlated with female weight. Male food contributions may be channelled directly into egg production, rather than female mass. During egg laying and incubation, females rely almost totally on food brought by males and it appears that male feeding contributions allow females to produce a large volume of eggs (relative to their mass) without losing weight.

The overall trend of weight change in *F. passerinus* is congruent with the adaptive loss hypothesis, since the majority of weight loss occurred before the female was involved in the intensive provisioning of young. The brood starvation hypothesis is unlikely, since little weight was lost during brooding. A small data set from 1990 provides the clearest indication that stress can also exert an effect on weight, although a larger sample from 1991 is currently being processed and is needed to add rigor to the analysis. The post-brooding stress hypothesis is supported by data from experimental females with eight young of the same age who lost more weight than females with eight staggered young. Furthermore, a widowed female in the unmanipulated trend group lost more weight than females who had male assistance. The asynchrony advantage hypothesis is likewise supported by the greater weight loss of females with synchronous young versus females with staggered young. Preliminary analyses of the 1991 data suggest that the number of young a female raised did not affect weight loss, but male feeding behavior may be an important correlate of weight change.

CONCLUSION

Knowledge regarding mass change in parrotlets can improve our understanding of parental investment strategies and their population-level implications for clutch and brood size. This is an example of an investigation designed to contribute to the refinement of ecological theory, i.e. the mechanisms of mass change, while enhancing fundamental behavioral and reproductive knowledge crucial for the conservation of threatened species. Use of artificial nest boxes to increase available nesting sites has allowed close investigation of theoretical questions while providing guidelines for the development of sustainable harvesting of parrot young to reduce trade pressures on wild populations (Beissinger and Bucher, 1992).

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MANAGING FOREST RESOURCES IN BHUTAN: MEETING THE PEOPLE'S BASIC NEEDS

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INTRODUCTION

Bhutan is a mountainous country with a total area of 18,000 square miles and a population of one and a half million. The population is currently growing at a rate of 2.5% (World Bank, 1990). It is located in the eastern Himalaya between India and China. The primary occupation of over 90% of the population is subsistence farming. Livestock and kitchen gardening form an integral part of the farming system, which makes the farmers relatively self-sufficient. Buddhism is the state religion and is practiced with an emphasis on aversion to killing and a love for nature. Although Bhutan is a small country, biodiversity is high because the altitude varies ranges from tropical to alpine.

The forests of Bhutan are still largely intact and pristine, and cover more than 64% of the land area. These forests represent the largest renewable natural resource of the country (UNDP/FAO, 1984). Managing this vital resource to meet the basic needs of the people while also protecting the environment is the Government of Bhutan's highest priority. It is becoming increasingly difficult to uphold this policy in the face of population increases and rural poverty. However, the Government is confident that the Forest Department's current policies will continue the present management approaches and meet the country's future needs.

More than 95% of the people depend on forests for fuelwood, construction timber, fodder, grazing, etc., which are considered necessary for the people's livelihood by the Government (Forest Department, 1985). This dependency on forest products will continue until appropriate and affordable alternatives are available.

FOREST RESOURCE POLICY

Direct revenue from the sale of timber is considered to be secondary to the role forests play in enhancing agriculture, livestock, hydro-electric development and providing habitat for diverse flora and fauna. Meeting the basic needs of the people is accorded highest priority, which would otherwise get overridden by short-term commercial ventures. Recognizing these important factors, and Bhutan's responsibility to downstream countries, a decision to maintain a minimum forest cover of 60% has been made (Forest Department, 1985).

Considering the fact that the villagers still do not have enough cash to pay for forest products, the Government has adopted a very pragmatic policy to address this problem. The villagers have the right to access forests for the collection of firewood, timber, fodder, herbs and grazing. To maintain a record of forest products removed, collecting permits are issued and a nominal fee is charged for marking the trees that are felled. The fee per tree increases proportionally to the number of trees an individual removes over time.

Because of the farmers' inability to pay transportation costs, firewood and timber are normally allotted from the forest area closest to the village. Per capita firewood consumption in Bhutan is one of the highest in the world at 3.00 cu.m per year (Forest Department, 1990). This is attributed to the fact that firewood is used both for heating and cooking by more than 95% of the people. A large amount of timber is used by the construction industry, and more than 25% of this wood is lost during the manual processing at construction sites (Forest Department, 1990).

The forest product requirements of urban centers are supplied by the Forest Department or through contractors whose operations are closely supervised by the Department. In order to reduce supervisory costs and theft the Forest Department keeps urban users from directly entering the forests. Taxes on forest products are frequently increased in order to encourage efficient use of forests products.

Similarly, to ensure that the forests are not overexploited, raw material supply to woodbased industries is highly regulated. All extractions of wood are guided by the theory of sustained yield. The forest product requirements of the villagers are met before the local forest officer issues permits for commercial extraction of any forest product. Wherever possible, forest areas are earmarked for specific villages which are off-limits to woodbased industries. Priority is accorded to the preparation of management plans for these areas over other forests.

POLICY IMPLEMENTATION

The forest resource management strategy is geared towards meeting the basic needs of the people. The first step is to assess the requirements of the people for forest products, taking into consideration the heterogeneity of village distribution. It is important to consult with the local people while demarcating forests so that the resources can be more effectively used to meet their requirements. Forests are then classified as productive or protection forests, taking slope, gradient and existing forest status into account. Carrying out an inventory of the forest resources is the next step in policy implementation, followed by the preparation of management plans.

Villagers are urged by the Government to do their part in making forest utilization sustainable. Implementation of one program is geared to reducing waste of forest products by the villagers. This waste reduction program encourages the use of hand saws instead of axes, and distributes improved cooking stoves to reduce firewood consumption. Similarly, social and community forestry programs are implemented with the aim of reducing pressure on existing forests and creating awareness of forest resource conservation. These programs were started in 1979 and included distributing free seedlings to the farmers. The program had only limited impact on the beneficiaries, which can be largely attributed to the Department's traditional extension approach. Instead of focussing on the Forest Department's agenda, emphasis is now placed on the recipients' needs and how they perceive social and community programs.

DISCUSSION

Although Bhutan does not have any single overarching forest resource problem, there are two worth mentioning. Firstly, there are inadequate numbers of trained personnel to manage forest resources. This limits the Forest Department's capacity to keep pace with management requirements in the field and its ability to reduce the absorbing power of donor agencies. Secondly, creating awareness of forest resource issues among local people and students has also been recognized as an area that the Department needs to address to improve its current policies. The current lack of awareness is largely attributed to the low literacy rate of 25% (World Bank, 1990) and the perception of abundance of forest resources.

Rural development and forest resources are inseparable in Bhutan. Unless the basic requirements of the people are met, no law can stop the utilization of the forest resources. The Government of Bhutan recognizes this fact, and has enacted practical policies and programs to give the basic needs of the people the highest priority. These policies can be effective only if the commercial operations are kept out of the areas allocated for the villagers. Simultaneously, the beneficiaries should also be educated on the need to use the resources judiciously.

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Footnote:
The author is currently on leave from the Forest Department, Ministry of Agriculture, Royal Government of Bhutan where he serves as Divisional Forest Officer, Forest Resource Management Division.

INVESTIGATING THE FLORISTIC COMPOSITION OF KAIETEUR NATIONAL PARK IN GUYANA

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INTRODUCTION

Accurate identification of plants and careful collection within a forest is essential for ecologically-sound forest management. A basic step in studying a forest is to determine its vegetative makeup. Plant families tend to have characteristic features, such as growth habits and breeding systems. By distinguishing which families inhabit a region, one can better understand the region's forest structure. Understanding structure is key to developing effective methods for conservation.

There are other scientific and sociological benefits from plant identification and specimen collection. For instance, using modern biochemical and electron microscopy techniques, scientists working with newly collected plant specimens can clarify the evolutionary relationships between species. Similarly, studies of diversity, cytology, plant chemistry, agriculture, forestry and medicine depend on the collection of new specimens. Improvements in our knowledge rely on the quality and selection of materials collected, particularly in unexplored regions, such as Guyana (formerly British Guiana).

The Smithsonian's Biological Diversity of the Guianas [BDG] program is a field-oriented program that for five years has been funded by the National Museum of Natural History's Biological Diversity Program. The "Flora of the Guianas," one element of the program, is a multi-national effort by a consortium of botanical institutions in Berlin, West Germany; Cayenne, French Guiana; Georgetown, Guyana; Paris, France; Utretcht, the Netherlands; Paramaribo, Surinam; New York and Washington, D.C. The goal is to produce a written account of the vegetation of the region over the next twenty years.

RESEARCH

In June of 1991, funded by the Tropical Resources Institute and the Smithsonian Institution's National Museum of Natural History, Department of Botany, I joined Field Botanist Tim McDowell, from the Smithsonian Institution, in collecting, recording, and identifying the relatively undisturbed vegetation of Guyana. A great central mass of flat-topped mountains (tepuis) covers much of western Guyana; it is a long chain that culminates in Mount Roraima, shared by Guyana, Venezuela and Brazil. McDowell and I collected on one of the tepuis near to Mount Roraima, called Haiamatipu.

After returning to the capital, Georgetown, I reviewed herberium sheets of specimens from Kaieteur Falls housed at University of Guyana, Jenman Herbarium. Then, using McDowell's collecting techniques, I based myself at Kaieteur National Park (5°N latitude and 59°W longitude), collected plant specimens, and recorded my findings.

Kaieteur National Park, in central Guyana, is located in a region which straddles both the ancient Guiana highlands (also called the Guiana shield) and the Amazon basin. This accounts for the extraordinarily high biological diversity and endemism. The Guiana and Brazilian shields have been colonized by plants longer than any other part of South America, resulting in the evolution of up to 10,000 species of vascular plants.

Deep in the interior, Kaieteur National Park cannot be reached by road, so rivers and thin, machete-cleared walking paths are the typical means of travel. Many of the paths along which I collected had previously been cleared by miners. When necessary, I cut my own paths. On several ocassions, Alwin Garcia, an Amerindian from the Pomeroon region, assisted me.

I was fortunate to be able to reach the center of Kaieteur National Park, the base of Kaieteur Falls, by river. Typically, rivers do not readily provide access to the interior because rapids, falls, or low water inevitably prevent navigation. Kaieteur Falls, at nearly 250 feet wide, and with a verticle drop of 741 feet (one of the tallest single drop falls in the world), is one such navigational nightmare.

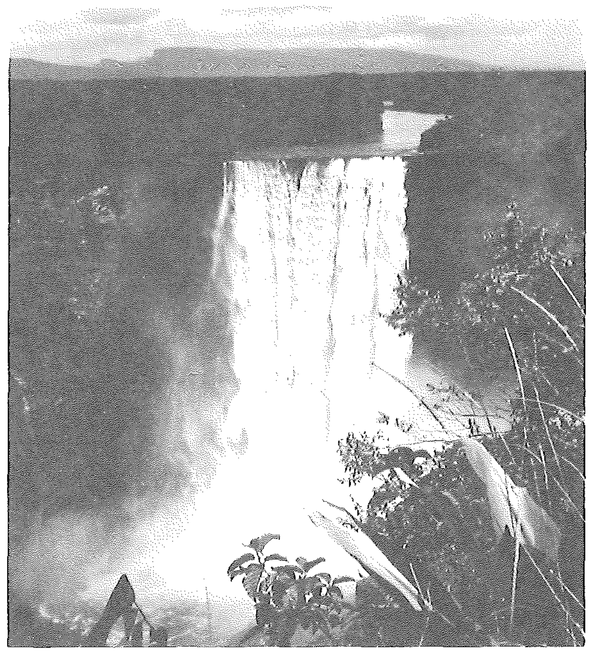
METHODS

The Director of the Smithsonian BDG program had instructed me to collect in areas where collections had not already been taken. I identified these as the base of the Falls, the north side of the Falls, and along an old mining trail from the base to the top. Due to steep ridges, slippery boulders, and longer travel time than estimated, these areas were difficult to reach. (Thoreau once said, "Give me a wilderness no civilization can endure." I think some of my collecting sites would have particularly pleased him).

For identification purposes, sterile collections of many plants are not useful, so I only collected plants in flower or with fruit. I accompanied each collection with pertinent field data (location, habitat type, orientation of leaves and branches, frequency of occurrence, size, flower color, presence of exudate, presence of odor, color of inner bark, etc.). I pressed the specimens in the field in a single fold of newspaper and then stacked them in a field press. Writing up comprehensive notes, numbering specimens and pressing specimens took up most of the daylight hours; in the evenings, I transferred specimens into large plastic bags, and soaked the specimens in a 70% alcohol solution. I relied heavily on Cronquist (1988), Heywood (1985), and Ter Steege (1990) for classification purposes.

RESULTS

Legumes (e.g., *Dicymbe*, *Eperua*, and *Peltogyne*) and members of Lauraceae were among the larger trees at Kaieteur Naional Park. Lower story trees belonged to



Kaieteur Falls, Guyana

Epiphytic growth in Kaieteur National Park

many families—Clusiaceae, Annonaceae, Lecythidaceae, and Palmaceae. At the forest floor, Bromeliaceae, Araceae, Melastomaceae, Marantaceae and Rapateaceae were most abundant.

The specimens I collected were to be dried at the University of Guyana, but due to unforeseen damages to the drying facility, the specimens were shipped to Washington for drying and processing. Due to a backlog of specimens from other expeditions, my collections from Kaieteur may not be processed for quite some time. Once processed, the findings from Kaieteur National Park will be added to the species list being compiled by the Smithsoniam Institution Department of Botany.

DISCUSSION AND CONCLUSION

Special attention is being given to Kaieteur National Park because the park has been designated for expansion and because various groups in Guyana would like to encourage tourism at Kaieteur Falls. According to scientists from NYBG (1989), expansion of the Park is very timely:

"Our review of the status of floristic and ecological inventories of the Guianas is more optimistic than that of other more threatened areas, such as the moist forests of the Pacific coasts of Ecuador and Colombia and those of eastern Brazil. Nevertheless, we would like to emphasize that the best time to locate, establish, and preserve natural areas before habitats are threatened with destruction. The Guianas present a unique opportunity for rational habitat preservation before severe pressures of economic development arrive."

Guyana still contains over 13 million ha of productive closed broad-leaved forest; the 6th largest reserve, out of 18, in tropical America, 15th in the world. More importantly, this represents over 63% of the country's total area. Pantropically, only Guyana's close neighbors, Surinam (68%) and French Guiana (84%), have a greater fraction of their land covered in productive tropical forests.

Recently, however, Guyana has taken strides to develop its forestry sector. It will be increasingly important to examine the floristic composition and structure of Guyana's forests in order to develop effective methods for conservation. Many government bodies have vested interests in the forests. The greatest threat to the expansion of Kaieteur National Park comes from mining concerns for gold and diamonds. The president of the Guyana Gold and Diamond Miners Association, Patrick Pereira, is reported by the Stabroek News (July 30, 1991) to have said, "It is generally agreed that Guyana's mineral wealth cannot be allowed to remain where it is for the idea of allowing the vast interior to remain so-called beautiful while our people remain in a poor state and the country is subjected to embarrassing financial pressures and dictates from external sources."

In order for the expansion of the Kaieteur National Park to occur, the ecological concerns of the scientific community will have to be rectified with economic concerns of the people in the region.

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COOPERATOR NOTES

CONFERENCE ON THE HIMALAYAN REGION

The annual TRI/ISTF (International Society of Tropical Foresters) Conference will be held October 17-18, 1992 on the subject of conservation and development in the Himalayan region.

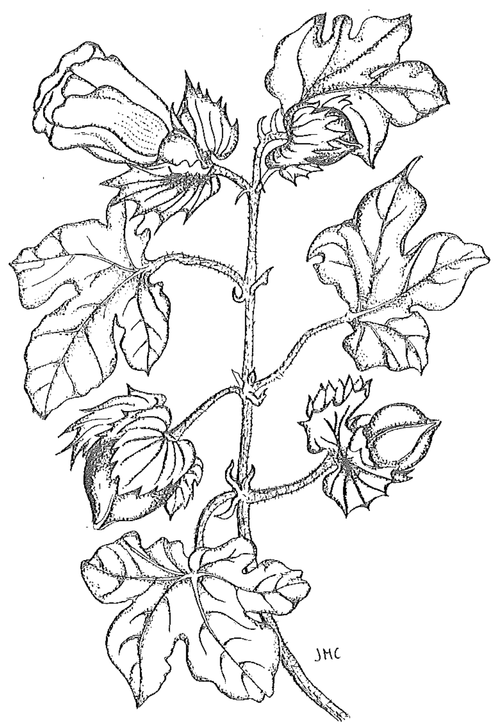
The planning committee of F&ES students is being advised by professors Florencia Montagnini and William Burch. The purpose of the conference is to promote the exchange of ideas among professionals and students on the following issues: uncertainties in Himalayan conservation, encouraging inter-agency coordination, co-managing forests for multiple values, and grassroots initiation of social forestry projects.

The format of the conference will consist of two speaker panels and working groups the first day, a roundtable discussion that evening, and two speaker panels and working groups the second day. The planning committee is hoping to bring in speakers from the Himalayan region as well as the U.S. All are highly encouraged to attend what is sure to be an insightful and stimulating conference. Please contact Sally Loomis or Maia Enzer at the School for more information. Telephone (203)432-5100, fax (203)432-5942.

FOREST RESOURCES WORKSHOP IN WOOD-BASED BIOMASS ENERGY AS RURAL DEVELOPMENT ASSETS

Dr. William Bentley organized a week-long workshop entitled "Forest Resources and Wood-Based Biomass Energy as Rural Development Assets," held in February, 1992. Florencia Montagnini, Mark Ashton, Bruce Larson, Bill Burch, Bob Evenson, and several F&ES students participated, along with professionals from the United States and several other nations. Nancy Peluso, Assistant Professor of Resource Policy, and Tom Hammett, who will lead the Yale/IOF Nepal project, were among the other participants.

The workshop was based on work for a cooperative research agreement with Winrock, sponsored by the U.S. Agency for International Development. Dr. Bentley teaches at F&ES as part of a collaboration between Yale and Winrock International. Winrock is a not-for-profit organization with a mission of reducing poverty worldwide through sustainable rural development.



Gossypium herbaceum

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