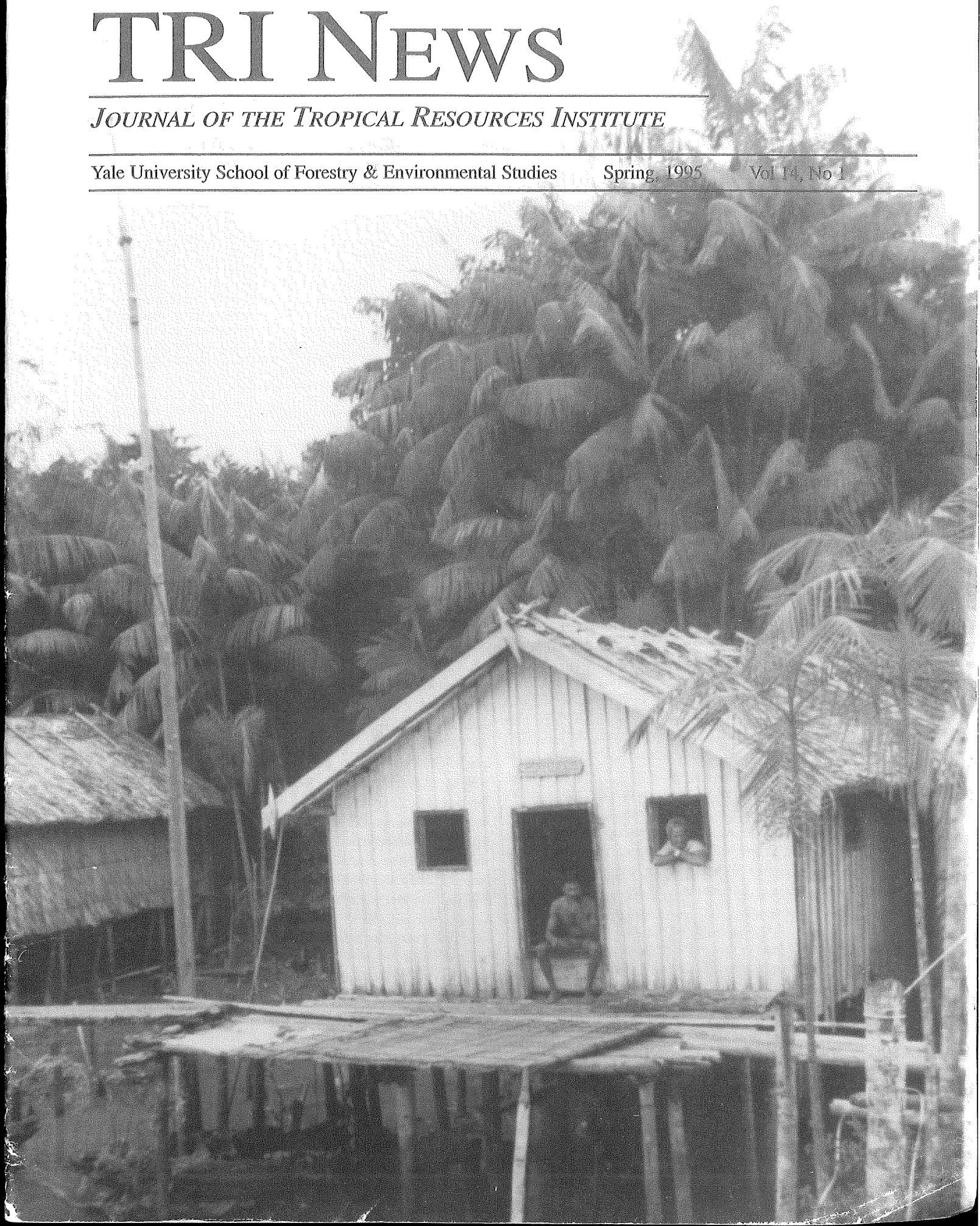
TRI NEWS

JOURNAL OF THE TROPICAL RESOURCES INSTITUTE

Yale University School of Forestry & Environmental Studies Spring, 1995 Vol 14, No 1



TRI INITIATIVE

LAND USE AND HEALTH IN THE AMAZON: AN UPDATE OF THE PROJECT'S SECOND YEAR

Nuria Muñiz-Miret
TRI Projects Coordinator

BACKGROUND

Over the past century, land use in the Brazilian Amazon basin has involved cutting of primary forests, building of access roads and opening of frontier settlements. Mass human migration into frontier colonies coupled with dramatic ecological transformation have promoted major epidemics: vector-borne diseases have become an integral part of the colonized Amazon. Frontier communities eventually develop infrastructures in close proximity to lands managed for ranching, agroforestry and mining. Associated with each of these land uses is a set of health risks. Yet the relationship between health, land use and socio-economic levels is poorly understood in both new and old settlements of the Amazon.

Land Use and Health in the Amazon is the first intensive study to integrate health and environmental factors in an effort to guide settlement in the various ecological settings of the Amazon basin. Through a combination of research, experimentation, extension and training, the project seeks to find appropriate methodologies to measure ecological and health risks based on satellite images and ground-level assessments. The project focuses on the relationship of insect transmitted diseases to deforestation and on sustainable land-use for socio-economic development.

Land Use and Health in the Amazon is an interdisciplinary effort, funded by the Rockefeller Foundation and the International Development Research Center (IRDC) of Canada. The project is jointly directed by Dr. Burton Singer of the Office of Population Research at Princeton University; Diana Sawyer at the Center for Regional Development and Planning (CEDEPLAR) in Brazil; and Dr. Florencia Montagnini, John M. Musser Director of TRI at the Yale School of Forestry and Environmental Studies. At Yale, the project is part of the Center for Human Ecology, Environment and Infectious Disease of the Yale Institute for Biospheric Studies and is administered by the Tropical Resources Institute.

The following sections highlight results and activities arising during the second year of this multi-year project. Only two of the three project modules will be discussed here: the Frontier and *Várzea* (floodplain) Modules. The third module, *Terra Firme* (high ground), which includes aspects of the other two, will be discussed in a later edition of this journal upon completion of the project. The described modules take place in the frontier settlements in the state of Rondonia and in *várzea* communities of the Amazon estuary in the state of Pará (fig.1). These results were extracted from the first narrative report to the Rockefeller Foundation 1993-1994.

Figure 1. Map of project location within the Amazon basin

MALARIA PREVALENCE IN THE FRONTIER SETTLEMENTS OF THE NORTHWESTERN AMAZON BASIN

This study, led by researchers at CEDEPLAR, takes place in northeastern Rondonia, in the Machadinho municipality, a settlement facilitated by the paving of highway BR 364, which links the states of Rondonia and Brazilia. During its first years of settlement, 1984-1985, Machadinho showed the highest prevalence of malaria in the country (Sawyer and Sawyer 1987). In some regions of Rondonia the API (annual parasitological index per thousand inhabitants) reached 4,000, meaning that on average, each inhabitant was diagnosed with four episodes of malaria per year. Having performed extensive field surveys in the Machadinho municipality prior to 1985, CEDEPLAR returned to this region to identify current trends in land use and malaria incidence.

In 1993, researchers found a reduction in malaria prevalence in Machadinho in both absolute and relative terms. For example, confirmed malaria incidents in 1988 accounted for 278,268 cases with 171.4 API, while in 1992, 137,426 cases were confirmed with 121.6 API. This reduction is attributed to interventions of government health agencies as well as the small exodus of high malaria-risk *garimpeiros* (surface miners) to other part of northern Amazonia.

Malaria incidents were found to be highly localized within several studied municipalities of Rondonia. For example, 19 of

Arthropods being collected from human bait with an aspirator

280 localities suffered 58% of malaria cases within Machadinho. In some cases high incidence of malaria was attributed to large-scale slashing of forests for ranching and subsequent increases in exposure to vectors. Also, compared to previous years, an increase in urbanization of malaria was seen in other municipalities of Rondonia.

Cases of malaria caused by the parasite *Plasmodium vivax* have increased in recent years. Whereas 30 years ago, 79% of Rondonia's 1,185 cases were confirmed to be caused by *Plasmodium falciparum,* in 1993 only 37% of the 137,426 cases belonged to *P. falciparum*, with the remainder attributed to the more benign *P. vivax.*

Increased malaria associated with *P. vivax* is consistent with recent reports that *Anopheles darlingi* — which transmits all three types of malaria — is not the only important vector in the area, as was previously thought. Other anopheline species, such as *A. oswaldoi* and *A. albitarsis,* are found in the area and appear to transmit only *P. vivax.*

These findings defy the prevailing wisdom that malaria is chiefly a rural problem and that *P. falciparum* is the main malaria parasite transmitted in Amazonia. It is reasonable to rethink an analysis of malaria prevalence in Rondonia by considering the behavioral and breeding patterns of other anopheline species in addition to *A. darlingi.*

In order to guide planning in the Frontier lands of the Amazon basin, the study will draw from recent health surveys and comparable data from previous years in several municipalities of Rondonia. This information will be used to conduct an analysis of the "spacialization" of malaria, deforestation and human settlement over time by using LANDSAT satellite images of the state. This reconstruction of Rondonia's colonization history will serve as a tool for researchers and developers to understand and predict the eminent risk of malaria in new settlements of the Amazon basin. Results from Rondonia will be complemented by a study of the movement of infected people into new settlements and their relation to malaria epidemics. In particular, researchers will focus on the movements of *garimpeiros* into the virgin lands of northern Mato Grosso.

Health and Socio-economic Development in the Estuarine *Varzea* of Pará, Brazil

As opposed to the Frontier module, the *Várzea* project is a recent effort. Most studies started in 1993, while some demographic and land use studies began a few years earlier. As the project continues, the information base for the *várzea* project strengthens, but only preliminary results are available at this time.

The *várzea* study takes place on the islands of Abaetetuba, about 80 km southwest from the city of Belém, Pará. This region is *várzea da mare* (tidal floodplains): low-lying terrain with high grounds not exceeding five meters above the highest tidal level. These lands are covered by tides twice a day for two to three hours, with the highest tidal levels occurring during the equinoxes (Hiraoka 1994).

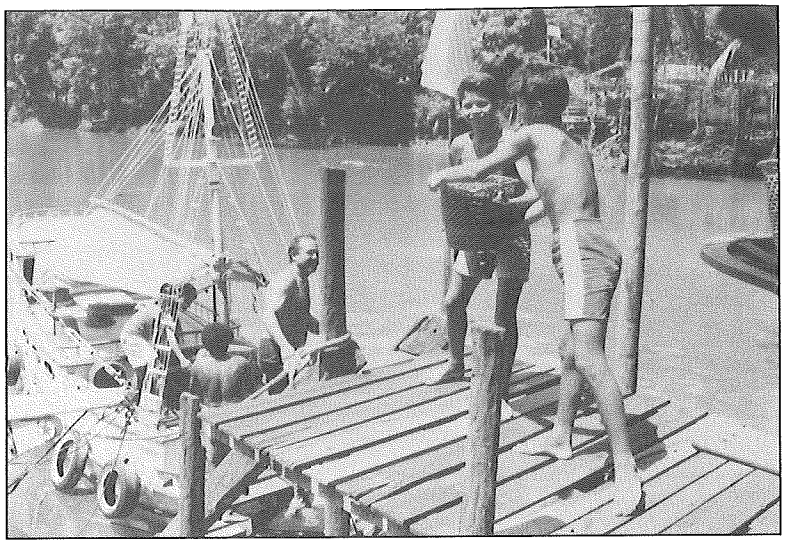
According to many researchers and developers, *várzeas* are among the most promising areas for rural development in Amazonia. Because population density is higher in these floodplains than in Amazonian *terra firme*, the studied *várzea* region is of special interest for human settlement planning.

The objectives of this project are to survey the incidence of health problems, including vector-borne diseases; to determine the relationship between prevalence of disease vectors and land management; and to examine traditional and innovative land use for socio-economic development. The project involves several collaborators including Dr. Mario Hiraoka, Professor of Geography at Millersville University, Pennsylvania; researchers from the Evandro Chagas Institute, a public health laboratory operated by Brazil's Ministry of Health and the Foundation for Public Health Service; and researchers from Yale University.

In contrast to the frontier settlements of Rondonia, *várzea* populations of Abaetetuba display more predominant health problems than malaria: according to a health perception study (Reeves 1994), the most significant diseases are intestinal parasites, flu viruses, anemia, high blood pressure and rheumatism. Cholera was also listed as a recent epidemic. Preliminary field analysis suggests that poor sanitation and diet play significant roles in disease contraction by the studied population. More research is needed in this region to assess these concerns.

In order to address the prevalence of vector-borne diseases, the Evandro Chagas Institute carried out a serological survey of the inhabitants of Abaetetuba. They found that 92.8% of human sera had no antibodies against yellow fever — a virus

transmitted by the mosquito *Aedes aegypti* — thus indicating that these individuals had never contracted or been vaccinated against the deadly disease. These results indicate that this is a risk-prone area, and researchers encourage establishment of a vaccination program, especially since yellow fever has been isolated in other communities at the boundary of the Abaetetuba district.

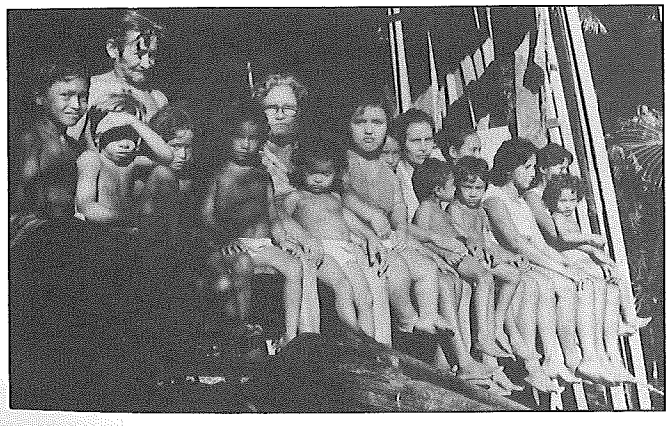


Baskets of açaí being loaded for transport to market

As part of this study, research teams also captured and identified mosquitoes and sand flies and tested the viscera and blood of wild animals, such as small mammals and birds. In order to identify possible links between prevalence of disease vectors and land use, several capture sessions were conducted within five sites representative of the region: four in the floodplain, including a sugar cane field; a 5-8 year old *capoeira* (regenerating stand); a 35-40 year old *capoeira;* an *açaizal*, or palm grove of *açaí* (assai, *Euterpe oleracea*); and a fifth site in a nearby *terra firme* (non-flooded) stand of mature forest, which was used as a control plot. Results of disease vectors captured at each site are to be integrated with ecological characterizations conducted by researchers at the Yale School of Forestry and Environmental Studies.

Ecological characterization of the sites included a mid-aged (15-18 year-old) *capoeira* in addition to the five representative sites. The study involved surveying one hectare of each site to determine species composition and measurement of height and diameter at breast height (dbh) of woody vegetation. Forest floor litter was measured within smaller subplots and soil chemistry was tested for each site. The characterization will assemble measurements of regenerating stands of sequential age in order to further understand vegetation development over time in managed ecosystems of the Amazon estuary.

The *várzea* project also includes extensive studies of sustainable resource management, including the establishment of experimental agroforestry treatments and passively irrigated small-scale rice paddies. Also studied is the introduction of small livestock, such as locally bred hogs, ducks and chickens, in order to examine their roles in supplementing household diets and income. Alternatives for generating income have also been introduced, such as handicraft production from fibers of the *miriti* palm (*Mauritia flexuosa*).



The project also is undertaking a study of the production and markets of *açaí* in order to determine whether this land use is ecologically and economically sustainable within the Amazon estuary. Field surveys of *açaí* productivity were conducted at three sites of increasing distance from the Belém market. Extensive interviews with producers were used to gather information on *açaí* management including the costs of production and transportation. Data on the price of *açaí* during the region's main harvesting season was conducted in the *Ver o Peso* market of Belém, which is the major market for this fruit in the Amazon estuary. Net present values of land managed for *açaí* extraction are being calculated for different locations in the Amazon estuary. *Açaí* production will be analyzed in the context of rural development and management of native landscapes.

Summary

Land Use and Health in the Amazon seeks to obtain knowledge about land management practices that promote health and economic well-being within an ecologically stable environment. The results are aimed at providing a basis for policies used at all levels of authority in Brazil, from local communities to municipal and national governments.

Literature Cited

Hiraoka, Mario. 1994. Land Use Changes in the Amazon Estuary. Global Environmental Change, In Press.

Reeves, Elizabeth. 1994. Disease Perceptions in an Amazonia Population of Brazil. A thesis presented to the faculty of the Department of Epidemiology and Public Health, Yale University.

Sawyer, Donald R. and Diana O. Sawyer. 1987. Malaria on the Amazon Frontier: Economic and Social Aspects of Transmission and Control. Belo Horizonte, CEDEPLAR.

An Economic Analysis of Sea Turtle Conservation in Cozumel, Mexico

Joanna Grand, MES Candidate
Zoe Rappoport, MES Candidate
Yale School of Forestry and Environmental Studies

Introduction

The benefits of endangered species conservation to humans and ecosystems are generally recognized yet rarely quantified. One way to provide incentive for ensuring the continued existence of natural areas and wildlife is through the economic valuation of these benefits. The goal of this research was to quantify the tourist value of a sea turtle protection program. The results may not only provide incentive for increased funding of sea turtle conservation on the island of Cozumel, but may also provide an indication of how successfully this type of conservation may be applied to other regions or species.

Study Site

The island of Cozumel lies 16 kilometers east of Mexico's Yucatán Peninsula. Two species of sea turtles, loggerhead (*Caretta caretta*) and green (*Chelonia mydas*), nest on the eastern shore of this island. Sea turtles that nest on the island are protected by federal laws as well as a local conservation program. In 1987, the city government of Cozumel declared the entire eastern side of the island an ecological reserve, providing over 20 kilometers of undisturbed beach area (Fig. 1). A field station was installed on the reserve two years later for state biologists to use during the six month nesting season from May to October. The Committee for the Protection of Sea Turtles of Cozumel was formed in 1990 to oversee conservation activities and to provide funding and supplies to the turtle project.

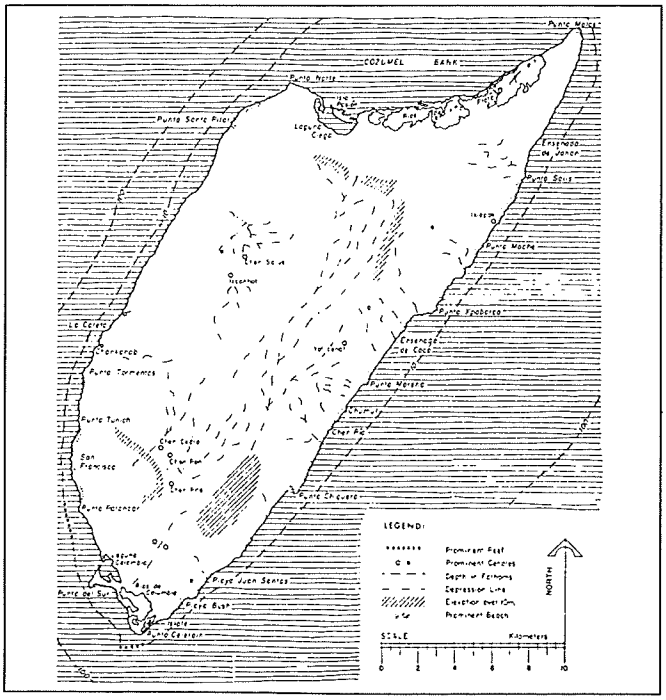


Figure 1. The island of Cozumel, protected area lies along the eastern shore

Program Description

Every evening during the nesting season, project members patrol the eastern shoreline for nesting turtles. When a female turtle or her tracks are sighted on the beach, project members collect the nest, consisting of approximately 100-120 eggs, and transport it to the field station. There, the eggs are reburied in a protected hatchery area and each nest is marked for identification. Sixty days later, when the hatchlings emerge from the nest, they are counted, examined for deformities, and released on various beaches along the eastern shore. Adult female population and hatchling success data are collected and analyzed each season (Zurita et al. 1991). Project participants include members of federal, state, and local governments as well as the Parks and Museum Foundation, a non-governmental entity. Members of the federal navy and city police also patrol the beaches to protect turtles from poachers.

In the past, Cozumel's Museum conducted a program in which tourists were permitted to participate in the nightly conservation activities. Small groups of visitors received a lecture on the biology and endangered status of the sea turtles, then were transported to the eastern beaches where they helped collect eggs, measure nesting females, record data, and re-bury eggs in the hatchery area. The popularity of this program prompted taxi drivers to bring tourists, unaccompanied by project members, to the nesting beaches. Large crowds and flash photography interfered with the conservation project, so public participation was halted. Currently, nighttime access to the shoreline road is limited to project members, and tourists can no longer actively participate in nightly activities. A daytime visit to the hatchery allows tourists to see nests in the protected area, talk with the biologist or his assistant, and often view the newly emerged hatchlings, to be released that evening.

Methods

The Travel Cost Method

The travel cost method (TC) provides a means of estimating the value of a natural resource above and beyond what consumers are willing to pay for access to the resource, which is equivalent to their cost of travel to the site (Clawson 1959, Burt and Brewer 1971). This value, the consumer surplus (CS), represents the total net benefits accrued to the consumer from the use of the resource. Figure 2 illustrates how CS is calculated for any one origin (in this case hypothetical origin A). The travel cost method quantifies the value of the natural resource by estimating the demand for trips to the site. It is assumed that tourists will continue to visit a site until the marginal cost of the trip is equal to the marginal benefit. The propensity to visit a site is a function of a number of factors, including personal character-

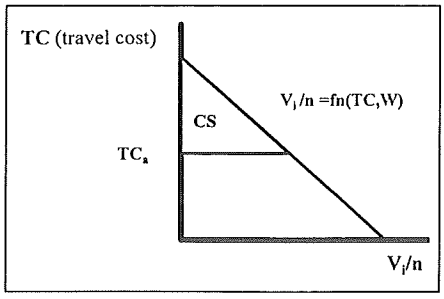


Figure 2. Sample demand curve with consumer surplus shown for origin A

istics (described below):

$Vi/n = fn\,(TC, W)$

where Vi/n is the visitation rate, TC is the travel cost, and W is personal characteristics.

The significance of a variety of personal and sociological characteristics in predicting tourist visitation was also explored. The characteristics examined include prior knowledge of the program, residence, length of stay on the island, income level, reported percent vacation enjoyment due to the turtle program (Brown and Henry 1989), willingness to pay for conservation of other types of endangered species, whether or not respondents SCUBA dive, whether or not there are sea turtle conservation programs in the region of residence, whether or not the region of residence is coastal, average regional income, percent of the region's population with college degrees, and average temperature in the region of residence during the month of July.

In the present study, the consumer surplus of visitors to Cozumel was estimated in order to determine the value of the island of Cozumel for tourists. The per capita consumer surplus of tourists involved in the sea turtle protection program was then compared with the consumer surplus of tourists with no involvement in the program. This comparison enabled us to quantify the value of sea turtle protection by examining how recreation demand varies among visitors as a function of their involvement in the protection program. The value of sea turtle protection was therefore determined by the following formula:

$$\text{Per capita value of sea turtle protection} = CS_{\text{visitors}} - CS_{\text{non-visitors}}$$

The annual value of the turtle conservation project was determined by multiplying the per capita value of turtles (CS) by the estimated yearly number of visitors to the project.

Although this method provides an estimate of the value of sea turtle protection, one of its main limitations is that it only takes resource users into account. The natural resource may also have value to those who never use it. Furthermore, the travel cost method does not incorporate non-use values, such as existence or option value, which are extremely difficult to measure. Therefore, this method provides us with the lowest estimate of the total value of the resource.

The Contingent Valuation Method

The contingent valuation (CV) method attempts to determine the value of the resource by asking questions regarding a person's willingness to pay for certain activities pertaining to the resource. The survey used in the present study included questions regarding existence value, visitation value and participation value. The values obtained from the CV analysis were compared to the travel cost analysis to determine if the results were consistent.

As with the travel cost analysis, multiple regression was used to determine if any personal/sociological characteristics explain willingness to pay for the above activities. This analysis also determined which groups of tourists benefit most from the Cozumel sea turtle protection program and thus identifies potential financial sponsors of the program.

Data Collection

Surveys were administered to 464 English speaking tourists around the island of Cozumel. Respondents came from the United States, Canada, Central America, South America, and Western Europe. Surveys were distributed at public and private beaches, hotel lobbies, the airport, and the turtle program field station. In addition, several dive shop owners administered the surveys to their customers. The travel cost segment of the survey was not administered to cruise passengers because Cozumel was only one of many destinations for these tourists. The sample may be biased due to the exclusion of non-English speaking Mexican tourists since this group represents almost one third of the summer tourist population (Cozumel Tourism Office, pers. comm. 1994). Nevertheless, economic estimates derived from these data provide a lower bound for the value of turtles.

Travel cost information was collected using two different methods. The survey method asked respondents to report all travel expenses incurred, including ground transportation. However, many tourists either refused or neglected to respond to this question. The second method of determining travel cost was through the Dow Jones Online Airline Information Service, which provided us with airfares from each region to Cozumel during the summer months. This method may be less accurate since it does not include costs of transportation to and from the airport; however these costs were assumed to be negligible relative to total costs. Therefore, two estimates of travel cost were derived: survey TC when reported/Dow Jones TC when not reported (S/DJ), and only Dow Jones TC.

Loggerhead turtle hatchlings (Caretta caretta)

RESULTS

Travel Cost Analysis

The S/DJ measure of travel cost represented a significant predictor of visitation to Cozumel. The only other variable included in predicting visitation rate to the island was summer

temperature of the visitors' state or country of residence. Although this variable was not highly significant, it was included in the regression because it caused an increase in the corrected R-squared value.

$$Vi/n = \underset{(\text{std.err}=1.093e\text{-}003)}{-3.0e\text{-}004\ \text{constant}} - \underset{(\text{std.err}=4.133e\text{-}007)}{8.653e\text{-}007\ TC} + \underset{(\text{std.err}=1.359e\text{-}005)}{1.822e\text{-}005\ \text{climate}}$$

Table 1 presents consumer surplus values calculated using the travel cost method.

TABLE 1. RESULTS OF TRAVEL COST ANALYSIS

a) Total CS for all visitors to Cozumel for 1994	US$105,640,000
b) Per capita CS	$594
c) Turtle program visitor per capita CS	$696
d) Turtle program non-visitor per capita CS	$535
e) Per capita value of turtles (c-d)	$161
f) Annual value of the turtle project (e * total # project visitors)	$11,740,925

Contingent Valuation Analysis

Average willingness to pay for levels of involvement in the turtle conservation program were calculated and results are presented in Table 2. The average reported percent enjoyment of the total vacation attributed to the turtle program was 5.7%. This percentage of total consumer surplus yields a value of US$34, which is relatively consistent with the reported willingness to pay for the existence of turtles on the island of Cozumel (US$21.03).

TABLE 2. RESULTS OF CONTINGENT VALUATION ANALYSIS

Average individual willingness to pay to visit turtle program	$9.29
Average individual willingness to pay to actively participate	$9.96
Average individual willingness to pay for turtle existence	$21.03

Multiple regressions indicated that willingness to pay to visit or participate in endangered shorebird conservation were highly significant predictors of willingness to pay to visit or participate in the turtle program and to ensure the continued existence of sea turtles on Cozumel. Prior knowledge of the program was inversely related to willingness to pay to visit or participate, and existence value was positively associated with willingness to pay to participate in the program. Reported income level, percentage vacation enjoyment due to turtles, SCUBA diving, residence in a coastal state, and travel cost did not significantly affect willingness to pay variables.

DISCUSSION

The visitation rate for all visitors to Cozumel was significantly linked to travel cost: fewer visitors came from farther away. However, a significant link did not exist between travel cost and visitation rate for turtle program visitors alone. There are two possible interpretations for this result. The first is that travel cost is not an important factor in determining the willingness of tourists interested in turtles to visit Cozumel. The second possibility is that this study did not include enough observations of turtle visitors to adequately describe their behavior.

The CV analysis showed that tourists who were willing to pay most for sea turtle conservation would also be willing to pay for conservation of endangered shorebirds. This indicates that this type of participatory program might be successful if applied to other endangered species. The inverse relationship between prior knowledge of the program and willingness to pay may suggest that since the program is at this time free of charge, tourists may be reluctant to pay for it. In addition, because existence value and participation value were strongly correlated, this may be an indication that existence value is just another measurement of use value.

In comparing the value of turtles obtained by the two methods, it is apparent that a much higher value is obtained using TC methodology (TC = $161, CV = $9.29). One explanation for this discrepancy might be that the TC method considers more than just the turtles in determining the value of the vacation site. However, it is clear that turtle program visitors valued their trip to Cozumel more than non-visitors. This is a strong indication that the continued existence of sea turtles on the island of Cozumel can contribute significantly to the island's tourism industry. This additional consumer surplus can also be utilized for future sea turtle conservation efforts by targeting tourists who visit the program as potential donors. The results of this study suggest strong potential for the success of similar programs in different regions involving public participation in endangered species conservation.

ACKNOWLEDGMENTS

Funds for this project were provided by the Tropical Resources Institute and the Coca-Cola World Fund at Yale University. We would like to thank biologists José Luís Miranda, Lizandro Domínguez Angulo, and Pablo de la Cruz Castillo Dzul; Juan Polanco and Francisco Gabriel Pech Uc from the municipal government; Minerva Marí Hadad, Jesús Benavides Andrade, and the rest of the staff of the Ecology Program at the Museo de la Isla de Cozumel. We are also grateful to the owners and staff of Aqua Safari and Discover dive shops for their assistance in distributing surveys. The guidance provided by Professor Rob Mendelsohn, Linwood Pendleton and Brent Sohngen is also greatly appreciated.

LITERATURE CITED

Brown, G. Jr. and W. Henry. 1989. The economic value of elephants. The London Environmental Economics Centre. London, England.

Burt, O. and D. Brewer. 1971. Estimation of net social benefits from outdoor recreation. Econometrica 39:813-827.

Clawson, M. 1959. Methods of measuring the demand for and value of outdoor recreation. Resources for the Future. Reprint.

Zurita G., J.C. Miranda and J.L. Miranda. 1991. Comite de protección de las tortugas marinas en la isla de Cozumel. Pages 159-168 *in* J. Frazier (ed.), Memorias del IV Taller Regional Sobre Programas de Conservación de Tortugas Marinas en la Peninsula de Yucatán, March 11-13, 1991, Mérida, Yucatán, Mexico. Universidad Autonoma de Yucatán.

From the Sea Up: A Case Study of Grassroots Reef Conservation in Roatán, Honduras

Nina Luttinger, MES Candidate
Yale School of Forestry and Environmental Studies

Introduction

In recent years increasing attention has been concentrated on the importance of preserving marine and coastal resources. UNCED's Agenda 21 calls for sustainable use and conservation of marine resources, addressing critical uncertainties in management of the marine environment and climate change, strengthening international cooperation and coordination, and sustainable development of small islands. This last goal may be increasingly hard to achieve, as tourism in many vulnerable marine regions, particularly small developing islands, has been soaring. Many of these islands are undergoing massive development to accommodate tourism growth but typically do not have sufficient funds to implement effective resource conservation strategies.

As populations rise and resources continue to become depleted due to unchecked exploitation, countries will need to design innovative approaches to marine and coastal area management. While many existing marine conservation strategies emphasize support from national governments or international non-governmental organizations (NGOs) to manage these imperiled resources, few concentrate on the ability of communities to organize and manage their own local resources and protected areas. Such "bottom-up" grassroots approaches to resource management have existed in various forms throughout the world for millennia, but are currently experiencing a crescendo of attention from the conservation community (White et al. 1994, Western and Wright 1994, WRI 1991).

Background

Situated 48 kilometers off the coast of Honduras, the Bay Islands share one of the largest coral reef complexes in the world, second only to Australia's Great Barrier Reef. Local islanders have traditionally used the reef as a means of subsistence: harvesting fish, lobster, conch, crab and other species. Historically, the island economy has depended on industries relating to the deep sea harvesting and processing of fish, shrimp and lobster. However, overexploitation of these resources during the 1970s and early 80s led to an estimated 50% decline in fish catch per unit effort between 1974 and 1983 (Halcrow 1983).

Since the 1980s, a global rise in tourism to natural areas has served to increase attention and visitation to the exceptional coral reef surrounding this archipelago. Gradually, growth in dive tourism has supplanted fishing industries as the base of economic development on the islands. Today, tourism is booming in the Bay Islands, up from 900 tourists in 1969 to 17,000 tourists in 1991 (Sorensen 1993). As tourism grows, prices for locally harvested fish, lobster, and conch also rise. Heightened demand has led to an almost complete decimation of these species in certain high-use areas. This problem has been exacerbated by the lack of effective conservation policies (or true implementation of existing ones) designed to guide development activities in a sustainable manner. With no formal laws to minimize user impact, the reef has received multiple assaults from anchors, tourists walking on the reef, spearfishing and curio collection. The reef, in fact, is being loved to death.

This situation points to a problem inherent in nature-based tourism: how to maintain the pattern of economic growth while staying *within* the capacity of the natural environment to absorb visitors. Recognizing the importance of conserving marine resources for their own economic survival, but lacking the support of the national government or international conservation NGOs, two communities on the main island of Roatán have established a grassroots marine reserve. The West-End-Sandy Bay Marine Reserve protects a thirteen kilometer stretch of the marine ecosystem from the multiple assaults of expanding tourism. In the few short years since its establishment, the marine reserve has been incontrovertibly successful in restoring the previously damaged reef ecosystem, as expressed by local residents and conservationists as well as returning tourists. Nonetheless, policy deficiencies clearly exist.

The value of the Roatán case study lies in its potential to provide a model for how community-based protected areas management can be initiated, organized, and maintained in a self-sufficient and sustainable manner. As participatory natural resource management becomes increasingly accepted as an effective strategy for achieving the balance between development and conservation needs, existing initiatives will provide invaluable learning tools.

Project Objectives

The broad purpose of this project is to develop an understanding of the social and economic aspects of a participatory natural resource management initiative. To this end, I examined the following:

1) the past history of conservation and development activities on Roatán;
2) the initiation and development of a community-supported marine reserve;
3) the structure, function and budget of the marine reserve;
4) local attitudes toward the marine reserve and island conservation in general; and
5) tourist information regarding travel costs, visitor expenditures, and willingness-to-pay a reef user fee.

The short term objective of this project is to record the information distilled from the above investigations in the form of a policy report containing a relatively detailed list of recommendations aimed at maximizing the success and effectiveness of the marine reserve initiative.

The long term objective is to create a conceptual framework and realistic operational guidelines for initiating, organizing, and maintaining a sustainable system of community-based marine protected areas management. Resources for distribution of this end product to island NGOs and communities throughout the Caribbean and beyond will be sought upon completion. In this article, I present only the background information and preliminary conclusions from the case study. More detailed information regarding the social and economic aspects of this project will appear in the forthcoming TRI Working Paper #81.

Methods

Preliminary investigations of historical conservation policies on the Bay Islands were accomplished through archival research. Using the library resources at the Bay Islands Conservation Association (BICA), I examined past conservation studies, management plans and proposals for the establishment of protected areas. This information was substantiated and enhanced through numerous interviews with local politicians, development agencies, conservation groups and long-time residents.

Information regarding the initiation, organization and budgetary concerns of the marine reserve was similarly gathered through extensive interviews with marine reserve board members and staff, and my own participation in marine reserve activities such as board meetings, town meetings with the mayor, fee collection, and patrol guard surveillance.

Attitudes and values of islanders regarding local conservation were recorded through the administration of over 50 surveys. My own participation in three community-oriented projects provided further insight into local social values towards conservation that may not have been revealed through the survey. Coordinating a local children's crusade (the Green Team) to clean up trash from marine reserve beaches on a weekly basis, canvassing for support to halt a massive development project in one of the island's largest wetlands, and producing and hosting a weekly radio program (ECHO Roatán- the Environment, Community, and Health Outreach, which broadcasted information on local island environmental news/workshops, island ecology, and human health issues) gave me an entirely different and tremendously valuable perspective on the human component of island conservation on Roatán.

Information regarding visitor travel costs and willingness-to-pay a reef user fee was collected through the administration of over 100 tourist surveys. Evaluating average travel costs and visitor expenditures helps put the willingness-to-pay figures in perspective, as it allows us to consider the relationship between what tourists pay to experience the reef and what those same tourists would be willing to pay to maintain the health of that reef. Similar reef user fees are being collected in marine parks all over the world, such as the Galápagos, Bonaire and Saba, and have been critical in helping to cover the expenses of reef protection, particularly on developing islands.

Preliminary Results and Discussion

The key problems with most conservation policies within the Bay Islands echo those faced by many developing countries around the world: inadequate funding, lack of technical expertise to effectively manage and regulate natural resources, relatively low priority given to environmental issues (as evidenced by the former two deficiencies), and lack of accountability. Financial support from the mainland government is extremely limited for all aspects of social welfare, including the environment. Unfortunately, most of the previously proposed management plans or proposals for protected areas have contained unrealistic, unattainable goals given the local social and economic context. This stems primarily from the top-down emphasis of previous plans, which overlooked the capacity of local people to manage their own resources.

Since political, economic and social structures presently interfering with conservation goals remain in place (while population and commensurate resource pressures continue to expand), it seems increasingly crucial to encourage communities to take an active role in managing local resources. As communities seek ways of launching such projects, it will prove critical to provide the organizational, budgetary, social and biophysical details required of successful initiatives. Although it may be unrealistic to assume such case studies can be generalizable across cultural and geopolitical boundaries, one can nevertheless surmise that a general set of prescriptive guidelines will be useful in all contexts.

The impetus for local action in Roatán was a combination of the increasingly apparent deterioration in marine resource quality and the motivation of one trusted member of the community. This individual educated himself about marine protected areas and spent several months talking to the community about the need for and benefits of such an endeavor. Community-wide recognition of the vital link between ecosystem health and the continued reliance on reef-based tourism became a vital factor in motivating locals to participate in a community-organized marine reserve.

After building consensus for establishing a protected zone, the reserve area, rules, enforcement and budget were planned at a series of town meetings. A three-km-long stretch of biologically rich but intensively used reef was initially decided upon for the reserve area (later expanded to about 13 km in length), and several former fishermen were trained to patrol the area. Reserve rules sought to control direct assaults to the reef ecosystem, such as those caused by anchors, spearfishermen, poaching of marine life and walking on coral. Since the reserve held promises to restore previously damaged marine populations and the overall health of the coral ecosystem, residents who owned tourism-related businesses such as dive shops or hotels, could easily see the benefits of contributing to the budget of the reserve. Members were asked to pay a regular monthly membership fee to support salaries for the elected Director and patrol guards as well as the maintenance costs of patrol boats. Most residents unassociated with the tourism industry respected reserve rules and participated

in the early planning meetings but cannot afford to contribute monetarily.

Although the benefits of establishing a marine reserve have already been generally recognized in Roatán, a number of policy deficiencies still exist that could adversely impact long-term usefulness of the protected area. The key problem thus far is unquestionably the lack of interaction between the marine reserve board and the agency guiding development policies on land. While the reserve has been critical in reducing direct physical damage, it has remained divorced from development activities on land.

Land development allowed to proceed without the guidance of carefully enforced environmental regulations can often result in negative impacts to coral ecosystems stemming from such problems as increased erosion, sedimentation, and sewage contamination. At the time of data collection for this project, an enormous wetland had just been filled for a development project adjacent to the most pristine part of the marine reserve. Lacking appropriate technical expertise and the authority to actively participate in development activities or permitting, the marine reserve has been relatively powerless to address these significant assaults. Furthermore, land development bordering the reef ecosystem has the potential to cause more damaging effects than those resulting from direct physical damage, as sediment and sewage-related problems leading to algal blooms can lethally smother a reef. Upon the marine reserve board's request, I submitted recommendations detailing a number of policy additions and changes regarding how best to remedy these deficiencies.

Social surveys of the local islanders have not been fully analyzed at the time of this publication, but several preliminary patterns have emerged. One hundred percent of respondents making their living from tourism-related businesses contributed a monthly fee to the marine reserve. Over 65% of the survey sample considered the coral reef to be the most important resource on the island. When asked if the reef would deserve protection if tourism did not exist on the island, 64% agreed it would still be worth protecting. These surveys indicate positive local views toward the reef, which may be vital during the process of building consensus for proposed marine reserves, and which may prove imperative to the overall long-term success of the marine reserve.

A number of community-wide trends and needs emerged through my direct participatory experience in local conservation on Roatán. There is a distinct need to expand access to education regarding conservation practices *beyond* the primary and secondary school levels. Currently, the primary targets for environmental/conservation education appear to be school children, not the adult residents who actually cause the greatest damage. One island NGO offers occasional workshops in conservation-oriented land management, but would clearly benefit from increased promotion and publicity. Judging from the response to the ECHO Roatán radio program, it seems such efforts are well appreciated and effective in transmitting valuable information that locals feel is useful to their everyday experience.

Tourists demonstrated an average willingness-to-pay a reef user fee of about US$22. If this number were extrapolated to the 1991 tourist visitation of 17,000, a reef user fee has the potential to generate approximately US$374,000 dollars per year. However, this figure should be observed with caution, because 1) the tourist sample was from only one region of the island and may not represent a true average willingness-to-pay for all tourists to Roatán, and 2) it carries the assumption that all tourists are using the reef and would be willing to contribute to the reef user fee, when in fact 17% of those surveyed did not indicate they would contribute to this cause. Even with a more conservative fee, such as the $10 fee used in the Bonaire marine park, an island-wide marine reserve has the potential to earn up to $170,000 annually. These collected fees could easily support present budgetary needs of the marine reserve and alleviate the financial burden now resting upon small businesses of the two marine reserve communities. Excess capital could be used to help upgrade community infrastruc-

ture that is adversely impacting marine resources, particularly local septic systems.

Finally, preliminary results of the tourist travel cost data show that the average cost per trip to Roatán is only US$200, because most tourists are on multiple destination trips. Average stayover for all tourists is roughly 7 days, and accommodation costs per night average US$16. This brings average tourist expenditures to about US$312 per visit to the reef. If extrapolated to all tourists, this would translate to a conservative total tourist expenditure of about US$5,304,000 for reef vacations to Roatán. Tourists are willing to spend about 7% of their current expenditures on protection of that resource.

The above investigations represent initial findings of this TRI project. Eventually, full results will be synthesized into a report that details the basic structure, function and organization of a community-based marine protected area set in the context of a rapidly developing island. This report will also define key social and economic variables in designing and implementing similar conservation efforts. Such analyses serve the double function of 1) aiding the Roatán marine reserve to re-evaluate current policies to increase effective protection of, and funding for, the local resource, and 2) providing a model for island communities with similar development and conservation pressures.

Acknowledgments

This project was supported by the Tropical Resources Institute. I would also like to thank the Bay Islands Conservation Association (BICA), the Commission, the Pro-Development Agency for the Bay Islands (APRODIB), Julio Cruz (Director of the marine reserve), radio station HRGS, the Green Team Clean-Up crew, and the many local residents of Roatán who helped me along the way and also became my friends.

Literature Cited

Halcrow, J. 1983. Roatán Island Environmental Control Plan. A Report published by the Office of Urban Planning of the Ministry of Public Works and Transport, Tegucigalpa, Honduras.

Sorensen, Jens C. 1993. A Plan to Establish, Develop, and Manage the Bay Islands National Marine Park. A Final Report to the Government of Honduras, the UNDP Program of Honduras, and the Environmental Programs Section of the Inter-American Development Bank.

Western, David and R. Michael Wright. 1994. Natural Connections. Washington DC and Covelo CA, Island Press.

White, Alan T., Lynne Zeitlin Hale, Yves Renard and Lafcadio Cortesi (eds.) 1994. Collaborative and Community-Based Management of Coral Reefs. Hartford, CT, Kumarian Press.

World Resources Institute. 1991. From the Ground Up: A Case Study Series.

Spatial Distribution and Abundance of *Desmoncus polyacanthos*, a Neo-tropical Liana

Austin Troy, MF Candidate
Yale School of Forestry and Environmental Studies

Introduction

Lianas have gained increasing attention as valuable non-timber forest products that could be sustainably extracted to economically benefit tropical forest communities without degrading forest ecosystems (Whitehead and Godoy 1991, Phillips 1991). Not only are lianas abundant in many neotropical lowland forests, but they are easy to process, non-perishable, and, because of their multiple uses, not at the mercy of a single market.

Furniture made from lianas is one of the largest non-timber forest product industries in the world and figures importantly in many national economies. For example, the Southeast Asian rattan furniture industry currently processes about 150,000 tons/year of raw rattan palms (*Calamus* spp.) at a value of almost US$3 billion annually (Caldecott 1988).

Though most of the world's rattan furniture comes from southeast Asian countries, recent research indicates that some species of neotropical lianas also might be suitable for manufacture in the rattan trade (Phillips 1991, Siebert 1991, Whitehead and Godoy 1991). Despite the emergence of a sizable domestic wicker industry in parts of Brazil, there have been few socio-economic or scientific studies on the native species involved in this industry.

This study looked at *jacitara* (*Desmoncus polyacanthos*), a climbing palm very similar in morphology and cane-quality to many species of Asian rattan, although only distantly related. The study area was in the Amazon estuary region west of the city of Belém, Brazil (49°W, 2°S). This vine is an auspicious potential resource because of its high cane quality and abundant growth in managed lands and disturbed areas. Nevertheless, local craftsmen and inhabitants claim that *jacitara* is rarely used for the manufacture of furniture.

This study was intended to quantify the relationship between several canopy characteristics and the abundance and distribution of *jacitara*. Establishing these relationships is necessary in determining the best canopy management strategies to encourage the sustained growth of this vine. It is also needed to determine in what forest type or land use type *jacitara* management should occur.

Methods and Site Description

Eleven transects were created in five sites. These sites are graphically described in figure 1 (next page). Site I was a

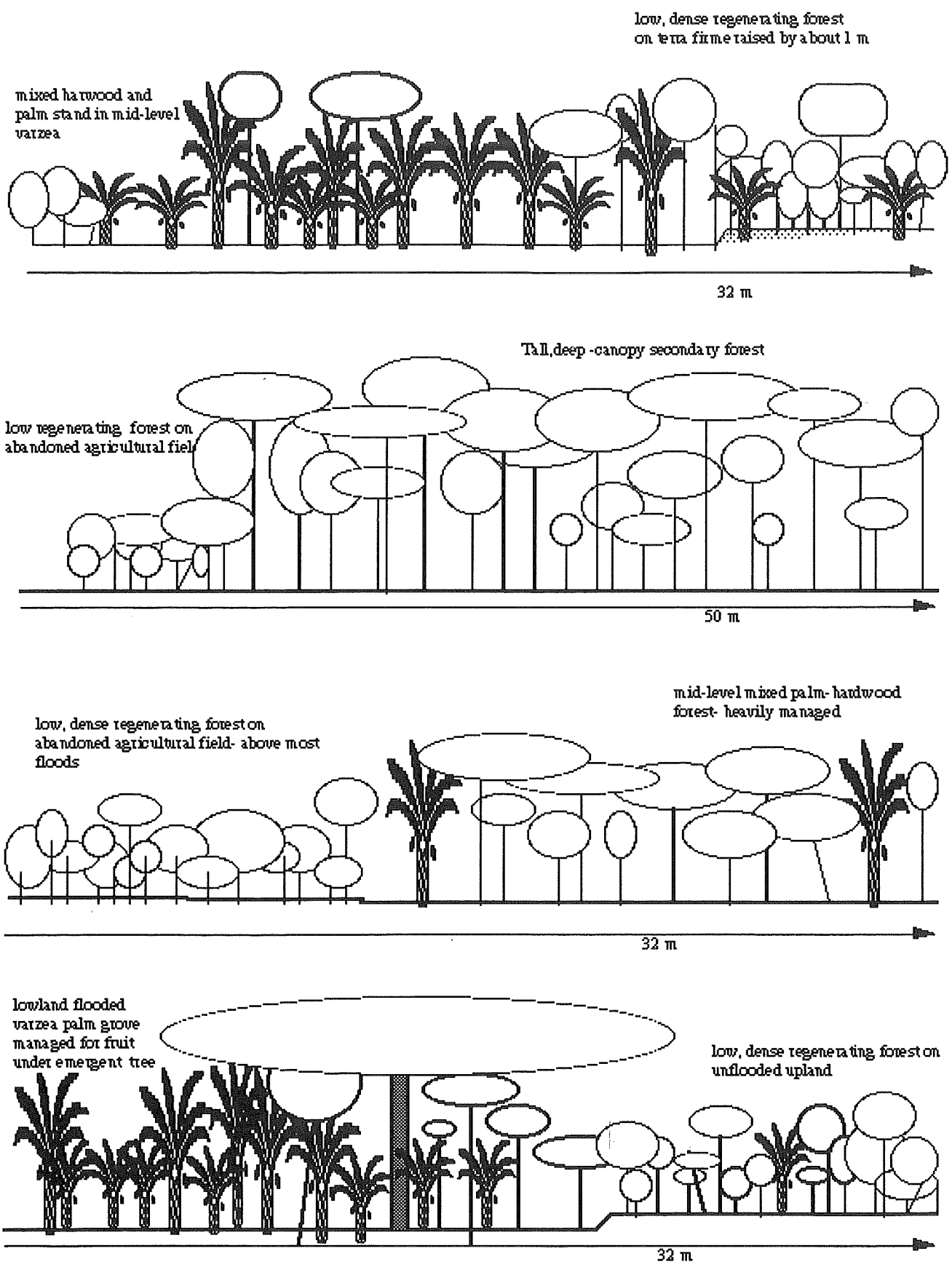


Figure 1. Study site descriptions (from top to bottom): Site 1, mid-level várzea *and slight upland; Site 2, upland* terra firme*; Site 4, transition zone between* várzea *and* terra firme*; Site 5, low* várzea *and regenerating upland forest. Site 3 (not represented) is also upland* terra firme *(like Site 2) but does not intersect regenerating forest.*

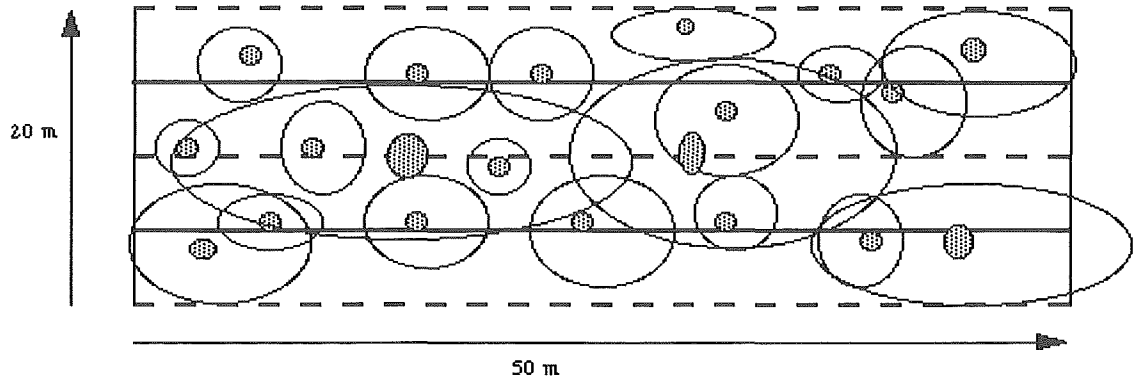


Figure 2. Transect design and dimensions for Sites II and III. Other sites were 32 x 8 m for every set of double transects.

highly managed, slightly elevated *várzea* (flooded forest) of which the lowest parts were flooded only several times a month and the highest parts were above almost all flooding. The higher side of this site bordered on dense, low, regenerating forest. Sites II and III were located in *terra firme* (high ground) forest. Because of its remoteness from settlement, this forest was less heavily managed, older and taller. Site II included a small segment of a low regenerating fallow at the forest's edge. Site III had several large windthrow gaps. Site IV followed the edge between *várzea* forest and upland, low regenerating forest. Site V was a low site influenced by daily floods. The inland side was higher and a dense low forest was regenerating upon it.

For each of these sites, two parallel transects were laid down next to each other, except in site I, where three were laid down. Individual transect dimensions were 4x32 m for sites I, IV and V and 5x50 m for sites II and III. Transect plans are shown in figure 2 (above). For each transect the base and top of all crowns were measured over each individual square. Each crown was mapped horizontally and vertically in the confines of the grid. Several characteristics of *jacitara* plants were measured within each square including leaf number, number of stems, vine height and diameter at base of stems. Leaf number was used in analysis because it is a good indicator of the present state of the vine. Vine vigor can change rapidly as the canopy is managed; if this change is adverse it results in rapid leaf death. Measurements of the woody part of the vine are representations of past health of the plant and do not necessarily bear a relationship to the current canopy.

Three characteristics were quantified for each square: depth (the distance from the bottom to the top of the canopy, including all crowns present in the square), thickness (the total portion of the canopy depth occupied by foliage) and density (the height of each individual crown added up, thus taking into account overlap of crowns). Two ratios were then derived for each square: thickness to depth, defined as the measure of the proportion of live crown present in vertical space within the canopy and density to thickness, defined as the proportion of the canopy's vertical space including overlapping crowns to the total vertical distance of the foliage, excluding overlap. A ratio of 1 means that there is no overlap while a high ratio indicates overlap or vertical clumping. This ratio is diagramatically explained in figure 3 (below).

These characterizations were examined for a possible statistical relationship to the size and abundance of *D. polyacanthos*. Each transect on each site was analyzed separately in order to determine if possible statistical relationships might differ between land types.

Results

The regression results demonstrated a significant relationship between the density to thickness ratio and vine leaf number in all transects (Table 1, below). However, the slope of this

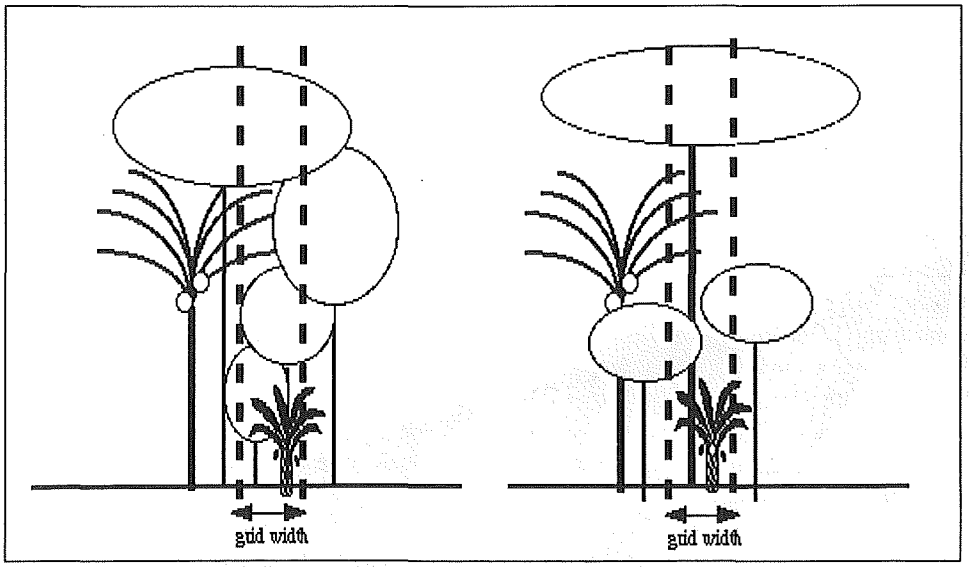


Figure 3. Diagramatic representation of crowns with high density to thickness ratio (left) and low density to thickness ratio (right)

relationship differed between sites; site I had an extremely steep slope, with leaf number increasing by 380 leaves (see "coefficient" in Table 1) for every one unit increase in ratio, while Sites II and III had a much more gradual curve, with leaf number increasing only by 100 for every one unit increase in the ratio; the other sites had similar slopes, with about a 200 factor increase for every one unit increase in ratio.

TABLE 1. Regression results of density:thickness(dtr) ratio on leaf number(ln) (leaf number = coefficient + intercept * ratio). F-statistic of each equation is significant at 99% level. All regression coefficients of each equation are significantly different from zero at 99% level. Letters denote level of significance according to Tukey's standardized range test (A>B>C). Coefficients with same letter are not significantly different.

Site	equation	R-squared
Site I	ln=381dtr-374 [A]	.36
Site II, III	ln=109dtr-100 [C]	.36
Site IV	ln=200dtr-195 [B]	.31
Site V	ln=185dtr-186 [B]	.55

DISCUSSION

The high correlation between leaf number and density to thickness ratio indicates that *jacitara* grows abundantly on frequently disturbed lands. Such a pattern is an indication that growing space has been opened up and that competition for that space is intense. This occurs when the canopy is opened by natural or anthropogenic means, resulting in great vegetal plasticity and competition for growing space. A high density to thickness ratio is an indication that the discreet stratification of an older-growth forest has been upset by the sudden removal of part of the overstory. Density-to-thickness ratio can be high both where a large opening has occurred in an older-growth canopy and where land has been cleared and subsequently abandoned, resulting in natural regeneration. This pattern of growth in areas of recent disturbance is common in many species of tropical vines (Caballé and Hegarty 1991).

This disturbance pattern is not necessarily the cause of vine growth but rather an indicator of its associated conditions. Direct causes are probably related to the opening of growing space and to the heterogeneous, bright and shady light regime found under clumpy, young vegetation as opposed to the uniform and diffuse regime under well-stratified forests. This is corroborated by the observation that *jacitara* never grows in totally open sunlight, but only under the protective shade of the outermost foliage, where it gets both direct sun and shade.

Land management appears, in this case, to account for most disturbance at these sites. Both frequency and magnitude of the management appear to determine the presence of *jacitara*. In site I, where there is selective but frequent cutting of the relatively tall canopy trees, there are fewer individual vines, but individuals are larger and taller. In young, regenerating fallows where the land had previously been cleared, there were many more individual stems and the vines were much shorter. In the older, less managed forest sites (sites II, III), *jacitara* tended to grow in large sunflecks, in tree-fall gaps, in areas of selective cutting and on edges with cleared areas or near the top of the canopy.

The difference in coefficients between sites, I believe, is attributable to the level of management. In sites II and III, the regression slope is low because of the deep and complex canopy, which only allows limited proliferation of the vine even where the canopy density is great. Also, where disturbance is present, the ratio is extremely high, due to larger canopy size. The slope is high in site I because of human-caused reduction of the density to thickness ratio. At this site frequent thinning of trees (mostly for harvesting of palm hearts) results in constant reduction of foliage at a faster rate than it can occupy newly opened growing space. This decreases the density to thickness ratio and thus steepens the regression curve. Conditions needed for vine growth are still there; the cutting, in decreasing the ratio, has merely altered the indicator, not the root cause of increased growth. The slopes of sites IV and V fall between those of I and II/III. This is probably because the intensity of management of these sites is intermediate in relation to sites II/III and I. This also stems from the fact that while IV and V contain regenerating vegetation, neither has undergone recent thinning.

CONCLUSION

Jacitara's propensity to grow on managed lands indicates it may be a resource of great potential benefit to communities. *Jacitara* grows in regenerating fallows, thinned forests and in clearings of older forests. This growth habit is significant for numerous reasons.

First, it reduces the need to collect from more pristine and remote forests. This is important because it greatly reduces travel time for collectors (thereby increasing the value to the collector), it avoids problems of depletion and limited supply associated with slow regenerating primary forest vines and it helps provide a reliable supply of materials for furniture manufacturers. Second, *jacitara* is compatible with currently employed land management systems. Because *jacitara* grows in forests under many types of management, it can easily be adapted to current management schemes, although some tradeoffs (i.e., additional canopy manipulation) would be required with increasing intensity of *jacitara* management. Third, managing for *jacitara* encourages long fallows because it tends to grow abundantly on these lands for many years. Fourth, the fact that it grows well on heavily managed lands means that it generally grows on private lands. This discourages "tragedy of the commons" scenarios in which resources on common lands are overharvested to the point of scarcity, as has occurred with many valuable species of vines that grow in

remote primary forests. Fifth, its abundance on recently cut lands indicates that *jacitara* grows very fast on managed lands. This decreases the period between returns and helps maintain a steady supply of the material.

These qualities give *jacitara* a great advantage over most of the other native species currently used in the Brazilian wicker industry, most of which grow only in old-growth forests and are subject to overharvest and scarcity. *Jacitara's* speedy growth allows supply to be maintained much more easily than by other currently used neotropical forest vines, which require long periods to regenerate in the wild. Since supply is one of the greatest limits to the Brazilian wicker furniture industry, *jacitara* could prove to be an important resource for businesses and for land owners. The more that is understood about the growth of *jacitara*, the more efficient its management will be, and the greater will be its contribution.

Acknowledgments

This research was made possible by a grant from the Yale Center for Biospheric Studies, administered through the Tropical Resources Institute. I would like to thank Drs. Mark Ashton and Bruce Larson for their assistance and guidance over the past six months. I greatly appreciated the help and support in Brazil of Dr. Mario Hiraoka, Shiro Hiraoka, Dr. Hideaki Matsuoka, Tanya Maruchak, Nuria Muñiz-Miret, Museo Goeldi, Carlos Agricola, Charleston Fonseca e Silva, Cleide Amorim de Jesus, the Serruya family, Michael O'Grady, Fernando Rebello, Marcos Loyola, Orlando Cruz, Denio and all those who were interviewed.

Literature Cited

Caballé, G and E.E. Hegarty. 1991. Distribution and abundance of vines in forest communities. pp.331-335 *in* Putz, F.E. and H.A. Mooney (eds.), The Biology of Vines. Cambridge University Press, Cambridge.

Caldecott, J. 1988. Climbing towards extinction. New Scientist 9: 62-66.

Phillips, Oliver. 1991. Ethnobotany and economic botany of vines. pp.427-475 *in* Putz, F.E. and H.A. Mooney (eds.), The Biology of Vines. Cambridge University Press, Cambridge.

Siebert, Stephen. 1991. Biology, utilization and silvicultural management of rattan plants. pp.477-492 *in* Putz, F.E. and H.A. Mooney (eds.), The Biology of Vines. Cambridge University Press, Cambridge.

Whitehead, B.W. and R. Godoy. 1991. The extraction of rattan-like lianas in the new-world tropics: a possible prototype for sustainable forest management. Agroforestry Systems 16(3): 247-256.

The Effects of Agroforestry Practices on the Biological Diversity of Birds and Indigenous Plants on the Southern Slopes of Mt. Kilimanjaro

Charles J. Kara, MES Candidate
Yale School of Forestry and Environmental Studies

Introduction

Rapid human population growth on the southern slopes of Mt. Kilimanjaro has accelerated the demand for natural resources and land for rural development (Kara et al. 1990) and cultivation (Cook and Grut 1990, Mwasaga 1991). Consequently, indigenous forests have been replaced with exotic plants such as coffee and banana. The increased intensity of habitat destruction and hunting have contributed to the decrease in numbers and complete disappearance of many species of birds (Moreau 1944) and mammals from the inhabited slopes of Mt. Kilimanjaro (Newmark et al. 1991). Kilimanjaro National Park has been established on the eastern slopes of the mountain, where illegal hunting and felling of trees are common (IUCN 1987). This trend will lead to an irreversible decline in the capacity of the land to support humans and wildlife (Kara et al. 1990).

This study was initiated in part because many studies elsewhere have shown that certain land use practices have either detrimental or beneficial effects on the biological diversity of birds. In the absence of intact riverine forests, I conducted a study in the disturbed riverine habitats in two sites: along Lombanga, moderately altered habitat, and Kichau, a severely altered habitat. These sites allowed i) comparison of bird and plant species diversity, ii) comparison of existing vegetation

Examples of moderately disturbed habitat (above) and severely disturbed habitat at the study site

strata and their significance to the avifauna and iii) suggestions for management and conservation of the area.

Study Area

The study area is situated on the southern slopes of Mt. Kilimanjaro. It is located approximately 3°15' South and 37°55' East and covers an area of about 5 km^2. It is 12 km from Moshi town and lies at an altitude of about 1,500 m elevation. The annual average rainfall is about 1200 mm. There are two rainy seasons: the long rains from March to June and the short rains from October to December. Temperatures range from 12°C to 22°C. Fertile volcanic soil is predominant in the area (Anderson 1982). Vegetation is comprised of both indigenous and exotic species. The most conspicuous indigenous trees include *Albizia schimperiana, Croton macrostachyus, Spathodea nilotica, Khaya nyasica, Ficus* spp., *Rauvalfia caffra* and *Tabernae-montana holstii.* Dominant exotic plants include *Grevillia robusta, Pinus randiata, Persea americana, Lantana camara, Coffea arabica* and *Musa* spp. (Kara et al. 1990). The Chagga people inhabit the foothills of Mt. Kilimanjaro. They practice a multistoried agroforestry cropping system referred to as the Chagga Homegardens (Maghembe 1989). Due to the homegardens' success, Mt. Kilimanjaro is one of the most densely populated areas in Tanzania (Cook and Grut 1991, Maro 1988).

Methods

Based on the previous survey and mapping conducted (Kara et al. 1990), I partitioned the study area into two blocks, approximately 1 km apart, of homogeneous vegetation and physiognomy. Block I was classified as moderately altered riverine forest because it is relatively intact. Block II was classified as severely altered riverine habitat because most of its natural vegetation had been cleared and replaced by coffee and banana plantations. I established a transect of 1.2 km x 0.2 km in the center of each block. Transects were traversed on foot to identify birds during the early morning and evening hours. The number of individual species encountered were recorded in inventory tables. In addition, activities performed by the individual bird or flocks of birds were recorded. The plant strata in which birds occurred were also recorded and characterized as herb/regeneration layer, shrub/regeneration layer and tree layer.

I randomly selected 30 transect belts to sample plant species. Sampled plants were identified to species. The heights of herb and shrub layer plants were measured with a tape measure and tree heights were estimated using a hyposometer.

Plant and bird species diversity in the two blocks were estimated using the Shannon-Weaver's Index (H') (Shannon-Weaver 1949, Ludwig and Reymond 1988) and Similarity Index (SI) (Odum 1971, Cook and Studdendieck 1986). Habitat stratification was analyzed by quantifying the mean height of each layer in each block. The significance of each block to bird life was evaluated by birds' activity frequency. Results from the two blocks were compared to evaluate the status of the two blocks as a basis for decision making.

Results

Table 1: Plant species diversity index

Layer	Block I	Block II
Herb	1.4	1.0
Shrub	1.1	0.8
Tree	1.1	0.5
Mean	1.2	0.8

Table 2: Plant species similarity and dissimilarity indices

Layer	Similarity Index(%)	Dissimilarity Index(%)
Herb	58	42
Shrub	50	50
Tree	29	71
Mean	46	54

Table 3: Bird species diversity index

Layer	Block I	Block II
Herb	1.2	0.5
Shrub	1.3	1.0
Tree	1.0	1.2
Mean	1.2	0.9

Table 4: Bird species similarity and dissimilarity indices

Layer	Similarity Index(%)	Dissimilarity Index (%)
Herb	18	82
Shrub	44	56
Tree	64	36
Mean	42	58

Discussion

Plant Species Diversity

As the two blocks are located in the same altitude, topographic aspect and soil type, they are expected to have the same diversity index (H') and similarity index (SI). The observed differences in H' and SI for the two blocks can therefore be largely attributed to human interference. Block I has been only moderately affected through cutting of trees for firewood, building poles, timber and forage for livestock. As a result, indigenous species of plants are still present, such as *Caesalpinia decapetala, Albizia schimperiana, Croton macrostachyus, Ficus* spp. and *Rauvalfia caffra.* In contrast, most of the natural vegetation in Block II has been replaced by *Coffea arabica* and *Musa* spp. Consequently, many indigenous species, especially shrubs, have been cleared. Habitat conditions between the two blocks are becoming increasingly dissimilar.

Habitat Stratification

Block II has been regularly weeded. This situation selectively favors the growth of tall cultivated food herbs such as *Colocasia antiquorum.* If Block II is left unattended for a longer period

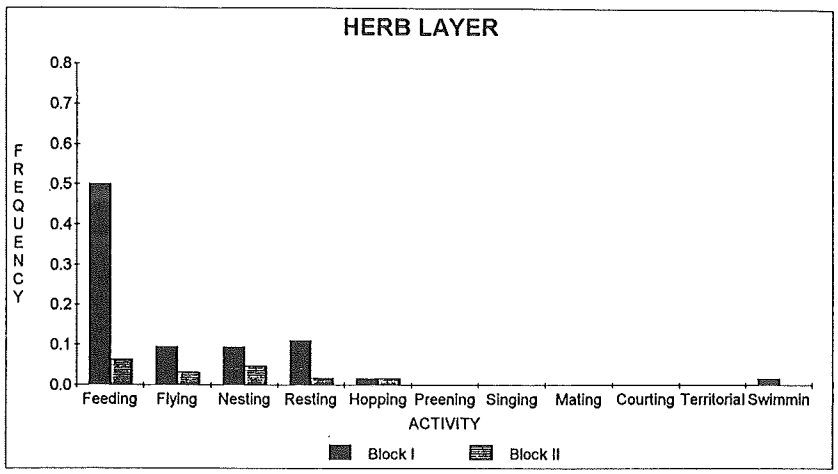
of time, the herb layer will be replaced by shorter perennial herbs characteristic of Block I, such as *Drymaria cordata, Aneilema petersii, Cyperus escullentus, Digitaria velutine, Eragrostis tennifolia, Oxalis latifolia* and *Ageratum conyzoides*. The difference in mean height of the shrub layers between the two blocks was due to coffee as the dominant shrub in Block II, whose height has been controlled by periodic pruning. Block I has a diversity of shrub species taller than that of coffee plants, as they have not been pruned.

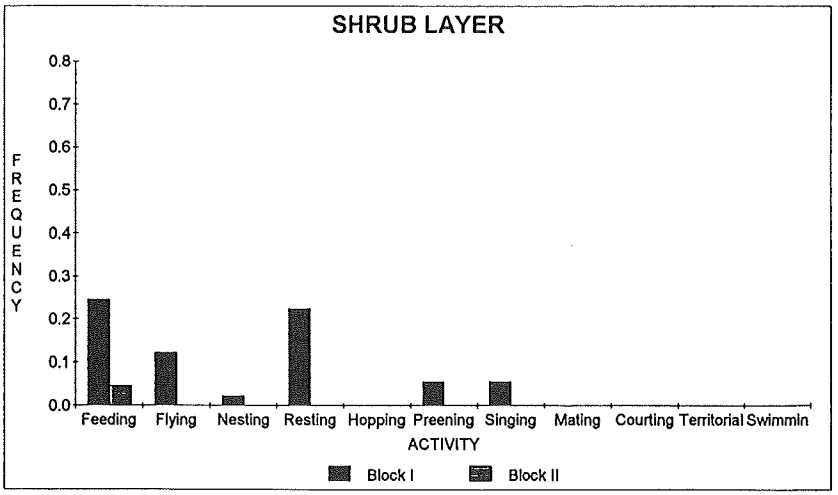
Bird Species Diversity

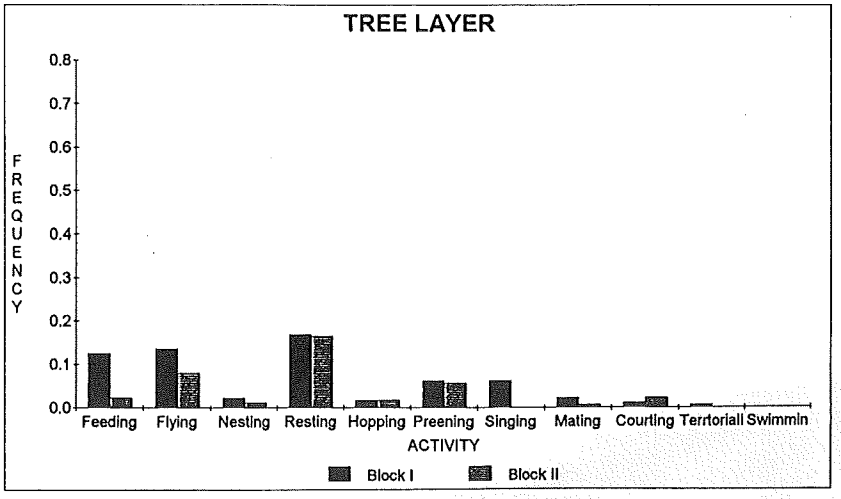
Because of their proximity, the two blocks are in the same climate and altitude, and are expected to share many plant species and bird species. This was not the case. The mean similarity index of 42% implies bird species diversity differs by 58% between blocks. The relatively high diversity index of birds in Block I can be attributed to the presence of more plant species in Block I. This suggests that the greater number of species of indigenous herbs and shrubs in Block I possibly provides more habitat welfare factors crucial for birds. The shrub layer in Block II is dominated by coffee and banana plants coupled with continuous weeding and mulching. Thus replacement of the indigenous mixture of shrubs and herbs resulted in the elimination of bird species from Block II. The bird life at the tree layer in both blocks consisted of roughly the same species. This may be because selective clearing of the original forest has left most mature trees intact in both blocks.

Bird Activities

Frequency of bird activities were used as indices of block and layer importance to birds. The predominance of activities provide a basis for speculating what welfare factors support observed bird life. The tree layer is predominantly important for activities such as resting, flying, preening and nesting in both blocks. The herb layer was predominantly important for feeding. However, due to continuous weeding of the herb layer in Block II there was far less feeding frequency there, suggesting that coffee and bananas do not provide welfare requirements for a number of bird species.







Figures: Species activity frequency observed in 16 samples between 7:00 - 10:00 am and 4:00 - 7:00 pm in each layer.

Conclusion

This study shows that flora and avifauna in the Lombango riverine forests (Block II) are negatively affected by the gross clearance of indigenous plant species and replacement by exotics. The reduction in indigenous plant species has led to the disappearance of welfare factors which in turn led to a reduction in bird species diversity in this block, especially the shrub layer. These effects are of concern because the riverine forests on the southern slopes of Mt. Kilimanjaro play an important ecological role to both its bird life and its people.

Recommendations

It is evident from this study that forest habitat condition is vital to the survival and protection of the indigenous genetic diversity of plants and birds on Mt. Kilimanjaro. My recommendations include:

1. Efforts should be made to conserve riverine habitats by controlling destructive activities in these areas.

2. A longer study covering several seasons and several disturbed habitats sharing the same altitude, topographic aspects, soil type and climatic conditions should be undertaken.

3. Data allowing the application of analysis of variance (ANOVA) should be collected to determine whether or not there are significant differences among the different types of disturbed habitats.

4. Environmental education and extension services on appropriate agroforestry techniques should be considered in the nearby villages.

5. Involvement of local people in the conservation and protection of forest resources should be given priority.

Acknowledgments

I would like to thank the World Bank for financing this study, Dr. O. J. Schmitz and Dean J. L. Cohon for guidance, Dr.and Mrs A. D. Fokker, Mr. H. Pilgrim, Dr. J. J. Otim, the College of African Wildlife Management (especially Dr. D. N. Manyanza, Messrs W. A. Foya, D. M. Gamassa, R. D. Turinawe, E. Z. Olemungaya, W. W. Lubajo, S. P. Lejiir, J. Mushi, H. Kironge), Thomas Hormel, A. B. Rego, N. K. Rotich, M. J. J. Mangubuli, A. S. Androga, Dr. M. Atchia, and Dr. T. Njoka for supporting and encouraging me in this endeavor.

Literature Cited

Anderson, G.D. , 1982. The Soils and land use potential of the Southern and Eastern slopes of Kilimanjaro.

Cook, C.W. and C. Stubbedieck (eds), 1986. Range Research: Basic problems and techniques. Society for Range Management, Colorado.

Cook, C., and F. Grut, 1991. The Chagga Homegardens. Agroforestry in Subsaharan Africa: Farmers Perspective. World Bank Technical Paper No. 112 .

Kara, C.J., C.C. Mahundi, H.J. Maingi, and N. Salum, 1989. Bird Species record at Mweka College Campus (unpublished).

Kara, C.J., E. Chengula, A.G. Kyomo, C. Mahundi and T. Moremi., 1990. Survey on Bird Species in and around Mweka College Campus (unpublished).

Ludwig, A.J., and J. F. Reynolds, 1988. Statistical Ecology. A Primer on Methods and Computing. John Wiley and Sons. New York.

Maghembe, J., 1989. The Chagga Homegardens multi-storeyed Agroforestry cropping system on Mt Kilimanjaro (N.Tanzania).

Maro, P.S., 1988. The agricultural land management under population pressure: TheKilimanjaro experience, Tanzania. Mountain Research Development Conference Proceedings 8 :273-282.

Moreau, R.E., 1944. Mt. Kilimanjaro and Mt. Kenya: Some comparisons with special reference to mammals and birds with a note on Mt. Meru (With bibliography of Kilimanjaro by C. Gillman). Tanganyika Notes and Records 14:28-59.

Mwasaga, B.C., 1991. The natural forest of Mt. Kilimanjaro. The Conservation of Mt. Kilimanjaro. IUCN/WWF. Gland Switzerland. Cambridge UK.

Newmark, W.D., C. A. H. Foley, J.M. Grenshaw, O.A. Chambega, A.C. Rutaza. 1991. Local extinction of large mammals within Kilimanjaro National Park and Forest Reserve and implications of increasing isolation and forest conservation. The conservation of Mt. Kilimanjaro. The IUCN Tropical Forest Program.

Newmark W.D., 1991 . Tropical forest fragmentation and the local extinction of understory birds in the Eastern Usambara mountains, Tanzania. Conservation Biology 5:67-78.

Odum, E. P., 1971. Fundamentals of ecology. Saunder College. Philadephia.

Shannon, C.E. and W. Weaver, 1949. The mathematical theory of communication. University Illinois Press, Urbana, Il.

World Conservation Union (IUCN) Directory, 1989.

ISTF Conference: Local Heritage in the Changing Tropics

The fourth annual conference of the Yale Student Chapter of the International Society of Tropical Foresters took place at Yale University in February. The title of this year's conference was "Local Heritage in the Changing Tropics: Innovative Strategies for Natural Resource Management and Control." The conference attracted 150 students, professionals, and academics from diverse fields related to tropical resource use and rights.

The keynote address was given by Dr. Janis Alcorn, the Senior Program Officer of the Biodiversity Support Program at the World Wildlife Fund. Dr. Alcorn's address presented the conflict between large-scale international conservation efforts and traditional peoples and their conservation of local resources. Dr. Alcorn demonstrated that local resource use and conservation is in many cases not properly considered by top-down conservation planning. Her presentation set the stage for a discussion of innovative strategies to enroll and empower local peoples in the natural resource planning process.

This discussion was divided into three sections, each of which examined in detail some aspect of the larger issues. The first section, "Legal Structures and Local Recognition", was begun by Dr. George Appell, a Senior Research Associate in Anthropology at Brandeis University. Dr. Appell presented a paper dealing with the problems of misinterpretation of traditional land right systems by management regimes grounded in western thought and intent upon codifying individual tenure.

This was followed by a discussion led by Dr. Steve Schwartzman of the Environmental Defense Fund, who described efforts to reoccupy and defend traditional Paraná territory in Southern Brazil, and Dr. Ted Macdonald, an anthropologist with Cultural Survival, who warned of an asynchrony of indigenous and national political leadership. The section was rounded out by Ing. Sebastián Poot of Yum Balam, a community-based integrated conservation effort in Quintana Roo, Mexico. Poot emphasized that despite strong Mayan cultural identification in Yum Balam, the group appreciates free inter-cultural interaction.

The second discussion group was entitled "Constructive Market Participation," and dealt with efforts to preserve cultural and ecological integrity through creative entrance into the global economy. University of Chicago anthropologist Dr. Terrence Turner described how the production of oils as an ingredient in Body Shop shampoos by the Kayapó of Brazil has resulted in a classic labor-capital relationship. Turner said The Body Shop has created not an equal trade partner but an exploitable figure to advance the market appeal of their products.

Sharon Flynn of Conservation International's SEED enterprises countered this example with examples of market development that are based strictly on the social benefit of product development. Flynn emphasized that regardless of sensitivity to cultural, social, and political issues, market participation is still capitalism.

Chico Ginu, President of the Alto Juruá Extractive Reserve (AJER) in Acre, Brazil, contributed his experience as a rubber tapper and community organizer struggling to participate effectively in international markets. Through a cooperative agreement with US firm Déja Shoe, AJER has been able to produce and market a value-added rubber product, vegetal leather, in the global arena. Ginu echoed Flynn's view that "green" products must compete in price and quality to be viable alternatives, but added that local community participation and capacity is equally important when considering the market potential (from the supply side) of a product.

The session was concluded by John Friede, founder and director of Worldview Ltd., an organization designed to aid educators in the development of curricula in social justice and environmental issues. Friede critiqued international capitalism and the effect of GATT on local and indigenous sovereignty, adding sobriety to the neo-economic environmentalism of the 1990s.

The third area of discussion, entitled "Information Technologies," was led by Dr. Peter Poole, Director of Low Earth Observation (LEO) and a specialist in photogrammetry and remote sensing. Poole described a specialized aircraft developed by LEO to conduct aerial photo surveys that can be geographically positioned with satellite images. Beto Borges, of the Rainforest Action Network, warned that effective networking among local peoples is generally characterized by long-term personal relationships. Borges pointed out that merely dumping information and networking capacity on local peoples will not serve to bridge the delicate transition into the information age.

Richard Labelle, developer of the SIDSNet (Small Island Developing States Information Network) for the UNDP, addressed the age-old issue of empowerment through information, focusing on the Internet. Though it remains dubious that many indigenous peoples will directly benefit from this technology currently, participants agreed that electronic networking has potential, particularly for groups already participating in large-scale networking and marketing. The section was concluded by Dr. Mac Chapin, an anthropologist directing the Center for the Support of Native Lands, who offered a mapping technique using local talent for surveying that required no remote sensing data, and produced maps exceeding the quality of those generated by government agencies in Central America.

Proceedings are available from:

Publications
Yale School of Forestry and Environmental Studies
205 Prospect St.
New Haven, CT 06511
fax (203)432-5942

Anthropogenic Landscape Transformation in the Amazon Estuary

Hugh Raffles, DFES Candidate
Yale School of Forestry and Environmental Studies

Introduction

Local people have radically transformed the landscape of the Amazon estuary over the past thirty years and continue to do so. Preliminary fieldwork shows that major waterways previously thought to be natural are, in fact, anthropogenic, opened by farmers to improve access to agricultural fields and forest products. This report describes ongoing doctoral dissertation fieldwork in the Amazon estuary and addresses data gathered through semi-structured interviews with local farmers. A complementary ecological study to quantify stream increment and distinguish between human and "natural" processes is not described. Instead, I present four examples of landscape management carried out by local farmers who have cut streams (*igarapés*) from tributaries of the main river channel. It should be emphasized that although these interventions may have initially occurred at what appears to be a fairly small and localized scale, incremental erosion of river banks and diffusion of the techniques within the population have given them a significance such that today's landscape is apparently quite different from that of thirty years ago. Furthermore, although research up to now has focused on those manipulations specifically associated with the community of Ipixuna Miranda and which form the subject of this report, I believe that these interventions are widespread in the estuarine *várzea* (floodplain).

Local Economic History

Ipixuna Miranda is a *várzea* community of approximately 25 families located on the Rio Ipixuna, near its confluence with the Amazon, about 5-6 hours by motor-launch northeast from Macapá, the state capital of Amapá (fig.1). As is common throughout the lower Amazon floodplain, people in the community support themselves through hunting and fishing, marketing shrimp and the palm-fruit *açaí* (*Euterpe oleracea*), and cultivating and selling bananas and other agricultural produce.

As with other floodplain areas relatively close to the urban markets at Belém and Macapá, modern economic and environmental histories have been closely bound to the rise and fall in demand for extractive products. In the early twentieth century this meant the extraction of timber, particularly *muritinga*, *cedro* and *virola*. By the 1940s, interest had shifted to seed extraction of *murumuru*, *andiroba* and *pracaxi*, animal skins, and to rubber, the latter under multiple stimuli of the US-sponsored battle for rubber during the Second World War. Much of this trade operated under structures derived from the old-style credit-and-supply *aviamento* system originated during the late nineteenth-century rubber period and tied the area to capital in Belém and Macapá, intermediate links in a chain leading across the Atlantic to Europe.

The 1950s saw the increasing importance of commercial fishing, particularly of catfish and shrimp, and the introduction of banana cultivation. By the 1960s, as in much of northeastern Amazon, *açaí* extraction, both for fruit and palmito, was becoming increasingly important, establishing a pattern which still persists, in which *açaí* and shrimp are the most significant goods produced locally for exchange.

This period, from 1960 to the present, is of particular interest for a history of landscape change and provides the focus of the present study. With the increasing valorization of minor forest products and the expanding market in bananas, permanent settlement began in the area. The first *fazendeiro* (large landowner) arrived in the early 1960s, bringing four families from his home district on Marajó Island.

Landscape Transformations I: Interventions in the 1960s

The landscape local people remember from the 1960s is startlingly different from that visible today. Movement between the two major tributaries, Rio Ipixuna and Rio Pedreira,

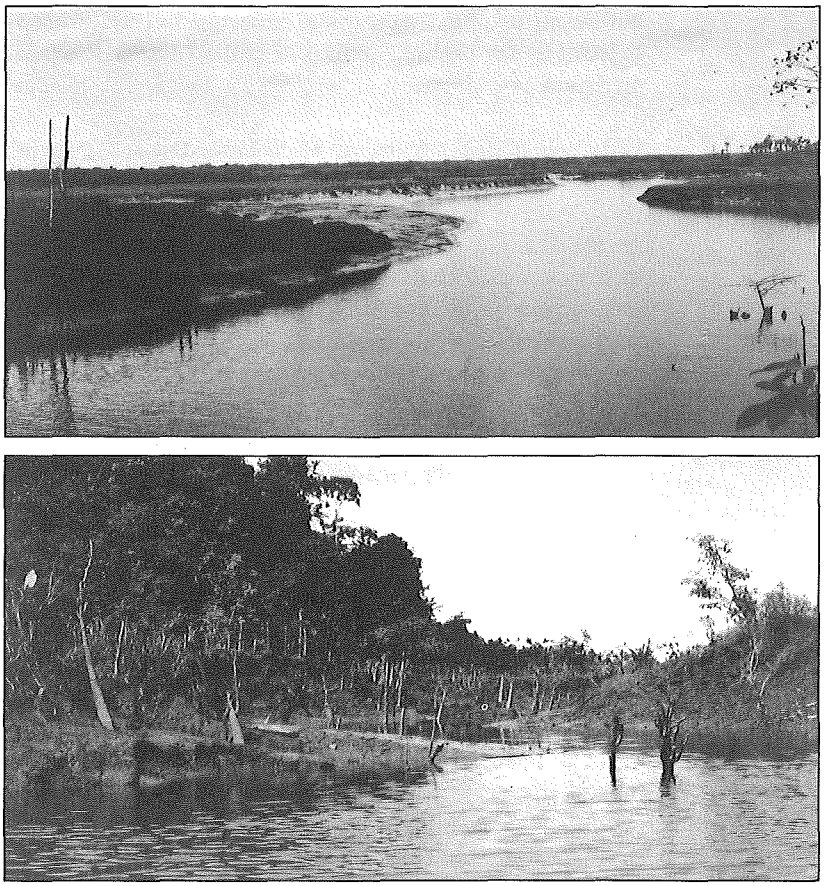
Figure 1. Brazilian Amazon: Study site located northeast of Macapá

for instance, appears not to have been possible. The complex network of streams and broad waterways that now typify the area was not present in the 1950s and early 1960s. The first interventions in the landscape can be documented from this period, when permanent modern settlement took place, along with human activities directed towards the extraction of forest products. Local farmers have described two episodes in detail:

i) Igarapé Coleira

This stream today extends for somewhat more than 3 kilometers, and is close to 100 m across at its widest point. It enables collectors of forest products to pass from the Rio Ipixuna into an area from which timber and palmito have been extensively harvested over the past thirty years (figs. 2 and 3, below).

Construction of Igarapé Coleira was organized by the local *fazendeiro* in the early 1960s. Work-teams from the four families then living in Ipixuna removed the dense vegetation of the aroid *aninga* (*Montrichardia arborescens*) and *taboa* grass (*Cyperus giganteus*) to open a channel approximately 2 m wide, enabling canoes to pass at high tide. The *aninga*, which reproduces vegetatively, was uprooted and the *taboa* cut close to the ground. Subsequent erosion that produced today's broad channel has occurred without further human intervention: the intent of this management, as in all cases so far documented, has been to alter the fluvial regime at the micro-level, initiating a process of accelerated stream increment.



Figures 2 & 3. Even at low tide (top) Igarapé Coleira provides easy access to the Rio Ipixuna. Forest valued for extractive resources (at left of bottom photo) border the Igarapé Coleira.

ii) Igarapé Pracaxi

Igarapé Pracaxi is a smaller channel than Igarapé Coleira. However, it is of interest to the present study for two reasons. First, although it was constructed by *caboclos* (smallholders) during modern settlement, it was opened independently from the *fazendeiros*. This is significant for a period in which local *caboclos* were compelled to sell their produce exclusively through the large landowner. Second, it is the site of current resource conflict, indicating ways in which disputes over access to resources are tied to control over the landscape.

This *igarapé*, which now extends approximately 500 m, was constructed from a narrow, seasonal channel by one *caboclo* family over several months. Again, the purpose was to improve access to forest products. In this case, people were particularly interested in extracting large timber species.

Landscape Transformations II: Recent Interventions

Techniques involved in landscape management have been adapted to changes in local social relations. A critical moment in the environmental history of this area was the introduction by *fazendeiros* of large numbers of water buffalo in the 1970s; heightened local tension can be correlated with the appearance of these animals. Water buffalo are difficult to control: they swim across rivers and often enter fields and destroy crops. *Caboclos* also complain of the buffalos' negative impact on water quality and fish harvests. The exacerbation of lateral erosion due to persistent grazing by buffalo on *aninga* is highly probable.

i) Igarapé Ipixuna

Despite the negative effects of buffalo on *caboclo* livelihood and the unremitting antagonism expressed towards them by local people, *caboclos* have been able to generate some compensatory effects from the animals through creative management. Specifically, channel opening since the 1970s has involved *caboclos*' utilization of buffalo belonging to *fazendeiros*, in what appears to have been a semi-clandestine fashion. The *igarapé* which connects Rio Ipixuna and Rio Pedreira, and which therefore now links communities on the Ipixuna and Macacoarí rivers with a recently-completed road to Macapá, was opened by a team of *caboclos* in an effort to improve transportation routes in the area. They first cut a 2 m wide channel through *campo lagado* and then repeatedly drove buffalo through the opening. Informants have suggested that all *igarapés* formed in recent years have been opened in this way.

ii) Igarapé Abacate

In 1974, a team of 30 *caboclos*, organized under their own management, spent a total of 30 working days clearing a 5 m channel approximately 2 kilometers through a dense covering of *aninga* and *taboa* to facilitate a family's access to their banana field. As with Igarapé Pracaxi, this route had previously been passable only in a small canoe, with great difficulty, and then only in the rainy season. In August, for instance, it was impassable. The rest of the year it was possible to travel a certain distance on foot, continue a little further by small canoe, before finally switching to a larger vessel. In 1984, in response to higher prices for bananas and to valuable harvests spoiling in inaccessible fields, the same channel was extended a kilometer further, providing access to several more farms.

Political Economy and Resource Conflict

The specificities of how and by whom stream management is carried out have varied across time and space. The different forms of labor mobilization apparent during the history of landscape management in Ipixuna can be linked to the local and regional political economy. Shifts in landholding structure and accompanying changes in the relations of production established the conditions for different forms of labor organization, at times either cooperative or quasi-coercive. Notwithstanding these differences, both large and small farmers have built channels as a way to benefit from the increase in market value of particular agricultural and extractive commodities. In turn, the markets in forest and agricultural products have been influenced by the shape of the landscape, which increases the flow of goods and may accelerate the depletion of extractive products. Moreover, changes in the landscape have complicated the local landholding structure by disturbing property boundaries and affecting the value of individual holdings.

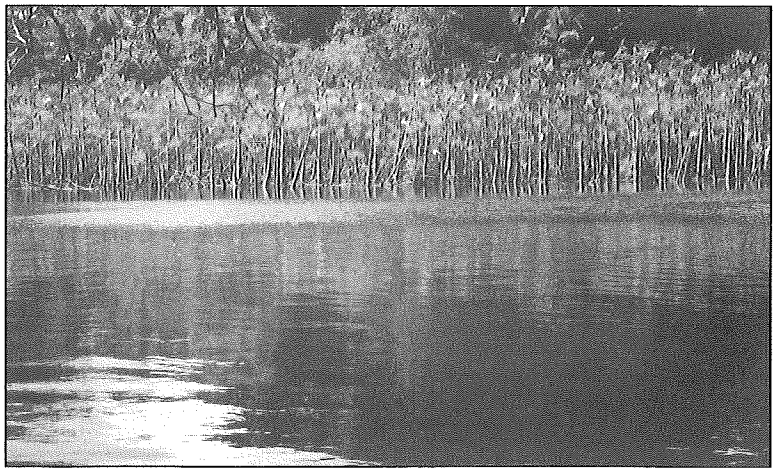


Figure 4. Igarapé Pracaxi currently terminates in an impassable barrier of aninga

With the recognition that local economic history is dialectically related to the shape of the landscape, it also becomes apparent that stream manipulations are an important factor in local resource conflict. For example, the resolution of ongoing conflict over *açaí* in Ipixuna will depend on the capacity of people in the area to exercise control over the landscape. *Açaí* has a central symbolic and nutritional place in the peasant diet and importance as a subsistence and cash crop (Anderson and Jardim 1989). However, for more highly-capitalized landowners the value of the tree lies in the destructive harvesting of the palm-heart for export. Current conflicts therefore center on the increasing scarcity of the palm. Igarapé Pracaxi, described above, is an example of a disputed channel which, if extended, would provide access to remaining wild stands of *açaí*. Despite pressure from local landowners, *caboclos* have prevented the landscape from being changed in this way, and, at present, the stream ends in an impassable thicket of aninga (fig. 3).

Ecological Considerations

The fluvial landscape in this area is subject to three types of "unnatural" disturbance: large-scale human stream construction through manual labor, stream opening in which both humans and buffalo are involved in the initial clearing process, and erosion induced by the physical impact of buffalo and their repeated predation on *aninga*.

In the undisturbed system, erosion is limited by dense stands of *aninga* and *taboa*, present either monospecifically or in association. When these are subject to continuous disturbance, degraded areas are initially colonized by an unidentified vine, and then by a dense covering of the thorny shrub *aturiá*. This second plant is aggressive and highly competitive and makes land unsuitable for either pasture or cultivation. An alternative pathway after the loss of *aninga* is a landscape denuded of all vegetation except close-cropped grasses and subject to rapid erosion. It is assumed that this latter system develops in locations with higher densities of buffalo in which *aturiá* cannot become established.

The ecology of stream management in Ipixuna is therefore complicated by two inter-related processes: the widespread, destructive activities of the buffalo herds, and the powerful erosive forces of the rivers themselves. In this context, it is important to re-emphasize that human interventions are concerned with the *location* of streams as modes of access to resources, rather than with the *rate* at which streams open and the landscape changes. Nevertheless, farmers do exert control over the rate and scale of stream-opening and development by their selection of location in relation to tidal flows of varying strengths. The relatively rapid growth of Igarapé Ipixuna, for instance, appears to be the result of its position as a link between the two major tributaries.

Implications

An important aspect of this study lies in its assertion of local human agency in relation to the Amazonian landscape. The elaboration of an anthropogenic Amazon allows us to question the familiar reading of the Amazonian landscape as a natural space and to emphasize the identity of the landscape as a cultural product of its population, one with a history of human management like any other. By documenting the extensive and transformative human

impacts on what has previously been considered a landscape subject only to natural ecological processes, we can begin to undermine the popular, academic and policy construction of the Amazon as a pristine domain. In this way, the present research builds on a body of Amazonianist literature which has emerged in the last decade and has documented the wide-ranging effects of traditional forest management (e.g., Posey 1985, Denevan and Padoch 1987, Balée 1989, Denevan 1992).

Acknowledgements

This research was carried out with the generous assistance of the Yale Center for International and Area Studies, the Yale Tropical Resources Institute, and the Program in Agrarian Studies at Yale University. Thanks to everyone in Ipixuna for putting up with me, and to Miguel Pinedo-Vasquez, Christine Padoch, Valdir Perreira, Jaime Robelo and Marcirene Machado and family, and Trish Shandley for advice and support.

Literature Cited

Anderson, A.B. and M.A.G. Jardim. 1989. Costs and benefits of floodplain forest management by rural inhabitants of the Amazon estuary: a case study of açaí palm production. *In* J. Browder (ed.), Fragile Lands of Latin America: the search for sustainable uses. Westview, Boulder.

Balée, W. 1989. The culture of Amazonian forests. *In* D.A. Posey and W. Balée (eds.), Resource Management in Amazonia: indigenous and folk strategies. Advances in Economic Botany 7. New York Botanical Gardens, New York.

Denevan, W.M. 1992. The pristine myth: the landscape of the Americas in 1492. Annals of the Association of American Geographers 82(3): 369-85.

Denevan, W.M. and C. Padoch, eds. 1987. Swidden-fallow Agroforestry in the Peruvian Amazon. Advances in Economic Botany 5. New York Botanical Garden, New York.

Posey, D.A. 1985. Indigenous management of tropical forest ecosystems: the case of the Kayapó indians of the Brazilian Amazon. Agroforestry Systems 3: 139-58.

The Role of Nutrient Dynamics in Maintaining Tree Species Diversity at Lambir Hills National Park, Sarawak, Malaysia

Lydia Olander, MFS Candidate
Yale School of Forestry and Environmental Studies

Introduction

To promote wise management and conservation it is important to understand the mechanisms and processes underlying the maintenance of floristic diversity. This understanding may reveal which sites are most important to protect and what size these areas must be to maintain present tree diversity and sustain the continuing evolution of species. It may also provide information for improving management of already established protected areas by focusing efforts on key species or mechanisms — components of the system essential for maintaining diversity. In addition, this knowledge is essential for reestablishing floristic diversity on degraded lands. Logging, swidden cultivation, and rubber and oil palm plantations are prominent land uses in Sarawak (Aiken and Leigh 1992, Whitmore 1984). Elimination of Malaysian forests is resulting in a significant loss of the world's floristic diversity. It will also critically impact the Malaysian economy, which is strongly dependent on forest products, especially timber (Kumar 1986, Caldecott 1988). Understanding floristic diversity of natural forest systems is essential for reestablishment of these diverse forests for the continued provision of environmental services and forest products, such as wood, fruit and rattan.

The tendency for biological diversity to be greatest in equatorial regions has been well documented (Gentry 1982, Stevens 1989), but reasons for variability in diversity within these regions remains largely unexplored. The concentration of floristic diversity in tropical regions has been widely correlated with moderate disturbance regimes, the non-equilibrium hypothesis (Connell 1978), or geologic and climatic stability resulting in increased specialization, the equilibrium hypothesis (Ashton 1969, Wallace 1878, Stevens 1989). Tree species diversity at Lambir is among the richest in the world. The latest estimate is 1150 species greater than 1 cm dbh found within a 52 ha plot (CTFS 1993). Since Lambir is characterized by an aseasonal climate and a low intensity disturbance regime, equilibrium processes are likely to dominate. This implies that tree species diversity results from the variable competitive ability of tree species across a heterogeneous habitat.

Project Overview

Peter Palmiotto (DF Candidate at Yale) is currently conducting research to describe mechanisms that create high tree species diversity by examining the interaction of soil type, small scale disturbance and soil organisms in relation to tree species' abilities to use limited resources across the major soil types at Lambir Hills National Park (Palmiotto, pers. comm). My project focuses on one aspect of this larger study. I investigated the role of foliar nutrient cycling in maintaining site differences in nutrient availability and the role of this heterogeneity in influencing species distribution through species' varying efficiencies in nutrient use. Lambir Hills is an ideal site because of an observed stratification of species by soil type, suggesting that heterogeneity in soil quality creates niches for specialized species to occupy.

The different site qualities correspond to two dominant soil types at Lambir: humult and udult. If the magnitude and rate of nutrient flux on these site qualities differs, there may be a significant effect on species composition, perhaps causing the observed differences in tree species composition. My approach for relating nutrient cycling to species distribution is two-fold: describing nutrient availability of the sites, and nutrient use of specialized species. Foliar nutrient content and foliar decompo-

sition rates were indices used to characterize site quality. The proportion of foliar nutrients retranslocated before senescence —also known as nutrient resorption— was used to characterize a species' nutrient use efficiency (NUE).

I hypothesize that species in this forest are specialized and adapted to slight differences in nutrient availability through variability in NUE. A species' NUE will affect its competitive ability at sites with differing nutrient availability and consequently will affect species distribution in a nutritionally heterogeneous environment. Species with higher NUE should grow predominantly on sites with lower nutrient availability (humult); species with lower NUE should be found predominantly on sites with higher nutrient availability (udult); and species with an intermediate or greater range of NUE may grow on both sites (generalists).

Study Site

Lambir Hills National Park (6°20'N, 116°E), is 10 km inland and 30 km south of the coastal town of Miri in Sarawak, East Malaysia on the island of Borneo. Lambir is the site of a Long Term Ecological Research plot initiated in 1991 by the Sarawak Forest Department, Peter Ashton, of Harvard University, and colleagues from Osaka City University led by T. Yamakura. It is one of a growing world wide network, administered by the Center for Tropical Forest Science of the Smithsonian Tropical Research Institute, created to monitor change in tropical forests.

Lambir receives approximately 3000 mm of rainfall annually (Watson 1985). Variable geology and topography have given rise to soils varying in depth, sand content, and nutrient concentrations (Palmiotto 1993). The two predominant soils at Lambir are: a humult, which is a deep nutrient poor, leached yellow ultisol with a distinct surface horizon of densely rooted raw humus, and an udult which is a deep yellow-red ultisol with variable accumulation of surface litter and a relatively high nutrient content (Watson 1985). Udult mineral soil is somewhat higher in humus, clay, magnesium, phosphorous, and potassium content than humult mineral soils. Humults are characterized by a deep superficial root mat in the surface organic layer, whereas udults have no root mat, but somewhat finer and deeper roots (Ashton and Hall 1992). Tree species communities on these two dominant soil types seem to differ; specialist species are found predominately on only one soil type while generalist species grow in either.

Methods

Foliar Nutrient Content and Nutrient Resorption

Twelve relatively common species from four different tree genera of Dipterocarpaceae were selected. Within each genus at least one specialist species for each site type (humult and udult) and when possible one generalist species were selected (Table 1). Three to four mature individuals of each species were chosen to make up a total sample of 39 trees. To obtain fully developed, live leaves, 2-4 branches growing in full sunlight were cut from the canopy of each tree. Diameter, height, and character of topography around each tree were noted. Mature leaves with no obvious infestation or infection were selected from these branches. Senesced leaves were collected in two tarps placed directly under each tree and were cleared daily to avoid leaching of nutrients from freshly fallen leaves.

Table 1. Species selected for resorption study

Species	Soil Type	Number
Drybalanops aromatica	udult	3
Drybalanops lanceolata	humult	3
Dipterocarpus palembanicus	udult	3
Dipterocarpus geniculatus	humult	3
Dipterocarpus confertus	generalist	4
Hopea pterygota	udult	3
Hopea beccariana	humult	3
Shorea balanocarpoides	udult	3
Shorea laxa	humult	3
Shorea macroptera bauilloni	udult	4
Shorea macroptera macroptera	humult	3
Shorea parvifolia	generalist	4
TOTAL	udult	16
	humult	15
	generalist	8
	total	39

To determine the proportion of foliar nutrients resorbed, nutrient concentration must be calculated in terms of fresh leaf area rather than dry weight. Thus a conversion factor of grams dry leaf to fresh leaf area was determined for each individual sampled. Oven dried leaves from each tree were finely ground. Foliar nitrogen and carbon content were analyzed using a LECO elemental analyzer. The concentration of phosphorous, aluminum, magnesium, calcium, and potassium are currently being determined using a Perkin Elmer Optima 3000 inductively coupled spectrophotometer.

Decomposition Rate

To tease apart factors that affect the rate of decomposition, three experiments were monitored: (1) leaf litter present at each site, (2) specialist litter at corresponding site type, and (3) specialist litter at the opposing site type. Three sites of each quality were used, for a total of six sites. The latter two experiments will allow me to distinguish between the importance of litter chemical quality and microclimate in the rate of decomposition. For specialist litter a known mass of leaves from three humult specialists were used: *Shorea laxa*, *Dipterocarpus globosis*, and *Drybalanops aromatica*. For udult specialists, *Shorea balanocarpoides*, *Drybalanops lanceolata*, and *Hopea pterygota* were used.

For each permutation of the study, a baseline sample was taken and a set of decomposition bags (30 bags per soil type) were removed from the field after 5 months. A second set will be collected at 10 months, and a final set (15 bags per soil type) will be removed at 12 months. The decrease in dry mass and total nutrient content of leaf litter over time will be determined.

Differences in the rate of weight and nutrient loss will be determined for both site qualities.

Analysis and Results

Foliar Nutrient Content and Nutrient Resorption

Mean foliar nitrogen content of both generalists and humult specialist species is greater than that of the udult specialist species. A two-way analysis of variance finds these differences significant (fig.1). The mean foliar carbon content is greatest for the humult specialists, intermediate for generalists, and lowest for udult specialists. The difference in C content between udult and humult specialists is significant (fig.2).

Resorption for each nutrient is calculated as the difference between the nutrient concentration (per leaf area) found in fresh leaves and that found in the senesced leaves. All species demonstrate a significant decrease in foliar N content after senescence. This loss is assumed to be the quantity of N resorbed. The proportion of foliar N resorbed is greatest for humult specialists, intermediate for generalists species, and lowest for udult specialists (fig.3). Although differences were not significant between these groups, a general trend is observed with humult species resorbing the greatest proportion of N, udult species resorbing the least, and generalists resorbing an intermediate amount. Differences between genera can potentially enhance the variability observed in resorption, therefore the data were also analyzed separately for each genera.

Fresh Foliar Nitrogen Content - By Site Preference

Summary	Count	Average	Std Dev
Generalist	8	0.196	0.033
Humult	15	0.196	0.048
Udult	16	0.166	0.036

ANOVA	P-value
Generalist vs Humult	0.992
Generalist vs Udult	0.059
Humult vs Udult	0.054

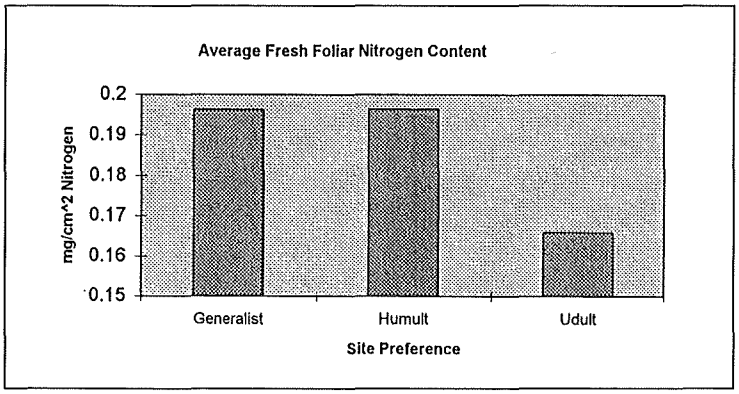


Figure 1

Fresh Foliar Carbon Content - By Site Preference

Summary	Count	Average	Std Dev
Generalists	8	6.085	1.140
Humult	15	8.394	2.876
Udult	16	5.743	1.075

ANOVA	P-value
Generalist vs Humult	0.042
Generalist vs Udult	0.479
Humult vs Udult	0.002

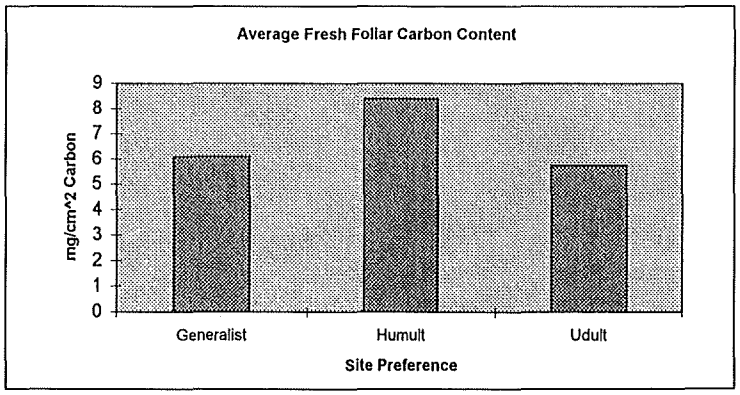


Figure 2

Proportion of Nitrogen Resorbed - By Site Preference

Summary	Count	Average	Std. Dev.
Generalist	8	0.367	0.113
Humult	15	0.374	0.130
Udult	16	0.340	0.130

ANOVA	P-value
Generalist vs Humult	0.895
Generalist vs Udult	0.619
Humult vs Udult	0.465

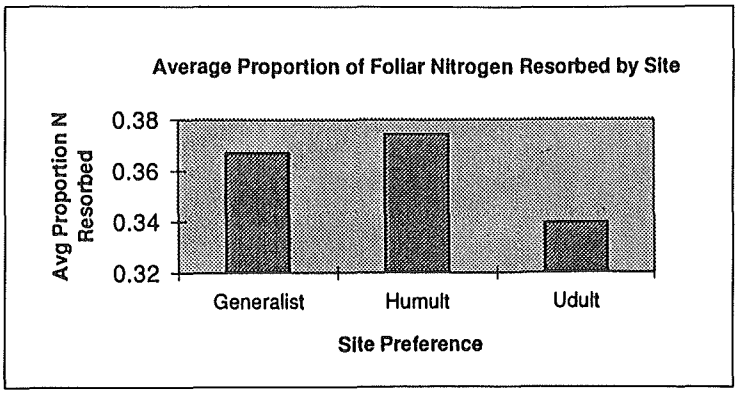


Figure 3

For N resorption this division increased the variability seen in the data and obscures the patterns between site preference. In part this may be due to a reduction in sample size. A similar data analysis will be conducted for the fresh foliar content of P, K, Ca, Mg, and lignin and resorption of these nutrients when chemical analysis is completed.

Decomposition Rate

Differences in decomposition rate in terms of weight loss and the change in proportion of N, C, P, K, Mg, Ca, and lignin will be compared between humult and udult sites for both general litter and specialist species litter. For the specialists species litter samples which were monitored on both site types, the relative importance of the forest floor environment and substrate quality (foliar nutrient content) in the decomposition process will be determined.

Discussion

Preliminary results find that foliar N content is greatest for humult specialists and lowest for udult specialists, reverse of the trend in soil nutrient content. This may be due in part to a nutrient conservation strategy, whereby a tree maintains a high N content by resorbing it before leaf senescence. Preliminary data on the proportion of N resorbed show that humult specialists resorb a greater proportion of N than udult specialists. Another possible explanation for a high foliar N content is an increased proportion of carbon based secondary metabolites which require N. In stands with nutrient limitations but abundant light, plant growth slows more than the rate of photosynthesis; therefore, carbon is abundant and carbon based chemicals (which include phenols such as tannins and lignins) are produced. As a result leaves and stems are high in carbon based defenses and low in nutrient content, which is an effective combination for reducing herbivory (Bryant et al. 1985, Chandler and Goosem 1982). This strategy may enable increased leaf longevity, reducing turnover and required nutrient uptake for leaf production. The high foliar C content observed for the humult species lends support to this explanation. If leaves of humult specialists contain greater quantities of secondary metabolites they will likely have greater foliar lignin content, demonstrate slower rates of litter decomposition, and have a decreased annual rate of leaf production. These attributes of udult and humult sites and species will all be analyzed in the coming months and will be available in TRI Working Paper #82.

Conclusion

Correlating nutrient use (resorption) to nutrient availability and flux (decomposition) begins to describe the mechanism by which nutrient cycling can effect species distribution and ultimately the maintenance of floristic diversity in a stable environment, a process which is the basis of the equilibrium hypothesis and theory of niche partitioning (Connell 1978, Ashton 1969). At present, specialized species are classified on the basis of topography and general soil characteristics. This study examines whether these species truly are physiologically distinct and specialized in relation to their nutrient use. If tree species at Lambir are specialized, having a competitive advantage based on small differences in nutrient availability, they may be able to partition the forest by these slight nutrient differences. In this manner variability in site quality will favor specialized species creating high floristic diversity. This would provide evidence to substantiate an equilibrium driven species distribution.

Acknowledgements

Support for this research was provided by the Tropical Resource Institute and the Sarawak Forest Department. I am grateful to Peter Palmiotto, Sylvester Tan, Dr. Kristiina Vogt and Dr. Mark Ashton for their guidance and support.

Literature Cited

Aiken, R. S. and C. H. Leigh. 1992. Vanishing Rain Forests: The Ecological Transition in Malaysia. Oxford Science Publications, Oxford.

Ashton, P.S. and P. Hall 1992. Comparisons of structure among Mixed Dipterocarp Forests of north-western Borneo. Journal of Ecology 80: 459-481.

Ashton, P.S. 1969. Speciation among tropical forest trees: some deductions in the light of recent evidence. Biological J. Linn. Soc. 1:155-196.

Bryant, J. P., F. S. Chapin, III, P. Reichardt, and T. Clausen. 1985. Adaptation to resource availability as a determinant of chemical defense strategies in woody plants. pp.219-238 *in* Gillian A. Cooper-Driver, Tony Swain, and Eric E. Conn. (eds.), Chemically Mediated Interactions between Plants and Other Organisms. Recent Advances in Phytochemistry Volume 19.

Caldecott, J. 1988. A variable management system for the hill forests of Sarawak, Malaysia. Journal of Tropical Forest Science 1(2):103-113.

Chandler, G. and S. Goosem. 1982. Aspect of rainforest regeneration: III. The interaction of phenols, light and nutrients. New Phytologist 92:369-380.

Connell, J.H. 1978. Diversity in tropical rain forests and coral reefs: high diversity of trees and corals is maintained only in a nonequilibrium state. Science 199:1302-1309.

CTFS. 1993. Center for Tropical Forest Science Newsletter. October.

Gentry, A. H. 1982. Patterns of Neotropical Plant Species Diversity. Pp.1-83 *in* Hecht, Wallace, and Prance (eds.), Evolutionary Biology, Vol 15.

Kumar, Raj. 1986. The Forest Resources of Malaysia: Their Economies and Development. Oxford University Press. Oxford.

Palmiotto, P. 1993. Report of research submitted to Sarawak Forest Department. Forest Research Branch. Sarawak, Malaysia.

Stevens, G. C. 1989. The latitudinal gradient in geographical range: how so many species coexist in the tropics. The American Naturalist. **133**:240-256.

Wallace, A. R. 1878. Tropical nature and other essays. Macmilan, London.

Watson, H. 1985. Lambir Hills National Park: Resource inventory with management considerations. National Parks and Wildlife Office. Forest Department, Kuching, Sarawak, Malaysia. Mimeo.

Whitmore, T.C. 1984. Tropical Rain Forests of the Far East.

We Are What We Eat: Political Ecology of Kalo (*Colocasia escuelenta*) in Waipa, Kaua'i, Hawai'i

Jonathan Likeke Scheuer, MES Candidate
Yale School of Forestry and Environmental Studies

While *kalo* (taro), *Colocasia escuelenta,* is often described as an aroid domesticated millennia ago in South Asia and grown today throughout the tropics for food (Handy and Handy 1972), Native Hawaiians describe its divine origin differently:

> The first child of *Wakea* and *Ho'ohokukalani* was an unformed fetus, born prematurely; they named him *Haloa-naka* (quivering long stalk). They buried *Haloa-naka* in the earth, and from that spot grew the first *kalo* plant. The second child, named *Haloa* in honor of his older brother...became the ancestor of all the Hawaiian people (Kame'eleihiwa 1992, p. 24).

For Native Hawaiians, the meaning of this story is clear: *kalo* and humans were siblings, meant to care and provide for each other.

This familial relationship between a people and a plant — a metaphor of the relationship between Native Hawaiians and their island ecosystem — is different from the relationship existing between people and Hawai'i's environment today. Demographically, politically, economically, and ecologically, the islands have been transformed. Stemming from these changes are frequent, occasionally armed, conflicts over land use and tenure between Native Hawaiians and the government.

To understand this historical change and these modern conflicts, it is useful to examine food, which intimately binds societies with ecosystems. Food is more than a packet of nutrients: it is the product of dynamic social and natural systems involved in its production, processing, and consumption. In theoretical literature this dynamic comprises a food system (Goodman and Redclift 1991), and it is within food systems that values and world views are given form in patterns of land use and culture (Pollock 1992).

I examined the past and current *kalo* food system that one group of Native Hawaiians — the Hawaiian Farmers of Hanalei — are recreating in Waipa, a former *kalo* growing valley. These current activities are placed in the context of Hawaiian history and the islands' modern political economy. This paper discusses the methods of the research, the historic background of the *kalo* food system in Hawai'i, and Waipa's past, present and future.

Methods

I lived and worked with the Hawaiian Farmers of Hanalei from May through August, 1994. The method used for data gathering and interpretation was political ecology, an analytic approach that examines the ways natural resources are used in a particular place, and how those uses are affected by history and the political economic systems in which they are embedded (Peluso 1992). Using the techniques of participant observation and semi-structured interviewing, I learned about the history and current activities of the group, its members and the surrounding community. Field notes were kept during interviews or were made from memory. Questions varied according to the method of progressive contextualization (Vayda 1983): promising lines of inquiry were investigated that were not apparent initially.

Off site information sources included interviews with people on Kaua'i and on O'ahu, including government officials at local, state and federal levels. Archival research was undertaken in collections on the island of O'ahu (Hawai'i State Archives, Hamilton Library at the University of Hawai'i, Bishop Museum, and the Hawai'i Public Library) and at the Beineke Rare Book Library, Yale University.

A paired set of questions guided the research:

Why do the Hawaiian Farmers of Hanalei want to grow *kalo*? Is it simply to provide food and money for their members, or do they wish to achieve larger and varied political goals related to control of land and natural resources?

What federal, state and local governmental actions affect the group's goals and activities? Do these actions support or discourage achievement of the Hawaiian Farmers of Hanalei's activities and goals?

Food and Change in Hawaiian History

Prior to Captain Cook's visit to Hawai'i in 1778, *kalo* was the center of diet, culture and land management systems. The staple of the Hawaiian people was *poi*, the mashed root of *kalo* (Handy and Handy 1972). This crop and other associated economic species supported an estimated pre-contact population of 1,000,000; with the introduction of Western diseases, the population plummeted by 95% (Stannard 1989). Today, approximately 200,000 of the 1.1 million people in the state are part Native Hawaiian; the number of pure Native Hawaiians is unknown because the US census bureau stopped counting them in 1960 after ruling that pure Native Hawaiians are "few in number and of questionable identity" (US census bureau in Bushnell 1993, p.270).

Land in pre-conquest Hawai'i was divided on ecological lines to facilitate the cultivation of *kalo*, and *ahupua'a* were the basic unit of land management. Usually entire watersheds, these political land divisions gave commoners access to all resources: rainforests, lowlands, flowing water, beaches and reefs (see diagram). Because *kalo* is grown in flooded fields similar to rice paddies, it depended on a system of irrigation within *ahupua'a*, tying the water sources in Hawai'i's upland rain forests to the irrigated fields below.

Western conquest brought significant change to the religious, ecological, land tenure, and political economic systems of the islands. Missionaries, who first came from Yale in 1820, succeeded in converting the population to Christianity in a few years. Non-native species brought by Westerners de-

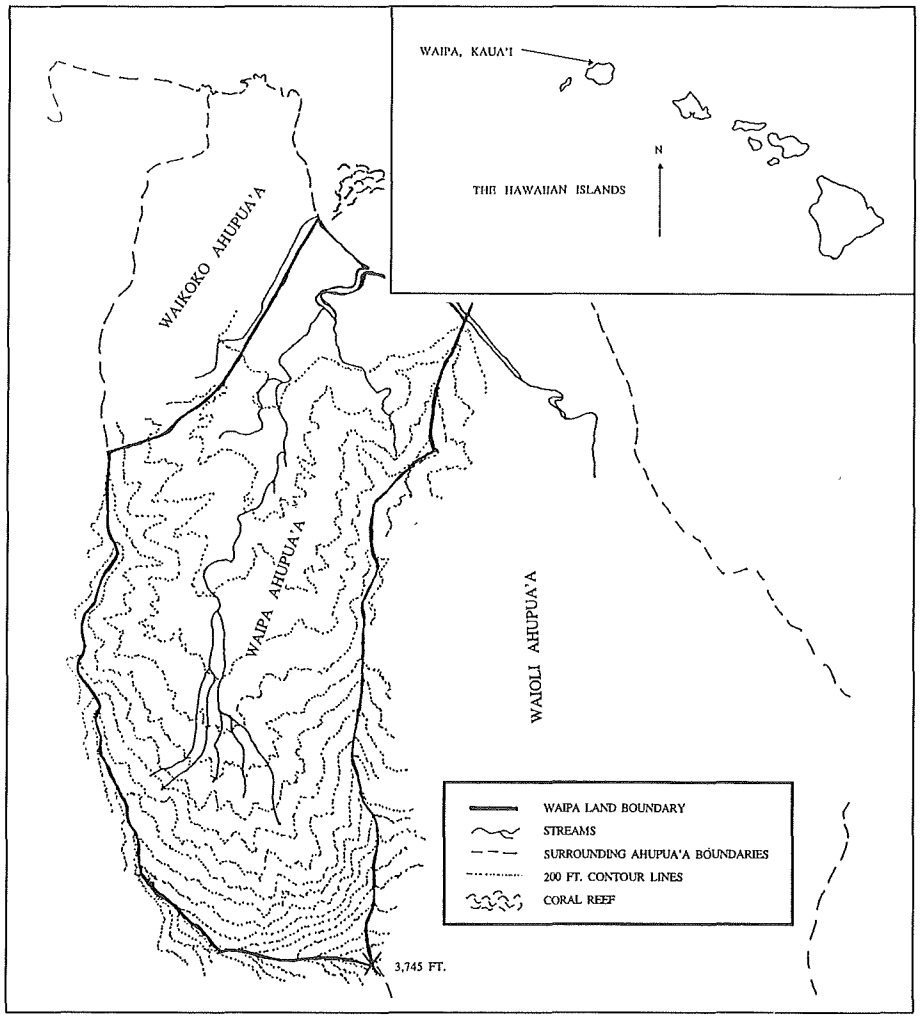


Figure 1. The Waipa ahupua'a with location in the Hawaiian Islands (inset). (Adopted from the USGS Hanalei quandrangle map, 1983)

stroyed forests and lowland cropping areas. These changes, combined with demographic catastrophe, paved the way for a different, missionary-inspired, tenure system. Soon after land was privatized in the period 1848-1852, most *ahupua'a* were alienated and subdivided, and many streams formally used to irrigate *kalo* were diverted to leeward sugar plantations.

The availability of abundant fertile land and water helped to make sugar growing an economic success, and the missionary-descended sugar planters took effective control of the government by the 1870s. When in 1893 the last Hawaiian monarch attempted to reassert the monarchy's former political control, a committee of planters aided by 160 armed US marines overthrew the Native government. They retained control through the time that Hawai'i was annexed as a territory in 1898, until the islands became a state in 1959. While tourism and the military have become the most powerful economic forces in the statehood period, the plantations still dominate vast land and water resources.

This has resulted in the irony that Hawai'i, the most isolated land mass in the world, is now dependent on the outside for nearly all resources. Residents eat mostly an imported American diet. The coercive acculturation of the remaining Native Hawaiian population — which has in the past included legal prohibitions on speaking their language and practicing Native arts, religion and healing — influenced many Native Hawaiians to abandon their diet of *poi*. All of this resulted in the fact that only 270 acres of *kalo* for *poi* were in production in 1990, compared to an estimated 20,000 acres prior to conquest. Instead, 215,500 acres, or 91 percent of agricultural land in production, were devoted to growing sugar cane, pineapple and macadamia nuts for export (Department of Agriculture 1991).

Historical Destruction of the Kalo Food System of Waipa

Waipa is a 1600 acre northward facing valley on the north shore of the island of Kaua'i (fig.1). Backed by a nearly four thousand foot, rainforest covered mountain, the land falls to rolling hills, well watered lowlands, and a broad beach front on Hanalei Bay (fig.2, right). While archaeological research in the valley has been minimal, nearby sites trace settlement back more than 1,000 years, and it can be safely assumed that *ahupua'a* such as Waipa, ecologically suited to growing *kalo*, were long settled and populous (Hoffman 1980).

The large scale changes to Hawai'i in the post-conquest period described above also occurred within the Waipa *ahupua'a*. Missionary documents show that the population of Waipa had plummeted to sixty-six individuals by 1847 (Schmitt 1973), reflecting a decline in Native economic activity. Still, *kalo* cultivation continued until the new sugar food system replaced it: a letter from the state archives by planter H. A. Widemann in 1862 documents his search for new places to plant rice, to provide food for the Asian immigrants who labored in his sugar plantation. At the time he describes the existence of one hundred acres of *kalo* in Waipa (Widemann 1862). With the advent of cheaper rice production in California around 1930, the local rice market collapsed; Waipa's land was converted to pasture and its irrigation systems were abandoned (Hoffman 1980).

The general pattern of privatization and subdivision of land in Hawai'i was not entirely followed in Waipa, and this has resulted in a different pattern of tenure in the present day. Waipa is one of the few *ahupua'a* that has not been subdivided and has a stream which has not been diverted to sugar plantations. Along with other lands in the islands, ownership of Waipa was given to the Native monarchs and later passed to the Kamehameha Schools/Bishop Estate (KS/BE) via the will of the last monarch descendent. The management of lands by

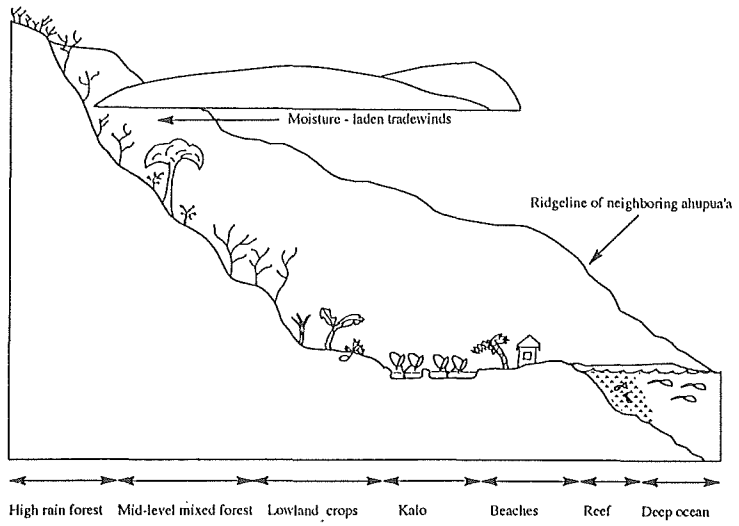


Figure 2. Diagram of ahupua'a system, showing how access to island resources was given

KS/BE provides income to run Kamehameha Schools for the education of Native Hawaiian children. The imperative for income has meant that most land management by KS/BE was development oriented; yet the remoteness of Waipa and the lack of infrastructure have made it relatively unattractive for development. Because Waipa's post conquest history differed slightly from that of the islands as a whole, the present re-establishment of the *kalo* food system by the Hawaiian Farmers of Hanalei was possible, despite the fact that land did not remain in continuous *kalo* cultivation.

Recent Re-establishment of the Kalo Food System of Waipa

The north shore of Kaua'i is still home to a relatively large Native Hawaiian population. In the 1960s and 70s these people had collectively lost access to numerous resources, including fishing grounds and *kalo* land, through corporate development, subdivision and state condemnation. This alienation was met with some protest, part of a general pattern of Native Hawaiian political and cultural resurgence across the islands.

In the mid-1980s, when KS/BE gave the lease for Waipa to a developer planning a subdivision for affluent foreigners, Native Hawaiians resisted. When the developer defaulted on the lease, KS/BE was open to negotiation. To gain control over the land, the Native Hawaiians had to provide an economic return to the owners and a logical plan of use.

Kalo became the Native Hawaiians' justification to KS/BE; access to land and water for growing *kalo* and making *poi* in Waipa would answer both economic and health dilemmas. Though many older Native Hawaiians had continued to eat *poi*, a shortage emerged when other people, including relatively more wealthy urban Native Hawaiians inspired by their new cultural and political activity, began to compete for the limited supply. This general shortage was exacerbated by a change of production and control in the manufacture of *poi*: two large O'ahu based mills now control the market and are able to maintain high prices by coercing *kalo* growers into long term contracts, thus constricting supply.

At the same time, there was a growing realization that the very poor health of most Native Hawaiians was related to diet. Trial programs on the islands of O'ahu and Moloka'i had shown that Native Hawaiians, who have the worst rates of diet related disease of any ethnic group in the US, responded with greatly improved health when they switched to a traditional diet, especially *poi* (Shintani et al. 1991). Native Hawaiians of the north shore saw an available local market for *poi* and also that poor health was related to a poor diet, which grew from and reinforced a lack of access to land for traditional agriculture.

In 1986, a lease was signed between KS/BE and a new corporation, the Hawaiian Farmers of Hanalei, whose board comprised representatives of the ten major Native Hawaiian family groups in the area. While organizational struggles and hurricanes have slowed progress, many objectives have been realized. Families and other community members work together as volunteers, in a mostly non-hierarchical structure. Fifteen acres of the valley are once again used to grow *kalo*. Every Thursday *poi* is made and distributed to Native Hawaiians on the north shore, with all volunteer labor. The average order is 3 pounds, and the price, US$2.50/lb., is less than the US$3.50/lb. common at supermarkets, when *poi* is available at all. This price includes a payment to *kalo* farmers greater than that from large mills with enough surplus to cover organizational overhead. The time spent manufacturing and distributing the *poi* is, additionally, an important time for community fellowship and communication.

Current Challenges and Waipa's Future

The Hawaiian Farmers of Hanalei have managed to regain resource control and create a modern *kalo* food system, establishing an integrated production and distribution system with a relatively stable supply and market. Yet there are a number of challenges that endanger their continued success, three of which I describe here. Re-establishment of *kalo* fields also created habitat for four federally listed endangered water birds, but makes some farming activities subject to regulation under the Federal Endangered Species Act, restricting some cultivation patterns that result in reduced production. In addition, the recent intrusion of alien *kalo*-eating apple snails (*Pomacea canaliculata*), which have no predators and a high reproduction rate, has devastated whole fields. Manual control of the pest is expensive and can harm the growing plants. The State Department of Agriculture has responded by accelerating the federal licensing of copper sulfate for use as a pesticide. Under the license, application protocols must be followed and violations can carry penalties of $50,000 under federal law — an amount which would bankrupt the organization. In addition, the destruction of some of the upland forests and irrigation systems during the period of grazing has constrained the water supply available for *kalo*.

Symbolic of the groups' interaction with government was a meeting I attended late in my residence. The state sees potential for plantation-scale *kalo* development and obtained a federal

grant of over $100,000 to explore the feasibility of building a commercial *poi* mill on Kaua'i. A consultant with the project, who has lived in Hawai'i five years, called a meeting of local farmers whose *kalo* would be needed to initially supply the mill. Many of the farmers had grown *kalo* their entire lives. His introduction to them was "Hi, my name's -- and I know more about taro than anyone else in the state of Hawai'i." His idea was that a mill would not successfully compete locally and that instead, a *poi* and taro chip market could be developed in Las Vegas, where many Native Hawaiians live.

Despite their frustration at the ecological, political, and economic forces which impede their activities, the group has continued to actively plan for the future. A land use master plan for Waipa was developed during the period of my residence. Their overarching goal was to recreate a traditional *ahupua'a* system. Their first priority is expansion of *kalo* production. Other traditional crops, such as *'uala* (sweet potato, *Ipomoea batatas*) were also identified as priorities, as well as restoration of irrigation systems and forests, development of a community center for Native Hawaiians on the north shore, and the development of trails and campsites for Native Hawaiian use.

Three public meetings were held to solicit wider community input, and responses coincided with the groups' goals. In an abstract sense, a ranking emerged for how land would be used at Waipa: first for food, then for education, and finally for recreation. This is the exact opposite from the priority for land use given by the state, which values tourism development first.

Conclusions

The group has been successful in part because growing *kalo* and making *poi* provides some economic return and thus an incentive for participation. Yet clearly the goal of growing *kalo* is both to feed people *and* to gain political and economic control. These people believe that, unlike the distinctions between research questions I originally asked, food and politics are inseparable.

Looking at the *kalo* food system of Waipa in its historic and political economic context reveals an important lesson for the future of Waipa. It is clear that for those involved with Waipa, "we are what we eat" is more than a phrase describing the physical nature of food. It is true in a deep, cultural sense: being Native Hawaiian means growing *kalo* and eating *poi*. The *kalo* food system of Waipa improves health, promotes ecosystem integrity, and positively addresses inequalities in the modern political economic system. Additionally, the *kalo* food system of Waipa is a powerful symbol for the continued existence of Native Hawaiians and their culture. Government laws and actions which at best miss these points, and at worst destroy the *kalo* food system or change it to a system more in the interest of the state, are inevitably headed for conflict. If the government wishes to avoid conflict and support Waipa, its actions will need to reflect an understanding and acceptance of these views.

This study also reveals an important point regarding the general pattern of conflict between Native Hawaiians and the government over land use and control. The struggle of the Hawaiian Farmers of Hanalei to recreate and maintain the *kalo* food system of Waipa is based on a set of priorities for land use that stands in sharp contrast to the one advocated by the state. Successful mediation of conflicts between the government and Native Hawaiians will be more likely if this different ranking is explicitly understood and valued.

Just as the growing of *kalo* in the pre-conquest era symbolized and embodied the familial relationship between Native Hawaiians and their island ecosystem, the growing of *kalo* in Waipa both symbolizes and embodies the conflicts between Native Hawaiians and the government over land use and control in modern Hawai'i.

Acknowledgments

Funding for this project was provided by the Tropical Resources Institute and by Cook Associates, Inc. Dr. Nancy Peluso served as my primary advisor and Drs. Gordon Geballe and Robert Forbes also assisted. I wish to thank the families of Waipa for their generosity and forbearance. While I accept all errors and omissions as my own, those things I have accurately told are from the knowledge that the Hawaiian Farmers of Hanalei shared so generously with me.

Literature Cited

Bushnell, O. A. 1993. The Gifts of Civilization: Germs and Genocide in Hawai'i. University of Hawai'i Press, Honolulu.

Goodman, David, and Michael Redclift. 1991. Refashioning Nature: Food, Ecology, and Culture. Routledge, London.

Handy, E. S. Craighill, and Elizabeth Green Handy. 1972. Native Planters In Old Hawai'i: Their Life, Lore, and Environment. University of Hawai'i Press, Honolulu.

Hawai'i Department of Agriculture. 1992. Statistics of Hawaiian Agriculture, 1991. Hawai'i Agricultural Statistics Service, Honolulu.

Hawaiian Farmers of Hanalei. 1994. Land Use Masterplan for the Ahupua'a of Waipa, Kaua'i. Cook Associates, Lihu'e.

Hoffman, Ellen S. 1980. Archeological Survey and Limited Test Excavations in Waipa and Lumaha'i Valleys. Unpublished manuscript, Department of Anthropology, Bishop Museum, Honolulu.

Kame'eleihiwa, Lilikalá. 1992. Native Land and Foreign Desires. Bishop Museum Press, Honolulu.

Peluso, Nancy L. 1992. Rich Forests, Poor People: Resource Control and Resistance In Java. University of California Press, Berkeley.

Pollock, Nancy J. 1992. These Roots Remain: Food Habits in Islands of the Central and Eastern Pacific Since Western Contact. Institute for Polynesian Studies, Lai'e.

Schmitt, Robert C. 1973. The Missionary Censuses of Hawai'i. Bishop Museum, Honolulu.

Shintani, T. T., C. K. Hughes, S. Beckham, H. K. O'Connor. 1991. Obesity and cardiovascular risk intervention through the '*ad libitum*' feeding of traditional Hawaiian diet. American Journal of Clinical Nutrition 53:1647S-51S.

Stannard, David E. 1989. Before the Horror: The Population of Hawai'i on the Eve of Western Contact. Social Science Research Institute: University of Hawai'i, Honolulu.

Vayda, A. P. 1983. Progressive contextualization: methods for research in human ecology. Human Ecology, 11(3):265-281.

Widemann, H. A. 1862. Letter to H. Spencer at Grove Farm. On reserve, State Archives, Honolulu.

Relationships Between Forest Management Practices, Light Conditions and Regeneration of Native Tree Species in Misiones, Argentina

Christopher G. Woodward, MF Candidate
Yale School of Forestry and Environmental Studies

Introduction

The Selva Misionera is an evermoist subtropical forest located in Misiones province of Northeastern Argentina (25°27' S, 4°55' W) (González 1993, Margalot 1985). The area is one of the country's most productive timber sources, with timber being harvested in both plantations and in native forest lands. My research focused on the native forest lands and examined the relationships between the regeneration of native tree species, light availability, and forest management techniques. Through my research I sought to characterize the effects of harvesting on the regeneration of native tree species that are increasing valuable and scarce. Yale is currently involved in a collaborative research program, funded by the A.W. Mellon Foundation, which focuses on the ecology of native tree species in the Misiones region. The Subtropical Institute of Forestry Research of the School of Forestry, National University of Misiones (UnaM), is Yale's major partner in the project.

In the 1960s, the Argentine government initiated a diameter limit forest management system that simply prohibited the extraction of certain tree species below a specified diameter limit. The system is still in operation. Diameter limit harvesting has several effects. First, it has led to the extraction of many of the large trees and greatly reduced seeding stock in many species (Mangieri 1980). Second, this extraction has allowed the development of a thick shrub cover which many suspect may hinder the regeneration of less shade tolerant species. The new ecological conditions seem to favor more shade tolerant species and many of the original light demanding commercial species cannot compete with more vigorous seedlings (Deschamps 1987, Montagnini 1993). In order to facilitate research on the effects of the diameter limit system, in 1991 UnaM mimicked a diameter limit cut on a 30 hectare portion of the Guaraní Forest Reserve, a 5340 hectare area of native forest (Montagnini 1993). The Guaraní reserve served as the site for my research, which looked more specifically at the effects of the diameter limit system on light conditions and native species regeneration.

Methods

The Selva Misionera comprises the southern-most extension of the Amazon pluvial forest and receives approximately 2000mm of rain per year (Perticari 1992; Boninsegna 1989). There is no seasonality to the rainfall, but peaks occur in spring and fall (Perticari 1992). Though the forest is located in a warm, subtropical humid climate, there are 7 frost episodes each year on average that significantly affect the vegetation that is present (UNaM 1992; Maradei 1980). In its mature form, the forest is a diverse biological community that encompasses numerous species in its several strata (UNaM 1992).

In order to better understand the effects of diameter limit cuts, I evaluated tree regeneration in a number of plots on both unharvested and diameter limit cut stands. In addition, I sampled the light conditions in each plot indirectly by examining canopy closure, and directly in a smaller number of plots with a quantum sensor. My research methods can be broken down into those two basic components.

Regeneration evaluation

To assess regeneration, I established eight transects in both the diameter limit cut forest and in an unharvested area on the reserve. The transects ran 100m in length and were at least 20m apart. Each transect included five sampling plots laid out at 20m intervals. Three additional plots were set up in each treatment for use in the direct light measurements. This brought the total to forty-three plots per treatment. Each plot center was marked with a permanent marking stick. Within each sampling plot, I set up two circular subplots: a seedling subplot with a radius of 1.26m and a sapling subplot of 2.82m. Both plots were centered on the permanent marking stick. I also set up a prism plot centered on the same point.

i) Seedling subplot

Seedling subplots had a 1.26m radius and an area of approximately $5m^2$. All individuals less than 1m in height were measured. The heights of all identifiable species were measured and noted specifically.

ii) Sapling subplot

The sapling subplot had a 2.82m radius and was approximately $25m^2$ in area. The measurements made were essentially the same as in the seedling subplot, except that here they included only individual plants between 1 and 4m in height and less than 10cm diameter at breast height (dbh). In the sapling subplot I also counted the total number of two common bamboo species as well as the total number of tree ferns. These species can be a significant portion of the understory, so their relative presence or absence may effect light conditions and/or regeneration.

Overstory measurements

Finally, I estimated overstory density using a 2 metric BAF prism to establish plots of variable area. I recorded the dbh of those trees greater than 10cm dbh included in the prism plot. This information is necessary to calculate overstory basal area and stem density (Ashton 1990; Kittredge and Ashton 1990).

Light assessments

i) Indirect measurements - Canopy densiometer

I made indirect measurements of light availability using a concave canopy densiometer. I placed the instrument at the

center point of each of the eighty-six plots, on a stick 1m above ground. The densiometer reading gives an estimate of canopy cover, which can be used as a rough indication of light availability.

ii) Direct measurements - Quantum sensor

To directly assess light conditions faced by seedlings and saplings I used a quantum sensor/data logger. I set up five plots in the harvested area and five more in the unharvested areaa. I selected plots to represent a broad range of light conditions. Like the densiometer, the sensor was placed at the center point of selected plot, 1m above ground. I logged light levels from 7am to 7pm on clear days, taking mean light levels over 10 minute periods (6 measurements each hour). I place one sensor on the end of a 4m bamboo pole, preferably in a gap opening, in order to determine the percentage of full sun that the individual sensor plots were receiving (Denslow 1987).

Results

While a full analysis of my data is not yet complete, there have been notable preliminary results. Approximately forty species were identified. While significant differences between aggregate species frequencies or abundances did not occur between the two treatments, there were significant differences between the mean heights and total individuals per plot of several species. Eight species showed significant differences for mean seedling height, six for mean sapling height, ten for total individuals of that species per plot, and five for the same measure in saplings.

Within each treatment, regression analysis showed significant correlations when comparing seedling and sapling means or total individual counts with a number of factors. I compared the means and totals in each plot to the plot's total bamboo count, total understory species count, basal area per hectare, densiometer reading, and the average means and composite totals for all species on that plot. Though I have not examined the meaning of these correlations, over fifty of the comparisons showed some statistical significance. A species by species analysis of these results will hopefully elucidate the response of certain species to the conditions that accompany the two forest types examined.

Finally, while there were no significant differences between the frequencies and abundances in the different treatments, these results do paint a good picture of the composition of regeneration in the treatments. Some species appeared over 100 times in a single treatment, while others appeared only once or not at all. Other species occurred in almost all the plots, and others again, only once or not at all. Similarly, some species are very common as seedlings, but relatively less common as saplings, possibly indicating a mortality pattern.

Table 1. Significant Differences Among Treatments at P-value α= 0.05 Comparing Harvested and Unharvested Plots

ANOVA	P-value	Species
Mean height, saplings	0.0002	*Trichilia* spp.
	0.0166	*Cedrela fissilis*
	0.0001	*Dicksonia* spp.
	0.0013	*Rapanea* spp.
	0.0148	*Acacia tucumanensis*
Mean height, seedlings	0.0390	Alecrin
	0.0160	*Trichilia* spp.
	0.0030	*Apuleia leiocarpa*
	0.0013	*Nectandra lanceolata*
	0.0060	*Nectandra saligna*
	0.0090	*Arecotram romanzoffianum*
	0.0015	*Rapanea* spp.
	0.0071	*Lonchocarpus leucanthus*
Total saplings	0.0002	*Trichilia* spp.
	0.0156	*Cedrela fissilis*
	0.0016	*Dicksonia* spp.
	0.0020	*Rapanea* spp.
Total seedlings	0.0024	*Cabralea canjerana*
	0.0110	*Trichilia* spp.
	0.0230	*Dalbergia* spp.
	0.0018	*Nectandra lanceolata*
	0.0005	*Nectandra saligna*
	0.0090	*Arecotram romanzoffianum*
	0.0176	*Prunus subcoriacea*
	0.0451	*Rapanea* spp.
	0.0211	*Ilex paraguariensis*

The indirect light measurements generated by the densiometer readings have been less conclusive. The quantum sensor data is much more precise and will hopefully prove more useful.

Discussion

Preliminary results seem to indicate differences in which certain species respond to diameter limit harvest methods in the Selva Misionera. Some species perform significantly better or worse under harvested conditions. Differences in bamboo concentrations and understory conditions, as well as basal area per hectare, are correlated with regenerative success in some species. Many of the differences in these factors are related to the harvesting of the forest. Understanding the relationships between factors such as these may be helpful in shaping future forest management practices in the area, and in knowing how to create conditions for planting or enrichment planting in which desired species are most likely to regenerate successfully.

Acknowledgments

Special thanks to Oscar Vebora for his help and knowledge. I am also grateful to Federico Robledo, Jose Cabral, Domingo Maiocco, Luis Grance, Roman Rios, and Lillian Szczipanski. Professors Florencia Montagnini, Beatriz Eibol and Mark Ashton all gave necessary guidance and direction.

Literature Cited

Ashton, P.M.S. 1990. Method for the evaluation of advanced regeneration in forest types of south and southeast Asia. Forest Ecology and Management. 36:163-75.

Boninsegna, J.A., R. Villalba, L. Amarilla, and J. Ocampo. 1989. Studies on tree rings, growth rates and age size relationships of tropical tree species in Misiones, Argentina. IAWA Bulletin. 10 (2): 161-69.

Cozzo, D. 1979. Enciclopedia Argentina de Agricultura y Jardineria. Editorial Acme S.A.C.I. Buenos Aires, Argentina.

Denslow, J.S. 1987. Tropical Rainforest Gaps and tree species diversity. Annual Review of Ecological Systems 18:431-51.

Deschamps, J.R. y M.O. Ferreira. 1987. Estudios sobre las comunidades postclimaxicas de Misiones, I: Los campos abandonados o "capueras". IV Jornadas Tecnicas. Facultad de Ciencias Forestales. Universidad Nacional de Misiones. Eldorado, Misiones, Argentina. Octubre 1987.

Eibl, B.I., F. Morandi, D. Muñoz, y L. Martinez. 1993. Enriquicimiento en fajas con especies forestales nativas en San Pedro, Misiones. VII Jornadas Tecnicas. Facultad de Ciencias Forestales. Universidad Nacional de Misiones. Eldorado, Misiones, Argentina. Noviembre 1993.

Gonzalez, A. 1993. Evaluation of the early growth dynamics of four native timber species in enrichment plantings in Argentina's subtropical forests. TRI News 12(1):7.

Mangieri, H. 1980. Reconstitución de los Bosques Misioneros y características biológicas de las principales especies. Administración Nacional de Bosques. Departamento Dasología de la Dirección de Investigaciones Forestales. Argentina.

Kittredge, D.B. and P.M.S. Ashton. 1990. Natural regeneration patterns in even-aged mixed stands in southern New England. Northern Journal of Applied Forestry 7:163-68.

Maradei, D. 1980. Cultivo de especies de la Selva Misionera.

Margalot, J.A. 1985. Geographia de Misiones. Buenos Aires.

Montagnini, F. 1993. Increasing collaboration in ecological research with academic institutions in Latin America: Phase I, 1990-1993.

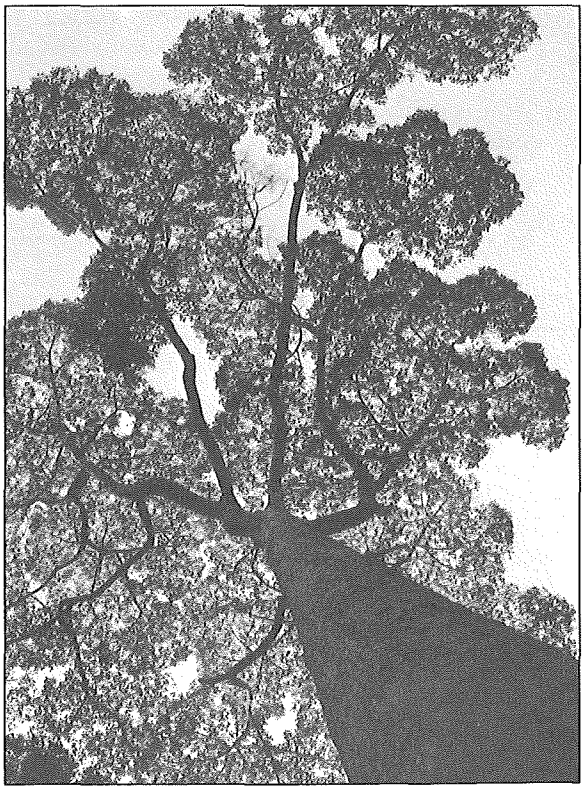
Petricari, C.A. 1992. Proyecto de creación de un reserva biósfera en la provincia de Misiones. Proyecto Yabotí.

Universidad Nacional de Misiones, Facultad de Ciencias Forestales. 1992. Centro Forestal Guaraní, El Dorado, Argentina.

Book Notes

The Centre for Natural Resources and Environment Management of New Delhi, India has released ***Agroforestry in India***, written by K.G. Tejwani (© 1994, 233 pp.). This book summarizes Indian knowledge of agroforestry, including both traditional practices as well as recent research findings. Seven chapters cover topics of agrosilviculture, plantations, agricultural and commercial trees, shifting cultivation, and other multiple use practices. The book is published by Mohan Primlani for Oxford & IBH Publishing Co. Pvt. Ltd., 66 Janpath, New Delhi 110 001.

Forest Resources and Wood-Based Biomass Energy as Rural Development Assets, edited by William R. Bentley and Marcia M. Gowen (© 1994, 376 pp. US$ 35.00), addresses the role of agroforestry in development. It suggests means of integrating forest-based energy technology with environmental sustainability, and also addresses issues of tropical forest management and economics. The book is available from Science Publishers Inc., 52 LaBombard Road North, Lebanon NH 03766, USA.



Dipterocarpus indicatus in Doi Suthep, Thailand

Stressed Ecosystems and Sustainable Agriculture, edited by S.M. Virmani, J.C. Katyal, H. Eswaran and I.P. Abrol (© 1995, 441 pp.), is a synthesis report from a workshop in Hyderabad, India in February 1993. This book presents issues and research needs for sustainable agriculture, particularly in stressed environments of the semi-arid tropics. A total of 34 papers provide information useful in creating a holistic and multi-disciplinary approach to land use in stressed and degraded environments. Contact Science Publishers, Inc., 52 LaBombard Road North, Lebanon NH 03766, USA.

The Greening of the Revolution: Cuba's Experiment with Organic Agriculture, edited by Peter Rosset and Medea Benjamin (© 1994, Ocean Press, 85 pp., US$ 11.95), reports the findings of the *International Scientific Delegation and Fact-finding Mission on Low-input Sustainable Agriculture in Cuba*, which was organized by Global Exchange, San Francisco. This book outlines the conversion from conventional, industrial agriculture to organic farming in Cuba, including motivations for this change as well as technical and social aspects of its implementation. Ocean Press books are distributed by The Talman Company, 131 Spring Street, New York NY 10012, USA.

A Revised Handbook to the ***Flora of Ceylon*** (volume VII: Poaceae), edited by M.D. Dassanayake, F.R. Fosberg and W.D. Clayton (© 1994 Amerind Publishing Co. Pvt. Ltd., 458 pp.), is now available. This book is part of a series published for the Smithsonian Institution and from Amerind Publishing Co. Pvt. Ltd., 66 Janpath, New Delhi 11000.

Book Review

Skip Barbour
PhD Candidate
Yale School of Forestry and Environmental Studies

The Biological Management of Tropical Soils Fertility, edited by P.L. Woomer and M.J. Swift, © 1994, John Wiley & Sons, New York, 243 pp.

The nine chapters in this book provide an excellent overview of current thinking in soil management for sustainable agriculture and forestry. The emphasis on quantitative data is particularly useful because so much of the discussion of sustainability in the literature is qualitative and perhaps even folksy.

Chapter 4 on synchronization of nutrient mineralization and plant demand by Meyers et al. is one of the most informative. The discussion of plant residue decomposition is clear and well written. There is also a good discussion of P availability. Unlike N or K, phosphate is not readily cycled. In a recent discussion, Pedro Sanchez, the director of ICRAF in Nairobi discounted the usefulness of biological recycling of P, stating that it usually must come in a bag. The Meyers et al. chapter is somewhat more optimistic about biological P recycling. It discusses the factors that influence P recycling and availability and differentiates between the C/P ratio and the N/P ratio as indicators of P availability.

For those who would like to know more about systems analysis of organic matter dynamics, there is a good chapter by Pardon et al. on the CENTURY soil organic matter model. The increasing total soil N and success of this model in predicting total soil organic matter, total soil N and especially important annual N mineralization is outlined.

This book is particularly useful if read in conjunction with two other recent publications: *Soil Organic Matter Dynamics and the Sustainability of Tropical Agriculture*, K. Mulongoy and R. Merckx, eds. (© 1993, John Wiley and Sons, New York) and *Myths and Science of Soils in the Tropics SSSA Special Publication Number 29*, R. Lal and P. Sanchez, eds. (© 1992, Soil Science Society of America, Madison, Wisconsin). While much of the same material is covered, the perspectives are different.

Unfortunately, Woomer and Swift suffers somewhat from sloppy editing. On page 102 in chapter 3 by Woomer et al., the reference to Vogt et al. (1986) is not found in the bibliography. Fifty and sixty word sentences in some of the articles leaves the impression that one is reading a translation from German. These are minor annoyances, however. In general, the writing is exceptionally clear, given the complexity of the topics.

Cooperators' Notes

Call for Papers: All individuals interested in presenting a paper, poster, or organizing a roundtable discussion at the ***Sixth International Symposium on Society and Natural Resource Management*** are encouraged to submit an abstract by November 1, 1995. The Sixth Symposium is being hosted by the Department of Agricultural Economics and Rural Sociology and The School of Forestry of the College of Agricultural Sciences and the Department of Hotel, Restaurant, and Recreation Management of the School of Health and Human Development at The Pennsylvania State University. It is scheduled for May 18-23, 1996 and will be held on the Penn State campus. Those wishing to present at the conference should submit abstracts no longer than two, double-spaced, typewritten pages. For more information or to submit an abstract contact: A.E. Luloff, Program Co-Chair; Department of Agricultural Economics anf Rural Sociology; 111 Armsby Building; The Pennsylvania State Universtiy; University Park, PA 16802; USA.

The Indian Institute of Forest Management of Bhopal will be hosting a **National Workshop on Combining Sustainable Development and Biodiversity Conservation in Integrated Watershed Management**, from 14-17 June 1995. This Workshop is being organized by IIFM to bring various scientists, professionals, policy makers and progressive farmers together to identify options for management of watersheds on an integrated basis, combining sustainable development and biodiversity conservation with the involvement of the local community. For more information contact Dr. T.H. Babu, Indian Institute of Forest Management, P.O. Box 357, Nehru Nagar, Bhopal 462 003 (M.P.), INDIA; phone: 91-755-67978; fax: 91-755-62878.

Conference proceedings are now available for ***Timber Certification: Implications for Tropical Forest Management***. This conference, held in February 1994, was hosted by the Yale student chapter of the International Society of Tropical Foresters. The proceedings are available from the Tropical Resources Institute at the following prices: US$10.00 for orders within the United States, US$12.00 for international surface orders, or US$22.00 for international air mail. Payment should be made to Yale University. International orders outside of Canada must be in the form of international money orders or checks drawn on American banks. Address requests to the Tropical Resources Institute, Yale School of Forestry & Environmental Studies, 205 Prospect Street, New Haven CT 06511, USA.

INTERNSHIP PROGRAM EXPANSION

The Tropical Resources Institute (TRI) is currently expanding its Internship Program database in order to increase the number of internship opportunities available to students of the Yale School of Forestry and Environmental Studies.

Each summer approximately 20 students are awarded funding for internships based upon a faculty committee's review of proposals. Among the requirements for funding is that the student have a collaborator with whom the project will be conducted. Only research-oriented proposals are accepted, but collaborations where a student will be contributing to ongoing projects are highly encouraged.

Project proposals are reviewed for funding in January/ February of each year by the Tropical Studies Committee; most students therefore establish firm contacts by December for the following summer's work.

The Internship Program is designed to promote research in a broad range of disciplines concerned with the social and ecological aspects of tropical ecosystems. Articles in this journal are the preliminary results of TRI Internship Projects.

If you are interested in the possibility of working with a TRI intern, please detach and complete the form below. Please indicate the types of research opportunities which might exist with your organization or institution.

If you have a specific project that might be appropriate for an internship, TRI will advertise this information in the School's internal newsletter so that interested students may contact you for more details.

Please contact Nuria Muñiz-Miret, Projects Coordinator, at the boxed address below if you have any questions.

INTERNSHIP PROGRAM, *Expression of Interest*

Contact Name(s)
United States:
Foreign:

Please return this form to:
The Tropical Resources Institute
Yale School of Forestry
& Environmental Studies
205 Prospect Street
New Haven, CT 06511 USA

Name and address of Institution:

Telephone:
FAX:
e-mail:

Description of institution's work, including site description, scope of project, number of years of project operation and potential for future continuation. Please attach a separate sheet if necessary and enclose any relevant brochures or literature.

Proposed internship project. Please include any preferred qualifications or language requirements.

Provisions (e.g. in-country room/board, air ticket, in-country transportation, etc.) that you/your institution could possibly provide.

ARTICLES

The Tropical Resources Institute sponsors research projects in tropical studies concerning the sustained management, restoration and conservation of tropical ecosystems. TRI News articles are produced by master's and doctoral students of the Yale School of Forestry and Environmental Studies who are working on these projects. Opinions expressed in these papers represent the views of authors only and not necessarily those of Yale University or TRI.

For more information about the Tropical Resources Institute contact:
The Tropical Resources Institute; Yale School of Forestry and Environmental Studies; 205 Prospect Street; New Haven, CT 06511 USA; telephone: (203) 432-3660; fax: (203) 432-5942

The Tropical Resources Institute
Yale University
School of Forestry and Environmental Studies
205 Prospect Street
New Haven, CT 06511 USA

Non-Profit Org.
U.S. Postage Paid
Permit No. 470
New Haven, CT