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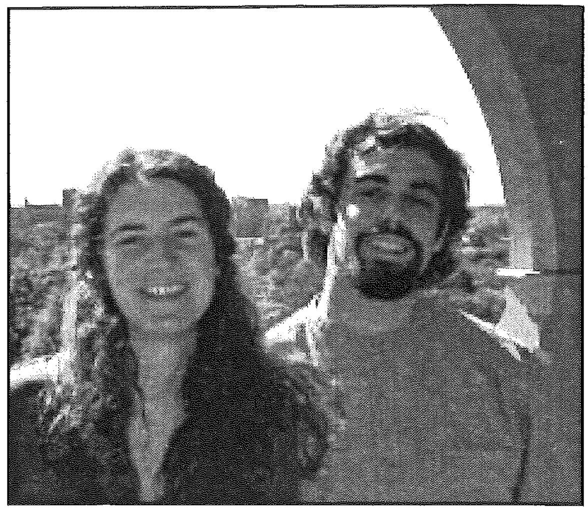
Yale School of Forestry and Environmental Studies

A Message from the *TRI News* Editors



The articles in this volume of *TRI News* all relate in some way to conservation. True to the diversity of the field, this collection of articles represents a wide range of conservation-related issues. Topics include the conservation of individual organisms (black-billed parrots), conservation of entire ecosystems (coral reefs), and conservation of abiotic resources (rivers). The research techniques that our authors have used are similarly varied: regression analysis, cluster analysis, surveys, interviews, workshops, and historical literature review. Just as important as the authors' findings are the questions that they asked before and during the research process. We hope that you will find the resulting articles as thought provoking as we have.

The Editors,

Chris Losi

April Reese

A Message from the TRI Directors

Now15 years old, the Tropical Resources Institute has helped provide numerous students of the Yale School of Forestry and Environmental Studies (FES) a basis for work on environmental issues in the tropics. Approximately 250 FES masters students have conducted their research in TRI internships in the past 15 years. Of the 48 FES doctoral students who have completed tropical-focused dissertations during that time, 27 began their research in TRI sponsored programs. A list of FES dissertations on tropical resource issues is included in this edition of *TRI News*. Several of these dissertation research projects were initiated as TRI Summer Internships. Much of this research has been supported by a grant from an anonymous donor; this year, the Doris Duke Foundation is also funding several students' research.

It is widely asserted that successful environmental managers must consider both the technical aspects of the resource and its social context. While this is easier to say than do, several present doctoral students, now completing their dissertations, have included studies of compelling social issues within their research in such fields as silviculture, wildlife biology, and forest ecology. Several of these doctoral research programs also provided sites for master's student research.

The 1999 masters and doctoral student interns continued the tradition of summer internships on a wide range of subjects. Some of these TRI summer internships are reported in this edition. The group of FES interns who have just completed summer research in the tropics is one of the largest yet: 12 master's students and 5 doctoral students engaged in their pre-dissertation or early dissertation research.

TRI goals for next year are to continue the established program while developing TRI cooperation in several focused, team projects in applied research. We are hoping to develop teams for cooperative research needed for the management of the Panama Canal watershed, the Isla Juan Venado Mangrove Reserve in northwestern Nicaragua, and a high elevation tropical protected area in the Venezuelan Andes. We also hope to be able to assist in the development of an environmental diagnostic and plan for the environmental management of the Machu Picchu Sanctuary, Peru.

James A. Bryan
Program Director

Mark S. Ashton
John Musser Director, Tropical Resources Institute

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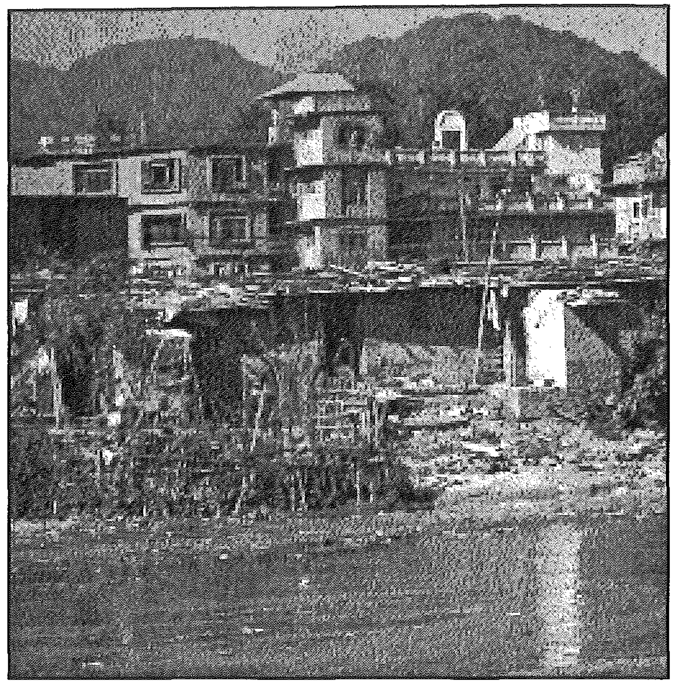
Restoration and Development:
Landless migrants and urban river management in the Bagmati Basin, Kathmandu, Nepal

Anne M. Rademacher
Master of Environmental Studies ('98)

It is estimated that by 2025, two-thirds of the world's population will live in urban areas (World Resources Institute 1996–1997). Human populations are increasingly concentrated in cities, particularly in developing regions. The environmental implications of the massive rural to urban transition underway in many parts of the world have received growing attention in international policy and development arenas. Donor-assisted programs and policies to define and promote ecologically sound urban growth are increasingly at the center of international development dialogue.

This research project examined the connections between rapid urbanization, river system degradation, and human migration and settlement patterns in the Bagmati Basin in Kathmandu, Nepal. A statement of research objectives and methodology appeared in the spring 1998 *TRI News*. This article presents some key insights from the project.



The small, semi-permanent structures along the Bishnumati riverbank mark land claims made by squatters in Kumaristhan. Large legal homes are seen in the background.

Background

The principle rivers of the Kathmandu Valley section of the Bagmati Basin, the Bagmati and Bishnumati, suffer severe ecological degradation inside the urban area of Kathmandu, conventionally delineated by Ring Road (see Figure 1). Characteristics of river degradation include reduced water quality and changed physical dimensions as well as, some argue, loss of the cultural and religious values traditionally attributed to the rivers. Ecological deterioration of the rivers is commonly described as having dramatically accelerated over the past ten years, a time of rapid urban growth as well as democratic transition in Nepal.

River degradation in Kathmandu has been linked to many interconnected factors. Comprehensive studies identify the main causes of river pollution inside the urban area as the discharge of untreated sewage and widespread dumping of solid waste into the rivers and their banks. Excessive sand mining in river beds, which supplies mortar and cement to the city's booming construction industry, is blamed for severe morphological and flow pattern changes. In addition to these factors, most policy and development discussions of river degradation identify human encroachment on the banks, floodplains, and river beds exposed by falling water levels as a further factor in the degradation process.

Illegal settlement on marginal riparian urban lands is a growing issue in the city. Urban growth in Kathmandu—at 6.5 percent the highest annual urban population growth rate in South Asia and double the average growth rate for the region (United Nations Population Fund 1995)—has catalyzed rapid urban development over a large area and increased population density throughout the city.

Despite a construction boom, housing supplies are insufficient to meet the overwhelming demand and rent prices have become inaccessible to many. For new migrants and poorer city residents, participation in the current land and housing markets is impossible.

As a result, many new migrants and long-term Kathmandu residents employ a strategy of "squatting": occupying marginal land illegally and claiming it through the construction of shelter. The resulting settlements and their occupants are referred to in Nepali as *Sukumbassis*. These settlements are growing at 12 percent annually, a rate twice that of the city itself; at this rate it would take less than ten years for the entire riparian corridor of the Bishnumati River, shown in Figure 1, to be claimed by Sukumbassi settlement (His Majesty's Government of Nepal and Asian Development Bank 1991).

In the fall of 1997, the time of this research project, the total number of settlements characterized as Sukumbassis in Kathmandu was 54. Half of these settlements were riparian, situated on the banks of the Bishnumati, Bagmati, or one of their larger urban tributaries (Tanaka 1996). Of the total population of Sukumbassis in the Kathmandu Valley in 1996, close to nine thousand (Tanaka 1996)--69 percent--lived in riparian settlements and about two-thirds of those occupied settlements on the Bishnumati or Bagmati Rivers. Figure 1 illustrates the location of most of these settlements.

The severity and complexity of river degradation in Kathmandu has led to extensive official dialogue focused on planning the restoration of the Bagmati and Bishnumati Rivers. International aid organizations and Nepali government agencies have produced a variety of reports which propose policy and projects to promote river restoration. Restoration efforts acknowledge the immense strips of human settlement present on the city's river banks—and, in some cases, on exposed bed. But almost always, the imperative solution to the "Sukumbassi problem" is identified as unconditional eviction,

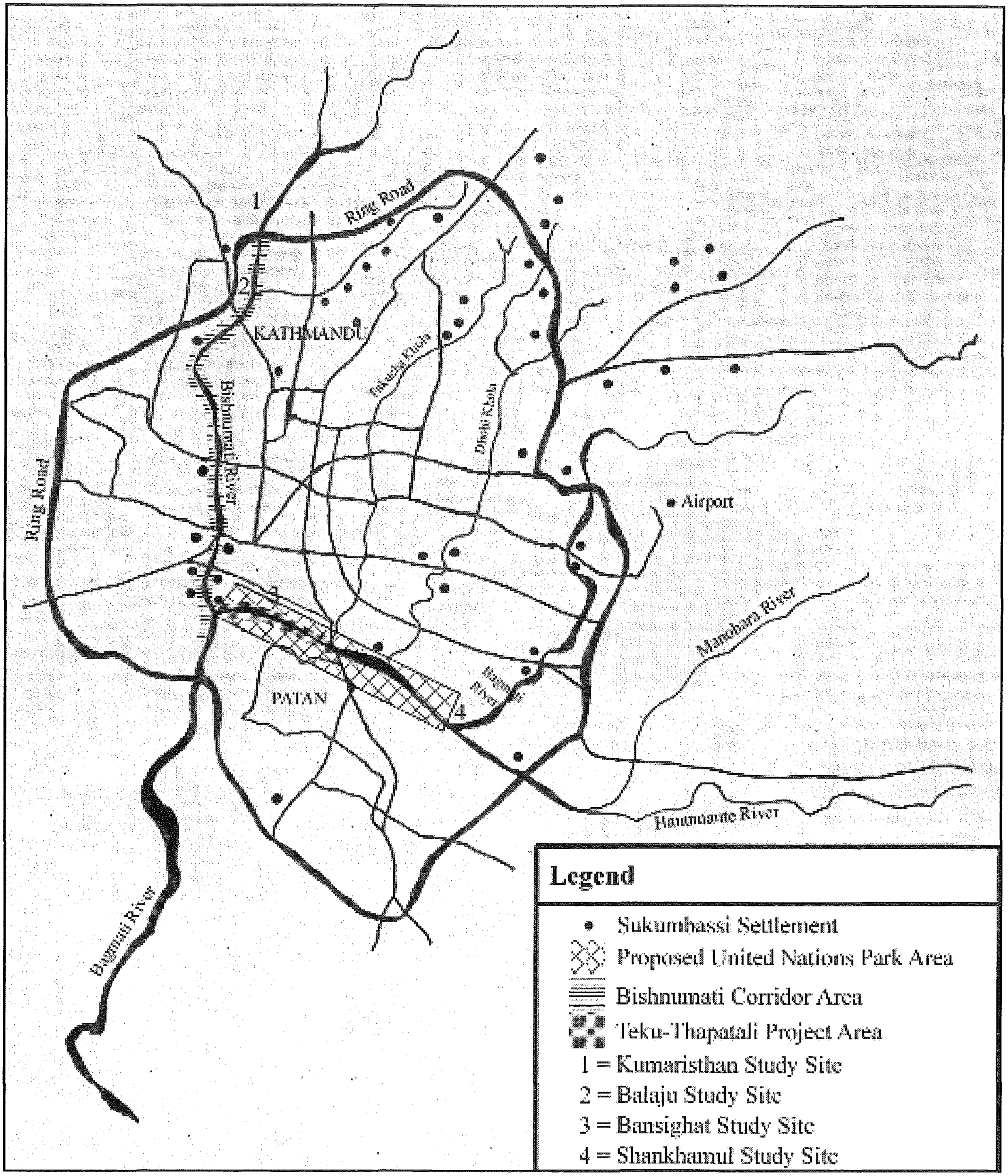


Figure 1: Sukumbassi settlements and major project sites in the Upper Bagmati Basin. (Twelve Sukumbassi settlements are not mapped.) Source: Tanaka 1997.

justified through claims ranging from undesirable aesthetics to the ecological integrity of the system to property rights and legality issues. Suggestions of eviction can be implicit or explicit, and they usually do not address the need for resettlement of Sukumbassi populations elsewhere. Projects designed to engage and involve the "local community" in river restoration activities nearly always exclude Sukumbassis.

Findings

Methods employed in this research included the review of policy documents related to river restoration initiatives on the Bagmati and Bishnumati, key informant interviews among Sukumbassis, NGO representatives, and policymakers, and an interview survey administered to a 5 percent sample of Sukumbassi community residents.

Policy documents that discuss river degradation in the Bagmati Basin generally concede that there is an overwhelming lack of biophysical data on which to base restoration initiatives. This lack of data and the prevalence of biophysical uncertainty in this case makes an analysis of power, problem representation, and the use of "restoration" as conceptual tools of development critical. What can be known and predicted scientifically is admittedly limited, leaving great liberty for social forces to exercise other agendas under the guise of river restoration. This has clear material consequences for those most proximate to the resource and, in many ways, the least powerful in its transformation.

Certain assumptions about Sukumbassis' attitudes, knowledge, and practices vis-á-vis the rivers are used to rationalize the exclusion of Sukumbassi communities from community-based initiatives associated with river restoration. Project documents that make assertions about riparian Sukumbassi attitudes regarding the condition and future of the rivers claim that the settlers' transient status and presumed instability prevent them from establishing a clear connection to, understanding of, and willingness to act on behalf of the river system. As a consequence they are either explicitly or implicitly ignored as stakeholders in the planning and execution of river restoration initiatives.

These policy assumptions were tested in a survey interview administered to a 5 percent sample of the riparian Sukumbassi population. Hypotheses driving the survey design were based on the assumption that if policy characterizations of Sukumbassi attitudes are true, one should be able to demonstrate that: 1) in a sample, Sukumbassis generally express low levels of awareness, concern, and action for the river to which they are proximate; 2) among Sukumbassis, the more recent the migrant the lesser her/his expressed awareness, concern, and action for the condition of the river. These assumptions should be evident in both the sample and the population.

The survey analysis found that both in the sample and in the population the data does not support the popular contention that Sukumbassis would, by nature of their status, express generally low levels of awareness or action with respect to the condition of the river. In each of the four dependent variables measuring attitudes about the river, high sample frequencies of responses indicating awareness, concern, and independent action to improve the river's condition, regardless of status, were observed. Overall, the results of the study strongly support a challenge to the popular representation of Sukumbassis as unaware, unconcerned, and inactive regarding the condition of the Bishnumati and Bagmati Rivers. Sample results suggest that the vast majority of Sukumbassis are not only aware of river conditions and find them intolerable, but they are also locally active in trying to manage the resource for a cleaner, healthier living environment.

Perhaps most important from a river restoration standpoint is the micromanagement documented in most riparian settlements. Many Sukumbassi communities are actively engaged with the river resource, performing tasks either collectively or individually which constitute efforts at management and improvement, as well as simple survival:

- Planting vegetation—from trees to grasses—is a common practice. Settlers interviewed were adamant about the potential stabilizing effects of planted vegetation.
- Settlers often described patrolling their settlement for illegal riverside dumping (practiced widely by the municipalities) and suggested that they should have more authority to watch for and halt direct solid waste dumping on the banks.
- Building riverbank retaining walls—to prevent flooding and further bank erosion—is a widespread practice. Several settlements had community-constructed toilets and services like water and electricity that were acquired through community action.
- The survey sample showed that 68 percent of Sukumbassis said that they had taken action to improve the condition of the river. In most cases, investments in river-related practices were made at personal expenses of time, money, and labor.

It is important to note these actions not simply as indicators of awareness, activity, and interest, but also as symbols of the extent of property claim common in the settlements. The extensive investments made in the communities and their environmental context illustrates the Sukumbassi belief in their own permanence on the landscape; this finding sharply contrasts with predominant policy representations of instability and impermanence. Rather than assert that every Sukumbassi is active in riverbank management and directly concerned with the river—which can be shown not to be the case—my intention is to highlight that which indicates that Sukumbassis are stakeholders in the condition of the rivers, from both a human habitat standpoint and a river restoration standpoint. Some of the most effective small-scale stewardship may very well be taking place where river meets people; in Kathmandu, that interface is nearly always at a Sukumbassi settlement.

Conclusions

Both quantitative and qualitative data collected in this study indicates that there may be severe misperceptions about Sukumbassis and their knowledge, attitudes, and practices related to Kathmandu's river system. These misperceptions have serious consequences for both the settlers themselves and for the restoration effort in general.

By current policy, rather than being engaged as stakeholders in the condition of the river system, Sukumbassi communities are excluded from river initiatives and threatened with eviction. More research and a careful review of the assumptions on which this programming is currently based are needed.

These findings indicate that, particularly over the short term, the restoration effort would benefit from the acknowledgement and incorporation of Sukumbassis into planned and ongoing projects. Even if the ultimate policy goal is the resettlement of migrant communities elsewhere, an inclusive policy would prove beneficial in the short term. Activities already underway in the settlements, including vegetation planting, retaining wall construction, and solid waste patrolling, can be strengthened and incorporated into current restoration activities. While the most significant restoration components, namely sewage treatment, are being planned and built, there exists a significant window of time to include Sukumbassis in restoration activities.

More broadly, it is essential to recognize that ecological restoration, particularly but not exclusively on an urban landscape, is a social, cultural, and political process. What is often represented as benign and technical in nature in fact entails social processes and transfers of power that dictate what is ecologically desirable and realistically feasible. The development narrative in the Bagmati Basin case reveals that underlying an ecologically focused agenda can be a host of complex social and political goals. As urban environmental restoration initiatives command more attention and international donor funding, attention to the social and political dynamics of urban ecology are increasingly critical considerations for resource managers.

A full report of project methodology, data, and analysis can be obtained as a TRI Working Paper entitled "Restoration as Development: Urban Growth, River Restoration, and Riparian Settlements in the Upper Bagmati Basin, Kathmandu, Nepal."

Acknowledgements

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The Effects of Artisanal Fishing in the Galápagos Islands

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Introduction

Over the last 25 years, a substantial artisanal fishery has developed in the Galápagos Islands, due in part to increasing immigration, increasing tourism, and improved technology allowing for the export of fresh fish (Merlen 1995). While this fishery is primarily confined to local fishermen using simple gear from small boats, the Charles Darwin Research Station (CDRS) estimated that in 1997 this fishery caught over 300 metric tons of fish (Bustamante 1998). Historically, a great deal of attention has been paid to the protection of the terrestrial species and ecosystems that make Galápagos unique. Despite this interest, little research has investigated the ecology of the marine systems of these islands, and no studies have examined the potential impacts of human use, such as fishing, on these communities.

Such questions are particularly germane at this moment. A group of local stakeholders, including representatives from tourism, fishing, science and conservation, and government, is currently rewriting the management plan for the Galápagos Marine Resources Reserve (Galápagos National Park Service [GNPS] 1997). While theoretically, the current plan allows the GNPS to regulate use of the Marine Reserve, it contains few specific mechanisms for the GNPS to exercise control over the users of the Reserve, especially fishermen. According to Rodrigo Bustamante, head of the Area of Marine Investigations, Charles Darwin Research Station, compliance with the current plan is sporadic and enforcement is nonexistent. For example, Ecuadorian and international industrial fishing vessels are expressly prohibited from fishing within a 40-mile limit of the islands, but boats caught within the reserve are at most lightly fined and released (Bustamante 1998).

The effects of artisanal fishing have been studied extensively in other areas of the tropics. A number of studies have found significant decreases in the size structure, abundance, and biomass of target species (e.g., Jennings et al. 1995; Jennings and Polunin 1997; Watson and Ormond 1994). The target species are usually higher predators (Koslow et al. 1988), and their removal may have indirect cascading effects at a number of trophic levels, leading to changes in community structure and species richness (Jennings et al. 1995). Jennings and Polunin (1997) notes that these indirect, community level effects on non-target (non-commercial) species are often difficult to detect. In the Galápagos, there have been a few indications that fishing affects the structure of the communities it exploits. Fifteen years ago, Reck (1983) found that one species of grouper *(Myc-*

teroperca olfax) was overwhelmingly the most important commercial species in the fishery, comprising over 40 percent of the catch. Preliminary results from the current CDRS fisheries monitoring study indicate that *M. olfax* now may comprise less than 20 percent of the catch by weight (Bustamante 1998). Anecdotal evidence from the fishermen also indicates that catch per unit effort has decreased, and long-term residents claim that abundance and average size of *M. olfax* have declined (Bustamante 1998). These examples indicate that fishing may have a significant impact on one commercial species, with unknown effects at the community level.

To determine the impacts of fishing on marine communities in the Galápagos, I conducted an observational experiment (Diamond 1986) using variation in fishing pressure between different sites as the treatment. For a variety of reasons, some areas in the Galápagos are fished more heavily than others. Areas that are difficult to reach or far from other potential sites tend to be fished only lightly, and the GNPS strongly discourages fishing near tourist sites. In contrast, areas near towns or near other fishing sites tend to be fished more heavily. My goal was to try to detect changes in the abundance and biomass of target species and changes in overall community structure as a result of fishing. Based on previous work (see Jennings and Polunin 1997 for a review), I hypothesized that fishing would directly reduce the abundance and biomass of target species, and would indirectly lead to changes in community composition and declines in overall species richness.

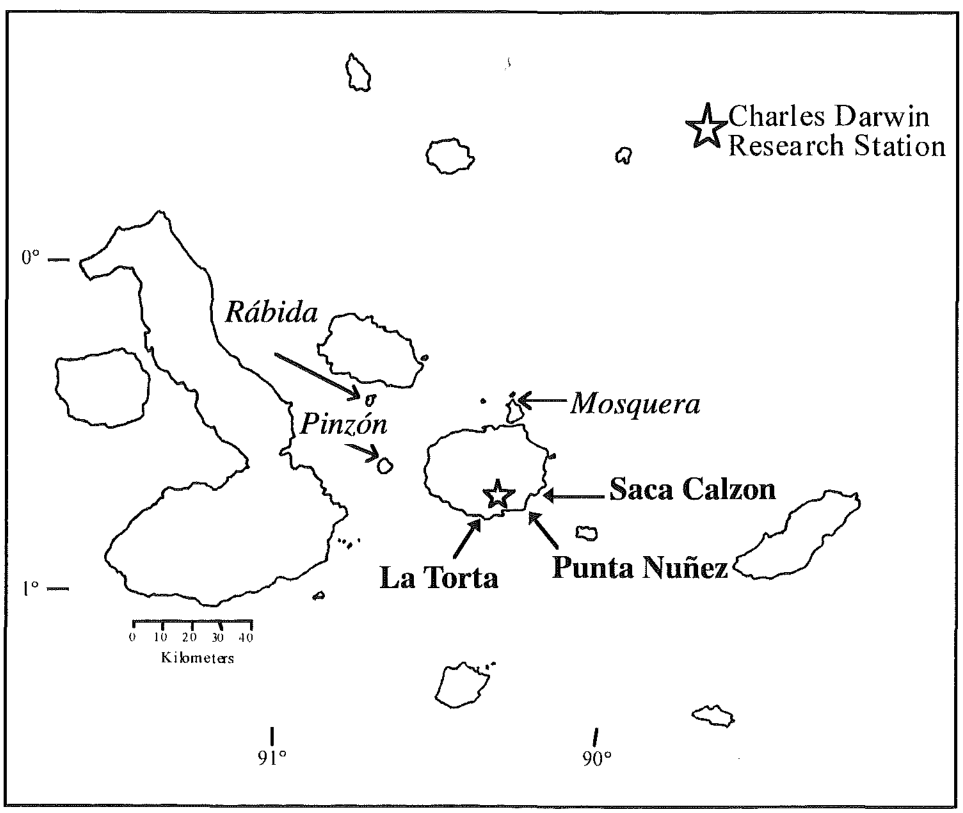

Figure 1: Map of Galápagos. Heavily fished sites are in bold type (Saca Calzon, Punta Nuñez, and La Torta); lightly fished sites are italicized (Mosquera, Pinzón, and Rábida).

Methods

Selection of Study Sites

This study was conducted at a variety of sites throughout the central islands of the Galápagos Archipelago (see Figure 1). I analyzed data from the fisheries monitoring study of the CDRS and generated a frequency distribution of fishing trips per site. Sites in the top quartile were considered heavily fished, and those sites in the bottom quartile were considered lightly fished. In order to reduce the effects of intersite variability and potential outlier effects due to the selection of an "atypical" site, I sampled three heavily fished sites and three lightly fished sites. I also controlled for other factors that lead to variability in fish assemblages, such as temperature and benthic topography. Sea surface temperatures can be highly variable in the Galápagos. Harris (1969) defined five hydrogeographic zones within the archipelago, and Jennings et al. (1995) found that fish assemblages correlated to these zones. To reduce the impact of different hydrogeographic zones, I attempted to select all sites from within the central zone that contains the Darwin Station. Only one site (Rábida) fell outside of the central zone, but it was on the border of the central zone and water temperatures at the time of sampling were consistent with temperatures at the other sites. Fishes are also differentially attracted to areas of differing substrate relief and substrate slope. To reduce the effects of habitat variability, I sought to standardize these variables. I selected only sites that had either flat or gently sloping rocky reef, as opposed to steeper slopes or vertical walls. Sites were also picked to have a range of benthic complexity that would provide suitable habitat for the fishes I sampled (McClanahan and Shafir 1990; McCormick and Choat 1987). After sampling a number of sites for habitat type, I selected La Torta, Punta Nuñez, and Saca Calzon as the heavily fished sites, and Mosquera, Pinzón, and Rábida as the lightly fished sites (see Figure 1). All of the heavily fished sites were located near the CDRS and could be reached on a daily basis, while the lightly fished sites were further from the research station and required week-long trips for sampling.

Survey of Reef Fish Population Densities

Quantitative estimates of abundance and size of fish were made using a point count underwater visual census technique (e.g., Samoilys 1997; Jennings et al. 1995). Within each site, only areas of appropriate habitat type and complexity were sampled and patchy areas of sand or low complexity were ignored. All fish counts were made between June 11 and August 12, 1998, which corresponded to the start of the cold season in Galápagos. The heavily fished sites near the CDRS were surveyed on an opportunistic basis via daily trips, thereby staggering sampling of these sites over the course of the two-month sampling period. Because the lightly fished sites were more distant from port (and hence less accessible to fishing), logistical considerations prevented more than one visit during the summer and each was sampled intensively over a few consecutive days.

The point count technique used was modified from that described in Samoilys (1997). Each count (hereafter referred to as a replicate) surveyed the abundance of all diurnally active reef-associated fish greater than 10 cm long in a circle of 150 m² (radius of 6.9 m). Density (the number of fish per plot) was recorded for each species. If no individuals of a given species were counted in a given replicate, the density for that species in that replicate was assigned a value of zero. I also estimated the size for all individuals of commercial species (larger *Serranids* and *Lutjanids*) and placed them in 5-cm size classes. Surveys were conducted by a buddy pair consisting of myself as the dive leader and a dive assistant. I indicated a spot at random on the substrate to begin the first replicate, where the dive assistant laid one end of a weighted 6.9 m line and proceeded to swim along a constant depth contour to place the other end of the line. While the assistant laid the line, I began the census, starting with the most active species, proceeding to territorial species, and finally to sedentary species associated with the benthos, using the 6.9 m line as a guide to estimate the radius of the circle. Only those individuals that were in the circle when the count began were included. These measures were necessary to avoid biased estimates of abundance due to fish moving into and out of the circle once the count began (Samoilys 1997). I estimated the size of individuals of commercial species as I counted them, and I developed and maintained accuracy of size estimation over the course of the summer by estimating segments of plastic tube cut into lengths that varied from 10 cm to 100 cm in 5 cm increments. Data was recorded underwater on waterproof forms.

I recorded environmental data for each replicate after completing the fish count. These data included visibility as horizontal distance in meters, depth in meters, and water temperature. In addition, I also used a relative scale of zero to three to estimate current, substrate complexity, and substrate gradient. We then swam along the contour line for around 50 fin beats, before beginning the next point count to avoid biasing counts by diver presence from previous replicates (Samoilys and Carlos 1992). Under normal circumstances, we were able to complete six to eight replicates in a dive. The number of replicates ranged from 24 to 48 per site, and we completed at least 35 replicates for all sites except La Torta where we completed only 24 replicates due to poor water visibility during the second half of the summer.

Results

Each species of fish was classified as either a target or non-target species for subsequent analyses based on susceptibility to various fishing gear, analysis of data from the fisheries database of the CDRS, conversations with fishermen, and available literature (Lavenberg and Grove 1997). Rare species from all categories were excluded from all analyses to avoid outlier effects, and data was analyzed using both the subset of target species and the full set of species. Using length-weight relationships from the literature and data from the CDRS fisheries monitoring study (Froese and Pauly 1998; Bustamante 1998), I calculated a value of average biomass for each commercial species per site. Both density and biomass of commercial species were significantly lower in heavily fished sites vs. lightly fished sites (MANOVA; $F=5.57$, $df=1$, $p=0.024$ for density; $F=5.19$, $df=1$, $p=0.029$ for biomass). Inspection of the means reveals that this trend is fairly constant across all sites (see Figures 2 and 3).

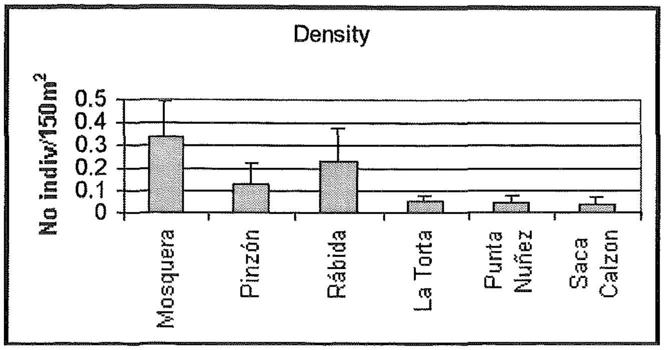

Figure 2: Aggregated density of six commercial species by site. Bars represent mean density (number of individuals/150 m²), and error bars represent 1 SE. The leftmost three sites are lightly fished, and the rightmost three sites are heavily fished.

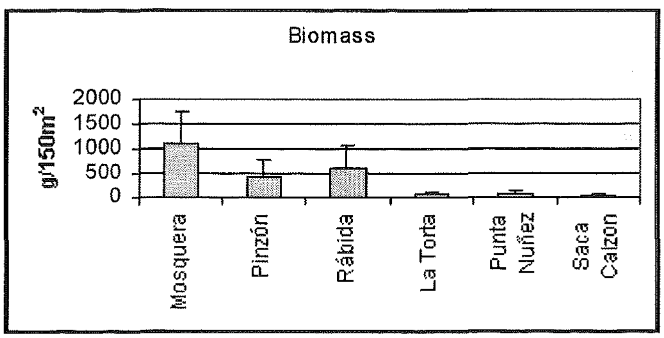

Figure 3: Aggregated biomass of six commercial species by site. Bars represent mean biomass (grams/150 m²), and error bars represent 1 SE. The leftmost three sites are lightly fished, and the rightmost three sites are heavily fished.

Overall community structure was analyzed using cluster analyses. This technique groups sites based on analyses of differences of the entire community assemblage. It computes a mean density value (number of individuals/150 m²) for each species at each site and compares these values across all six sites. From a comparison of density values for each species in the community, similarity values between sites are calculated. These similarity values are represented by a dendrogram, where shorter branches of the dendrogram represent greater similarity between sites. The resulting dendrogram from these data show that sites cluster into two distinct groups that correspond to fishing pressure (see Figure 4).

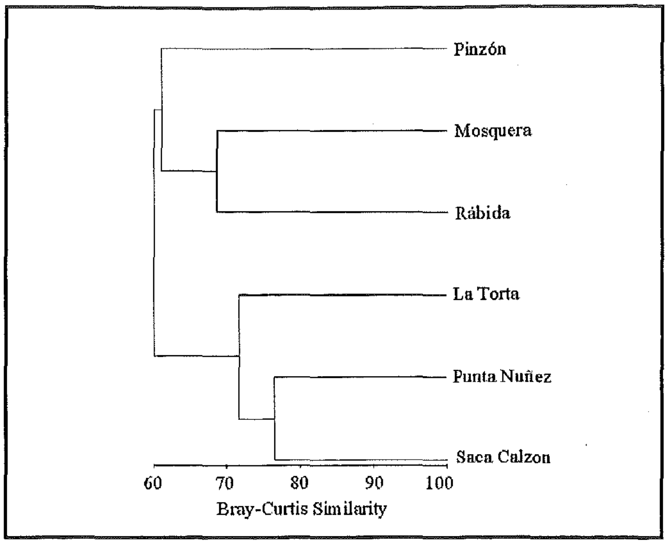

Figure 4: Cluster analysis based on community assemblage, computed using a Bray-Curtis Similarity.

I analyzed species richness using the total number of species encountered on a dive, aggregated by site (see Figure 5). No significant differences existed between heavily fished and lightly fished sites (t-test; t=0.735, df=4, NS).

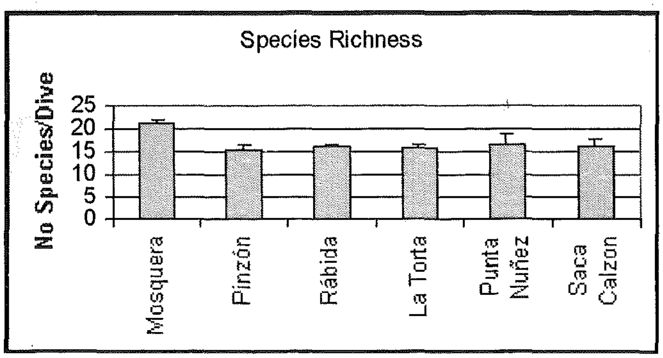

Figure 5: Species richness by site. Bars represent the mean number of species seen on a dive, error bars represent 1 SE.

Discussion and Conclusions

The initial results of this study support the hypothesis that fishing has had an effect on the abundance and biomass of the primary commercial species, as both the density and biomass of these species were lower in heavily fished areas than lightly fished areas. In addition, there is also support for the hypothesis that fishing has cascading effects throughout the community, as evidenced by the cluster analysis of sites. Within this dendrogram, the lightly fished sites appear to be more dissimilar from each other than are the heavily fished sites. This could be the result of greater inherent variability within the lightly fished, more pristine sites. As environmental conditions in Galápagos are variable, community structure and species assemblages may change with this environmental variation (Jennings et al. 1994; McCosker and Rosenblatt 1984). Fishing in these areas may cause a shift in community structure such that the "new" communities more closely resemble each other. In other words, fishing may not only cause changes in community structure, but it may reduce variability between sites as well. Changes in community structure may be manifest through changes in the relative abundance of various species rather than a change in the species richness that a particular system can support. These possible shifts to new states will be most detectable through long term monitoring of species assemblages in the Marine Reserve, for which this study will serve as an effective baseline.

The Galápagos is one of the last remaining tropical marine areas that have not been severely affected by anthropogenic influences, but this study has provided the first evidence for ecosystem changes that may be occurring as a direct result of humans. However, with no information available to estimate carrying capacity, productivity, or rate of depletion of the fishery, it is unclear whether this level of exploitation is sustainable. An improved understanding of the interactions that structure this community is vital to successful management of marine resources in Galápagos and in other exploited tropical reef systems. Better control and monitoring of the use of marine resources in Galápagos will be the first step towards improved management and conservation of this unique ecosystem.

Acknowledgements

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The Reproductive Biology of Jamaica's Endemic Black-Billed Parrot *(Amazona agilis)* and Conservation Implications

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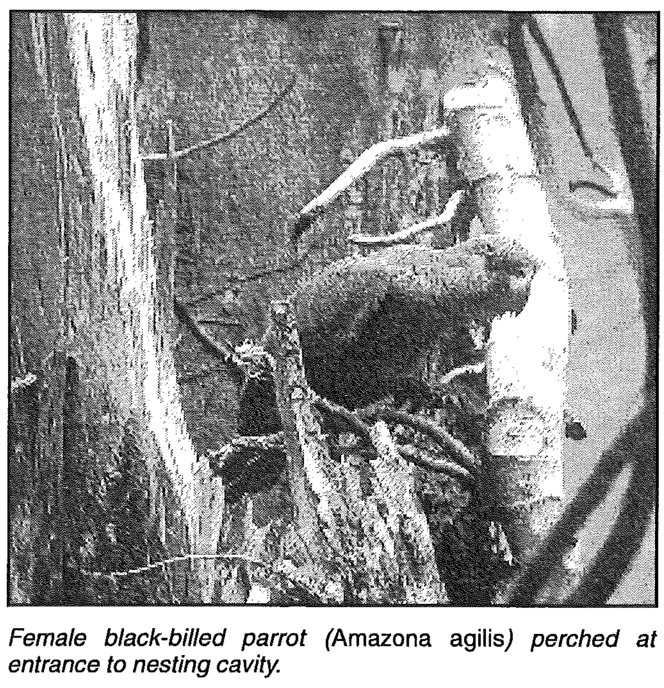
Doctor of Philosophy

Introduction

Jamaica, the third largest island in the Caribbean, is recognized globally as an important area of biodiversity because of high levels of endemism among plants (Heywood 1995), reptiles and amphibians (Groombridge 1982) and birds (Stattersfield et al. 1998). Jamaica, unfortunately, also has the distinction of having one of the highest rates of deforestation in the world, estimated at 7 percent per annum (World Resources Institute 1998–99). Where historically nearly 97 percent of the island was covered with closed-forest ecosystems, current forest cover amounts to only about 35 percent (World Resources Institute 1998–99). Of the remaining forest, only 5 percent have survived relatively undisturbed by humans and occur in only the steepest or most remote, inaccessible parts of the island.

Two species which have suffered population decline as a result of this deforestation are the black-billed parrot *(Amazona agilis)* and the yellow-billed parrot *(A. collaria)* (Gosse 1847; Scott 1891–1893; Danforth 1928; Cruz and Gruber 1981; Varty 1991). Major populations currently are restricted to extant mid-level wet limestone forests of the John Crow and Blue Mountains and the karst region known as Cockpit Country. This latter region encompasses 50,000 acres of contiguous closed-canopy forest and represents the stronghold of the black-billed parrot. In previous decades, populations have been estimated between 1,000 and 2,000 each, with the black-



Female black-billed parrot (Amazona agilis) *perched at entrance to nesting cavity.*

billed parrot thought to be rarer than the yellow-billed parrot (Cruz and Gruber 1981; Varty 1991). More recently, University of the West Indies Masters Candidate H.A. Davis estimated populations of at least 4,000 per species.

Both parrot species are listed on Appendix II of the Convention on International Trade of Endangered Species (CITES) and possession is regulated by Jamaica's Wildlife Protection Act of 1945. Cruz and Gruber (1981) identified poaching as a significant short-term threat, particularly for the yellow-billed parrot, which is preferred of the two in the pet trade. Poaching of nestlings continues, although not at the alarming rates experienced by many mainland psittacines where nearly 100 percent of nestlings in certain populations were poached (Collar and Juniper 1992; Martuscelli 1995). Rather, deforestation and habitat alteration are identified as the most important long-term threats to the persistence of Jamaica's parrots (Wiley 1991). This paper summarizes my findings concerning the reproductive biology of Jamaica's black-billed parrot and examines anthropogenic effects on the long-term survival of the species.

Jamaica Parrot Project

In 1995 I helped establish the Jamaica Parrot Project to: 1) census populations of Amazona parrots and more accurately delineate their ranges, 2) collect baseline natural history information on breeding biology and identify factors limiting reproductive success. One of the earliest questions we raised was whether suitable nesting resources and quality habitat limited the parrots. For non-excavating cavity nesters, it is recognized that as native forests are removed there will be a concomitant quantitative loss of trees in which hollows form and a qualitative change in remaining resources (reviewed by Newton 1994). Therefore, we initiated an intensive monitoring program of the breeding biology of both species. Our goals were to collect data on reproductive performance (e.g., hatching success, duration of nestling period, fledging success), to identify causes of nest failure, and to identify physical characteristics of nesting resources that contributed significantly to nesting success and failure.

To our surprise, and contrary to reports in the literature, black-billed parrots are locally common in the northern and interior regions of Cockpit Country. We located 56 nesting sites that were used in 77 breeding attempts from 1995 to 1998. In contrast, we located only 11 yellow-billed parrot sites. Whether this is due to yellow-billed parrots needing larger nest trees, as reported by local villagers, or some other mechanism, is unclear. The forests of Windsor and neighboring Coxheath were logged heavily in the 1940s–1950s; so much of the forest cover on hillsides is regenerating edge habitat. A few large, older snags remain on hilltops, and it was in these snags that yellow-billed nests were found most commonly. Yellow-billed parrots do occur regularly in the southern region of Cockpit Country.

Nesting success was low (approximately 65 percent of nests fledge no chicks) for black-billed parrots compared to other insular Amazona parrots (e.g., Puerto Rican parrot *A. vittata,* Cuban parrot *A. leucocephala,* and red-necked *A. arausiaca* and imperial parrots *A. imperialis* of Dominica; Snyder et al. 1987; Koenig 1994). The primary cause of nest failure was due to predation. Although I have not yet been successful in obtaining direct confirmation of predator identity, all evidence strongly suggests predation by the endemic and endangered yellow boa *(Epicrates subflavus).* For example, only one nest failed during incubation and this was due to the female abandoning the nest with a flurry of squawks at 4 PM hours (the site was 30 m from our research station). We found her eggs buried in the substrate but intact. As eggs began hatching, daily survival probabilities decreased dramatically. However, only live chicks "disappeared," eggs were never taken, nor were there marks (e.g., rodent teeth, bird beak) on them, and there were never mammalian feces in the nest. These patterns are indicative of snake predation. Perhaps the best evidence obtained was of a shed snake skin and fecal pellet containing the leg bands of a yellow-billed parrot chick, which was observed fledging, found one meter from the nest tree on the ground. A yellow-billed pair adopted this nest the following year. Around the estimated time of hatching we climbed the tree to check nest contents, but found only a shed snake skin at the cavity entrance.

Data that correlate the success rate of nests with the position of the nest tree also support the importance of predation in the population dynamics of this parrot. Black-billed parrots which adopted cavities in trees covered with vines or trees in which the canopy was interconnected with neighboring trees on all cardinal compass points (north, south, east, and west) had a significantly greater probability of failing (see Table 1). Such features have correlated positively with the preferred foraging habitat of the Mona boa *(Epicrates monanesis)* (Chandler and Tolson 1990), a species closely related to Jamaica's yellow boa. Further, the probability of a nestling falling prey to a snake depended upon the location of the nest tree (see Table 2). Black-billed parrots that used nest trees located in badly degraded edge habitat (e.g., an isolated tree within a cattle pasture) or in minimally disturbed interior forest had significantly greater nesting success compared to parrots that adopted nest sites in "intact" edge habitat of regenerating forest. This regenerating edge forest is characterized by a dense understory of herbaceous vegetation and vines. Although we lack data on the densities of yellow boas, one can speculate that proximity to human settlements and their vermin (e.g., rats) may provide a year-round prey base for snakes in the two types of edge forest. Yet encounters with humans carrying machetes in open pastoral habitat may increase snake mortality and decrease their population density, whereas the regenerating edge habitat may provide a highly suitable medium for the snakes to move throughout the forest canopy, thus avoiding encounters with humans.

I attributed the second major cause of nestling mortality to exposure and hypothermia. Although one of the benefits typically ascribed to nesting in a tree hollow is protection from inclement weather, the degree to which nests protected chicks from rain and, most important, flooding of the substrate, varied. Although black-billed parrots should be considered generalists in the types of cavities they use for nesting (see Table 1), nest sites without a protective ceiling and with poor drainage had prolonged periods (e.g., two to three days) of standing water following heavy rainstorms. Chicks were much less likely to drown in nests with good drainage, such as cavities that formed in dead tree trunks (e.g., snags). These latter nests, however, suffered heavy rates of predation (see Table 1). The observance that nearly 50 percent of nesting attempts failed raises two questions: 1) is this significant to black-billed parrot long-term

Table 1: Characteristics of 49 trees adopted for use in 65 breeding attempts by Amazona agilis *in Cockpit Country, Jamaica, 1996–1998. Nesting attempts were considered successful if at least one nestling fledged during this period.*

Characteristic	Successful (n=35) Mean + SD	Unsuccessful (n=14) Mean + SD
Tree height (m)	15 + 6	13 + 6
Crown radius (m)	3 + 2	2 + 2
Canopy coverage over entrance (%)	65 + 30	73 + 30
Tree health*	Alive	Snag
Presence of vines*	None	Few +
Diameter at breast height (cm)	49.5 + 21.1	51.4 + 27.7
Cavity height above ground (m)	9.4 + 5.6	8.4 + 3.7
Length of cavity entrance (cm)**	71.4 + 48.0	39.0 + 22.8
Width of cavity entrance (cm)	18.4 + 8.2	19.8 + 8.2
Orientation	221+ 94	166 + 119
Internal diameter at entrance (cm)	18.5 + 4.3	19.7 + 5.8
Cavity depth (cm)	208.4 + 111.7	192.3 + 121.2
Internal diameter at base (cm)**	23.8 + 6.5	19.6 + 4.8
Thickness of cavity wall at base (cm)	5.0 + 2.4	5.3 + 2.9

*Chi-squared, P < 0.01
**Student's T-test, P < 0.01

viability; and 2) if management efforts are required, what will be the most effective solutions? First, we must look back at the failure patterns across the habitat gradient of badly to minimally disturbed forest (see Table 2). Whereas over 70 percent of nests located in regenerating edge forest failed, only 40 percent failed in badly degraded edge and minimally disturbed interior forest, respectively. If we assume that adult survival rates and life span are comparable to the closely related Puerto Rican parrot *(Amazona vittata),* which was estimated to have an annual survival rate of 0.90 (Snyder et al. 1987), then the nesting success observed in the interior and badly degraded edge will yield a positive population growth rate (r = 0.05). However, when the lower reproductive performance associated with regenerating edge habitat is incorporated into a demographic population projection model, population growth becomes negative, albeit just barely (r = -0.02). Thus, regenerating edge habitat may represent sink habitat for black-billed parrots. Conversely, this habitat type and structure and an abundance of parrot nestlings may represent critical habitat and food resources for the endangered boa.

Table 2: Patterns of Amazona agilis *nest failure across a gradient of habitat types in Cockpit Country, Jamaica.*

	No. of nests (%)		
Nest fate	Edge/pasture	Edge regenerating	Interior
Fledge > 1	17 (61%)	8 (26%)	3 (60%)
Predation	6 (21%)	15 (50%)	0 (0%)
Dead-in-nest	2 (7%)	3 (11%)	2 (40%)
Other/unknown	2 (7%)	4 (13%)	-----

Conservation Implications

The results of my research make several features salient and provide direction for Jamaica's natural resource managers. Although many non-excavating cavity nesting bird species are limited by the availability of suitable nesting substrates (reviewed by Newton 1994), Jamaica's black-billed parrots do not appear to be limited quantitatively by nest site availability and readily adopt a wide variety of cavity types. The quality of the actual tree hollow does not appear to be as important as the quality of the surrounding habitat. As such, while the addition of artificial nest boxes and efforts to rehabilitate natural nest sites are often cited in parrot conservation plans, this management tool does not appear warranted for the black-billed parrot population in Cockpit Country.

Understanding the relationship between parrots and snakes across the gradient of habitat types created by anthropogenic activities is essential for parrot conservation to succeed. At present, black-billed parrots are quite common within Cockpit Country. However, their near exclusive restriction to this area renders them highly vulnerable to disturbance of this critical habitat, particularly as human activities disrupt natural interactions among wildlife. Whereas the rugged, hilly terrain of Cockpit Country rendered the region unsuitable for the historically important crop of sugar cane, the previous 30 years have seen a shift in the agricultural market to increasing production of yam and other tubers (World Resources Institute 1998–99). This shift in production affects Cockpit Country's native flora and fauna on two fronts: 1) farmers clearcut hillsides and create banks of yam, reducing forest cover and suitable nesting substrates; and 2) yam plants require a support stake that is typically a sapling approximately 8–10 cm in diameter. This translates into an estimated 5 to 9 million saplings harvested annually from Cockpit Country.

Jamaicans are therefore not only removing the regeneration source for mature trees in which nesting cavities will form, but are also extending their disturbance regime further into the interior, potentially affecting the predator/prey balance between snakes and parrots. Because we lack a clear understanding of this dynamic process, Jamaica's resource managers should strive to maintain the integrity of the interior forests. Resource managers should also work with yam farmers in the peripheral communities of Cockpit Country to develop alternative support stakes for yam plants (e.g., non-timber materials, plantations of appropriate trees for sapling production). Such alternatives, which reduce pressures on natural resources, will assist in efforts to ensure the persistence of individual species within a functioning ecosystem.

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Facilitating Local Participation in a Conservation Planning Workshop

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Introduction

Western and Wright (1994) highlight what they call the "biggest conservation challenge of all: how to deal with the vast majority of the earth's surface, where there are no parks and where the interests of local communities prevail." Perhaps nowhere in the world is the need to recognize local communities' interests greater than in Papua New Guinea (PNG), where 96 percent of the land is privately owned, many areas are still inaccessible by road, and the magnitude of biological and cultural diversity is still relatively unknown. Six species of tree kangaroos *(Dendrolagus,* spp.*)* occur in PNG and all are endemic to the island of New Guinea. Due to changes in land use and human population growth, a plan for tree kangaroo conservation is needed, yet little information is available about these tree-dwelling marsupials. It was in this context that the Conservation Breeding

Specialist Group (CBSG) was invited to conduct a Population and Habitat Viability Assessment (PHVA) and Conservation Assessment and Management Plan (CAMP) workshop on the tree kangaroos of PNG.

The workshop took place in Lae, PNG from August 31 to September 4, 1998. The workshop process uses group dynamics and risk characterization tools based on population and conservation biology, human demography, and the dynamics of social learning in intensive, problem-solving workshops to produce recommendations for both captive and wild species management. In addition, a commitment to fund education and conservation projects based on these recommendations was made by the Australasian zoo community.

Introduction to the Conservation Breeding Specialist Group

The Conservation Breeding Specialist Group (CBSG)—part of the Species Survival Commission (SSC) of the World Conservation Union (IUCN)—has over 15 years of experience in developing, testing, and applying a series of scientifically based tools and processes to assist risk characterization and species management decision making. Since 1997 CBSG has been involved in a systematic effort to better integrate social science data and local knowledge into the traditionally biologically based workshop process (Seal et al. 1998). First attempts at integrating more of the "human dimension" into the PHVA process in Uganda and Brazil fell short of expectation. While international experts were present, local counterparts' participation was not secured, and there was a lack of access to and information on local resource use that directly affected the species of concern. Pimbert and Pretty (1995) point out that often, interdisciplinary conservation efforts look no further than attempting to "get the science right." For this reason, it was believed that in-depth information at the village level should be considered in the risk assessment done for tree kangaroos. The authors of this study comprised the CBSG team who planned and carried out a visit to Tekadu village, Morobe province prior to the workshop. We also facilitated the workshop process in collaboration with the workshop hosts.

The goals of visiting the village were: 1) to collect human demographic information, 2) to prepare village representatives for the workshop process, and 3) to obtain information about local resource use, habitat change, and hunting of tree kangaroos. The Tekadu research team was comprised of three members of the CSBG team and a representative from a national NGO who works at a research station near Tekadu. Two Tekadu landowners, an elder in the village and his nephew, also participated in all the activities, with a mix of other hunters and villagers participating in group discussions over the three-day visit.

While many data were obtained in the field, we would like to highlight two specific components of the pre-workshop data gathering that enhanced the workshop process: 1) expansion of a democratic process for conservation planning, and 2) operationalization of "the human dimension" in a population model and in international criteria for evaluation of species status (World Conservation Union 1994).

Tree kangaroo, Papua New Guinea. Photograph by Philip Nyhus.

Multi-stakeholder Participation: Democratic Planning Process

The 47 participants in the workshop included members of the international and national zoo community, landowners (representing six villages), researchers, educators, government representatives, and local and international conservation NGO representatives. The interests of these groups varied. The workshop began with an issue generation session that set the stage for collaboration on all issues raised by stakeholder groups. This grounding exercise identified the interests of each stakeholder group. The groups were self-identified as landowners, captive managers, and biological and social scientists. (See Figure 1 for issues identified by the landowner group.) The issues highlighted during this exercise served as a reference point to ensure consideration of all stakeholder groups' concerns throughout the workshop. After the initial issue generation session, participants divided themselves up into mixed-stakeholder, topic based groups, including life history and modeling, government and legislation, and socio-economic issues. Plenary consensus sessions each day served two critical purposes: to help keep all issues at an equal level and to ensure that responsibility for management and policy recommendations was taken by all participants. Because of the inclusion of a broad range of stakeholders, information available to participants was expanded and the workshop recommendations were improved.

Figure 1: Issues generated by the landowner stakeholder group at the tree kangaroo workshop (Bonaccorso et al., 1999). All group recording and discussion was done in Pidgin. An English translation is below.

- Many habitats of the tree kangaroo are vanishing (due to mining, logging, oil palm).
- People go against the Wildlife Management Area regulations for the tree kangaroo and other animals; they want to hunt as much as possible; landowners don't have the power to enforce.
- There is not enough experience for the people to teach locals and those responsible for looking after tree kangaroos in wild and in zoos.
- The population of tree kangaroo is going down.
- Additional hunting pressure from immigrants and increasing human populations (e.g. Wau - people coming in to mine).
- New technology is being used to hunt (e.g. guns). (As a landowner who hunts tree kangaroos, he has hunted with dogs now and in the past.) He doesn't know how many tree kangaroos are in his bush.
- Landowners have information about the tree kangaroo (e.g. what tree kangaroos eat, where they are, when they breed) to share and haven't been given the opportunity to share.
- There is little time to think about conservation because of other social needs (health, transportation, education).

Putting Local Knowledge into the Analysis

The status and level of threat to the PNG populations of six species of tree kangaroos were described using the "categories of threat" classification system of the IUCN Red List (World Conservation Union 1994). The IUCN criteria are typically assigned through a review of the literature, and the presence of landowners from the home ranges of these species provided an expanded resource and knowledge base for the threat assessment.

Systematic analysis tools were used to incorporate the broad range of data available. At this workshop, the creative integration of participatory tools in the village with quantitative modeling techniques bridged disciplines and aided in equal expression of ideas in the process. One of the primary tools of the assessment process is the use of the population modeling software VORTEX (Lacy 1993). The model is used as a risk assessment tool to determine: 1) risk of extinction under current conditions, 2) factors making the species vulnerable to extinction, and 3) which factors, if changed, may have the greatest effect on preventing extinction. In an effort to better incorporate local use information, qualitative data from the landowners were translated into quantitative measures for the VORTEX model. Examples of tools used in this experiment to improve the parameter estimates for the species population model include village maps, a village history, estimates of hunting pressure, and assessment of species preference.

Village Maps

Perhaps the most revealing exercise in the village was the production of maps for four of the six hamlets in the Tekadu region. Population numbers, primary resource use (gardens, gold mining, hunting), and whether the household owned dogs for hunting were established. While the short visit was only the beginning of an understanding of the distribution of resource use among the hamlets in the Tekadu region, the maps will continue to be used by the in-country team member who lives and works extensively with the village.

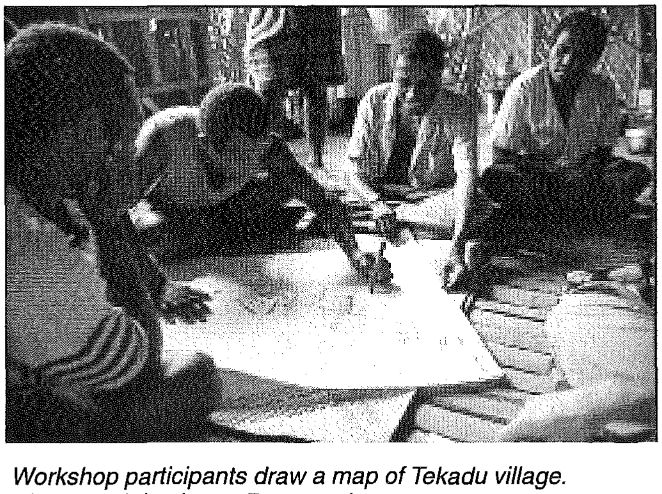
Village History

Another parameter in the population model is the frequency and intensity of catastrophes (e.g., flood and drought) that affect the viability of the species. Several story-telling sessions with village elders allowed us to develop a village timeline. The timeline allowed the researchers to put dates on events and estimate historical trends in village resource use.

Hunting Pressure

Many discussions during (and before) this workshop pointed to the speculation that a major threat to tree kangaroo populations throughout PNG is local hunting pressure. A risk assessment for this group of species, then, should include an analysis of the effects of hunting on tree kangaroo populations. To estimate the number of tree kangaroos killed by hunters throughout the Huon Peninsula, Morobe Province, the team began by talking to one of the landowners while he was attending the workshop. The landowner was asked how many tree kangaroos he had killed or captured, the size of the area from which these animals were obtained, and the time it took him to kill them.

To estimate the number of households in his area that hunt, and to establish a general population size, the team used a village mapping technique to obtain a description of all the households in his village and then the number that hunted. This information was used to estimate that hunters make up approximately 25 percent of the village population. This was the same estimate derived from detailed household data from hamlets in the Tekadu area, gathered by the team prior to the workshop. Moreover, based on published demographic information ground-truthed in the Tekadu area, an average household size of five was estimated. The transformation of these into a quantitative input for the VORTEX model is detailed in Figure 2.



Workshop participants draw a map of Tekadu village. Photograph by Jenna Borovansky.

Figure 2: An example of the translation of qualitative participatory data into quantitative parameters that can be used in the population risk assessment model.

N	=	Total population size >1,800
Suitable villages	=	0.5 (half of the villages suitable, i.e. have "good bush")
Households	=	0.2 (estimated 5 people/household)
Hunters	=	0.25 (proportion of households that have hunters)
Hunting rate high	=	1 (1tree kangaroos/hunter/year)
Hunting rate low	=	0.5 (1 tree kangaroos/hunter/2 years)
Harvest rate	=	[N] x [Villages] x [Households] x [Hunters] x [Rate]

For example, if the total human population in the region of interest is 10,000, the annual number of tree kangaroos extracted from a particular tree kangaroo population would be 250 per year at a high extraction rate.

Species List and Preference

Much information concerning the villagers' wildlife use practices was shared with the research team that visited Tekadu. While data collection was focused on tree kangaroos, a comprehensive list of species in the area, using local names, was developed. Data also suggest that in this area, there are other preferred wildlife species (most notably the cuscus) and that tree kangaroos are most likely used in proportion to their abundance.

It cannot be assumed that every hunter hunts tree kangaroos or that every male in the village hunts. This assumption would greatly exaggerate actual hunting. In fact, in the Tekadu region, gold mining and fishing were more common occupations than hunting. If, then, we assume that tree kangaroos harvested in proportion to their abundance, harvest would be reduced in areas of scarcity until their numbers increase. Hunting strategies appear to be focused on gaining the first meat available, and while tree kangaroos may be a preferred food, they are not essential. In other areas of PNG, the pelts are important as ceremonial dress and therefore may be hunted preferentially. In Tekadu, fur is typically burned off the tree kangaroo in the process of cooking. This example highlights a possible difference in tree kangaroo harvest rates based on location specific resource use, which was revealed through the use of participatory tools.

Limitations of the Workshop

While landowners provided extensive information on resource use, complete translation of data into the model was hampered by a lack of clear population estimates for the region at large. While estimates could be made for the hamlets in the Tekadu village, these estimates could not be expanded beyond the local area. Topographic maps of tree kangaroo habitat would have enabled translation of village data, using rivers and ridges as markers, to actual hunting and habitat area. Nevertheless, until this experiment, it was unknown how or if this knowledge could be integrated into the workshop process.

Recommendations

The working groups made recommendations for management in three topic areas. These recommendations addressed each stakeholder group's issues and will form the basis for international funding priorities and landowner planning efforts in their own villages. Recommendations for community education programs, suggested biological research, bilingual information newsletters, and a national survey were made. It was proposed that an ad hoc team of scientists and landowners visit the villages in the range of the critically endangered Tenkile, or Scott's tree kangaroo *(Dendrolagus scottae)*. Their goal would be to assess the status of this species in the wild and investigate the possibility of a moratorium on hunting in this area with the landowners.

Conclusions

The goals of the workshop process are manyfold. This article highlights several new tools incorporated into the CBSG workshop process that had not been previously used, and it is believed they enabled improved networks among participants and enhanced the data available for the population model.

Other authors have discussed the value of networks created among PHVA participants (Westley and Vredenburg 1997). This workshop provided several valuable opportunities for these conservation networks to emerge. Prior to the workshop, the Australian zoo community made a commitment to fund projects based on the consensus workshop recommendations. The presence of Department of Conservation representatives and the open dialogue between them and village representatives did much to further understanding of each group's interests and limitations. This cooperation helped ensure that practical recommendations that took advantage of resources available to the participants were made.

The purpose of modeling is not only to gather quantitative estimates. Modeling is also a heuristic used to help determine which data are most needed in solving a problem. In traditional population viability analyses, the modelers would never consider not estimating animal growth rates, however crude the guess. The CBSG workshop process is evolving to recognize that the model will be less effective as a risk assessment tool if the same urgency is not attached to the human side of the system. The role of risk assessments is twofold: to summarize available data and to identify data gaps that need to be addressed. The incorporation of local resource use data was a step toward integrating the human dimension into population models. It is hoped that discussion around the population model helps natural resource managers recognize that they would benefit from daily interaction with social scientists and vice-versa. As land use and culture changes, so does the survivability of species. Conservation policy needs to continue to develop and enhance tools that examine these changes together. The ultimate goal and benefit of the workshop process is to move toward a self-sustaining and democratic process of conservation management planning. Tools that help to integrate traditional knowledge and science will help conservationists and communities to reach this goal together.

Acknowledgements

The workshop was sponsored by the Adelaide Zoological Gardens, Royal Melbourne Zoological Gardens, Taronga Zoo, Columbus Zoological Gardens, Perth Zoological Gardens, Currumbin Sanctuary, San Antonio Zoological Gardens and Aquarium, Roger Williams Park Zoo and the Mill Mountain Zoological Park. The workshop was co-hosted by the PNG Department of Environment and Conservation, PNG National Museum and Art Gallery and the Rainforest Habitat at Unitech University. CBSG and a grant from the Social Science and Humanities Research Council of Canada, as well as the Foundation for People and Community Development, Papua New Guinea sponsored the Tekadu research team. The Yale University Sperry Mellon Fund and the Tropical Resources Institute provided additional support for Jenna Borovansky to participate in the village visit. None of this research would have been possible without the logistical support of Peter and Diane Clark and Banak Gamui, and the participants in the workshop. Many thanks to Prof. Tim Clark who has provided extensive input and support to Jenna Borovansky for this research.

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Chronic Environmental Disturbance in a High Elevation Forest in Oaxaca, Mexico:

Implications for natural regeneration in a sub-tropical dry forest

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Introduction

Disturbance is an integral component of the natural process of forest development. In general, natural disturbances promote forest regeneration by releasing growing space and increasing light intensity at the forest floor. The degree to which disturbance will benefit regeneration will, of course, depend to some extent on the magnitude, frequency and nature of disturbance (Oliver and Larson 1996). Human disturbance regimes in developed countries often mimic acute natural disturbances in order to maximize regenerative potential of the forest (Singh 1998, Taulman 1998).

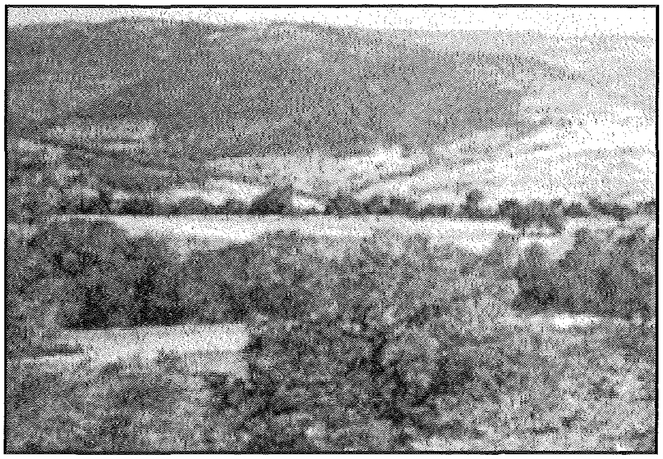
Conversely, disturbance regimes in developing countries tend to be more chronic in nature (Singh 1998). Forests in many countries remain an important resource for subsistence agriculture; grazing; and the collection of fuelwood, charcoal, and animal fodder. The ceaseless demand for forest products is perhaps the most distinguishing feature of chronic degradation. Consequently, forests are seldom allowed to adequately recover (Singh 1998).

While many studies have examined the role of acute disturbances in forest structure and natural regeneration, few studies have looked at the effect of chronic disturbances on the process of natural regeneration. Dry forests in tropical and subtropical regions may be at an even greater risk for exposure to chronic disturbance than tropical rain forests, as they are often more suited for cultivation (Laurance et al. 1997). Many of the world's tropical forests are located in developing countries, where they are more likely to fall subject to chronic disturbance regimes.

There has been very little research on the dynamics of natural regeneration in dry forests; however, there is some evidence that seedling mortality is greater in the gaps of seasonal dry forests than in the shaded understory (Gerhardt 1996). Consequently, seedling density may be higher in shaded sites of dry forests than in open areas typically associated with high seedling density. This has severe implications for dry forests undergoing clearing due to human activities, and is especially critical for those forests enduring chronic disturbances where clearings are typically maintained for long periods of time. The purpose of this study was to test the hypothesis that there will be less natural regeneration in a chronically disturbed high-elevation dry forest than in its less disturbed counterpart.

Site Description

The study area is located in the communal lands of San Pedro Cantaros Coxacaltepec and Huaculilla in the Nochixtlan region of the Mixteca Alta in Oaxaca, Mexico (17°30' N, 97°10' W). The climate is seasonal, with a 6 to 8 month dry season occurring from November to April. The dry forests in this area are dominated by oak *(Quer-*



Disturbed forest landscape, Cantaros, Oaxaca, Mexico

cus crassifolia, Q. acutifolia, Q. castanea, and *Q.* spp.), and are typically found in moisture-stressed environments at lower elevations (2,100 to 2,500 meters) in the region.

Forest formations throughout the Mixteca Alta are primarily composed of oaks, pines, and juniper. The relative abundance of pine to oak changes with site, varying from "pine forest" to "pine-oak associations" to "drought-deciduous oak woodlands" with minor species including juniper *(Juniperus deppeana),* madron *(Arbutus glandulosa),* zumaque *(Rhus virens)* and other shrubs.

Forests in the Mixteca Alta in southern Mexico are heavily utilized for many resources. Intensity of use generally relates to distance from forest to village, with forested areas near villages experiencing more disturbance than those at greater distances. Charcoal remains an important source of energy and income for Mixtecan communities, and kilns used for the burning of wood to create charcoal are constructed in the forest. Many forests experience heavy grazing pressure by goats and cattle, which threatens the recruitment and survival of regenerating seedlings. Additional forest uses include the harvesting of small-dimension lumber and fuelwood and the collection of medicinal plants.

The total size of the study area was approximately 115 hectares (ha) with 64 ha in Cantaros and 48 ha in Huaculilla. The two study sites were located in a contiguous forest; however, each had different land use histories. The Cantaros site is located in close proximity to its respective village of the same name. Present-day land use practices in this forest are less intensive than in the past; the majority of cultivated lands have been abandoned and are now used for grazing cattle and goats. However, coppicing for timber and fuelwood continues. Villagers in Huaculilla, who live further from their forest, have chosen a management strategy that results in a much lower level of disturbance at their site. This forest is used for occasional grazing of livestock, but little for the harvest of fuelwood.

Methods

Boundaries for each site were delineated using an aerial photograph and a topographic map. Four transects were established in each study site, and circular plots were demarcated every 50 m along each transect for a total of 128 points or "plot centers."

To facilitate the collection of information at different scales, nested plots were established at each point along the transect. A 3 m^2 circular plot was nested within a 50 m^2 plot, which itself was nested within a plot of radius 25 m. Within the 3 m^2 plot, we recorded measures of height and diameter for each seedling, sapling and shrub; additionally, we noted the mode of regeneration and species for seedlings and saplings. Seedlings were classified as tree or shrub species measuring less than 50 cm in height. Saplings were classified as tree species greater than 50 cm and less than 200 cm. Shrubs were classified as shrub species greater than 50 cm in height; there were no "shrub saplings." We measured leaf litter depth and collected soils for laboratory analysis of soil carbon and nitrogen at each plot. Additionally, we measured percent canopy opening (using a densiometer), estimated the slope, and calculated the percentage of ground cover by vegetation type.

Within the 50 square meter circular plot, we calculated tree density, measured the diameter at breast height (dbh) for each tree (defined as a woody species with height > 2 m and diameter > 5 cm), and recorded species information for each individual. We also measured tree basal area using a prism (basal area factor 2.0).

To assess broad-scale patterns on the landscape, we measured the number, orientation, and size of all forest clearings within a 25 m radius of the sampling points. Clearings were defined as open areas larger than 5 x 5 meters. We determined the likely origin (natural or anthropogenic) of each clearing by assessing conditions in and around the clearing with respect to the structure and composition of the vegetation, evidence of grazing, and the presence of paths, charcoal kilns, and cultivated lands. We also recorded distance and bearing to all charcoal kilns within (or overlapping) this 25 m radius and estimated the age and intensity of usage for each.

A measure of large-scale forest openness was calculated using measures of distance from each point to a clearing, and the size of each respective clearing. This measure, hereafter referred to as the clearing index, was calculated at each of the 128 plot centers. At each plot center my co-researcher, William Price, took the area of each clearing less than 25 m from the plot center, divided it by its distance to the plot center and took the base-10 logarithm of the quotient. He then summed these values together to obtain the clearing index. Thus, the clearing index can be expressed as $\Sigma \log_{10}$ (clearing area/distance of clearing to plot center), where all clearings < 25 m from the plot center are considered. It is assumed that the area of clearings and their location with respect to points is related to the intensity of utilization that differs dramatically between the two sites.

Results

Results of the study do not support the hypothesis that there is less natural regeneration in the chronically disturbed forest. The number of seedlings in each site was nearly equal; however, there were significant differences in the composition of the seedlings (see Table 1). Huaculilla had twice the number of tree seedlings as Cantaros, while Cantaros had a greater number of shrubs than did Huaculilla. The tree seedling to shrub seedling ratio was 1:1.5 in Huaculilla and 1:3.8 in Cantaros. While the adult population in each site consisted of greater numbers of trees than shrubs, the tree-to-shrub ratio in Cantaros (2:1) was still much less than in Huaculilla (6.5:1).

Table 1. Seedling density per plot in Huaculilla and Cantaros

	HUAC 64 plots	CANT 64 plots
All seedlings	4.1	3.9
Tree seedlings	1.61	0.796**
Shrub seedlings	2.5	3.14*

* P < 0.05, **P<0.01, one-sided Student's T-Test

The majority of tree and shrub seedlings in both sites arose from vegetative sprout; however, there were marked differences in the modes of regeneration of trees and shrubs between the two sites. A chi-square test indicated that there was a significant difference in the mode of regeneration for tree seedlings between sites (P=0.02, x^2=5.54, 1 df) with more tree seedlings arising from seed in Huaculilla than in Cantaros. More shrub species appeared to be arising from seed in Huaculilla than in Cantaros, though the difference was not significant (see Table 2).

Cantaros and Huaculilla were once part of a contiguous forest; therefore, in the absence of disturbance, significant differences in forest structure would not be expected. However, Cantaros had significantly lower tree basal area and tree density, as well as significantly higher canopy openness. There is no evidence to indicate that natural disturbance events were responsible for the observed differences, and discussions with local villagers support this conclusion. Therefore, the differences were attributed to the chronic anthropogenic disturbance that has been documented on the site for many years. Factors associated with human disturbance such as the number of clearings, number of charcoal kilns, and size of clearings were all significantly greater in Cantaros than in Huaculilla (see Table 3).

In both sites, tree basal area, tree density, and canopy closure are significantly (negatively) related to the clearing index, suggesting that the creation of forest openings was related to changes in forest structure (Figures 1a–1c). However, more forest clearings in Huaculilla were attributed to natural causes (85 percent) than anthropogenic causes. There was no significant relationship between the area of clearings and tree basal area, tree density, or canopy openness, indicating that the clearing index may be a better measure of disturbance than of clearing area alone. Indeed, it is reasonable to expect that clearings in close proximity to plots would have the greatest impact on the forest structure of that plot.

*Table 2. Apparent mode of natural regeneration**

	SEED	SPROUT	Totals
HUACULILLA	48% (126)	52% (137)	(263)
Tree species	58% (60)	41% (43)	(103)
Shrub species	41% (66)	58% (94)	(160)
CANTAROS	35% (88)	65% (164)	(252)
Tree species	39% (20)	61% (31)	(51)
Shrub species	34% (68)	66% (133)	(201)
	(214)	(301)	(515)

* Data collected by William Price

Table 3. Difference in forest structure in Huaculilla and Cantaros, by seedling type and clearing presence.

	All Plots			**Plots w. tree and/or shrub seedlines**			**Plots with tree seedlines**			**Plots with shrub seedlines**			**Plots with center points in clearing**		
Site	**Huac**	**Cant**		**Huac**	**Cant**		**Huac**	**Cant**		**Huac**	**Cant**		**Huac**	**Cant**	
Number of plots	**66**	**64**		**43**	**28**		**24**	**13**		**19**	**14**		**13**	**30**	
Forest Structure															
Open canopy (%)	15.44	47.35	**	14.70	16.99		12.23	11.74		17.87	22.32		36.52	80.68	**
Trees per 100 m^2	19.8	15.04	*	19.44	25.72		22.08	31.08		16.73	19.86		10.46	3.14	**
Tree basal area (m^2 ha -1)	15.55	10.12	**	16.43	17.05		17.15	24.70		16.22	10.08		14.6	5.32	**
Shrubs >50cm per plot ($3m^2$)	1.53	3.9	**	2.02	7.68	**	5.91	12.61	*	5.94	17.07	**	1.84	1.06	
Seedling total per plot ($3m^2$)	4.1	3.94		6.09	9.00	*	na	na		na	na		2.61	0.9	*
Tree Seedlings per plot ($3m^2$)	1.61	0.796	**	2.39	1.82		4.29	3.26		na	na		0.62	0	
Shrub Seedling per plot ($3m^2$)	2.5	3.14	*	3.69	7.17	**	na	na		4.05	7.35	*	2	0.9	
Saplings per plot ($3m^2$)	0.765	0.468		0.98	1.03		1.50	1.07		0.31	1.07		0.23	0.1	
Broad-scale Spatial Factors															
Mean number patches per plot	1.92	2.41	*	1.84	3.07	**	1.63	2.08	**	1.89	3.57	**	1.3	1.43	
Mean patch area (m^2)	671	185,992	**	609	79,255	**	619	143,457	**	582	19,101	**	784	326881	**
Clearing index[1]	1.74	3.30	**	1.71	2.60	**	1.64	2.87	**	1.77	2.24		2.43	4.34	**
Number charcoal pits per site	0	21	**	0	7	**	0	3	*	0	4		0	8	*

* P < 0.05, **P<0.01, na=not applicable, One-sided Student's T-test

[1] log10 [(area of clearing)/(distance to point)]

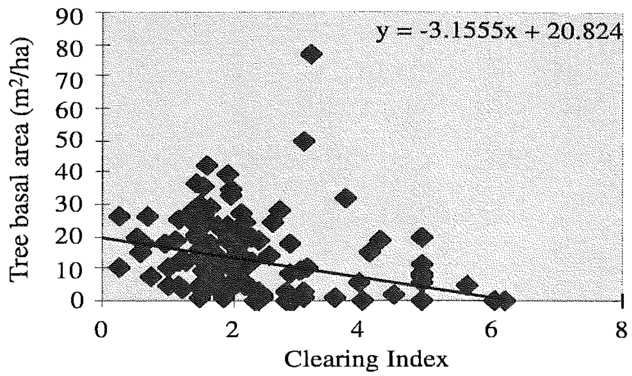


Figure 1a. Clearing Index vs. tree basal area, both sites

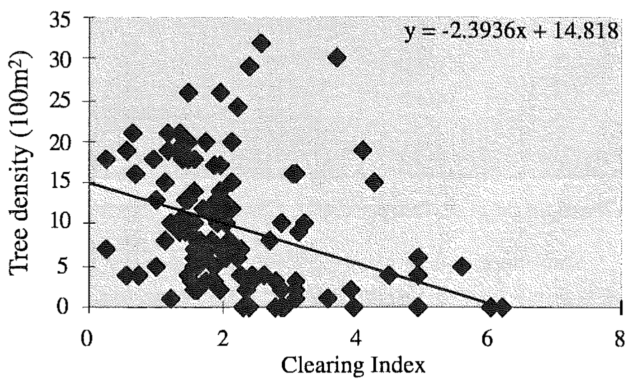


Figure 1b. Clearing Index vs. tree density, both sites

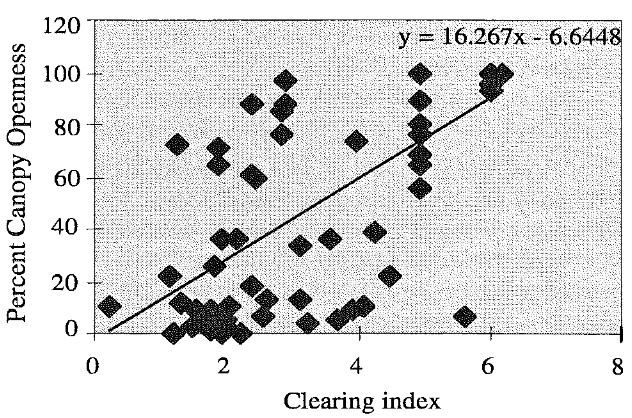


Figure 1c. Clearing Index vs. canopy openness, both sites

Seedling density in each site was regressed against direct measures of disturbance (tree basal area, tree density, and canopy openness). In Huaculilla, seedling density was significantly related (positively) only to tree density (see Figure 2). There was a positive relationship between total seedling density in Huaculilla and both tree basal area and canopy openness; however, this relationship was not significant. In Cantaros, seedling density was positively related to tree basal area and tree density and negatively related to canopy openness (see Figures 3a–3c). Seedling regeneration in Huaculilla was present in plots with a mean tree basal area nearly identical to the average basal area on the site. However, in Cantaros, seedlings were present in plots with a mean tree basal area significantly higher than the average for the site (Student's T-test, P=0.03). In fact, the average basal area at those plots with tree seedlings was higher in Cantaros than at those plots with tree seedlings in Huaculilla (Student's T-test, P=0.07) (see Table 3).

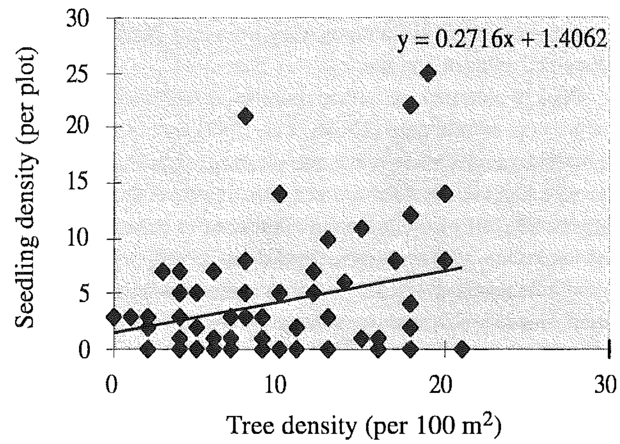


Figure 2. Tree density vs. seedling density in Huaculilla

Over one quarter of the plots in the study area fell directly in a clearing. However, only 14.5 percent of the total regeneration was found in these plots. Of the 14.5 percent, only 11 percent of the regeneration consisted of tree seedlings, and 100 percent of those were found in Huaculilla. Not a single tree seedling was found in a "clearing plot" at the Cantaros site.

Discussion

Despite the observed differences in the overstory, total tree and shrub seedling density did not differ significantly between sites. Rather, effects of chronic disturbance were markedly evident in the species composition of the seedlings. There were many fewer tree seedlings and many more shrub seedlings in Cantaros, and the majority of these seedlings arose from vegetative sprout. The analysis of forest structure (Table 3) suggests that conditions in Cantaros are much less favorable for the establishment of both tree and shrub seedlings from seed. It also supports the assumption that in Cantaros, chronic disturbance, as indicated by the clearing index, was strongly correlated with the observed forest structure as well as the differential success of tree and shrub seedlings.

Human disturbance regimes can perpetuate shifts in species composition through several mechanisms. There is a long history of coppicing practices in Cantaros. Continual coppicing of some tree species can lead to weakened stumps, which in turn result in poorly growing stems. Additionally, coppicing leads to the creation of forest clearings in which shrubs can easily establish. Additional coppicing of shrub vegetation may perpetuate or even increase the shrub-tree imbalance through root and stump sprouting. Grazing, which occurs more frequently and extensively in Cantaros, may also encourage the growth of shrubs due to preferential grazing of tree seedlings and saplings (Oliver and Larson 1996). The high shrub-to-tree shrub ratio in Cantaros may be indicative of a species shift in progress.

It is possible for natural patterns of regeneration to be lost altogether in chronically disturbed forests. This may culminate in the loss of specialist species in areas of severe disturbance (Urban et al. 1987). If disturbance in Cantaros continues at the present intensity, it is likely that some oak tree species, such as *Quercus crassifolia* and *Q. acutifolia,* will be lost altogether. While seedlings of these two species were present in Cantaros, they were only found in relatively undisturbed areas on the site.

Gaps or clearings on human dominated landscapes are typically larger than natural gaps (Urban et al. 1987) and, indeed, Cantaros had both larger and more numerous clearings than Huaculilla. Consequently, Cantaros had fewer trees, less tree basal area, and a more open canopy. All of these factors contribute to increased light and wind exposure and may have especially severe hydrologic and microclimatologic implications for regeneration in this study system, since the forest must endure harsh environmental conditions for extended periods of time. Water availability in intact dry forests is limited, and any disturbance that opens the forest to increased solar radiation and increased wind exposure places additional stress on the system.

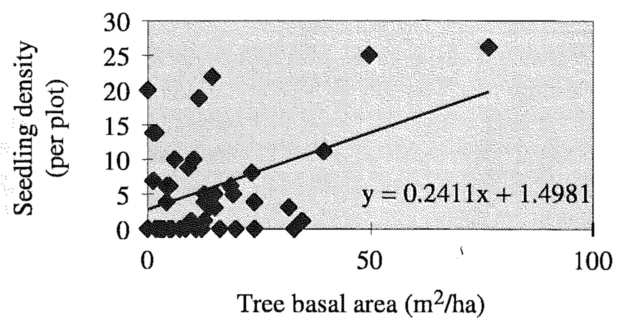


Figure 3a. Seedling density vs. tree basal area in Cantaros

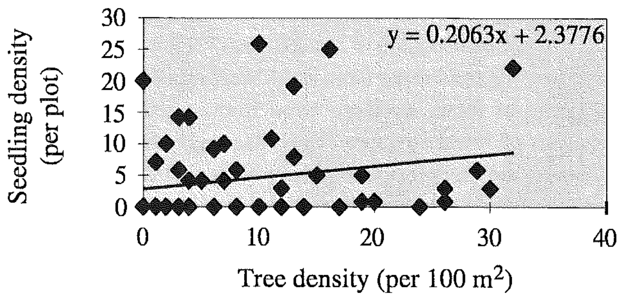


Figure 3b. Tree density vs. seedling density in Cantaros

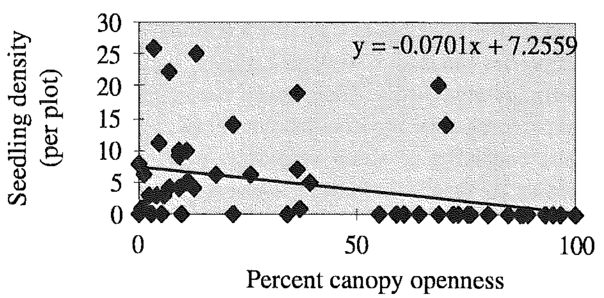
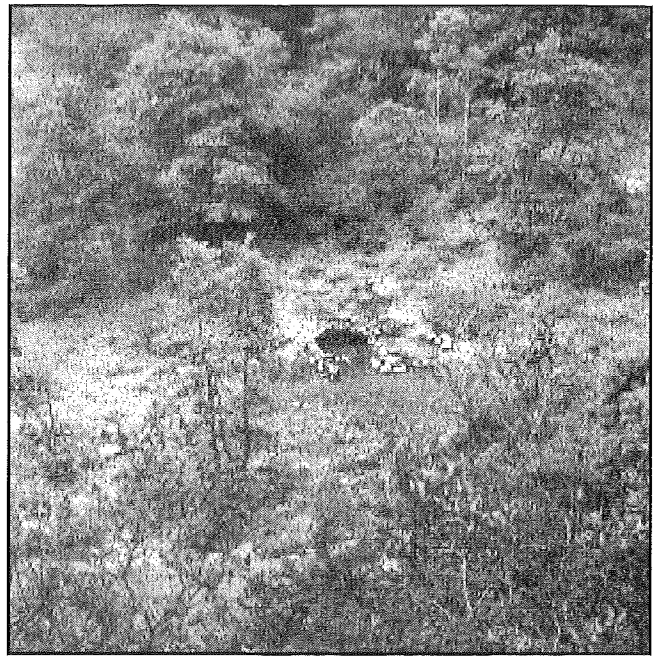


Figure 3c. Seedling density vs. canopy openness in Cantaros



Charcoal pit in disturbed forest, Cantaros, Oaxaca, Mexico

Shrub species dominated the seedling composition in Cantaros, but it is not clear if the shrubs are outcompeting tree species for resources, or if they are simply better adapted for survival in harsh environmental conditions. Gerhardt (1996) found that seedling performance in one dry forest was significantly related to the competitive ability of a species to obtain moisture. Preliminary results from Heidi Asbjornsen's study on this site indicate that shrub species in the study area are able to access deeper moisture supplies than the tree species (Asbjornsen 1999).

Results of this study suggest that there may be special implications for dry forests undergoing chronic disturbance. Seedlings in the Cantaros site were present in the most shaded sites in the study area. Results suggest that even in Huaculilla, the relatively undisturbed forest, there were positive relationships between seedling density and canopy closure, tree density, and tree basal area. However, the presence of shaded sites does not appear to be nearly as important a factor for seedling regeneration in Huaculilla as it is in Cantaros. The limited number of seedlings found in clearings, especially in Cantaros, suggests that mortality in open areas is greater. The observed high tree-to-shrub seedling ratio in Cantaros may be indicative of a species shift from oak trees to shrubs.

The scope of this study was limited to the relationship between chronic disturbance and the patterns of natural regeneration. A more complete understanding of the processes of natural regeneration in forests undergoing chronic disturbance requires further analysis to identify microsite factors that most closely influence the differential establishment of seedlings by species.

Acknowledgements

First, I would like to thank William Price for his boundless energy and much appreciated participation in the collection of field data. I would also like to thank Heidi Asbjornsen for providing the guidance, assistance, and logistical support that made this study possible. Many thanks to the following people for their insightful comments and suggestions on the paper: Rebecca Young, Dr. James Bryan, Dr. Mark Ashton, and Chris Losi. Special thanks to Dr. James Bryan, Chris Losi, and April Reese at the Tropical Resources Institute for their unfailing support and much appreciated patience during the writing process. Additionally, I would like to thank members of CEDICAM who provided logistical support throughout the field season. Lastly, this project could not have been completed without the generous assistance of our three forestry interns, Eleazer Garcia, Ruben Lopez, and Javier all of whom shared with us their extensive knowledge of the history and ecology of the study area. This project was generously supported by the Tropical Resources Institute.

Collaborator Notes

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Mexican Forest History:
Ideologies of state building and resource use

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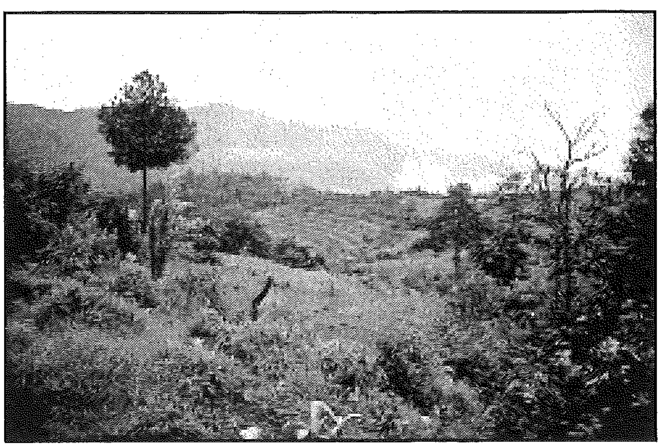
Doctoral Student

Introduction

Throughout its history, forestry has been closely associated with state projects of resource control in the countryside, and foresters have acted as agents of a centralizing state (Scott 1998). During the nineteenth and early twentieth centuries, one of the main justifications for protection of forests was the globally reproduced myth of desiccationism, which connected climate with forest cover (Grove 1995). Forest removal was said to cause declines in rainfall, lower water tables, and declines in river flow. As a scientific theory, desiccationism has generally been discredited since the 1920s (Smith et al. 1986), although in certain circumstances (e.g., cloud forests) condensation on trees can amount to about 20 percent of total precipitation (Larcher 1995). However, as a political myth desiccationism has remained the justification for forest management, long after it has ceased to be supported by science (Saberwal 1997).

In this paper I look at the relations between forest science, forest politics, and wider political history in Mexico. I link narratives of forest decline and management with political narratives of social reform and development and of indigenous conservationism, looking at two key episodes in Mexican forest history: the closure of the Mexican forest department in 1940 and the move towards community forest management in the 1980s. The political history and experiences of the participants in forest management continue to affect how they perceive the forests. Using interview data I collected in Mexico in the summer of 1998, I trace the links between present day struggles over forest management and the historical experiences and political locations of the different stakeholders.



Terracing near Capulalpam, Sierra Juarez, Oaxaca 1998, pointed out as one of the "failures" of the Papaloapan watershed project of the 1950's. The story is probably more complex: who is keeping those terraces clear?

Early Mexican Forest Conservation

A key figure in the history of Mexican forestry is Miguel Angel Quevedo (1862–1946) (Simonian 1995). Quevedo founded the Mexican forest service and fills a similar historical position to that occupied by Gifford Pinchot in the United States. Quevedo was trained as a civil engineer (with a specialization in hydraulic engineering) in France in the 1880s, at a time when desiccationism was a well-accepted scientific theory both in France and in Mexico. On his return to Mexico he noticed environmental degradation caused by deforestation, attributing flooding in the valley of Mexico to deforestation on the surrounding hills. In Mexico the mountainous terrain and erratic rainfall makes deforestation a much more catastrophic event than in temperate Europe. Quevedo was all the more aware of possible human impacts upon the environment as a result of his involvement in large-scale projects to drain the lakes of the valley of Mexico.

Quevedo warned of the negative effects of deforestation on climate. The human interactions with nature that he observed would have negative repercussions upon society, and only conservation and forest protection could prevent it. Between 1901 and the outbreak of the Mexican Revolution in 1910, Quevedo was successful in increasing public parks in and around Mexico City and in founding tree nurseries.

In general, the Diaz regime was not sympathetic to managing forests, as forest concessions were in the hands of large foreign corporations and Mexican elite capitalists (Lartigue 1983; Espin Diaz 1986). Diaz seems to have been primarily interested in parks near cities as a measure of public hygiene and an effort to beautify and modernize Mexico City. However, Quevedo succeeded in gaining support from the Mexican government, ultimately founding a forestry school with French forestry professors in 1908. The Mexican Revolution forced Quevedo into exile in 1914, and forced the forestry school to close.

In the 1920s Quevedo continued his support for forest protection, founding the journal *Mexico Forestal* in 1923. This journal was to be an influential voice for a group of desiccationist conservation scientists for the succeeding 20 years. A statement in the first issue of *Mexico Forestal* summarizes the thinking of this group:

> the conscientious citizen must think of the future and thus "must clamour against the silence in our country against the national suicide that signifies the ruin of the forest and the scorn of our tree protector." (*Mexico Forestal,* p. 82, cited in Simonian 1995)

This statement shows the way Quevedo and the conservationists were using a narrative of destructive human/environment interactions to claim legitimacy for certain environmental politics: protection of forests. The forest is described as the "tree protector" which should not be "scorned." This moral language placed nature as an agent that protected society, and forest scientists claimed the right to speak for this agent.

The forest scientists convinced the Calles government (1924–1928) to pass a forest law in 1926 which regulated forestry activities on private lands, required plans for forest activities, and pledged the federal government to create a forest service, reestablish the forestry school, and establish tree nurseries. However, this law was not enforced, and the forestry school was closed again in 1927. At a time when the Mexican state was just beginning to establish itself in rural society, the implementation of the law was neither politically nor financially possible.

Ixtlán community forester Sergio Pedro looks at a recently treated pine stand, Ixtlán de Juarez, Oaxaca, 1998. The foresters had applied a prescribed burn after the overstory removal, and he was worried about the lack of regeneration.

Forest Conservation and Agrarian Reform

Genuine efforts to enforce the law and train foresters remained on hold until the administration of Lázaro Cárdenas (1934–1940). Cárdenas had become aware that forest degradation and soil erosion were serious problems during his time as governor of Michoacán from 1928 to 1934. However, his governorship of Michoacán was also a starting point for his program of agrarian reform that was to collide with his interest in conservation. In Michoacán he had actively supported the creation of links between the government political party and peasant groups, creating a contract of mutual loyalty and support. He nominated local leaders who would organize the *agrarista* (agrarian) land reform factions in the rural communities, and they moved to claim land that had been alienated from the community. The *agrarista* leaders were tied into a system of obligations of clientage to Cárdenas, the peasant unions, and the institutions of the Mexican state, especially the *Instituto de Reforma Agraria,* which oversaw the repartition of large land holdings and the allocation of legal titles to land. Cárdenas's period in office was marked by the transfer of control of vast areas of land to a new legal form of community, the *ejido.* In distributing land, Cárdenas created a myth which supported the legitimacy of the Mexican state: that it had fulfilled the promise of the Revolution, and given land to the landless. When Cárdenas turned to forest protection in the late 1930s, he risked treading on that myth, with potentially explosive results.

In 1935, Cárdenas created an autonomous Department of Forestry, Fish, and Game, with Quevedo as its first head, using as a rationale the dessicationist discourse which Quevedo and the conservationists had been adhering to for so long. Quevedo then set about implementing the program of forest conservation he had advocated for so many years. The forestry school was reestablished and over a thousand foresters were trained. They were given the responsibility of enforcing the 1926 forestry laws, restricting logging, resin tapping, and conversion of forests to agriculture. Large numbers of trees were planted and educational programs were set up to teach landowners how to plant trees and protect their land. In his efforts to enforce the forestry laws, however, Quevedo soon ran into political opposition. Poor peasants needed to exploit the forest to survive, and in 1938 Cárdenas made exceptions for them, allowing them to exploit the forest free of taxes. Cárdenas's supporters also informed him that the complete ban on forest extraction was untenable, and he gave legal authorization to the ongoing pine resin extraction (Espin Diaz 1986).

In 1939, Cárdenas closed the Department of Forestry, Fish, and Game, and passed its responsibilities for forest protection over to the Ministry of Agriculture. There was to be no independent forest department until 1951 (Mejia Fernandez 1988). Quevedo had been denounced for misconduct and administrative errors. The accusation which carried the most weight, and which was probably the reason for his loss of power, was that he had failed to allow the proper development of natural resources, and therefore held "anti-revolutionary" beliefs. Quevedo did not favor Cárdenas's land reform program because he feared that peasants would expand their fields at the expense of the forests. In disagreeing with land reform Quevedo had threatened the legitimacy of the Mexican state, which Cárdenas was trying to build. Subsequent to Quevedo's loss of power, desiccationism was attacked by agronomists whose central focus was agriculture, not forestry. The 1926 forestry laws remained largely unmodified, but they generally were not enforced. Agriculture was the focus of government attention; forest concessions were often used as political rewards for powerful supporters.

When forestry rose again in the 1950s, it rose in a new form, and explicitly repudiated forest protection as a rational policy, advocating industrialization and technical forestry instead. The official silvicultural system chosen by the Mexican state in the 1950s was the *Metodo Mexicano de Ordenación de Montes* (Snook 1997). This diameter limit selection system removed technical judgement from the forester; his only responsibility was to see that small trees were not taken (which was, in any case, unprofitable). This system made the forester a bureaucratic functionary who did not claim any particular ecological expertise. Claims of expertise had to be linked to the project of building a modern bureaucratic state, not to an independent ideology of environmental degradation.

Logging Concessions and Exploitation

In Mexico during the 1950s and 1960s, forest exploitation was in the hands of concessionaires, both foreign and national. Local level utilization of forest products was officially forbidden, although cutting for charcoal, firewood, and timber continued. State functionaries blamed forest destruction upon "irrational peasants," and later upon foreign timber concessions. Many areas of forest were theoretically closed to extraction, but little effort was made to enforce these bans, which provided a source of income for corrupt local officials and for forest entrepreneurs who colluded with them (Simonian 1995; Klooster 1997).

During the 1960s the Mexican state set about remedying this situation by setting up forest exploitation industries. These were large parastatal corporations, which held monopolistic purchase powers and logging concessions over large areas of forest. In 1958, 261,000 hectares of forest in the Sierra Juarez of Oaxaca were given in concession to the parastatal Tuxtepec Paper Company (FAPATUX) and the private Oaxaca Forestry Company (Bray 1991; Chapela and Lara 1995). By far the largest concessionaire was FAPATUX, with over 240,000 hectares (personal communication, Ramirez Santiago, 1998). FAPATUX extracted timber for pulp production from the oak/pine forests of the Sierra Juarez, negotiating yearly contracts with the communities who nominally owned the forests. A government commission set the prices for timber and kept them artificially low, thereby inflating profits for FAPATUX (personal communication, Escarpita 1998). To add insult to injury, what revenues were received as logging dues were paid into a central fund administered by the government. Communities had to apply to this fund for money for approved activities such as building schools and roads. The communities that owned the forests received few benefits as a result of logging (Bray 1991; Klooster 1997).

During an extended interview during the summer of 1998, Jaime Escarpita, a former director of FAPATUX told me:

> We built the roads for each community. Half were tar roads, for all season supply. They were well built, and we would also negotiate to build schools and churches in return for a contract [annual permit to extract timber], but that isn't recorded in history.

Escarpita describes the relationship between FAPATUX and the communities as a paternalistic one. The communities had no choice but to sell timber to FAPATUX. They received benefits in kind from FAPATUX, and some *comuneros* (community members) got to work as loggers for the company. However, in the view of the former director of FAPATUX, the *comuneros* had no experience or knowledge about the forests: "they learned how to use chainsaws from us." The official view was that the *comuneros* had no useful knowledge about the forest and that their political agency and technical knowledge was irrelevant to managing the forests.

However, the inhabitants of the Sierra Juarez had a long history of resistance to central government claims over natural resources. In 1944, massive flooding in the Papaloapan valley was blamed on deforestation in the watershed, and the Papaloapan Commission was set up to coordinate development of the region (Tamayo and Beltran 1977). The project was not a success; villagers resented being asked to build terraces and change agricultural practices which they saw nothing wrong with. When I asked about this period, a village leader pointed to some abandoned terraces as remains of the project: "It failed, and actually it caused more problems than it solved, as erosion is not really a problem up here." What this project did teach *comuneros* was that the government viewed their land use as potentially damaging and that the government might use arguments of forest destruction to justify development projects. The government could claim land from peasants both because they deforested it and because they were not developing it properly. The linkage of forest protection and development was to reemerge in the discourses used by local communities to claim control of the forests.

Peasant Communities and the Narratives of Local Control

During the 1960s, the government tried to relocate settlers who had been displaced by the enormous Miguel Alemán Dam on the lower Papaloapan into the Sierra Juarez. The communities of the Sierra Juarez protested vigorously. They said "they were there to defend the forest, and that the forest was theirs; no outsider had a right to control it." (personal communication, Ramirez Santiago, 1998). In the end, the government backed down, and the settlers were relocated elsewhere. These experiences taught *comuneros* that the quality of their management of the forest was a political tool, and that they could claim control of the forest by claiming to be the legitimate guardians of the forest.

By the 1970s, discontent with FAPATUX had boiled over; the community of San Pablo Macuiltianguis organized 14 other communities to boycott FAPATUX. Initially, these protests were aimed at securing a better deal on the logging contracts, but as the concessions came up for renewal in 1983, an organization was formed to claim control of the forests. The name of the organization was *Organización en Defensa de los Recursos Naturales y Desarrollo Social de la Sierra de Juarez* (Organization to Defend the Natural Resources and Social Development of the Sierra Juarez). The name alone shows how the *comuneros* were self consciously adopting the government rhetoric of development and protection of natural resources to support their claim to the forests. A vigorous protest was launched with the grassroots magazine *Tequio* (Communal Labor). A statement from the first edition summarizes the aims of the organization:

> We will no longer permit our natural resources to be wasted, since they are the patrimony for our children. The forest resources should be in the hands of our communities, and we will struggle for greater education that will permit rational expansion. (*Tequio,* cited in Bray 1991)

The *comuneros* were adopting the rhetoric of rational use and environmental protection in order to support their claim to the forest.

The grassroots movement for control of the forests came to a head when there was a group of reform-minded bureaucrats within the forest service, including Cuauhtemoc Cárdenas, the son of Lázaro Cárdenas, director of the forest service from 1976 to 1980 (Mejia Fernandez 1988). The reformist bureaucrats had a number of justifications for their policies, but one important strand was the ideology of *indigenismo*: the belief that the indigenous communities were ecologically sensitive guardians of nature and should be given land to compensate for their past sufferings. This ideology is reproduced in international policy documents, national level policy statements (Chapela and Lara 1995), and at local levels in the Sierra Juarez. In my conversations with the *comunero*/biologist Gustavo Ramirez in the summer of 1998, he repeatedly stated that indigenous communities were the best protectors of biodiversity and the forests.

The reformist bureaucrats succeeded in pushing through the cancellation of most of the concessions between 1983 and 1986, so that the forest could potentially be handed over to the communities which theoretically owned it. However, the government still required that the forests come under management plans written by foresters. A rapid succession of forestry laws since 1983 has served to assert the rights of communities to own and manage their forests (Bray 1996). There is a wide range in the degree of organization of the communities, from those that sell standing timber to outside contractors to those that employ their own foresters and process the timber in their own sawmills.

The Future of Mexican Forestry: Ideology and conflict

The experience of struggle to gain control of forest resources has created a particular understanding of the forest for the communities of the Sierra Juarez. I have only been able to interview foresters, but the disputes between foresters and *comuneros* over forest management reveal quite different understandings of what the forest is and how it should be managed. In 1998 I interviewed foresters in two communities in the Sierra Juarez. Both foresters told me that a key problem for them was getting the communities to accept the seed tree system of regeneration that they were trying to apply in the pine forests. This system requires the removal of 60 to 80 percent of the adult trees, leaving a scattering of parent trees to produce seeds, which germinate on the scarified soil below. Pines are light demanding pioneers, so the seed tree regeneration system is designed to mimic the ecological requirements of the species. The previous selection system only took a few large trees, but prevented regeneration, and encouraged non-commercial oak species to proliferate at the expense of the pines (Snook and Negreros 1987).

In the eyes of the two communities, the seed tree system was unacceptably harsh: one community fired their forester; in another, the foresters repeatedly told me that the silvicultural system was the greatest source of friction between them and community members. In some meetings the foresters had been heavily criticized by the *comuneros* for overcutting. Why the conflict? Although I have not interviewed any *comuneros* on the subject, I have a tentative explanation.

The history of struggle for control of the forests has taught the *comuneros* that they can gain control of the foresters by being ecological guardians and by preventing deforestation. Deforestation has become a political symbol used to claim control of the forest. The *comuneros* have gained control of the forest by claiming to be its guardians. They are, therefore, unwilling to give up this moral high ground by adopting what they see as destructive practices. The foresters have a very different understanding, based upon the idealized history of the silvicultural system they are trying to apply and the scientific facts they derive from it. If they are accused of irrational deforestation, they can defend themselves by showing that the forest has remained intact. In one community a process of negotiation appears to be taking place. The *comuneros* are watching the regeneration on trial stands. If it goes well, they may let the foresters carry out the orthodox seed tree treatment.

In this section I have looked at the way forestry is contested and created in the Sierra Juarez, and the way the narratives (scientific or political) of the different stakeholders affect how forest management is applied on the ground. I do not have enough data to do more than gesture toward the narratives of *comuneros,* but I suggest that they are different from those of foresters, and that they are related to the political history of struggle for control of the forests. The *comuneros* have gained control of the forest by claiming to be its guardians and linked to the land in a special way.

I have a better idea of the way foresters see nature: they claim to understand it and to have the ecological knowledge to manage it wisely. Ironically, the foresters are applying a silvicultural system that is based upon Finnish experience of pine management, which is not necessarily the most socially or economically appropriate for the Sierra Juarez. They too bare the scars of past history: since the closure of the forestry department in 1940, foresters have had little training in the then-controversial ecology, which was linked to the discredited doctrine of desiccationism. Thus, their relative lack of ecological knowledge is in part the product of the battle between Miguel Angel Quevedo's conservationism and Lázaro Cárdenas's agrarian reforms.

Conclusions

In this paper I have linked the historical experiences of the different stakeholders in Mexican forest management with their present day interpretations of how the forest should be managed. I have shown how technical knowledge is interpreted within a wider political and economic context, and how a lack of awareness of the political context can result in the rejection of foresters and forestry. This points towards the need for a more politically astute forestry. Foresters need to self-consciously analyze the histories and political narratives of the people they work with if they are to succeed in building the broad consensus that is essential to successful forest management. Rather than bewail the politicization of forestry, we must recognize that science has always had to contend with competing political narratives. Foresters, if they wish to achieve their goals, must also be competent political actors.

Acknowledgements

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Forestry and Environmental Studies Doctoral Student Research in the Tropics

James Bryan
TRI Program Director

In October 1998, several doctoral students got together to discuss their research in the tropics with new students in the School of Forestry and Environmental Studies. Some, including Susan Koenig (see article this volume), Rajesh Thadani, Asia Ratanapojnard, and Jai Mehta (see abstracts below), had begun their studies in the biological or physical sciences, and realized that the systems they were studying were dominated, more or less, by social issues. In wanting to make their research useful, they all had been faced with difficult decisions about how much to include the social issues in their research and subsequent work.

During this school year, 1998–1999, 36 of the school's doctoral students were working on tropical research projects. Twelve were in the process of writing up their dissertation research. We thought it would be useful to include abstracts of some of their work in this issue of *TRI News*.

In examining our program this fall, we created a list of the tropical dissertations written in the school in the past 15 years, since the establishment of the Tropical Resources Institute. I was surprised by the number of dissertations and the scope of the research accomplished. Believing that the titles themselves are valuable, interesting, and descriptive of our program, I am presenting the list at the end of this section.

The major source of energy in the Central Himalaya - fuelwood.

Disturbance, Microclimate, and the Competitive Dynamics of Tree Seedlings in Banj Oak (*Quercus leucotrichophora*) Forests of the Central Himalaya, India

Rajesh Thadani
Doctor of Philosophy

The decline of banj oak *(Quercus leucotrichophora)* is considered to be an important ecological problem in the forests of the Central Himalaya. For the local people, banj oak is the primary source of fuelwood, fodder, and leaf litter used to make compost fertilizer. The subsistence hill economy is dependent on energy and nutrient inputs from the forest ecosystem and banj is the species with the highest utility for these purposes. Banj-dominated forests also have high biodiversity and are considered more important than other forest types for their ability to prevent soil erosion and dampen floodwater discharge.

My study aims to understand the mechanism of banj forest decline. I look at the effect of chronic human disturbance on the abiotic environment as well as its role in changing the competitive dynamics between banj oak and two co-occurring species viz. tilonj oak *(Q. floribunda)* and chir pine *(Pinus roxburghii).*

I hypothesize that light and moisture are the abiotic variables most commonly limiting to growth in this ecosystem. To better understand their fundamental niche, I grew the three species under varying light and moisture conditions in growth shelters for a two year period and studied their morphological and physiological responses.

Chronic disturbance, in addition to changing the understory microenvironment, also results in physical damage of seedlings. To understand these effects, seeds and seedlings of the three species were planted in sixteen stands differentiated by their exposure to human disturbance levels. As germination of banj is reported to be particularly sensitive to microsite conditions, its acorns were germinated under different understory environments. Finally, a regeneration survey was conducted in thirty stands in the region to determine the patterns of oak and pine regeneration.

Chir pine has a pioneer-like strategy. When grown in understory light regimes it is vulnerable to desiccation due to very low allocation to roots. Tilonj seedlings do not flourish in exposed environments as they are susceptible to droughty conditions. Tilonj responded more strongly to high light environments than the other two species if moisture was not limiting. Banj showed an intermediate response to light and moisture conditions.

Banj regeneration was not lacking under disturbed forest condi-

Trees in the Central Himalaya also provide an important source of fodder for livestock.

tions and 2000–3000 seedlings per hectare were found irrespective of the disturbance level. However, seedling recruitment was lower in disturbed stands. Also, despite higher grazing levels, banj regeneration showed improved growth performance in disturbed forests due to more favorable light levels. This contradicts the existing hypothesis that banj forest decline is a consequence of regeneration failure in heavily disturbed forests.

My studies indicate that the decline in the extent of banj is a consequence of chronic disturbance that preferentially occurs in banj oak stands. Chir trees are less susceptible to lopping or grazing due to their lower socio-economic utility. Instead, they are able to expand their realized or ecological niche into a larger portion of their fundamental or physiological niche. Chronic disturbance changes the competitive dynamics between the pine and the oaks. In forests with low anthropogenic disturbance, oak is a superior competitor, but selective pressure for biomass extraction by local villagers nullifies the competitive edge of oak, and the pine can extend into sites formerly occupied by oak. Banj is more susceptible to human disturbance than tilonj oak because 1) banj stands are located closer to human habitation than tilonj stands, and 2) its acorn dispersal strategy allows tilonj to more tenaciously persist in sites with a tilonj overstory.

Many of the pure stands of banj probably originated as a result of acute human disturbance—agricultural clearing followed by the subsequent abandonment of terraced fields and a period of recovery. This kind of acute disturbance regime, with a recovery period that promoted the development of pure banj stands, is now uncommon in the Himalaya. Due to increased habitation and permanent settlements, chronic disturbance plays a greatly increased role in forest dynamics.

The lack of formation of new banj stands is primarily due to the inability of established banj seedlings to reach the pole-tree stage. This vulnerability at the sapling stage is probably due to lopping. At this stage tree diameters (1–5 cm dbh) allow for easiest collection of fuelwood. Grazing of seedlings and inadvertent damage during grass harvest reduce seedling growth, while lopping of trees cause stress reactions at the adult stage. Thus banj is susceptible to chronic disturbance at all stages of its life cycle. Consequently, protection from grazing and lopping is essential if banj is to be successfully regenerated. The principle of coercive conservation has been unsuccessfully tried by the forest service. Participatory management would appear to hold the best probability of success. Protection may be more successfully instituted if tenurial rights are more strongly defined and village institutions are strengthened.

Effects of the Community-oriented Biodiversity Environmental Education Program on Cognitive, Affective, and Behavioral Domains among Rural Fifth- and Sixth-grade Students in Buriram, Northeastern Thailand

Sorrayut (Asia) Ratanapojnard
Doctoral Candidate

With the ultimate goal to better protect biodiversity through improved education, the Community-Oriented Biodiversity Environmental Education Program (COBEE), a one-year environmental education program was implemented in four primary schools in Buriram province of northeastern Thailand. The author, local teachers, and community leaders used the national fifth- and sixth-grade educational guideline to develop a biodiversity integrated curriculum, in which students and teachers together actively learned all course subjects using hands-on activities—such as field inventories, observations, experiments, and interviews—to construct their own knowledge about their local environment. Research was conducted

Paladmum School students conduct interview to collect social data from a key informant, one of the founders of the village and its oldest member—107 years old.

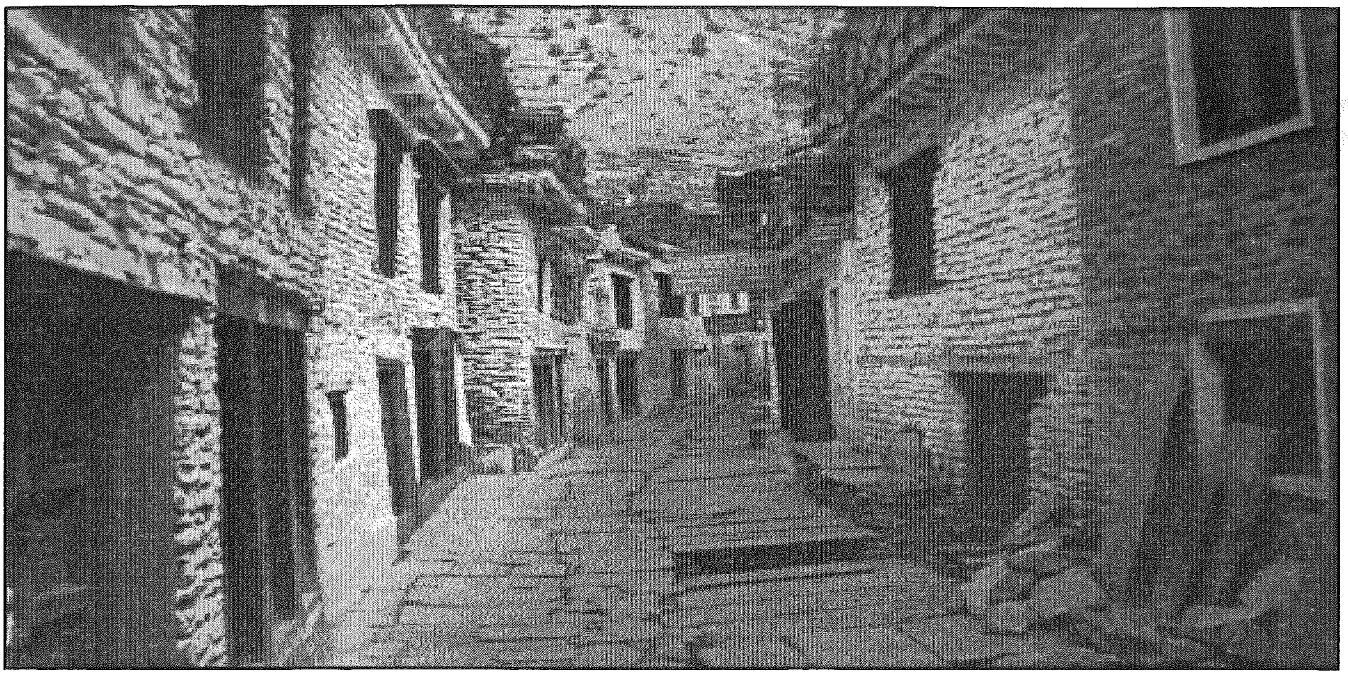
Dialog with a local fisherman turned school teacher. Teacher Ekachai invited a local fisherman to teach his class how to weave a fishing net, and the teacher learned the technique with his students.

to 1) describe the prevailing educational achievements related to biodiversity among fifth- and sixth-grade students in Buriram primary schools, 2) measure changes after the COBEE, and 3) determine what factors of the COBEE had the most significant influence.

Changes in students' educational outcomes were measured in three domains: cognitive, affective, and behavioral. A set of test instruments was developed to gather quantitative data in the three domains employing the expanded Solomon Four-Group approach in the pretest/posttest/delayed-posttest experimental design. Qualitative data were collected throughout the study from interviews, observations, photographs, and student environmental journals. Some key dependent variables evaluated are knowledge of ecological principles and processes, knowledge of problems and issues related to biodiversity, value system related to biodiversity, and participation in responsible environmental behavior.

Preliminary data analysis shows statistically significant increases in students' educational outcomes in all three domains. They gained both greater knowledge and appreciation of their local flora, fauna, and associated indigenous knowledge. They more actively participated in positive biodiversity-related behaviors, including not hunting rare species, practicing organic farming, and using medicinal plants. Data analysis indicates that the COBEE not only enhances educational outcomes related to biodiversity, but also improves performances in general education such as higher enthusiasm, grades, literacy, participation, and other learning skills.

Science experiment testing effects of chemical versus organic fertilizers on vegetables.



Lodges and teashops along the trekking route in Annapurna Conservation Area. (Note stacks of firewood on rooftops.)

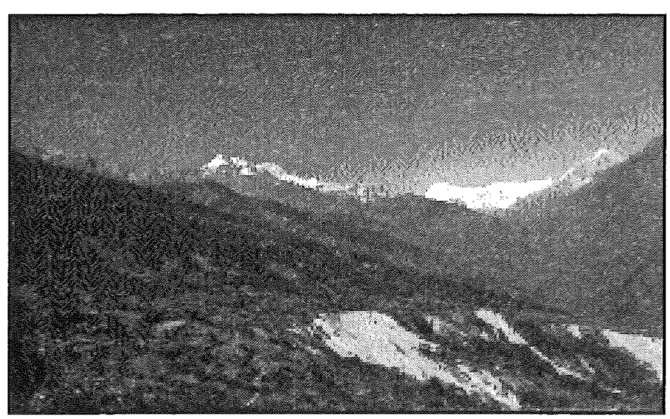
Rhetoric, Practice and Incentive in Community-based Conservation in Nepal: Case studies of Annapurna and Makalu-Barun

Jai Mehta
Doctoral Candidate

Jai Mehta is working on community-based conservation policy in Nepal. He conducted case studies in the Annapurna Conservation Area and the Makalu-Barun National Park and Conservation Area using a questionnaire survey, formal and informal interviews, and review of published and unpublished literature.

Annapurna Conservation Area (ACA) is the most popular trekking destination in Nepal, attracting about 50,000 foreign tourists every year and growing at an annual rate of 17 percent. Over 1,000 lodges and teashops owned and operated by local communities have sprung up along the trekking routes to cater to the needs of tourists. Most of these lodges and teashops use firewood to meet the cooking and heating needs of tourists and their supporting staff (porters and guides). The firewood, as well as construction timber demand to make new lodges and teashops to accommodate the ever increasing number of tourists, exert additional pressure on forested areas, which are already stressed from the local population (growing at an annual rate of 2.5 percent) and their concomitant forest resource demand. ACA is trying to address this threat to forest resources by introducing and promoting an array of alternative sources of energy (biogas, solar energy, hydroelectricity) and firewood-saving devices (such as improved stoves and back-boiler water heaters). Most importantly, ACA has formed several grassroots level institutions such as a conservation area management committee, women's groups, and lodge management committees to enlist local participation in conserving resources and developing communities.

Forest degradation, deforestation, and landslides are typical features in most parts of Makalu-Barun Conservation Area, Nepal. Forest degradation and deforestation in this area are caused by uses of forests that range from overcollecting of forest products to overgrazing and converting of forests to agricultural fields or pastures. Landslides are caused by both natural forces and human-induced deforestation. Makalu-Barun Conservation Project (MBCP), which manages this area, is striving to minimize human-induced deforestation and forest degradation by handing over the responsibility of managing forested areas to local communities through its community forestry program. Local communities are delegated legal rights and authority to manage and use their community forests. MBCP hopes that people will have a greater stake in conserving forests if they have a sense of ownership.



A typical landscape in Makalu-Barun Conservation Area.

Dissertations on Tropical Resource Issues, 1984-1999
School of Forestry and Environmental Studies

Year	Name	Dissertation Title	Advisor
1984	Miguel A. Musalem	Effect of Environmental Factors on Regeneration of *Pinus Montezumae* Lamb., in a Temperate Forest in Mexico	François Mergen
1984	See Chung Chin	Agriculture and Subsistence in a Lowland Rainforest Kenya Community	David M. Smith
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Community training in forest management, Sitla, Central Himalaya, India. Photograph by Rajesh Thadani.

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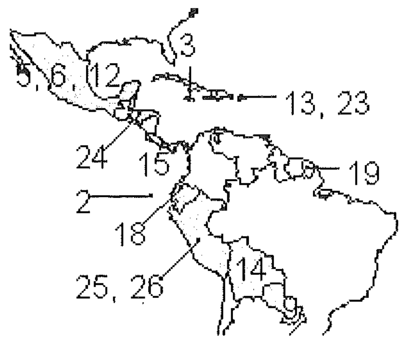

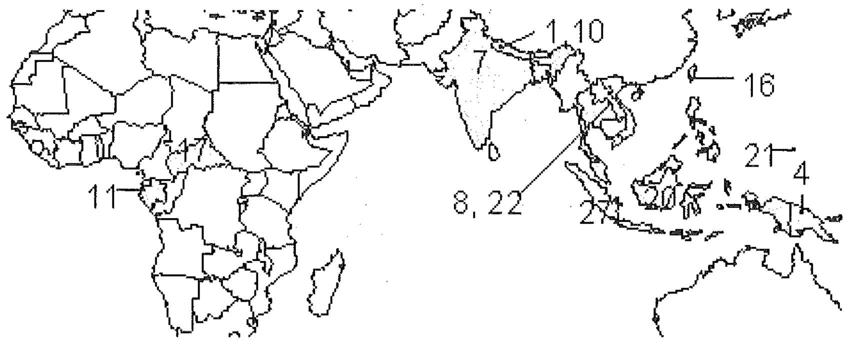

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