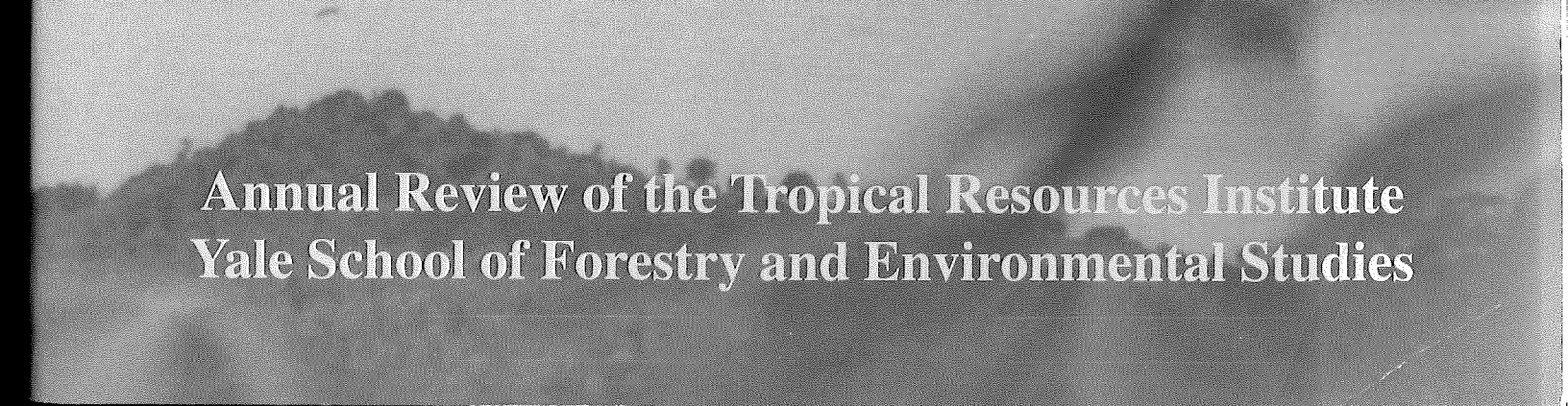
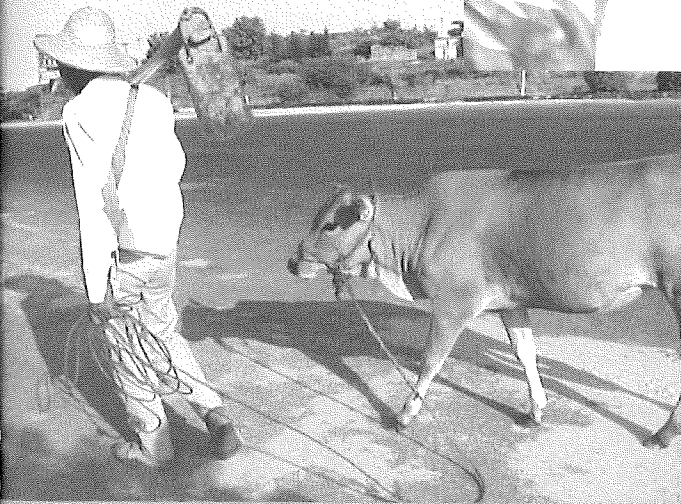
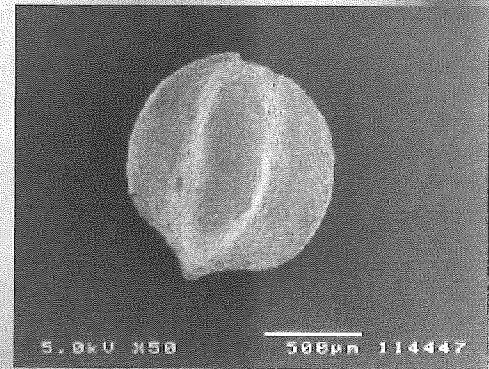
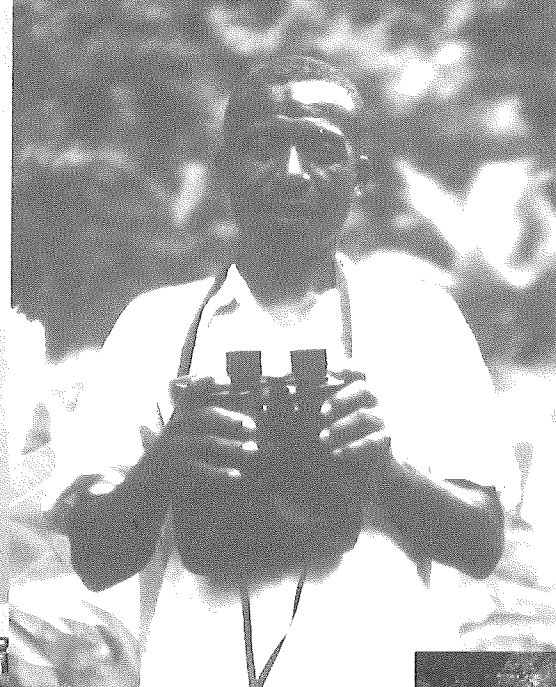
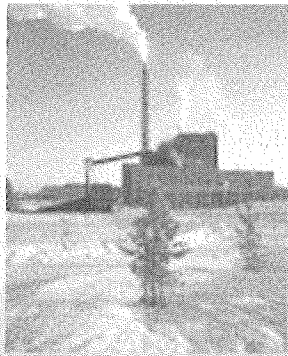


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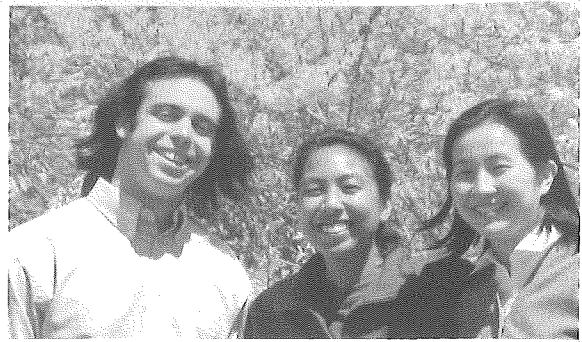


Annual Review of the Tropical Resources Institute
Yale School of Forestry and Environmental Studies

A Message from the *TRI News* Editors

Now in its 19th year, *TRI News* continues to provide a forum for tropical research conducted by students at the Yale School of Forestry and Environmental Studies. Edited and written by students, the original research papers presented in this issue range from social research to basic ecology.

Yet while research papers are good at answering questions, problem solving requires the additional perspective of personal experience. For this reason, we have included in this volume several short articles about people who have devoted a large part of their lives to tropical issues. From an interview with the new dean of our school, to profiles of faculty members, to short biographies of our alumni, we hope to present to you a broader picture than would be possible from a purely research-oriented magazine. Just as the Tropical Resources Institute has provided academic and financial resources for students at the Yale School of Forestry and Environmental Studies, we hope that *TRI News* will be an intellectual resource for you, the reader.



*Chris Losi and Abigail Sarmac, editors
with Noriko Oshima, graphic designer*

Chris Losi

Abigail Sarmac

A Message from the TRI Directors

This year we have embarked on an ambitious research program involving TRI faculty and students and Central and South American collaborators. Under our People and Forests Program we have set up long-term research sites in Panama and Peru. In Panama, we are working on the development of small-holder reforestation and restoration models for protection of the Canal Watershed, with the Smithsonian Tropical Research Institute, ANAM, the Panamanian Authority of the Environment, JICA, the Japan International Cooperation Agency, and several other organizations. The Panama Canal Watershed comprises the nexus between resource protection and use and the impacts of this resource on downstream values of drinking water supply and the working of the canal itself. In Peru, the Machu Picchu Program, the Andean Center for Regional Studies "Bartolome de las Casas," the University of Cuzco and several other organizations are important TRI partners in research concerning the protection and environmental management in of this Andean cultural heritage.

The faculty at the School continue their studies in various regions abroad. The School has been awarded a grant from NASA to collaborate with the Center for Earth Observation of the Yale Geology Department, and colleagues in Nigeria, Cameroon and the Central African Republic. This investigation will examine how accurately the latest satellite imagery can detect land use change and forest dynamics across north - south gradients in climate and vegetation type, from savanna to evergreen rain forest. As usual, the School organized several field trips to the tropics in connection with courses this year, to Costa Rica (protected areas), Roatan - Honduras (coastal management) and to Puerto Rico (plant systematics).

TRI helped sponsor pre-dissertation field work for 10 doctoral students during 1999 and 2000 in Brazil, Cameroon, Honduras, Indonesia, Mexico, Nepal, Peru, Puerto Rico and Tanzania. Most of these doctoral research projects are efforts to combine social issues with technical issues. The idea that both the social and technical must be included for effective management remains central to TRI's philosophy and program planning. We hope to provide reports on these new research programs, as well as on several of this summer's 20 master's student research projects, in next year's *TRI News*.

James A. Bryan
Tropical Resources Institute Program Director

Mark S. Ashton
John Musser Director, Tropical Resources Institute

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A Bill of Rights for the Global Constitution: An Interview with James Gustave Speth

Christopher Losi

The new dean of the Yale School of Forestry and Environmental Studies, James Gustave Speth, returns to New Haven with an impressive record. Raised in rural South Carolina, Speth got his Bachelors Degree from Yale College in 1964, then won a Rhodes Scholarship to study at Oxford. Returning to the United States, Speth started the Natural Resources Defense Council (NRDC) after completing his law degree (also at Yale). NRDC was the first legal defense fund for the environment, and remains an important force for environmental advocacy. Most recently, Speth served as administrator of the United Nations Development Programme (UNDP). With a budget of more than \$2 billion, the UNDP provides technical assistance in capacity building to over 100 developing countries (Fellman, 1999).

I recently had the opportunity to interview "Gus" Speth. In the wake of protests both in Seattle and Washington, DC, which were directed against international aid organizations, I was interested in Speth's perspective on the current state of development and his visions for the future.

TRI News: I'd like to start with a little background. A recent Yale Alumni Magazine cover story about you had the cover caption, "A Globalist Takes to the Woods" (Fellman, 1999). Yet to me it seems that the more interesting story might be called, "A Country Boy Goes Global." I'm curious how someone like yourself, who grew up in rural South Carolina, was drawn towards the international policy arena. What were the steps along the way that pushed you in that direction?

Speth: Well, I think that a lot of people growing up in rural areas spend much of their time doing things like fishing and hunting, and really being exposed deeply to the natural world. I certainly was. When I came to college in the Northeast, and saw the "emerging rust belt"—a lot of declining industrialization, tremendous amounts of air and water pollution—I realized that it didn't all have to be like it was in South Carolina. Now the Northeast has come a long way since then, but I think that at that time it stamped on me a kind of early environmentalism.

Then, when I was casting about at the end of law school, I had this idea that we could start an environmental legal defense fund like the American Civil Liberties Union or the NAACP Legal Defense Fund.

TRI News: So you did, and that was the NRDC?

Speth: That became NRDC.

TRI News: And that is a national group?

Speth: A national group, doing more and more international things, but it was certainly nationally oriented when I was there. But there's an important pattern. It was certainly true in my life, and it is true in a lot of people's lives:

People who get interested in an individual concrete case all of a sudden realize that it's connected to something much bigger. People who were concerned about a power plant that was being built

in the neighborhood began to get interested in energy policy. People who fought a highway became interested in transportation policy. People who began to worry about pesticides became interested in agriculture policy and subsidization.

For me, I got a glimpse of the dimension of the global environmental problems and their links to development when I was chairman of the president's Council on Environmental Quality. President Carter commissioned us to do something that became the Global 2000 report. It was issued in 1980 and defined a new agenda of global-scale concerns.

And I realized at that time that we were building a fool's paradise here at home. So much of the environmental effort in the US was going into national concerns, while huge problems were outside our borders and we were ignoring them. So we started the World Resources Institute to tackle these global-scale problems—the global change agenda.

TRI News: So why development, why the UNDP?

Speth: As we got into these global-scale environmental issues, we realized that there was no way to deal with them unless you also dealt with the development challenges in these countries.

We realized that the only way to solve environmental challenges and to protect the environment in developing countries was in the context of successful development where people were realizing their aspirations. Solving these problems meant creating sustainable livelihoods, but livelihoods nevertheless. A lot of the pressure on the resource base was coming from people who were desperately poor and had no other alternatives other than do things like eat their seed corn.

So we created a center for international development within WRI and I began to work with UNDP as part of that. Then, when the possibility of leading UNDP came up, I was eager to take that up.

TRI News: What would you say were the greatest accomplishments made by the UNDP under your tenure?

Speth: We built a very strong program in environmentally sustainable development. By the time I left we were spending about a quarter of our resources on the environmental aspects of sustainable development.

TRI News: When you say this are you specifically talking about research or on the ground assistance?

Speth: On the ground assistance. We developed a big Montreal protocol program and we introduced a major program in sustainable energy. We introduced a significant program in international cooperation for sustainable forestry (led by a graduate of the School, by the way). And we're building a program in sustainable livelihoods to build small and medium scale sustainable enterprise, through micro-credit and small business incubators.

TRI News: How large of a staff did the UNDP have?

Speth: About 5,000

TRI News: And about how many projects might they be working on at any one time?

Speth: Oh perhaps a thousand, collectively. We've fought against "project-itis" for six years.

TRI News: So a lot of that had to be done with collaboration from other organizations, is that right?

Speth: Well, it's important to understand that UNDP is very decentralized. Its specialty is to work closely with organizations in the country, and to work with the governments. The governments in developing countries have got to succeed. You're not going to have success in development, or in environmental sustainability, unless the government succeeds.

Now I don't just mean any government succeeding in any way, or staying in power. I mean succeeding in becoming effective forces for sustainable human development. So we worked very closely with governments to build up their own capacities in the areas that reflected these values of poverty alleviation and environmental regeneration.

TRI News: One of the biggest criticisms (Ferguson, 1994) of organizations like the UN is that since they spend so much time working with governments, in a lot of cases, their efforts may serve to strengthen governments whose policies may hurt large portions of their people.

Speth: That's a very legitimate concern. I never felt that it was a problem for our organization, particularly. In part because the UN programs, even collectively, are not that big. You could add up all of the UN programs, 20 agencies, and you'd still have something that's smaller than the World Bank. And most of the projects were not large-scale infrastructure projects that provide a lot of largesse for the government.

Secondly, we worked a lot with NGOs, and the process was very transparent. We had a very open planning process at the country level, where there had to be consultations with affected communities before the plan that the UN was going forward with would be put in place.

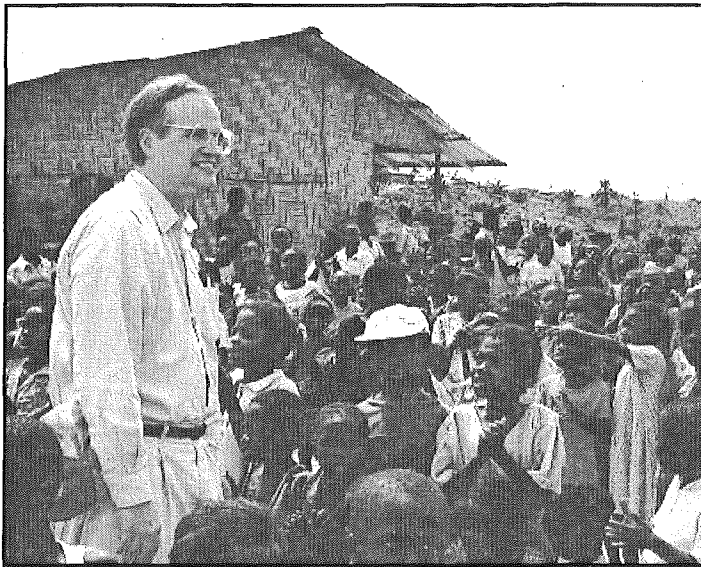
Yes, I think it's a legitimate concern. But I think there's another concern as well. Too often, in my view, the international community—because the government was not behaving in accordance with internationally accepted values, or because there was a conflict going in the country—held back, and did not provide sup-

port. This was a very common pattern, and as a result the international community would lose its capacity to encourage things in the right direction.

I saw this in Democratic Republic of Congo, after Kabila came into power and overthrew Mobutu. Governments were not providing any assistance to Kabila. Now you can say Kabila is not the perfect person that we want to see in the Democratic Republic of Congo, but the fact is that by not providing any support, we have not helped to stabilize the region. We now have an ongoing conflict, Africa's First World War. We did not help to provide stability or progress in the country, so the people are still living on almost nothing.

And in some cases like in Myanmar—Burma—we basically refused to work with the government at all, and that was kind of a gutsy position for a UN agency to take, but that was our position in Myanmar.

TRI News: I'd like to come back to the here and now: The Yale School of Forestry and Environmental Studies. Who should the school be training, what should they be training?



Speth: In my view, the real answers in the future will not be found simply at the global level or simply at the local or national level. The real answers are not going to be found in hard sciences, or in forestry, or in social sciences or in policy analysis. The real answers are going to be found in the very exciting synthesis of these things. I think the great strength of this school is that it can bring together such a broad array of different disciplines and different levels of science and policy and management.

One way of looking at this, from my perspective, is that these are people who have compressed into an educational experience, culminating in a Yale

degree, what it took some of us 30 years to learn!

TRI News: And you think that's possible?

Speth: I do. Some of us started out with no formal training in any of these issues 30 years ago. Now, we have to be able to communicate the learning of that period, the science, the policy, the management, both the successes and mistakes, and make it available to people so that they don't make the same mistakes that we made. The new generation must do a better job than mine has done. This may well be our last chance to get it right.

TRI News: Of course, Yale is an institution that trains primarily upper middle class white Americans. Some people would say that since most of us are not citizens of these countries undergoing development that the School should stay out of policy. We can give science, since we are an educated country, but we should stop there. My guess is that you would disagree with that.

Speth: Yes, to put it bluntly, I think that's a little screwy. Let me say first that the school is fortunate to have almost a third of its student body from abroad, and I hope that that can increase in the future.

But just focusing on "Americans:" America is the only superpower left; America is the most potent influence in every international negotiation on environment; America is what is holding back progress right now on climate change. America has not signed the convention on the Law of the Sea, or the Biodiversity Convention, or a long list of other agreements, where our company in not signing these conventions usually consists of countries like Libya and Sudan. America is a huge force in the world, often for good but too often not. So if you ask me "should we be training Americans to appreciate the importance of America's policy positions in the world?" I would say yes.

TRI News: Do you see a good future for the UN, for the UNDP, for the World Bank?

Speth: Well, the biggest problem, indeed in many ways the only dominant problem right now, is the decline in the financing for development cooperation, Foreign Aid. That decline unfortunately started right after the Rio Earth Summit where everyone promised to double international assistance. It started falling in 1993 and has continued to this day to fall. So we have a great tragedy. These institutions have learned a lot from their mistakes and are capable of doing more, but the resources that are needed are drying up.

TRI News: A law professor here, Dan Esty, has referred to this period in our history, specifically in the context of world trade, as one where we are forming a "global constitution." Through trade, and through the supervisory roles that international groups have to play, we are forming a constitution that has the opportunity to bring a lot of superior environmental and social concerns to a large number of countries.

Speth: Well I think Dan is right, but the problem is that we haven't gotten around to the Bill of Rights yet. We have a constitution forming, but we don't really have the protections coming yet.

TRI News: But that's a familiar situation, isn't it?

Speth: Well, that's true, economic globalization has far outstripped political integration and the global economy is far in advance of the global polity. What I want to see happen is more like what happened in Europe, where the economic integration of Europe, starting with the Iron and Steel Community, became a force for driving integration on environmental and social issues. Europeans now realize that those things have to be regulated on a common European-wide basis. So we really are at the very early stages.

TRI News: But I sense that you feel that this global trade organization can help bring a lot of good.

Speth: I think we need a world environmental organization to match the WTO, but that's another example of how the economic progress is so far outstripping any concern for the people who are being marginalized or left behind by the globalization process. Globalization has proceeded but the gap between rich and poor has widened dramatically—astoundingly, in fact. The wealthiest 20% of the people

and the poorest 20% of the people are now more than 150 times apart, and that gap has almost tripled in the last 40 years.

TRI News: Do you think that trade is a powerful counteracting force to that sort of thing?

Speth: Well, first, we don't really have very fair trade today. We have a lot of places that are protecting their markets from developing country exports. It is certainly true that economic growth is a necessary condition for large poverty alleviation, but it is by no means a sufficient condition. The countries that have achieved large reductions in poverty are countries that have put together programs involving 5 or 6 critical dimensions and have reached out to the majority of citizens who are quite poor. The trade situation is much the same. It will benefit those who have resources but it also can be a spur of growth, which can be used by the right kinds of governments to benefit the people in the country. But if you ask me whether the international trading regime needs to be reformed, I would strongly agree that it does. The WTO has bad procedures and poor policy guidance.

TRI News: What do you see as a future role for the Tropical Resources Institute?

Speth: I think that TRI has a tremendous opportunity to take advantage of the new directions that we're pursuing in the school. We want to become a truly global school of the environment, and we want to develop strong programs in the area of environmentally sustainable development. We have a tremendous interest among the students in this area, as TRI's agenda reflects. I think TRI needs to think through how it can become a major force for strengthening the internationalization of the school, and for helping us build a major program focusing on environmentally sustainable development in the tropics.

TRI News: Yet TRI only gives student grants for original research—not for management, not for developing policy, but for original science and social research.

Speth: That's an interesting point. The school needs to develop policy analysis and understanding capabilities that are as profound as our technical understanding is in tropical regions. If TRI can rise to that occasion it will certainly continue to play an extraordinarily important role in the school.

Christopher Losi, MF 2001, is conducting summer research in Panamá, where he will develop mathematical models of carbon sequestration for tropical tree plantations.

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Faculty Profiles

Academic and Research Interests of Some Current Faculty

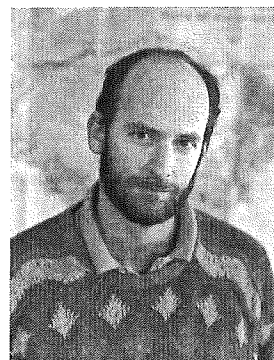
Mark Ashton



Mark Ashton has been working for fifteen years at the Sinharaja Man and the Biosphere Reserve with colleagues from the University of Sri Jayawardenapura (Dr. B.M.P. Singhakumara) and from the University of Peradeniya (Professors Nimal and Savitri Gunatilleke). Over this time, a considerable body of information has been generated that will be published as a series of reviews in the UNESCO/Parthenon Press series next year. Initially, most of his work concentrated on understanding the regeneration dynamics of the rainforest. Now, Mark and his colleagues are involved with several forest restoration projects on degraded sites within protected parks and reserves. Agroforestry plantings of native and non-native commercial plants have also been tested as plantings beneath the canopy of pine plantations. These plantings have proven so successful that villagers are eager to apply these treatments and species combinations elsewhere. As a result, a joint community development project was set up involving the forest department, the villagers, and Mark and his colleagues utilising the buffer zones and plantations for the benefit of landless poor.

Mark was recently awarded a grant to work in collaboration with the Yale Center for Earth Observation (CEO) to study forest changes in relation to land use. He will be investigating whether the most recent satellite images will detect differences in forest type. This work is being done across the forest savanna interface of West and Central Africa and will be in collaboration with Dr. Prasad Thenkabail (CEO) and Jeff Hall, a doctoral student at the Yale School of Forestry and Environmental Studies with considerable African rainforest field experience. Mark continues to teach his protected areas assessment course with Prof. Timothy Clark. This year the class went to Costa Rica to evaluate the resource issues surrounding La Amistad National Park.

Robert Mendelsohn



Robert Mendelsohn has been at the Yale School of Forestry and Environmental Studies since 1984. While at Yale, Professor Mendelsohn has pursued three themes in tropical studies: valuing NonTimber Forest Products (NTFP's), measuring the value of ecotourism sites, and developing a global model of forest resources.

The NTFP valuation studies are all interdisciplinary analyses combining the insights of ethnography, economic botany, and economics. The research is part of a larger effort to determine the value of the standing tropical forest. Beginning with careful biological inventories of tropical forests, interviews with native collectors reveal the economics of NTFP harvests. Subtracting the costs of harvest, transport, and refining from the revenues earned at market indicates that these NTFP's have surprisingly high values per hectare. Combining the timber and NTFP values together reveals that the standing forest is often worth more than more destructive uses such as agriculture and grazing. These studies have involved a large number of F&ES students over time.

The second theme of research involves measuring ecotourism. Using travel cost methods, Dr. Mendelsohn with students from F&ES revealed that ecotourism sites in tropical forests and tropical coral reefs often have surprisingly high values. The studies reveal that these special sites deserve to be conserved. Interestingly, the beneficiaries of these sites include many residents from the Organization for Economic Cooperation and Development (OECD) who spend large sums to enjoy these remote locations.

The final theme of research concerning tropical forests involves an analysis of global forests. Drs. Sohngen, Mendelsohn, and Sedjo have developed a dynamic model of the world's forests. The model combines inventory information in each region with tree productivity to predict timber supply over time. Combined with a global demand function, the model can predict timber prices, aggregate supply, and investment in forest plantations over time. This important tool for tropical forests can predict where forests will be harvested, turned into plantations, or left alone. The model has already been used to examine conservation plans in one part of the world and the ensuing market response in other places. It has also been used to study the impact of climate change on world timber markets.

William R. Burch, Jr.— Connecting Humans with their Environment

April Reese

Bill Burch's cluttered, dimly lit office reveals much about the man who works within it. At various locations around the small, cramped room shoe-horned into a corner on the third floor of Yale University's Sage Hall are posters of foreign places, pictures of former students, awards, an old computer salvaged from the school's computer graveyard ("I got it fixed and it works fine," he says), a troll with pink hair, a small collection of buttons (pinned to a lampshade), a wall of file cabinets, stacks of papers (some on the floor), and books—lots of them (some titles: *Ecosystem Preservation Policy*; *Ancient Judaism*; *Playing God in Yellowstone*; *The Making of Society*; *America the Raped*).

Burch has attracted almost as many titles as he has in his library: community forester, social ecologist, education reformer. His official title at the Yale School of Forestry and Environmental Studies, where he has taught for over a decade, is Frederick C. Hixon Professor of Natural Resources. When he isn't teaching, Burch is out in the field, helping to retool tropical forestry curricula in developing countries, establish green space in an inner-city neighborhood, or get a community-based forest conservation project off the ground. His work has involved both rural and urban populations in the US and abroad, including tropical regions in Asia and Latin America.

Bill Burch's professional career spans almost forty years. Before coming to Yale, Burch conducted groundbreaking work on wildland recreation behavior in Oregon and Minnesota and held research positions with the USDA Forest Service, the Connecticut Department of Environmental Protection, and the National Park Service. He also helped establish higher education curricula with institutions throughout South and Southeast Asia, including a six-year effort sponsored by USAID at the Institute of Forestry in Pokhara, Nepal. His vision of people and their environments coming together to benefit both is the compelling force that has moved Burch through a remarkable career spanning three decades and multiple continents.

That vision led Burch to help establish the Tropical Resources Institute (TRI) in the 1980s. As one of the first Directors of TRI, Burch forged research alliances with Peru, Costa Rica, and other developing countries on behalf of the school. The idea was simple: provide internship opportunities for Yale Forestry and Environmental Studies students while helping the host countries address their environmental challenges. In 1989, Burch handed over the TRI baton to Florencia Montagnini to devote more time to spearheading an \$8 million education project in Nepal. His program helped transform the country's traditional top-down, forestry curriculum into a community-based, bottom-up one. The project was a success, both on paper and on the ground: "We educated a lot of people," he says. "You could see it in the landscape."

Credited with inventing the term "social ecologist," Burch sees his work as a subdivision of biology. When asked about human impacts on the environment, he is quick to point out that *Homo sapiens* often forget that they are made up of the same stuff as the rest of living nature, and must limit themselves accordingly. "Our species has really existed within a covenant of constraint and an arc of opportunity," he says, pinpointing the tension between our need to live "within the means that the earth provides us," and our tendency to overexploit the environment, which results from "our capacity to

invent things." Burch stresses that our proclivity for curiosity and innovation can be beneficial, too; new technologies, used responsibly, actually can help us reduce our impact on the environment. But he warns that sinking more resources into research and development alone is not enough; we each have to recognize our responsibility for improving the health of the natural world. "Constraint has to come from individual transformation," he says.

Sometimes that transformation occurs in the classroom. Burch's students at the Yale School of Forestry and Environmental Studies describe him as "brilliant" and "passionate," the kind of professor that can inspire students to reach their potential—or even find potential they never knew was there. Burch teaches the way he does everything else—with energy and commitment—and he expects his students to match his enthusiasm. Blind trust is also a prerequisite for Burch's courses. Leigh Shemitz, a former student who was Director of the Urban Resources Initiative (URI) for many years, remembers being thrown into a class assignment she had no idea how to tackle. "You teach your way out of it," she explains. "He creates an environment in which you learn the material by doing."

Over his many years of teaching and field work, Bill Burch has become famous for many things: his energy; his uncanny ability to synthesize disparate concepts; his high expectations; his groundbreaking work in the field of social ecology and community forestry; and, perhaps most importantly, the catalytic force of his ideas.

These days, that force is driving a new agenda: rethinking tropical forest policy. Burch believes that connecting research objectives with knowledge needs of tropical forest policy makers is a necessity for the twenty-first century. Presenting a paper to tropical foresters and policy-makers in Thailand in 1996, he said, "The burden of change will fall upon researchers and educators—not the farmers, CEOs of multinationals or policy makers whose investments are more in sustaining present trends rather than in expanding future options." That change, he insists, must include improving education curricula, integrating local knowledge into scientific discourse, using a multidisciplinary approach to problem-solving, and strengthening community-based forestry as a field of study.

Burch can't be accused of romanticizing the human relationship to nature. He is quick to point out that humans always modify their environment to some extent, and that the behavior of our species toward the natural world is not well understood. He has little patience for what he calls the 'doom-and-gloom types:' "Perhaps, rather than running around moralizing about how the sky is falling, maybe we should get on with the tough research job of understanding the patch dynamics of what is going on in this ongoing history of humans as one of the long-time natural forces in forest perturbation," he told the Thailand conference crowd in 1996. "Until we start to systematically understand the origins, nature and types of this form of natural perturbation, we are doing sacred moralizing, not science. Anything less than significant attention to such issues seems to be simply shifting the trees around upon a sinking ark." He offers as an example of this "sinking ark" approach the fact that less than one percent of the money spent on global change research goes

to "understanding the behavioral pattern and process of the animal causing the concern"—humans.

Burch warns that leaving *Homo sapiens* out of the policy loop can backfire. Setting aside land for a wilderness area, for example, will improve access for some people but deny access for others—often those most familiar with the land, and most dependent upon it. To him, the needs of a community must be considered along with the environmental problems of the area. Only then can an effective, long-term solution be hammered out.

In general, Burch says, when it comes to land use, a little of everything is better than a lot of just one thing. He advocates a mix of ecotourism, some logging, fuelwood extraction, herbs and medicinal crops, improved agriculture—in other words, diversified use of the land. "I see an unlikely future in simply keeping people in some subsistence state," he says. "I place my faith in community-based ecologies that are directed to making money, maybe even wealth... In short, I trust systems that accept and even encourage the social mobility of rural and urban underclass populations." Empowerment, not dependence, he adds, should be the overriding goal.

He strongly believes that cities need the attention of tropical forest managers. Cities in tropical countries are growing faster than urban areas in other parts of the world, he points out, and that growth is going to intensify environmental pressures. These megacities will "exploit the hinterland and return to it polluted air, water and other wastes," he says. Because of the voracious demand of cities for natural resources, he adds, the fate of tropical forests will be decided by them.

"You see that?" Burch points toward a chain-link fence separating the Newhallville neighborhood of New Haven, Connecticut from Beaver Pond Park. "There's a park right down there and these people are cut off from it by that fence. Sure, it keeps out dumping, but it also keeps out people."

Burch is reiterating a common theme, one that surfaces when discussing rural and urban environmental challenges alike: the need to reconnect people with their surroundings.

The School's University's Urban Resources Initiative (URI), which Burch helped found after TRI got off the ground, engenders that reconnection by working with urban communities to plant trees and neighborhood gardens or turn abandoned lots into open green space. But digging in the dirt is only the beginning. "The physical change is just a small part of the project," he says. "You can't see what it takes to get a community together...it takes a vision, working hard to establish relationships."

Parks are places where those community ties are strengthened, he points out as we walk across the parking lot of Beaver Pond Park. We pass what appears to be a randomly placed stretch of wooden gate before coming to the edge of the pond, but the vegetation is so overgrown that we can hardly see the water. Segments of cement pipe left behind by public works employees render what could be a shore-side trail an obstacle course. Burch frowns.

"There's no love for this thing," he says. But then his eyebrows lift as he goes on to exuberantly describe the possibilities: a small dock could be built for the neighborhood fishermen here, those invasive phragmites could be cut away there, a trail could be built to encircle the entire pond. Like he has done in Peru, Nepal, Bangladesh, India, and other parts of the world, Burch sees opportunity in places other people would most likely write off as hopeless.

Leigh Shemitz says that one key to his ability to make the most of that opportunity is his ability to communicate with people from all walks of life, from USDA Forest Service officials in Washington, D.C. to inner city residents in Baltimore to peasants in Bhutan. He has a talent for cutting through bureaucratic muck to "get to the gist of the problem," she adds, and his patience and integrity can win over even the most determined skeptic. "He walks the walk," she says, noting that he works hard to make often complex and difficult ideas reach fruition in the field. This, says Shemitz, is how Bill Burch turns ideology into dirt-under-the-fingernails reality.

Bill Burch's influence has been felt by the faculty and staff of the School. According to Shemitz, community forestry and outreach have gained new favor at the School in recent years, partly due to Burch's presence. In fact, the School's expanding urban ecology program "wouldn't have happened without Bill," she says. Morgan Grove, another former student who has worked with Burch on the Baltimore version of URI since 1989, says that one of Burch's biggest contributions to forestry is "the knowledge and inspiration that he has instilled in his students." All of this makes the School—students and faculty alike—wary of his inevitable departure. At 67, Burch could retire any day now. But with the energy and agility of a much younger man, as well as a seemingly inexhaustible desire to pass along his lifetime of knowledge about forests and people, Burch shows no signs of slowing down.

Back at the empty parking lot at New Haven's Beaver Pond

Park, Bill Burch folds his expansive frame into the driver's seat of his tiny Mercury Capri, bumping his knee against the miniature plastic Buddha hanging from the cigarette lighter. It swings to and fro as he glances out the window at the park one last time before heading back to the office. "The benefit is more just knowing it's there, appreciating it," he says. He's talking about the value of the park for the community, but he could just as well be talking about his own importance to the extensive community of students, foresters, conservationists, and, most importantly, urban and rural residents throughout the world whose lives have been changed, either directly or indirectly, because of his work. It's good, they say, just knowing he's around, working toward a better future for the world's people and the land that sustains them.

April Reese, MES '00, has written about environmental issues for E MAGAZINE while working toward her degree and hopes to pursue environmental journalism full-time after graduation.



"Bill Burch has helped transform Nepal's traditional top-down forestry curriculum into a community-based bottom-up one"

Alumni Reports

Updates from a Selection of Graduates Dedicated to Tropical Issues

Abigail Sarmac

Over the years, TRI has supported several students pursue research in tropical resource issues. Where are they now? We tracked down a few past tropical resources alumni and found a gamut of fascinating stories...

Manuel Guariguata, DF '93

Manuel is now leading a project on forest silviculture at the Tropical Agricultural Research and Higher Education Centre in Turrialba, Costa Rica (CATIE, its Spanish acronym). CATIE is a regional institution involved in promoting wise use of natural resources through research, education, dissemination, and local capacity building. Manuel's project focuses on the application of ecological principles to ensure the biological sustainability of neotropical upland and lowland forests managed for timber. Main research activities take place in Central America, and these include (1) developing ecological criteria for seed tree retention (with special attention to vertebrate-dispersed species), (2) evaluating the effects of forest fragmentation and defaunation on seed dispersal and early recruitment of animal-dispersed timber species, and (3) determining species-specific ecological requirements of regeneration from seed in secondary forest timber species (those that have regrown in abandoned agricultural or pastureland).

Contact Manuel at:

Centro Agronomico Tropical de Investigacion y Enseñanza (CATIE)
7170 Turrialba; Costa Rica
Phone: +506 5560401
E-mail: mguarigu@catie.ac.cr

Robert Mowbray, MF '63

Robert recently retired from USAID as Senior Natural Resources Management Specialist/Senior Forest Ecologist. He spent most of his career with the Peace Corps and USAID working in Latin America. Among many assignments at USAID, Bob developed the Sustainable Uses for Biological Resources project in Ecuador and, in Washington, managed the \$45 million Forest Resources Management Project, which accesses U.S. Forest Service and Peace Corps support for USAID activities to conserve tropical forests and associated natural resources (biodiversity, soils, and water) and mitigate global climate change. Before USAID, Bob worked in Ecuador and Paraguay with the Peace Corps. He now works as a consultant, mostly with firms carrying out work for USAID. Most recently, he worked with a team providing training for 50 Panamanians involved in various aspects of management of the Panama Canal watershed. In 1999 he also reviewed a proposal submitted to the U.S. Initiative for Joint Implementation by an NGO to carry out a carbon sequestration and sustainable coffee project in Guatemala.

Contact Robert at

2218 Wheelwright Ct.
Reston, VA 20191-2313
Phone: (703) 758-1959
E-mail: rnmowbray@worldnet.att.net

Laura Snook, MFS '80, DF '93

Laura currently works for the Center for International Forestry Research (CIFOR), the newest of 16 research centers funded by donor countries with the mission of bringing scientific knowledge to bear on major decisions affecting the world's tropical forests and the people who depend on them. Key policy topics are food security, poverty alleviation, and environmental protection in developing countries. CIFOR has 60 scientists from 25 countries and operates regional offices in Brazil, Peru, Cameroon and Zimbabwe. As the leader of CIFOR's Sustainable Forest Management Program in Bogor, Indonesia, she coordinates research on tropical forests in Africa, Asia and Latin America to produce information for policy-makers, development banks, NGO's, and governments. Her program seeks to contribute to the establishment and maintenance of a permanent forest estate, the adoption of improved timber harvesting practices, and improvement of forest management to yield multiple benefits, including improved livelihoods for local people and biodiversity conservation.

Contact Laura at:

Sustainable Forest Management; Center for International Forestry Research (CIFOR);
P.O.Box 6596;
JKPWB, Jakarta 10065; Indonesia
Phone: (62-251); 622-622
E-mail: l.snook@cgiar.org
Also take a look at CIFOR's website: <http://www.cgiar.org/cifor>

Bruce S. Kernan, MFS '81

Bruce currently works as an independent consultant based in Quito, Ecuador. He started his career as a USAID International Development Intern in Ecuador and worked on various USAID projects, including forestry sector development, integrated rural development, coastal resources management, and land titling. He resigned from USAID in order to stay in Ecuador and start his own plantation for growing cut flowers for export. He also did consulting in Ecuador, Guatemala and Bolivia. In 1994 he returned to USAID as the regional environmental advisor for South America. In that capacity he worked in Peru and Bolivia on the environmental aspects of the U.S. government's efforts to reduce the production of coca, in Paraguay on the establishment of private forest reserves, and in Ecuador on the environmental effects of tourism and spread of introduced species in the Galapagos Islands and on the inclusion of watershed protection as part of the cost structure of potable water supplies to urban areas.

Contact Bruce at:

PO Box 17.16.1025
Quito, Ecuador
Phone: (593-2) 371- 885 / 373 - 889
E-mail: bkernan@uio.satnet.net

Susan Braatz, MFS '80

Susan is currently a forest policy analyst with the Food and Agriculture Organization based in Rome, Italy. She is the coordinator of two major FAO activities, "State of the World's Forests" (SOFO) and the "Forestry Outlook Study for Africa: Towards 2020". SOFO is a biennial publication that provides an overview of the status and trends of the forestry sector worldwide, and of the major issues facing the sector today. The Forestry Outlook Study for Africa (FOSA) is a three-year study examining the future of the forestry sector in Africa to the year 2020. FAO is the United Nations agency with the lead role for international assistance on forests, food, agriculture and sustainable rural livelihoods. Its major functions are to provide direct development assistance; to collect, analyze and disseminate information; to furnish policy and planning advice to governments; and to provide an international forum for discussion and debate on food and agriculture (including forestry) issues.

Contact Susan at:

Food and Agriculture Organization
Viale delle Terme di Caracalla
Rome 00100 Italy
Phone: +39-06 5705-3902
E-mail: susan.braatz@fao.org

J. Kathy Parker, M.Phil. '81, Ph.D. '85

Kathy has spent the majority of her professional career as a Social Ecologist working on a range of issues including sustainable rural development, biological diversity, and social forestry. Recently, she was named in the Who's Who in America in Science and Engineering. Kathy obtained a BA in Sociology and History from Trinity University and a MS degree in Park Administration from Texas Tech University before entering the international arena. After receiving her M.S., she worked as Recreation Planner for the Bureau of Land Management in Washington. In late 1975, on the same day she was offered a job to work for the Bureau of Land Management in Oregon, she got a call from the Peace Corps offering her a job as a National Park Administrator in Brazil. Within 6 weeks of that call, she was in Brazil. Toward the end of her work in Brazil, she met a former F&ES grad, James Shaw, who suggested that she think about going to Yale. Life after Yale has included work for the USAID, the US Congress' Office of Technology Assessment, consultant to public and private organizations in various parts of the world. She is now President of The Heron Group, LLC, located in Georgetown, Delaware. The Heron Group, LLC., principals and associates use their broad experience in organizational diagnosis, program management, strategic planning, information management, and monitoring and evaluation to facilitate improvements in management operations. The company has had contracts with Penn State University, USAID, the World Bank, and other public and private organizations.

Contact Kathy at:

The Heron Group, LLC
P.O. Box 741
Georgetown, DE 19947
Phone: 302-856-3324
E-mail: jkparker@dca.net

Keith "Keegan" Eisenstadt, MFS '97

Since leaving Yale, Keegan has carried out several natural resources consulting activities in Latin America, North America, and South Asia and has worked on projects for the United States Agency for

International Development, The World Bank, local nongovernmental organizations, and the private sector. After receiving his B.Sc. in Ecology and Molecular Biology, Keegan served in the Peace Corps in Paraguay. He then worked as a watershed scientist for the government—spurring him to attend graduate school. Keegan is also a founding partner of Eisenstadt Enterprises Inc. in Albuquerque, New Mexico, which assesses profitability and environmental suitability of potential real estate investments. Currently working for Development Alternatives, Inc. (DAI), Keegan is a forestry and water resources specialist in DAI's environment and natural resources group where he focuses on watershed management and the decentralization of decision-making processes so stakeholders are informed and empowered to make their own resource management decisions. Keegan uses integrated watershed analysis methods that include cumulative impact modeling, risk assessment, socioeconomic variables, and capacity building and training to promote local control of natural resources. Finally, perhaps his most important post has been as teaching assistant at Great Mountain!

Contact Keegan at:

Development Alternatives, Inc.
7250 Woodmount Ave., Suite 200
Bethesda, MD 20814
Phone:(301)718-8699
E-mail: keegan_eisenstadt@dai.com

Tomohiro Shibayama, MFS '97

Tomohiro obtained a BS in Biology from Waseda University in Japan before entering the Yale F&ES. While at the School, he concentrated in areas such as forest ecology, agroforestry, silviculture and forest management. His interest lay in restoration of degraded forestlands in the tropics. Regeneration is of special concern for his work. For his master's project, he spent a summer in the Sinharaja Man and Biosphere Reserve, Sri Lanka, examining effects of fire on the recruitment of native vegetation within pine plantations. Experiences and courses at the School provided him a basic background to pursue professional a career as a forestry consultant. After receiving his MFS at the Forestry School, he began working as a forestry consultant at the Japan Forest Civil Engineering Consultants Foundation. His major responsibility is to carry out design and development studies for forestry and forest-related projects, mainly administered by the Japan International Cooperation Agency (JICA), working in developing countries as a member of consulting teams. Past work activities included project-finding surveys in Bolivia and Paraguay; however, he has spent most of his career in forestry-related projects in Vietnam. Currently, he is involved in a design study of a forestation project in the coastal sandy areas of the south-central Vietnam. His major task is to design an appropriate planting stock production plan establish 3,670 ha of forest over a 5-yr project.

Contact Tomohiro at:

Japan Forest Civil Engineering Consultants Foundation
Phone: 81-3-3582-1955
E-mail: shibayama@jfec.net, tomshiba@ceres.dti.ne.jp

Abigail Sarmac, MEM '01 is conducting summer research in the Phillipines.

If you are a graduate of Yale F&ES working on tropical issues, we would love to hear what you are doing. Write us at trinews@pantheon.yale.edu

Adaptive Co-Management of Forests: How Powerful Stakeholders Represent Local Communities

Steve Rhee

Introduction

Community forestry initiatives grow out of an awareness beginning in the 1970s amongst social and biophysical scientists concerned with the conservation of natural resources and sustainable development (Thompson 1999). Prior to this period, the history of forestry in countries such as Indonesia involved a shift from traditional tenure to state control (Poffenberger 1990). Two factors contributed to the reformulation of forest management in terms of local communities: first, there was a recognition of the need to redress the inequitable results of many state forestry schemes as well as the recognition of the pragmatic value of local people's participation (Fisher 1995, Thompson 1999). Secondly, there has been a substantial amount of literature published attesting to the sustainable use of natural resources by local people (for examples, see Fisher 1995, Ghimire and Pimbert 1997, Poffenberger 1990, and West and Wright 1994).

A common feature of community forestry projects is that they attempt to elicit the active participation of local communities; community participation is considered a fundamental aspect of the success of these projects. Ubiquitous in project proposals, community participation and/or co-management are seen as vehicles to increase the vested interest of local communities to engage in the management and protection of forests. In spirit, community participation is a devolving of authority and responsibility to local communities; it is a sharing of power, viz., "empowering people to mobilize their own capacities, be social actors rather than passive subjects, manage the resources, make decisions, and control the activities that affect their daily lives" (Cernea 1985: 10).

However, the notion of community participation and its actualization in collaborative management projects has been problematic at best and non-existent at worst. Fisher (1995: 27) suggests that "participation has come to mean so many things that it sometimes means nothing." Further, in their evaluation of Integrated Conservation and Development Projects (ICDPs) in Indonesia, Barber et al. (1995: 3) mention that "although the term 'participation' percolates through the ICDP discourse, there is little agreement on what this means in practical and political terms." Lastly, Ghimire and Pimbert (1997: 23) note that "despite repeated calls for peoples' participation in conservation over the last twenty years (e.g., Forster, 1973; McNeely and Miller, 1974; McNeely, 1993), the term 'participation' is generally interpreted in ways which cede no control to local people."

It is clear from these studies that terms such as participation, co-management and collaboration have grown nebulous and their implementation somewhat ineffectual. This ambiguity is borne out partially because projects often assume that there is a consensus among stakeholders as to what community participation or co-management should achieve, although in actuality these various stakeholders hold disparate notions of what a co-management project should accomplish. What then are the assumptions that stakeholders have of co-management or community participation? More specifically, what are the assumptions and perceptions of community participation held by stakeholders who maintain the greatest political power either to maintain the status quo or to effect a change in the

existing arrangements of control over and access to natural resources? It is this latter question that I attempt to answer in this essay.

Methodology

This essay is based on three months of fieldwork in Indonesia, in 1999, during which I conducted research in collaboration with the Center for International Forestry Research (CIFOR) on their community forestry initiative "Local People, Devolution and Adaptive Co-Management" (hereafter referred to as ACM). The specific field location is within a parastatal forest concession in East Kalimantan, Indonesia that is also home of several Dayak ethnic groups and is currently being mined for export quality coal by a private Indonesian company. At the time of the fieldwork period, CIFOR had just initiated implementation of its research activities.

The stakeholders in project are as follows: CIFOR, Government of Indonesia, Inhutani II— a government-owned logging company, Bara Dinamica Muda Sukses (BDMS)— an Indonesian coal company, and local Dayak communities. The goal of the ACM project is "to develop or identify a set of models, institutional arrangements, methods, tools and strategies to enable local communities to achieve more sustainable and equitable management of forest resources and human well-being in a multi-stakeholder environment" (www.cgiar.org/cifor/research/projects/Adaptive.html). In this essay, I show what forest co-management means for powerful stakeholders by illuminating how these powerful actors perceive and represent local people. Further, by highlighting how powerful stakeholders represent and perceive Dayak, I aim to show that the foremost obstacle to co-management is the institutionalized attitudes of powerful stakeholders toward local people.

The three-month research period was divided between living in Long Loreh with a Kenyah Dayak family and working in the nation's capital of Jakarta and the provincial capital of Samarinda. Long Loreh is a predominantly Dayak village located within the Inhutani II timber concession. I triangulated information by asking the same questions to different stakeholders. The objective of the triangulation was not so much to get to the "truth" about some issue, but rather to capture the differences and similarities of attitudes towards local people and analyze why the overlap or lack thereof existed.

In addition to participating in everyday activities and meeting with villagers, during my 1.5 months in Long Loreh, I frequently met with timber and coal company employees and managers to discuss relations and perspectives. In more politically powerful locations and formal situations, I interviewed representatives from bi/multi-lateral aid agencies, NGOs and government offices. All discussions and interviews were conducted in Indonesian. In addition to formal and informal interviews, data collected consisted of surveys, project documents, government reports and relevant Indonesian laws and regulations regarding local communities, natural resources and their management.

Results

By examining how powerful stakeholders represent local people, it becomes clear that co-management does not entail redistribution of rights and property, but rather is a means to "civilize" Dayak. In discussing the representations and perceptions of Inhutani II, BDMS and GOI, I classify these stakeholders under a single rubric of "political-economic elite" for the following reasons: Both Inhutani II and BDMS have been provided legal sanction by the Government of Indonesia (GOI) to operate in the area, both companies share the objective of extracting resources, and all three are powerful, extra-local players that deny the legitimacy of Dayak livelihoods.

In his article, "Representations of the 'Other' by Others," Dove (1999) details how Indonesian plantation officials consistently represent peasants pejoratively, thereby privileging the government's claim over peasants land claims. Dove (1999: 204) suggests that "the issues at stake in this process of privileging are not merely rhetorical: as Berry (1988: 66 cited in Li [1999]) writes: 'Struggles over meaning are as much a part of the process of resource allocation as are struggles over surplus or the labor process.' . . . [power] works more subtly through the conceptual structures by means of which the planters perceive and represent the plantation world. Relations of power between planter and peasant are embedded in these perceptions and representations."

Many of the comments made by company personnel confirm Dove's (1999, 1983) analyses of how Dayak and their livelihoods are conceptualized by powerful extra-locals. Managers at BDMS and Inhutani II frequently commented that Dayak do not think of the long term and only for the present, but that since the companies' arrival, some Dayak had become sadar (aware/civilized), i.e., some Dayak had come to be "civilized." One company person informed me that "Dayak are like monkeys—when given a fruit they will eat the fruit and throw away the seed," the implication being that Dayak are short-sighted, whereas the company plans for the long term.

The comments made by a senior manager at BDMS regarding local Dayak succinctly convey not only the worldview of most company officials I spoke with, but also illuminate the discourse they deploy, which is articulated in terms of culture, thereby obfuscating the political and economic dimensions of conflicting land claims (Dove 1983). In informing me how BDMS compensated villagers in Long Loreh for the destruction of their primary source of drinking water, this manager tallied off the numerous material/infrastructure contributions donated to Long Loreh by BDMS: water pumps, water pipes, water wells, timber planks to build a church, money to refurbish the village cooperative, and a vehicle. He continued by noting that many of these contributions were abused or left in disrepair because Dayak culture reinforces their being "backward," "lazy" and "uneducated"—in essence, because of their traditions, Dayak were not culturally mature or developed enough to be capable to manage their affairs. He further noted Dayak lack of discipline in examples of their not being able to meet deadlines when hired for wage labor or their unwillingness to work unless their entire work crew attended, attributing this lack of discipline to their culture.

Indeed, it is true that much of what the company provided Long Loreh villagers is in need of repair, but to villagers this is a political and economic issue, not a cultural one. According to villagers, BDMS should repair the aforementioned items to compensate for the land that these companies had taken and the destruction of their primary source of water. Further, Long Loreh villagers com-

mented that they only infrequently sought out wage labor with Inhutani II and BDMS because the wages were marginal, and hence they were better off engaging in some other activity.

Company officials' representations of Dayak also suggest that there is a trajectory of "development" or "progress" upon which company personnel are much further along, and that Dayak are at the lower reaches of this trajectory because of their culture. The location of Dayak on this trajectory was made explicit when one manager commented that after two generations of interaction with extra-locals such as himself, Dayak would develop from being keras (uncivilized) to sadar (aware/civilized), as long as they remained close to the company. The implication here is that extra-locals such as himself, i.e., from Java and Sumatra, are the role models that Dayak should mimic. According to officials' comments, Dayak culture and mentality are "backwards," which is evinced by their inability or reluctance to repair items donated to them, but that by interacting with company personnel, they will slowly become "civilized."

In representing Dayak as culturally "backwards" and "primitive" and "needing to be developed," company personnel imply that Dayak culture is the reason for the "laziness" and "mental deficiency." By stating that if Dayak remain close to the company they can belajar (learn), BDMS and Inhutani II personnel further suggest that it is the company that will teach Dayak to be "civilized" and hence facilitate their "progress" along the trajectory of high modernism.

The political-economic elite also represent Dayak as ecologically destructive because of their practice of swidden agriculture, thereby allowing the companies to delegitimize Dayak agricultural practices. One provincial level Forestry Department official informed me that the government could not sanction swidden agriculture because of the ecological damage it causes to forests, viz., that opening a swidden requires cutting down primary forest, and hence was destructive to the environment.

In addition to verbal comments made by company and government officials, official written documentation also reinforces this representation of Dayak as environmentally destructive and culturally "backwards." As part of its timber concession license, Inhutani II is obligated to implement community development projects commonly referred to as Bina Desa. As part of this program, the timber company carries out a diagnostic study of villages in and around the concession to identify the potentials, conditions, and values of the community as the basis for planning Bina Desa activities (Inhutani II 1993: 2).

The description of Dayak within this government-sanctioned study reinforces the representations of Dayak as "backwards," while also couching these representations in terms of agricultural inefficiency and ecological damage, e.g., swidden cultivation results in low harvests, burning fields threaten forest protection, and opening forests accelerates the process of soil erosion (Inhutani II 1993: 54). The sheer fact that Dayak still practice swidden agriculture, the report explains, attests to their ignorance (Inhutani II 1993: 54). Dayak ignorance of agricultural techniques is highlighted throughout: the report claims that swidden agriculture does not require much knowledge, and hence swidden farmers lack any technical skills related to farming (Inhutani II 1993: 55).

The reports goes on to claim that local people's desire to adopt wet rice cultivation is an indication of their willingness to "progress" or "be developed" (Inhutani II 1993: 56). Hence, one of the key community development activities that requires implementation is to inform Dayak of the losses and destruction created by swid-

den farming and then convert them to wet rice cultivation. These politically powerful actors represent the Dayak as technologically primitive, mentally and culturally deficient, and ecologically destructive. Hence, by converting Dayak to wet rice cultivation, the elite will not only bring Dayak into a "civilized" condition, but also diminish the ostensible risk that swidden agriculture poses to forests and the people themselves.

The question of intentionality or motivations, however, requires explanation. Are the elite intentionally representing Dayak in this fashion? Indeed this portrayal of Dayak does serve the agenda of the politically powerful. "The ease with which the local or 'indigenous' people can be labeled primitive permits their claims to be ignored or dismissed" (Li 1999: 19, also see Dove 1983). Moreover, I would suggest that the politically powerful do not consciously intend to portray the Dayak in a pejorative manner. However, they seem to be culturally embedded within a discourse that associates wet rice cultivation as the model exemplar of agricultural development in Indonesia and, conversely, places Dayak in a "backwards" socio-political position (Li 1999).

The representation of Dayak by the political economic elite is also a case of "structural ignorance," which Dove (1988) defines as "the failure to perceive that which is not in one's own best interests to perceive" (Dove 1988: 28). This structural ignorance is also reinforced by widely circulating images of Dayak as "backwards" and "primitive"—"a premise widespread in Indonesia's upper and middle class as the ideology of pembangunan (development) that encompasses it" (Dove 1999: 210). Even Indonesian researchers whom I met in Kalimantan, most of whom were from Jakarta, seemed more interested in myths surrounding Dayak sexuality and magic than issues regarding livelihood practices and forest management. One researcher emphasized Dayak simple-mindedness, subsistence practices and bartering. No mention was made regarding their engagement with the market economy or the fact that swidden agriculture is a sophisticated farming practice requiring an intimate knowledge of the environment. Thus, even those without self-interest in maintaining a representation of Dayak as "primitive" indeed do just that.

Hence, the question of intentionality is less relevant, than is the observation that the trajectory of "development" has been translated into the vocabulary of culture—with Dayak and swidden rice cultivation being the nadir—that privileges the claims of the political economic elite. As Dove explains in delineating relations between plantation officials and peasants in Indonesia, representation of peasants as "backwards" and "primitive" is one of many "devices that privilege the reality of the planters at the expense of the reality of the peasants" (Dove 1999: 209). In his discussion, Dove (1999: 215) suggests that "[representations] are based less on social reality, the local variation in which they would otherwise reflect, than on an ideological reality, consisting of a pan plantation political and economic agenda." I would go further and add that the physical proximity of company personnel to Dayak settlements strengthens their claims that their representation of Dayak are accurate, even though company personnel's interactions with Dayak are infrequent.

Conclusion

CIFOR's ACM project attempts to diminish global environmental risk and more specifically diminish risk to local forest dependent communities through equitable, sustainable forestry management arrangements amongst all stakeholders. To foster the ideal scenario of adaptive co-management, CIFOR frames the issue of co-manage-

ment in terms of building consensus among multiple stakeholders and asserts that through negotiation and mutual understanding stakeholders will embrace equitable and sustainable forest management arrangements. As this essay indicates, central to their research initiative should be an ethnographic study of powerful stakeholders. Without a study of how power works, one can foresee much effort exerted by local communities as being without the support or understanding of other stakeholders. Since the political playground disfavors local communities, multi-stakeholder negotiations may seriously debilitate the little political maneuverability that local communities have. Much of how communities operate and interact with the natural environment is still, to use Scott's (1998) term, "illegible" to companies. For example, some of the precise locations of villagers' fields and gardens and the regions of forest from which villagers gather valuable forest products are unknown to companies or government. Without an ethnographic study of the worldview of the politically powerful, multi-stakeholder negotiations have the potential of undermining community activities, which greatly favors those with government support.

That this "illegibility" can often offer an amount of protection of village activities from detrimental outsider exploitation is illustrated by the current problem of gaharu (*Aquilaria* spp.) exploitation by extra-locals who have government support and license. Gaharu is a forest product exported to India and the Middle East and commands high market prices; it is an important source of cash income for Dayak—harvesters can sell top quality gaharu to middlemen for as much as 3 million rupiah per kilogram (approximately US\$428). Dayak have traditionally been the primary harvesters of gaharu and have an intimate knowledge of regions of forest that contain trees infected with the fungus that produces it. Since not all trees are infected by the fungus, Dayak normally check for infection and leave intact those trees that do not contain gaharu, since at some later point the tree may be infected.

Extra-local harvesters, who normally remain in the region for a few weeks or so, however, have discovered regions of forest that Dayak normally harvest from, and since these extra-locals have no vested interests in long-term or sustainable harvesting, they fell all the trees potentially containing gaharu without checking whether the tree contains the resin. Because these extra-locals have the support of government—indeed, sometimes being sponsored by government and company officials—local Dayak have no avenue of recourse to protest these environmentally irrational acts.

If how the politically powerful perceive and represent Dayak is not fully studied, ACM activities may result in non-compliance by these politically powerful actors or perhaps even put community at greater risk than they already are. I illustrate this point and close this essay by way of anecdote. During the research period, CIFOR held a meeting with Inhutani II to discuss ACM. When informed by a CIFOR researcher that this project attempts to bring all stakeholders together to manage natural resources sustainably and that CIFOR would act as a "bridge" between local communities and Inhutani II, an astute company manager posed the question of how this project would benefit company production since the community development (Bina Desa) budget is tied to production. A long, awkward pause ensued.

This awkward moment indicates the worldview of the company: besides conflating co-management with the company's community development program (Bina Desa), which delegitimizes Dayak culture and livelihood practices, the manager's comments indicate that any company endeavor should be tied to timber produc-

tion. Also, that the community development budget is tied to timber production levels evinces the structural incompatibility of co-management, which attempts to legitimize local people's claims to forest, and the company's objective, which is to maximize production.

One senior company manager spoke of the relationship between Inhutani II and CIFOR as a bermitra (partnership). The actualization of this partnership, according to this manager, would entail CIFOR supporting and transferring skills to timber company personnel so that they can implement community development activities better. There was no questioning of the community development activities or framework itself, which is assumed to lead to improved local livelihoods, viz., Dayak will no longer practice swidden agriculture. Given the worldview of these powerful players and their understanding that CIFOR would act as a "bridge," for these stakeholders, the role of CIFOR is to assist companies in bringing Dayak to understand their cultural and agricultural deficiencies and halting their traditional livelihood practices.

Steve Rhee, MEd, will begin the doctoral program at the Yale School of Forestry and Environmental Studies in the fall of 2000 and will continue to conduct research on the politics of natural resource use conflicts in Indonesia.

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Cost Analysis of Biomass Availability— A Case Study in Jiangsu Province of China

Xiaoping Wang

Introduction

Great concern has been expressed over the environmental consequences resulting from the burning of fossil fuels, such as release of carbon dioxide, and other air, water and soil pollutants. One of the remedies to limit the rising content of carbon dioxide in the atmosphere is aggressive use of biomass fuels, including wood and crop residues. When plants grow, they sequester CO₂. Burning plant biomass releases the CO₂ that would have been mostly released through the natural process of decomposition and therefore results in no net increase in atmospheric CO₂. On the other hand, burning fossil fuels releases CO₂ into the atmosphere that has been sequestered for millions of years and that would not have otherwise been released.

Biomass use appears promising not only because biomass can be turned into cooking gas with available state-of-the-art conversion technologies, but also because it can be stored without any technical problems. Therefore, it is readily accessible for energy production. In most cases it also has the advantage of being relatively cheap compared to other renewable energy sources (Kaltschmitt, 1994).

China is well known as an agricultural country with an abundant crop residue resource as a byproduct of agricultural production. Even today, crop residues provide 38% of rural domestic energy demand for cooking, heating, lighting, etc (Florig, 1997). Crop residues assume a minimal proportion of China's commercial energy supply (there is only 800 MW installed generating capacity from biomass, mostly sugarcane residues), but they account for half of the non-commercial energy supply in China, the other half mainly being fuel-wood. However, with higher incomes and reliable access to other types of commercial fuels, many rural households are switching to fuels such as kerosene, liquefied petroleum gas (LPG), electricity and coal briquettes.

Other uses of crop residues in China include animal feed (about thirty percent) and industrial use such as paper pulp making, fuel for small brick kilns, nurseries and so on. Due to the increasing efficiency of livestock production and market fluctuation in the price of animal products, the demand for fodder from crop residues has shrunk significantly. In addition, with recent new regulation phasing out small paper mills for environmental concerns, the industrial use has also decreased substantially, and exists only in the regions where the relatively large paper mills survive. It should be noted that such industrial use is so limited that there has been no established market for crop residues. Due to the decreasing demand, farmers often burn the crop residues in the field after the harvest.

The replacement of crop residues with fossil fuels runs counter to the need of increasing renewable energy use so as to mitigate carbon dioxide emission. According to preliminary estimate, for every thousand tons of crop residues used to replace coal or LPG, 1,400 tons of carbon dioxide emission can be avoided (ERI, 1998). In order to increase biomass use for energy purposes, the foremost issues that need to be addressed are the long-term availability and the associated costs.

This paper presents a case study on the costs of increasing biomass generation in Chinese agriculture. It first surveys the current production of crop residues and associated costs, and then calculates the cost of increased production through the shift to biomass intensive crops and to dedicated biomass production of firewood on the same plot of land.

Site Selection

The selected site, Sunyang Village, is located in Jiangsu province where I grew up. The Province is on the eastern coast of China. The study site is located in the Yangtze River Middle and Lower Reach Plain. It belongs to a northern subtropical zone, where the winter temperature is 0-5 degrees Celsius. The area has a frost-free period of 210-250 days. The climate is wet with annual precipitation above 800mm. It has a monsoon climate, warm in winter and hot in summer with four quite different seasons. Average annual temperature is 15 degrees Celsius. The arable land in this area is among the best in the country with plentiful water resources.

The province belongs to one of the major agricultural zones and is also the fastest-developing area. Proficiency in the local dialect helped me communicate with different social groups, including farmers, cadre, and family heads, and win their cooperation, while collecting statistical data and conducting interviews. The site was also recommended by my Chinese partner, Mr. Li Junfeng, with the Center for Renewable Energy Development (CRED).

Sunyang Village has 900 residents and 1034 mu of arable land (15 mu = 1 ha). I examined the agricultural crop mix and unit yield of the village and the province and determined that the village was representative of the province as a whole.

Methods for Estimation of Crop Residue Yield

Since crop residues are used mainly by the household that produces them, there is no documented information on actual yield of crop residues. However, one can derive the agricultural residue production by multiplying the average grain yield by the crop to residue ratio (CRR). CRR is the ratio of grain weight to total plant weight, and varies depending on species.

The crop yield data was first taken from the semi-official statistics at village level, but I was warned of the credibility of such data. I verified the data through interviews with the local farmers. The interview data were used instead when deviation of village statistics from interview data is greater than 10%.

Crop Switching

In order to obtain more biomass than is available from current crops, switching to biomass intensive crops (crops that generate a larger amount of residues and greater BTU output) and dedicated biomass crops (firewood) is considered. For the sake of convenience and consistency with the literature (Editorial Team, 1990), the research employed the standard coal equivalent (TCE) to represent the energy content. (The heat value of standard coal equivalent is 7000 Kcal/kg. The absolute number of heat value depends on the moisture content).

Hereafter, all the weight data assume that the moisture status of crop residue is ten percent by air-drying.

Identifying crops with high rates of biomass production is an iterative process. First, I assembled a list of crops that are grown or could be grown in this geographical location. Then, I obtained the data on grain outputs, and derived the residue yields from the outputs using the CRR. Finally, I calculated the heat value of residue on a per mu per year basis, taking the inherent heat value of different crops into account.

There are few alternatives to winter wheat, so only alternatives to the summer rice crop was considered.

Firewood

Firewood growth is perceived intuitively to yield more biomass in terms of heat output than crop residues as a side-product of agricultural operations.

The WB/UNDP joint study team of China GHG study recommended fast-growing species such as *Eucalyptus*, poplar (*Populus*) and larch (*Larix*), which fit the climatic conditions of my study site. Although the soil fertility in the WB/UNDP study area is lower than the Yangtze River Delta, I elected to use the WB/UNDP recommended tree species for this analysis, but adjusted the annual firewood production estimate from 7.0 tons/ha to 7.5 tons/ha.

Because firewood would grow all year around, and thus replace both the summer and winter crops (i.e. mainly rice and wheat), the net increase in biomass production from firewood planting is obtained by subtracting the amount of both wheat and rice straws from the total biomass from firewood.

Following one of the approaches introduced by Kaltschmitt (1994) for estimating the energy carrier costs for biomass, I assumed that the costs of the energy carrier straw should be in the same range as the current market value of straw. In Sunyang Village, after the use of crop residues as cooking fuel, the next most significant use is fuel for brick and tile kilns. Therefore, the purchase price paid by kilns was used as the proxy of market value of current crop residues, which is 0.04 yuan/kg of straw on average or 0.093 yuan/kg of TCE.

The costs of crop residues after crop switching need to take into account the forgone revenue due to the reduction of grain yield and the value (unit market price) of different grain crops. An underlying assumption is that the establishment costs of a new grain crop are the same as that for rice.

I used the state procurement price for the revenue calculation, because the agricultural economy is still characterized by highly centralized planning and the trend is expected to continue in the foreseeable future.

The total cost of residues derived from switching crops to firewood or other food products is the sum of the grain profit forgone and the market value of residues before switching. The market value of residues before switching can also be considered the cost of harvest and collection.

The costs of firewood production are composed of the forgone grain revenue from crops and the costs of planting, maintaining and harvesting the firewood. The former was obtained by subtracting the annual farming costs from the gross annual revenue. It represents a simplified estimation because it ignored the willingness of the farmers to switch from farming to tree planting. Since farmland is the only resource for most farmers to make a living, therefore their unwillingness to give up farming could be very high.

As a side note, I conducted 20 interviews of farmers on their willingness to switch land use and got a wide range of answers from 3000 yuan to 10,000 yuan per year. The low end of the answer is equivalent to actual income from farming. The upper end is more dependent on the age, skills and the sources of additional income (e.g. masonry, carpenters or urban construction workers). However, these farmers only have the rights to use the land for growing crops under contracts—they do not own the land. Therefore, they can't decide to use land for other purposes than crop growth. As a consequence, the exclusion of willingness to change land use in the analysis is plausible.

The costs and yields of firewood vary greatly under different planting regimes (Sedjo, 1983). The independent variables for yields include location, species, and management practices. A few studies provide the yield of biomass in volume (Editing team, 1980). The conversion to weight is needed in order to be comparable with the measurement of crop residues. While such conversion is possible, it may invite error due to moisture content and the nature of different species.

The factors determining costs of biomass produced from firewood include site preparation, planting, managing and harvesting. Those costs were taken from a similar study that was carried out in an abandoned mountainous area by the UNDP/WB ESMAP project (Editorial Team, 1990). However, I have taken the difference of soil fertility into account by augmenting the unit yield of biomass from 7.0 tons/year to 7.5 tons/year. The service cycle of firewood is 20 years, and biomass is harvested in rotation of five years after plantation. Using a discount rate of 15%, the total planting cost over 20 years is 2472.9 yuan, giving an annual planting cost of 123.6 yuan.

Results

Table 1 shows the energy content of each crop residue in terms of TCE, which is derived from residue yields multiplying by the respective TCE factor. The CRR from the Chinese literature is used to compute the residue yields from crop yields, (i.e. residue yield=crop yield × CRR). Data from Barneard & Kristoferson (1985) is also included for comparison. Among summer crops, only corn generates more biomass than rice in term of the net energy increment. Therefore, corn is considered to be the only alternative to rice in this analysis.

Table 1: Energy content for selected crops

Crop	Yield (kg/ mu)	Residue	CRR ¹	CRR ²	Residue yield (kg/ mu)	TCE/kg	TCE (kg) ³
Coal						0.714	
Rice	501	Straw	1.1-2.9	1.0	501	0.429	214.9
Wheat	390	Straw	1.0-1.8	1.0	390	0.5	195
Cotton	60	Stalk	3.5-5.0	3.0	180	0.543	97.74
Corn	391 ⁴	Stalk + cob	1.2-2.5	2.0	782	0.529	413.7
Soybeans	170.5	Stalk	—	1.5	170.5	0.543	92.6
Firewood in cropland		—	—		500	0.571	285.5
Firewood in idle land		—	—		466.7	0.571	266.5

¹Crop to Residue Ratio (CRR) as calculated by Barneard and Kristoferson (1985).

²CRR as calculated by The Editorial Team (1990). This data was used for all future calculations.

³TCE is total coal equivalent. The TCE of biomass with different energy content are computed for comparison.

⁴As no corn was grown in the village, I use the provincial average yield for corn instead, obtained from the Provincial Statistical Yearbook (1995).

Table 2: Cost Estimates for Biomass Generated from Various Options

Options	Grain revenue (yuan/mu)	Planting cost (yuan/mu)	Grain profit forgone ¹ (yuan/mu)	TCE (kg/mu)	Collection & Harvest Cost (yuan/mu)	Total cost of TCE (yuan/mu)	Price (yuan/kg TCE)
2-crop/year Agricultural Options							
Wheat & Rice	429 701.4	207 295	—	195 214.9	— 20.0	— —	— 0.093
Wheat & Corn	429 625.6	207 295	— 75.8	195 413.7	— 20.0	— 95.8 ²	— 0.23
1-rotation (20 year) Forestry Options							
Firewood ³ in cropland	0	123.6	628.4	285.5	2	764 ⁴	2.68
Firewood in idle land	0	123.6	0	266.5	2	125.6	0.47

¹ Values in this column represent the total profit from grain that was not made as a result of switching from wheat and rice. For corn and wheat, it is the profit from rice. For firewood in cropland, it is the combined profit of rice and wheat. For firewood in idle land there is no possible grain profit.

² Grain profit foregone + Harvest & Collection Cost

³ Values for firewood are based on year-round totals, other crops are based on one growing season.

⁴ For both forestry options: Total Cost of TCE = Planting Cost + Grain Profit Foregone + Harvest & Collection Cost. The annualized harvest and collection cost for firewood is estimated to be 2 yuan/mu since firewood is harvested every five years and collection of firewood is less labor-intensive than rice straw or corn stalks.

The unit cost of biomass produced under each option is shown in Table 2. Switching from rice to corn would yield more biomass at 0.23 yuan/kg of TCE, more than twice the cost before switching. However, the 1997 price of coal for household use was 0.347 yuan/kg of TCE (www.gcinfo.com/becon/price.html). Compared to the market price of coal, biomass energy gained from crop switching is still cheaper.

The firewood planting in current cropland generates 285.5 kg of TCE/mu. In contrast, the annual rotation of rice and wheat produces (214.9+195)=409.9 kg of TCE/mu. Therefore, the dedicated biomass production in this agricultural area yields less biomass compared to crop production (surprising!). Furthermore, the unit cost of biomass from firewood is 2.68 yuan/kg of TCE, much higher than the current market value of biomass of crop residues. As a result, the firewood option is not justified in this area in term of yield and cost biomass generated. I also calculated the yield and cost of firewood production in idle land for comparison. The calculations show that dedicated biomass production in idle land (i.e. no grain production activities) is superior to that in crop-land, but less valuable than corn production, as seen from the lower yield (266.5 kg of TCE/mu) and higher cost (0.47 yuan/kg of TCE). Therefore, assessing the availability and the potential of using crop residues for energy purposes is site specific. Some regions have comparative advantage in providing crop residues while others are superior in dedicated biomass production, depending on the quality of the land, climate, etc.

Discussion

There are a few factors that could complicate the cost estimates of production of biomass as a potential modern energy resource. The study assumes unrestricted change of land use in the market economy. However, the current crop growth (rice and wheat rotation) represents the most valuable land use option, which is fundamental to meeting the pressing need for food in China. Furthermore, the amount of arable land is decreasing every year due to the encroachment of booming industrial enterprises (National Agricultural Resource Plan Office, 1997). Therefore, the change of land use from grain to dedicated biomass production may turn out to be difficult, if not impossible.

In addition, if rice paddies are dedicated to biomass production or corn growth, grain output will decrease and thus the price

will increase. For corn growth, the corn price will go down as a result of the increased output. Consequently, the biomass cost will increase, and possibly put either option out of question.

Importing biomass from other villages is another option to get more biomass. The typical transport distance of crop residues for kiln use is within a radius of 10 kilometers. The kiln managers usually pay double the on-field price for crop residues transported to the kilns, including unloading and loading costs. The on-kiln price is comparable to that of the crop-switching option. However, if advanced biomass technology (such as village-size gasification) is commercialized and widely adopted by farmers, each village would like to retain crop residues to meet its own need first. Only the excessive part would be available

for neighboring villages. Therefore, in the long haul, the reliance on imports of crop residues is insecure.

Another factor pertaining to the use of crop residues for energy is the seasonality of supply. Residues are only available for a limited time during the year. In order to be able to supply them year around, sizeable storage capacities will be required. Although the storage problem can be reduced significantly by compacting the residues into pellets or briquettes and by employing appropriate drying methods, storage is generally expensive, especially in wet climates.

The availability of biomass for energy conversion is also constrained by other competing uses such as organic fertilizer and animal feed. About twenty one percent of arable land is treated with crop residues to improve the soil fertility around China. Some crop residues are also used for fodder, the wastes of which are then returned to the field as fertilizers. It not only affords significant economic benefit in animal husbandry, but also eliminates the concern about pest and weed control where crop residues are returned directly to the field. If all crop residues are supplied for gasification process, the benefits derived from other competing uses will be gone. During my field trip, the government officials expressed an intention of increasing recycling of biomass as organic fertilizer. However, as there is currently an excessive supply of crop residues, the future of such a political will is uncertain.

Conclusion and policy implications

There is a plentiful supply of crop residues for conversion to modern energy in the agricultural areas of eastern China. Their utilization should be confined to the source of production or to the local community in order to avoid expensive long-distance transportation. More biomass can be attained through crop switching from rice to corn. However, dedicated firewood production in fertile farmland would drive the cost of biomass much higher than other fossil fuel substitutes. Thus, it would not make economic sense for this area to develop dedicated biomass production.

In addition, as a result of this fieldwork, the need for consideration of several additional issues has become clear. As far as the science is concerned, there is much room for R&D of new biomass conversion technologies. Although technology to convert biomass into cooking gas looks promising, technical difficulties exist for

using rice straw, due to its high silica content. With straw and stalks as raw materials, a fair amount of tar is produced, which is hard and costly to remove from the gas.

Furthermore, given the availability of sound technologies, many institutional and informational barriers will need to be overcome. First of all, the technical capacity for use of biomass gasification technology is limited in China. The low heat value of gas (about one third of coal) substantially increases pipe network costs (although it does not affect end-use). Second, farmers have little access to credit. For a 200 household gasification system, the average up-front cost per household is above RMB 2,000 yuan, nearly equal to annual per capita income in medium developed rural areas. In China, very limited credit flows to the rural areas except the Township and Village Enterprises (TVEs). This can be explained by a) farmers have no credit reputation; b) the small amount of each request leads to a high transaction cost; c) there are not many credit requests under the traditional self-sufficient agro-economy. Although the 200 million rural households nationwide represent a huge potential market, the lack of credit targeting farmers forms an insurmountable barrier to market development. Third, standards and codes of practice do not exist. Without unified standards, users are unsure of the product quality. Fourth, no service and commercialization infrastructure exists. There is no sales and service network; sales must be made directly from the manufacturer to the user. Fifth, there is inadequate awareness of the new technology and its potential among rural households and policy decision-makers. Little market information is available for businesspersons and users.

Nevertheless, rural China presents us with a potentially huge market for promoting biomass use. The vast rural population who has little knowledge of global warming could be brought to the front lines in contributing to the mitigation efforts. Policy makers should consider this enormous GHG reduction potential when deciding on China's future energy policies.

Xiaoping Wang, MES'99, is enrolled in the Ph.D program on science, technology, and environmental policy at the Woodrow Wilson School of Public and International Affairs of Princeton University. Her research is focused on the co-benefits (global and local) of air pollution control in developing countries and energy policy implications.

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An Evaluation of Samoa's Co-Management Regime for Coastal Resources

John W. Virdin

Introduction

The Pacific Island country of Samoa (also known as West Samoa) is home to many communities that depend on the surrounding coastal resources for food and income (World Bank, 1999). However, it has been widely reported over recent years that catches of fish and shellfish have been declining in the lagoons and inshore reefs of Samoa (Horsman and Mulipula, 1995 in King and Fa'asili, 1999). This decline has resulted from overharvesting of the resources, as well as destructive harvesting methods and habitat degradation due to pollution (King and Fa'asili, 1999). Unfortunately, these threats to the coastal resources are not unique to Samoa, as a recent World Bank survey of 31 communities throughout the Pacific Islands region found an overwhelming majority of respondents perceived that coastal resources were declining (World Bank, 1999).

In order to reverse this trend, many of the governments of Pacific Island countries have committed over the last few years to implement collaborative management (co-management) regimes that devolve some of the responsibility for management of coastal resources to the communities, rather than the centralized, top-down regimes inherited in large part from colonial experiences (Adams, 1998). These co-management regimes represent collaborative strategies that incorporate institutional mechanisms to share the responsibility for management of the coastal resources between the government and the communities, resource users, and various other stakeholders involved (Singleton, 1998, Kildow, 1997). As these regimes continue to be created and implemented, it will be essential that the countries create optimal institutional arrangements to serve as the foundation for management of their coastal resources.

Methodology

Towards the creation and implementation of a co-management regime to manage coastal resources in the Pacific Islands, Samoa has been the leader, serving as a model for the rest of the Pacific Island countries since the regime was created in 1996 with the help of AusAid. In order to determine if the institutional arrangements of Samoa's co-management regime were working and could possibly be transferable to other Pacific Island countries, this paper studied the co-management experience in Samoa based on the current documents available as well as through interviews conducted with Samoan managers. The study was used to form a brief outline of the Samoan co-management regime, summarized by an institutional diagram created as a point of reference from the study. The institutions forming the Samoan regime were then evaluated using the current literature and examples available of institutions successfully created to implement co-management regimes for coastal resources. Based on this evaluation of the Samoan co-management regime, it was possible to highlight some strengths and weaknesses of the regime and make some recommendations for future management.

Results

In order to create a co-management regime to respond to the decline of Samoan coastal resources, the Fisheries Division (the national fisheries agency in Samoa) began in 1995 by developing a

policy framework that would enable communities and Government to share management responsibility, with the assistance and promised financial support of AusAid (King and Fa'asili, 1998). The co-management regime was set up in 1996 as a demand-based institution, responding to community needs for technical assistance and information.

According to the policy framework, the Government (Fisheries Division) would act within its capacity on a graduated basis to provide extension services to 10 communities a year. The goal of these extension services was to provide an initial link to negotiate the process, provide technical assistance and information, and help create community institutions to manage the coastal resources, which could be given legal recognition. Legal recognition would come from rules adopted by the community institutions that Government extension officers could harmonize with national laws, and then codify into legally binding rules (King and Fa'asili, 1998).

This process is designed so that extension officers would first meet with the community institution in authority, which is the village council, or fono. Then, if the fono was interested or convinced of the need to manage their coastal resources, the extension officers would meet with the entire community to negotiate the co-management process (King and Fa'asili, 1998). These negotiations might consist of defining what functions the Government will perform, what functions need to be performed in general to manage the resources, who will perform these functions, and what rules and regulations will be needed.

In addition to the negotiating process, the extension officers work with the community to define the community institution that will be responsible for the actual day-to-day management of the resources. In this case, that institution is the Fisheries Management Advisory Committee (FMAC), which works with Government extension officers and the technical assistance, information, and national laws that they provide in order to create a management plan with rules governing the use of the resources (King and Fa'asili, 1999). Often, one of the major parts of the functions performed by Government extension officers is to help the FMAC adopt and adapt national rules locally. In cases where traditional rules already exist, Government extension officers can take these and make them into legally recognized by-laws, where these rules formerly relied on respect for the traditions.

The FMAC takes the management plan to the fono for approval, upon which the FMAC becomes the official Fisheries Management Committee (FMC) to implement and perform management, remaining in contact and communication with the Government extension officers (King and Fa'asili, 1998). Once the management plan is approved by the fono, representatives from the FMC take it to the Government extension officers (Fisheries Division) to harmonize the rules and regulations with national law. The final version is submitted to the Attorney General's Office to be codified into law, and then published and disseminated, often over the radio (Fa'asili, Personal communication).

What are the results of the implementation of these institutions for co-management in Samoa? By 1999, the Fisheries Division

had assisted 61 communities to begin or strengthen management of the coastal resources, and 53 had created rules to govern their use (noted as by-laws in the Samoan legislation).

Discussion

When comparing the Samoa's co-management regime with examples from the current literature of institutions successfully created for co-management, one of the most readily apparent differences is that the fono cannot legally exercise customary marine tenure (ownership or user rights to the coastal zone or its resources), as the Samoan Constitution does not recognize exclusive rights to the resources (Fa'asili, Personal communication). It has been noted in other experiences with co-management regimes that clearly defined boundaries of community ownership or user rights to the coastal resources in the coastal zone are a key component for empowering local management, allowing communities to monitor and enforce rules in that area (C. Pomeroy, 1994). Without customary marine tenure in Samoa, the result is that coastal areas cannot be limited access resources—any restrictions or rules must apply to everyone, so communities cannot restrict external harvesting effort without limiting their own. Thus, the lack of formally recognized customary marine tenure does not allow management to be as flexible as it could be, and often results in more harvesting rather than less.

Another difference, and perhaps a hindrance, is the institutional structure of Government cooperation with the communities, and that structure's capacity to perform the necessary functions. As mentioned previously, the current structure relies on an extension program to work with the community institutions responsible for management (FMAC/FMC) and to provide them with technical assistance and information, an open channel of communication, and legal assistance to harmonize rules and regulations with and codify into national laws. In contrast, several examples from the literature suggest joint committees for regions or communities between Government representatives and representatives from the community institutions (Berkes, 1989, Jentoft and Mikalsen, 1994). The Fisheries Division's extension plan does share some of these structural features, with extension officers and assistants for each region of Upolu and Savaii. This structure shares some of the advantages of joint committees, since officers and assistants for a region maintain scheduled meetings with FMACs/FMCs to provide the necessary services. However, more formalized joint committees could improve the efficiency of these services, the regularity of meetings, and also allow for FMACs/FMCs from different communities to communicate to each other as well. Another advantage of this approach is that it prevents arbitrary and preferential treatment of extension services, as committees are more accountable.

The need for a more efficient institutional process to exist within the extension program is just one aspect of the challenges facing this program. The program simply has not been able to meet the demands of the communities for the necessary functions of a co-management regime. Although the policy for implementing the co-management regime calls for a staggered implementation process (10 communities a year), even this graduated approach may be too much for the Fisheries Division to carry out, as the extension work required just to provide the initial link to these communities may exceed their capacity. This is exacerbated in part by poor management of the extension officers by the Division, with low salaries and little recognition for what is becoming an unwanted job. With the present resources, the Fisheries Division will have to ration its extension services, providing the initial link to negotiate the policy

process and facilitate the creation of FMACs. After this function is performed, Government extension may be less and less necessary, as long as the community has open communication channels to communicate problems such as pollution, and/or receive technical assistance, information, and national laws to adopt locally.

A tapered schedule of extension services agrees with the guidelines set by the external funding source for the co-management regime in Samoa (AusAid). These guidelines state that the Government extension to provide the initial link for communities should not end there, but continue to provide technical assistance through at least monthly visits. It would seem probable that this schedule for performing the necessary functions of the extension could be performed more efficiently by regular meetings of a joint committee.

Unfortunately, the extension services of the Fisheries Division do not appear to have been able to support themselves after AusAid funding terminated, as the continued extension services for management have proven difficult for Samoa. Generally, co-management regimes require large initial investments to create (mostly in order to provide the initial link), but are fairly inexpensive to operate, once an efficient institutional structure has been put in place. The problem with some inefficiencies with the Samoan institutional model have been noted, but it is a difficult situation for the Government since the process is a graduated one that continuously demands larger investments of time and resources to provide the initial link to communities. External funding is often key to providing this initial link for developing nations, and Samoa will continue to face this obstacle until all target communities have initiated management plans. This is not to say that the inputs to operate the program are not low compared to the prospects of Government monitoring and enforcement; however initiating a co-management regime is a large undertaking for many countries like Samoa, as it requires a commitment of funding from the Government.

Lastly, a comparison between the two institutional structures reveals the lack of coordination of Government activities in the coastal zone of Samoa. The co-management regime stems from the Fisheries Division, rather than a committee with joint jurisdiction across Government. Were such a committee to exist, and if the Fisheries Division were in communication with that committee, then the impacts of habitat degradation from pollution could be communicated from the communities to the Fisheries Division and a coordinating committee. The result would be that the effects of policies and activities on the coastal zone that are under the responsibility of separate Ministries could be understood and remedied by the relevant Ministry.

Conclusion

Samoa has created a working model of a co-management regime for coastal resources in the Pacific Islands region. The Fisheries Division has become a demand-based agency providing technical assistance and legal recognition to community management institutions. However, examples from current literature suggest that customary marine tenure is a key component of a co-management regime, while Samoa does not recognize closed access to the coastal resources. This has not been a major problem yet because traditional rules set by Chiefs over the resources are still respected by outsiders, but if external pressures begin to erode traditional management then customary tenure may need to be legally recognized.

The co-management regime in Samoa has been somewhat of a success in reaching communities and establishing shared responsibility for the resources, but funding to drive the program is

running low, as management is not a revenue-generating exercise. The Government will have to commit funding to continue to operate demand-based institutions that include communities in coastal management, as external funding may not always be available. Hopefully, the process that has begun to devolve responsibility for management of coastal resources to the communities will continue, in Samoa and throughout the Pacific Islands region.

John W. Virdin, MES '99, is currently working on marine and coastal resource management issues at the World Bank, assisting the Regional Economic Review of the Pacific Islands

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Economic, Ecological and Social Implications of the Betel Production, Consumption and Market System on Yap, Federated States of Micronesia

Sylvia M. H. Stone

Introduction

The custom of betel chewing is a significant aspect of the culture, society and economy of the island of Yap, Federated States of Micronesia (FSM). In this article, I focus on several of the economic, ecological and social implications of the rising export levels of the betel chew components. The overall sustainability of the betel production, consumption and market system for the people and island of Yap is also considered. On Yap, the betel chew is composed of areca palm fruit (*Areca catechu* L.), betel pepper leaves (*Piper betle* L.), slaked lime produced from coral (*Acropora* spp.) and imported tobacco (*Nicotiana* spp.). The economic and social implications to Yap of this fourth major component of the betel chew, imported tobacco, is also discussed.

Background

Yap State is part of the Federated States of Micronesia (FSM), and is located in the Caroline Island Archipelago (see Figure 1). Together with the states of Chuuk, Pohnpei and Kosrae, the FSM extends across 1800 miles of the North Pacific Ocean. Yap State includes a cluster of four main islands with an area totaling approximately 39 square miles (Yap Proper, herein referred to as Yap) and fifteen outer island groups (Falanruw et al. 1987). Yap was settled approximately four thousand years ago by people ultimately derived from insular Southeast Asian populations to the west and south of Micronesia

(Hunter-Anderson 1991). The current population is 6,919 people (Yap State Census Report 1996) although past population density is estimated to have ranged between 26,000 and 40,000 (Falanruw 1992).

The Betel Custom

The fruit of *Areca catechu* L. a member of the palm family Arecaceae, is chewed throughout parts of South Asia, Southeast Asia and Oceania by an estimated 10% of the world's population (Rooney 1993, Conklin 1958). The custom of chewing the fruit is over 2000 years old and speculated to have arisen in the Indonesian archipelago (Rooney 1993). The areca fruit is often chewed as a masticatory in combination with the leaf, stem or inflorescence of *Piper betle* L., a vine in the pepper family Piperaceae. In addition, lime in the form of calcium hydroxide or calcium carbonate is added to these two ingredients to form the three primary components of what is known as the betel chew or quid (Rooney 1993). The combination of the three ingredients provides the basis for the stimulatory effect of the quid, due in part to the chemical reaction of the areca fruit and the lime. The most recent addition to the betel quid on Yap is tobacco (*Nicotiana* spp.) that is imported in the form of rolled tobacco leaves or cigarettes. The areca fruit are generally referred to incorrectly as nuts, and on Yap the English term used to describe the fruit is betel-nut, the term I use throughout this article.

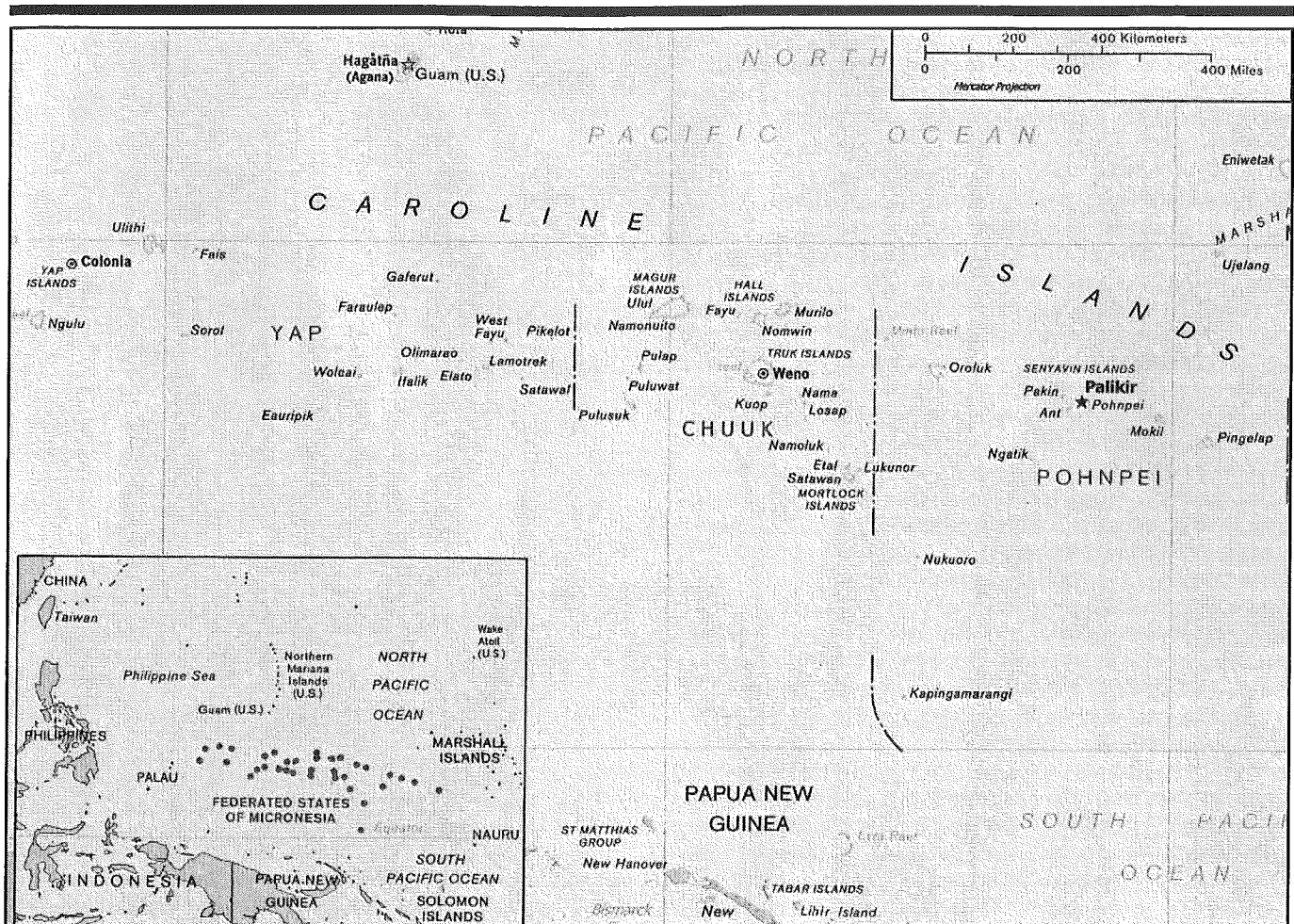


Figure 1: Yap is the westernmost state of the Federated States of Micronesia. Research was conducted on Yap Proper, a cluster of four main islands that is home to Colonia, the state capital.

Methods

In order to assess the ecological, economic and social implications of the betel production, consumption and market systems of Yap, two types of data were gathered. Qualitative information consisted of interviews with Yap State government officials from the Division of Agriculture and Forestry, the Division of Commerce and Industry, the Business License Board and the Legislature. In addition, semi-structured interviews were conducted with four out of Yap's five primary betelnut exporters. Finally, unstructured interviews and participant observations were carried out with Yap residents, the majority of whom manage, harvest, purchase or consume betel products.

The second type of data consisted of a written questionnaire aimed at assessing the economic gain to smallholders resulting from the sale of betelnut, as well as export records from Continental Air Micronesia for the first six months of 1999. From these records, the questionnaire and a survey of betelnut prices, an estimate of the amount and monetary value of betelnut exported from Yap in 1999 are made. In addition, available government and aid agency documents, websites, local publications and published literature are also used in this analysis.

Economic Implications of the Betel System

Betelnut, betel leaves and lime on Yap have been a key component in the traditional economy, where they are used as offerings to the

family members of deceased persons at funerals. In addition, members of a husband's family give betelnut and betel leaves as gifts to the wife's family at weddings. When a person is sick or in the hospital, visitors often bring offerings of betelnut, betel leaves and lime, as well as other items such as coconuts (Mochien pers. comm.). Data from the past 20 years (Falanruw unpublished) indicates that betelnut has also been a market commodity sold locally, a practice that has increased significantly over time. The local cash economy surrounding the components of the betel chew links the smallholder to the local retailer and the consumer. Betelnut, betel leaves and lime are sold readily at stores and gas stations as well as the airport.

The export market for betelnut and betel leaves has been especially important to Yap since the first significant amounts began to be exported in 1990 (Tamag pers. comm.) (See Figure 2). State quarantine records indicate a steadily rising amount of betelnut exported, and data from the freight records of the major airline servicing Yap shows the same trend (Division of Agriculture and Forestry 1996-1998, Continental 1999). When the quantity of betelnut exported is calculated to reflect the dollar value (at the time of my research) of the commodity, the resulting value is over US\$2.5 million for the year 1999. Assuming my calculation approximates the level of actual returns, betelnut stands as the most valuable agricultural commodity for Yap, greatly surpassing the income generated from the state regulated production and export of copra (produced

from coconut, *Cocos nucifera*) (See Figure 2). It may also render this product the most significant export agricultural commodity for the entire FSM and is documented as such for 1995 (FSM Trade Bulletin 1998).

I conducted a survey of 61 smallholders on Yap to assess the value of betelnut earnings to individuals. Although this survey was conducted at the individual level it serves to approximate the relative value of betelnut to households on Yap. The results of the survey indicate that the average income gained from betelnut sales was over 160% of other income earnings, and 75% of total responses indicated that this income was spent at least partially on food. More than half of the respondents indicated that selling betelnut to exporters and local stores was common and a preferred action. Seventy-two percent of respondents had engaged in selling the fruit for over a year, and 84% engaged in this activity once or twice a week. Forty percent of respondents indicated that they had been selling betelnut for more than five years. Thirty-six percent of those surveyed had no other source of cash income (Tables 1 & 2).

The income gained by the export of betelnut and betel leaves provides local smallholders with a significant amount of cash relative to their per capita income. The average annual individual income reported from sales of betelnut was US\$4,889 and the median was US\$2,860, while the average annual individual income from all other sources was only US\$3,056 and the median was only US\$2,602. Over 90% of the respondents indicated that the income gained from betelnut sales was either 'very important' or 'important' to their livelihoods, and 93% of the respondents stated that this income was 'more important' to them than when they first began to sell betelnut.

Because of the official 'subsistence' status of betel production, there is no national or state taxation for smallholders unless their produce is sold to an established business, in which case there is a business license fee of US\$25 (Tiltongin pers. comm.). For

Table 1: Smallholder Survey Results: Income from Betelnut

72.13% of respondents	Have been selling betelnut for over a year
83.61% of respondents	Sell betelnut once or twice a week
36.07% of respondents	Have no other source of cash income
\$188.07 every two weeks	Average income from betelnut
\$117.56 every two weeks	Average income from other sources
\$110.00 every two weeks	Median income from betelnut
\$100.10 every two weeks	Median income from other sources
161.98%	Percentage that average betelnut income exceeds average income from other sources
109.89%	Percentage that median betelnut income exceeds median income from other sources

Table 2: Smallholder Survey Results: Spending Behavior and Importance

75.41% of total responses	Indicate that income earned from betelnut is spent partially on food
60.60% of total responses	Indicate that income earned from betelnut is spent partially on alcohol and tobacco
91.80% of respondents	Claim that income earned from betelnut is either 'very important' or 'important'
93.44% of respondents	Claim that income earned from betelnut is 'more important' now than when they began

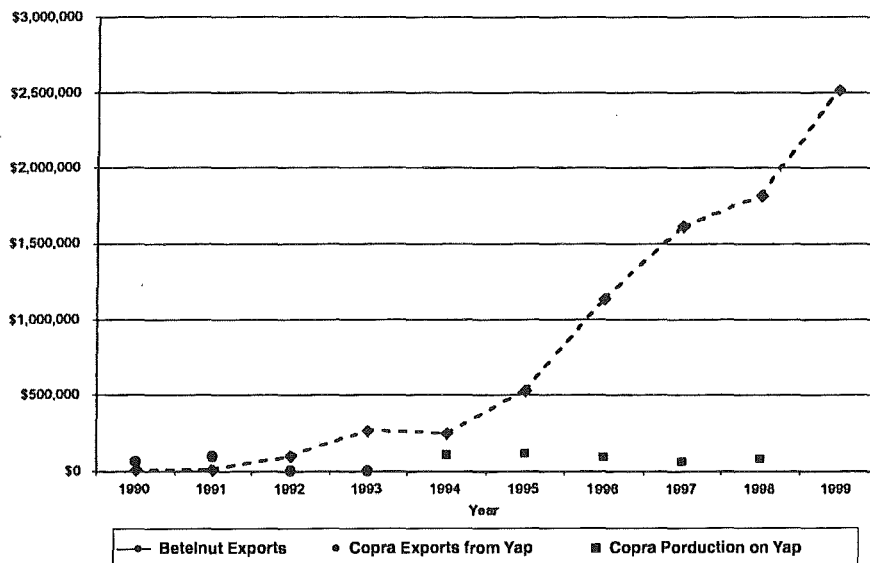


Figure 2. A comparison of betelnut and copra production and export levels for Yap, 1990-1999. Values are in US dollars

exporters of betelnut there is a FSM government annual export license fee of US\$250, and a Yap State agricultural permit fee of US\$1.50 per shipment (Tiltongin pers. comm.). However, both of these costs are minor when compared to reported annual revenues ranging between US\$24,000 and US\$201,490 (Young-Uhk 1998), given that the average household annual income on Yap is US\$9,166 (Yap State Census Report 1996).

The betel chewing custom has increased in recent years in other regions of Micronesia, either as a result of emigration of people from traditional betel chewing areas or because progressively more people have begun to engage in the practice. Areas where the custom was indigenous include Yap, Palau and the Mariana Islands, primarily Guam and Saipan (Lichtenberk 1998). However, further east in the Caroline Island archipelago on the islands of Chuuk, Pohnpei and Kosrae where there is no history of the betel chewing custom, islanders have begun to increase their consumption of betelnut (Sulog pers. comm., Falmngar pers. comm.). The overwhelming majority of Yap's betelnut exports currently go to Guam and Saipan. In 1998, 101,280 pounds of betelnut were reportedly exported to Guam and 80,750 pounds were sent to Saipan (Division of Agriculture and Forestry 1998).

The stability of the demand for Yap's betelnut on Guam and Saipan is relevant to the overall sustainability of the economic and market system. Although betelnut is produced on Guam and Saipan, the majority of their production is of a 'red' variety traditionally preferred by indigenous Chamorros. Therefore the 'pale' variety produced and exported from Yap fits a market niche in that the demand for the 'pale' variety on Guam and Saipan is not met by local supply. There is also a temporal dimension to Yap's market niche, as areca palm trees on Saipan reportedly only produce fruit for roughly 6 months of the year, whereas Yap's trees produce continuously year round (Tamag pers. comm.) although less so during the dry season. However, the demand for Yap's betelnut in other regions of Micronesia may decrease if efforts to grow areca palms (of the 'pale' variety) on other islands increase. Some effort to locally produce betelnut has begun in several of the eastern states of the FSM, notably on Pohnpei (Falanruw pers. comm.).



A dense area of areca palm within an agroforest, betel vine (*Piper betle*) is growing on the trunk of the centermost tree.

A significant cost to Yap from the betel system may come from the economic cost of importing tobacco to Yap. On Palau, where some 70-80% of the population add tobacco to their betel chew, the cost of tobacco imports is reported to be US\$9.4 million (Palau Horizon 1999). Given similar per capita tobacco usage rates on Yap, the cost of tobacco imports may potentially exceed the economic returns from the export and sales of all three other betel chew components.

Ecological Implications of the Betel System

The areca palm and the betel vine are both cultivated in traditional Yapese tree garden and taro patch agroforestry systems that are generally found around villages close to the coast (Falanruw 1993). Within the tree gardens, about 55 trees are commonly grown in association with around 60 species of shrubs and herbs (Falanruw 1993) that are useful to people for timber, medicine, fiber, ornamentation, food and spices (Falanruw 1994). The system as a whole represents a great wealth of genetic diversity, as many species have several varieties planted for their unique characteristics (Falanruw 1994).

In addition to providing humans with direct sources of food and other resources, the agroforestry systems have ecological functions that mimic natural forests and hydrological cycles. The tree canopy protects soil from erosion while providing nutrients in the form of litter, and the taro patches serve to filter sediments from water before reaching the ocean (Falanruw 1993). The structural complexity and species diversity of the tree garden and taro patch systems render them resilient to disturbances and provide ecological stability in the long run (Falanruw 1993). However, if the cultivation of areca palm (and to a lesser extent betel vine) continues to increase

within these agroforestry systems, they may begin to replace other species in terms of area and density. There is local concern that the increased dedication of scarce land area to the cultivation of areca palms will subtract from the resources needed to maintain the other components of the agroforest, especially those species which provide food (Sulog pers. comm.).

The harvesting of coral (*Acropora* spp.) and mangrove wood (*Rhizophora* spp.) for the production of lime also has potential ecological implications. The coral is collected live from the nearshore fringing reef, and the mangrove wood is harvested from areas of mangrove forest with a motorized chainsaw (Garachbar pers. comm.). However, the knowledge, skill and intensity of the labor involved in the production process may stand in the way of a significant increase in the production of lime. This could therefore keep stable the ecological impacts of harvesting coral and mangrove for this purpose.

At present, the management of the nearshore reef and mangrove forest for the production of lime is conducted at the village level. Access to the reef and the mangrove forest is open to the lime producers. At the Yap State government level, the Division of Marine Resources (Taflicheg pers. comm.) conducted no monitoring of the harvest of these natural resources at the time of my research.

Social Implications of the Betel System

The chewing of the betel quid has an important social role. Betel is chewed on Yap in mundane everyday contexts as a stimulant (Hirsch 1995) and also has important ritual significance in meetings, as offerings, and at funerals and weddings. The societal obligation of giving betelnut and betel leaves to others is still strong today in Yap. When friends or family members gather or pass by each other, it is common for one person to ask the other for betelnut.

The increasing value of betelnut as a cash income earner has increased the theft of betelnut throughout the island. Traditional village chiefs have in the past dealt with theft locally, but a recent bill passed in Yap State legislature mandates a restitution of US\$500 if a person is convicted of stealing betelnut. The concerns voiced about this bill surround the issue of the balance between the traditional role of village chiefs and the Yap State government (Journal of the Fifth Legislature 1999). The specific fine designated for the theft of betelnut is a notable example of the influence of the crop's economic status on Yap, as theft of any other property does not come with a predetermined fine (Vosseller pers. comm.). Finally, there has been concern voiced among island elders that the export of betelnut reduces the availability and increases the price of betelnut on Yap itself, especially during the dry season (Falanruw pers. comm.).

A major societal implication of betel chewing stems from the health concerns associated with the custom. Some studies indicate that the three primary components of the chew can be carcinogenic, although it is unclear which one is the causative agent (Norton 1998). In particular, the use of the lime and the betelnut appear to be harmful to the mouth, head and neck. According to one American doctor on Yap, the Yapese rate of oral cancer is about 15 times the world rate, rendering this "practically an epidemic" (Rutstein pers. comm.). The cause of the most concern however is the tobacco component of the chew, which is said to greatly increase the chance of oral cancer (Rutstein pers. comm.). The social cost of the betel custom is therefore high given its potential health risks.

Conclusion

Yapese ecological and social systems have allowed for the successful production of areca palm fruit, betel pepper leaves and slaked lime, the three primary components of the betel chew on Yap. Until recently, the production system appears to have remained stable, allowing for a sufficient supply of each resource for resident islanders. Over the past decade, international demand has resulted in a rise in the amount of betelnut exported, creating a significant source of cash income for local smallholders and exporters. These trends in the betel production and use systems may have far-reaching effects, economically, ecologically and socially.

Economically, although the international demand for Yap's betelnut will likely remain strong in the short term, if efforts on other islands to produce betelnut locally succeed there could be a decline in demand over time. In addition, the economic costs of importing tobacco may potentially exceed the economic benefits of the formal and informal market system of betel production on Yap. Ecologically, increased production of betelnut may impact the agricultural ecosystems in Yap that provide the basic ingredients for the betel chew. Socially, Yap has already experienced increases in betelnut theft and some traditional and state institutional responses. Another significant social cost to Yap is posed by the use of tobacco in the betel chew, which is implicated in the high rates of oral cancer. Thus, although the economic benefits to Yap are high and seem to be increasing, there are significant social and ecological implications with the betel system. A thorough analysis of the implications of the above trends of the betel production and use system need to be undertaken if the goals of socio-economic development through sustainable use of these natural resources is to be pursued on Yap.

Sylvia Stone, MESC '00, will continue to live in New Haven, CT pursuing research in tropical resource issues.

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Current Stand Structure of *Polylepis reticulata* in the Sacha Huayco Forest of Ecuador and Implications for Regeneration

Jennifer Osha

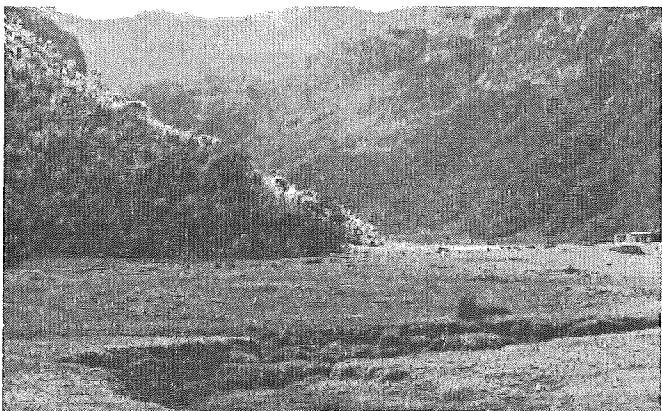
"Páramo" is both a general and local term for the area above the continuous forest line but below the permanent snowline. The term páramo includes both grasslands and scattered relict woodlands dominated by *Polylepis*, *Gynoxys*, and *Buddleja*. Although only a few tree species are found in the páramo, these woodlands contain an understory that is both high in endemic species and extremely biologically diverse. The rapidly increasing human population in the Ecuadorian Andes has resulted in an almost complete conversion of remaining high Andean forest to agricultural land. Currently, very little closed canopy forest remains. In response to increasing problems of erosion, land deterioration and conversion, and negative impacts from foreign species, the propagation of native Ecuadorian trees is becoming increasingly important. A deeper understanding of the growth and establishment needs of native trees is needed for successful reforestation programs to be implemented.

This study presents new information about the overstory structure of páramo woodlands dominated by *Polylepis reticulata*, one of the few trees in Ecuador which grows at elevations of over 4000 meters. Such base-line data is necessary for further research questions to be designed. In addition, this research makes comparisons in the structure of *Polylepis* stands at different positions along a slope to facilitate understanding about the requirements of *Polylepis* for growth and establishment.

Studies like this one are essential if local reforestation projects with *Polylepis* are to occur. Information gained from this study was presented to the department of Natural Resources at the Escuela Superior Politécnica de Chimborazo, Ecuador, in January, 2000. In addition, access to this project's findings will be made available to Proyecto Páramo, an organization that is currently working with local communities to design a páramo management plan.

Introduction to Páramos

Páramo vegetation can be found within the tropical regions of Central and South America, Africa, Malaysia, Mexico and Hawaii. Within the Andes, these areas are known locally as "páramo" in northern South America, "puna" in the central Andes, and "jalca" in northern Peru. In Ecuador, "páramo" is used specifically to signify a humid, mostly open system of vegetation from 3000m to 5000m



The Ecuadorian páramo

dominated by rosette plants, evergreen shrubs, and tussock grasses (Luteyn, 1999). The current appearance of the páramo has anthropogenic origins, having been maintained by cutting, periodic burning, and grazing, practices that have intensified within the last 3000 years (Ellenberg, 1979; Luteyn, 1999). In contrast to the "puna" of southern Ecuador and Peru, the central Ecuadorian páramo generally has moisture in the form of fog, clouds, or rain throughout the year.

Páramo soils are generally only slightly developed and are dominated by Andisols, Inceptisols, Histosols, and Entisols. These soils are deep, humic, black or dark brownish, and acidic with a pH from 3.7-5.5. These soils are continually moist or even saturated with water because of the daily formation of dew and frost and the water-retaining capabilities of the highly organic, peat-like content (Luteyn, 1999). These water-retention capabilities make the páramo an important factor in the water supply of Andean communities. High altitudes at tropical latitudes are characterized by an enormous variation in diurnal temperatures. In Quito, the capital of Ecuador, there is only a 0.5°C difference in temperature between July and January as compared to a 9°C difference in mean diurnal temperature (Goldstein et al, 1994). Plants and animals living in the páramo therefore experience all "seasons" in the same day.

Although páramo accounts for only 2% of the land area in countries where it is found, it is extremely high in endemic species as well as biological diversity (Luteyn, 1999). The páramo is dominated by grasses of the genera *Agrostis*, *Bromus*, *Calamagrostis*, *Festuca*, and *Poa* (Luteyn, 1999). Peat bogs often occur in the páramo as well, with cushion plants such as *Plantago rigida* and *Distichia muscoides*. Trees of the genus *Polylepis* often mix with *Gynoxys* and *Buddleja* to form isolated stands of trees. Plant diversity under *Polylepis* stands is much higher than in the surrounding areas. In addition, certain plants in the páramo can only grow under *Polylepis*. One study (Kessler, 1991) found that 35% of plants used for edible and medicinal purposes by local peoples grow only in *Polylepis* woodlands.

Polylepis Woodlands

Polylepis (Rosaceae) likely occurs naturally at higher elevations than any other arborescent angiosperm genus in the world (Goldstein et al, 1994). Also called Quenua or Yagual in Ecuador, it grows at elevations of 2600 to 5000 meters. The *Polylepis* is an important genus in preventing erosion and land degradation as well as providing the major source of fuel and building supplies for local communities. In Ecuador six species of *Polylepis* have been found: *P. incana*, *P. racemosa*, *P. sericea*, *P. cuadriflora*, *P. besseri*, and *P. tomentella* and *P. reticulata* (CESA, 1993; Simpson, 1979). In higher altitudes, one to two species form stands where *Polylepis* constitute up to 90% of the tree species.

Eucalyptus globulus and *Pinus radiata* have been used widely in plantations and reforestation programs in Ecuador. However, the extensive planting of these exotic species has been challenged by ecologists, who view it as a threat to the local ecosystems (Brandbyge, 1992; Fjeldsa, 1996). Concern within Ecuador about the use of exotic species, as well as land deterioration, erosion, and

damage to watersheds, have resulted in a number of studies on the propagation and uses of native trees (CESA, 1993; Idrobo, 1992). Great strides have been made towards increasing knowledge about the uses of native species, but there remains a lack of basic knowledge on the growth requirements for many native species.

Although some research has been done on the taxonomy and speciation of *Polylepis*, (Romoleroux, 1992; Simpson, 1986) there is very little information about the regeneration needs and physiological adaptations of the Ecuadorian *Polylepis* species. The question of why the *Polylepis* grows in patchy, limited forests is also in constant debate (Fjeldsa, 1996; Smith, 1978; Simpson, 1979; 1986). This study is the first to provide base-line overstory data on *Polylepis* woodlands.

The restriction of *Polylepis* woodlands to specific sites can be attributed partly to the sporadic occurrence of suitable microhabitats in the páramo and in part to human influences (Simpson, 1986). Research on *Polylepis sericea* (Smith, 1978) growing in Venezuela suggested four possible explanations for its distribution patterns. Talus slopes may provide a habitat without intense competition, an explanation upheld by Smith's findings that seedlings died first in vegetated quadrats (Smith, 1978). Other possible explanations include: talus slopes are less accessible to cattle and wood cutters than páramo areas, are more sheltered from the wind, and may provide a warmer soil microclimate than that of the páramo (Smith, 1978). Smith's work (1977) indicates that protection of seedlings from frost heaving or freezing of the roots is necessary for successful establishment and may help to explain the usual occurrence of high-elevation *Polylepis* trees of shrubs in crevices, rocky soil, or on hill-sides.



Polylepis (Roseaceae) likely occurs at higher elevations than any other arborescent angiosperm genus in the world

Site Description

This study was conducted in the Sacha Huayco valley in the Chimborazo flora and Fauna Reserve of Ecuador, at an approximate altitude of 4000-4500 meters. Sacha Huayco is a tropical montane forest located in a valley beneath the glacier of the dormant volcano Carihuayrazo. This site was chosen because of the relatively large unbroken patches of remnant forest. Sacha Huayco is comprised of *Polylepis* (Rosaceae) woodlands bordered by páramo as well as grasslands highly impacted by fire and cattle grazing. Due to the remote location and steep terrain of Sacha Huayco, only a few families live near the forest. However, landowners hire locals to keep cattle in the lower parts of the valley in direct violation of the regulations of Chimborazo reserve. Locals continue to use accessible trees for building material and firewood. Fires are often set to clear grazing area, as well as to scare game for hunting purposes.

In Riobamba, the closest city to Sacha Huayco, the average temperature for June, July, and August ranged between 12.6° C and 13.9° C (Ministerio de Energía y Minas, 1999). In our study site, approximately 1000 meters above Riobamba, the average low was 2° C and the average high was 15.1° C. This large diurnal temperature change is characteristic of páramo systems, where diurnal fluctuations in temperature are much larger than seasonal variations. Precipitation in Riobamba was 63.2 cm in June, 7.9 cm in July, and 28.6 cm in August. In contrast to the dry months in Riobamba, Sacha Huayco has a year-round source of water from the glacier of the dormant volcano Carihuayrazo.

Methods

A series of 12 transects were run through the Sacha Huayco forest, 6 transects on each side of the river. Transects were purposefully run through stands of *Polylepis* and not through páramo grasses. Each of the twelve transects started at the intersection of *Polylepis* woodlands and the valley floor, and ran directly uphill. Transects were designed to include 6 contiguous circular plots with an area of 100 m² for a total of 72 plots.

In each plot, all trees over 2 meters were counted, identified, and the diameter at breast height was taken. Each tree was also determined to be healthy, sick, or dead using standards predetermined by the research groups.

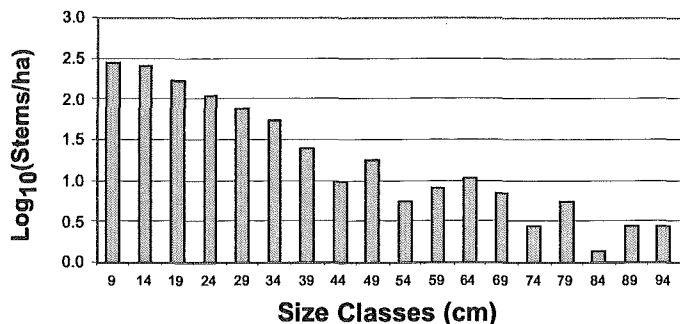
Table 1: The basal area, density, and mean DBH are compared between *Polylepis reticulata*, *Gynoxys acostae*, and the remaining species.

Species	Basal Area (m ² /ha)	Density (#/ha)	Mean DBH (cm)
<i>Polylepis reticulata</i>	40.43 ± 4.68	959.72 ± 77.31	17.87 ± 0.53
<i>Gynoxys acostae</i>	4.71 ± 1.75	204.17 ± 30.16	12.3 ± 0.62
Other	.18 ± .18	1.39 ± 1.39	39.04 ± NA
Total	45.31 ± 5.06	1165.28 ± 70.85	16.92 ± 0.45

Results

In the 72 plots surveyed, four species with a DBH of greater than 4 cm were found: *Polylepis reticulata*, *Gynoxys* sp., *Baccharis* sp. (Asteraceae), and *Escalonia mirtiloides*. Of the four species found, *P. reticulata* accounted for 81.85% of all the trees measured. *Gynoxys* sp. made up 17.94% of all stems measured, and the remaining 2 species accounted for only 0.21% of the stems measured. In

Size Distribution of *Polylepis reticulata*



Size Distribution of *Gynoxys acostae*

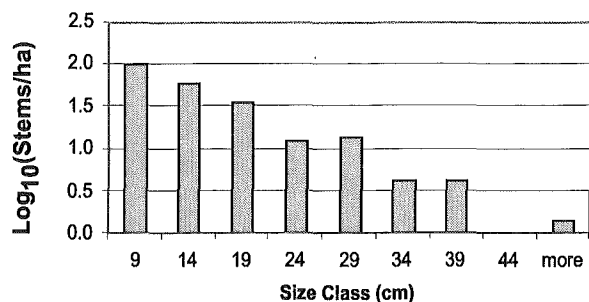


Figure 1: Stems per hectare for *Polylepis reticulata* and *Gynoxys acostae*. Bars represent the mean number of stems per hectare from the 72 plots sampled. The x-axis denotes the upper limit of each 5 cm size class, with 4 cm as the lowest DBH sampled.

Table 1, the basal area, density, and mean diameter at breast height (DBH) is presented for *P. reticulata*, *G. acostae*, and other. *P. reticulata* had the highest basal area of $40.43 \pm 4.68 \text{ m}^2/\text{ha}$ as well as the highest density of 959.72 ± 77.31 stems per hectare.

In Figure 1, the total number of stems from all 72 plots of *Polylepis reticulata* and *Gynoxys* sp. are graphed by size class. The stems were divided into 10 cm size classes and graphed on a scale of log 10 (stems per hectare) versus the upper limit of the size class. *P. reticulata* and *Gynoxys* sp. both show exponential decrease in stems per hectare with increasing size class.

In these woodlands the canopy layer was comprised almost completely of *P. reticulata*, with *Gynoxys* sp. dominating the sub-canopy layer. This stratification is shown by the fact that the upper limit of *Gynoxys* sp. is approximately 40 cm DBH, while a few *P. reticulata* stems reached a DBH of 100 cm or greater.

Due to the sampling design, the first plot in each transect was lowest and the last was highest in elevation. The first plot also marked the boundary between *Polylepis* woodlands and the valley floor. A comparison of plots 1 and 6 across all transects showed that there were significantly fewer individuals in the lower plots than the upper plots (T-test: Paired Two Sample for Means, $p=0.0247$, $DF=12$). However, when trees with DBH under 30 cm were removed from the analysis, no statistical difference was found between the upper and lower plots ($p=0.4087$). In Figure 2, the total number of *P. reticulata* stems in the highest and lowest plots is grouped by size class. Note the distinct difference in stems per hectare between the lowest and highest plots for the three smallest size classes.

Discussions and Conclusions

The most striking finding in this inventory is the extremely high density and basal area of forests growing over 4000 meters above sea level. The basal area of *P. reticulata* ($40.43 \text{ m}^2/\text{ha}$) is comparable to the basal area of all species with dbh >5 cm in the cloud forest at Cajanuma, Ecuador ($44 \text{ m}^2/\text{ha}$), at a much lower elevation of 2900m. At Pasochoa, Ecuador, at an elevation of 3300m, the basal area was much lower ($25.7 \text{ m}^2/\text{ha}$). Unlike Sacha Huayco, Pasochoa is dominated by *Miconia* sp. (Melastomataceae). The high basal area and density of *P. reticulata* found in this study reflect an area with almost total forest cover. There are very few areas today where *Polylepis* woodlands can cover an area of more than a few hectares (Sarmiento, 1993; Fjeldsa, 1996). The data presented here applies to undisturbed *Polylepis* woodlands. *Polylepis* woodlands with a more characteristic patchy growth pattern may show very different patterns.

The presence of only four different overstory tree species in this inventory is not surprising. *Polylepis* woodlands are an excellent example of an oligarchic forest, a forest dominated by very few species. A comparison of the species richness of the different life forms in the high Andes with that in the Ecuadorian Amazon lowlands showed that herbs, shrubs, and epiphytes are less species rich in the lowlands, and trees, lianas, hemiepiphytes, and saprophytes are more species-rich (Jorgensen et al, 1995). The extremely low number of overstory tree species is characteristic of *Polylepis* woodlands. The diversity of the paramós, and of *Polylepis* woodlands, is found much closer to the ground.

In Table 1, the relatively low mean DBH of *P. reticulata* compared to that of other species demonstrates the high number of small *P. reticulata* stems as compared to the low number of large stems. The high mean DBH of the other species can be explained by the lack of regenerative individuals. The only stems of other species were mature individuals.

The effect of altitude on the abundance of *Polylepis* smaller than 44cm dbh can be explained by a number of factors. Cattle graze more intensively in the lower portions of the valley and are more likely to trample small trees. In addition, these lower areas are more accessible to people, so it is more likely that trees there are being impacted by fire, hunting, or firewood extraction. The upper areas have slopes ranging from 50% to 81%, and are effectively impenetrable by livestock and people. Altitude alone does not

Stems per Hectare in High versus Low Plots

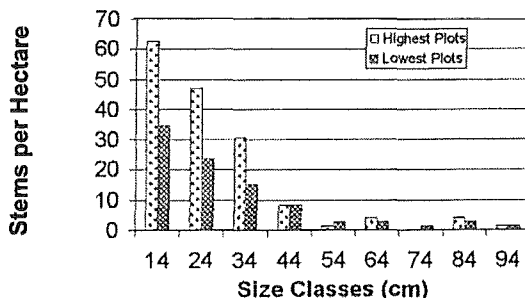


Figure 2: Comparison of *P. reticulata* stems per hectare between the 6 highest plots and the 6 lowest plots. The x-axis represents the end point of each 10 cm size class, with 4 cm as the lowest DBH sampled. Notice the differentiation in stems per hectare within the first three size classes.



appear to be the direct causative factor, since transects were only 67m long and began at different altitudes.

The size-class data shown in Figure 1 suggests that, barring major disturbances, *Polylepis* is naturally regenerating. However, the lower density of smaller (<44 cm) trees in the lower plots as opposed to upper plots may indicate future problems in the recruitment of new canopy individuals and the maintenance of *Polylepis* stands in these areas. If the lack of a viable mid-story is due to trampling by humans and livestock, future management and restoration efforts will need to take this into account. Subsequent analysis of understory seedling data will be necessary to assess the long-term regenerative capability of these *Polylepis* stands.

The protection of fragile forest remnants and the reforestation of the high Andes are immediate concerns in Ecuador. The benefits of *Polylepis* are substantial: regulation of run-off, control of erosion, fuelwood, and increased water catchment capacity. In order to move forward with these goals, a deeper awareness is needed of the requirements, uses, and benefits of native Ecuadorian trees.

Additional Research

The main emphasis of this TRI internship was to describe the Sacha Huayco forest quantitatively, and to use the data collected to form additional research questions. For the purposes of this paper, only overstory data was considered. Starting in January of 2000, understory data gathered during this internship will be analyzed. Areas for increased study will include: the relationship between soil depth and percent cover, and the structural differences in *Polylepis* woodlands at increasing altitudes and slopes. In March of 2000, I will be returning to the Sacha Huayco forest to begin a study on the growth rates of *Polylepis*. I will inject gentian dye into the outer cambium layer of trees of differing diameters. In March of the following year, I will return to core the dyed trees to determine the amount of annual growth of each tree. This study will be extremely important in predicting growth rates for areas reforested with *Polylepis* trees.

Jennifer Osha, MF '01, will be pursuing a Summer Internship with the Mountain Institute to develop a Community Forestry Program in West Virginia, USA.

Acknowledgments

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An Analysis of *Pteropus livingstonii* Roost Habitat: Indicators for Forest Conservation on Anjouan and Mohéli

Elise Granek

Introduction

The rate of deforestation on the Comoros Islands of Anjouan and Mohéli has increased to a rate of 5.6% per year during the 1990s (UNDP, 1998). This change in land cover has implications for all living things, especially endemic plants and animals. In order to halt the deterioration of environmental conditions, the Global Environment Fund, in collaboration with IUCN and UNDP, has initiated a 5-year project working with the Comorian Ministry of the Environment to establish National Reserves and Protected Areas in the Comoros (UNDP unpublished report). Two of these parks will focus on tropical forest regions on the islands of Anjouan and Mohéli.

To create reserves that are sufficient to protect wildlife and are feasible in terms of community support, a suite of questions must be addressed in both the social and ecological realms. Livingstone's fruit bat (*Pteropus livingstonii*), an endangered and endemic species found only on the islands of Anjouan and Mohéli, has been chosen as a focus of these protected areas due to its endangered status and its perceived sensitivity to habitat degradation. However, if *Pteropus livingstonii* is indeed a useful indicator of the habitat type that other endemic species on these islands utilize, it becomes essential that we understand the various biotic and abiotic requirements of these bats' habitat. I studied the kind of habitat that the Livingstone's fruit bats prefer through an analysis of various biotic and abiotic factors measured at the roost site. Learning the characteristics of the habitat in which this species roosts is the first step toward conservation of *P. livingstonii*.

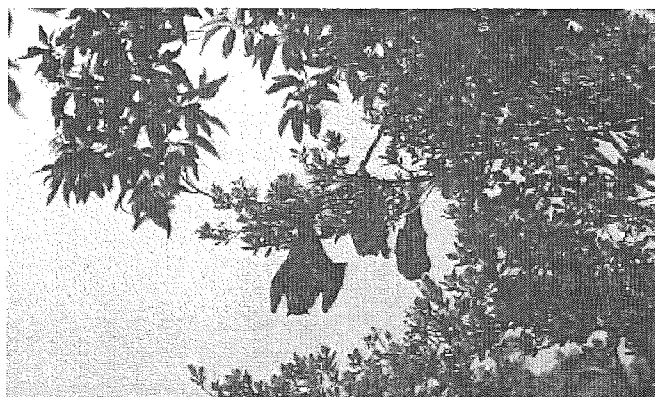
Using the known characteristics of existing roost sites, including approximate slope, altitude range and the presence of forest cover, I was able to locate new sites where *Pteropus livingstonii* were likely to roost. By comparing the sites where bats were found to those where they were not found, I could identify additional factors common among bat roost sites. Also, in order to determine whether dry and rainy season roost sites were the same, I measured the abundance of *Pteropus livingstonii* at the identified roost sites during both the dry and rainy seasons.

At the same time, I identified villages that I felt were currently active in environmental work and would assist in the protection of designated areas. Without local environmental groups supporting the parks and protected areas, the likelihood of protecting these sites over the long-term is quite low. Work was performed with two of the most active villages that have roost sites within their territory to create village maps of land utilization and to identify sites for potential protected areas.

Background on Livingstone's Fruit Bat

Livingstone's fruit bat, a member of the order Megachiroptera, is a species of Old World Fruit Bat found only on Mohéli and Anjouan in the Comoros Islands. Other species in the genus *Pteropus* are found throughout the Western Indian Ocean, predominantly on islands, though also on the Indian subcontinent and Australia. *Pteropus livingstonii* are jet-black bats, although some individuals have rust-colored patches of fur around the genital area or on the upper back. They can reach a size of up to 2 meters in wingspan and are distinctive

with their big, rounded ears. Like other *Pteropus*, Livingstone's fruit bats are tree-roosting frugivores that depend on a diet of fruit, pollen and leaves. They are found roosting during the day in groups of 6 to 160 individuals in 1 to 8 roost trees per site. Livingstone's Fruit bat is believed to be a "sequential specialist," feeding at any one time on one or a few plant species among a group of potential food plants available at that time/season (Marshall 1983). Such a diet may cause roost sites to vary, depending on the season and food availability. There is very little known about their diet, behavior, and reproductive patterns, though there is some indication that females with young move to maternity roosts while their babies are still in their first few months of life.



Livingstone's fruit bats roost predominantly on south- and east-facing slopes, suggesting that bats are sensitive to wind and sun.

Study Site

This study was conducted from August to December 1998 in the tropical forests of Anjouan and Mohéli, two of the four volcanic islands comprising the Comoros Archipelago. The habitat type is primarily steeply sloped montane tropical rainforest; however, some areas in the region have been heavily deforested. While not as species-rich as mainland tropical forests, the ecosystem is comprised of numerous endemic and native tropical tree species. Some important species are: *Khaya comorensis*, *Nuxia pseudodontata*, *Brachylaena ramiflora*, *Anthocleista grandiflora*, *Cussonia sputata*, *Ocotea comoriensis*, *Weinmania comorensis*, *Litsea glurinos*, *Eugenia comorensis*, *Calycophyllum inophyllum*, *Tambourissa leptophylla*, unidentified single species in the *Draceana* and *Gambeya* genera, and several species of *Ficus* (Adjanahoun et al. 1982, Action Comores 1997). Anjouan and Mohéli receive a maximum rainfall of 4925 mm and 3086 mm respectively, with most rainfall occurring between November and March (Adjanahoun et al. 1982).

Methods

Before this research began, there were only nine known *P. livingstonii* roost sites. All of these sites had the following three characteristics: 1) they were between 500-1100m in elevation; 2) the land was steeply sloped; 3) some native forest cover was present. I then

looked for all sites on the islands of Anjouan and Mohéli that met these three criteria. (Trehwella 1998). After locating likely roost sites, I compared sites where bats were found (new sites and those previously discovered) to several sites where bats were not found.

With help from local assistants, I recorded altitude, aspect, slope, tree species growing within 75 meters of a roost tree, land cover type, proximity to water, number of roost trees, and distance of the site to the nearest human settlement. For each roost tree we recorded the species, measured the height and diameter at breast height (dbh), and counted the number of bats per tree. The island on which the site was found, the season, and the current weather conditions were also recorded to compare seasonal changes in the number of individuals. I also described the cover type on a numeric scale of 1 to 4 according to the following guidelines: 1) intact forest; 2) forest cover under-planted with fields; 3) mixed forest and fields; 4) fields with few forest trees remaining.

To test for dependence of bat presence or absence on these factors, a G-test of independence was run (Sokal & Rolff 1981). The effect of season on population size was tested using a paired t-test.

At the same time, I tried to determine which villages would successfully participate in conservation programs. I invited village environmental groups with roost sites in their territory to participate in my research in order to train them for future monitoring of *P. livingstonii*. I paid special attention to a village that had previously been identified by IUCN consultants as a probable site for a forest reserve (UNDP unpublished report).

In villages with demonstrated interest, I worked with the local environmental associations to create village maps of the territory within their villages. I then asked them to map land use across this territory. Finally, I asked them to identify areas where they would prohibit specific uses if they were given authority to do so, and what those uses would be.

Results

Abiotic factors

On Anjouan and Mohéli, I was able to locate thirteen new sites that met the three known criteria for roost sites as given in the previous section. Six of these sites were indeed roost sites, significantly increasing the number of known *P. livingstonii* roosts. In all, I counted a total of 663 bats, the largest number of individuals of this species ever found. Three of the six new roosts were large sites with more than 50 bats present during the rainy season. A g-test of independence indicated that presence of bats was positively correlated with presence of water in the same valley ($p < 0.005$) and an East- or South-facing slope ($p < 0.1$ and $p < 0.05$ respectively) (Table 1). All of the roost sites and 5 of the absence sites were found in 'bowls' (i.e., a valley protected by mountains on three sides). No significant effect of altitude or forest cover on bat presence was observed. However, this may be merely an artifact of choosing absence sites within the same range of altitudes and cover types as the roost sites that were chosen.

Biotic Factors

A g-test was used to analyze the effect of various tree species on bat presence or absence at a site (Table 1). Bats showed positive association with two tree species: *Gambeya* sp. and *Nuxia pseudodentata* at the $p < 0.05$ level. A paired t-test revealed that *P. livingstonii* abundance was significantly higher in the rainy season than in the dry season for the seven sites at which counts had been made in both seasons ($p < 0.05$).

Table 1: G-test of independence for 15 roost and 7 non-roost sites as affected by a variety of factors

Factor	Roost site	Absence site	p-value ¹	
Water Availability	Water in valley	14	2	
	Absence of water in valley	1	5	< 0.005
Aspect²	North-facing	2	3	
	South-facing	13	1	< 0.05
	West-facing	3	2	
	East-facing	14	1	< 0.1
Tree Species	<i>Nuxia pseudodentata</i>	9	1	
	Absence of <i>N. pseudodentata</i>	6	6	< 0.05
	<i>Gambeya</i> spp.	13	3	
	Absence of <i>Gambeya</i> spp.	2	4	< 0.05

¹ P-value shows level of significance for unadjusted G-value and was obtained from a chi-squared table with $df=1$.

² Numbers of roost and absence sites for aspect are not equal to 22 for several reasons: 1) Some large sites are represented by two observations if site faced two different directions; 2) Aspect was not recorded for three of the seven absence sites; 3) Aspects were one of the cardinal directions (N, S, E, W) and did not have an orthogonal component (i.e. Site facing due E has no N-S component).

Looking now specifically at roost trees, the mean roost tree dbh was 103 cm (SE = 10.7, $n=43$) and mean roost tree height was 24.35 m (SE = 1.02, $n = 43$). Of the 43 roost trees, seventeen were *Ficus* spp., six were *Nuxia pseudodentata*, and six were *Gambeya* sp. The remaining roost tree species were represented by four or fewer individuals. In three cases, the roost trees were growing together, entwined or fused with other tree species, generally a fig tree growing with another *Ficus* species.

Human factors

Two villages showed notable interest in participating in bat monitoring and a third village had previously been identified by IUCN consultants as a probable site for a forest reserve (UNDP unpublished report).

Both roost sites on the island of Mohéli are within the territory of the village Ouallah-Mirereni. The village environmental association had independently taken steps to ensure the protection of the previously discovered roost site by banning farming around and below the roost and relocating those farmers whose fields border on the roost site. When a new roost site was discovered in October 1998, the association forced herders from a neighboring village who had been grazing their cattle in Ouallah-Mirereni's forest to cease their herding activity in the area of the newly identified roost sites. The association denoted the roost sites as areas in which utilization would be limited to the collection of traditional medicine and non-timber forest products. The rivers were also identified as territory in which use should be limited.

On Anjouan, The village of Nindri showed notable interest in the protection of the roost. The Nindri association discovered the roost site in 1995 and members of the group visit the roost regularly to check on the status of the bats. When asked to delineate protected areas and designate usage, the roost and the Nindri River were identified as critical habitat in need of some level of protection.

Also on Anjouan, the village of Lingoni has been identified by visiting consultants (UNDP unpublished report) as an ideal site for a forest reserve because of the extent of undisturbed primary forest, the rivers in the region, and the size of the roost, which is the largest ever identified for *P. livingstonii* (with counts of 150 individuals in some years). The Lingoni environmental association was requested to draw a village map that would note land use limitations. Again the association recognizes the importance of protecting the rivers in the valley as well as the forested area in which the roost exists. In these three village environmental associations, there was an understanding of the importance of the bats as a valuable component of the ecosystem as well as a potential income-generating tourist attraction if the forests where bats reside are indeed protected.

Discussion

Livingstone's fruit bats are strongly associated with a number of habitat variables. Prominent among those was aspect, with bats found predominantly among SE facing slopes (Figure 1). In the Southern Hemisphere, these slopes receive morning sun and are shaded from noon until late afternoon when the bats are leaving their roosts to feed. Such a finding is one of the many indications that bats are sensitive to temperature. Each of the roost sites was located in a

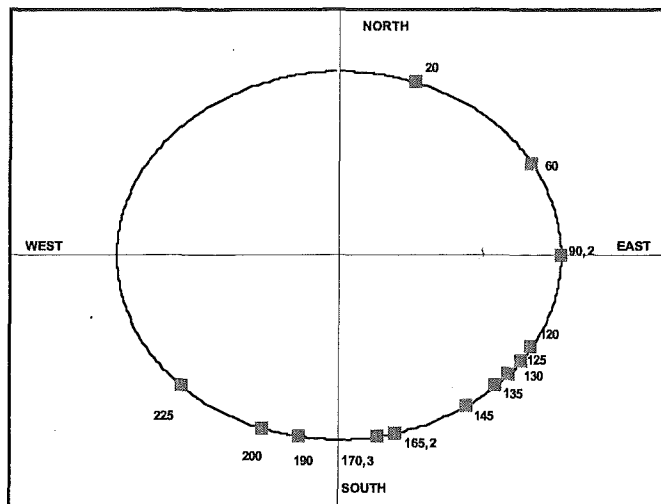


Figure 1. Aspect of Roost sites

First number is aspect angle, 2nd value is the number of sites at that aspect)
 Note: Some large sites were given two values for roost site aspect if it was determined that the slope faced in two directions

bow, a topographic feature which moderates climate by sheltering the bats from wind and sun (Pierson and Rainey, 1992). This affinity for valleys is supported by their preference for SE facing slopes. Water was present in all 15 of the roost sites, either in the valley itself or in the form of a river running through the valley below. Their preference for valleys containing water, which are therefore more humid, may indeed be a factor of their temperature sensitivity. *P. livingstonii* are at elevations and on slopes on which forest cover is still present—above 500 meters on Anjouan and above 200 meters on Mohéli. As the population density of Anjouan is much higher, little forest remains below 500 meters altitude whereas on the southern and western sides of Mohéli, forest can be found as low as 200 meters altitude. Below these altitudes, the temperature is much warmer due both to the elevation itself and to deforestation. This corresponds to the trend of finding *P. livingstonii* at lower altitudes

on Mohéli. However, two of the newly discovered sites were found in areas with forest cover type 4, which indicates that remnant populations are still present where up to 90% of the forest cover has been removed. A dependence on several native tree species is further evidence of characteristics specific to Livingstone's roost sites.

Livingstone's fruit bat may be considered keystone species in the tropical rain and cloud forest of Comoros because of their essential role as forest pollinators and dispersal agents (Fujita 1988 and 1991). For this reason the United Nations Development Programme/Global Environmental Fund "Biodiversity Conservation and Sustainable Development" program has targeted *P. livingstonii* as a focal species for protected areas priority (UNDP unpublished report). My data demonstrating seasonal sensitivity to habitat characteristics supports this need and further identifies *P. livingstonii* roost sites as priority forest habitat for conservation.

Social indicators point to the village of Ouallah-Mirereni as a focal region for Mohéli and the villages of Nindri and Lingoni as foci for the forests of Anjouan. Further education and training in monitoring techniques is necessary for these three villages; however, a solid foundation of basic ecological understanding lends confidence to the possibility of success if forest reserves are overseen by these village associations. The size of roost sites located near these three villages further supports the preference for this prioritization.

Conclusion

Livingstone's fruit bats appear to prefer habitat that is protected from wind and mid-day sun yet allows morning sun. The bats seem to be attracted to certain topographic characteristics and tree species that are specific to the forest zone where these species exist. To ensure the survival of this species, roost habitat must be protected.

However, the protection of roost habitat alone is insufficient to ensure the survival of *P. livingstonii*, a species critical for forest regeneration. For example, it is known that they spend much of their time at feeding sites. Further research on dry season distribution, maternity roosts, and feeding sites is essential for the survival of the species. As the human population on the islands of Anjouan and Mohéli grows at a rate of 3.3% per year (UNDP 1998), the feeding sites, many of which are found at lower elevations, will become more threatened. This threat to feeding sites is a serious risk to the species, believed to be a "sequential specialist." As the human population moves up slope, clearing land for agriculture on increasingly steeper slopes, the need for protection of these roost sites increases.

In order to ensure the success of protected areas in the region, established community environmental groups must be involved in enforcing the restrictions on protected areas. I therefore recommend focusing on the roost sites at Ouallah-Mirereni on Mohéli and at Lingoni and Nindri on Anjouan initially, with potential for future work with other villages such as Bazmini and Mpage where large roost sites were found.

The establishment of protected areas must be accompanied by continued research on the roost site distribution, feeding ecology, roost behavior, and reproductive biology of *P. livingstonii* as well as the continued awareness-raising and training of local communities concerning the importance of the bats and methods for monitoring the forest.

Elise Granek, MEdSc '00, is currently working as the Ecology Specialist for an IUCN project entitled "Biodiversity Conservation and Sustainable Development in the Federal Islamic Republic of the Comoros".

Collaborator Notes

This research was conducted in Comoros with the assistance of Action Comores, a British-based NGO focused on conservation of Livingstone's fruit bats and their habitat. The Comorian Ministry of the environment in MDE, Grande Comores and the Centre National pour la Documentation et la Recherche Scientifique (CDNRS) in Moroni, Grande Comores also facilitated this project. Ishaka Said of Anjouan served as Field Assistant, making this field work a success.

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Dietary Overlap and Relative Abundances of Two Sympatric Bat Species in Central French Guiana

Heather Peckham

Introduction

Many studies have shown that the structure and composition of Neotropical forests depend on the intricate relationships between animals and plants (Howe and Wesley, 1986; Gilbert, 1980; Leigh, 1993). Animals pollinate plants and disperse their seeds. Plants in return reward the animals with nectar or fruit. Approximately half of all mammalian species in the tropics are bats (Wilson, 1997). Consequently, their impact on plant diversity is substantial. The role of bats is especially important when they are the only vectors for a keystone plant species. If a keystone species declines from the loss of a pollinator or disperser, many other species may decline as well through what Myers (1986) describes as "cascades of linked extinctions."

Bats may have an effect on the diversity of fragmented primary forests as well as on the rehabilitation of deforested areas. The understory frugivores, such as species in the genus *Carollia*, forage on plants in natural gaps in the forest and in cleared areas. They disperse the seeds of many pioneer species that are the first trees to colonize old field environments. Bats are successful seed dispersers because, unlike most birds, bats fly away from the plant with the fruit in their mouths to a night roost. Seeds dropped farther away from the parent tree have a higher survival rate. Janzen (1981) attributed this trend to density-dependent mortality and increased predation near the parent tree. Finally, almost all of the seeds dis-

persed into cleared areas occur during the night, suggesting that bats are the largest seed contributors (Gorchov et al., 1993; Charles-Dominique, 1986; de Foresta, 1984). The pioneer species later provide suitable habitat for the more shade tolerant, late seral tree species.

Habitat disruption has been found to lower bat species richness (Broseth et al., 1996; Simmons & Voss, 1998), which may then affect plant diversity of remaining fragments and regenerating forests through the loss of pollinators and dispersers. Several bat inventories in French Guiana found that *Carollia brevicauda*, an important seed disperser of pioneer species, were either rare or entirely absent in more disturbed areas (Simmons & Voss, 1998, Broseth et al., 1996). On the other hand, *C. perspicillata*, a closely related species, proliferated in these same areas. The rarity of *C. brevicauda* may be related to its specialization on highly nutritious *Piper* spp. fruits.

The diet of *C. brevicauda*, the smaller bat, has been found to contain more *Piper* spp. fruit than *C. perspicillata*, the larger bat (Fleming, 1991; Gorchov et al., 1995). Larger bats can afford to eat fruits with less protein because of a lower demand for energy and protein relative to their mass. *C. brevicauda* may not be able to persist in less diverse forests where their preferred species of *Piper* may not be available. The *Piper* spp. fruits that are available in this habitat may be depleted rapidly. Only a few *Piper* fruits on an individual

plant ripen each night in the understory or within forest gaps (Fleming, 1991). If foraging times of the two species differ, the species that forages earlier in the evening will have more *Piper* fruits available to them.

Past studies in Peru and Costa Rica have analyzed the dietary overlap between three species of *Carollia*. In Peru, Gorchov et al. (1995) captured *C. brevicauda*, *C. perspicillata*, and *C. castanea* in primary forest, secondary forest and logged strips and found that they had significantly different diets. *C. perspicillata* was captured twice as often as *C. brevicauda*, 448 and 235, respectively. However, the number of bats captured in each of the three forest types was not distinguished. In Costa Rica, Palmeirim et al. (1989) caught the same three species in early successional strips and the dietary overlap was between 0.49-0.60. In this case, *C. brevicauda* was caught twice as often as *C. perspicillata*, 32 and 72 captures, respectively. However, no study has looked specifically at their dietary overlap in a primary forest.

I hypothesize that in a primary forest, the two species may coexist by preferring different species of *Piper*, which should be reflected in their degree of dietary overlap. I predict that *C. brevicauda* populations will be relatively abundant and the dietary overlap between the two sympatric bat species will be low. I also predict that the smaller *C. brevicauda*, which has greater nutritional requirements per body weight, should have a larger proportion of *Piper* fruit in its diet than *C. perspicillata*. In addition, the more nutritious, but less abundant fruits should be foraged upon earlier in the evening.

Site Description

French Guiana is a 90,000-km² territory of France with 95% of its area still covered in lowland rain forest (Thiollay, 1989). The study was conducted in an evergreen lowland moist forest surrounding the village of Saül in Central French Guiana (3°30', 3°45'N; 53°-52°28' W). The primary forest matrix in Central French Guiana contains small patches of disturbed habitat where homesteads have been established and areas have been cleared for agriculture. Over 1861 plant species in 111 families have been identified in this mixed forest. The forest is dominated by trees of the following families: Burseraceae, Sapotaceae, Lecythidaceae, Mimosaceae, Caesalpiniaceae, Rubiaceae, Moraceae, Chrysobalanaceae, Meliaceae, and Bombacaceae. The tallest trees in the forest (*Hura crepitans*, *Ceiba pentandra*, *Huberodendron swietenoides*, and *Terminalia guyanensis*) reach 55 to 65 meters in height (Mori et al., 1997).

The average temperature in Saül is 27.1° C with a range between 20.9° and 31.5°. Drier months have a slightly higher temperature. There is a distinct dry season from August to November and a short dry season in February and March (Mori & Prance, 1987). The rain falls unevenly throughout the year with an average rainfall of 2413 mm/year. The elevation of the Saül forest ranges between 200-762 m (Mori & Boom, 1987).

Methods

Prior to the fieldwork, neotropical species native to Central French Guiana with fruits potentially dispersed by bats were determined by an extensive literature review and compiled into a Microsoft® Access database. The database contains 58 families and 147 genera that have fruit reported to be eaten by bats. The plant species in this database are those for which seeds have been collected in the feces of bats or those that have been collected below bat roosts and reported in the literature. The fruit/bat database potentially indicates which

neotropical plants potentially benefit from seed dispersal activities by bats.

Fieldwork took place during the dry season (August) when the rainfall was low (150mm/month) and the maximum temperature was high (32°C). Plant species listed in the database as having been consumed by *C. brevicauda* or *C. perspicillata* were collected if they were fruiting at the time. Specimens were made of the reference plants and the fruit was placed in glassine envelopes that were dried in the sun for three days. The collected fruit served as the reference collection for comparison with seeds in the bat feces and were supplemented by seeds taken from herbarium specimens at The New York Botanical Garden.

Bats are lunar phobic and are infrequently caught when the forest is moonlit. Accordingly, bats were caught using mist nets for 12 consecutive nights after the full moon on July 28 (sampling with replacement). After each successive night, the forest would become darker and the number of captures would be expected to increase. Each night 6 m and 12 m 75-denier ground level nets were moved either to trails in primary forests or to small, open modified habitats. Nets were opened around 7:00 PM and closed around 11:00 PM. Bats were placed in individually numbered cloth bags. The bag number, time of capture, bat species, and sex were recorded immediately after each capture. The fecal samples were removed from the cloth bags and stored in glassine envelopes. They were then placed in the sun to dry for three days.

Several seeds from the bat fecal samples and from the reference collections were transported to the NY Botanical Garden and cleaned. Scanning Electron Microscope (SEM) pictures at 50x were then taken of the cleaned seeds. The diets of *C. perspicillata* and *C. brevicauda* were determined by comparing the seeds in the feces to the seeds in the reference collection.

The presence of one or more seeds of the same species in a fecal sample was considered a seed record. If seeds from two or more species were found in the feces of the same individual, they were treated as separate seed records. Fruit diet overlap between *C. perspicillata* and *C. brevicauda* was determined using Horn's (1966) modification of Morisita's index of overlap. This index ranged from 0 (no overlap) to 1 (complete overlap) and was calculated as $C = 2\sum y_i x_i / \sum (y_i^2 + x_i^2)$ where x_i = the proportion of *C. brevicauda* diet that is made up of food item i and y_i = the proportion of *C. perspicillata*'s diet made up of food item i . The chi-squared test for two-way tables was used for determining whether the diets of the two species were significantly different.

Results of Literature Review

A search of the database revealed that *C. brevicauda* has been reported to eat fruit from 12 plant families and 33 different species in the Neotropics. The greatest numbers of species were in the Piperaceae (9), Solanaceae (5), and Cyclanthaceae (4) families. *C. perspicillata* has a much more extensive diet. It has been reported to eat fruit from 43 plant families and 173 different species in the Neotropics. The Piperaceae (27), Solanaceae (18), Moraceae (17) families have the greatest number of species consumed by *C. perspicillata*. Thus, Piperaceae and Solanaceae make up a large part of the diet of both species.

Considering only data collected on these bats in French Guiana, the families with the greatest number of species consumed by *C. brevicauda* were Piperaceae (3), Solanaceae (2), Marcgraviaceae (2), and Cyclanthaceae (2). *C. perspicillata* consumed plant

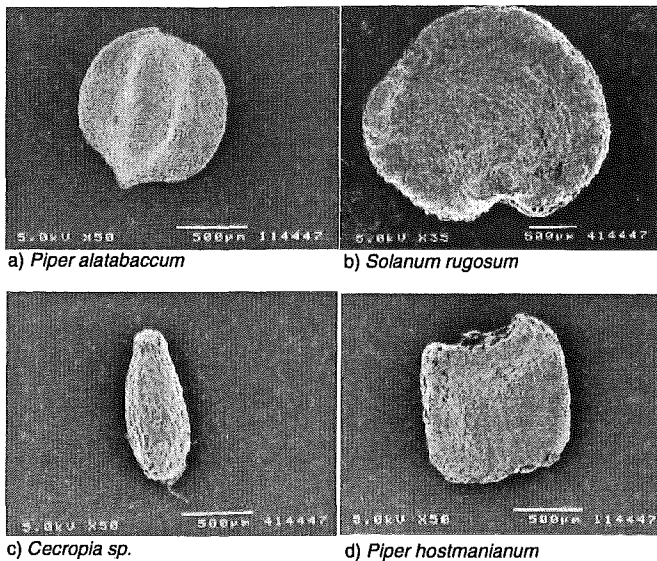


Plate 1: Scanning Electron Microscope (SEM) photos of seeds at 50x

species in the Piperaceae (9), Anacardiaceae (3), Clusiaceae (3), Sapotaceae (3), and Solanaceae (3).

Results

Three hundred and eighty one bats representing 40 species were caught. *C. brevicauda* and *C. perspicillata* represented 8.4% and 7.1% of the bats captured respectively. From the captured individuals, 25 fecal samples were collected from *C. brevicauda* and 20 fecal samples were collected from *C. perspicillata*. A few of the captured bats did not produce fecal samples.

The diet of *C. brevicauda* consisted mostly of *Piper* fruits with 84% (21/25) of the fecal samples containing *Piper* seeds. *C. brevicauda* consumed eight different plant species, five of which were of the genus *Piper*. *P. alatabaccum* (Plate 1a) was the most common species eaten with its seeds found in 9/25 of the fecal samples. Four of the captured *C. brevicaudas* foraged on *Solanum rugosum*. *C. brevicauda* preferred *Piper* spp. and *Solanum rugosum* (Plate 1b) earlier in the night, with an average capture time of 8:28 PM and 8:09 PM, respectively (Figure 1). Bats consuming the less nutritious *Cecropia* (Plate 1c) and *Vismia angusta* fruit had an average capture time of 9:20 PM and 8:45 PM, respectively.

Like *C. brevicauda*, the diet of *C. perspicillata* was mostly dependent on *Piper* with 85% (17/20) of the samples containing *Piper* seeds. *C. perspicillata* also consumed eight different plant species, six of which were *Piper*. *C. perspicillata*'s most common food choice was *P. hostmanianum* (Plate 1d) which was found in 13/20 of the fecal samples. Bats consuming *Piper* fruits had an average capture time of 8:01 PM, half an hour earlier than *C. brevicauda* (Figure 1). However, using a two sample t test statistic, their foraging times were not significantly different ($t=0.158$, $df=21$; $p>.25$). Two of the captured *C. perspicillata* also foraged on *Passiflora* spp. early in the night with an average time of 7:21 P.M. Like *C. brevicauda*, *C. perspicillata* foraged on *Cecropia obtusa* later in the evening with an average time of 8:17 P.M.

The diets of *C. brevicauda* and *C. perspicillata* differed significantly ($\chi^2 = 28.26$, $df = 9$, $p < 0.0001$) (Table 1). The diet overlap using Horn's (1966) modification of Morisita's index was calcu-

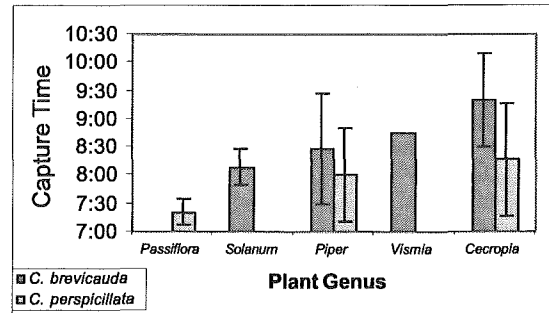


Figure 1: Capture time of *C. perspicillata* and *C. brevicauda* for fecal samples containing seeds of five plant genera. Error bars show std dev from the mean time of capture.

Plant Species	<i>C. perspicillata</i>	<i>C. brevicauda</i>
<i>Piper alatabaccum</i>	5	9
<i>Piper anonifolium</i>	1	0
<i>Piper nigrispicum</i>	2	8
<i>Piper hostmanianum</i>	13	1
<i>Piper hispidum</i>	1	6
<i>Piper dilatatum</i>	1	3
<i>Passiflora sp.</i>	2	0
<i>Cecropia obtusa</i>	2	4
<i>Solanum rugosum</i>	0	4
<i>Vismia angusta</i>	0	1
Total Seed Records	27	36
df = 9		$\chi^2 = 28.26$

Table 1: Number of fecal samples containing a given species of food for both bat species.

lated to be 36%. The two bat species ate many of the same species of *Piper* but they had different preferences. The greatest overlap between the two species was for *P. alatabaccum* fruit.

Discussion

In the primary rain forest of Central French Guiana *C. brevicauda* and *C. perspicillata* are approximately equal in abundance and their dietary overlap is low. Although they forage on many of the same species of *Piper*, their preferred fruit species differ. There was no significant difference in foraging times for the same food between bat species, which suggests that they are not dividing up their resources temporally. Past research has suggested that *C. brevicauda*, because of its small size, is more dependent on *Piper* spp. than *C. perspicillata* (Fleming, 1991; Gorchov et al., 1995). However, the proportion of their fecal samples containing *Piper* spp. seeds was almost identical.

Several captured *C. brevicauda* supplemented their diet with *Solanum rugosum* fruit, which are also known to be nutritious (Dinerstein, 1986). Consequently, they are not entirely dependent on *Piper* spp. in this forest. However, *Sturnira lilium* and *S. tildae*, two other understory frugivorous bat species inhabiting this forest, have been reported to specialize on *Solanum* spp. (Charles-Dominique, 1993). *C. brevicauda* may be overlapping with *Sturnira* spp. for *Solanum* spp.

Like *C. brevicauda*, *C. perspicillata* also chose fruit from a plant genus other than *Piper* early in the night. Instead of choosing *Solanum* spp. fruit, *C. perspicillata* foraged on *Passiflora* spp. fruits. Although no nutritional data is available for *Passiflora* fruits, the early foraging time may suggest a high protein content like the fruits

of *Piper* spp. and *Solanum* spp. Both species opportunistically chose the more abundant, but less nutritious fruits of *Cecropia obtusa* later in the evening when it was likely that *Piper*, *Solanum*, and *Passiflora* fruits had been depleted.

In summary, the results from this study suggest that *C. brevicauda* and *C. perspicillata* are not competing for the same food resources in primary forests. Whether the dietary overlap between the two species is greater in disturbed areas needs to be investigated. *C. brevicauda*'s preferred species of *Piper* may also not be available in less diverse habitats. Conversely, the absence of *C. brevicauda* in forests may have an impact on plant diversity and forest succession. If biodiversity is to be maintained, the habitat requirements of both the plants and their dispersers and pollinators needs to be considered.

Heather Peckham, MFS '00, has been accepted into the joint degree Ph.D. program with the Yale School of Forestry and Environmental Studies and the New York Botanical Garden. She will continue studying the role of frugivorous bats in the regeneration of forests in Amazonia.

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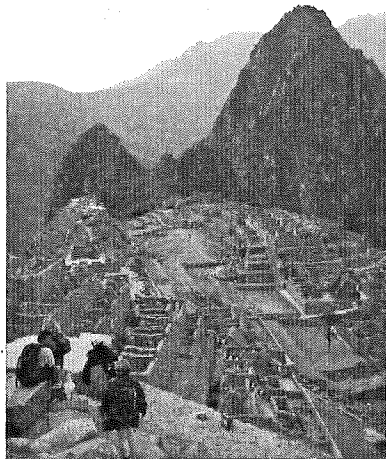
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Tropical Resources Institute Collaborative Research Sites

Peru— Macchu Picchu and Amazonia

Both the Inca architecture and the mountains of the Machu Picchu Historical Sanctuary in Peru are among the most beautiful in the world. Machu Picchu has become the destination of great numbers of tourists, who, while a necessary source of income for the region, are now threatening the long-term well-being of the architectural monuments of the Sanctuary, the Inca Trail, and the surrounding environment. Javier Dominguez, MF 1994, then program manager of the Programa Machu Picchu, a Finland-sponsored effort to support the conservation of the Sanctuary, initiated FES involvement in research at Machu Picchu. The research of several F&ES students is now part of a large effort, involving both Peruvian and international organizations, to form a



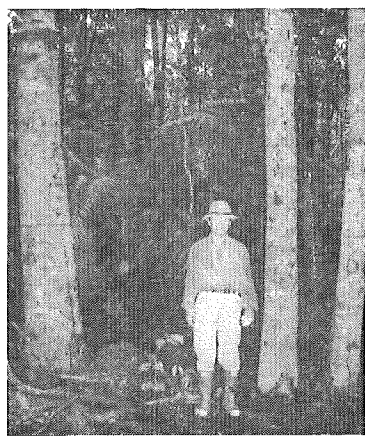
basis for effective management of the Sanctuary. Keely Maxwell, MFS 1998 and now a doctoral candidate, and Greg Jones, F&ES master's student, will both be working on interactions between people and the landscape around Machu Picchu. César Flores, MFS 1995 and now a doctoral candidate, is now working on a Machu Picchu forest dynamics study.

César Flores and Bronson Griscom have been conducting their doctoral research in Amazonian Peru, on regeneration of an important Amazonian tree, *Cedrela odorata*, and on the ecology of a bamboo in Amazonian fields, respectively, with the support of a strong and vigorous Conservation International team there.



Panama— Panama Canal Watershed

TRI involvement with research needed for effective management of the Panama Canal watershed was advanced by a field trip to Panama in 1998, led by Mark Ashton, Associate Professor of Silviculture and Director of TRI, and Tim Clark, Professor of Wildlife Ecology and Policy. Mirei Endara, MES 1994, then Director of INRENARE (now named ANAM, the Panamanian National Authority of the Environment), and Taka Hagiwara, MFS 1993, who works in Panama for JICA, the Japanese International Cooperation Agency, coordinated the visit to important environmental sites in Panama and meetings with key environmental managers. Following the field trip, Manrique Rojas Araya



and Ben Gardner, both MES 1998, returned to Panama to conduct a study of farming and forests in the Canal Zone, which challenged several widespread assumptions about the problems of forest restoration there. This summer, Mark Wishnie will be studying Riparian vegetation and stream structure in the Canal Zone. Chris Losi, *TRI News* editor, will be working on the development of mathematical models for measuring carbon sequestration, in cooperation with STRI, JICA and Ecoforest. Further collaboration with several Panamanian universities and agencies is developing.

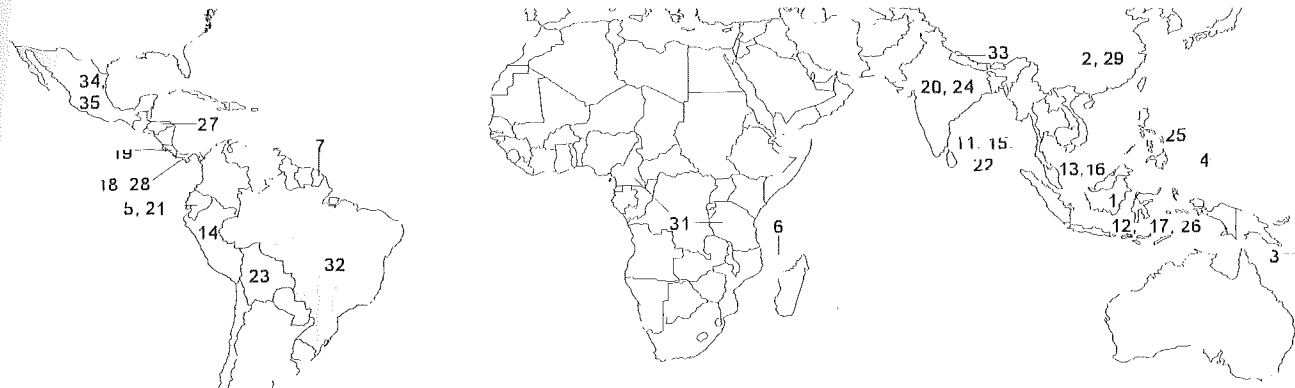
Nicaragua— Dry Tropical Forest and Isla Juan Venado Mangrove Reserve

TRI has also facilitated work in León, northwestern Nicaragua, by two F&ES students. Douglas Elliott, MES 1997, has worked on various issues related to improving production and sustainability on small farms. Both the dry tropical forests and the farms of the region have been damaged by decades of clearing forests for cotton production, which depleted the soil's fertility and required high pesticide inputs. Downstream from the forests and farms, the coastal mangroves, increasingly rare on the Pacific coasts of Central America, still support a diverse and abundant avifauna.



Kevin Eddings, F&ES doctoral student, working with the National Autonomous University of Nicaragua in León, looked at the educational needs for community participation in the management of the Isla Juan Venado Mangrove Reserve, an area to be protected for its importance in bird breeding and migration. Shrimp farming is of enormous economic importance here, often overwhelming environmental concerns. Here, collection of shrimp larvae is taking place within the Mangrove Reserve. We hope to develop more on-going programs with our Nicaraguan collaborators in these dry tropical forests, the farms, and the mangroves.

Tropical Resources Institute Research Sites



Current Authors

- 1 - Suk (Steve) Bae Rhee: East Kalimantan, Indonesia
- 2- Xiaoping Wang: Jiangsu Province, China
- 3- John Virdin: Samoa
- 4- Sylvia Stone: Federated States of Micronesia
- 5- Jennifer Osha: Ecuador
- 6- Elise Granek: Comoros Islands
- 7- Heather Peckham: French Guyana

21- Christopher Nyce: Ecuador

- 22- Kristen Ohlson: Sri Lanka
- 23- Jonathan Padwe: Bolivia
- 24- Shimona Quazi: India
- 25- Abigail Sarmac: Philippines
- 26- Mochammad Luthfi Susanto: Indonesia
- 27- C. Lincoln Vaughan: Honduras
- 28- Mark Wishnie: Panama¹
- 29- YinLan Zhang: China

Masters Student Internships for 2000

- 11 - Uromi Manage Goodale: Sri Lanka
- 12- Aya Hirata: Indonesia
- 13- Rusaslina Idrus: Sabah, Malaysia
- 14- Gregory Jones: Peru¹
- 15- Pradeep Kurukulasuriya: Sri Lanka
- 16- Eugene Lee: Malaysia
- 17- Christian Lentz: Indonesia
- 18- Christopher Losi: Panama
- 19- Jeff Luoma: Costa Rica
- 20- Smita Malpani: Uttar Pradesh, India

Doctoral Student Internships for 1999

- 31- Sanjay Baliga: Cameroon and Tanzania
- 32- Christiane Ehringhaus: Brazil
- 33- Anne Rademacher: Nepal
- 34- John Tuxill: Mexico
- 35- Julie Velasquez Runk: Mexico

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James Bryan, TRI Program Director
Chris Losi (MF '01) and Abigail Sarmac (MEM '01), *TRI News* Editors
Noriko Oshima (MESC '01), *TRI News* Graphic Designer

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TRI News

Yale School of Forestry and Environmental Studies
205 Prospect Street
New Haven, Connecticut 06511
United States of America
Tel: (203) 432-3660
Fax: (203) 432-5043
<http://www.yale.edu/tri>
trinews@yale.edu

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