TRI NEWS

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A MESSAGE FROM THE DIRECTOR

Dr. Florencia Montagnini

This issue of TRI News is dedicated to the memory of John Miller Musser, a prominent benefactor of the Yale School of Forestry community and a generous advocate of the Tropical Resources Institute. I am honored and privileged to be the first to hold the John Miller Musser Directorship of the Tropical Resources Institute at the Yale School of Forestry and Environmental Studies.

TRI's mission is and has been to promote academic studies on the sustained management, restoration and conservation of tropical ecosystems, and to provide expertise to the decision-makers concerned with the management and restoration of tropical ecosystems. Since its inception in 1983 under the directorship of Professor William Burch, TRI has been consistent in following this mission. However, because there has been so much global progress in these areas in the last few years, it is now time for TRI to take more concrete action. As the new director, I would like to re-emphasize the specific mission and goals of the Institute as I see them today. The nature of the debate concerning deforestation, land degradation and species loss in the tropics has changed drastically in the last five or ten years. In the early 1980s, our focus was on raising the consciousness of those in charge, ''setting off alarms'' concerning the situation. Today, people may disagree on rates of deforestation in specific geographic areas but there exists a consensus on the need for urgent action to stop forest destruction, or to find means to alleviate its deleterious effects.

Concurrently, drastic changes occurred in the field of social forestry when development agencies realized that little was being done on behalf of the rural poor, in spite of the large sums of money invested in projects throughout the tropics. With this realization comes an emphasis on traditional production systems, such as agroforestry techniques which promote land use sustainability and economic development.

Our present challenge, then, is to convert this new knowledge and understanding into direct action by promoting as well as continuing the research that has brought us this far. My belief is that we are very well equipped to do so through the programs conducted by TRI here at the Yale School of Forestry and Environmental Studies.

We have established, beginning next year, two Tropical Studies Concentrations within our Master's of Environmental Studies program: one with an emphasis on the Sciences and the other with an emphasis on Policy. Both programs provide a broad education in Tropical Studies; while each requires concentration in the specific fields, neither will produce someone limited to a ''pure science'' or ''pure policy'' background.

Students and faculty have the opportunities for hands-on experience with field trips to Puerto Rico and Costa Rica. Similarly, TRI's internship program gives the students an opportunity to carry on research in a tropical country under the guidance of a faculty advisor. Often, these internships turn into research at the doctoral level or into research articles publishable in refereed journals. In addition, TRI News acts as a major means for outreach to international collaborators and the tropical research community.

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To facilitate these and future programs, the Tropical Resources Institute serves as an "umbrella" organization to promote more international collaboration. Over the years many memoranda of understanding have been signed with international collaborators, the most recent being in Costa Rica, Argentina, and Brazil.

In conclusion, I wish to make clear that our student body is what makes all of this possible. Without this very enthusiastic and creative group coming in every year from around the U.S. and the world, none of these programs would be possible.

TRI UPDATE

COLLABORATION IN COSTA RICA AND ARGENTINA: FOREST AND SOIL RESTORATION EXPERIMENTS

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INTRODUCTION

The Tropical Resources Institute (TRI) of the Yale School of Forestry and Environmental Studies maintains collaborative agreements with a number of institutions worldwide dedicated to the study and promotion of sustainable land use systems and ecological restoration. As part of these efforts, and with funding from the A. W. Mellon Foundation, we are working in humid forest regions of Costa Rica and Argentina to promote the use of native tree species of economic value for reforestation and agroforestry, focusing on species with positive effects on the restoration of soil fertility in degraded areas.

EXPERIMENTS IN COSTA RICA

In the Atlantic humid lowlands of Costa Rica many indigenous tree species are much appreciated for their timber and other uses and can be grown in open plantation. Out of 13 native species in an experimental plantation at La Selva Biological Station of the Organization for Tropical Studies (OTS), at least five had growth rates and economic values similar or greater than the exotic species currently recommended (Espinoza and Butterfield 1989). These indigenous species contributed to soil fertility restoration by increasing organic matter, nitrogen and soil cation levels to values close to those considered adequate for agricultural crops (Montagnini and Sancho 1990a, 1990b).

However, more experience is needed on how to grow native trees for economic yields and soil restoration. The main hypothesis is that mixed species plantations are more productive and have greater positive effects on soils than monospecific stands. These mixed species plantations are also hypothesized to be economically advantageous alternatives for the recovery of degraded lands in the region. To test these hypotheses, experimental plantations are being established in collaboration with OTS and the Center for Agricultural Research of the University of Costa Rica (UCR), on abandoned pasture sites at OTS La Selva Biological Station. Growth rates in pure and mixed stands are being compared, and the impacts of these systems on soil fertility restoration are also being examined. Trees that were chosen are native to the Atlantic region of Costa Rica, have relatively rapid growth rates (data from OTS

TABLE 1.

List of species and their combinations, experiments in Costa Rica.

GROUPS	COMMON NAME	FAMILY
Group 1:		
1- *Stryphnodendron excelsum*	vainillo	Leguminosae (Mimosoid)
2- *Vochysia hondurensis*	mayo	Vochysiaceae
3- *Jacaranda copaia*	jacarand	Bignoniaceae
4- *Lacmellea panamensis*	leche de vaca	Apocynaceae
Group 2:		
5- *Albizia guachapele*	guaitil	Leguminosae (Mimosoid)
6- *Vochysia ferruginea*	botarrama	Vochysiaceae
7- *Terminalia amazonia*	roble coral	Combretaceae
8- *Virola koschny*	fruta dorada	Myristicaceae
Group 3:		
9- *Pentaclethra macroloba*	gaviln	Leguminosae (Mimosoid)
10- *Hyeronima oblonga*	piln	Euphorbiaceae
11- *Laetia procera*	manga larga	Flacourtiaceae
12- *Zanthoxilum mayanum*	lagartillo	Rutaceae

forestry projects, e.g. Espinoza and Butterfield 1989) and have relatively high economic value. Other criteria for choice of these species included consideration of nutrient requirements, effects on soil and nutrient cycling (e.g., Montagnini and Sancho 1990a, 1990b) as well as seed and seedling availability. In addition, field observations of tree architecture, growth habit, presence of insect damage and presence of root nodules in the leguminous trees was also considered.

In each mixture there is at least one leguminous, nitrogen fixing tree and another species with large production of leaf litter (Table 1). The structural architecture of each species was also taken into account to minimize competition for light.

The plantations are in randomized blocks, with four replicates and six treatments: four pure-species plots of each species: a mixed-species plot (mixing the four species): and natural regrowth. Initial plantation distance is 2mx2m to speed up canopy closure and obtain early impacts on soils. Thinning, pruning and other silvicultural treatments will be applied when needed to avoid excessive competition. There are 24 plots in each of the two 24,576m² (approximately 2.5 ha) plantations. The plots are 32mx32m, with a total of 256 trees in each plot.
The existing vegetation in the abandoned pasture sites is inventoried and mapped prior to site clearing in order to detect potential differences in tree growth due to the effects of previous soil cover. The soils are sampled by vegetation types before site cleaning and annually thereafter.

Site cleaning is done manually. Seeds are collected from trees in the La Selva reserve or from other areas in the Atlantic region, and seedlings are produced at the OTS nursery. The first plantation was established in June, 1991, a second one is scheduled for November, 1991, and a third one for June, 1992.

TABLE 2.

List of species and their combinations, experiments in Argentina.

SELECTED SPECIES	COMMON NAME	FAMILY
Plantation in San Antonio:		
Cordia trichotoma	loro negro, peteribo	Boraginaceae
Ocotea puberula	laurel guaia	Lauraceae
Peltophorum dubium (Caesalpinoid)	caafstola	Leguminosae
Parapiptadenia rigida	anchico colorado	Leguminosae (Mimosoid)
Plantation in Eldorado:		
Bastardiopsis densiflora	loro blanco	Malvaceae
Enterolobium contortisiliquum	timb colorado	Leguminosae (Mimosoid)
Lonchocarpus muehlbergianum	rabo molle	Leguminosae (Papilionoid)
Balfourodendron riedelianum	guatamb	Rutaceae

Figure 1 - Cassava (manioc) (Manihot esculenta) interplanted in a young stand of Hyeronima oblonga (pilon), in a 10 ha farm in La Flaminea, near La Selva. The seedlings were given to the farmer as part of an on-farm plantation study. Eugenio Gonzalez and Beatriz Eibl in the photograph.

EXPERIMENTS IN ARGENTINA

In Misiones, NE Argentina, about 20 miles east of the Brazilian border and 15 miles south of the Iguaz National Park, experimental mixed plantations with native trees have been started in a subtropical humid forest region. This work was initiated and continues in collaboration with the Subtropical Institute of Forestry Research (ISIF) of the School of Forestry, National University of Misiones (UNAM). In this region, the clearing of large areas of natural forest began in the 1960s, mostly as a result of government incentives for commercial plantations for pulpwood (principally *Pinus elliotii*) and cash crops of high market value such as soybeans, yerba mate (*Ilex paraguariensis*), and tea (Kozarik 1986). Native trees are still extracted from the remaining forests as they provide much of the good quality timber, but this resource is becoming scarce. There is virtually no experience with the silviculture of native trees, many of which extend in their natural range from southeastern Amazonia (Reitz et al. 1979).

The plantations, located in San Antonio and Eldorado, Misiones, were established in November, 1989, and August, 1990. The design of each mixture, as well as site treatment and management, are done using similar criteria as for La Selva experiments (Table 2). We are also evaluating the economic feasibility of these land use systems by comparing them with other alternatives common in each region and by assessing the economic value of the recovery of the degraded lands to a more fertile and productive stage. In Costa Rica, we are studying the potential of the most promising species for combination with agricultural crops (Fig. 1). In Argentina, we are also using some of the native tree species in agroforestry combinations with commercial crops and in forest enrichment practices (Fig. 2). Our interactions with local institutions operating in both regions are expected to ensure the dissemination of the results and contribute to the implementation and management of these systems among the local farmers.

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REFERENCES

Espinoza Camacho, M. y. Butterfield, R. 1989. Adaptabilidad de 13 especies nativas maderables bajo condiciones de plantacion en las tierras bajas humedas del Atlantico, Costa Rica. pp. 159-172. In R. Salazar (ed.). Manejo y aprovechamiento de plantaciones forestales con especies de uso multiple. Actas Reunin IUFRO, Guatemala, 3-7 de abril 1989. CATIE. Turrialba, Costa Rica.

Kozarik, J. M. 1986. Jornadas Silviculturales. ISIF. Facultad de Ciencias Forestales, Universidad Nacional de Misiones, Eldorado, Misiones, Argentina. Octubre 1986.

Montagnini, F. and Sancho, F. 1990a. Influencia de seis especies de arboles nativos sobre la fertilidad del suelo en una plantacion experimental en la llanura del Atlantico de Costa Rica. Yvyraret (Argentina) 1(1):29-49.

Montagnini, F. and Sancho, F. 1990b. Impacts of native trees on tropical soils: a study in the Atlantic lowlands of Costa Rica. Ambio 19(8):386-390.

Reitz, R., R. M. Klein and A. Reis. 1979. Madeiras do Brasil. Santa Catarina. Ed. Lunardelli. Florianopolis. 320 pp.

Figure 2 - Bastardiopsis densiflora (loro blanco) in a three year old enrichment plantation experiment in San Pedro, Misiones. The tree is approximately 7 meters high. Management of light availability in the lines is key to obtaining fast growth rates. Other individuals of the same species in more shaded areas on the same line were shorter.

USING PERENNIAL PIGEON PEA FOR GRAIN AND WOOD BIOMASS PRODUCTION ON MARGINAL SOILS

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INTRODUCTION

A major bottleneck in extending agroforestry systems to farmers' fields in the semi-arid tropics (SAT) is the competition for moisture between trees and crops, often resulting in poor performance by both the components and non-availability of immediate monetary benefits from such systems. Recent studies have shown that the perennial pigeon pea (*Cajanus cajan* (L) Mill sp.) is highly adaptable to semi-arid environments as well as being suitable for marginal and below marginal lands. It has been hypothesized that the legume *Cajanus cajan* enriches soil nitrogen and thereby helps to improve soil fertility. Pigeon pea is mainly grown as an inter crop with cereals in India, with a perennial variety usually confined to kitchen gardens in certain localities. Pigeon pea is a multipurpose species. Its protein-rich leaves are used as fodder, its green pods as vegetables, its dry seeds as pulse, and its dry stems for fuel (Daniel and Ong, 1990). In view of such qualities, *Cajunus* could become a good substitute for trees in agroforestry systems in the semi-arid tropics, as it would provide immediate benefits to the farmers. A study was conducted to find out the yield and biomass production potential of perennial pigeon pea apart from the nutrients that are recycled and the results are presented below.

LOCATION

The study was carried out at the research farm of the Central Soil and Water Conservation Research and Training Institute in Bellary, under rainfed conditions on shallow black vertisols. Bellary (15 09'N & 76 51'E) lies at an altitude of 445 m in the rain shadow region, and receives an average rainfall of 500 mm annually, spread over 36 days. The rainfall is highly irregular in terms of duration and intensity in this region. The rainy season lasts from September to November and all rainfed farming operations are confined to this period. Soils have a high clay content with 50 to 60% clay and can hold 18 cm of water in a profile of 1 m depth when saturated. Water availability is the prime constraint for crop production in the region.

METHODS

Perennial pigeon pea (ICP 8094) was grown at a spacing of 1 x 1 m, during August, 1989, in an area at the research farm where soil depth is 40 cm, with a pH of 8.2 to 8.5. The site has low available nitrogen and phosphorus. No chemical fertilizers were applied although periodic weeding was carried out during inter-culturing. The rainfall received during 1989 was 522.9 mm. At the end of the season, pods were collected and grain yield was assessed. After the first season, the stand was pruned to a height of 0.5 m from the ground to bring all the plants to a uniform level and the crop was managed through the next season, as was done in the previous year. In 1990-91, litter was collected regularly at monthly intervals from 1 x 1 m quadrants laid out on the ground. The leaf litter was dried at 80° C, and dry weight recorded. Litter samples were retained for total N, P and K estimation and analysis was carried out using standard laboratory techniques. Similarly, fresh leaves were also collected every month and analyzed. The total nitrogen, phosphorus and potassium realized annually were assessed.

RESULTS

In the year 1989-90, grain yield obtained was 124.65 kg/ha but no estimations were made for dry matter produced. In 1990-91, a total grain yield of 200 kg/ha was obtained and the dry matter production from the dry stems was 800 kg/ha. As can be seen from the table, a total of 1785 kg/ha of litter was produced in one season and this contributed 2994 kg/ha of N, 288.5 kg/ha of P and 289.5 kg/ha of K. These figures of nutrients returned are much higher than expected and appear to be the consequence of the plant accumulating essential elements during favorable weather conditions. However, a prolonged dry spell (Dec - Mar) resulted in leaf drop in the plants that had to reduce their foliage to cut down on moisture loss through transpiration. This phenomenon needs further analysis and is currently being studied. Although yields were lower than for those grown under optimal conditions (200 kg/ha), the crop yielded a woody biomass of 800 kg/ha, after the stems had been cut back to 0.5 m. This is advantageous in that the same shoot produces a new flush of leaves and branches and yields again in the next season.

The study demonstrates that pigeon pea is able to survive satisfactorily for at least two years under rainfed conditions on marginal soils. In order to effectively utilize the litter for soil amelioration, it would be beneficial if the litter is worked back into the soil, since litter on the surface will not decompose in situ due to lack of moisture. Alternatively, the litter could be added to other crops as an additional input of nutrients.

SUMMARY

Initial trials with perennial pigeon pea revealed that it could be successfully grown in alleys of different widths as an inter crop for improving soil fertility and total biomass production. This species remains under-appreciated in the semi-arid tropics despite its potential benefits. A more organized effort to propagate it in the semi-arid tropics is needed.

LITERATURE CITED

Daniel, J.N. and C.K. Ong (1990). Perennial pigeon pea: a multi-purpose species for agroforestry systems.

Table 1

Monthly changes in leaf litter mass, nutrient concentrations and total quantity of N, P, K returned through litter fall in perennial pigeon pea in black vertisols.

Months	Leaf Litter (kg/ha)	Quantity Returned (kg/ha) N	P	K
September	160.0	208.00	17.76	16.32
		3.80 a	0.52 a	9.36 a
		1.30 b	0.11 b	9.10 b
October	107.3	144.80	11.37	9.33
		4.89 a	0.50 a	0.34 a
		1.35 b	0.10 b	0.08 b
November	150.0	214.50	17.85	15.30
		3.92 a	0.75 a	0.46 a
		1.43 b	0.11 b	0.10 b
December	818.4	1661.30	149.76	142.40
		3.94 a	0.40 a	0.30 a
		2.03 b	0.18 b	0.17 b
January	380.0	573.80	61.56	71.82
		2.64 a	0.37 a	0.34 a
		1.51 b	0.16 b	0.19 b
February	60.0	61.20	10.20	12.18
		3.06 a	0.50 a	0.46 a
		1.02 b	0.17 b	0.20 b
March	109.5	130.30	20.03	22.22
		2.35 a	0.35 a	0.27 a
		1.19 b	0.18 b	0.20 b

Note: "a" and "b" represent the % concentrations of N, P, K in green leaves and litter respectively in the same order down the column.

RESEARCH AND CONSERVATION OF GREEN SEA TURTLES IN TORTUGUERO, COSTA RICA

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INTRODUCTION

The non-profit Caribbean Conservation Corporation (CCC) and the University of Florida-Gainesville co-sponsor the longest ongoing green sea turtle tagging program in existence at Tortuguero, Costa Rica. Historically, the Atlantic green sea turtle (*Chelonia mydas*) has been threatened by overhunting, nest robbing, and shrimp trawling. In 1954, Dr. Archie Carr established the extended tagging program at Tortuguero to gather biological and demographic data on the turtles and implement a rescue plan. With the vital assistance of volunteers and longer-term research assistants (RAs), the research continues each summer at Tortuguero's Green Sea Turtle Research Station as part of an ongoing conservation initiative.

Funding from the Tropical Resources Institute, at YSF&ES, gave me the opportunity to conduct an independent research project in Tortuguero during the summer of 1991, while I concurrently worked as a RA in CCC's sea turtle research program. The purpose of the independent study was to research mammalian predation of green sea turtle eggs and predator control options for conservation management. Since land-based predators are a particular threat to turtle eggs and hatchlings at Tortuguero, information is needed about the mammalian predation process as well as predator control methods in order to develop an effective sea turtle conservation plan for the area.

BACKGROUND

The green sea turtle is an endangered species in need of continued conservation and research at Tortuguero, Costa Rica. The turtle's life history makes it especially vulnerable to human overexploitation and predation. One life history trait which makes the species vulnerable to exploitation is its breeding biology. Since its foraging and nesting habitats are separated by great distances, the turtle must migrate from feeding areas to colonial nesting beaches such as Tortuguero (Carr 1979). Reproductive females gather by the thousands to go through their ritualized nesting behavior, making them targets of mass capture (Nietschmann 1979). Furthermore, the species has relatively slowed growth rates, delayed sexual maturity and low reproductive effort. These life history characteristics result from the green turtle's herbivorous specialization on the seagrass, *Thalassia testudinum*, which has low nutritive value (Bjorndal 1979). The turtle adaptively maintains population levels under these life history conditions with long reproductive lifespans. However, if the lifespans are cut short by exploitation of adult turtles, population levels drastically decline. The green turtle's reproductive success is also threatened when eggs are raided either by humans or by predators that in many cases have been introduced by man or allowed to form unnaturally high population densities as a result of human disruption of ecological balances (Pritchard 1980).

PREDATION

When human interference directly disturbs the green turtle, its nests, or the ecosystem on which it depends, non-human predation becomes an important component in a suite of mortality factors threatening a turtle population (Stancyk 1979). The common mammalian predators at Tortuguero include feral dogs (*Canis familiaris*), coati mundis (*Nasua narica*), and raccoons (*Procyon lotor*) (Fowler 1979, Stancyk 1979). Some important non-mammalian predators include black vultures (*Coragyps atratus*), turkey vultures (*Cathartes aura*), and ghost crabs (*Ocypode quadrata*). According to Fowler (1979), the most destructive predators of turtle eggs at Tortuguero are feral dogs and coati mundis. The dogs are man-introduced predators which feed mostly at night, while coatis are native, diurnal predators. Assessment of the predation process can reveal the effects of mammalian predation and what predator control options can best protect turtle nests at Tortuguero.

Placing treated green sea turtle eggs along beach-forest border

PREDATOR CONTROL

When predation limits turtle nesting success, predator control methods may be needed for conservation management purposes. Control methods for mammals may include predator removal, protection of eggs and hatchlings, or treatment of eggs with aversive chemicals. The treatment of eggs with aversive, nonlethal chemicals is considered a potentially hazardous management option because of possible harmful side effects on the developing embryos or harmless, scavenging species (Stancyk 1979). In addition, spraying chemicals on eggs may be ineffective because most predators do not eat egg shells (Conover 1984). Taste repellents are only effective as long as they remain on the food item; after removal, feeding rates return to normal.

An alternative method is to deceive predators by scattering out eggs injected with a chemical that causes nonlethal gastrointestinal illness after egg consumption. Theoretically, the predator develops a conditioned taste aversion (CTA) to the treated eggs, generalizes the aversion to untreated eggs, and stops depredating all eggs (Conover 1990). Compounds such as emetine dihydrochloride (emetine) and LiCl have been found to cause CTAs in some mammalian predators of bird eggs (Conover 1989, 1990). The effectiveness of the CTA method in deterring mammalian predators of sea turtle eggs had been previously untested, but the method was tested in the present study for predator control in Tortuguero.

METHODOLOGY

The field research was conducted in Tortuguero along a protected 2-mile section of the 22-mile continuous strip of green sea turtle nesting beach. The month of July was spent in studying the egg-eating habits of mammalian predators such as raccoons and coati mundis. Qualitative data was collected on the predation process. Predator tracks were identified and counted around nests at different positions on the beach during morning, afternoon, and evening times of day. The digging process and state of the excavated turtle eggs were described for all depredated nests.

Quantitative data was also collected on the survival of nests and frequency of predation on fresh versus older nests. During the first two weeks in July, nests were marked with a stake and assigned a number the night they were laid. The fate of the nest was then followed for each subsequent day in the month and recorded as surviving if no turtle eggs were dug up. A nest was considered depredated if any eggs were excavated, and the day the predation event occurred was recorded.

The last three weeks in August were spent researching the CTA predator control method. Predators were discouraged from eating turtle eggs by the injection of experimental eggs with .05g LiCl per ml H_2O. The experimental eggs were sea turtle eggs that would have been tide-washed if left in natural nest sites, and were obtained with permission from Tortuguero National Park officials.

Two separate strips of beach were established, one serving as the treatment site and one as the control site. Each site consisted of a transect with 25 single eggs spaced 25m apart. The two transects were set along the forest-beach border to maximize mammalian predation on the experimental eggs. Mammals converge on the beach from the forest (Fowler 1979) and will likely intercept the eggs before reaching the beach. The eggs were also placed along the border to lessen variation in predator egg location preferences and in the types of predators attracted to the eggs, and to minimize predator interference with other turtle eggs on the nesting beach.

At the treatment site, the experimental design consisted of a pretreatment, treatment, and post-treatment period, each period lasting one week. Untreated eggs were set out during the pre- and post-treatment periods for four days of the week, while eggs were treated with LiCl during the treatment period for six days of the week. All eggs were removed for the remaining days of each week. Only untreated eggs were set out at the control site. At both sites, the eggs were checked daily at a standard time and recorded as depredated (missing, cracked, eaten) or surviving to establish the daily depredation rate. All depredated or desiccated eggs were replaced each sampling day at each site.

A key assumption of the study, after Conover (1990), was that if predators develop a CTA to the treated eggs, then egg losses at the end of the treatment period should be significantly less than they were by the end of the pretreatment period. If predators generalize the aversion to untreated eggs, depredation during the post-treatment period should be less than during the pretreatment period. Further statistical analyses will reveal if these differences exist.

RESULTS/DISCUSSION

Preliminary analyses suggest that the predator control method of deceiving predators with LiCl egg treatments can in fact induce CTAs in mammalian predators. At the control site, where only untreated eggs were set out, the number of eggs depredated increased steadily over the three time periods. In contrast, at the treated site, the number of eggs depredated dropped significantly. The eggs were initially avoided in the post-treatment period at the treatment site, but later the number of eggs eaten increased again, suggesting that the effect of the treated eggs may not last once untreated eggs are available. However, if the study was conducted over a longer time period, giving the mammals more time to build a CTA over more weeks of egg treatment, perhaps the evidence for egg avoidance of even untreated eggs would be stronger.

The results suggest that the CTA predator control method has potential applications in Tortuguero. The effectiveness of LiCl in deterring mammalian predators has been shown in this study, but the side effects of the chemical on other organisms in the food chain are unknown and need to be tested. For conservation management purposes in Tortuguero, the treatment of turtle eggs with LiCl or other potential CTA-inducing chemicals could get overly time consuming and expensive on a large-scale basis. Nevertheless, the method has potential and may be useful when combined with other conservation measures. After further analysis of the predator control data and other data on the predation process, the project results will be presented in a TRI working paper.

REFERENCES

Bjorndal, K.A. 1979(82). The consequence of herbivory for the life history of the Caribbean Green Turtle, *Chelonia mydas* in K. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution, Washington, D.C.

Carr, A. 1979(82). Notes on the behavioral ecology of sea turtles in K. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution, Washington, D.C.

Conover, M.R. 1984. Response of birds to different types of food repellents. J. Applied Ecology 21:437-443.

Conover, M.R. 1989. Potential compounds for establishing conditioned food aversions in raccoons. Wildl. Soc. Bull. 17:430-435.

Conover, M.R. 1990. Reducing mammalian predation on eggs by using a conditioned taste aversion to deceive predators. J. Wildl. Manage. 54:360-365.

Fowler, L.E. 1979. Hatching success and nest predation in the green sea turtle, *Chelonia mydas*, at Tortuguero, Costa Rica. Ecology 60(5):946-955.

Nietschmann, B. 1979(82). The cultural context of sea turtle subsistence hunting in the Caribbean and problems caused by commercial exploitation in K. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution, Washington, D.C.

Pritchard, P.C.H. 1980. The conservation of sea turtles: practices and problems. Amer Zool. 20:609-617.

Stancyk, S. 1979(82). Non-human predators of sea turtles and their control. in K. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Smithsonian Institution, Washington, D.C.

FOREST RESOURCE USE BY VILLAGES NEAR THE BEZA MAHAFALY SPECIAL RESERVE IN S.W. MADAGASCAR

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INTRODUCTION

Villagers in rural southwest Madagascar are highly dependent on forest products in their daily lives. Almost all of their meals are cooked over a wood fire. Houses are constructed with a mixture of wood poles, grass thatching, reeds, vines and barks. They collect traditional medicines from nearby forests and use them to treat a wide variety of illnesses. In addition, forest foods are important on a seasonal basis.

A research grant from World Wildlife Fund gave me the necessary support to spend 12 months studying forest product use, and the effects of gathering practices and grazing on forested areas around the Beza Mahafaly Special Reserve.

BACKGROUND

The Beza Mahafaly Special Reserve (ca. 23 30'S, 44 40'E) (F.T.M. 1954) is a unique forest area consisting of two parcels of land. The first parcel of 110 ha is gallery/transition forest bordering the intermittent Sakamena River. The parcel is dominated by *Tamarindus indica*, and *Acacia rovumae*. It has been fenced off with barbed-wire since 1979, soon after the Reserve was established. The second parcel of 520 ha is a mixture of xerophytic vegetation and transition vegetation from the gallery forest. It is most often characterized as spiny forest because of the distinctive cactus-like trees *Alluaudia procera* and *Pachypodium spp.* that grow there.

The Beza Mahafaly Project, which manages the Reserve and the adjacent research site, is hoping to expand the Reserve by 800 ha within the next year (Rakotomanga, personal communication). This expansion will connect the two parcels of the Reserve and enlarge the first parcel to the north and to the south.

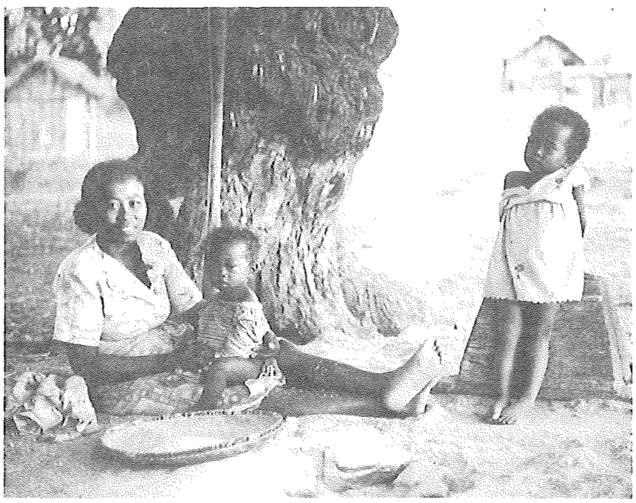
Three villages, Mahazoarivo, Antevamena and Analafaly are within four kilometers of the Beza Mahafaly Special Reserve. These villages will be most affected by the proposed expansion of the Reserve. The villages rely heavily on forest areas adjacent to the first parcel for firewood supplies.

METHODS

A student from the University of Tulear acted as my interpreter and assistant during this study. We collected information by interviewing villagers, accompanying them on gathering trips to the forest, and participating in their daily/seasonal activities. We also collected information from randomly selected sample plots of 100 m^2 in four gallery/transition forest areas. In the sample plots we tried to identify, count, and record diameters (DBH) of all shrubs and trees greater than 2 cm in diameter and/or greater than 2 m tall. We sub-sampled a portion of this area for regeneration. We also measured the volume of all deadwood that could be used as firewood as an estimate of available firewood. Three of the forest areas sampled are used by nearby villages for gathering and grazing. The other forest area, considered the control plot, is the fenced first parcel, which is used for botanical and faunal research only. Comparing information from the four sampled forest areas helped us to see what effects gathering and grazing activities may be having on the forest.

RESULTS

Women from these villages walk between 15 and 35 minutes to gathering sites. They gather wood in as many as 15 forest sites. Nineteen species of firewood are used in the northern most village, Mahazoarivo, which has a higher population density than the other two villages and whose nearby forest is already degraded. In the other two villages, which are closer to well-forested areas, between 9 and 12 tree species are used as firewood. The average woman spends between 1.5 and 4.5 hours collecting wood each week, averaging 2.4 hours per trip. Some women collect firewood three times per week, others collect enough wood in one trip (with an ox-cart) to last two weeks. Only dry dead wood found as stumps, branches on the ground, or dead stems on a live tree are gathered. Rotted wood, or wood that has been eaten by termites is left behind.



Mahafaly woman sitting with her two children after threshing rice for the evening meal. Analafaly, Madagascar.

The amount of firewood a family needs per week is dependent upon family size and family health. Of the 25 families surveyed, the average family size was 4.3 people. These families used an average of 37 kg of firewood per week. Wood supplies are used up faster when wood is needed to cook medicines or certain traditional foods for people who are sick, pregnant, nursing, or old.

Over 36 plant species are used by villagers around the Beza Mahafaly Special Reserve to build houses and make other items such as ox carts, tool handles and coffins. These woods, vines, barks and grasses are collected from woods, forests, or savanna areas within a day's cart ride from home. Forest foods are collected throughout the year and are particularly important in the rainy season when crops have just been planted and other foods and money are scarce. People collect a variety of fruits and roots, as well as eggs, insects, birds and small mammals.

Data collected in forest sample plots indicate that the first parcel, the fenced area, tended to have a better rate of tree regeneration than the gallery/transition forest areas outside of the Reserve. In contrast, the data show that species diversity (as measured by the average number of species in the sample plots for each forest area) as well as the quantity of deadwood (that meet firewood criteria) tends to be greater not within the Reserve, but rather further from villages and agricultural fields. The regeneration data imply that the fence around the first parcel is effectively discouraging villagers and domestic animals from entering the forest. The species diversity and deadwood data indicate that diversity and deadwood in the first parcel have not yet recovered from pre-reserve exploitation.

DISCUSSION

From a conservation viewpoint the future expansion of the Reserve is necessary and encouraging. The expansion will join the two existing parcels as well as adding on pieces of prime habitat. Four types of lemurs inhabit this forest area, most visibly *Propithecus verrauxi verreauxi* and *Lemur catta*. An assortment of reptiles including *Geochelone radiata* (an endangered turtle), and chameleons, as well as a wide variety of birds, and insects also inhabit varying strata within the forest (Beza Mahafaly Project 1990). The unique plants of this area and the soils on which they grow will benefit from the reduced grazing and the nutrients made available through decomposition of dead branches (which otherwise might be carried away as firewood). The branches will also provide habitat for small animals and insects.

From the local peoples' perspective, however, the future expansion of the Reserve has negative implications. Important gathering areas will be placed off-limits to villagers, and forested areas outside of the Reserve will consequently come under increased wood gathering and grazing pressure. As people go further from the village to find the necessary forest products they have less time at home or in their fields. Thus the extra minutes required to search out forest products add up to an additional burden on the villagers.

Few alternatives to forest exploitation exist at present and people still appear to be unconcerned about their dwindling forest resources. The following activities have been tested as small-scale interventions in villages around the Reserve, but require additional testing and extension before they might be adopted as village practices: tree nurseries and woodlots, fuel conserving cookstoves, and soil conservation techniques.

The results of this study show that the local people are highly dependent on the gallery/transition forest and that gathering practices have a definite impact on the forest in terms of deadwood, regeneration (also affected by grazing), and species diversity. In addition, it quantified the time it takes for women to gather firewood as well as the amount of firewood that is used by families in this area.

LITERATURE CITED

Project Beza Mahafaly. 1990. Note Sur la Reserve Speciale de Beza Mahafaly.

FTM. 1954, 1986. FIle F59, Sakamena. Institute National de Geodesie et Cartographie. Antananarivo, Madagascar.

Rakotomanga, P. Beza Mahafaly Project Manager. Personal Communication.

LOCAL INCENTIVES FOR CONSERVATION OF LAKE NAKURU PARK

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INTRODUCTION

Lake Nakuru National Park is a bird and wildlife sanctuary located in the Rift Valley region of Central Kenya. It lies only 5 kilometers from the city of Nakuru, which has expanded from a population of 40,000 in the late 1960s to nearly 150,000 today. Nakuru's rapid growth has put pressure on the Lake as settlements have expanded to the Park fence. Erosion originating from the farms has resulted in the increased sedimentation of the Lake. The flamingo population, for which Lake Nakuru is famous, has decreased markedly and sedimentation as well as sewage and industrial contamination are speculated to be the cause.

The tremendous scarcity of arable land in Kenya has forced farming right up to the Park fence, leading to crop damage from wildlife. Correspondingly, the ecosystem of the Park is being threatened by the farming activities outside. Thus, the Park and the settlements affect one another directly. Yet, if locals are not receiving benefits from the Park, and in fact are suffering substantial losses, they have no incentive to protect it.

METHODS

Funding from the Yale Councils of International Relations and African Studies enabled me to work with the Lake Nakuru Conservation and Development Project (LNCDP), a project of Worldwide Fund for Nature. From June through August, 1991, I studied the impacts of this project, with my findings to be used in a proposal for project extension. My research involved designing and conducting individual and group surveys of rural farmers to study the impact of LNCDP and their attitudes towards the Park. Additionally, I conducted formal and informal interviews with representatives of the Park and from other governmental and non-governmental organizations active in the area. The opinions in this article are based on these communications and observations.

Impala grazing in Lake Nakuru National Park

BACKGROUND

The Park consists of a 40km^2 shallow, alkaline-saline closed basin lake and a 2 km wide buffer between the Lake and surrounding settlements. Its vegetation ranges from savannah to woodlands of *Acacia xanthophloea* to Kenya's sole remaining natural *Euphorbia candelabrum* forest. The Park is encircled by an electric fence and has no river outflow.

The village of Mwariki borders the Northwest region of the Park. Plots average only about 1.6 hectares. Settlers, many of whom came from more fertile areas, are receiving unexpectedly low crop yields from the alkaline soils and unreliable rainfall. As the area has been severely deforested, even without the fence, the Park/ settlement boundary is clearly discernible by the immediate absence of trees. Wood is in short supply and Mwariki residents spend up to 30% of household income on fuelwood (LNCDP 1989). After the electric fence was erected in 1986, fuelwood poaching from within the Park was virtually eliminated, but the desire for access to it by the surrounding population is still strong.

Although the fence has successfully kept out local people, it has been less successful at keeping in wild animals. Farmers with plots bordering the Park routinely suffer substantial crop losses. Porcupines and wild pigs burrow under the fence at night and raid root crops. Far more damaging are the baboons, who devour a large portion of maize, the staple food of the area. Farmers' estimates of maize losses of 50% or more are not uncommon. Although this figure is probably exaggerated, personal observations verify that extensive damage is occurring. One ear of maize can supply a baboon with as many calories as it can receive from hours of scavenging in the Park. Thus even if a field is guarded, they are quite willing to wait for hours if necessary until an opportunity arises.

Kenya Wildlife Service (a government-owned corporation created in 1990 to administer all National Parks) eliminated monetary compensation for farmers suffering wildlife damages, proposing revenue sharing of park receipts instead. Unfortunately, fenced parks are not anticipated to be eligible as there is supposedly no longer 'unmitigated wildlife conflict' (KWS 1990). Park wardens, although acknowledging the damage, feel they have shown good faith by constructing the fence, and there is little else they can do. Culling is not presently an option, nor would it appear to be effective, as crop raiding appears to be due to ease of food access, rather than as a result of overpopulation.

CONSERVATION AND DEVELOPMENT

LNCDP's stated objective is to protect the Park ecosystem from threats originating outside its boundaries. Its primary activities involve promoting tree planting, agroforestry and erosion control measures on the surrounding farms in an effort to increase soil productivity, increase the wood supply and decrease sedimentation. Nevertheless, LNCDP has recognized the wildlife pest problem as inextricably linked to improving both people's welfare and attitudes towards the Park. They are promoting the planting of *Caesalpina decapetala* (Mauritius Thorn) as a hedge along Park borders. This hedge has sharp thorns, and if managed correctly, grows very densely. Farmers who planted one year ago, report that it is indeed stopping the baboons. However, as long as there are farms without mature hedges, baboons will not attempt to enter through the thicker shrubs. If the baboons are not able to pass once a continuous hedge is in place (about 2-3 years), then this strategy will have been successful. However, residents report that it took these clever primates only two weeks to discover how to pass through the electric fence.

The Project's second component involves protecting livestock from contracting diseases carried by Park wildlife. Cape Buffalo carry many tick-borne diseases which are transferred to livestock, such as often fatal East Coast Fever. LNCDP has coordinated with existing government veterinary officers to initiate a treatment center. Twice a week the officers staff a creche constructed at the project nursery. The officers are willing to participate as it gives them a break from walking all day and the farmers seem cooperative as it relieves them of the burden of having to locate an officer in the field, often an impossible task.

IMPACTS

LNCDP's close collaboration with Park wardens has resulted in Park personnel beginning to participate in activities in the bordering settlements. Activities such as showing wildlife films in Mwariki and bringing people inside for soccer matches have increased local goodwill towards Kenyan Wildlife Service (KWS). Park officials are no longer only rifle-carrying, uniformed agents of enforcement. This change is apparent in the mostly favorable attitude of locals towards the Park, damages notwithstanding. Nevertheless, tangible benefits will likely be needed for conservation to be successful. Even if crop damage is eliminated, the Park still represents an area of plentiful firewood and available crop land.

Park wardens have few original income generation ideas, other than replicating constructing mock local villages and curio sales. Such ideas are somewhat successful in Parks near more traditional tribes, such as the Maasai or Samburu, but will likely fail as the settlers around Nakuru do not dress or live traditionally and so are unlikely to interest tourists.

Few farmers reported receiving any tangible benefits from the Park and most were surprised to be asked. Locals do not receive any of the revenues and cannot even visit the Park due to lack of transportation. As hiring for the tourist lodge and KWS staff is done centrally from Nairobi, employment opportunities are not available locally either. The local perceptions of potential benefits from the park are limited to firewood access, visiting the Park, or in a few cases, transforming the Park into cropland. It seems that because the Park has been separate and off-limits for so long, the people have rarely considered potential interaction or benefits from the tourists or wildlife.

DISCUSSION

Successful income-generation approaches, such as the CAMPFIRE program in Zimbabwe or elite big game hunting safaris in Tanzania, exploit a buffer zone between Parks and settlements where people live with and can utilize animals. As Mwariki residents do not share land with animals, and in fact are physically excluded from the Park and its economically valuable wildlife, multiple use strategies such as these are not viable.

LNCDP has attempted to emphasize the development aspects of conservation in their project activities. Thus, while their primary objective in encouraging tree planting is preservation of the Park, they emphasize the benefits to the farmer in terms of windbreaks or wood products. Even if sedimentation still negatively affects the Park, individual farmers will receive these benefits on their own farms. By emphasizing the development aspect, with conservation as a bonus, LNCDP is hoping to improve the chances of sustainability.

CONCLUSIONS

Because the fence is not completely successful in preventing park wildlife from raiding local croplands, KWS should reconsider its restriction on revenue sharing with the local farmers. Who qualifies as 'local' and how distribution will be arranged are difficult questions, but certainly not insurmountable. Efforts should be made to allow locals to visit the Park. Wardens have requested a bus from KWS for this purpose, yet have not received a response. If people are allowed to share in what is at stake, they may be more supportive of conservation measures. As Kenyan citizens, local people have a right to see what over 125,000 foreigners annually are allowed to enjoy. Crops unpalatable to baboons, such as castor, could be promoted to farmers bordering the fence to reduce animal related damages. Yet it must be remembered that eliminating wildlife conflicts still does not give locals a benefit from the Park or an incentive to conserve it.

Lake Nakuru National Park is a small, fenced-off haven for wildlife surrounded by a sea of human-altered landscapes. Its future is utterly dependent upon developing a mechanism whereby local people benefit from its existence. Otherwise the two cannot coexist on a sustainable basis. This situation requires creative solutions. KWS and LNCDP have taken a belated, yet promising, initial step in recognizing the need for local participation. Because tourism is Kenya's leading source of foreign exchange, the needs of the parks have traditionally come before the needs of local people. However, with Kenya's burgeoning population coming increasingly into conflict with the protected areas, and with their activities threatening the areas themselves, local people must be active participants in and beneficiaries of conservation if these valuable resources are to be preserved.

REFERENCES

Anonymous. 1988. People, Parks and Wildlife, Guidelines for Public Participation in Wildlife Conservation: Case Studies in Kenya. Kenya Wildlife Fund Trustees and UNEP, Nairobi.

Kenya Wildlife Service. 1990. Annex 6: Community Conservation and Wildlife Management Outside Parks and Reserves.

Lake Nakuru Conservation and Development Project. 1991. Plans and Budget for the Period April 1991 to March 1992.

Lake Nakuru Conservation and Development Project. 1989. Survey of Energy Consumption in Mwariki-Rhonda.

Lake Nakuru Conservation and Development Project. 1988. Project Proposal.

AGROFORESTRY IN THE EASTERN ISLANDS OF INDONESIA: THE TREND TOWARDS FAMILY FORESTS

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INTRODUCTION

A study conducted from June through July, 1991, involved studying the activities of Yayasan Tananua (YTN), a small farmer-run NGO that has projects on three islands in the eastern region of Indonesia: Sumba, Flores, and Timor. The study, funded by TRI, consisted of visiting farms which employ agroforestry technologies introduced by YTN in East Sumba. Farmers, as well as YTN staff, were interviewed regarding the general farming systems and family forests, which are marginal sections of a farm where fruit, cash crops, fuelwood and timber trees are planted.

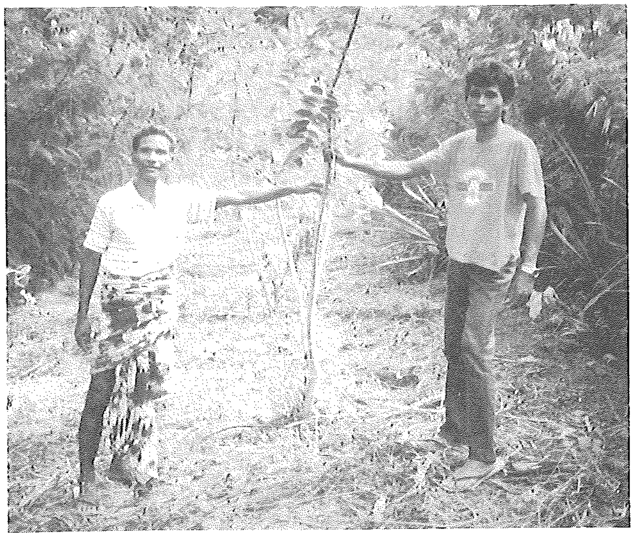
The interviews conducted during this study revealed a need for basic silvicultural information on the most common tree species planted in family forests. As a contribution to extension outreach, this information will be provided to YTN for the creation of a brochure to be distributed to farmers.

BACKGROUND

Unlike Java, which has nutrient-rich volcanic soil, Sumba's soils are quite infertile and very prone to erosion. The climate is classified as humid, semi-hot equatorial with a pronounced dry season and an annual rainfall of approximately 884 mm over 70 days (Fox, 1977). The native vegetation is tropical, dry deciduous forest, although most of the island is deforested. The eastern two-thirds of the island is sparsely populated, with a density of only 14 people per square km in 1971 and a growth rate of 0.91% (Forth, 1981) and is much drier than West Sumba. Farmers in East Sumba generally practice subsistence maize agriculture, however, the low soil fertility and degradation of the land from farming makes the "musim lepar" (season of hunger) an annual event. The few remaining forests are owned by the government, which requires wood-collectors to purchase an expensive collecting license, making it very difficult for poor subsistence farmers to obtain fuelwood (Rourke, 1989). Because of its remote location, low population density and few natural resources, Sumba rarely receives needed government aid for development programs, and few scientists have done ecologically-focussed research there.

YAYASAN TANANUA

YTN was founded in 1981 with funding from World Neighbors to address the development needs of East Sumba. YTN works to promote soil and water conservation by encouraging farmers to construct contour ditch and terracing systems using nitrogen fixing trees. In addition, this grass-roots organization has some smaller projects dealing with nutrition, especially for children, and encouraging the practice of traditional medicine. All of YTN's staff members (with the exception of the two coordinators) are farmers who demonstrate agroforestry technologies on their own fields. This farmer to farmer extension has been very successful because the staff live in the villages and have a long term interest in the community. In addition, there are no "giveaways" or "handouts" so that earned improvements are more satisfying (Bunch, 1982). One such improvement is a result of the nitrogen-fixing hedgerow program. In the past, farmers had to rotate their fields every three to four years because of low fertility, but currently, those farmers that have hedgerows are still farming the same land 10 years after they planted the nitrogen-fixing trees. This success has made the staff enthusiastic about trying new technologies.



Two Sumbanese farmers with a young mahogany tree

They share this enthusiasm and exchange ideas with other farmers at quarterly farmer-meetings. Each meeting typically lasts five days and brings together over 50 farmers who travel for days, often on foot, to a specified village. These meetings facilitate the "multiplier effect" of spreading technologies and experience from farmer to farmer (Bunch, 1982). One of the drawbacks to these meetings is the difficulty women have in participating because they must either stay in their home village to take care of children and household chores, or do all the cooking and serving of food during the meeting.

Although the hedgerow program has been successful with the farmers that are involved with YTN, there are still many farmers and whole villages that are not involved. This is mostly due to the small number of farmer advisors (staff members living in villages) and coordinators who can not respond to all of the requests for assistance. YTN has tried to expand by recruiting people outside of Sumba, but the newly hired people generally do not like Sumba's remoteness and the low pay. YTN is now concentrating more on hiring and training local farmers for extension outreach.

FAMILY FORESTS

In the past two to three years some of the more advanced farmers have gone beyond the use of trees in terraced hedgerows to plant family forests. YTN is encouraging this development, but has not taken a leading role in promoting specific species or planting patterns. This advancement toward tree crops, a technology not promoted by YTN, demonstrates the farmers' confidence in their ability to solve their own problems.

Farmers have planted family forests in order to fulfill certain short, medium and long term needs, and to derive benefits from otherwise useless, marginal land. Other farmers believe planting trees will improve the hydrologic conditions of the site, reduce erosion, and improve the soil. The farmers most interested in family forests are those that are most involved with YTN. Their basic needs are being met by their terraces, so they can afford to plant trees for future use. Interviews with these farmers revealed that cash crops such as coffee (*Coffea sp.*), cacao (*Theobroma cacao*), candlenut (*Aleurites moluccana*) and cinnamon (*Cinnamomum litseifolium*) are being planted for long term income generation. The family forests also serve to fulfill needs traditionally met by the natural forest, such as providing fuelwood, building materials, fodder, and various non-timber forest products. For these purposes, mahogany (*Swietenia mahogani*) and many native tree species have been planted.

Annual crops have also been planted in some family forests. Cassava (*Manihot esculenta*), corn (*Zea mays*) and pineapple (*Ananas comosus*) are planted in the early years to receive more immediate benefits from the land, and to prevent the seedlings from being overgrown with weeds.

PROBLEMS

The species of trees planted by farmers is based on their own needs, past experience of tree performance and the experience of other farmers. This has resulted in a haphazard planting pattern and an often poor choice of species. YTN has been encouraging farmers to draw pictures of their farms to facilitate farm-planning. Some of the participating farmers are extending this planning concept to their family forests. Shade tolerance, spacing and selective harvesting are being considered, but cannot be properly addressed with the farmers' current state of knowledge. They have requested species-specific information on planting, subsequent care, spacing, thinning, pruning, marketing the harvest, and production increase. This information is especially lacking for native species, although more information on these species will probably only come from farmers' own experiments, not from outside scientists, since very few scientists do long term research on native species in East Sumba.

The fact that only a few farmers are requesting this very basic information demonstrates the urgent need for extension outreach programs in these remote villages. YTN has tried to bring in foresters to answer these questions and make recommendations, but follow-through over time is lacking and it is difficult for staff working in remote villages to obtain and share technical information.

One of the major problems facing farmers in areas where rice is the staple crop is the lack of time to establish family forests, because growing rice is very labor intensive. In other areas where it is too dry to grow rice, those farmers that have a family forest claim to have enough time for it in addition to their terraces. Like the agricultural terraces, most of the labor for establishing a family forest is required in the initial stages: obtaining or growing seedlings, digging the holes, and planting the seedlings. Some weeding is needed during the first several years, and many farmers are planning to clear a fire-break around the family forest in addition to clearing a circle around each tree, because of the threat of fire in this dry environment. Other problems include the uprooting of seedlings by wild pigs from the forest, lack of water, and tree pests and diseases.

CONCLUSION

An extension brochure containing basic silvicultural information on specific tree species will attempt to address the farmers' need for extension assistance in a small way. What is really essential is long-term research on native species and the response of exotic species to the local environment. There is a need for YTN or World Neighbors to appeal to the scientific research community to focus on native species in East Sumba, or perhaps on family forests, investigating planting patterns, inputs and outputs to the system and their contribution to the household economy.

It is an encouraging sign of YTN's success that farmers have started to plant family forests on their own initiative, especially when coupled with farm planning. The challenge is for YTN to reach more farmers in East Sumba without losing the enthusiasm they have generated through successful terracing programs and constructive participation. The key will be tapping into and expanding village level organization of farmers, increasing the involvement of women and being able to recruit qualified staff who have a long-term interest in dry, remote East Sumba.

REFERENCES

Bunch, Roland 1982. Two Ears of Corn: A Guide to People-Centered Agricultural Improvement. World Neighbors, Oklahoma City, Oklahoma, USA.

Forth, Gregory L 1981. Rindi: An Ethnographic Study of a Traditional Domain in Eastern Sumba. Martinus Nijhoff, The Hague, Netherlands.

Fox, James J 1977. Harvest of the Palm: Ecological Change in Eastern Indonesia. Harvard University Press, Cambridge, Massachusetts, USA.

Rourke, Mary 1989. Tana Nua Farmers Participate in Cooperative Planting. Nitrogen Fixing Tree Association News 9:1-2.

RESTORING THE SUBTROPICAL FORESTS OF ARGENTINA: A STUDY OF THE ECONOMIC AND ECOLOGICAL ASPECTS OF NATIVE TREES

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INTRODUCTION

Current methods of tropical reforestation involve predominantly those species which traditional foresters already know much about, i.e. *Pinus*, *Eucalyptus*, and *Tectona*. While adequate levels of productivity have been realized, there are several disadvantages to this approach. Exotic species have no natural adaptations to the soils, pests and pathogens of the region. Monospecific plantations in no way approximate the diversity of flora and fauna that previously existed, and local farmers may hesitate to incorporate the unfamiliar trees into their land use systems.

The inclusion of trees on a site can do much to increase the sustainability and productivity of the system. The presence of trees can have positive effects on both the physical and chemical properties of the soil (Young, 1989). The incorporation of beneficial tree species into properly managed, land-based production systems is a viable alternative to present patterns of tropical land utilization.

Recent studies have indicated that many species native to the tropics grow as well as exotics (Montagnini and Sancho, 1990). In part because data on native tree species is severely lacking for most tropical and sub-tropical regions, native tree species have been overlooked due to a lack of knowledge on the part of the technology exporters. We studied both the economic and ecological aspects of eight tree species native to the subtropical province of Misiones, Argentina. Our results may help to further incorporate native trees into economically and ecologically sustainable land use systems.

METHODS

The province of Misiones is in the northeast corner of Argentina, between 26° & 28° South latitude, bordered by Paraguay to the northwest and Brazil to the east. It has an area of 30,719,000 km² — 1% of the country's total. The mean annual rainfall is 1700 mm and the mean temperature is 14° C in July and 24° C in January. The subtropical regime is without a pronounced dry season. This area is major national supplier of wood, contributing 41% of the Argentine demand (IFONA 1985). While the wood supply consists mainly of cultivated tree species (Pinus, Eucalyptus and Melia) a significant 21% of Misiones' supply consists of native trees from virgin or secondary forests (Fahler 1989; IFONA 1985).

The eight species selected for this study (all native to the sub-tropical Amazon basin) have been chosen based on the previous studies and recommendations of the Faculty of Forest Sciences of the National University of Misiones (UNaM) and Dr. F. Montagnini of the Yale School of Forestry and Environmental Studies (YSFES). These same species are being utilized for experiments in mixed plantation and forest enrichment studies as part of the UNaM-YSFES collaboration project. The species are: *Cordia trichotoma* (Peteribi or Loro negro), *Ocotea puberula* (Guaica), *Peltophorum dubium* (Canafistola), *Parapitadenia rigida* (Anchico colorado), *Bastardiopsis densiflora* (Loro blanco), *Enterolobium contortisiliquum* (Timbo colorado), *Balfourodendron riedelianum* (Guatambu), *Lonchocarpus muehlbergianus* (Rabo molle).

Peteribi and Guatambu are high quality timber trees. Canafistola, Guaica, and Loro blanco are valued for timber, although somewhat less so than the former, but these trees are also known to be especially fast growing. Anchico colorado, Timbo colorado, and Rabo molle are all leguminous, nitrogen fixing trees.

To study the influence of trees on soil fertility, natural, single-species stands of the tree species under investigation were located for the removal of soil, root, leaf and branch samples. Soil samples were collected at a randomly chosen point 1 meter from the base of the tree from depths of 0-5, 5-15, 15-30, and 30-45 cm. Root samples were taken from two randomly chosen locations 1 meter from the base of the tree at a single depth of 0-5 cm using a root corer of known volume, such that root densities in the highly competitive topsoil layer could be determined. Leaves and branches were collected to give an indication of both nutrient requirements and potential recycling of nutrients by each species.

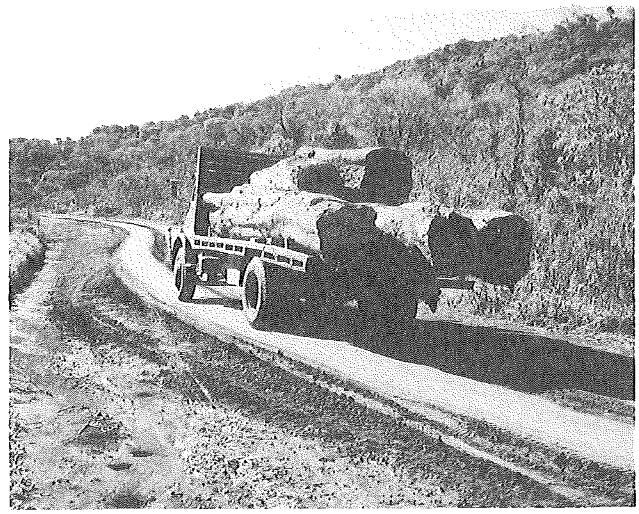
Soil samples were sieved through a 2 mm soil sieve, dried, and are currently undergoing analysis for pH and concentrations of N, P, K, Ca, Mg, and Al at YSFES. A comparison will be made between soils under the trees and soils outside of the influence of the trees in order to determine the trees' influence on soil chemical properties.

An economic evaluation was conducted in order to determine if cultivation of native trees would be profitable relative to other land use systems in the region. Because the cultivation of native species is not a common practice in Misiones, some information must be inferred by using existing data from currently cultivated exotic species. For example, information such as cultivation costs are known for several species managed in the region. Factors such as annual growth increments and rotation length will be calculated from field data from known aged, regenerated and monospecific stands. Each stand will be accounted for separately according to its particular management history.

Three land-use systems are considered in this study: the cultivation of native tree species, the cultivation of pine for sawn wood and pulpwood, and the cultivation of Yerba Mate, a tea-like cash crop. Economic data for each land-use system were acquired by interviewing agents from eight local companies. These companies were chosen as a representative sample of the regional industries. The economic data included sawmill price per cubic meter of *pinus* or native trees; gross market price of pulpwood and yerba mate; cultivation costs including, purchase of seedlings, maintenance, use of machinery, transportation and harvest.

The ecological data was acquired through interviews, literature review and field work. This data included the density of regenerated or cultivated (monospecific) stands, soil fertility and annual growth increments (height and dbh trees and kg of leaves per year for Yerba Mate).

The analysis will use both the economical and ecological data to estimate an economically optimal rotation length for the cultivation of native species. This data will also be used to determine the possible economic values of a hectare of native trees at different densities. These values will be compared with other traditional land use practices such as



The harvesting of native forest species in Misiones, Argentina

the cultivation of pine and yerba mate.

CONCLUSION

Due to passing of laws providing tax incentives for the planting of *Pinus spp.*, there are thousands of hectares of these exotic trees throughout Misiones. Few birds and animals utilize these plantations and there is evidence that several rotations of *Pinus* may contribute to serious soil acidification (Fernandez, 1987). The cultivation of native tree species as opposed to exotics may help in the protection of wildlife and in the conservation or restoration of soil fertility.

Some examples in which the cultivation of native species could create a profitable land-use system include the cultivation of soil-improving species on otherwise unproductive lands, cultivation of high quality (high priced) native species on farms far away from main roads where the transportation costs exceeds the mill price of pine, integration of native species into traditional systems such as Yerba Mate plantations, and cultivation of native species as temporary shade trees into silvopastoral systems.

Further research in this area should contribute demonstrably to understanding and promoting the use of native tree species in tropical and subtropical land-use systems.

REFERENCES

Fahler, Jorge C. 1989. Estado Actual de la Tecnologia y Manejo de las Forestaciones en el N.E.A. IV Jornadas Forestales de Entre Rios (3) 1-23.

Fernandez, R.A. 1987. Influencia del sistema de desmonte-reforestacion con *Pinus spp.* sobre algunas caracteristicas quimicas de los suelos. Ciencia del Suelo 5(2):123-129

I.F.O.N.A. 1988. Jornadas para el Desarollo del Sector Forestal Argentino.

I.F.O.N.A. 1985. Anuario de estadistica Forestal 1985

Montagnini, F. and Sancho, F. 1990. Impacts of native trees on tropical soils: A study in the Atlantic lowlands of Costa Rica. Ambio 19(8):386-390

Young, A. 1989. Agroforestry for Soil Conservation. ICRAF, Nairobi, Kenya.

LOW-TECH LEAF MULCH EXPERIMENT IN MADAGASCAR: NEGATIVE EFFECTS OF *TAMARINDUS INDICA* ON CORN

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INTRODUCTION

The World Wildlife Fund of the United States (WWF-US) provided me with funding to work for one year as the Project Forester at the Beza Mahafaly Integrated Conservation and Development (ICD) Project (TRI NEWS No. 7 Fall 1989) in southwest Madagascar. Part of my work involved carrying out a leaf mulch experiment.

As farmers cultivate the same field year after year, soil organic matter (OM) decreases (Foth 1984). Given the direct relationship between OM and soil water holding capacity (Altieri et al. 1987), local farmers could be negatively impacting the soil's available water. The fact that the local farmers in the Reserve area claim a worn-out soil "does not have any water" lends support to this cause and effect sequence.

Depletion of soil OM could be mitigated by the small yearly inputs of OM provided by trees in a dispersed tree agroforestry (AF) system (Nair 1984). In this system, scattered trees are left in an agricultural field when the forest is cleared, or trees are planted in the field while cultivation is still in progress. By maintaining higher levels of soil OM, this system may extend the period of cultivation fields in the Reserve area can sustain. Also, having trees in a field when it is fallowed could facilitate the regeneration of a forest cover, thus shortening the fallow period. Finally, relative to a more intensive AF system (i.e. alley cropping or hedgerows), a dispersed tree AF system would require little change in present agricultural practices.

Before any of these benefits can be realized a number of issues need to be addressed. Competition for sunlight between the trees and crops can lower yields, especially with crops such as corn that can use large amounts of sunlight very efficiently (Salisbury and Ross 1978, Singh et al. 1974). Trees may serve as habitat for seed eating birds and other agricultural pests. Also, many trees have leaves that inhibit plant growth, making them unsuitable for a dispersed tree AF system. The effects of the tree leaves on corn yield were investigated during the 1990-91 agricultural season.

METHODS

The experimental plot was located in a field that has been cultivated for approximately 45 years. This site was chosen anticipating that, because of its long cultivation history, it would produce the clearest possible results. Also, the field is representative of the agricultural plain used by a number of the villages near the Reserve.

Tamarindus indica and *Acacia myrmecophylla* were chosen for this experiment. Often, *T. indica* is already growing on land cleared for agriculture so incorporating it into a dispersed tree AF system would not require nursery propagation and outplanting. It is also a very useful multipurpose tree (Jambulingam and Fernandes, 1986, and von Maydell, 1983). *A. myrmecophylla* is an acacia and therefore may fix atmospheric nitrogen. It grows away from the nearby Sakamena River so it is more likely to be deeply rooted, minimizing tree/crop competition for water. In addition, its leaflets are very fine allowing for quick decomposition.

Leaves were collected just before the forecasted start of the rainy season in mid-November. Only freshly fallen leaves which had not begun decomposing were collected. Living leaves were not collected because leaf composition can change with leaf senescence (Salisbury and Ross 1978, Thiman, K.V. 1980) and, therefore, their effects on agriculture may not be the same as leaves that fall naturally. All of the leaves were cleaned of twigs, fruit, other leaves, and debris and then samples were weighed out.

In the Reserve area, farmers sow corn by placing 6-8 seeds in a small hole and lightly covering them with soil. The holes are spaced about 1 meter apart. The treatments consisted of

Table 1. Effects of *T. indica* and *A. myrmecophylla* Leaf Mulch on Corn*				
	100 g *T. indica*	200 g *T. indica*	100 g *A. myrmeco.*	Control
Average corn emergence (plants/hole)	3.8a	3.8a	5.8b	5.2b
Average grain bearing ears/hole	3.9a	3.3a	5.6b	5.0b
Average grain/hole (grams)	203.6b	178.3a	230.0b	263.7b
Average grain bearing ears/stalk	1.14b	1.11b	1.04c	1.00a

* Averages in the same row that do not share the same letter are statistically different.

tracing a circle 1 meter in diameter around the holes, spreading the leaves uniformly within the circles, and then lightly incorporating the leaves into the top few centimeters of soil with a hoe. We lightly hoed the soil around the control holes to maintain consistency between the treatments and the controls.

The treatment levels, 100 g and 200 g (or 1.27 and 2.54 tons per hectare), were derived by spreading leaves on a flat surface and visually relating a weight to what could be expected from the leaffall of a pruned tree. The treatments were 100 g of *T. indica* (n=10), 200 g of *T. indica* (n=6), and 100 g of *A. myrmecophylla* (n=5), with 10 controls. The experimental plots were located in a uniform area of the field and the treatments were randomly placed within the plot.

Corn was sown on December 21 and the mulch put in place one day later. Emergence was measured 13 days after the seeds were sown by tallying the germinated plants per hole. After harvesting the corn on March 31, the ears per stalk and ears per hole were counted, and the grain per hole was weighed. The data are presented in Table 1.

Three of the control samples were lost during the season. Also, one ear was heavily damaged by insects (treatment: 200 g of *T. indica*). The weight of grain on this ear was estimated by averaging the weight from two other ears of nearly equal size. Another ear was completely missing (treatment: 100 g of *T. indica)*. In this case the diameter of the stem that had connected the ear to the stalk was measured. The grain from two ears with similar sized stems was weighed and averaged and this was used to estimate the weight of the missing ear's grain.

RESULTS

Results in Table 1 show that 100 g and 200 g of *T. indica* leaves had a negative effect on corn emergence (significant at $p > 0.025$ and $p < 0.01$ respectively). The difference between the controls and the corn treated with *A. myrmecophylla* leaves was not statistically significant. The corn treated with *T. indica* leaves seems to have responded to the initial decrease in emergence by producing more grain bearing ears per stalk (significant at $p>0.10$ for both treatment levels). But the corn was unable to compensate completely and, in the case of the 200 g treatment, produced less grain per hole ($p>0.10$). Statistical conclusions were calculated using pooled standard deviations and, for ears per plant, "t tests" were used (Ott, 1984).

Because *A. myrmecophylla* did not lower germination or yield of grain, the observed decrease is probably due to some characteristic of the *T. indica* leaves not shared by the *A. myrmecophylla* leaves. The average length of *T. indica* leaflets is 19.1 mm (n=10) versus 4.25 mm (n=10) for the *A. myrmecophylla*. Perhaps the smaller *A. myrmecophylla* leaflets decomposed more quickly or offered less physical resistance to the emerging corn plants. A second possibility is that *T. indica* leaves contain an allelopathic chemical able to decrease emergence.

The data in Table 1 show that, with approximately 10,000 holes per hectare, corn yield in the old field would be decreased by 854 kg $\pm$111.4 kg per hectare (90% confidence interval) with the addition of 2.54 metric tons of *T. indica* leaves. Based on these results, it is unlikely *T. indica* would be suitable for intercropping in agricultural fields.

CONCLUSION

This test generated significant results that could be useful in planning future AF interventions in the area of the Reserve. Also, these results were produced in a rustic setting with very little outside technical support showing that such support is not always a prerequisite to practical small-scale research activities.

Current research is continuing under the advisement of the Director of the Tropical Resources Institute at Yale, Dr. Florencia Montagnini. Options include replicating the results in a controlled laboratory setting and carrying out a more sophisticated statistical analysis of the results.

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REFERENCES

Alteri, M.A., F.J. Trujillo, and J. Farrell, 1987. Plant-Insect Interactions and Soil Fertility Relations in Agroforestry Systems: Implications for the Design of Sustainable Agroecosystems. Pages 89-108 *in* H.L. Gholz, ed. Agroforestry: Realities, Possibilities and Potentials. Martinus Nijhoff Publishers, Boston, USA.

Foth, H.D. 1984. Fundamentals of Soil Science 7th ed. John Wiley and Sons, New York, USA.

Jambulingam, R. and E.C.M. Fernandes 1986. Multipurpose Trees and Shrubs on Farmlands in Tamil Nadu State (India). Agroforestry Systems Journal 4:17-23.

Nair, P.K.R. 1984. Soil Productivity Aspects of Agroforestry. ICRAF, Nairobi, Kenya.

Ott, L. 1984. An Introduction to Statistical Methods and Data Analysis. Duxbury Press, Boston, USA.

Salisbury, F., and C. Ross 1978. Plant Physiology 2nd ed. Wadsworth Publishing Company, Inc., Belmont, California, USA.

Singh, M., W.L. Ogren, and J.M. Widholm 1974. Photosynthetic Characteristics of Several C_3 and C_4 Plant Species Grown Under Different Light Intensities. Crop Science 14:563-566.

Thimann, K.V. 1980. The Senescence of Leaves. Pages 85-117 in K.V. Thimannin, editor. Senescence in Plants. CRC Press, Inc., Boca Raton, Florida, USA.

von Maydell, H.J. 1983. Arbres et Arbustes du Sahel. Leur Caracteristiques et leurs utilisations. GTZ, Eschborn, pp. 358-364.

COOPERATOR NOTES

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SYMPOSIUM ON SOCIETY AND RESOURCE MANAGEMENT

School of Natural Resources, University of Wisconsin - Madison

The Fourth North American Symposium on Society and Resource Management will be held on the University of Wisconsin campus from May 17 - May 20, 1992. A call for papers from persons interested in presenting a paper or poster at the symposium went out and abstracts were due to the Program Chair on December 1, 1991.

Participants in the symposium will take part in a variety of events encompassing the symposium theme of Integrated Resource Management. Activities may include concurrent paper/video sessions, plenary theme addresses, round table discussion, a poster session, field trips and receptions. The symposium will focus on the integration of social biological sciences in addressing natural resource and environmental issues.

For further information contact:
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LITERATURE

AGROECOSYSTEMS, BIOLOGICAL, FORESTS, SOIL

Adesina, F. 1990. Planted fallows for sustained fuelwood supply in the humid tropics. Transactions-Institute of British Geographers 15(3):323-330.

Amazonia: deforestation and possible effects. Forest ecology and management, 38(3-4):119-304, 1991. Special issue. Proceedings of a symposium, 46th International Congress of Americanists, July 1988, Amsterdam.

Brown, S. et al. 1990. Biomass of tropical forests of south and southeast Asia. Canadian Journal of Forest Research 21(1):111-117.

Barnes, R. 1990. Deforestation trends in tropical Africa. African Journal of Ecology 28(3):161-173.

Colinvaux, P. et al. 1991. Rain-forest ecosystem as a resource for hunting and gathering. American Anthropologist 93(1):153-159.

Devilliers, P. et al. 1991. Method of sampling food consumption by free-ranging elephant. South African Journal of Wildlife Research 21(1):23-27.

Dregne, H. 1990. Erosion and soil productivity in Sub-Saharan Africa. Journal of Soil and Water Conservation 45(4):431-436.

Ekanade, O. et al. 1990. Zoning tree crop production under intensive land use: an investigation into soil quality differentiation under varying cropping patterns in Western Nigeria. Journal of Environmental Management 32(2):105-114.

Flint, E. et al. 1990. Historical analysis of changes in land use and carbon stock of vegetation in south and southeast Asia. Canadian Journal of Forest Research 21(1):91-110.

Fujisaka, S. 1991. A diagnostic survey of shifting cultivation in northern Laos: targeting research to improve sustainability and productivity. Agroforestry Systems 13(2):95-110.

Ghuman, B., R. Lal, and W. Shearer. 1991. Land clearing and use in the humid Nigerian tropics. I. Soil physical properties. II. Soil chemical properties. Soil Science Society of America Journal 55(1):178-187.

Gillespie, A. et al. 1990. Refining estimates of carbon released from tropical land-use change. Canadian Journal of Forest Research 21(1):118-131.

Hamilton, L. 1990. Tropical forest misinterpretations. Journal of Forestry 89(1):5-11.

Houghton, R. 1990. Releases of carbon to the atmosphere from degradation of forests in tropical Asia. Canadian Journal of Forest Research 21(1):132-142.

Karr, J. et al. 1990. Survival rates of birds of tropical and temperate forests: will the dogma survive? American Naturalist 136(3):277-291.

Lugo, A. 1991. Tropical forestry research: past, present, and future, many early myths are alive and well. Journal of Forestry 89(3):10-12.

Malmer, A. et al. 1990. Soil disturbance and loss of infiltrability caused by mechanized and manual extraction of tropical rainforest in Sabah, Malaysia. Forest Ecology and Management 38(1-2):1-12.

Milnergulland, E. et al. 1990. Impact of the ivory trade on the African elephant (Loxodonta africana) population as assessed by data from the trade. Biological Conservation 55(2):215-229.

Noss, R. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4(4):355-364.

Pandey, M. et al. 1990. Effectiveness of smokeless stoves in reducing indoor air pollution in a rural hill region of Nepal. Mountain Research and Development 10(4):313-320.

Roberts, P. 1991. Water disinfection: a review with some consideration of the requirements of the Third-World. Critical Reviews in Environmental Control 20(5-6):341.

Smith, N. et al. 1990. Deforestation and shrinking crop gene-pools in Amazonia. Environmental Conservation, 17(3):227-234.

Vaughan, D. et al. 1990. Gene flow from the jungle to farmers. Bioscience 41(1):22-28.

SOCIAL, CULTURAL, ECONOMIC

Anderson, A. 1990. Smokestacks in the rainforest-industrial development and deforestation in the Amazon Basin. World Development 18(8):1191-1206.

Atkinson, A. 1990. Comparing poverty rates internationally: lessons from recent studies in developed countries. World Bank Economic Review 5(1):3-22.

Barrow, E. 1991. Evaluating the effectiveness of participatory agroforestry extension programmes in a pastoral system, based on existing traditional values, a case study of the Turkana in Kenya. Agroforestry Systems 14(1):1-22.

Burnett, G. et al. 1990. National park and equivalent reserve creation in French and British Africa. Society and Natural Resources 3(3):229-242.

Child, G. et al. 1990. Underselling national parks in Zimbabwe: the implications for rural sustainability. Society and Natural Resources 3(3):215-228.

Christensen, J. et al. 1990. Project evaluation for energy supply in rural areas of developing countries. European Journal of Operational Research 49(2):230-248.

Dedear, R. et al. 1991. Thermal comfort in the humid tropics: field experiments in air conditioned and naturally ventilated buildings in Singapore. International Journal of Biometeorology 34(4):259-265.

Farrell, B. et al. 1990. Ecology and tourism. Annals of Tourism Research 18(1):26-40.

Harrison, S. 1990. Population growth, land use and deforestation in Costa Rica, 1950-1984. Interciencia 16(2):83-93.

Neff, A. 1990. Not in their backyards, either: a proposal for a foreign environmental practices act. Ecology Law Quarterly 17(3):477-538.

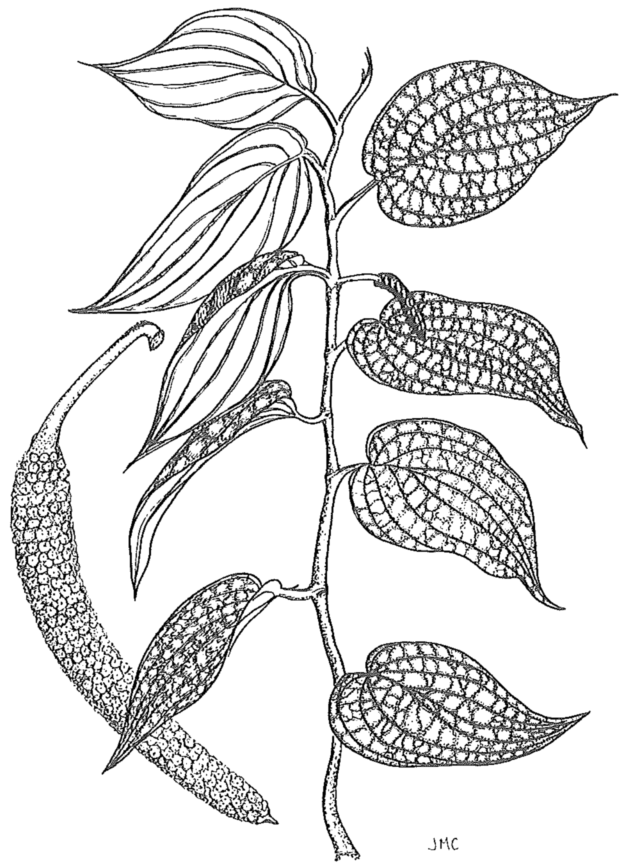
Nyerges, A.E. 1990. Coppice swidden fallows in tropical deciduous forest—biological, technological, and socio-cultural determinants of secondary forest successions. Human Ecology 17(4):379-400.

Patterson, A. 1990. Debt for nature swaps and the need for alternatives. Environment 32(10):5-13.

Sanders, J. et al. 1990. Developing new agricultural technologies for the Sahelian Countries: the Burkina-Faso case. Economic Development and Cultural Change 39(1):1-22.

Proceedings of the international workshop on professional education and training in agroforestry in Gainesville, Florida, U.S.A., December 1988. 1990. Agroforestry Systems 12(1):3-133.

Southgate, D. et al. 1990. Resource degradation in Africa and Latin-America: population pressure, policies, and property arrangements. American Journal of Agricultural Economics 72(5):1259-1263.



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