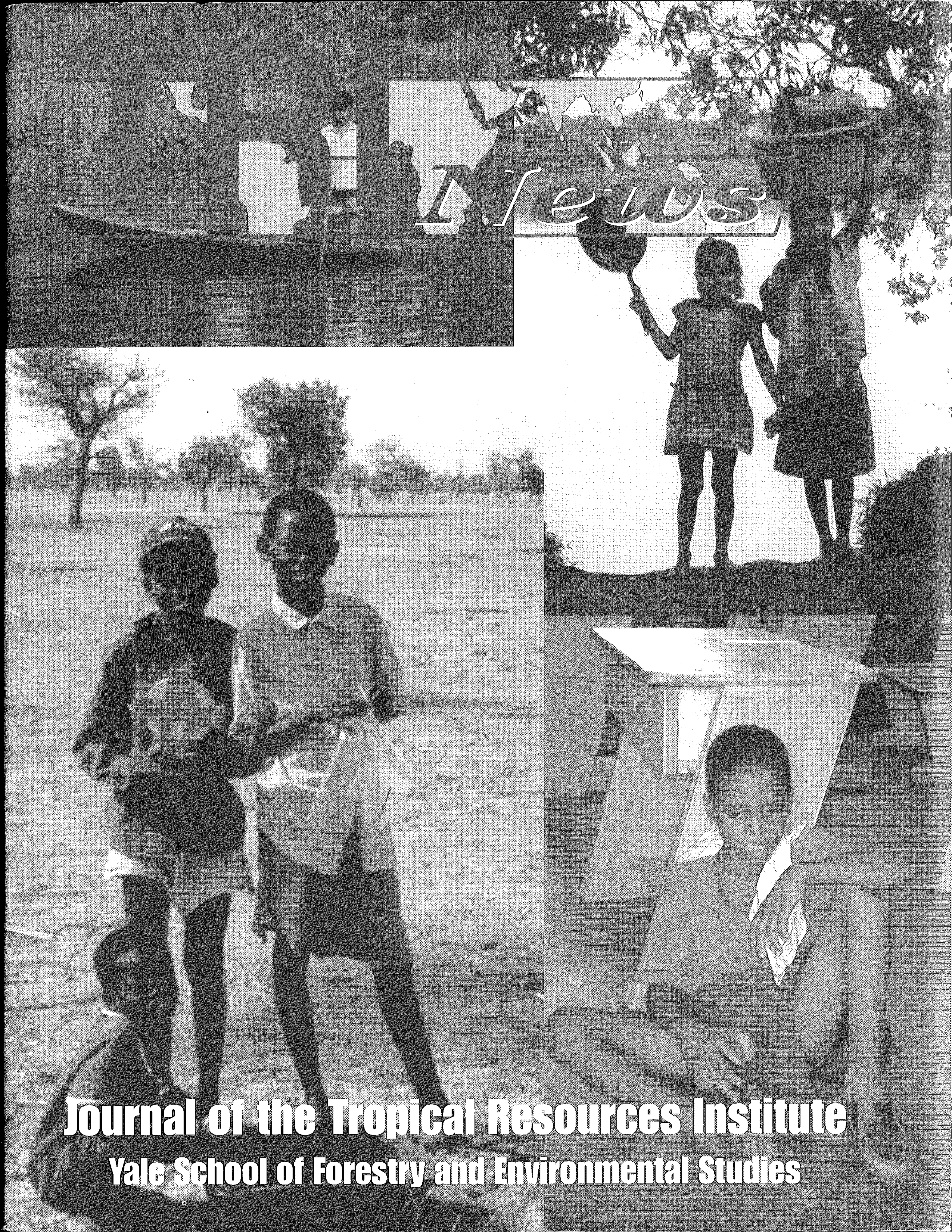
# TRI News



## Journal of the Tropical Resources Institute

Yale School of Forestry and Environmental Studies

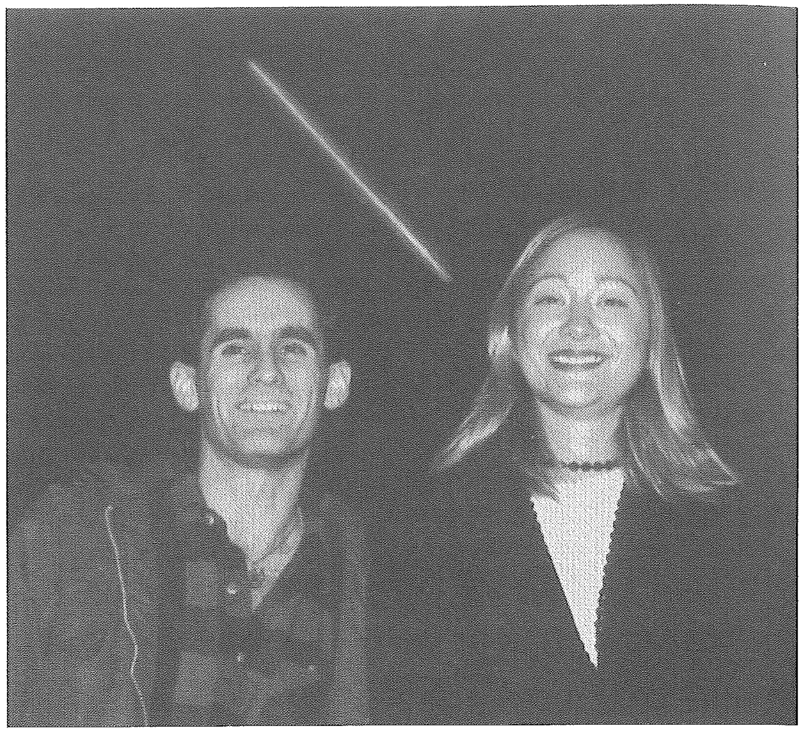
# Word from the Editors

Once a year *TRI News* rises from the mail pile to renew its relation with you. With our new mission statement TRI is now renewing its ties with its cooperators in 50 countries around the world, especially in Africa where TRI's presence has been proportionately lacking (see pages 34–36). *TRI News* is transforming itself into the intermediary between these cooperators and the research Yale is doing. As you know we have refined our membership database (hence the white postcards you filled out) and will continue to shape our readership to our mission. Most notably we would like to serve more tropical and local non-governmental organizations. We want to know their successes and perhaps establish channels through which our interns might do research in service to local projects.

We also strongly encourage all readers to send us press releases, conference proceedings annoucements, new projects and programs, and comments on how TRI can be more useful to you. You can send them in via email or snail mail. Just remember that we publish only once a year in May so timely information is difficult to publish.

We are trying to package our new mission in a journal with format and content innovations. Readers have indicated they want more features, so we have our feature story on coffee plantations. Our mission calls for more networking, so we are beginning to cover cooperators themselves. We want a sharper look (such as the new logo designed by forester-designer Adrian Fabos '97) and hopefully we have accomplished that too.

Soon *TRI News* will go back into hibernation and will reappear again next year; in the meantime, we hope you do not forget to drop us a line.



*Editors Jon Kohl '97 and Andrea McQuay '98 pose with comet Hale-Bopp which flew over New Haven during production time of* TRI News.


**1997** **TRI STAFF** **Volume 16**

Florencia Montagnini, Director
Jim Bryan, TRI Coordinator
Karen Steer and Kelly Keefe, TRI Assistants

Jon Kohl and Andrea McQuay, TRI Editors

**TRI STEERING COMMITTEE**

Mark Ashton, Gaboury Benoit, Graeme Berlyn, Florencia Montagnini





*TRI News*
Yale School of Forestry and Environmental Studies
205 Prospect Street
New Haven, Connecticut, USA 06511
Tel: (203)432-3660; fax: (203)432-5043
www.yale.edu/tri trinews@yale.edu


## *TRI News* Mission

*TRI News* exists for the overriding purpose of creating, supporting, and maintaining relationships between Yale students and faculty and the cooperators with whom they work and conduct research. Its readership is composed of, first, the Yale University community including Yale alumni, second, the foreign cooperators, third, institutions and organizations in developing tropical countries for whom the research may be useful, and a wide variety of others interested in tropical issues. *TRI News* strives to acknowledge, through the high quality of the articles it publishes, that one of the principal links in maintaining the association between cooperators and TRI is through dissemination of student and faculty research done in collaboration with a host of international cooperators. Therefore, much of *TRI News* content will be dictated by the nexus of student interests with cooperator willingness to sponsor students and availability of projects. *TRI News* is an educational endeavor which strives to provide students (both staff and writers) with writing, editing, and managerial experience by covering topics that affect the quality of the environment and all its denizens, in conjunction with the mission of the Tropical Resources Institute: "To promote research, education, outreach, and information management in tropical studies, focusing on sustainable utilization, restoration, and conservation of tropical ecosystems, and problem-solving, which draws from both the biological and social sciences."

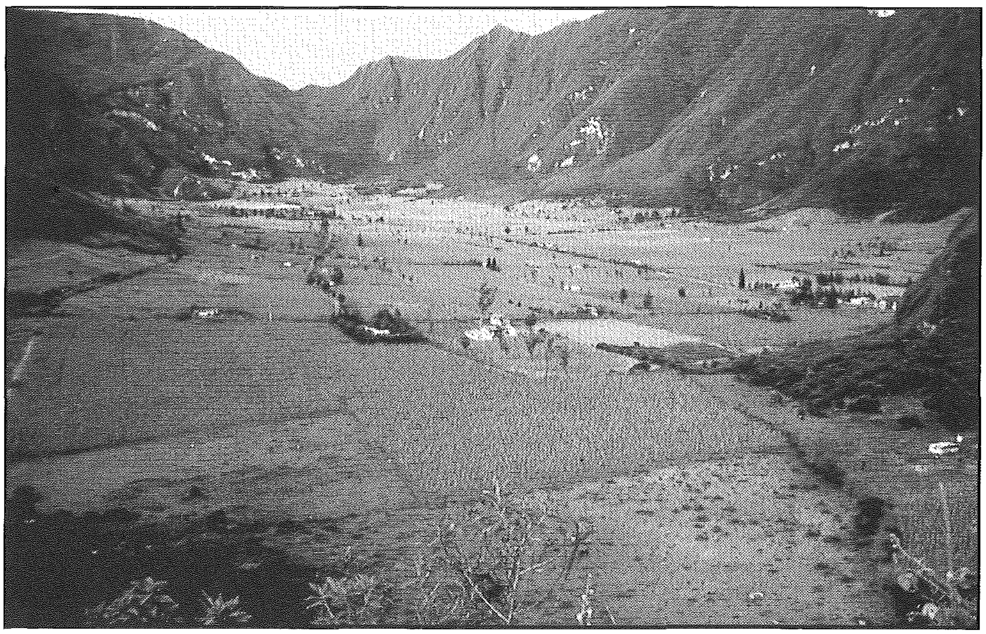
Cover Photos (clockwise from upper left): Hornbostel, Hornbostel, Westley, Rehmus. Other photos are by authors unless otherwise noted.

# Recruiting a PRA Team that Works

**Jon Kohl**
**Candidate for Master's of Environmental Studies**

**Indra Candanedo**
**Candidate for Master's of Conservation Biology[1]**

In 1949 the World Bank sent 14 international advisers to Colombia. These experts in foreign exchange, transportation, industry, agriculture, and others represented the first mission of its kind to attack "underdevelopment" with a comprehensive program calling for intervention in all social and economic aspects of importance (Escobar 1995). While this interventionist strategy still clings tightly in many sectors, a new participatory approach to development has been spreading rapidly in the world. It marks a switch from an outsider, expert-driven, prescriptive approach to one that attempts "to enable local people to conduct their own analysis and often to plan and take action (Chambers and Guijit 1995)."



*The community Pululahua rests inside its volcanic cradle.*

The term "participatory rural appraisal" (PRA) combines a group of approaches and methods designed to enable local people to share, enhance, and analyze their knowledge of life and conditions, to plan and to act (Chambers 1994). Its rapid spread throughout the world has precipitated a similar spread in myths and dangers that have led to its misuse. One such myth says that communities can use information generated by a PRA to kick start their own development, thus relieving facilitators to leave as they please. Some practitioners (Selener 1996, Erhart 1996) argue that if local communities were able to carry out their own development with ease, they would have already done so.

Selener further posits that an appropriate institutional context must exist before any PRA can be carried out. That is, an institution must already be committed to helping a community before the PRA is undertaken. If no such commitment exists, then the PRA should not be done; at the least it would waste locals' time and at the most it would destroy their faith in the participatory process.

If this institutional context must exist, then one of the primary charges of a PRA is to convert the context into a relationship between the community and the outside agency by overcoming barriers of mistrust and misunderstanding. In theory the development process will then emerge and proceed from this fundamental relationship.

Thus the responsibility of outsiders to the target community shifts from technical omniscience to facilitation accompanied by a wide range of new attitudes, such as a recognition of the importance of local expertise and priorities, understanding, honesty, transparency, cooperative spirit and equality between local people and facilitators. Each facilitator, then, no longer has to specialize in a single discipline but must have a variety of knowledge and skills that prove adequate and sensitive to the uniqueness of each situation. Promoting a participatory approach, therefore, requires a careful recruitment of the facilitation team.

## The Pululahua Recruitment Experience

The Pululahua Geobotanical Reserve, created in 1966, is a state protected area 20 minutes north of Quito, the Ecuadorian capital, in the Andes Mountains. Pululahua's primary feature is a five-kilometer wide extinct volcanic crater that shelters a small farming community inside. On all sides steep volcanic walls rise up. The boundary between the naturally vegetated escarpment and the corn fields of the community delimits protected area from community members' privately owned property. The spectacular geology and patches of primary montane cloud forest, as well as a great variety of orchids and other plant and animal species rarely found near Quito, make Pululahua an important conservation site and a uniquely accessible tourist destination.

The Quito-based conservation organization, EcoCiencia, has proposed the establishment of an interpretation system based on Pululahua's natural and historical attributes. Due to the political disorganization of this community, EcoCiencia found it difficult to learn the community's own perception of local problems and did not know if EcoCiencia development ideas would be welcomed. Thus the group sponsored a participatory rural

[1]University of Maryland - College Park

appraisal to obtain a better picture of the community's realities and interests.

To form the PRA team, the organizer (Kohl) recruited three other members based on technical knowledge, previous experience working with agrarian communities, Spanish fluency, and team gender equity. In June 1996, this group of Master's students from universities in the US and Canada arrived in Pululahua to carry out a PRA. The team worked in coordination with national Ecuadorian natural resource institute (INEFAN), the governmental agency managing protected areas and wildlife programs, and EcoCiencia. The team had two objectives:

1) To carry out a PRA that identifies and prioritizes the problems of the community and arrives at viable solutions to problems of highest priority.
2) To integrate the participation of EcoCiencia into the PRA framework in order to build a communication bridge between the community and the outside agency.

In order to achieve the second goal, we had to include in our team of outsiders Ecuadorian members of our sponsoring agencies. We solicited representatives from our principal collaborators, EcoCiencia and INEFAN. We also approached various offices within the Ministry of Agriculture (of which INEFAN is a division), the International Institute for Rural Reconstruction (IIRR), and a recent college graduate in sociology in order to add local people who could help to carry on the longer term relationship with the community after we departed.

Unfortunately, neither EcoCiencia nor INEFAN were willing or able to assign a person. Although we found an enthusiastic Ministry of Agriculture agronomist who had worked with women's groups in the area, bureaucratic delays prevented her participation. IIRR had a staff agronomist who had worked in the community of Pululahua and had an active proposal to create jobs there, yet he did not participate either. Finally, the sociology student, who had organized student field trips to the community with EcoCiencia two years ago, opted not to join.

Despite these recruiting shortfalls, the four-person team carried out six activities that resulted in a community map, transect, brief history of the community, seasonal calendar, institutional diagram, and tendency lines for several important variables mutually chosen by the team and participants. Results indicated that, among other things, there has been a long history of division within the community and that the relationship between INEFAN and the community was weak. Similarly EcoCiencia and IIRR were unknown in Pululahua, even though both had worked there. During the final assembly, community members prioritized problem areas and clearly voiced their priorities: the near absence of health and educational services (#3), lack of political organization (#2), and overwhelmingly the community's very difficult access to markets (#1). The community adhered to the idea of constructing a road as the only solution to facilitating their passage out of the fertile crater. The road would go from the crater floor, through the crater wall (destroying the popular overlook on the rim), and would join the nearby road.

This solution, however, would not prove easy. The road faces several engineering and legal challenges. Foremost of these, such large-scale alteration violates the conservation goals of a protected area, thus resulting in INEFAN's strict prohibition of the road. With these limitations in mind, the facilitators attempted to steer the discussion to alternative cheaper and more efficient ways of getting agricultural products out of the crater. The community, however, demonstrated no patience in such discussions. The meeting ended without having defined either viable alternatives or an action plan.

The team prepared the proceedings of the PRA and distributed copies to key members of the community and organizations with development interests in Pululahua. The team left Ecuador without assurance that further action would be taken by the community, EcoCiencia, or INEFAN. PRA results showed that the community is politically divided and their interests may conflict with those of INEFAN. Further research might focus on community participation potential and awareness of conservation and natural resources. In short, we concluded that written proceedings distributed to development agencies were no substitute for first-hand experience — an agency cannot know a community through a paper document. Although our charge was to construct a bridge between the community and outside agencies, we worried that this bridge would be one of paper.

## Framework for Recruitment of a PRA Team

We have identified four selection characteristics for a successful PRA team. While we do not pretend that this list is complete, these four basic characteristics are generalizable for many PRA situations. The examples here are hypothetical and not meant as criticisms of agencies or people.

*Four General Characteristics of Ideal Team Recruits*

1. Cultural Similarity
The more culturally similar team members are to the local community, the better able they will be to ask useful questions of locals, make accurate interpretations of data, and understand and empathize with the views and interests of local residents. Some have argued for the essentiality of host nationals on PRA teams, but the term "outsider" has a more useful function than "national." Since a continuum of cultural similarity exists, a dichotomy between nationals and foreigners does not prove useful in this case (Figure 1).

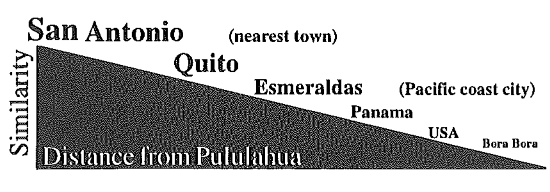



*Figure 1. Cultural similarity varies along a continuum.*

CASE EXAMPLE: Had the sociology student with experience in Pululahua participated, we might have been better prepared for the eventual outcome — staunch support for the road — which she had foreseen.

2. Diversity of Technical Knowledge
Members from different disciplines facilitate the asking of more useful questions about complex problems. Such knowledge also dispels confusion surrounding technical debates on appropriateness and feasibility.

CASE EXAMPLES: Although we knew the road presented technical challenges, we could not offer the scope of legal or engineering considerations that a representative of INEFAN could have provided. Also, the participation of IIRR's agronomist might have helped to identify real problems and solutions. For example, in his Quito office he had mentioned ways to increase efficiency of pack animals as an alternative to road construction. His credibility and presence in the field, moreover, might have helped to avert the abrupt ending of the final assembly.

3. Experience in Participatory Methodology
Participatory methodology requires experience across a gamut of skills such as activity execution, communication, facilitation, conflict resolution, and cross-cultural understanding (Institute of Development Studies 1996). Such experience goes far in the process by which the facilitator team constructs the bridge between community and outside agency.

CASE EXAMPLE: The participation of the government agronomist, who had experience with area women's groups could have improved the participation of Pululahua's women in the PRA. Women's contributions to the PRA dialogue could have deepened the understanding of the community and influenced the outcome in many different ways.

4. Agency Representation
A relationship cannot be established by proxy and in participatory methodology, it is not pre-arranged. Representatives of the outside agency play a crucial role in motivating the community, PRA team, and collaborating agency itself. "Including policy makers themselves as members of PRA teams seems to be one of the best ways of generating the commitment needed to motivate real change... One report from Guinea speaks of 'the profound effect this had on the perspectives of the government functionaries who participated'" (Institute of Development Studies 1996, World Resources Institute 1993). Agents officially convey the parameters of help the outside agency is willing to commit so as to reduce false community expectations and doubt. Such enhanced mutual understanding would be crucial to all post-PRA follow-up.

CASE EXAMPLES: Had EcoCiencia participated with the team in Pululahua, the participant group could have been motivated to consider alternatives, possibly averting the final outcome. Certainly, the independent PRA team could not officially represent the organization. Had INEFAN been present, they could have clarified the government's position regarding the road and saved the community time otherwise wasted in argument mired in misinformation. Also had INEFAN officials attended the final meeting, they would have a better understanding of the community's passion for the road and could have engaged in a meaningful dialogue which, according to PRA results, lacked in the community.

## Acknowledgments

We would like to acknowledge the other two PRA team members, Christine Housel and Kelly Charnetski. Also we owe our thanks to the community of Pululahua, Mario Garcia of EcoCiencia and Guillermo Romero of INEFAN, without whom this project would still be just an idea. I (Kohl) also direct my gratitude to Dr. William Burch for his influence in the ecosystem management approach I used. Last, we are grateful to the Tropical Resources Institute whose support got this project off the ground.

## References Cited

Chambers, R. and I. Guijit. 1995. PRA—five years later: Where are we now? Forests, Trees and People Newsletter 26/27:4–14.

Chambers, R. 1994. The origins and practice of participatory rural appraisal. World Development 22(4):953–969.

Erhart, C. 1996. Doctoral candidate at Cambridge University, working in Ecuador. Personal communication.

Escobar, Arturo. 1995. *Encountering Development: The Making and Unmaking of the Third World.* Princeton University Press: Princeton, NJ.

Institute of Development Studies. 1996. The Power of Participation. Policy Briefing Issue 7.

Selener, Daniel. 1996. *Documenting, Evaluating and Learning from our Development Projects: A Systematization Workbook.* International Institute for Rural Reconstruction: New York.

World Resources Institute and Grupo de Estudios Ambientales, AC. 1993. *El Proceso de Evaluación Rural Participativa: Una Propuesta Metodológica.* Mexico City, Mexico.

*Pululahua contains one of the last primary cloud forests in the valley of the capital city, Quito.*

# Comparison of Ant Diversity in the Leaf Litter of Mixed and Pure Native Tree Plantations in the Humid Atlantic Lowlands, Costa Rica

**Shana Strongin**
**Candidate for Master's of Environmental Studies**

## Introduction

Most international efforts to protect biodiversity in the humid tropics have focused on establishing nature parks and preserves (Miller and Lanou 1995). While these "islands" of pristine wilderness are critical for the survival of species which require undisturbed habitats, they may prove inadequate for maintaining biodiversity over time if diversity in surrounding areas is not conserved as well (Miller 1996, Wilson 1982). Disturbed habitats adjacent to protected sites may create a barrier to species migration and disrupt nutrient cycles (Bierregaard *et al.* 1992). Therefore establishing biologically diverse managed systems, such as mixed tree plantations, in addition to wildlife preserves, may prove to be the best long-term strategy for maintaining species diversity (Roth *et al.* 1993).

At the La Selva Biological Station in the humid Atlantic lowlands of Costa Rica, several economically valuable indigenous trees in mixed and in pure species stands are being studied to determine their levels of productivity and ecological value in reforesting abandoned pasture lands (Montagnini 1994, 1995, Montagnini *et al.* 1993, 1994, 1995). In 1990–91, three experimental plantations were established for this purpose and since that time scientists have monitored and compared changes in the chemical and physical conditions between treatments (Kershnar 1995, Montagnini *et al.* 1995, Parker 1995).

From 1 June–15 July 1996, I conducted an insect diversity study in one of these experimental tree plantations at La Selva. The purpose of the study was to test the hypothesis that mixed tree plantations promote greater levels of diversity than pure tree plantations. Specifically, I compared the mean number of ant genera found in the leaf litter of the mixed-tree plantations with that found in the monocultural-tree plantations.

Ants were selected as measures of biodiversity for the following reasons: 1) Ants are generally among the most abundant arthropods in tropical forests (Roth *et al.* 1993), and therefore it was expected that each $m^2$ of leaf litter sampled for this experiment would contain a large number of ants. 2) Since ants often play a significant role in seed dispersal (Kaspari 1996) and cycling nutrients through the system as either parasites, herbivores, or predators (Dindal 1990), differences in ant diversity between each plantation may indicate relative diversity and abundance of other organisms within the system. 3) La Selva's extensive ant collection and detailed keys greatly facilitated the process of identifying ants (Longino, date unknown).

## Site Description

The La Selva Biological Station is located in the Atlantic humid lowlands of Costa Rica (10° 25' N, 86° 59' W, 50 m mean elevation, 24°C mean annual temperature, 4,000 mm mean annual rainfall, mean soil pH < 5.5). The soils are Fluventic Dystropepts (high Al saturation, low cation exchange capacity, and low extractable P) which were derived from alluvially deposited volcanic materials. They are deep, well drained, stone-free, with low or medium organic matter content, moderately heavy texture, and generally acidic and infertile (Sancho and Mata 1987). The experimental area is on a flat, uniform terrain. The study site was logged in the 1950s and used for cattle grazing until 1981, a common land use pattern in the area (Montagnini 1993).

## Methods

### *Plantation Design*

Twelve indigenous tree species were chosen, based on their growth rate, impacts on soil fertility, and on their economic value. The site was divided into three plantations (96 m x 256 m); each was planted with only four of the twelve tree species. The plantations were divided into four replicates, or blocks, (64 m x 96 m total) of six treatments (32 m x 32 m each): four pure-species plots (one for each of the four test species), one mixed-species (with all four species), and a natural regrowth plot (unplanted) (Montagnini *et al.* 1995).

Samples were collected from two blocks in plantation #2. This plantation was established in November 1991 and contains *Albizia guachapele, Terminalia amazonia, Virola koschnyi,* and *Dipteryx panamensis* tree species. The first block, Block A, lies closest to a dirt road. The second, Block B, lies farthest from the road. Block B is adjacent to a small strip of secondary forest. Samples were not collected from the regrowth treatments because overgrowth inhibited passage.

### *Field Sampling*

Ten 1-$m^2$ leaf litter samples were collected from each of the pure and mixed treatments in Blocks A and B in plantation #2. Samples were not collected from the two middle blocks as they do not contain each treatment, making it difficult to determine if there is a block effect. Since ant behavior is affected by weather variability (Levings 1983), samples were collected over a two-week period (1–14 July) between the hours of 0700–1100. Samples were collected from the same relative position within each treatment to minimize sampling inconsistencies. A 1-$m^2$ PVC frame was placed over the sample site and all of the litter within the frame down to the top of the soil was collected and brought back to the lab for processing.

### *Ant and Litter Processing*

Berlese funnels were used to separate ants from leaf litter samples (Soto *et al.* 1994). Once the ant populations were collected in alcohol, they were sorted by genera, pointed, labeled, and pinned. The mean number of genera collected from each sample in each treatment was calculated and compared between treatments. Dried litter samples were weighed and grams of litter collected per sample were determined along with mean number of ant genera collected per sample per gram litter. All of the quantitative data were analyzed using one way analysis of variance (ANOVA) and LSD multiple range test (MRT) (critical value = 0.05).

## Results

I. Mean number of ant genera per sample per treatment:

The names of the ant genera/treatment are shown in Table 1, and the number of ant genera/sample/treatment are displayed in Figure 1. The Mixed (b) contains a statistically higher mean number of ant genera than any of the other treatments. The Mixed (a) has the highest mean number of ant genera over any of the other treatments in Block A, though the mean is lower compared to most of the treatments in Block B. The sum of the mean number of ant genera per block in Block B is significantly greater than that in Block A.

II. Mean number of genera per gram of litter collected from each sample site:

To better understand some of the factors which may influence number of ant genera present in any sample, the dry weight of leaf litter per m$^2$ sample was calculated along with the average number of genera/sample/leaf litter (gm). Results indicate that there is a positive relationship, though not always statistically significant, between the amount of litter per sample and the number of genera collected from that litter (Figure 1). In addition, the sum of litter (gm) collected per sample is greater in Block B than Block A. Generally, treatments with the highest average number of genera/sample, such as: Mixed (a) and (b), *D. panamensis* (b), and *A. guachapele* (b), also had the greatest amounts of litter collected per sample. The Mixed (b) treatment, which has statistically more genera per sample than all other treatments, also has statistically the largest number of grams of litter collected per sample.

**Figure 1: Ant Diversity**

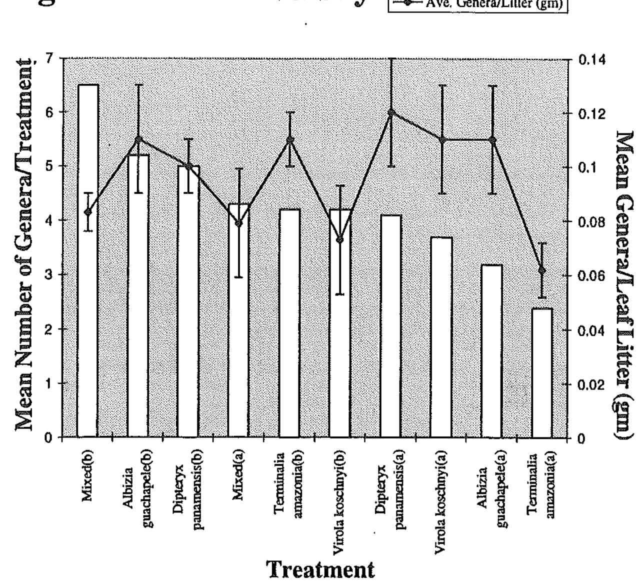



**Table 1: Number of Ants Collected Per Treatment**

| Treatment / Genera | *Mixed (a)* | *Mixed (b)* | *Albizia guachapele (a)* | *A. guachapele (b)* | *Dipteryx panamensis (a)* | *D. panamensis (b)* | *Terminalia amazonia (a)* | *T. amazonia (b)* | *Virola koschnyi (a)* | *V. koschnyi (b)* |
|---|---|---|---|---|---|---|---|---|---|---|
| Crematogaster | | 27 | | | | 1 | | 2 | | |
| Cyphomyrmex | 3 | 4 | 6 | 3 | | 4 | 1 | 2 | | 3 |
| Ectatomma | 9 | 8 | 10 | 10 | 7 | 8 | 4 | 6 | 11 | 10 |
| Hyponera | 17 | 8 | | 2 | 2 | | 3 | | 3 | 2 |
| Lachnomyrmex | | 5 | | | 3 | 3 | | 1 | | |
| Pachycondyla | 2 | 18 | | 4 | 2 | 12 | 1 | 3 | 51 | 4 |
| Paratrenchina | 4 | 24 | 4 | 12 | 6 | 19 | | 16 | 6 | 12 |
| Pheidole | 95 | 95 | 25 | 110 | 83 | 50 | 35 | 58 | 34 | 110 |
| Solenopsis | 57 | 118 | 13 | 29 | 31 | 70 | 45 | 50 | 59 | 29 |
| Tapinoma | | 11 | | 101 | | 24 | | | 151 | |
| Wasmannia | 33 | 279 | 148 | 245 | 59 | 44 | 8 | 142 | 164 | 245 |
| Total ants | 220 | 597 | 206 | 516 | 193 | 235 | 97 | 278 | | 566 |
| Total genera | 9 | 12 | 6 | 9 | 8 | 10 | 8 | 9 | 6 | 8 |

## Discussion

The results of this study indicate that treatment location may have a greater effect on the number of ant genera than treatment type. Block B is adjacent to a strip of secondary forest; therefore, seeds from this strip may be more readily carried by insects or dropped from trees into these treatments as opposed to those in Block A. In addition to providing ants with seeds as a food source, the secondary strip may also provide a diverse habitat which supports a greater diversity of ants than any of the other treatments. This "warehouse" of ants may migrate from the secondary strip into the adjacent plantations, thus accounting for the greater number of genera seen in Block B. That the two plantations which are situated directly next to the secondary strip, Mixed (b) and *A. guachapele* (b), have the highest number of ant genera/sample supports this. It would be necessary to collect ants from the secondary strip in order to further examine this relationship.

Within each block, the Mixed plantations have the greatest number of ant genera/sample. This supports the hypothesis that Mixed plantations promote a greater degree of ant diversity than monocultural plantations. The effect appears to be influenced by proximity to the secondary forest as well as by leaf litter accumulation in each treatment.

## Conclusion

It is recognized that all else being equal, natural forest ecosystems generally support a greater degree of biodiversity than managed forests (Ananthakrishnan 1996). In addition, studies by Roth *et al.* (1993), Miller (1996), and Pimentel *et al.* (1992) indicate that floristically diverse managed forests may promote a greater variety of macro- and micro-organisms than monocultural designs. The results of this study suggest that the mixed-forest plantations may indeed support a greater number of ant genera than the monocultural plantations. In addition, ant diversity in forest plantations may be influenced by proximity to a secondary forest. Therefore, if leaf litter ants are true indicators of the abundance and diversity of other taxa (Roth *et al.* 1993), then mixed forest plantations established adjacent to protected areas may provide a more favorable environment for biodiversity and possible species migration, than monocultural forest plantations.

## Acknowledgments

I thank my advisor, Florencia Montagnini, for her support, editorial comments, and for making my visit to La Selva possible. Thanks to Ray Pupedis for providing lab space, insect wisdom, and humor. The staff at the ALAS lab and the La Selva Biological Station were tremendously helpful in locating equipment and identifying ant genera. Nisa Horn was a great field partner and ant sorter. I acknowledge Maura Maple and Debra Clark for their comments regarding experimental design and Carla Eastis for discussions in statistical analysis. This work was funded by the Andrew J. Mellon Foundation and administered by TRI.

## References Cited

Ananthakrishnan, T. 1996. *Forest Litter Insect Communities: Biology and Chemical Ecology*. Science Publishers: Lebanon, New Hampshire.

Brady, N. 1990. *The Nature and Properties of Soils*. 10th ed. Macmillan Publishing Company: New York.

Bierregaard, R., T. Lovejoy, A. Kapos, and R. Hutchings. 1992. The biologcial dynamics of tropical rainforest fragments: A prospective comparison of fragments and continuous forest. Bioscience 42:859–866.

Dindal, D. 1990. *Soil Biology Guide*. John Wiley and Sons Incorporated: Canada.

Kershnar, R. and F. Montagnini. 1995. Leaf litter decomposition and mulch performance of four indigenous timber trees in the Atlantic humid lowlands of Costa Rica. Tropical Resources Institute Working Paper #86.

Kaspari, M. 1996. Worker size and seed size selection by harvester ants in a neotropical forest. Oecologia 105:397–404.

Levings, S. 1983. Seasonal, annual, and among-site variation in the ground ant community of a deciduous tropical forest: Some causes of patchy species distributions. Ecological Monographs 53(4):345–455.

Longino, J. Date unknown. Unpublished picture guide to the ants in the La Selva Biological Research Station: Costa Rica.

Miller, K. and S. Lanou. 1995. *National Biodiversity Planning: Guidelines Based on Early Experiences Around the World*. World Resources Institute, United Nations Environmental Programme, and World Conservation Union: Washington D.C.

Miller, K. 1996. *Balancing the Scales: Guidelines for Increasing Biodiversity's Chances Through Bioregional Management*. World Resources Institute: New York

Montagnini, F. 1994. Agricultural systems in the La Selva region. In *La Selva: Ecology and Natural History of a Neotropical Rain Forest*. 307–316. L. McDade, K. Bawa, H. Hespenheide, and G. Hartshorn, eds. The University of Chicago: Chicago, Il.

Montagnini, F. 1995. Rehabilitating forest ecosystems in the humid tropics: Recent experiences from Latin America. IUFRO International Symposium on Growth and Yield of Tropical Forests: Tokyo, Japan.

Montagnini, F., C. Gonzales, C. Porras, R. Rheingans, and F. Sancho. 1995. Mixed-tree plantations in the humid tropics: Growth, litterfall and economics of experimental systems in Latin America. Proceedings from IUFRO international symposium on growth and yield of tropical forests. 26 September–1 October. Tokyo University of Agriculture and Technology: Tokyo, Japan.

Montagnini, F. and F. Sancho. 1993. Litterfall, litter decomposition and the use of mulch of four indigenous tree species in the Atlantic lowlands of Costa Rica. Agroforestry Systems 23:39–61.

Montagnini, F. and F. Sancho. 1994. Net nitrogen mineralization in soils under six indigenous tree species, an abandoned pasture and a secondary forest in the Atlantic lowlands of Costa Rica. Plant and Soil 162:117–124.

Parker, G. 1994. Soil fertility, nutrient acquisition and nutrient cycling. In *La Selva: Ecology and Natural History of a Neotropical Rain Forest*. L. McDade, K. Bawa, H. Hespenheide, and G. Hartshorn, eds. The University of Chicago: Chicago, Il.

Pimentel, D., D. Stashow, H. Takacs, A. Burbaker, J. Dumas, J. Meaney, D. O'Neil, D. Onsi, and D. Corzilius. 1992. Conserving biological diversity in agricultural/forestry systems. Bioscience 42:354–362.

Roth, D., I. Perfecto, and B. Rathcke. 1993. The effects of management systems on ground-foraging ant diversity in Costa Rica. Ecological Applications 4(3): 423–436.

Sancho, F. and R. Mata. 1987. Estudio detallado de Suelos Estación Biológica La Selva. Organisación para Estudios Tropicales: San José, Costa Rica

Soto, G., A. Avarado, F. Montagnini, and C. Porras. 1994. El Efecto De Monocultivos Forestales y Plantaciones Mixtas Sobre La Biología de Suelos. Centro de Investigaciones Agronómicas: Universidad de Costa Rica and Yale School of Forestry and Environmental Studies. Unpublished.

Wilson, W. and A. Johns. 1982. Diversity and abundance of selected animal species in undisturbed forest, selectively logged forests, and plantations in East Kalimantan, Indonesia. Biological Conservation 24:205–218.

# Women, Men, and Manure: Assessment of Gender and Wealth Interactions in a Soil Restoration Project in Northern Senegal

**Karen Westley**
**Candidate for Master's of Forest Science**

## Introduction

For the past eight years, the Institut Senegalais de Recherches Agricoles (ISRA) and the Regenerative Agriculture Resource Center (RARC) have collaborated in a soil restoration project in Ndiamsil-Sessène, Senegal. This USAID-funded participatory research project has trained farmers to use manure and compost to increase soil fertility. As part of the monitoring and evaluation component of the project, I conducted an ecological and social evaluation in 1996 to answer three related questions. First, how have the recommended restoration treatments affected the soil. Second, have the treatments increased crop yields? And third, if soils fertility and crop yields have increased, have these benefits been allocated equally to different social groups within the community?

Ndiamsil-Sessène is in the Djiourbel Region of Senegal, part of an area known as the Peanut Basin (see map). The Peanut Basin has low soil fertility and low rainfall. Soils are deep and sandy with low organic matter contents, cation exchange capacity (CEC), moisture retention, and weak structure (Rodale Institute 1989). Production of millet (*Pennisetum glaucum*) and peanuts (*Arachis hypogea* L.), the two main crops in the region, has been declining since the 1960s as a result of the continuous exploitation of agricultural areas, once left fallow for several years at a time (Ndoye 1996).

## Methods

I used both qualitative and quantitative methodologies to answer my research questions. Experimental fields were divided into control plots and four treatment plots which received 2,000 kg of manure/ha, 4,000 kg manure/ha, 2,000 kg compost/ha and 4,000 kg compost/ha. Plots have been treated every two years since 1991. I analyzed soil carbon to assess the effects of treatments on levels of soil organic matter which contributes to improvements in soil structure, moisture retention, and CEC (Brady 1990). The carbon contents of soils from treated and untreated plots were analyzed on a LECO Carbon, Hydrogen, and Nitrogen Analyzer. I took samples one year after the second treatment. Three sets of replicates were analyzed from fields on the two soil types found in the village: dior (entisols) and dek (alfisols) soils in the Wolof classification. Yield data has been collected by ISRA over the past six years; millet and peanut yields for each treatment were weighed after harvest (Ndoye 1996).

To collect social data I lived for three weeks in the village conducting semi-formal group and individual interviews with a translator. I also interviewed staff from the two project implementing institutions. I used interview and triangulation methods derived from Molnar (1989).

**Table 1. Percent Carbon In Experimental Plots on Dek and Dior Soils**

*DEK SOIL*

| *Treatment* | *n* | *Sum* | *Mean* | *Variance* |
|---|---|---|---|---|
| Control | 3 | 1.62 | 0.27 | 0.00028 |
| 2000 kg/ha manure | 3 | 1.7 | 0.283333 | 0.001147 |
| 4000 kg/ha manure | 3 | 2.04 | 0.34 | 0.00108 |
| 2000 kg/ha compost | 3 | 1.87 | 0.311667 | 0.000217 |
| 4000 kg/ha compost | 3 | 1.83 | 0.305 | 0.00035 |

*DIOR SOIL*

| *Treatment* | *n* | *Sum* | *Mean* | *Variance* |
|---|---|---|---|---|
| Control | 3 | 1.33 | 0.22 | 0.000137 |
| 2000 kg/ha manure | 3 | 1.59 | 0.265 | 0.00047 |
| 4000 kg/ha manure | 3 | 1.8 | 0.3 | 0.00172 |
| 2000 kg/ha compost | 3 | 1.66 | 0.277 | 0.00147 |
| 4000 kg/ha compost | 3 | 1.44 | 0.24 | 0.00012 |

*The difference between these soils is clay content: dek soils contain more clay than dior soils and consequently have higher CEC and organic matter content.*

## Soil Analysis

Percent carbon was very low in all samples (Westley 1997). In dior soils control plots had an average of 0.22% carbon; in dek soils the average for control plots was 0.27%. The largest difference in carbon levels was found in the 2,000 kg/ha compost treatments: 0.28% carbon in dior soils and 0.31% carbon in deck soils. Although the carbon levels are very low in all treatments, a one-way ANOVA found the differences in carbon levels to be significant ($p<0.0001$) (Table 1).

## Crop Yields

Ndoye (1996) found millet and peanut yields to be significantly higher in all treatments (Table 2).

## Gender and Wealth Interactions in Access to Manure

In 1988, Sagna-Cabral conducted a survey of households in Ndiamsil. She collected data on the number of animals owned by each household, the amount of manure produced by these animals, and the pre-project patterns of manure use in the village. Although gender and wealth interactions were not the focus of her study, she collected important baseline information which gave rise to my third research question.

In Ndiamsil, households and the arrangements of production and consumption within them, conform in general pattern to those studied in other regions of Senegal (Mackintosh 1989). While male and female members of a household may all live in the same compound and eat from a communal bowl, they often cultivate separate parcels of land and retain control of their own incomes from cash cropping. Men own the land and women

## Table 2. Yields of Peanut and Millet Seeds on Experimental Plots (Ndoye 1996)

| Treatment | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|
| *PEANUT SEED YIELD (kg/ha)* | | | | | |
| Control | 469 | 236 | 383 | 170 | 455 |
| 2000 kg/ha manure | 736 | 360 | 652 | 502 | 870 |
| 4000 kg/ha manure | 676 | 361 | 671 | 527 | 933 |
| 2000 kg/ha compost | 1014 | 668 | 1327 | 848 | 1384 |
| 4000 kg/ha compost | 992 | 577 | 893 | 988 | 1388 |
| *MILLET SEED YIELD (kg/ha)* | | | | | |
| *Treatment* | *1991* | *1992* | *1993* | *1994* | *1995* |
| Control | 458 | 174 | 330 | 252 | 465 |
| 2000 kg/ha manure | 780 | 332 | 529 | 544 | 707 |
| 4000 kg/ha manure | 890 | 361 | 689 | 531 | 673 |
| 2000 kg/ha compost | 1248 | 765 | 1250 | 762 | 1020 |
| 4000 kg/ha compost | 1055 | 611 | 1038 | 1054 | 1404 |

have usufruct rights to different parcels each year based on the decision of the male head of household (Sagna-Cabral 1988). Men also own large animals like horses, cows, and donkeys and use the manure that they produce; women own goats and sheep which produce significantly less manure. In 1988, male household heads used on average 70% of the manure produced, women used 13% (Sagna-Cabral 1988).

Sagna-Cabral divided households into three groups based on wealth indicators: livestock, farm equipment, and labor availability. Wealthier households spread an average of 6.8 tons of manure per hectacre on their fields; poor households spread an average of 2.33 tons. Of the seven households that Sagna-Cabral studied in depth, none of the women from the poorest households used manure; all of the women from the wealthiest households used it. Based on these findings, I hypothesized that those who had access to more manure (based on wealth and gender status) would be able to improve their soils, raise their yields, and hence increase their incomes by participating in the project, whereas those who did not have access would not.

Based on the same wealth categories used by Sagna-Cabral, I interviewed men and women in the five households in the highest income group; four of the six in the middle income group; and nine of the fourteen in the lowest income group. In order to measure the changes in income in the households over the course of the project period, the numbers of cattle, horses, donkeys, goats, and sheep were counted. Ten households had more animals than before, eight had less.

Despite the limited number of farmers trained, by 1996, 35 of the 38 men and women interviewed used some form of organic amendments on their fields. Three women out of the 20 interviewed did not use manure at all. A larger proportion of women said they were using manure in 1996 than in 1988.

Three out of the five men in the wealthiest households reported that they had enough manure. None of the nine poorest households had enough manure. In the wealthiest households, both men and women use manure on their fields. The three women who do not use manure are from the poorest households. The five women who only use manure from sheep and goats are from the poorest households. These data confirm Sagna-Cabral's findings that as manure becomes limited in a household, women are less likely to use it.

A serious limitation for both women and for poorer male farmers is transportation. Women carry the manure in basins on their heads to the fields. Men use horse carts. Five men from the poorer households either borrow or hire carts. Two women reported that their husbands transport manure to their fields for them. Four women explicitly stated that they did not have enough time to use manure on their fields because they were busy with housework.

Although both men and women observed that compost gave the highest yields, only men use compost. The men who were trained and given equipment to build pits all continue to use compost both on the research plots and on their own fields. Besides the expense of the pits, which are lined with cement, water scarcity and a lack of organic materials limit compost production. Six male farmers who had not been trained and had not built pits were using compost that they made by their own methods. Having observed the increased yields obtained on the fields of farmers who were trained to use compost, they decided to learn how to make it themselves. Women did not use compost for two reasons: they either said they did not know anything about it, or they said there was not enough or they found the work of digging pits too arduous. Six women helped their husbands make compost by carrying water from the well to the pits.

All but three households report an increase in yields whether they are involved in the research trials or not. Only three households had experienced a decrease in yields since the project inception. In two of these households a millet pest called *striga* had destroyed crops. Twelve male farmers estimated that their yields had almost doubled (from an average of 600 kg of millet/ha to more than 1,000 kg/ha). These estimates match the findings in the experimental plots. Sixteen of the seventeen women who use manure also noticed an increase in yields. Both male and female farmers who had increased yields thought they had increased their income in two ways: they had more millet to eat at home and did not need to buy as much in the dry months as they used to, and they were able to sell more peanuts.

*The outline of the manured plots is seen distinctly against the non-treated plots that surround it.*

## Discussion and Recommendations

This evaluation highlights the links between wealth, ownership of livestock, soil fertility, crop yields, and household income. While the data outline some interesting trends, they do not conclusively show that the project either increases or decreases gender and wealth divisions within the village. The same disparities in access to manure have persisted from 1988 to 1996. Farmers awareness of the effects of manure and compost on their plots indicates the probable continuation of these practices in the future. Continued training is unecessary. Monitoring impacts on soils, yields, and social processes is important, particularly if the project is to be replicated elsewhere.

Because women do not own land and cultivate different plots each year, the long- term benefits of soil restoration can only benefit them if men use manure and compost on all of their fields. Although women have access to less manure than men, they did not seem to feel a direct conflict over manure use in the household. However, one woman joked that she would steal it when her husband was not looking, which may imply a certain element of competition over this resource, which was not explicit in the interviews. Conflict aside, there is a need to increase women's access to manure in the village. One way to do this is to set up a credit or community banking system that enables women to buy more livestock.

## Acknowledgments

First I would like to thank the people of Ndiamsil-Sessène for the collaboration that made this research possible. I would also like to thank staff at ISRA, particularly Moussa Ndoye and Fari for all of their help. I would also like to thank the RARC team for their logistic support. Bob Wagner, Amadou Diop, and Jonathon Landeck also provided unlimited guidance. Lastly, I would like to thank TRI and the Agrarian Studies Department at Yale University for the support that got me to Senegal and back.

## References Cited

Brady, N. and R. Weil. 1990. *The Nature and Properties of Soils.* Upper Saddle River, New Jersey: Prentice Hall.

Mackintosh, M. 1989. *Gender, class and rural transition: Agribusiness and the food crisis in Senegal.* London: Zed Books.

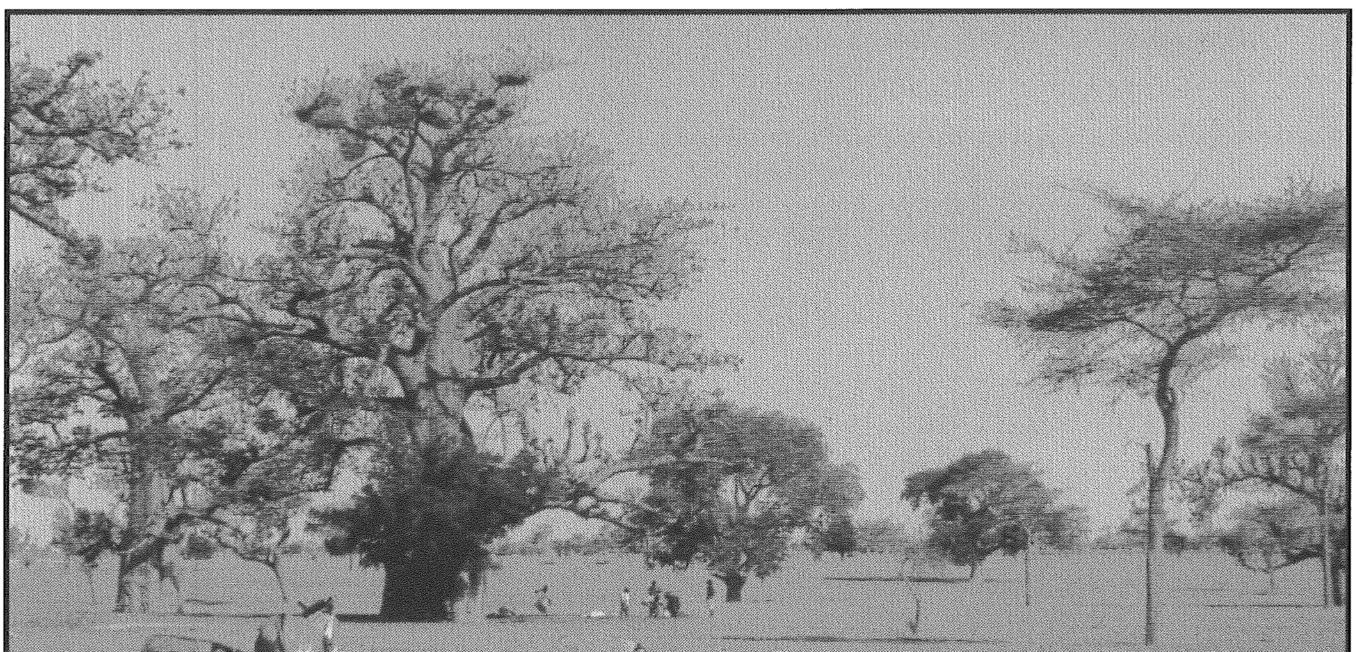
Molnar, A. 1989. *Community Forestry Rapid Appraisal.* Food and Agriculture Organization of the United Nations. Rome.

Ndoye, M. 1996. Fertilisation des Sols: Rapport de Synthèse. Bambey, Senegal: Institut Senegalais de Recherches Agricoles.

Rodale Institute. 1989. Soil degradation and prospects for sustainable agriculture in the Peanut Basin of Senegal. Kutztown, PA: Rodale Institute.

Sagna-Cabral, M. 1988. Utilisation et gestion de la matière organique d'origine animale dans un terroir du centre nord Sénégal: cas du village de Ndiamsil-Sessène. Mémoire d'étude. Dijon, France: Ecole Nationale Supérieure des Sciences Agronomiques Appliqués.

Westley, K. 1997. Changes in soil carbon in a soil restoration project in Northern Senegal. Unpublished paper.



*Livestock graze under the Acacias and baobabs.*

# Developing Paradise: Land Conversion on the Island of Roatán, Honduras

**Scott Rehmus**
**Candidate for Master's of Forest Science**

## Introduction

The beauty of the tropics draws tourists, and tourists demand food, shelter, and services. In order to provide these necessities, land must be developed for food production, resorts and vacation homes, and housing for workers. Such development often leads to environmental degradation through increased air and water pollution, solid waste, and disturbance and destruction of both flora and fauna (Andereck 1995). Consequently, nature-based tourism has the potential to become trapped in a self-destructive cycle: increased tourism negatively impacts the environment which in turn undermines the ability of the area's natural beauty to attract tourists. On the Honduran island of Roatán, a rapidly growing tourism industry has instigated the widespread conversion of land from forests, mangroves, and grazing land to resorts, vacation houses, and housing for people hoping to take advantage of the thriving economy. For Roatán, the interplay between tourism development and environmental damage has important consequences for the sustainability of nature-based tourism on the island.

In 1993, researchers at Yale University's School of Forestry and Environmental Studies initiated a project to study the impact of development on the quality of near-shore waters and the health of coral reefs surrounding the island of Roatán. This multifaceted project incorporates analysis of satellite imagery and aerial photographs, soil samples, sediment cores, water samples, and coral reef monitoring data. The study aims to collect information annually from designated watersheds in order to develop a long-term database. This paper presents the methodology developed to study land cover and land use on Roatán. Although similar terms, "land cover" provides information on the physical features of an area such as vegetation and urban development while "land use" focuses on how humans are utilizing a given piece of land. The research presented herein utilizes remote sensing techniques in conjunction with data collected on the ground in order to quantitatively measure and map land cover and land use on Roatán.

## Background

The island of Roatán is 53 km long and 5 km wide and is located 65 km off the northern coast of Honduras (Garoutte 1995). Its 127 km″ makes Roatán the largest of the 68 islands and cays which make up the Bay Islands (Stonich *et al.* 1995). Fought over and settled by the British and the Spanish for 200 years, the island was ultimately ceded to Honduras by Great Britain in 1857 (Jacobson 1992). Since that time, the island's population has continued to grow, from 4,003 in 1935 (Valladeres 1939) to almost 30,000 in 1995 (Garoutte 1995). Historically, fishing has dominated the economy, and in 1992 it was estimated that approximately 85% of the island's population received at least some income from the fishing industry (Jacobson 1992).

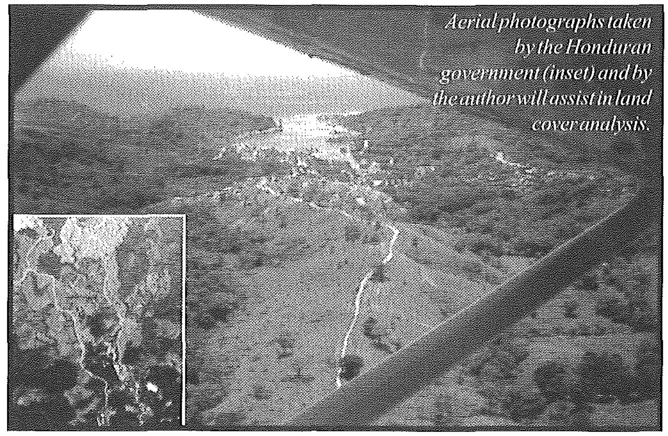
Roatán's extensive fringing coral reefs have not only supported the fishing industry, but also made the island a premier SCUBA diving destination. As a result of the reef's attraction, Roatán has experienced a dramatic growth in the number of visitors, rising from 900 in 1969 to approximately 40,000 in 1994 (Sorenson 1993, Stonich *et al.* 1995). Not only is tourism supplanting fishing as the mainstay of the economy, but it has also dramatically changed the island's land use patterns. New roads, houses, resorts, and a modern airport have been built to accommodate both the increased number of tourists and the booming local population. Over the past five years, several real estate agencies have fueled this land conversion by facilitating

the sale of land to North American and European investors. Development, however, is occurring without a viable management plan. Consequently, the potential exists for Roatán's reefs to become a natural area "loved to death" (Luttinger 1995).

## Methods

In order to study land conversion on Roatán, three types of data are being utilized: satellite images, aerial photographs, and field measurements and observations made during an 11-week research trip from June to August 1996. Satellite imagery allows for rapid assessment of the land cover of large portions of the island. The use of aerial photographs helps to overcome the limitations associated with the relatively coarse resolution of satellite imagery as well as provides a mechanism for determining the accuracy of the interpretation of the satellite images. Field work establishes ground control points required to reference the aerial photos to a known map projection as well as enables the researcher to associate land cover with land use.

During the first stage of this research in November and December 1995, a multispectral satellite image of Roatán taken on 21 December 1993 by the French satellite system, *Système Probatoire pour Observation de la Terre* (SPOT), was utilized to produce a land cover classification map. The SPOT image has a 20 m spatial resolution and consists of three bands of data covering the visible green, visible red, and near infrared portions of the electromagnetic spectrum (Lillesand and Kiefer 1994). Using the imagery analysis program ERMapper, a land cover classification of five watersheds on the south side of the island was generated, based on the spectral differences between the bands. However, interpreting the results of this classification proved difficult because neither aerial photographs nor other detailed information were available upon which to base an interpretation (Rehmus and Tighe 1995). Therefore, a 1:24,000 scale topographic map was used to assign each class to one of two categories: disturbed lands or undisturbed lands. Although this process quantified the relative amount of development between the study watersheds, our initial findings had limited



*Aerial photographs taken by the Honduran government (inset) and by the author will assist in land cover analysis.*

utility due to uncertainty surrounding their accuracy and precision.

In order to improve upon this work, two types of data were collected during the summer research trip: aerial photographs and field measurements taken to reference the remote sensing data. An airplane was rented, from which photographs and videos of the island from an elevation of approximately 235 m were taken. Four watersheds in our study area were completely photographed. Subsequently, objects identifiable on the film such as trees, docks, and roads were located on the ground. Using a Magellan global positioning system, the position of these objects was determined within 2 to 5 m. This process created "ground control points" (GCPs), which associated objects in the photographs with known coordinates.

As the research project progresses, these GCPs will be used with the aerial photographs to improve the previous land cover classification map. The aerial photographs will be digitized and the GCPs in each photo will be identified. Using ERMapper, the appropriate latitude and longitude will be linked to each GCP. Through a process known as geometric correction, the digitized photographs of each watershed will be reshaped to conform to a standard map projection (Lilles and and Kiefer 1994). When viewed simultaneously, the corrected photographs will create a montage of images for each watershed. These photographic montages will be used in conjunction with field notes to delineate

areas of contiguous land cover such as palm trees, grazed cattle land, and development. Once delineated, the boundaries of these contiguous areas will be overlaid on top of the satellite image. ERMapper will utilize these boundaries as "training regions," classifying all other pixels of the satellite image based on similarities between the spectral signature of each pixel and that of the training regions. This analysis will produce a more detailed and accurate land classification map of Roatán.

## Discussion

An accurate classification map of land cover on Roatán offers several benefits to the research goals of this long-term study. First, this land cover map can be interpreted using information collected in the field in order to develop a land use map of the watersheds. Even though land cover can offer a great deal of insight into how the land is being used, it is important to use information collected in the field to confirm assumptions about land use based on land cover classification maps (Adeniyi 1986). The first stage of this research included an analysis of a previous study of Roatán, which produced a land cover and land use map using only remote sensing data (Vega *et al.* 1993). When compared to the SPOT image and to observation made in the field, these maps poorly represented the actual land use patterns on the island (Rehmus and Tighe 1995).

Second, these maps will provide a baseline record of the status of development on the island, to which future land cover/ land use analysis can be compared. With the acquisition of additional remote sensing data over time, the amount and rate of change on the island can be measured. As this paper goes to press, I have contracted for a second image of Roatán to be acquired by the sensors aboard SPOT, and have purchased from the Honduran government black and white aerial photographs of the island taken in 1989. These remote sensing data will greatly enhance research efforts by both extending in time the information available for analysis and providing a set of aerial photographs which will be only slightly distorted during the geometric correction process because they were taken from an angle nearly horizontal to the ground.

Third, analysis of these maps will quantify the actual area of specific land cover and land use types in each watershed. Once this information is incorporated into the project database, researchers will be able to determine statistical correlation between land use patterns and various coral reef health measurements and water quality parameters. With the addition of information over time, the long-term effects of different types of development and land use can be monitored and quantified. By quantifying these relationships, our research will help identify land use patterns that negatively impact the reefs and near shore waters as well as provide a means to measure the relative amount of damage and rate of environmental degradation associated with these land use patterns. Such an understanding of the relationship between changes on land and the health of coral reefs is vital to creating a plan for controlling the development on the island. Only a development plan which incorporates this relationship between the land and the water will insure the sustainability of tourism based on the natural beauty of Roatán.

## References Cited

Adeniyi, P. 1986. Agricultural land use inventory and mapping in Nigeria: The application of remote sensing. In M. J. Eden and M. T. Parry, eds. *Remote Sensing and Tropical Land Management.* John Wiley and Sons: New York.

Andereck, K. 1995. Environmental consequences of tourism: A review of recent research. In *Linking Tourism, the Environment, and Sustainability.* USDA Forest Service General Technical Report, INT-GTR-323.

Garoutte, C. 1995. *Diving Bay Islands.* AquaQuest Publications: NY.

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.

Jacobson, S. K. 1992. *Bay Islands: Nature and People.* Self published.

Lillesand, T. and R. Kiefer. 1994. *Remote Sensing and Image Interpretation.* John Wiley & Sons: New York.

Luttinger, N. 1995. From the sea up: A case study of grassroots reef conservation in Roatán, Honduras. TRI News 14: 8–11.

Rehmus, S. and C. Tighe. 1995. The use of remote sensing for coastal watershed analysis: A case study of Roatán, Honduras. A report for Observing the Earth from Space, Yale University.

Sorenson, J. 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 IADB.

Stonich, S., J. Sorenson, and A. Hundt. 1995. Ethnicity, class, and gender in tourism development: The case of the Bay Islands, Honduras. Journal of Sustainable Tourism 3(1): 1–28.

Valladares, A. 1939. *Monografía de las Islas de la Bahía.* Talleres Tipográficos Nacionales. Honduras.

Vega, A., W. Alevizon, R. Dodd, R. Bolaños, E. Villeda, C. Cerrato, and V. Castro. 1993. Watersheds, Wildlands, and Wildlife of the Bay Islands, Honduras: A Conservation Strategy. A report prepared for the United States Agency for International Development, Paseo Pantera Project.

## Acknowledgments

This project was supported by the School of Forestry and Environmental Studies, Coca-Cola World Fund at Yale, and the Tropical Resources Institute. I thank Dr. Wingfield Rehmus for unswerving motivational support, Cristin Tighe for her determination and good spirits during the first stage of research, and Gaboury Benoit and Linwood Pendleton for initiating Yale's research on Roatán. Many on the island gave generously with resources and assistance, including Julie Dutcher, Gayle Hood, Eric Anderson, and all who allowed me access to their properties.

# Liana-Tree Interactions in a Second-Growth Forest Stand in Eastern Amazonia

**William G. Stanley**
**Candidate for Master's of Forest Science**

## Introduction

During the late 1960s land rush in the eastern Amazonian state of Pará, the majority of the forest cleared was for the creation of cattle pastures (Mahar 1989). Many of these pastures were abandoned within a few years due to the poor productivity of forage grasses caused by low phosphorous levels, insect attack, and competition with native plants (Nepstad *et al.* 1996, Uhl *et al.* 1988, Nepstad *et al.* 1991). After two decades of natural forest regeneration, plant competition continues to shape the landscape significantly. In this paper I discuss interactions between trees and lianas in a regenerating forest in Pará, analyzing the direct effects lianas have on trees, and differences between tree species that influence their susceptibility to lianas. My hypotheses are that since the presence of lianas in tree crowns decreases tree growth rates, and that faster growing tree species are less likely to be colonized by lianas.

Lianas are said to impede tree growth by competing for growing space and causing mechanical damage (Clark and Clark 1990, see Putz 1980). Therefore, trees that avoid or shed lianas may have a competitive advantage relative to other trees. Some of the more successful tree species appear to have relatively high mean branch-free bole heights (Campbell and Newbery 1993, Balfour and Bond 1993). However, Putz (1984) reports that crown depth (total height-height to first branch) seems to have no effect on rates of liana colonization. Putz (1980) suggests that trees with large leaves shed lianas with their leaves. Branch shedding, bark smoothness, rapid diameter growth, and flexibility of stems may also be contributing factors (Putz 1984). Chalmers and Turner (1994) found few lianas on small trees and suggested that it was because liana species do not grow well in the understory. While several of these authors consider the importance of tree growth rates, with varying conclusions, they do not directly test for a correlation between tree species-specific height growth rates and liana presence.

## Site Description

Research was conducted in a second-growth stand regenerating from an abandoned pasture located at the Fazenda Vitoria ranch, about 6.5 km northwest of the town of Paragominas (2°59' S, 47°31' W). Following land clearing and burning in the late 1960s, the site was planted with forage grass (*Panicum maximum*) and grazed for about 10 years under varying intensities. The pasture was periodically cut and burned to limit growth of non-forage plants and was finally abandoned in 1977 (Grogan 1995). Land use intensity falls into the "moderate use" pasture category as defined by Uhl *et al.* (1988). Approximately 70% of the abandoned pastures found in the region fall within this category. The terrain is flat and surrounded on all sides by second-growth forest having the same use history. There is an active pasture less than 75 m east of the site.

Between the 10$^{th}$ year of regeneration (1987) and 19$^{th}$ year of regeneration (1996) the stand was in the stem exclusion stage of development (Oliver and Larson 1996). The total number of live trees \$2 m in height decreased by 37%, from 1,106 (9,217 stems ha$^{-1}$) to 696 (5,800 stems ha$^{-1}$). In 1996 the stand was patchy with areas of high (13 m to 16 m) canopy and an obvious multi-layered structure. Other portions of the stand were characterized by greater densities of lianas generally associated with smaller trees (10 cm dbh or less and 10 m tall) and less well defined crown structure. Species identification is incomplete, but tree diversity has increased slowly since 1987, to more than 75 species.

Precipitation is seasonal with an average of 1,750 mm annually and < 250 mm from July to November (Nepstad *et al.* 1994) with occasional droughts of 30 consecutive days or more each year (Nepstad *et al.* 1991, Uhl and Kauffman 1990). Temperatures in Paragominas have historically ranged from an average monthly maximum of 34° C in September and October to an average monthly minimum of 21°C in July and August (EMBRAPA/CPATU 1985). The soils are Oxisols with iron-rich concretions (Uhl and Kauffman 1990).

## Methods

This analysis makes use of data collected in 1987 and 1996 in 12 permanent 10 m x 10 m plots (0.12 ha total) arranged along two east-west transects. The transects were placed 40 m apart and the six plots in each transect were at 50 m intervals.

Stems \$2 m in height were identified taxonomically and marked with permanent identification tags by Christopher Uhl in 1987. Diameter at breast height (dbh), and height was measured for all live trees in 1987 and 1996. In 1996 I collected information on the presence of lianas, stem growth form, and canopy position. For each tree I recorded whether lianas were or were not intertwined with the crown. When a liana passed through a tree crown without intertwining with the branches it was not tallied. Stems were tallied as "bent" if the angle of the main stem at its most horizontal point was 45 degrees or more from vertical. Trees were placed into one of three crown classes: dominant and co-dominant (no competing crowns overtopping, or overtopping less than 10% of crown area), intermediate (competing crowns overtopping 10–90%), or overtopped (competing crowns overtopping 90% or more).

For the purposes of this research each tree stem serves as a separate sample. Of the 696 live stems \$2 m in height in 1996, 74% (516) were \$2 m in height in 1987 and were used in the diameter, height, and growth rate calculations. To make comparisons, mean heights, diameters, growth rates, and standard errors were calculated for trees with and without lianas in their crowns. To explore if that faster growing tree species are less likely to be colonized by lianas, the seven species with greatest densities, including sprouts \$2 m heigh in 1996 were analyzed separately.

Analysis of Variance (ANOVA) was used to determine the significance of liana presence and species-specific differences with regards to mean diameters, mean heights, and growth rates (LSD, $p < 0.05$). Regression analyses were used to detect trends between tree species-specific growth rates and liana presence. Growth rates were derived from trees without lianas in their crowns to control for any influence lianas may have on tree growth rates.

## Results

*Impact of Lianas*

Forty-four percent of the 516 trees included in this study supported lianas in their crowns in 1996. Mean diameters of trees with lianas were not significantly different than those that did not support lianas (Table 1). Mean heights were not significantly different in 1987, but trees with lianas in their crowns were significantly shorter in 1996 ($p = 0.047$). Differences in mean annual diameter increment were not significant but height growth rates ($p = 0.007$) of trees with lianas were significantly lower. Trees with lianas in their crowns were almost four times as likely to have "bent" stems than those without lianas.

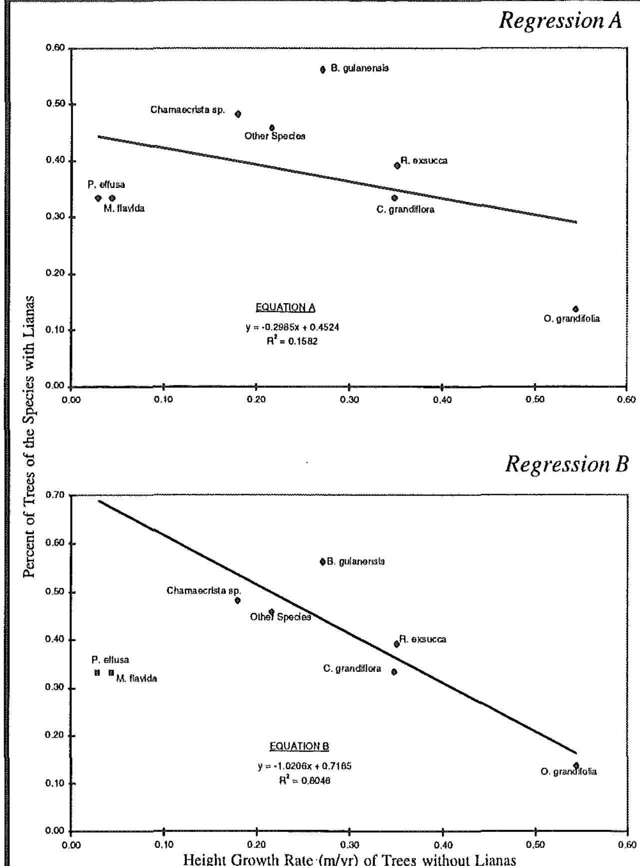
*Species-Specific Growth Rates and Liana Presence*

The seven most abundant tree species accounted for 48% of live stems ≥2 m in height in 1987 and 44% of live stems ≥2 m in height in 1996. There are significant interspecific differences between mean heights and mean growth rates (Table 2).

The tree species that had the lowest percentages with lianas in their crowns are *Ocotea grandifolia* (0.14), *Casearia grandiflora* (0.33), *Metrodorea flavida* (0.33), and *Poecilanthe effusa* (0.33). These species had the first highest (0.54 m $yr^{-1}$), third highest (0.30 m $yr^{-1}$), and lowest (0.06 and 0.03 m $yr^{-1}$) height growth rates respectively (Table 2).

The regression analyses of growth rates of trees without lianas in their crowns in relation to liana presence show a negative correlation (Figure 1).

### Figure 1. Relationship Between Species-Specific Height Growth Rates and Liana Presence.




*When all species are included in the regression there is a weak linear trend ($R^2$=0.158) for a negative correlation between mean annual height growth rate and liana presence (Regression A). The data for* P. effusa *and* M. flavida *suggest that other factors are important. When* P. effusa *and* M. flavida *are removed (Regression B), the model shows a much stronger trend ($R^2$=0.805). Though not presented here, mean annual diameter increment versus liana presence showed similar trends ($R^2$=0.269 and $R^2$=0.799 respectively).*

### Table 1. Differences Related to Liana Presence

| Liana Status 1996 | Mean DBH(cm) 1987 | Mean DBH(cm) 1996 | Mean DBH Growth Rate (cm/yr) | Mean Height(m) 1987 | Mean Height(m) 1996 | Mean Hgt Growth Rate (m/yr) | Percent Bent |
|---|---|---|---|---|---|---|---|
| No Liana | 2.98 a | 5.10 a | 0.24 a | 4.44 a | 6.48 a | 0.23 a | 0.06 |
| Liana | 2.92 a | 4.80 a | 0.21 a | 4.42 a | 5.97 b | 0.17 b | 0.23 |
| All | 2.95 | 4.97 | 0.22 | 4.43 | 6.26 | 0.20 | 0.14 |

*N = sample size. Means sharing the same letter are not significantly different (P > 0.05, LSD). Since "percent bent" is a simple tally, tests for significance are not appropriate. The group "All" was not included in the ANOVAs.*

### Table 2. Height Growth, Crown Position, and Liana Presence for the Most Abundant Species

| Family | Genus and species | All Trees N | Mean Height(m) 1987 | Mean Height(m) 1996 | Mean Hgt Growth Rate (m/yr) | Trees w/o Lianas N | Mean Height(m) 1987 | Mean Height(m) 1996 | Mean Hgt Growth Rate (m/yr) | Dom. (%) | Inter. (%) | Over. (%) | Percent with Lianas |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Lauraceae* | *Ocotea grandifolia* | 22 | 5.78 a | 10.61 a | 0.54 a | 19 | 5.95 a | 10.85 a | 0.54 a | 0.41 | 0.27 | 0.32 | 0.14 |
| *Annonaceae* | *Rollinia exsucca* | 23 | 4.77 abcd | 7.90 b | 0.35 b | 14 | 4.85 abc | 8.01 b | 0.35 b | 0.30 | 0.39 | 0.30 | 0.39 |
| *Flacourtiaceae* | *Casearia grandiflora* | 24 | 5.19 ab | 7.88 b | 0.30 bc | 16 | 5.13 ab | 8.26 b | 0.35 b | 0.29 | 0.46 | 0.25 | 0.33 |
| *Flacourtiaceae* | *Banara guianensis* | 73 | 4.56 bc | 6.66 c | 0.23 cd | 32 | 4.35 bc | 6.79 bc | 0.27 bc | 0.27 | 0.48 | 0.25 | 0.56 |
| *Leguminosae* | *Chamaecrista sp.* | 54 | 3.90 d | 5.77 cd | 0.21 cd | 28 | 3.93 c | 5.55 cd | 0.18 c | 0.24 | 0.17 | 0.59 | 0.48 |
| *Rutaceae* | *Metrodorea flavida* | 21 | 2.69 e | 3.26 e | 0.06 e | 14 | 2.37 d | 2.76 e | 0.04 d | 0.00 | 0.10 | 0.90 | 0.33 |
| *Leguminosae* | *Poecilanthe effusa* | 45 | 4.46 bcd | 4.76 d | 0.03 e | 30 | 4.28 bc | 4.54 de | 0.03 d | 0.07 | 0.33 | 0.60 | 0.33 |
| Others | NA | 254 | 4.43 cd | 6.08 c | 0.18 d | 138 | 4.48 bc | 6.43 c | 0.22 c | 0.16 | 0.32 | 0.52 | 0.46 |
| All | NA | 516 | 4.43 | 6.26 | 0.20 | 291 | 4.44 | 6.48 | 0.23 | 0.19 | 0.33 | 0.48 | 0.44 |

*The most abundant species are those having the greatest stem densities in 1996. N = sample size. Means between species sharing the same letter are not significantly different (P > 0.05, LSD). The group "All" was not included in the ANOVAs.*

## Discussion

The most statistically robust finding is that trees harboring lianas in their crowns have grown more slowly in height over the last 10 years than trees without lianas. This appears to be related to competition for light and to compensation for structural loads, as demonstrated by stem bending that was often associated with liana presence. Another explanation, however, is that species and trees which grow slowly are more prone to liana colonization.

The species with the highest growth rates, *O. grandifolia, R. exsucca,* and *C. grandiflora,* were relatively successful at avoiding lianas. This supports the hypothesis that species-specific height growth rates and liana presence are negatively correlated. The growth strategies of these species may enable them to "outpace" lianas in height growth. While lianas are capable of growing very quickly given optimal conditions, the crowns of the fast growing trees cast shade on the forest floor reducing available growing space and vigor of lianas that are located in the understory.

Trees that grew slowly under shade conditions, such as *P. effusa* and *M. flavida*, also avoided lianas, adding credence to the hypothesis put forth by Chalmers and Turner (1994) that lianas do not thrive in the understory. *P. effusa* and *M. flavida* had larger proportions of trees in the overtopped crown class than any of the other species (Table 2). At the Fazenda Vitoria, percentages of trees having lianas in their crowns varied between the overtopped (36%), intermediate (56%), and dominant (41%) crown classes, with the most shaded trees being the least likely to support lianas. It appears that many of the lianas in tree crowns are light demanding, or at least not as shade tolerant as some tree species. Shade tolerant tree species may have mechanisms that enable them to shed lianas. For example, trees may have flexible stems that make liana colonization difficult, or they may drop their branches (Putz 1984).

Due to the effect of lianas on tree stem form and growth, liana removal should have a positive impact on the grade of timber provided by commercially valuable tree species. To forego the costs of liana removal forest managers may chose to plant or encourage species that avoid lianas through high growth rates. They could also manage for understory species that reduce growing space for lianas by limiting light infiltration, thereby providing a buffer between young lianas and dominant timber species. Alternatively, the growth of tree species that provide support for lianas could be encouraged to promote the growth of commercially valuable lianas, such as those which produce valuable fruits or provide material for making rattan furniture or other products. Additional research is needed to compare effects across varying stand and ecosystem types before these strategies are promoted on a large scale.

## Acknowledgments

The Tropical Resources Institute and the Instituto de Pesquisa Ambiental da Amazonia supported this project. I thank my advisors, Professors Mark Ashton, Florencia Montagnini, and Chris Uhl, and Dan Nepstad for their guidance, and the able field technicians in Paragominas for their assistance. I am especially grateful to the Matos family and Elizabeth Busteed for the generosity which helped make this research possible.

## References Cited

Balfour, D. and W. Bond. 1993. Factors limiting climber distribution and abundance in a southern African forest. Journal of Ecology 81:93–99.

Campbell, J. and D. McC. Newbery. 1993. Ecological relationships between lianas and trees in lowland forest in Sabah, East Malaysia. Journal of Tropical Ecology 9:469–490.

Chalmers, A.and J.Turner. 1994. Climbing plants in relation to their supports in a stand of dry rainforest in the Hunter Valley, New South Wales. Proceedings of the Linnean Society of New South Wales 114(2):73–89.

Clark, D. and D. Clark. 1990. Distribution and effects on tree growth of lianas and woody hemiepiphytes in a Costa Rican tropical wet forest. Journal of Tropical Ecology 6:321–331.

Empresa Brasileira de Pesquisa Agropecuaria/Centro de Pesquisa Agropecuaria dos Trópicos Umidos (EMBRAPA/CPATU). 1985. Boletim Agrometeorológico No. 10: Belém, Brasil.

Grogan, J. 1995. The effect of fire on secondary vegetation in the northeastern Amazon basin, Pará, Brazil. Unpublished paper.

Mahar, D. 1989. *Government Policies and Deforestation in Brazil's Amazon Region.* World Bank 1-56.

Nepstad, D., C. de Carvalho, E. Davidson, P. Jipp, P. Lefebvre, G. Negreiros, E.da Silva, T. Stone, S. Trumbore, and S. Vieira. 1994. The role of deep roots in the hydrological and carbon cycles of Amazonian forests and pastures. Nature 372:666–669.

Nepstad, D., C. Uhl, C. Pereira, and J.Cardoso da Silva. 1996. A comparative study of tree establishment in abandoned pasture and mature forest of eastern Amazonia. Oikos 76:25–39.

Nepstad, D., C. Uhl, and E. Serrao. 1991. Recuperation of a degraded Amazonian landscape: forest recovery and agricultural restoration. Ambio 20(6): 248–255.

Oliver, C. and B. Larson. 1996. *Forest Stand Dynamics.* John Wiley & Sons, Inc., New York, N.Y.

Putz, F. 1984. How trees avoid and shed lianas. Biotropica 16(1):19–23.

Putz, V., 1980. Lianas vs. trees. Biotropica 12(3):224–225.

Uhl, C., R. Buschbacher, and E. Serrao. 1988. Abandoned pastures in eastern Amazonia. I. Patterns of plant succession. Journal of Ecology 76:663–681.

Uhl, C. and J.Kauffman. 1990. Deforestation, fire susceptibility, and potential tree responses to fire in the eastern Amazon. Ecology 71(2):437–449.

Storm clouds enshrouded the coffee fields of Costa Rica's Central Plateau as my plane descended into San José. It was May, the rainy season in Costa Rica, when daily downpours scour the sooty streets of San José, soak the surrounding coffee fields, and send sun-seeking tourists home to northern latitudes. I came not as a tourist but as an environmental studies graduate student — and confirmed coffee addict — because I had learned that my love of coffee might conflict with my love of the natural world.


*Full-sun coffee (*Coffea arabica, *var. Caturra) farms undulate over Volcán Poás, in Costa Rica's Central Valley.*

North American conservation groups such as the Rainforest Alliance and the Smithsonian Migratory Bird Center (SMBC) have described two types of coffee-growing systems, "shaded" and "full-sun," separated by a distinct environmental line. Traditionally, coffee farms used shade trees to shelter coffee, resulting in lower coffee yields and higher levels of environmental quality. SMBC biologists describe and advocate "rustic" shade systems, where coffee is inserted into the understory of existing natural forest, forming a rich habitat for birds (Perfecto *et al.* 1996) and insects (Perfecto 1996). In contrast, the Rainforest Alliance's Elizabeth Skinner describes full-sun farms as "ecological deserts... chemical-saturated landscapes where nothing can grow besides chemical-fed coffee trees, contributing to soil erosion, chemical runoffs that poison fish and wildlife, and the destruction of [migratory bird] habitat" (Schapiro 1994). These descriptions represent the extremes of coffee cultivation; but the coffee-producing regions I visited in Costa Rica comprise a spectrum of cultivation choices.

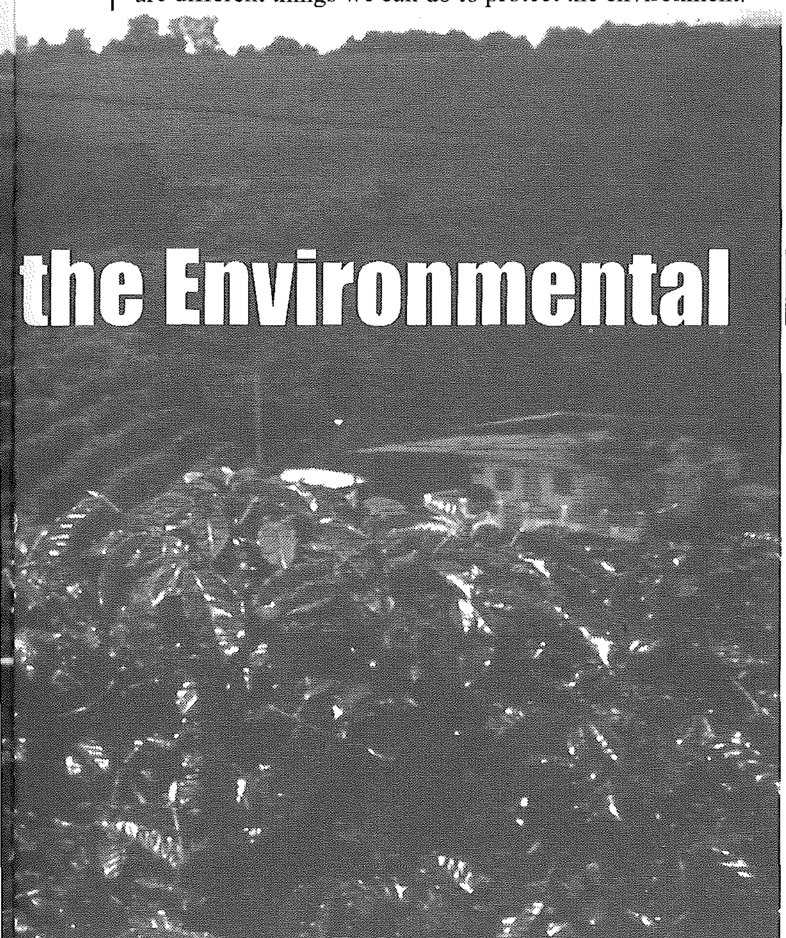
"Full sun" technology was developed in Hawaii in the 1940s and introduced to Costa Rica shortly thereafter. Today, shaded cultivation persists in some areas, but full-sun farms dominate the Central Plateau, Costa Rica's primary coffee-producing area. However, in Tarrazú, an equally renowned coffee-producing region, shade farms dominate the landscape. I was curious to discover why two regions that produce coffee of similar quality and price employ different cultivation techniques.

In practice, a multitude of variables blurrs the environmental line between "shade" and "sun". Local environmental conditions — climate, soils, topography — necessitate site-specific management approaches: shade tree species, shade tree management, and widely varying applications of agricultural chemicals. These choices determine the environmental impacts of the farm and vary significantly with the personal preferences of the farmer.

## Meseta Central

Ringed by the Poás, Irazú, and Barva volcanoes, the Central Plateau, *Meseta Central,* represents coffee's ideal growing conditions: deep volcanic soils, high altitudes, and a cloudy climate with distinct dry seasons and ideal rainfall. Coffee took root here in the late 18$^{th}$ Century, and coffee fields have since cloaked the plateau (Hall 1984). Today, full-sun technology enables farmers to extract from these soils the highest coffee yields on the planet (Castillo 1996). Here I decided to start my

# Shade / Sun
# the Environmental Dividing Line



research, at a full-sun *finca* spanning 300 hectares on the slopes of the Poás Volcano.

The owner of Finca Alsacia, Alfredo Robert, greeted me warmly. As we walked to his truck, he talked of past and current cultivation techniques, price trends, and coffee politics. Robert was interested in the "shade versus sun" environmental debate. He stated slowly, "I understand there are ecological differences between shade and sun farms. On my farm, I do not use shade trees because it is not necessary, but you will see there are different things we can do to protect the environment."

He started his pick-up and we drove to the gates of his *finca*. Expecting a monotonous expanse of "ecological desert," I was surprised to see a lush landscape. As far as I could see, rows of coffee trees traced green grooves across the hillside, each tree heavy with small, green fruits. Their pattern was interrupted by shelterbelts of timber trees and occasional *Inga* or *Erythrina* trees, planted not to provide shade, but to fix nitrogen and produce organic matter for soil enhancement. The coffee trees were spaced closely together, their branches intermingling, at densities approaching 6,000 trees per hectare. On the slopes of Poás, plentiful cloud cover protects coffee trees from excess sun. "Here I have an ideal growing climate for coffee," said Robert, smiling. "I don't *have* to use shade trees."

Full-sun cultivation is intensive for both land and coffee trees. Coffee trees' rates of photosynthesis increase dramatically because of increased exposure to sunlight, resulting in heightened demand for nutrients. The plants deplete soil nutrients and require spiraling applications of fertilizers, fostering the systems' dependence on chemical sustenance. Farmers, however, can take steps to mitigate the depleting impact on soils, and Alfredo Robert does.

When I asked about soil fertility, Robert got down on his hands and knees and started to dig. I joined him. We scraped away layers of twigs and rotting leaves to expose dense, cocoa-colored earth. The earth was mottled with chunks of coffee hulls, *la broza de café*, salvaged from the effluent of coffee processing mills and used as natural fertilizer. This practice, common in Costa Rica, results in the dual benefit of fertilizer production and pollution reduction. Robert led me to the next row piled high with twigs and branches of pruned coffee trees. Coffee is pruned regularly to extend the plant's longevity and increase yields, and coffee tree wood can be used as mulch for the soil.

Coffee hulls and coffee twigs, however, cannot provide a critical nutrient: nitrogen, the most important element for coffee growth (ICAFE 1989). Sustaining full-sun production requires large quantities of nitrogen-based fertilizers. Coffee farms in other regions plant shade trees selected for their ability to fix nitrogen. Although Robert had planted some nitrogen-fixing trees sparsely in his coffee, he was experimenting with other ideas. He showed me a nitrogen-fixing ground cover — "A relative of the peanut!" he told me.

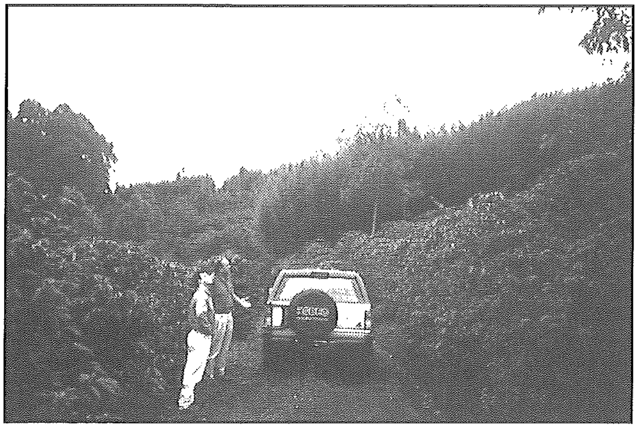
Sun farms are reputed to need higher levels of other chemicals such as pesticides, herbicides, and fungicides. But applications of these chemicals vary with local growing conditions and the preferences of the farmer. In humid regions, shade farms may require higher applications of fungicides than sun farms because fungal outbreaks are positively related to humidity. Robert uses herbicides and fungicides sparingly because he is concerned with the chemicals' impact on his coffee trees. He chooses not to use insecticides.

Swarms of biting insects were the most obvious proof of his scant pesticide use. I noticed that the insects were coming from a nearby stream, which was obscured by a wide buffer zone of vegetation, a tangle of branches and lianas. Robert explained that it was a remnant of natural forest, left in place to filter agricultural runoff. I looked through the treetops and noticed a

**Shauna Swantz**
**Candidate for Master's of Forest Science**

manicured tract of coffee trees on a nearby hillside. The neighboring farm, which resembled a golf course, defined "monoculture."

I later visited the farm, clearly operated to maximize profit. The soils were bare between the uniform rows of coffee trees that traced a smooth pattern of furrows across the hillside. The *Meseta Central*'s environmental conditions enable this type of cultivation, at least in the short term. But decades of such intensive cultivation may have hidden social costs such as exhausted soils and polluted waters. Escalating levels of production may mine native soil nutrients and contribute to long-term declines in coffee yields (Gomez 1996). In addition, nitrate leaching from sun plantations has been found to be three times greater than from shaded plantations in the *Meseta Central* (Babbar and Zak 1995). Other studies (Aranguren *et al.* 1982, Imbach *et al.* 1989) show that nitrogen is cycled more tightly within shade coffee farms and that nutrient leaching levels from systems comprising coffee and poró (*Erythrina poeppigiana*) were in the same range as native or plantation forests in tropical areas. In the *Meseta Central*, 50% of groundwater recharge area is under coffee management, and groundwater nitrate concentrations occasionally exceed levels considered to represent a health hazard (Frazer *et al.* 1980). To many farmers, however, groundwater contamination may seem like a remote risk, rather than an imminent reality, and management practices reflect their level of concern.



*Alfredo Robert explains his use of shelter belts.*

"We all manage our farms differently," observed Robert. He understood that farm management, aside from being an economic choice, is a personal preference. His own full-sun farm, while no rainforest, was not an "ecological desert" — due mainly to his own interest in sustainable agriculture. His use of living ground covers, organic mulches, shelterbelts, and stream buffers of native forest were measures to minimize the environmental impacts of his farm and to invest in the longevity of its production. High yields attest to the health of his land, but Robert spoke modestly of his efforts: "I have ideal growing conditions. To see shade farms, go to Tarrazú: rich coffee from poor soils."

## Los Santos de Tarrazú

To the southwest of San José, over the Cordillera, lies the Tarrazú region. Stippled with small towns such as San Marcos, Santa Elena, and San Cristóbal, part of the region is known as *Los Santos de Tarrazú* — the Saints of Tarrazú. The area is sparsely developed, its beauty largely undiscovered by the flocks of tourists who descend upon Costa Rica each year. The first farm I visited, *Finca La Minita,* rests on a ridge between two canyons. From the apex of this ridge, emerald mountains undulate westward to the Pacific coast. These mountains used to be home to a massive tract of tropical cloud forest. Today, coffee farms quilt the hillsides, and as foggy mists creep through the canyons, shade trees glean their moisture and sift it to the coffee trees below.

As a result of high clay content, the soils are deep red, and contrast starkly with the cocoa-colored earth of the *Meseta Central*. Tarrazú's red soils have been weathered by a harsher climate (Gomez 1996): the sun's rays pierce the dry air, and the steep slopes send rain water streaming downhill, carrying nutrients away. Miguel, *La Minita*'s farm manager, assured me that shade trees play an indispensable role. They shelter coffee from the sun's burning rays during the peak of the dry season, which is essential to proper coffee bean maturation in Tarrazú. Miguel explained that the shade allows the beans to mature more slowly, concentrating more "honey" in the bean, and resulting in a better tasting coffee. The trees also add root structure to the hillsides, conserving the farm's vulnerable topsoil.

*La Minita*, however, did not mirror the descriptions of shade farms I had read in the States. A contiguous shade canopy did not shroud the landscape; instead, shade trees sprinkled the hillsides. Some areas were fully exposed to the sun. Shade tree density depends on an area's orientation and length of exposure to daylight. Density, in turn, determines the magnitude of the shade trees' environmental benefits — as do the choice of tree species and how they are tended.

As on many Costa Rican coffee farms, most of the shade trees at *La Minita* were a species known locally as poró *(Erythrina poeppigiana)*. Poró is popular because it can be pollarded. Pollarding, or cutting the tree back to the trunk, is crucial for the coffee-growing environment because it allows the manager to control bean maturation by regulating the amount of sunlight coffee receives. Workers pollard the shade trees once a year. Poró cuttings can be used to improve soil fertility and structure (Arias 1994). Poró leaves are rich in nutrients — N, P, K, Ca (Alpizar *et al.* 1985) — and decompose rapidly (Hueveldop *et al.* 1985, Von Platen 1996). At *La Minita*, workers mixed poró cuttings with Tarrazú's red earth to enrich soil fertility.

Necessary for coffee management, pruning trees renders them useless as bird habitat. Migratory birds, a major focus of environmental concern over coffee production, would have a hard time making homes in the skeletal structures left behind after pruning. Unpruned shade trees — the kind described by the Smithsonian Migratory Bird Center — may mimic the habitat functions of native forests, but these were not the kind of shade trees I observed in Costa Rica.

The next shade farm I visited in Tarrazú was permanently thinning shade tree cover from 80% to 30%, and rivaled many sun farms in the quantity and frequency of its agrochemical applications. Girdled and dying *Inga* and *Erythrina* trees washed the farm with sickly yellow leaves. I watched workers soak the soils of the *finca* with a chemical cocktail, part of the farm's new strategy to increase yields by increasing sun exposure and agrochemical applications. This shade farm more closely resembled the "chemical-saturated landscape" the Rainforest Alliance opposes as characteristic of sun cultivation. Clearly, the mere presence or absence of shade trees did not determine a farm's ecological standing.

Three months later, as my plane ascended from Costa Rica, thegreen expanses of the *Meseta Central* reminded me that I carried home a very different image of coffee farms and coffee farmers than was described in the environmental literature I had pored through in the States. This information described only the extremes of coffee production, conveniently termed "shade" and "sun."

These two extremes did not dominate coffee-growing regions of Costa Rica, and to generalize about coffee production based on extremes is to misrepresent its complexity. Shade trees can impart environmental benefits, but the nature and the magnitude of those benefits are determined by how the farmer manages the shade trees and his farm as a whole. The people who have spent their lives coaxing coffee from the fine soils of tropical highlands understand the complexity of coffee cultivation—particularly, the site-specific management decisions necessary to address varying climatic, edaphic, and topographic conditions. Eco-conscious consumers have much to learn from these farmers before separating into distinct categories what is really a spectrum of cultivation choices with widely varying environmental impacts.

**This article was adapted from *Fresh Cup* (January 1997), a specialty coffee trade publication based in Portland, Oregon.**

## Acknowledgments

Greatest appreciation to Grace Mena, owner of Deli Cafe Exportadora, San José, Costa Rica. Also, Alfredo Robert of Finca *Alsacia*, Russell Kramer of Hacienda *La Minita*, and Helga Rodrigues and Henning Von Platen of Finca *La Suiza*, Turrialba. Special thanks to Drs. Florencia Montagnini and Lynne Bennett of YFES.

## References Cited

Alpizar L., H. Fassbender, J. Hueveldop, G. Enriquez, and H. Folster. 1985. Sistemas agroforestales de café (*Coffea arabica*) con laurel (*Cordia alliodora*) y café con poró (*Erythrina poeppigiana*) en Turrialba, Costa Rica. Turrialba 35:233–242.

Aranguren, J., G. Escalante, and R. Herrera. 1982. Nitrogen cycle of perennial crops under shade trees: Coffee. Plant Soil 67:247–258.

Arias, J. 1994. Propagación de árboles de sombra. Noticiero de Café (Revista del Instituto del Café de Costa Rica) 87:1–3.

Babbar, L. and D. Zak. 1995. Nitrogen loss from coffee agroecosystems in Costa Rica: Leaching and denitrification in the presence and absence of shade trees. Journal of Environmental Quality 24:227–232.

Castillo, J. Personal communication. 3 July 1996. Departamento de Estudios Agrícolas y Económicos, Instituto del Café (ICAFE), San José, Costa Rica.

Frazer, P., C. Chilvers, B. Beral, and M. Hill. 1980. Nitrate and human cancer: A review of the evidence. International Journal of Epidemiology 9:3–11.

Gomez, O. Personal communication. 13 August 1996. Cartografía y estudios edafológicos, Ministerio de Agricultura y Ganaderiá de Costa Rica.

Hall, C. 1984. Costa Rica: Una interpretación geográfica con perspectiva histórica. Editorial Costa Rica: San José, Costa Rica.

Hueveldop, J., L. Alpizar, H. Fassbender, G. Enriquez, and H. Folster. 1985. Sistemas agroforestales de café (*Coffea arabica*) con laurel (*Cordia alliodora*) y café con poró (*Erythrina poeppigiana*) en Turrialba, Costa Rica. II. Producción agrícola, maderable y de residuos vegetales. Turrialba (35) 4:347–355.

ICAFE (Instituto del Café de Costa Rica). 1989. Manual de Recomendaciones para el Cultivo del Café. San José, Costa Rica.

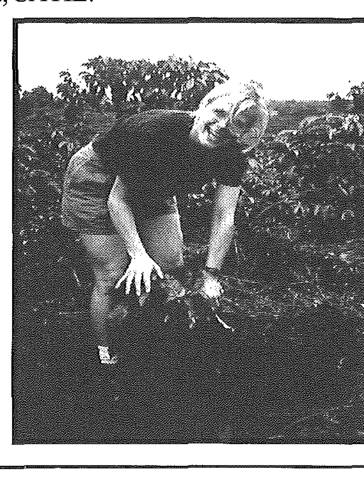
Imbach, A., H. Fassbender, J. Beer, R. Borel, and A. Bonnemann. 1989. Sistemas Agroforestales de café (*Coffea arabica*) con laurel (*Cordia alliodora*) y café con poró (*Erythrina poeppigiana*) en Turrialba, Costa Rica. VI. Balances hídricos e ingreso con lluvias y lixiviación de elementos nutritivos. Turrialba 39(3):400–414.

Perfecto, I. Personal communication. 16 September 1996. Presentation at Smithsonian Migratory Bird Center's First Sustainable Coffee Congress: Arthropod Diversity in Coffee Agro-Ecosystems.

Perfecto, I., R. Rice, R. Greenberg, and M. Van der Voort. 1996. Shade Coffee: A disappearing refuge for biodiversity. Bioscience (46) 8: 598–608.

Schapiro, M. 1994. Muddy waters: The lore, the lure, the low-down on America's favorite addiction. Utne Reader 66:58–56.

Von Platen, H. Personal communication. 9 June 1996. Owner, Finca La Selva, La Suiza, Turrialba, Costa Rica, and Agricultural Economist, CATIE.



*The author helps out on the finca.*

# Harvesting Palm Fruits in the Jaci-Paraná Extractive Reserve, Brazil

**Anita Sundari Akella**
**Candidate for Master's of Environmental Studies**

**Renée Ankarfjard**[1]
**Candidate for Doctorate of Systems Ecology**

## Introduction

The Organização de Seringueiros de Rondônia (Rondônia Rubber Tappers Association [OSR]), from the state of Rondônia in Brazil's northwestern Amazon, has recently (January 1996) been successful in its efforts to have 21 pieces of land traditionally used for extractive purposes decreed by law as state extractive reserves. With such status come long-term usufruct rights for the rubber tappers who have been working the land for the last few decades.

As in the rest of the Brazilian Amazon, the primary products extracted by the rubber tappers in Rondônia have been rubber (*Hevea brasiliensis)* and Brazil nuts (*Bertholletia excelsa)*. Fluctuations in the markets for these two goods make them unreliable as a basis for continued subsistence (Pereira *et al.* 1995); OSR, however, is interested in diversifying the extractive base to include other non-timber forest products (NTFPs) such as fruits, resins, and medicinal plants, to better ensure the long-term sustainability of their livelihood.

This study assesses the economic viability of extracting fruits from two palm species, açaí (*Euterpe precatoria)* and buriti *(Mauritia flexuosa)* from the Jaci-Paraná State Extractive Reserve. The objective of this research is to determine whether the revenue to be earned through the extraction exceeds the costs involved in harvesting and marketing them, sufficiently to warrant an investment by OSR in expanding the reserve's productive base.

In Brazil, while studies valuing NTFPs have been conducted in other Amazonian states, Rondônia's resources are largely unexplored. This research is inspired by previous research efforts aimed at valuing NTFPs of the Amazon rainforest. It is innovative in that it a) addresses a region that has not yet been the subject of economic valuation studies and b) represents an effort initiated by the rubber tappers of Rondônia themselves to understand the economic and productive capacity of their resources. Furthermore, this study methodologically improves on previous studies of this nature by capturing fluctuations in market prices for these fruits over the harvest season rather than using an average price and by applying the analysis to the entire landscape of the Jaci-Paraná State Extractive Reserve, rather than dealing with only one or a few plots.

## Site Description

The reserve is located in the northwest part of the state of Rondônia. It covers 205,000 ha and is accessible only by boat from the village of Jaci-Paraná, 80 km west of the state capital, Porto Velho, which is also the primary market.

The area has a mean temperature of 32 °C and annual precipitation of 2,300 mm of which 85% falls during the rainy season, October through April (Pereira *et al.* 1995). The reserve is dominated by soils of low fertility unsuitable for agriculture. While rubber tapping has traditionally been the main economic activity of the extractivist population that work on the reserve, it is today insignificant due to low world prices and difficulties in transporting the product (Pereira *et al.* 1994).

Estimates of buriti fruit production were obtained in the community forest of São Sebastião, located just across the Rio Madeira from Porto Velho. They were found in a large *'buritizal'*, a permanently flooded swamp forest heavily dominated by *Mauritia flexuosa*. These swamps are commonly found in narrow depressions that run parallel to river beds in the central and western Amazon (Kahn and de Granville 1992).

The açaí fruit production estimates come from the Itacoã community forest, 70 km northwest of Porto Velho along the Rio Madeira. Açaí fruit has been commercially extracted since at least the mid-1970s, according to local harvesters. The estimates were made in an *'açaízal,'* a wetland community dominated by *Euterpe precatoria,* the açaí palm. This forest type is characterized by periodic flooding of whitewater rivers with high sediment loads and alluvial soils (Kahn and de Granville 1992).

## Methodology

*Population Density Estimates*

The height of all palms mature enough to produce fruit were noted along transects of 500 m x 10 m (0.5 ha) in two *buritizais* and in two *açaízais* on the reserve. The objective of collecting this information was later to combine height distribution data and productivity estimates to calculate the productive capacity of the *buritizais* and *açaízais* in the reserve.

*Productivity Estimates*

Productivity estimates for açaí and buriti were obtained in the riverine communities of Itacoã and São Sebastião respectively, using the ethnobotanical approach employed in earlier studies of the potential value of NTFPs (Peters *et al.* 1989, Grimes *et al.* 1994). Experienced fruit harvesters were separately taken to the same individual palms to estimate the annually harvested fruit production of each. Height of each palm was again noted. This process was repeated until the whole range of height classes had been covered with repeated observations. After per-tree productivity estimates were obtained, group interviews were conducted with harvesters to identify the processes involved in the harvest or processing of each of these fruits. This information later served as the basis for time and cost estimates used in the net present value (NPV) calculations.

[1]Department of Systems Ecology, Stockholm University

The productive capacity of the açaí and buriti stands on the reserve was calculated using the ethnobotanical estimates of annual fruit production in Itacoã and São Sebastião. From these data, estimates of average productivity per height class were calculated; the inventoried palms from the reserve were then divided into the same height classes and productive capacity per hectare was calculated.

The per-hectare productivity estimates thus calculated were then compared to productivity results obtained by other researchers on similar sites in other regions of the Amazon. Our productivity estimates for buriti proved to be eight times larger than estimates made in other research. It seemed likely that the discrepancy resulted from errors in the ethnobotanical estimates for sex-ratio and per-tree productivity. To correct for this error, estimates for buriti were then recalculated using the population density estimates obtained on the reserve, sex-ratio estimates from a study cited in Kahn and de Granville (1992), and per-tree productivity estimates from Peters *et al.* (1989). Once recalculated, the resultant per-hectare productivity estimates for buriti were consistent with those found in the literature.

*Market Prices and Total Cost Estimates*

Both products are typically harvested by riverine populations along the Rio Madeira and its tributaries and then brought to Porto Velho in a boat, either by the harvesters themselves, or by a middleman. From the riverside dock, açaí is then sold as fruit either to people who sell *'vinho do açaí'* (a non-alcoholic drink made from the pulp of açaí) in the market, or to local businesses. Buriti pulp, already processed by the harvesters, is also sold either to the people who will ultimately sell it in the market or to local businesses.

Information on market prices for these two products and seasonal price fluctuations was gathered through interviews with sellers of these products in Porto Velho's weekly market.

Total Annual Revenue per hectare (TAR) for each product was calculated as follows:

$$TAR = \Sigma[K_i * P_i]$$

where K represents the number of kilograms harvested, P is price per kilogram in the market, and i represents the month of the harvest season.

Total Annual Costs per hectare (TAC), then, were calculated as follows:

$$TAC = (E_t) * (t)$$

where E represents the expenses per trip and t represents the number of trips made.

NPV of the land was calculated on a per hectare basis using a 5% long-run average inflation-free discount rate and NAV is net annual value:

$$NPV = NAV/r$$

where NAV = Total Annual Revenue - Total Annual Costs and r is the long-run inflation-free interest rate.

## Results and Analysis

*Açaí*

Açaí's productivity fluctuates throughout its five-month harvest season (January through May), starting low in January and rising to its peak productivity in March, and then falling again through the end of the harvest season in June. Price per kilogram of fruit in the markets of Porto Velho fluctuates accordingly, rising as high as US$0.45/kg when supply is low, and falling to as low as US$0.15/kg at the height of the harvest season. Calculations show Total Annual Revenue per hectare of açaí to be US$1,323.00 (Tables 1 and 2).

Travel-cost analysis shows that NPV of açaí extraction is only positive if the total (round trip) travel time per trip is less than 3.6 days (data not shown). This implies that the round-trip distance to and from the harvest site must be less than 113.75 km, with NPV increasing substantially as distance to the harvest site and therefore total travel time decreases.

Two noteworthy conclusions can be drawn from these results. First, with the current 500-kg boat owned by the rubber tappers association, harvest sites located within a 114-km radius of the start of the reserve have a positive NPV and are therefore economically viable for açaí fruit harvest. Furthermore, NPV calculations made using different boat sizes demonstrate the general trend that using a larger boat on harvesting trips can make viable harvest sites located at greater distances from the start of the reserve. However, optimal boat size cannot be determined until a more complete understanding of the reserve's resources is achieved. The purchase of boats, however, must be based not only on economics, but also practical and ecological considerations as well.

**Table 1. Costs of Açaí Production**

| Capital Items | Unit Cost | Number Needed | Capital Expense | Expense Items | Unit Cost | Number needed | Expense |
|---|---|---|---|---|---|---|---|
| Machete | $10 | 2 | $20.00 | Propane | $6.50 | 3 | $19.50 |
| Fuel Container | $35 | 3 | $105.00 | Motor Oil | $2.50 | 2 | $5.00 |
| | | | | Labor (2) | $10/day | 3 days | $60.00 |
| **Total Capital Expense** | | | $125.00 | Boat | $10/day | 3 days | $30.00 |
| **Annual rent on capital** | | | $18.75 | Rent | $0.38 | 1 week | $0.38 |
| **Total cost per trip** | | | $114.88 | | | | |

**Table 2. NPV of Açaí Production**

| Month | Month's Yield (kg) | Price/kg | Gross Revenue/ month | # Trips | Monthly Cost | Net revenue |
|---|---|---|---|---|---|---|
| January | 490 | $0.45 | $220.50 | 1 | $114.88 | $105.62 |
| February | 980 | $0.30 | $294.00 | 2 | $229.76 | $64.24 |
| March | 1,960 | $0.15 | $294.00 | 4 | $459.52 | -$165.52 |
| April | 980 | $0.30 | $294.00 | 2 | $229.76 | $64.24 |
| May | 490 | $0.45 | $220.50 | 1 | $114.88 | $105.62 |
| | Kg | | TAR | | TAC | NAV |
| **Annual** | 4,900 | | $1,323.00 | | $1,148.80 | $174.20 |
| | | | | | **NPV of açaí** | **$3,484** |

In the case of buriti, the marketable product is the pulp, or oily mesocarp, of the fruit. Since relatively little pulp is collected per volume of harvested fruit, the boat is best used if unusable parts of the fruit are discarded during the harvesting trip itself. Productivity of the buriti palm also varies throughout its four-month growing season (March through June); pulp yield is 74 kg/ha in March and in April and 233 kg/ha in May and June.

Our calculations show that buriti extraction is not economically viable in the months of March and April. In these months of low fruit yields per hectare, collection becomes a very time-consuming and labor-intensive process; thus, the costs of harvesting a hectare outweigh revenue from pulp sales. This analysis applies even to sites close enough that they can be reached without renting a boat; extraction becomes increasingly unprofitable as travel time, and therefore costs (boat rental, additional labor days), rise (Tables 3 and 4).

In order for buriti to be viable in these months, price per kilogram of pulp would have to rise significantly (all costs being held constant). Where no travel costs are involved, buriti could be profitable if the price were to rise by 50% to $0.75/kg. For buriti collected at any distance from the boundary of the reserve to be viable, price would have to more than double, to $1.10/kg.

In May and June, buriti extraction is viable if harvest sites are located within 17 km of the reserve's boundary. In these months, fruit yields per hectare are at least three times higher than in March and April — this makes collection less time-consuming and also implies much higher revenues per hectare. Travel-cost analysis (data not shown) shows that NPV of extraction in May and June for a site located at no distance from the reserve's boundary is $1,688.40, dropping to $152.40 for a site that is a third of a day's round trip journey (11.2 km away), and reaching zero at just under a half-day round trip journey (17 km).

## Table 3. Costs of Buriti Production

| Capital Items | Unit Price | # Needed | Capital Expense | Expense Items | Unit Price | # Needed | Expense |
|---|---|---|---|---|---|---|---|
| Machete | $10 | 2 | $20.00 | Propane | $6.50 | 3 | $19.50 |
| Fuel | $35 | 3 | $105.00 | Motor Oil | $2.50 | 2 | $5.00 |
| Container Spoon | $1.50 | 2 | $3.00 | 2 Harvesters | $10/day | 4 days | $80.00 |
| | | | | Processors | $5/day | 4 days | |
| | | | | March-April (1) | | | $20.00 |
| | | | | May-June (4) | | | $80.00 |
| **Total Capital Expense** | | $128.00 | | Boat | $10/day | 4 days | $40.00 |
| | | | | Rent | $0.38 | 1 wk | $0.38 |
| **Annual rent on capital** | | $19.20 | | Plastic Bags | $0.10 | 5 | $0.50 |
| **Rent per week** | | $0.38 | | | | | |
| **Total Cost per Trip** | *March/April* | **$165.38** | | | | | |
| | *May/June* | **$225.38** | | | | | |

## Table 4. NPV of Buriti Production

| Month | Fruit yield (kg/ha) | Pulp yield (kg/ha) | Price per kilo pulp | Gross revenue /ha | Cost per trip | Hectares harvested* | Cost per ha | Net revenue/ha |
|---|---|---|---|---|---|---|---|---|
| May | 1,842.24 | 233 | $0.50 | $116.68 | $225.38 | 2 | $112.69 | $3.99 |
| June | 1,842.24 | 233 | $0.50 | $116.68 | $225.38 | 2 | $112.69 | $3.99 |
| | kg/ha | kg/ha | | TAR | | | TAC | NAV |
| Annual | 3,684.48 | 467 | | $233.35 | | | $225.38 | $7.97 |
| | | | | | | | NPV of Buriti/ha | $159.40 |

*Number of hectares harvested to fill a 500-kg boat to capacity on each trip

## Acknowledgments

This project was funded by the UNDP technical outpost in Rondônia and by Yale University Tropical Resources Institute. Special thanks to the Organização de Seringueiros de Rondônia, and our forest guides Zé Canuto, Januário, Toninho, and Manuel; to Douglas Daly, Chuck Peters, and the helpful folks at the NYBG's Institute for Economic Botany; to Gabriel Lima Ferreira and Eduardo Amaral Borges of UNDP; and to Robert Mendelsohn of Yale University for guiding this analysis.

## References Cited

Grimes, A., S. Loomis, P. Jahnige, M. Burnham, K. Onthank, R. Alarcon, W. Palacios Cuenca, C. Ceron Martinez, D. Neill, M. Balick, B. Bennett, and R. Mendelson. 1994. Valuing the rain forest: The economic value of nontimber forest products in Ecuador. Ambio 23(7):405–410.

INDIA. 1994. Levantamento Socio-Economico e Fundiario da area extrativista do Estado de Rondônia: Rio Jaci-Paraná. Instituto de Pesquisa em Defesa da Identidade Amazonica: Porto Velho.

Kahn, F. and J. de Granville .1992. *Palms in Forest Ecosystems of Amazonia.* Springer-Verlag: New York.

Pereira, A., H. Dos Santos Mota, R. Silva Martins, S. Carvajal Feitosa. 1995. Diagnóstico da Área Proposta á Criação da Reserva Extrativista do Rio Jaci-Paraná. Governo do Estado de Rondônia, Instituto de Terras e Colonização de Rondônia. Porto Velho.

Peters, C., A. Gentry, and R. Mendelsohn. 1989. Valuation of an Amazonian rainforest. Nature 339: 655–656.

## Congratulations!

Anita and Renée won first place in the student poster competition at the conference "Building Bridges with Traditional Knowledge" at the University of Florida in Gainesville. Held from 11 to 16 February 1997, the conference was attended by prominent ethnobotanists from around the world, as well as representatives from indigenous communities and industry. A panel of participants judged the poster competition and chose the poster based on the research presented in this article as number one.

# Effect of Substrate on Germination Success for Two Common Trees Found in a Hawaiian Wildlife Refuge

**H. Casey Cordes**
**Candidate for Master's of Forest Science**

## Introduction

The Hawaiian islands have evolved some of the most unique flora and fauna in the world (Wilson 1992). More than 95% of all native birds and insects are endemic. Unfortunately, these same species are also some of the most threatened in the U.S., with only one in ten bird species existing at healthy population levels. Habitat destruction, including competition from introduced species, is a primary threat (Tangley 1988). Without adequate habitat, protecting these species and reestablishing sustainable populations become problematic. A focus of conservation efforts then must be habitat restoration.

For over 100 years, ranching activities occupied large parts of the Hakalau Forest National Wildlife Refuge (US Fish and Wildlife Service 1995), with significant changes to native communities, particularly the koa-'ohi'a (*Acacia koa* and *Metrosideros polymorpha*) forest. Forests were cleared, and new species were introduced for pasturage. With the refuge's establishment, the cattle have been removed, but the legacy of the large, open pastures containing introduced species remains.

Koa-'ohi'a forest provides the most promising habitat for endangered forest birds. Because of disease, competition from naturalized species, and habitat destruction, populations of endemic forest birds in other areas and forest types have been reduced (Scott *et al.* 1986); the refuge has the highest densities of three endangered species, including the 'Akiapola'au (*Hemignathus monroi*), the Hawaiian creeper (*Oreomystis mana*), and the akepa (*Loxops coccineus coccineus*).

As a result of its elevation, upper portions of the refuge are largely free of the mosquitoes that carry avian pox and malaria; however, these are the same areas most affected by ranching. Abandoned pastures are poor habitat for both the seeds and seedlings of many native trees upon which the birds depend. Restoring trees of forage value to these pastures is a high priority. Before this step can be taken, however, refuge managers must know more about the basic biology of these trees. Thus, a study was initiated to identify seed bed preferences for four common species. This article presents the results for two of the species used: 'ohi'a (*Metrosideros polymorpha*) and mamane (*Sophora chrysophylla*).

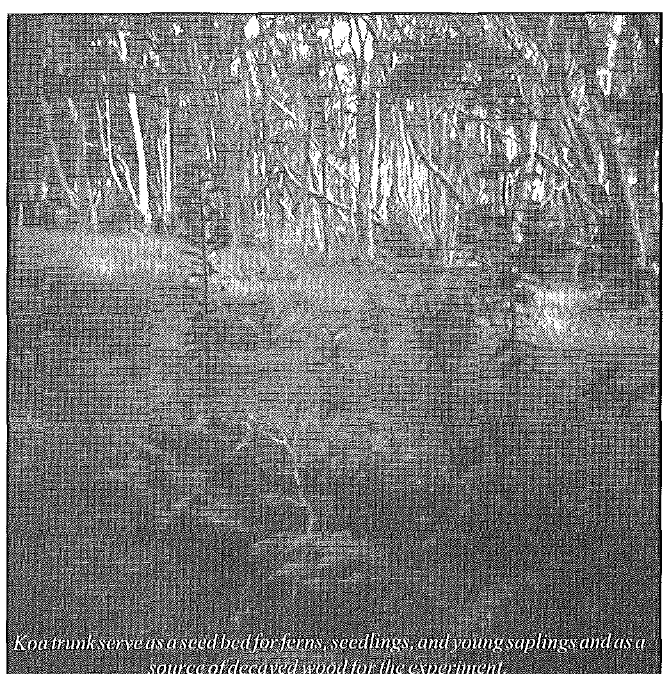
## The Study Site

The Hakalau Forest National Wildlife Refuge lies approximately 20 km inland on the windward, northeast coast of the island of Hawaii. The refuge lies between 760 and 2,000 m on the eastern slope of Mauna Kea — a dormant shield volcano that rises to 4,205 m (US Fish and Wildlife Service 1995). The refuge partially protects the state's largest mesic, upper montane, koa-'ohi'a forest (*A. koa* and *M. polymorpha*). While much of the refuge's approximately 13,000 ha is closed canopy forest, over 2,000 ha are abandoned cattle pasture (US Fish and Wildlife Service 1995).

Because the upper boundary of the refuge corresponds to a climatic transition zone, an ecotone persists, and at one time, a dry koa-mamane (*A. koa-S. chrysophylla*) woodland merged with the koa-'ohi'a forest in this area. The former is a seasonal, subalpine community, receiving between 1,500 and 2,000 mm of rainfall per year, the koa-mamane community is no longer present in the refuge (US Fish and Wildlife Service 1995).

As a result of ranching, a third community is now present in the upper portions of the refuge. Open pastures contain introduced grasses, vines, and shrubs. Together, these species have completely or partially displaced native vegetation, and have created large openings between remnant patches of koa-'ohi'a forest. Introduced grasses include kikuyu (*Pennisetum clandestinum*), sweet vernal grass (*Anthoxanthum odoratum*), meadow ricegrass (*Ehrharta stipoides*), and velvet grass (*Holcus lanatusa*). Thickets of gorse (*Ulex europaeus*) and patches of banana poka (*Passiflora molissima*) also occupy portions of some pastures (US Fish and Wildlife Service 1995).

While some large, relic trees are scattered throughout the upper pastures, for some reason tree regeneration has been suppressed (US Fish and Wildlife Service 1995). Scowcroft (1992) investigated natural regeneration at the refuge. His findings showed that while mineral soil accounted for most of the potential seed bed substrate in former pastures, most regeneration occurs on organic substrates. In contrast to the mineral soil, decaying logs, which accounted for less than 2% of the potential seed bed area, supported 70% of natural regeneration.



*Koa trunks serve as a seed bed for ferns, seedlings, and young saplings and as a source of decayed wood for the experiment.*

## Table 1. Germination Success for 'Ohi'a and Mamane by Substrate and Sowing Depth[1]

[1] *Numbers are in mean germinants per tray (=n) per treatment (±one standard deviation) where n=8, except DW where n=7. Twelve seeds for each species were sown in both shallow and deep positions.* [2] *Substrate abbreviations are as follows: DW = decayed wood, TF = tree fern trunk, KL = whole koa log, FS = forest soil, PS = pasture soil, and SS = subsurface soil.*

| Species | Planting Depth | Substrate[2] DW | TF | KL | FS | PS | SS |
|---|---|---|---|---|---|---|---|
| 'Ohi'a | Surface | 4.00 | 4.75 | 1.89 | 3.25 | 3.00 | 1.88 |
| | | 3.16 | 1.75 | 1.81 | 2.44 | 3.12 | 1.55 |
| | 5 mm Deep | 1.43 | 1.25 | 0.38 | 0.50 | 0.63 | 0.38 |
| | | 1.40 | 1.28 | 0.52 | 0.54 | 0.92 | 0.74 |
| Mamane | Surface | 4.57 | 5.13 | 2.16 | 9.00 | 9.38 | 7.88 |
| | | 1.13 | 1.89 | 1.36 | 1.60 | 1.19 | 1.46 |
| | 5 mm Deep | 0.57 | 2.38 | 0.75 | 8.75 | 8.50 | 6.13 |
| | | 1.13 | 1.92 | 1.75 | 2.12 | 1.93 | 3.83 |

## Table 2. Mean Differences Between Surface and Deep Sowing by Substrate and Statistical Significance for Mamane and 'Ohi'a Seeds

[1] *See Table 1 for abbreviation codes.* [2] *Mean = Average mean difference between surface and deep germinants (surface - deep).* [3] *DF = degrees of freedom.* [4] *T-value for individually paired t-tests.*

| | Mamane | | | | 'Ohi 'a | | | |
|---|---|---|---|---|---|---|---|---|
| Substrate[1] | Mean[2] | DF[3] | t-Value[4] | P-Value | Mean | DF | t-Value | P-Value |
| DW | 4.000 | 6 | 5.527 | .0015 | 2.571 | 6 | 1.941 | .1003 |
| FS | .250 | 7 | .218 | .8335 | 2.750 | 7 | 3.120 | .0168 |
| TF | 2.750 | 7 | 3.924 | .0057 | 3.500 | 7 | 4.041 | .0049 |
| KL | 1.375 | 7 | 4.245 | .0038 | 1.500 | 7 | 2.121 | .0716 |
| PS | .875 | 7 | 1.178 | .2771 | 2.375 | 7 | 2.297 | .0552 |
| SS | 1.750 | 7 | 1.340 | .2221 | 1.500 | 7 | 2.121 | .0716 |

## Materials and Methods

The effect of substrate on germination and seedling establishment was studied in a greenhouse setting. An open-ended greenhouse at the refuge (1,980 m elevation) was used for the study. The study employed a randomized block design with four replicates for each treatment. The justification for the design was based upon preliminary research and restoration efforts conducted to date: none of the species tested have survived well when planted in high elevation pastures, and each is a component of critical habitat for one or more endangered birds (US Fish and Wildlife Service 1995).

Six substrates were tested including surface soil from a pasture, subsurface soil from the same pasture location, surface soil from a nearby forest remnant, decayed wood (*A. koa*) from a pasture area, whole logs (*A. koa*) from the same location, and tree fern trunks (*Cibotium* spp.) from a nearby forest. Soil and decayed wood was sieved through a 0.9-cm sieve, and placed into shallow trays to a depth of 5 cm. Blocks of wood and tree fern trunks were split to size and then laid in the shallow trays.

The experiment was also designed so that the effect of a biotic inhibitor to germinating seeds, if present, might be apparent. Two sterilization regimes on the substrates were employed: none and gamma radiation. Half the substrate material was irradiated using a radioactive source at the University of Hawaii at Manoa. Significant differences in germination rates between sterilized and unsterilized substrates might indicate one or more biotic factors, such as pathogens, nematodes, and invertebrate grazers although the experiment is not designed to identify a specific functional group (fungus or nematodes).

Seeds were collected from nearby sources within the refuge or from the road leading to the refuge. Seed preparation was minimal. Mamane seeds were removed from their pods and nicked just prior to planting. 'Ohi'a seeds were removed from their capsules at the time of collection. Specific seeds were selected on the basis of their apparent fertility according to Drake (1993), when examined under a microscope. Within each tray, 24 seeds of each species were sown in a eight-by-twelve grid using 3 x 4 cm spacing. Half of the seeds were sown at the surface and the other at 5 mm below the surface.

During the experiment, the natural variability in microclimate was limited with each seed bed provided approximately the same lighting, moisture, and temperature. A bench in the greenhouse served as the random block with tray assignment to a specific position determined randomly. Trays were kept under a tent constructed of 62% shade cloth and watered 2–3 times daily. Weeding of trays and counts of the emerging seedlings were made at intervals. Germination was defined as raised cotyledons (embryonic leaves) above the substrate and appearance of the radicle, or root. After four weeks and no germination, 'ohi'a seeds were recollected and the trays resown. Results were analyzed using paired t-tests and one-way analysis of variance.

## Results and Discussion

General findings of the experiment showed both expected and mixed results. The larger, heavier mamane seed maintained a higher level of germination success across all substrates except for decayed wood than the light, wind-dispersed 'ohi'a seeds (Table 1). Mamane germination was significantly greater in the three soil substrates compared to ‘ohi‘a (p-values < .0001) whereas mean germination differences between the two species in the other substrates were not significant. Both mamane and ‘ohi‘a showed a preference for surface sowing (t-values 4.62 and 6.35, respectively, p-values < .0001) while germination rates in sterilized and unsterilized substrates were not significantly different. Furthermore, while mamane showed a strong preference for soils over organic substrates, ‘ohi‘a exhibited a weaker preference for some of the organic materials.

Mamane showed a strong seed bed preference for pasture soil and forest soil, and to a lesser extent subsurface soil. Total mamane germination was significantly different in these three soil substrates when each was compared individually to mamane's germination success in decayed wood, koa logs, and tree fern trunks (p-values < .0001 for all combinations). In these preferred substrates sowing depth was not a significant factor; however, it was significant in the organic substrates (Table 2).

‘Ohi‘a seed showed the greatest germination success on tree fern trunks and decayed wood. Total ‘ohi‘a germination was significantly higher in these substrates when compared independently to ‘ohi‘a germination on whole koa logs and subsurface soil (p-values < .0049 for tree fern trunks versus koa logs *or* subsurface soil, and p-values < .0192 for decayed wood versus the same). Total ‘ohi‘a germination on these preferred substrates was not significantly different from the germination on pasture and forest soils, however. ‘Ohi‘a preferences for sowing depth were less conclusive: without pattern, they were significant for some substrates (forest soil and tree fern trunks) and borderline for others (Table 2). These results may be less definitive as a result of ‘ohi‘a's low germination across many of the substrates, and limited replicants in the experimental design.

Although ‘ohi‘a showed a preference for organic substrates, whole koa logs were paradoxically one of the least favored seed beds for ‘ohi‘a as well as for mamane (Table 1). While undecayed koa logs may not be the most preferred substrate for germinating ‘ohi‘a seeds, the experiment may not have satisfactorily duplicated natural precipitation and the wetting and soaking patterns experienced by this material. Koa logs experienced noticeable drying throughout the experiment. Conversely, some trays of subsurface soil became waterlogged by the watering regime. These conditions may have contributed to depressed germination for these two substrates for ‘ohi‘a.

Although the sterilization treatment did not show significant differences, other biotic inhibitors, such as large vertebrate herbivores or competition from introduced grasses, cannot be ruled out and may still be impeding tree regeneration under natural conditions. By creating an inhospitable environment for the seeds and seedlings of native tree species, these biotic factors may be selectively culling young seedlings in natural environments. This phenomenon may help explain the disproportionate amount of ‘ohi‘a regeneration observed by Scowcroft (1992) on organic surfaces.

The results of the greenhouse experiment justify further research using the same or additional species whose germination requirements and substrate preferences are unknown, but whose value to bird life is well documented. The experiment could be repeated to include different watering regimes or methods to determine if koa logs may serve as a more suitable substrate under different conditions. The greenhouse experiment might also be adapted *in situ* using existing pig exclosures and a variety of substrates found naturally in the refuge.

## Conclusion

The germination patterns of mamane and ‘ohi‘a may provide both management challenges and opportunities in on-going restoration efforts to develop seedlings for outplanting in the refuge and to encourage natural regeneration processes. Mamane may have an immediate role as an alternate species to the *A. koa* seedlings currently planted in abandoned cattle pastures. Given their presence at higher elevations, these trees may prove more frost tolerant than koa in some of the higher portions of the refuge; however, more post-planting care may be required to overcome possible competition in the pastures. Until refuge personnel can successfully germinate and outplant ‘ohi‘a seedlings on a large scale, naturally occurring organic seed beds should be protected and perhaps seeded to enhance ‘ohi‘a regeneration. In any case, the importance of seed bed preferences should not be overlooked in restoration at the refuge.

## Acknowledgments

This research was made possible by grants from the Tropical Resources Institute and the Edna Bailey Sussman Foundation. I would like to thank Drs. Graeme Berlyn and Florencia Montagnini and my collaborator, Paul Scowcroft of U.S. Forest Service Institute of Pacific Islands Forestry for their guidance as well as the following U.S. Forest Service and Fish and Wildlife personnel: Donovan Goo, Alan Urakami, Baron Horiuchi, and Dr. Richard Wass, without whose assistance and support this work would not have been possible.

## Literature Cited

Drake, D. 1993. Germination requirements of *Metrosideros polymorpha*, the dominant tree of Hawaiian lava flows and rainforests. Biotropica 25(4):461–467.

Scott, J., S. Mountainspring, F. Ramsey, and C. Kepler. 1986. Forest bird communities of the Hawaiian Islands: Their dynamics, ecology, and conservation. *Studies in Avian Biology No. 9*, Cooper Ornithological Society. Allen Press: Lawrence, KS.

Scowcroft, P. 1992. Role of decaying logs and other organic seedbeds in natural regeneration of Hawaiian forest species on abandoned montane pasture. USDA Forest Service: Pacific Southwest Research Station General Technical Report PSW-129.

Tangley, L. 1988. Fighting deforestation at home. Bioscience 38(4):220–224.

U.S. Fish and Wildlife Service. 1995. *Reforestation Management Plan: Hakalau National Wildlife Refuge*. U.S. Department of Interior, Fish and Wildlife Service: Hilo, Hawaii.

Wilson, E.O. 1992. *The Diversity of Life*. Norton: New York.

# Survival Rate of Planted *Myrciaria dubia* Seedlings, Peruvian Amazon

**Vicki Hornbostel**
**Candidate for Master's of Environmental Studies**

## Introduction

In the Department of Loreto, Peru, near the jungle city of Iquitos, many of the local people or riberenos (mix of detribalized natives, mestizos, and Europeans) live in villages along the Amazon and its tributaries, surviving by subsistence farming and fishing (Padoch and de Jong 1990, Parker 1985). Their main dietary staples are manioc, plaintains, and fish (Hiraoka 1995). Many grow crops in the floodplains of the Amazon and its tributaries. These floodplains contain rich soil deposited by seasonal floods. This region, typical of the Amazon, is experiencing increasing human population pressures, fluctuations in demand for agricultural products, decreasing fish populations, and increasing deforestation and conversion of forests to farmland or pasture. In response, a Peruvian company, CAMPFOR (Compania Amazónica de Producción Forestal), has begun efforts to reforest some floodplain with native trees. The company hopes to increase forest cover, production per unit, and economic development by promoting perennial crops of marketable timber and non-timber forest products, and decrease slash and burn.

One of the 70 tree species CAMPFOR uses is *Myrciaria dubia* (Myrtaceae). *M. dubia* is a shrub or small tree that grows naturally along the flooded banks of tributaries and ox-bow lakes of the Amazon River (Peters and Hammond 1990). It is adapted to periodic flooding of 4–7 months (FAO 1986, Padoch and Pinedo-Vasquez 1991). The fruit of *M. dubia*, known as camu-camu in Peru and as cacari in Brazil, is locally popular. The acid pulp is edible and is used in juice, ice cream, pastries, and a home-made liqueur (Peters and Hammond 1990). Camu-camu is one of the richest known sources of vitamin C, containing 2,000–2,994 mg of ascorbic acid per 100 g of pulp (Zapata and Dufour 1993, FAO 1986, Peters and Hammond 1990, *El Comercio* 1996). By buying fruit from farmers and selling it internationally, CAMPFOR hopes to improve the economic situation of farmers in the region.

CAMPFOR determined farm suitability for *M. dubia* based on farmer interest and land type. The informal agreement between CAMPFOR and the farmers was that CAMPFOR would provide the seedlings, plant them, and buy the fruit (in 3–5 years) in exchange for the farmers' maintaining seedlings.

This study evaluated the survival of *M. dubia* seedlings to determine whether there were significant differences in average survival based on land type, intercropping, and farm maintenance. Since *M. dubia* naturally grows in *bajeals*, the most flooded areas, it was hypothesized that seedlings would survive best in *bajeals*, compared with other land types. Additional hypotheses were that seedlings in the less maintained farms would have a lower survival rate and those in intercropped farms would have a higher survival rate because of greater time and effort invested in those areas.

*This fruiting Camu-Camu is about 10 to 15 years old.*

## Study Sites

The study surveyed all of CAMPFOR's 25 *M. dubia* farms located in five villages within 170 km of Iquitos. They are located along the banks of the Amazon and Ucayali Rivers. The climate of this region is humid tropical, with an annual rainfall of about 2,500 mm and a mean temperature of 29°C (Peters and Hammond 1990). *M. dubia* seedlings grown in greenhouses in Iquitos were planted between 30 September and 28 October 1995. When planted (on a 2 x 2 m grid) the seedlings averaged 15 to 20 cm in height. At the time of this study, the seedlings had been planted approximately nine months earlier.

There were three land types in which seedlings were planted: *bajeal*, low *restinga*, and high *restinga*. *Bajeals* are the lowest areas, flooded every year, and have the longest and highest inundation period. Low *restingas* are higher in altitude than bajeals and flood every few years, and high *restingas* rarely, if ever, flood. Some farms were intercropped with corn, tomatoes, manioc, and other annual crops; some farms were maintained by clearing weeds around the plants, and others were abandoned. Maintained farms included two types: 1) those intercropped and thus cleared of weeds primarily to assist annual crop growth; and 2) those not intercropped but maintained and cleared of weeds for the care of *M. dubia* seedlings.

## Methods

Plots ( ≤ 10% of seedlings in each form) were selected in each farm based on accessibility. To measure seedling survival in each plot, the number of seedlings present and alive out of the number of seedlings planted were counted. Some of the farms were so overgrown that they could not be evaluated. Some farms were considered two different plots because they differed in land type, intercropping, or maintenance; thus the total number of plots evaluated was 22.

For statistical analysis, a 3 (land types) x 2 (intercropped or not) x 2 (maintained or abandoned) logistic regression was performed using S+ software. This analysis fit a model using proportions (the proportion of seedlings alive out of the total number of seedlings). The model was fit using iterative reweighted least squares (McCullagh and Nelder 1983). This analysis weighed the different plots according to their different sizes. Each plot was considered one observation. This analysis fit a model of proportions and determined whioh factors (and how much) affected whether seedlings live or die.

## Results

A logistic regression of survival rate on three independent variables (land type [*bajeal*, low *restinga*, high *restinga*], intercropped or not intercropped, and maintained or not maintained) fit the seedling survival proportions to a model that was found to be significant (indicating that all factors combined significantly affect whether a seedling lives or dies [Tables 1 and 2]). The model also revealed the following: i) there was no significant difference in survival percentage among the three land types; ii) a main effect of intercropping was that seedlings planted in nonintercropped versus intercropped areas had a significantly higher survival percentage (47% survival versus 40%); iii) a main effect of farm maintenance was that seedlings planted in better maintained farms (63% survival) had a significantly higher survival percentage than nonmaintained farms (45% survival); and iv) a main effect of the interaction between land type and intercropping was that seedlings planted in intercropped high *restingas* had a significantly lower survival (34% survival) than the other interactions, particularly high *restinga*, not intercropped (73% survival). Other two-way interactions were not significant.

**Table 1. Seedling Survival**

| Land Type | Maintained | | Not Maintained | | Total |
|---|---|---|---|---|---|
| | Intercropped | Not Intercropped | Intercropped | Not intercropped | |
| *Bajeal* | 154/398 (4) 38% | 89/121 (2) | N/A | 108/244 (3) 44% | 351/763 (9) 46% |
| Low *restinga* | 120/228 (3) 53% | 49/86 (2) 57% | N/A | N/A | 169/314 (5) 54% |
| High *restinga* | 128/375 (4) 34% | 157/204 (3) 77% | N/A | 18/35 (1) 51% | 303/614 (8) 49% |
| Total | 402/1001 (11) 40% | 295/411 (7) 72% | N/A | 126/279 (4) 45% | 823/1691 (22) 49% |

*Table shows number of seedlings that survived over the total seedlings for each combination of factors. Number of plots is in parentheses. Total column is number of seedlings survived over total seedlings by land type and percentage survival; last numbers in that column are total seedlings survived and total percentage survival. Total row indicates total seedlings survived over total by the combined categories in those columns.*

**Table 2. Treatment Significance**

| Treatment | df | Deviance* | p Value |
|---|---|---|---|
| Land type | 2 | 5.62 | < .06 |
| Intercropping | 1 | 45.91 | < .001 |
| Abandoned | 1 | 36.54 | < .001 |
| Land by Intercropping | 2 | 29.38 | < .001 |

**The deviance is the difference between the null deviance and the residual deviance in the model for that effect. Thus, the higher the deviance difference, the greater the influence of that effect.*

*The Amazon River serves as backdrop to a Camu-Camu farm intercropped with tomatoes.*

## Discussion

The overall average survival (49%) was lower than CAMPFOR's estimate (Pinedo 1996). *M. dubia* is hardy and can survive at an expected 99% (Pinedo 1996) on the company's own farm. It is not surprising there was no significant difference in survival rate among the three different land types, since the seedlings had been planted only nine months before the study. Although *M. dubia* is adapted to *bajeals*, plantings fared worse than natural growth. In general, seedlings in the high *restingas* appeared to be the tallest, but also appeared to have the most pest problems. Survival rate in the next few years may end up being greatest in *bajeals*, where pests are controlled by the inundation (Burckhardt and Couturier 1988). More longer-term studies are needed to compare survival among land types.

Survival rate was significantly higher in nonintercropped farms than intercropped farms. The lower survival rate in these intercropped farms, however, is apparently because camu-camu seedlings are inadvertently cut, cleared, or smothered when farmers clear, weed, plant, and harvest their annual crops. It is extremely time-consuming to clear (with a machete) the tremendous weed growth in these farms while trying to avoid seedlings.

In maintained farms, seedling survival rate was significantly higher than in abandoned farms. These results indicate that the seedling survival rate is aided by clearing the weeds around the seedlings. The survival rate in maintained farms will likely increase in the next couple of years compared to abandoned farms, where weeds will outcompete and smother seedlings.

In terms of interactions among the variables, the interaction between land type and maintenance is significant. Thus, in all land types, those farms that were abandoned had lower survival rates. Most significant is that abandoned high *restinga* farms had low survival rates. This is surprising considering that some of the worst weeds grow in the lower land types, but may indicate effects, such as allelopathy, strangulation, or shading, by a different weed type that grows in high *restingas*.

Other variables that may affect survival include the size of seedlings and weed types. A few farmers mentioned that some seedlings might have been dead when planted or died because they were planted in the driest season.

## Conclusions and Recommendations

This study indicates no significant difference in survival among land types, but the future may show that those in the *bajeals* survive better, since those conditions are closest to the natural conditions in which *M. dubia* survive. The seedlings in nonintercropped (versus intercropped) sites and maintained (versus abandoned) sites survived better. Some recommendations to improve the project include the following:

- Assist farmers with maintenance of the reforested parts or choose farmers that are able to maintain the areas.
- Communicate better with farmers. They need to be better educated about the growth and maintenance of *M. dubia* and the future benefits its fruits will incur.
- Plant in a wetter part of the season.
- Control weeds.
- Place sturdy stakes to mark all seedlings to assist in seedling location when clearing weeds.
- CAMPFOR representatives should follow-up with the farmers after planting.
- Larger seedlings should be planted to better withstand environmental conditions.

This is one of the first projects involving *M. dubia* in local farms. With the recommendations above and further monitoring and research, *M. dubia* survival rate and growth can be improved.

## Acknowledgments

I would like to thank the Yale School of Forestry and Environmental Studies Tropical Resources Institute for funding; everyone at CAMPFOR for their assistance and support; my assistant Carlos Veintemilla; all of the farmers from the various villages who assisted us; Mario Pinedo Pandero, Miguel Vasquez, Kristiina Vogt, Os Schmitz, Mark Ashton, and Chuck Peters for their input on my project proposal; and Kristi Lemm, Jonathan Reuning-Scherer, and Mark Ducey for their assistance in statistical analysis.

## References Cited

Agresti, A. 1990. *Categorical Data Analysis*. Wiley & Sons: New York.

Burckhardt, D. and G. Couturier. 1988. Biology and taxonomy of *Tuthillia cognata* (Homoptera: Psylloidea), a pest on *Myrciaria dubia* (Myrtaceae). Annals Soc. French (N.S.) 24:257–261.

"El Camu-Camu Puede Convertirse en el Nuevo 'Boom' de la Selva," *El Comercio*, 9 August 1996. Lima, Peru.

Hiraoka, M. 1995. Aquatic and land fauna management among the floodplain riberenos of the Peruvian Amazon. In *The Fragile Tropics of Latin America*. United Nations University Press: Tokyo.

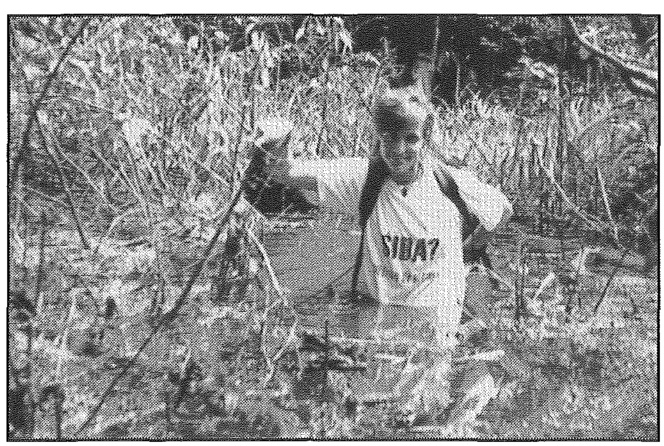
McCullagh, P. and J. Nelder. 1983. *General Linear Models*. Chapman and Hall: London.

Padoch, C. and W. de Jong. 1995. Subsistence- and market-oriented agroforestry in the Peruvian Amazon. In *The Fragile Tropics of Latin America*. United Nations University Press: Tokyo.

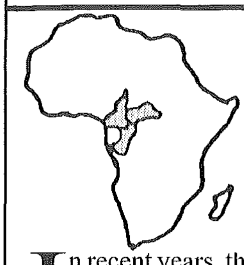
Pinedo, M. July 1996. Agronomist at CAMPFOR. Personal communication.

Peters, C. and E. Hammond. 1990. Fruits from the flooded forests of Peruvian Amazonia: Yield estimates for natural populations of three promising species. Advances in Economic Botany 8:159–176.

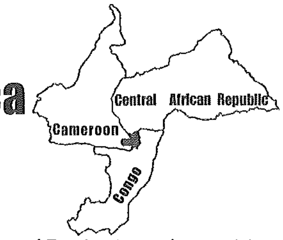
Zapata, S. and J. Dufour. 1993. Camu-Camu *Myrciaria dubia* McVaugh: Chemical composition of fruit. Journal of Food and Agriculture 61:349–351.




*The author wades to the next farm.*



# YFES Teams up with the Anthropology Department on Natural Resource Use in Africa



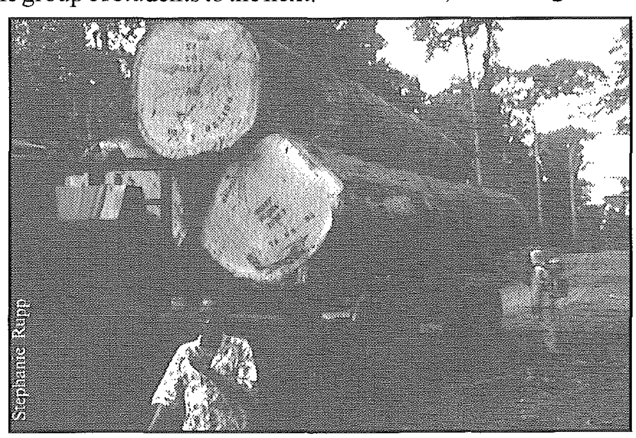

In recent years, the School and TRI have only lightly supported activities in Africa, emphasizing instead Latin America. This year, however, a number of students have been actively promoting discussion of natural resource management in Africa, which has united efforts of students of the Anthropology Department, Forestry School, and the Yale Council on African Studies. Students formed the African Natural Resources Group. Supported by TRI, in whose offices ANRG has taken up residence, they are assisting a transnational conference on natural resource relations in the Northwestern Congo River Basin, Sangha River Region, scheduled for next September in New Haven.

TRI has always endeavored to represent all tropical regions and in this issue of *TRI News* we offer a special report on some of these African activities. In the next few pages each of the three principal organizers of this conference, who wrote the following articles, talk about the events and their research. Coincidentally, perhaps, Dr. Eric Worby who conducted his PhD research on livestock management in Botswana, has just been appointed associate professor in the Anthropology Department. He, along with YFES professor, Stephen Kellert, are co-advising the conference described on the next page. — Editors.

## African Natural Resources Group


**Heather Eves**
**Candidate for Doctorate of Forestry and Environmental Studies**


The African Natural Resources Group (ANRG) of the Yale School of Forestry and Environmental Studies was formed in September 1996 by students, faculty and staff interested in natural resource issues in Africa. Many YFES students have worked in Africa over the past years; however, they have generally arranged their studies or research independently and without much continuity from one group of students to the next. The purpose of ANRG was to facilitate our future research and study programs there and to help make the resources of YFES more useful for work in African natural resources. ANRG is primarily composed of YFES masters students and a few YFES doctoral students, but also includes students from the Anthropology Department and the Council of African Studies; some FES faculty and staff have also participated.



*A truck loaded with logs in Lobéké Forest, Cameroon.*

During the fall semester, surveys of the YFES faculty and students were conducted. The energetic faculty response (over 50% responded) was largely supportive of our efforts. The faculty made numerous suggestions of potential resources, particularly former students who have worked in Africa; we are now establishing a database with the suggestions. From the student survey and other input, it is clear that understanding of African natural resource issues is an important part of the education of many YFES students; it appears that as many as 10% of YFES students are considering pursuing careers in Africa.

Three Master's students have proposed the following studies in Africa and Madagascar for the coming summer:

Institutional dynamics of bushmeat use around Kyabobo Range National Park, Ghana, West Africa;

Collaborative management in Tanzania: Resource use patterns in a changing pastoral economy in Maasailand; and

Lemur ecology and its implications for their management and conservation: The Milne-Edward's sifaka (*Propithecus diadema edwardsi*) in Madagascar.

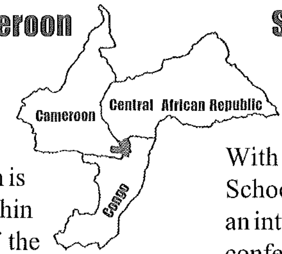
Current doctoral research in Africa includes the following: the lowland gorilla in the Central African Republic (completed successfully during the past year), communities and wildlife management outside protected areas in northern Congo, the economics of national park management in Botswana and Zimbabwe, and the silviculture of African mahogany in Cameroon.

ANRG has been involved in assisting the International Society of Tropical Foresters develop a lecture series on social forestry when several speakers with African backgrounds spoke at Yale.

A conference focusing on conservation and development in Central Africa is being planned by doctoral students from Anthropology and YFES. This conference will be held at Yale in September 1997 (see next page).

It is our hope that ANRG will continue to become an active group at YFES, acquire funding to support African natural resource research and education, and help develop links with other institutions to provide research and educational opportunities for students in and from Africa.

## Natural Resource Management of the Lobéké Forest, Southeastern Cameroon




**Stephanie Rupp**
**Candidate for Doctorate in Anthropology**

The Lobéké forest of southeastern Cameroon is a pocket of semi-deciduous, tropical forest within a much larger block on the western rim of the Congo River basin. This region of central Africa boasts great ecological and cultural diversity. Myriad ethnic communities of Bantu and Oubangian origins, including communities of peasant farmers, fisher-people, and hunter-gatherers, have created intricate social networks within the complex ecological system. Invading and migrating African communities have swept into northern reaches of the forest, bringing with them Islam, trade, and enslavement. A century ago, colonial entourages from Germany and France descended into the forest and imposed colonial authority, while competing viciously for access to resources such as rubber, ivory, skins, and timber.

Now western companies have set up bases to take advantage of tropical hardwoods as well as promote safari game hunting. Enterprising Cameroonian politicians, hunters, and merchants have also joined the rush. Additionally, European and American development and conservation agencies have moved into southeastern Cameroon to mitigate social and ecological perturbations. The forest and its resources (human, faunal, and floral) have been interpreted, mapped, and managed using many tactics by an array of interest groups marching through the Lobéké forest over the past century. Through my research I will examine the environmental, cultural, and social change in the Lobéké forest through one small community, the Bangando.


*Bangando woman plants maize in forest.*

My research in the Lobéké forest focuses on the cultural ecology and patterns of resource utilization of the Bangando, a community of peasants who practice swidden agriculture as well as gathering, fishing, and hunting. Through participant observation, oral histories and interviews, and archival work, I am exploring questions of Bangando uses of forest resources, land tenure, cultivation techniques, and the interaction between culture and ecology. I am examining the hypothesis that Bangando women's perspectives on the management of natural resources are critical for understanding the relationship between culture and environment. Women provide the backbone of subsistence production and social reproduction and thus shape the human-forest relations that characterize the Lobéké region. I am also interested in the multiple external agents that have historically pressured the resource base. Thus I am exploring the wider political ecology of the forest, looking at the impacts of timber companies, safari-hunting outfits, development and conservation agencies, and non-local bushmeat hunters on the ecological and social systems of the forest. These institutions comprise some of the external, post-colonial interest-groups that compete with the Bangando for access to and control over the forest resources, and have developed out of the historical rivalries over resources initiated in the late 19th century.

## Transnational Natural Resource Use Relations: Sangha River Region, NW Congo River Basin

### CONFERENCE

With the support of the Department of Anthropology and the School of Forestry and Environmental Studies, Yale is hosting an interdisciplinary conference on 25–28 September 1997. This conference will bring together African, American, and European scholars and conservation professionals specializing in the densely forested Sangha River region of the northwestern rim of the Congo River basin. This trinational region is located along the borders of Cameroon, the Central African Republic, and Congo and is experiencing rapidly increasing exploitation of its natural resources. Through a series of questions concerning present conditions, conference participants will address the region's ecological and social context and will explore the relevance of the region as a unit of analysis and action. These issues are especially pertinent given the contemporary political upheaval and flux in equatorial Africa. The goals of this conference are both academic and applied, and represent a unique opportunity for scholars and conservation professionals, from varied national and disciplinary backgrounds, to share research results and perspectives, and to initiate relationships of collaboration and constructive criticism.

Goals:

1. To present results of ongoing research and to identify gaps in existing knowledge. Participants will assess the relevance of research results and practices to the region's resource management and economic development strategies.

2. To identify and analyze current conservation actors: their historical roots, contemporary organizational structures, methods, results, and future plans. Participants will address the ways that these conservation agencies reflect and shape knowledge (biological, social scientific, and indigenous).

3. To plan a more comprehensive conference to be held in a central African setting in 1998, drawing representatives of industry and government into this emerging network of scholars and professionals for critical reflection, reaction to policy, and contribution to an ever-increasing knowledge base about the western Congo River basin.

Conference proceedings will be available. Also a web page will be set up. Keep an eye on www.yale.edu/tri for a link.

FOR FURTHER INFORMATION, please contact Donna Perry, conference coordinator:

Yale University, Department of Anthropology
51 Hillhouse Avenue, New Haven, CT 06511
email: donna.perry@yale.edu
tel: (203) 432-3700 (to leave a message)
fax: (203) 432-3669

Outside YFES

# Translating the Forest: Tourism and Social Change

**Rebecca Hardin**
**Candidate for Doctorate of Philosophy**
**Yale Department of Anthropology**


I examine a unique form of nature and cultural tourism in the Dzanga Sangha Dense Forest Reserve, an experiment in integrated conservation and development for southwestern Central African Republic (CAR). Established in 1988 by an accord between the CAR and World Wildlife Fund (WWF), USA, the project promotes tourism as a non-extractive alternative to commercial hunting, logging, and mining within the region's dense moist forest. The CAR government Ministry of Water, Forests, Game, Fish, Tourism, and Environment (MEFCPTE) manages the area in conjunction with WWF, enjoining long-term residents of the region to limit their hunting, fishing, and gathering to designated techniques and areas. This combination of limited subsistence activities with recent wage labor and commerce from timber, diamond, and safari hunting in the region has substantially altered local political, economic, and property patterns. Residents have been faced over the last several decades with an influx of state officials, immigrant labor from other regions, and foreign managers. The arrival over the past five years of curious tourists seeking gorillas, elephants, and pygmies represents a striking departure from said employment options. I document how both residents of and visitors to the reserve understand and shape tourist activities and the actual impact of such activities and income on social relations.

Tourism in Dzanga Sangha is qualitatively different from most "nature tourism" in Africa (Whelan 1992, Boo 1991). It entails movement on foot through thick forest with extremely high population densities of elephant, buffalo, forest hog, and gorilla (Carroll 1986, 1993) or in dugout canoes on the Sangha River with moderate densities of hippo and crocodile. Visitors thus depend heavily for their safety and enjoyment upon the communication and tracking skills of local people working as individuals or in pairs. Ninety percent of official visitation revenues remain within the reserve, as opposed to many African destinations where revenues are directed almost entirely back to national coffers. Fifty percent of official visitation fees (approximately $15 per visitor) are used for reserve maintenance and administration. Ten percent is paid to the MEFCPTE. The remaining 40% is channeled through a local committee and distributed through consensus by locally selected delegates to residents proposing entrepreneurial or community projects. Tourism money also circulates through individual contacts with visitors for tips and wages, or through gifts and theft.

These allocations, and local opinions about them, reflect ways in which long-standing relations of exchange among certain families of "BaAka" ("pygmies" living on the outskirts of town and in the forest) and "Sangha Sangha" ("villagers" living largely along the river in distinct neighborhoods) are persisting, breaking down, or changing with regard to more recent immigrants to the region. Oral historical accounts and interviews with these resident groups trace historical relationships to one another, to non-African expatriates engaged in exploitation of the region's resources (French, Yugoslavian, German, American, and Portuguese), and to north African immigrants (Mauritanians, Chadians, and others) attracted by "boom" and "bust" cycles of a sawmill in the region since 1971. Such narratives emphasize the roles of newcomers in inter-clan or individual conflicts since colonial incursion in the late 1800s, and reveal a complex, changing mosaic of inter-ethnic alliance and competition for tourist and other resources. As such, the study of tourism not only addresses specific management issues, but also entails multiple levels of broader social relations of power, property, and processes of change.

**References Cited**

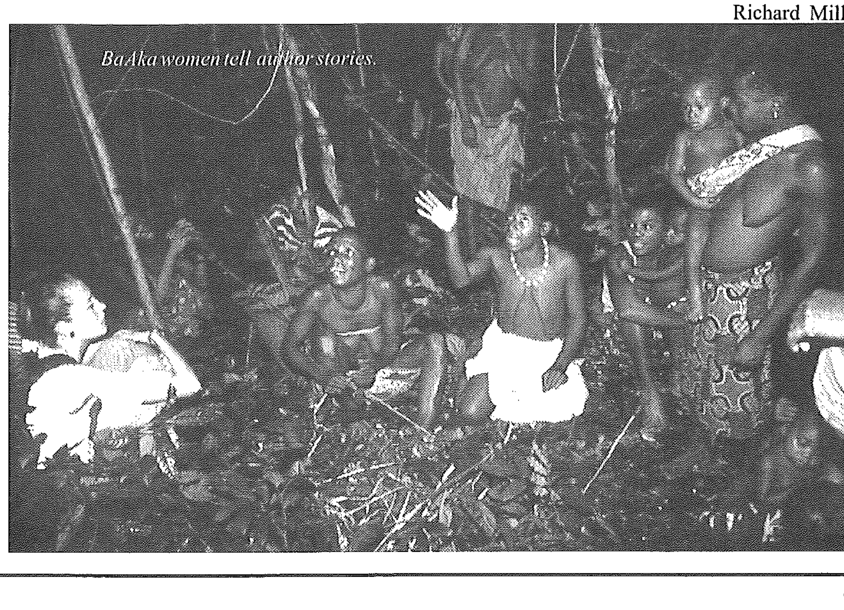
Boo, E. 1990. Ecotourism: The potentials and pitfalls. World Wildlife Fund: Washington, D.C.

Carroll, R. 1986. The creation, development, protection, and management of the Dzanga-Sangha Dense Forest Sanctuary and the Dzanga-Ndoki National Park in Southwestern Central African Republic. Master's thesis. Yale University School of Forestry and Environmental Studies: New Haven, CT.

Carroll, R. 1993. Gorilla feeding ecology (*Gorilla gorilla gorilla*) in the Dzangha Sangha Region of the Central African Republic. Doctoral thesis. Yale School of Forestry and Environmental Studies: New Haven, CT.

Whelan, T. 1991. Nature tourism and managing for the environment. Island Press: Washington D.C.

Richard Mills



*BaAka women tell author stories.*

**Outside YFES**

# Evaluating the Fight Against Malaria on Roatán, Honduras

**Wingfield Rehmus, MD**
**Candidate for Master's of Epidemiology and Public Health, Yale School of Epidemiology and Public Health**

Malaria has returned to the forefront of public health attention. Early attempts at global eradication failed (World Health Organization 1993) as the malaria problem has worsened in recent years: the number of cases has increased, the parasite has become resistant to drugs in many parts of the world, and the *Anopheles* vector has become resistant to insecticides. Given these changes, researchers have renewed their attack as they search for innovative remedies to this ancient problem.

On the island of Roatán, some 65 km north of mainland Honduras, this struggle for safer control methods has given rise to a new regional malaria control program. When the documented incidence of malaria rose from 1.6% in 1992 to 3.8% in 1994 (Pacheco 1996), the municipality of Roatán recognized that malaria threatened both the health of local residents and potential growth of the tourist industry. In response, the municipality requested and received money from *Fondo Hondureño de Preinversión* (FOHPREI), a Honduran governmental agency, for the development of a regional malaria control project. The municipality hired a private consulting firm for 18 months to aid in early implementation. The project aims to lessen the social and economic burden of the disease by controlling the mosquito population, rapidly diagnosing and treating illness, and educating residents. The vector control component is utilizing *Bacillus thuringiensis* var. *israelensis* (*B.t.i.*) as a mosquito larvicide. In order to improve diagnostic and treatment capabilities, an existing network of community volunteers is being strengthened and expanded. Finally, the educational component utilizes secondary school teachers to reach a large portion of the population.

During the summer of 1996, I assisted in the implementation of this malaria control program. Now for my Master's thesis, I am performing an evaluation of it. The evaluation will include both quantitative and qualitative analyses of the program's components. The results will help the project meet the specific needs of the island. The information will be particularly valuable when the private consulting firm relinquishes control of the project to the local municipality in August 1997.

The evaluation must consider Roatán's unique characteristics. Features such as the island's fringing reef, topography, bilingual and multi-cultural population, and its close ties to mainland Honduras will have an impact on the success of the program. For example, a significant portion of the project effort has been on vector control. Because of potential damage to the reef, traditional methods of vector control, such as insecticide spraying, are not feasible on the island. The project thus turned to a mosquito larvicide that has no known environmental impacts. Thus, the choice of *B.t.i.* was sound from an environmental standpoint and has been shown from mosquito traps to be successful at killing larvae. However, the topography of the island may make the long-term use of *B.t.i.* unfeasible. To be effective, *B.t.i.* must be applied biweekly to all standing water (Kroeger *et al.* 1995). Because of the steep slopes and thick vegetation, many areas of the island are difficult to reach and this application frequency is nearly impossible. Although *B.t.i.* is environmentally safe and effective, due to the island's unique characteristics, it may not be a sustainable option.

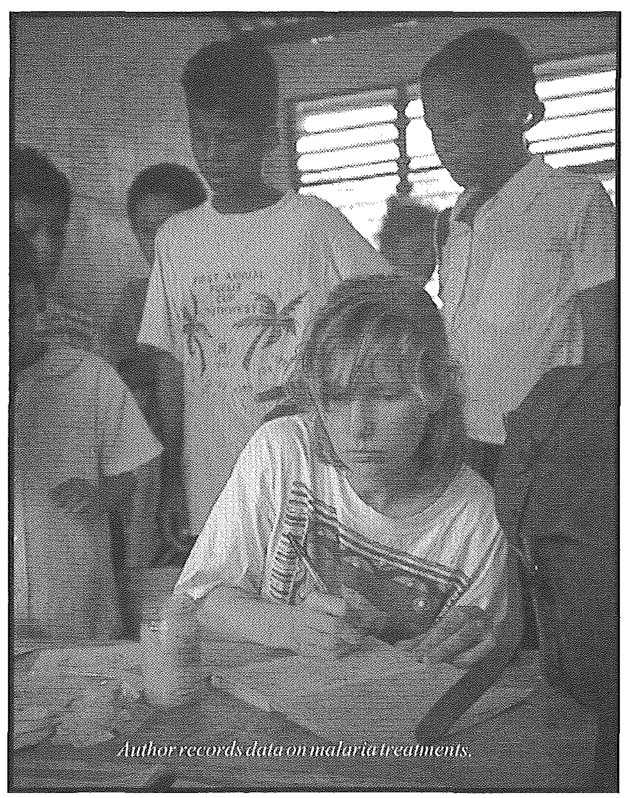
Evaluation that takes into consideration the unique characteristics of the island can be applied to the other major arms of the project as well. Additional quantitative variables include length of time to diagnosis, distribution of cases and of volunteer collaborators, and incidence rates. Qualitative analysis will take into consideration factors such as effort and ability to reach the target population. As the transition to local government control approaches, it is important for all involved parties to evaluate the early stages of the project and to use this evaluation to improve the project through the transition.

## References Cited

World Health Organization. 1993. A Global Strategy for Malaria Control. Geneva, Switzerland.

Pacheco, M. July 1996. Personal communication. Ministerio de Salud. Hospital Roatán: Roatán, Honduras.

Kroeger, A., O. Horstick, C. Riedl, A. Kaiser, and N. Becker. 1995. The potential for malaria control with biological larvicide *Bacillus thuringiensis israelensis* (*B.t.i.*) in Peru and Ecuador. Acta Tropica 60:47–57.



Scott Rehmus

*Author records data on malaria treatments.*

# Economics in the Tropics: Profile of Professor Robert Mendelsohn

Edwin Weyerhaeuser Davis Professor of Forest Policy

In response to sustained student and faculty interest in tropical forestry, Robert Mendelsohn has been involved in a number of collaborative projects involving land use and forestry in tropical ecosystems. The unique ecosystem characteristics of tropical forests combined with their special cultural history make tropical forests an intriguing and important area of research. Mendelsohn has explored several key issues in the tropics with students and colleagues including the value of non-timber forest products (NTFPs), the importance of property rights to forestry, the potential of ecotourism, and improving swidden agriculture.

*Charles Peters, now an ecologist at the New York Botanical Gardens, first raised the issue of valuing NTFPs while still a doctoral student at YFES. Anthropologists have long observed that rural people in these forests collect many products from the forest. Because most of these products are bought and sold locally, they were ignored by central governments who focused primarily on export products. Peters wanted to value NTFPs in a carefully measured plot in the Peruvian Amazon in order to demonstrate that these products actually had great economic value. Working with Mendelsohn, Peters's analysis carefully integrated the biology of the forest with the economics of the NTFP market and demonstrated that NTFPs were indeed economically valuable. In fact, income from collecting NTFPs exceeds income that one could have earned using more destructive land uses such as agriculture and grazing. This research has since been extended to Belize, Mexico, Nepal, Ecuador, and Brazil by Michael Balick of the New York Botanical Garden (also a visiting professor at YFES) and many students from YFES and the undergraduate Yale College. The results demonstrate that NTFPs are in fact an important reason to conserve large tracts of tropical forests.

*In a recent set of studies, Balick and Mendelsohn found that the conservation value of NTFPs lies primarily in products currently being used by local people and not in potential new drugs for the pharmaceutical industry as is often stated in the press. Although hidden drugs in tropical plants are of great value to society, they are so expensive to find that their value as an untapped resource is limited. Golden needles are valuable but haystacks which contain only a few hidden needles are not.

*A second strand of research in tropical forests has tracked the rapid increase of tourism to natural sites. Ecotourism offers a new motivation for local people and governments to engage in tropical forest conservation. Through several studies of tourist behavior in Costa Rica, Madagascar, Belize, Caribbean islands, and Burundi, YFES students advised by Mendelsohn have found that ecotourism can generate substantial value for both domestic and foreign tourists. Unique sites are able to attract tourists from around the world, justifying setting aside these special sites. The research indicates that these sites could easily charge relatively high fees which would help to pay for their conservation. By sharing these revenues with local people, it would be possible to make these sites economically and ecologically sustainable.

*The absence of private property rights and the presence of political instability offers another major hurdle for forestry. Dr. Mendelsohn has demonstrated that, because forests take many decades to mature, an owner is highly vulnerable to changing political conditions and poor ownership guarantees. If new political rulers seize the forests or if insurgencies make forestry impossible, the owner can lose his entire investment. This problem reduces investment in tropical forests, leaving them relatively inaccessible and encouraging more short-sighted and unsustainable land uses instead.

*Mendelsohn's most recent research on tropical forests was done in collaboration with Florencia Montagnini, director of TRI. This research reexamined swidden agriculture where villagers burn a small forest opening and plant crops for a few years. In traditional swidden agriculture the plot is then abandoned and sometimes lightly managed for NTFPs. Montagnini's research, however, indicated that careful planting of certain native tree species could improve soil quality quickly and lead to valuable timber harvests. By combining this managed forest fallow with agriculture, the improved swidden practice would be both sustainable and economically viable. Extensions of this research to more areas look promising.

## Selected Bibliography

Balick, M. and R. Mendelsohn. 1995. The value of undiscovered pharmaceuticals in tropical forests. Economic Botany 49:223–228.

Houghton, K. and R. Mendelsohn. 1996. An economic analysis of multiple-use forestry in Nepal. Ambio 25:156–159.

A. Grimes, B. Bennett, P. Jahnige, S. Loomis, M. Burnham, K. Onthank, W. Palacios, C. Ceron, D. Neill, M. Balick, and R. Mendelsohn. 1994. The value of tropical forests: A study of nontimber forest products in the primary forest of the upper Napo Province, Ecuador. Ambio 23:405–410.

Montagnini, F. and R. Mendelsohn. 1997. Managing forest fallows: Improving the economics of swidden agriculture. Ambio 26:118–123.

## Cooperators Wanted!

TRI is always looking to add new collaborators to its database in order to increase the number of internship opportunities available to students of YFES.

Each summer approximately 15 students are awarded funding for internships based upon a faculty committee's review of proposals. To qualify for funding, student must have an in-country collaborator with whom the project will be conducted. Only research-oriented proposals are accepted. Projects that contribute to ongoing projects are highly encouraged.

Project proposals are reviewed for funding in January of each year by the committee; most students therefore establish firm contacts by December for the following summer.

The program is designed to promote research in a broad range of disciplines concerned with the social and ecological aspects of tropical ecosystems. Both articles in this journal and working papers are the products of internships.

If you are interested in having a TRI intern working in association with your project, please contact the TRI Coordinator indicating the type of opportunities which might exist with your organization or institution.

Once you have specified an appropriate project, TRI will advertise this information at YFES, so that interested students may contact you for more details.

Jim Bryan
TRI Coordinator (trinews@yale.edu)
205 Prospect Street
New Haven, CT 06511 USA
Tel (203) 432-3660; fax (203) 432-5043

## Working Paper Series

TRI interns write working papers based on their research funded by TRI. Opinions in these papers are solely those of the author. The following papers have been published over the past two years. Prices depend on size of working paper, domestic or international, and type of postal service. Please see www.yale.edu/tri/wp.htm or contact TRI at the above address.

95a. Participatory Rural Appraisal in an Andean Farming Community, Ecuador. Jon Kohl. 1997. 44 pp.

95b. Sondeo Rural Participativo en una Comunidad Campesina en los Andes Ecuatorianos. Jon Kohl. 1997. 44 pp.

94. Defining Parameters for Forestry-Related Development: Ecosystem Management in Northwestern Zimbabwe. Andrea Lee. 77 pp. 1997.

93. Assessing the Future of Non-Timber Forest Products of Guyana. Michele Dash. 31 pp. 1997.

92. Local Knowledge, Mosquitoes, and Malaria: An Ethnobotanical Investigation in the Repellents of Brazil. Robin Sears. 34 pp. 1997.

91. An Attitudinal Survey of Resident Perceptions of Conservation at Five Blues Lake National Park, Belize. Alison Ormsby. 15 pp. 1997.

90. Open Access, Hidden Meaning: Public Forests and Private Paddies in the Mekong Delta of Viet Nam. James Spencer. 38 pp. 1997.

89. Forest Protection in a Himalayan Hamlet. Andreas D. Eicher. 52 pp. 1997.

88. Patterns of Spatial Distribution and Abundance of *Desmoncus polyacanthos*, a Neo-tropical Liana, in Relation to Forest Structure. Austin Troy. 26 pp. 1996.

87. An Ecological Study of Bayleaf Palm (*Sabal morrisiana*) in the Rio Bravo Conservation and Management Area, Belize. Jennifer O'Hara. 44 pp. 1996.

86. Leaf Litter Decomposition and Mulch Preformance of Four Indigenous Timber Trees in the Atlantic Humid Lowlands of Costa Rica. Rebecca Kershnar and Florencia Montagnini. 33 pp. 1995.

85. Relationships Between Forest Management Practices, Light Conditions, and Regeneration of Native Tree Species in Misiones, Argentina. Christopher G. Woodward. 65 pp. 1995.

84. Leaf Litter Decomposition and Mulch Performance from Mixed and Monospecific Plantations of Native Tree Species in Costa Rica. Rachel Byard, Kristen C. Lewis, and Florencia Montagnini. 48 pp. 1995.

83. Impacts of Native Tree Species In Mixed and Pure Plantations, On Soil Structure at La Selva, Costa Rica. Megan McGroddy. 38 pp. 1995.

82. Relative Leaf Litter Decomposition of Four Indigenous Tree Species in Pure and Mixed Plantations in the Atlantic Humid Lowlands of Costa Rica. Jessica Ruvinsky and Florencia Montagnini. 14 pp. 1995.

81. An Economic Analysis of Sea Turtle Conservation in Cozumel, Mexico. Joanna Grand and Zoe Rappoport. 17 pp. 1995.

80. The Economic Potential of Cultivating Guatambœ, *Balfourodendron riedelianum* (Rutaceae), in the region of Misiones, Northeastern Argentina. (Optimal Harvest Age of Timber and Swidden Agriculture with Yerba Mate). Nuria Muñiz-Miret. 32 pp. 1995.

79. Leaf Harvest on the Understory Palm *Geonoma deversa* (Poiteau) Kunth in the Southeast Peruvian Amazon. Cesar Francisco Flores Negtron. 38 pp. 1996.

## Thank you!

We would like to thank the following who have provided financial support to *TRI News*: Doug Henderson (Cambodia Environmental Management Project, Phnom Penh), Lisa Kircher Lumbao (Manila, Philippines), Peter Schuyler (Wai Manalo, Hawaii, USA), D.M. Botanical Center (Des Moines, Iowa, USA), and Marlene Cole (USA). All contributions are welcomed. Checks should be made to Yale School of Forestry and Environmental Studies with *TRI News* on the memo line, at above address.

# YFES Student Group Activities

## Social Forestry Interest Group

**Anne Rademacher**
**Candidate for Master's of Environmental Studies**

Social ecology... social forestry... community development... community forestry. A quick assessment of student interests finds these phrases voiced over and over again. This past fall, a large percentage of students entering or continuing in Master's programs in the School expressed an interest in the social dimensions of the study of natural resource management and environmental studies. Some students have prior experience in natural resource management in developing countries, while others seek to hone their skills as resource professionals in a community development context. Many students, regardless of their professional aspirations, are interested in learning the theory and methodologies of social and community forestry.

Historically, the Yale School of Forestry and Environmental Studies has offered a broad array of courses and strong faculty in the study area of Social Ecology and Community Development. The strong reputation of the concentration continues to attract students interested in learning to integrate social science methods and ecosystem management.

This year, however, students found the Social Ecology and Community Development study area in a state of flux. Uncertainty about the future composition of the faculty, a limited selection of fall courses, and speculation about the possible weakening of the concentration prompted students to question the breadth and depth of the program that initially attracted them.

The Social Forestry Interest Group (SFIG) emerged as a student response to this uncertainty. SFIG organized at the end of the fall semester to discuss how we might improve the program. We spoke with students and faculty and consulted the School's long-term strategic plan in order to better understand the future direction of YFES and the concentration.

This spring, the SFIG has continued to meet and define strategies for expressing our support for the improvement of the Social Ecology and Community Development concentration. Through the cooperation and encouragement of the faculty and Dean Cohon we have been able to participate in a variety of issues affecting the future of the program. While the current focus is the future composition of the faculty, our interests and discussions have also concentrated on possible course additions, seminars, and lecture series. At issue in all these matters is the importance of maintaining and strengthening the program so that it can train capable, informed natural resource managers and professionals. SFIG's most recent event was an open forum for students (held March 24) to discuss the future of the study area. The results of that meeting were then formally presented to a group of faculty members and the dean of the School. The result will be a future plan inclusive of student input and interests.

Students from all study areas are invited to participate in future discussions through attendance at the meetings or postings on our email list. *To have your name added to the SFIG email list, contact anne.rademacher@yale.edu or write to her care of* TRI News.

## International Society of Tropical Foresters Yale University Student Chapter

The Yale University Chapter of the International Society of Tropical Foresters presented a lecture series entitled "Social Forestry: Interdisciplinary Perspectives on Community Based Management" this spring. The seminar series was organized to address a strong interest among the student body: how to use forest ecosystems without sacrificing their ecological integrity, coupled with the belief that this challenge is most meaningfully confronted at the community level. This exciting task links a variety of disciplines involved with community forestry. However, the primary challenge associated with an interdiciplinary approach lies in defining common terms such as "sustainable" and "ecosystem integrity."

There is also a need to explore the tension between respecting ecosystem integrity and achieving a desired standard of living for forest inhabitants. To what extent are these goals synergistic, and to what extent do they involve trade-offs? The challenge, therefore, involves finding ways that local communities can take advantage of, rather than be victims of, expanding national and international markets.

Finally, the social, economic, and environmental dimensions of community forestry should consider incorporating both local wisdom and scientific knowledge. With these tools, community forestry systems can be flexible and opportunistic enough to develop the sophistication and resilience necessary to survive in the context of rapidly changing conditions that characterize our time.

The lecture series was organized into five separate weekly sessions, each with its own focus. The topics were: 1) introductory session given by Dr. William Burch, 2) forest management by Gary Hartshorn and Charles Peters, 3) economics by Sarah Scheer and Christine Padoch, and 4) institutional dynamics given by Davidson Gumbo and Susan Huke. Each session featured two speakers and a YFES faculty member who led the discussion.

*Because building relationships between cooperators and Yale students and faculty is integral to the TRI Mission, the following notes, written by this year's TRI interns, provide short biographies of each individual cooperator. The cooperator profiles on the next page are intended to highlight cooperators who are currently working with Yale master's and doctoral students. In some cases, detailed information about particular projects and contacts is provided. Others provide brief sketches. In all cases, more detailed information can be supplied by the TRI offices via phone or e-mail.*

**_TRI News_ Offices**
**Yale University School of Forestry and Environmental Studies**
**205 Prospect Street**
**New Haven, CT 06511 USA**
**203-432-3660**
**trinews@yale.edu**

# Cooperator Notes

My summer research in Hawaii was done in conjunction with Paul Scowcroft, a forest researcher with the U.S. Forest Service in Honolulu, Hawaii. He can be reached at the Service's **Institute of Pacific Islands Forestry**. The Institute conducts research in and distributes grants to many Pacific island nations, particularly Trust territories. - *Casey Cordes*

The **Ecuadorian Foundation for Ecological Studies** (EcoCiencia) introduced us to the people that we worked with in Ecuador. EcoCiencia is a private non-profit institution that by means of research works for the conservation, planning, and management of protected natural areas in Ecuador. It also designs environmental education and interpretation programs to improve natural resource use in order to satisfy the needs of present and future generations in a sustainable development context. This year EcoCiencia served as a contact for one of TRI's interns who will be working with a local non-governmental organization in Pacific mangrove areas of Ecuador. EcoCiencia is also establishing cooperative arrangements with various foreign universities and institutions whereby college classes can travel to Ecuador and take a conservation course that will take students around the country learning various conservation techniques. For more information on this program contact Danilo Silva at Casilla 17-12-257, Quito, Ecuador. Tel/Fax: (593 2) 451-338, 339. eco-cia@ecocia.exc.ec - *Jon Kohl*

My research was conducted in conjunction with **Companía Amazónica de Producción Forestal** (CAMPFOR) a private Peruvian company located in Iquitos, Peru. CAMPFOR was founded a few years ago by four scientists who formerly worked for other government agencies or companies. It is involved in a number of reforestation projects in the area with various types of native tree species. They also have on-going research on one of their own 20-ha plots near Iquitos, experimenting with the flood resistance of various tree species, as well as experimenting with various improved annual crops such as corn and rice. They provide many farmers in the area with seeds for these improved crop species. Mario Pinedo from CAMFOR can be contacted in Iquitos, Peru at the following telephone/fax number: 011-51-94-23-7438. - *Vicki Hornbostel*

I spent most of my summer at the offices of **Deli Café**, a specialty coffee export company owned by Grace Mena, the first female owner of a coffee export company in Costa Rica. Grace is on the board of the Specialty Coffee Association of Costa Rica, and formerly served as the "Junta Directora" of the Instituto del Café de Costa Rica. Deli Café is a major exporter of organic coffees and is actively involved in the development of environmentally sensitive coffee product lines. - *Shauna Swantz*

My in-country coordinator was Dr. Paulo Moutinho of the **Instituto de Pesquisa Ambiental da Amazonia**. IPAM is heavily involved in research being conducted at a research station located in Paragominas, Pará, Brazil. Dr. Daniel C. Nepstad, a research associate from the Woods Hole Research Center in Massachusetts, is also a knowledgeable contact and proved to be of major assistance. Dan is involved in the management of research at the station, and is an alumnus of YFES. There is a lot going on in Paragominas, ranging from a National Science Foundation funded project on global warming to the creation of deep (10+ m) shafts in the forest floor which are used to study soil moisture, rooting depths, and the claustrophobic tendencies of interns. There are good accommodations for visiting scientists and fantastic research opportunities involving ecosystems subjected to a wide range of disturbances. For More information contact either: Dr. Paulo Moutinho, Forest Ecology Program, IPAM, Caixa Postal 8610 Belem, Pará, Brasil 66075-970. Phone: 001 55 91 249 1534 E-mail: pmoutinho@mcimail.com; or Dr. Daniel C. Nepstad, Woods Hole Research Center Woods Hole Research CenterWoods Hole, Massachusetts 02543 Phone: (508)540-9900, E-mail: dcnwhrc@mcimail.com. - *Bill Stanley*

Last summer, I conducted my research with the Institut Senegalais de Recherches Agricoles (ISRA). ISRA is the Senegalese government's agricultural research division. It has stations throughout the country. I worked with the Bam Bambey Station and hired an ISRA technician to help me collect samples and conduct interviews. Additionally, I received assistance from the Regenerative Agriculture Resource Center, an NGO that was founded in Thies, Senegal in 1987. The information exchange and extension organization collaborated with ISRA in a USAID-funded natural resource based agricultural research project. - *Karen Westley*

# Cooperator profiles

In 1978, a group of students and faculty conceived an organization within YFES that would be devoted totally to the research of tropical issues. Today, TRI sponsors approximately 15 students per year for research with cooperators in countries ranging from Madagascar to Brazil. Many of the students involved in building the initial foundation of TRI have gone on to careers dedicated to conserving tropical biological diversity. One such example is Dr. Laura Snook, who received her Master's of Forest Science from YFES in 1980 and her Doctorate of Forestry in 1993. TRI funding, combined with other funding sources, assisted Snook in conducting doctoral research in Quintana Roo, Mexico, where she focused on stand dynamics of mahogany and associated species. Currently, Snook is an assistant professor of conservation biology at the Duke University School of the Environment. Together with Duke and The Nature Conservancy, she works on the conservation of biological diversity in forests including the tropical forests of Mexico and Belize. Her research focuses on silviculture, sustainability, and how forestry practices, which yield timber and non-timber products, can contribute to conservation strategies in both the US and Latin American tropics.

This summer, Luisa del Carmen Camara Cabrales, a YFES Master's candidate will work with Snook on a joint Duke, Man and the Biosphere Program, and TRI sponsored research project entitled: "Mahogany (*Swietenia macrophylla* King) fruit and seed production in Quintana Roo, Mexico: Ecological information needed for forest management."

## Spatial Pattern Analysis on Two Tropical Mountain Ecosystems in the Mixteca Alta Region, Oaxaca, Mexico

**Paulus Boon**
**Candidate for Master's of Forest Science**

In collaboration with Heidi Asbjornsen, a YFES doctoral student, and Dr. Leo Schibli from SERBO (Society for Study of Biotic Resource of Oaxaca), I am quantifying landscape structures in San Pedro Tidá and San Pedro Cantáros, two tropical mountain ecosystems, to determine the effects of long-term human disturbance on the landscape. Quantifying landscape structures involves measuring different geometric parameters of each patch of homogeneous agricultural field, clearcut, forest, and forest edge. The geometric parameters are area, perimeter, shape, fractal dimension, and nearest neighboring patch. The influence of the distance between human settlements and the area of natural resources (zone of influence) will be examined. I will develop a fragmentation index using Idrisi (Geographic Information System software), FRAGSTATS (spatial pattern analyses program), and SAS (statistical package). The analyses will be applied using aerial photographs and on-ground data that were collected from ground truthing in the summer of 1996 in San Pedro Cantáros. These ground-truthed data were collected to determine variability of fragmentation within the landscape at a 1 x 1 m resolution. The images and plot data contain forested patches and open patches (gaps). After the fragmentation index is established, Asbjornsen will use these data in combination with ecological data to understand the function and structure of the landscape at different scales. This fragmentation tool will be applied at different landscapes in Oaxaca. Schibli has done extensive vegetation classification in the Mixteca Alta region with the help of satellite imagery and ground-truthing. He can be contacted via email at serbo@atequera.com.

## *Pinus caribaea* Research in the Sinharaja Biosphere Reserve, Sri Lanka

**Tomohiro Shibayama**
**Candidate for Master's of Forest Science**

During the summer of 1996, I conducted an independent research project in the Sinharaja Biosphere Reserve in the southwest lowland wet zone of Sri Lanka. My research investigated the recruitment of native vegetation and the dynamics of soil seed banks within adjacent *Pinus caribaea* plantations. My stay and research in Sinharaja would not have been successful without the generous assistance of Dr. B. M. P. Singhakumara of the University of Jayewardenapura.

Singhakumara, a senior lecturer and the dean of the Department of Forestry and Environment Science, has been one of the principal Sri Lankan collaborators of Dr. Mark Ashton, YFES associate professor of silviculture, since the early 1990s. YFES participates in this silvicultural and socio-economic program in the Sinharaja in association with Center for Tropical Forest Science of the Smithsonian Tropical Research Institute.

Singhakumara is mainly involved in research issues related to regeneration ecology, natural forest silviculture, and restoration ecology of the Sinharaja. His interests, however, lie not only in the lowland rainforests, but also in the forests of other regions of Sri Lanka. Currently, he is conducting extensive research and floristic surveys in dry zone forests and in montane forests. During the past several years, Singhakumara has been supervising YFES students conducting research in the Sinharaja. He is a taxonomist by training and students (especially myself!) enjoyed the beauty of the Sinharaja with him. Singhakumara can be contacted through the Department of Forestry of the University of Sri Jayewardenepura, Nugegoda, Sri Lanka or singha@sri.lanka.net.

# Contents

## TRI Research Articles



## Feature



## Special Africa Section