Conservation of Useful Plants: An Evaluation of Local Priorities from Two Indigenous Communities in Eastern Panama[1]

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Dalle, Sarah Paule *(Department of Plant Science, Macdonald Campus of McGill University, 21111 Lakeshore Dr., Ste-Anne-de-Bellevue, Québec, Canada H9X 3V9; e-mail: sarah.dale@magill.ca)* **and Catherine Potvin** *(Biology Department, McGill University, 1205 ave Dr. Penfield, Montréal, Québec, Canada H3A 1B1).* CONSERVATION OF USEFUL PLANTS: AN EVALUATION OF LOCAL PRIORITIES FROM TWO INDIGENOUS COMMUNITIES IN EASTERN PANAMA. *Economic Botany 58(1):000–000, 2004. On both theoretical and practical grounds, respect for, and inclusion of, local decision-making processes is advocated in conservation, yet little is known about the conservation priorities on local territories. We employed interviews and ecological inventories in two villages in order to (1) evaluate the local perception of the conservation status of important plant resources; (2) compare patterns of plant use; and (3) compare perceived conservation status with population structure and abundance in the field. One-third of the 35 species examined were perceived to be threatened or declining. These were predominantly used locally for construction or sold commercially, but were not necessarily rare in the field. The destructiveness of harvest was the most consistent predictor of conservation status in both villages. Contrasting patterns were found in the two villages for the frequency of plant harvest and the relationship of this variable with conservation status. We suggest that local knowledge is an efficient means to rapidly assess the status of a large number of species, whereas population structure analysis provides an initial evaluation of the impact of harvest for selected species.*

CONSERVACIÓN DE PLANTAS ÚTILES: UNA EVALUACIÓN DE PRIORIDADES LOCALES EN DOS LOCALIDADES DEL ESTE DE PANAMÁ. *Tanto desde una perspectiva teórica como práctica el respeto e inclusión de los procesos locales de toma de decisiones es una forma en que la conservación puede ser promovida. Sin embargo, poco se sabe sobre las prioridades de conservación en territorios indígenas. En el presente estudio se emplearon entrevistas e inventarios ecológicos en dos localidades indígenas para (1) evaluar la percepción de los habitantes locales sobre el estado de conservación de recursos vegetales importantes; (2) comparar los patrones de uso de plantas; y (3) comparar la percepción del estado de conservación con la estructura de las poblaciones y la abundancia de las especies en el campo. Una tercera parte de las 35 especies estudiadas fueron percibidas como amenazadas o en proceso de declinación. Se trata de plantas utilizadas principalmente como materiales de construcción o que aportan productos que son comercializados, pero que no son necesariamente escasas en el campo. En ambas localidades la variable que predijo el estado de conservación de forma más consistente fue el grado de destrucción de las plantas asociado a las prácticas de cosecha. Encontramos patrones contrastantes entre las dos localidades con respecto a la frecuencia de cosecha y a la relación de esta variable con el estado de conservación de las plantas. Sugerimos que el uso de conocimientos locales es una forma eficiente de evaluar con rapidez el estado de un gran número de especies, en tanto que el análisis de la estructura de poblaciones aporta una evaluación inicial sobre el impacto de la cosecha para algunas especies de interés.*

1? **Key Words:** conservation, comparative ethnobotany, indigenous territories, local knowledge, Panama, population structure, rapid assessment, useful plants.

Efforts to conserve tropical forests are increasingly seeking the involvement of local communities. On both theoretical and practical grounds, respect for, and inclusion of, local decision-making processes is advocated (Norton 2001; Western et al. 1994), and it is increasingly recognized that cultural perception is an important component of conservation action. Further-

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more, conservationists are now seeking alliances with indigenous peoples, whose territories encompass a large proportion of the remaining forest in Latin America and elsewhere (Colchester 2000; Peres 1994; Schwartzman et al. 2000).

One way in which local involvement may be achieved is to focus conservation efforts on resources important to local economies (Ticktin et al. 2002). A number of examples exist of local people adopting conservation actions (e.g., Gadgil et al. 1993; Pinedo-Vasquez et al. 1990; Ventocilla et al. 1995), and many of these are motivated by perceived threats to local resource bases. Ethnobotany, by focusing on the knowledge, use, and management of plants by people, can provide an understanding of the nature of management problems and the potential for conservation on local territories. Local knowledge about the status of plant resources, for example, has begun to be explored as a way to determine conservation priorities (Potvin et al. 2002). Hellier and colleagues (1999) examined the use of local knowledge for identifying declines in animal and plant species, as well as in forest cover in highland Mexico, whereas vegetation change in an African savannah was assessed using local perceptions and population structure analysis by Lykke (1998, 2000). Ethnobotanical research can contribute to such an approach by characterizing patterns of plant use and management and investigating how these relate to plant declines or conservation priorities.

In this paper we present results from a study aimed at examining the conservation priorities for plant resources of two villages in the biogeographic region of Darien, Eastern Panama. Darien is home to three indigenous groups who have cohabited on these lands for hundreds of years (the Kuna, the Embera, and the Wounaan) and is a global priority for forest conservation (Davis et al. 1997). Problems of resource deterioration and over-exploitation on indigenous territories in the region have been reported (Herlihy 1986; Ventocilla et al. 1995). We employed a participatory approach with local people in one Kuna and one Embera community to examine the conservation status of traditional plant resources. The two villages studied differ substantially in land-use history. Specifically, our goals were to:

(1) Evaluate the conservation status of important plant resources as determined by local knowledge in the two villages and identify ecological and use characteristics associated with declining or threatened species;
(2) Contrast patterns of plant use in the two villages, especially the frequency of harvest; and
(3) Compare the perceived conservation status with population structure and abundance in the field.

Our discussion then considers the utility of local knowledge and participation for plant conservation and makes recommendations for further research.

Study Area

The two focus villages of this study are situated approximately 75 km apart. Ipeti is an Embera village located along the Ipeti River near the foothills of Serrenia Maje (9°00′ N, 78°05′ W), province of Panama, while Nurna is a Kuna village located near the headwaters of the Chucunaque River in the province of Darien (9°00′ N, 78°03′ W). Both territories are covered by forests classified as ''humid tropical'' in the Holdridge life zone system (Instituto Geográfico Nacional 1988) and range in elevation from approximately 50 to 300 m above sea level. Average annual precipitation in the area is around 2500 mm with annual temperature averages of 25°C (Instituto Geográfico Nacional 1988). There is a pronounced dry season from December to April (Tosi 1971).

Whereas both villages are found in ecologically similar regions, they differ in the degree of anthropogenic alteration of their surroundings. Ipeti is a recent village organized as an indigenous ''Tierras colectivas'' of 3198 ha. When the Bayano hydroelectric reservoir was flooded in the mid-1970s, the Embera people living in the area were relocated to Ipeti and to the neighboring community of Piriati, both along the Panamerican highway (Wali 1993). Travel to Ipeti from Panama City takes five hours by bus. The largely forested indigenous territory is embedded in a matrix of land used by colonists for cattle ranching. There are 50 houses in Ipeti and we estimate the population to be around 400 people. Most inhabitants of Ipeti speak Spanish with the exception of some older women; the younger generation tends to use Spanish rather than Embera in their daily activities. The local economy appears rather diversified. Men and women work for day wages in various colonist

TABLE 1. ETHNOBOTANICAL CHARACTERISTICS OF PLANTS SELECTED FOR STUDY BASED ON THEIR IMPORTANCE TO THE LOCAL CULTURE IN IPETI AND NURNA.

				I. Nurna (Kuna)			II. Ipeti (Embera)		
Species	Family	Herbarium voucher*	Life form	Name	Principal use	Part	Name	Principal use	Part
I. Plants only in Nurna									
Apeiba tibourbou Aubl.	Tiliaceae	SD 229a,b	Tree	Dubsip	Rope fiber	Bark	—	—	—
Arrabidaea chica (Bonpl.) B. Verl.	Bignoniaceae	SD 237a,b	Liana	Magep	Ritual	Leaf	—	—	—
Bactris coloradonis L. H. Bailey	Arecaceae	SD 204a,d	Palm	Alar-uar	Pot holder	Stem	—	—	—
Cordia alliodora (Ruiz & Pav.) Oken	Boraginaceae	SD 227a	Tree	Ugar-uar	Firewood	Trunk	—	—	—
Gustavia superba (Kunth) O. Berg	Lecythidaceae	SD 239a,b	Tree	Tupu-uar	Edible	Fruit	—	—	—
Myroxylon balsamum (L. Harms)	Fabaceae	SD 200a,b	Tree	Baila-uar	House post	Trunk	—	—	—
Oxandra sp.	Annonaceae	SD 201a,c	Tree	Uichur-sichit	Roof post	Trunk	—	—	—
Peltogyne purpurea Pittier	Fabaceae	SD 223b	Tree	Ipup	Firewood	Trunk	—	—	—
Swietenia macrophylla King	Meliaceae	SD 236a,b	Tree	Kaoban	Construction, timber, canoe	Trunk	—	—	—
Symphonia globulifera L. f.	Guttiferae	SD 234a,b	Tree	Mutu	Tool for bead-work	Latex	—	—	—
No id	Sterculiaceae	SD 207a,b	Tree	Bunur-sapi	Hand beater	Branch	—	—	—
No id	Rutaceae	SD 233a,b	Tree	Puarsip	House post	Trunk	—	—	—
No id	Bombacaceae	NS	Tree	Sianele	Edible, ritual dolls	Fruit, trunk	—	—	—
II. Plants in Nurna and Ipeti									
Aechmea magdalenae André ex Baker	Bromeliaceae	NS	Herb	Oa	Ritual, edible	Leaf, fruit	Yi	Fiber	Leaves
Astrocaryum standleyanum L. H. Bailey	Arecaceae	UC 9a,c	Palm	Naba	Edible, house wall	Fruit, trunk	Chunga	Basketry	Leaves
Carludovica palmata Ruiz & Pav.	Cyclanthaceae	SD 238a	Herb	Nai-uar	Basketry	Petiole	Nawala	Basketry	Petiole

TABLE 1. CONTINUED.

Species	Family	Herbarium voucher*	Life form	I. Nurna (Kuna)			II. Ipeti (Embera)		
				Name	Principal use	Part	Name	Principal use	Part
Dalbergia retusa Hemsley	Fabaceae	SD 205a,b	Tree	Koibur	Construction	Trunk	Cocobolo	Black dye	Trunk
Genipa americana L.	Rubiaceae		Tree	Sabdur	Cosmetic, ritual	Fruit	Kipara	Body painting, ritual	Fruits
Heteropsis oblongifolia Kunth	Araceae	SD 210a,b	Hemiepiphyte	Sargi	Latching	Roots	Bejuco real	Basketry	Roots
Ochroma lagopus Sw.	Bombacaceae	UC 2a,c	Tree	Ukur-uar	Ladder, carrying post, ritual dolls	Trunk	Balsa	Ladder, ceremonial	Trunk
Oenocarpus mapora H. Karst	Arecaceae	UC 5a,c	Palm	Siler	Basketry, house walls	Petiole, trunk	Maquenque	Construction, basketry	Trunk
Sabal mauritiiformis (H. Karst) Griseb. H. Wendl.	Arecaceae	JH 2a,c	Palm	Soso	Thatch	Leaf	Guagara	Thatch	Leaves
Socratea exorrhiza (Mart.) H. Wendl.	Arecaceae	UC 4a,c	Palm	Ila	House walls	Trunk	Jira	Floor	Trunk
III. Plants in Ipeti only									
Aechmea sp.	Bromeliaceae	NS	Herb	—	—	—	Pita sin espina	Fiber	Leaves
Bactris sp.	Arecaceae	NS	Palm	—	—	—	Uvita	Construction & pot holder	Trunk
Bombacopsis sp.	Bombacaceae	NS	Tree	—	—	—	Cedro espino	Canoe	Trunk
Calathea latifolia (Willd. ex Link)	Marantaceae	UC 1a,c	Herb	—	—	—	Bijao	Cooking	Leaves
Cedrela odorata L.	Meliaceae	UC 8a,c	Tree	—	—	—	Cedro amargo	Canoe	Trunk
Manettia sp.	Rubiaceae	NS	Liana	—	—	—	Kidave	Toothpaste	?
Manilkara sp.	Sapotaceae	NS	Tree	—	—	—	Nispero	Construction	Trunk
Oenocarpus bataua Mart.	Arecaceae	NS	Palm	—	—	—	Trupa	Drink & oil	Fruits
Xylopia frutescens Aubl.	Annonaceae	UC 6a,c	Tree	—	—	—	Malagueto	Construction & rope	Trunk & Bark
No id	Gramineae	NS	Bamboo	—	—	—	Chiru	Flute	Trunk
No id		NS	Shrub	—	—	—	Tinta roja	Red dye	Leaves
No id		NS	Liana	—	—	—	Motete	Basketry	Stem

* Collectors are Sarah Dalle (SD), Ultiminio Caisamo (UC) and Jane Hutton (JH); a = deposited at PMA, b = deposited at FMNH, c = deposited at SCZ, d = deposited at NYBG, NS = no specimen collected.

enterprises such as farms, logging companies, or private houses. All households also engage in subsistence agriculture, fishing, and hunting. In the past two decades, basket weaving (for women) and, to a lesser extent, wood carving (for men) have become an important source of supplementary income. The intensification of basketry raised the level of consciousness of the community regarding resource availability, and this concern facilitated the present study.

According to oral history, Nurna was established approximately 70 to 100 years ago when a fire destroyed a previous settlement located higher up in the San Blas mountains. Nurna is part of the recently legalized (2000) Comarca Wargandi. The village's traditional lands are extensive (approximately 10 000 ha). There is no road access to Nurna; during the time of the present study (1998–1999), reaching Nurna from the city of Panama involved an eight-hour bus ride and an eight-hour hike. Nurna is surrounded by largely intact forests. Large predators, e.g., jaguar (*Panthera onca*) and harpy eagle (*Harpia harpyja*), are still reported in the region of Nurna by villagers (field observation). The population of 200 people is predominantly Kuna-speaking. Only a few people (four younger men) speak Spanish and can read and write. The local economy is based on swidden/fallow agriculture complemented by permaculture agroforestry along the riverbanks, hunting, and, to a lesser degree, fishing. Since approximately 1995, cash income has been obtained almost exclusively through contracts established with Panamanian logging companies for the commercial extraction of valuable timber species, mainly *Swietenia macrophylla*. Previously, cash income was much more limited and was derived from occasional timber sales, as well as that of Ipecac (*Psychotria ipecacuanha*) in the medicinal herb markets in Panama City. At the onset of this project, most inhabitants of Nurna showed relatively little preoccupation for the status of their resources, feeling that the surrounding forests were plentiful.

METHODS

In both villages the objectives and progress of the research was presented and discussed with the communities in the village congress. In Ipeti, work was coordinated directly with the local organization OUDCIE (Organización para la unidad y el desarrollo de la comunidad de Ipeti-Emberá). Research in Nurna was coordinated with support from Fundación Dobbo-Yala, a Kuna nongovernmental organization that has been working in the area since 1996 (see Lopez and Dalle 2001 for more details).

SPECIES SELECTION

We worked with inhabitants in both villages to select species considered important to the local culture. We did not focus on medicinal plants, as this topic was considered sensitive in both communities. In Ipeti, we conducted a one-day workshop. Twenty men and 20 women met separately to establish a list of plants they considered most important for Embera culture. The workshop yielded a list of some 38 species with 11 species overlapping between the respective lists of men and women. Twenty-two of these species were selected for our study. The criteria for inclusion were representation of male and female choice, diversity of life form, uses, and harvested plant parts. In Nurna, species were selected from an initial list of 70 species obtained from free-listing interviews with two men and two women, as well as a group of five young men who volunteered as informants. Informants were asked to list all species known in each of five use categories (construction, weaving/utility, edibles, firewood, ritual). This list was reviewed for accuracy with the ''Agriculture Committee,'' a group of four men who, among other responsibilities to the community, were charged with coordinating with the research team. They were asked to prioritize species in each category according to their perceived importance. The final list of 23 plant species was selected from the ''priority'' species by maximizing diversity in uses, life form, and use by men/women. In both villages, species were identified using local flora (Croat 1978; Gentry 1996; Henderson et al. 1995). Voucher specimens were collected and deposited at the the Herbario Nacional de Panamá (PMA) or sent to other herbaria for identification. In a few cases we were unable to obtain a scientific identification, largely because the species were never encountered in the field. These species are referred to in this paper by their local names. The final list of species from the two villages is shown in Table 1.

ECOLOGICAL INVENTORIES

Ecological inventories were carried out to study the species abundance and distribution in both Nurna and Ipeti. Dalle et al. (2002) provides a detailed description of the field sampling methodology. Briefly, the sampling consisted of a stratified random sampling design, in which a total of 50 transects in Ipeti and 52 transects in Nurna were laid out across an area of approximately 3000 ha surrounding each village. In Ipeti, this corresponded to the entire Tierras colectivas whereas in Nurna it encompassed the regions most frequently used for wild harvesting of forest products, as well as some unharvested areas. The abundance of the species and habitat characteristics were recorded in three 12-m radius circular plots (452 m^2) located at 250-m intervals along each transect. For trees and palms, abundance was recorded separately for each of five size classes. Size classes (SC) for the trees were defined as follows: SC1 $<$ 0.5 m height, SC2 $>$ 0.5 m height and $<$ 10 cm dbh, SC3 10–20 cm dbh, SC4 20–40 cm dbh, and SC5 $>$ 40 cm dbh. For the palms, size classes were SC1 $<$ 0.5 m height, SC2 $>$ 0.5 m height, trunkless, SC3 trunk $<$ 3 m height, SC 4 3–7 m height, SC5 $>$ 7 m height. SC1 was recorded in a 3-m radius sub-plot. In the case of *Socratea exorrhiza,* which has trunk development from the seedling stage, SC2 was defined as palms 0.5 to 1 m tall, and SC3 as 1 to 3 m tall. In this paper data on only the established size classes (2–4) are employed. In Nurna, data from three additional transects (12 sampling sites), positioned in regions of non-harvested *Sabal mauritiiformis* populations, were included in the analyses of population structure.

The environmental variables recorded in each plot were elevation, land-use, forest structure, drainage, and soil color and texture. In Nurna, information was also recorded on harvest activities at each site. In Ipeti, field work was initiated in June 1998 and ended in November of that year, whereas in Nurna field work was conducted between September 1998 and April 1999. In both villages the sampling order of the transects was randomized in order to control for seasonal and/or temporal differences. In Ipeti, the village appointed a young man with a high school professional degree in agronomy who was trained during June 1998. Once sufficient competence was gained in the field techniques, he teamed up with another man and they started the work independently. In Nurna, the village congress nominated two men who were trained by S. Dalle. The two men alternated working in the field with S. Dalle; this team was accompanied by other men from the village.

Interviews

Interviews were carried out to characterize patterns of resource use and conservation status in the two villages. Cultural differences between Ipeti and Nurna forced us to conduct the ethnobotanical component in a different way in each community. In general, due to a number of factors, including language and literacy, as well as experience with previous research and foreigners, access to people, especially women, was greater in Ipeti than in Nurna. In Ipeti, ethnobotanical information was first collected by means of a formal questionnaire focusing on five key areas: knowledge transmission, plant phenology, location where found, harvest practices, and use. The questionnaires were implemented by two older women ($>$ 50 years) and two younger women ($<$ 30 years) chosen by the community. In each household, men were interviewed by one team while the second team interviewed the women to minimize gender competition in answers. On any single day, a questionnaire focusing on four to six plant species was applied to 16 different community members. A total of 236 interviews were carried out between June and October 1998. More than 90% of the 50 households in the village participated. Participants ranged from 18 to 74 years in age and had lived in Ipeti for varying lengths of time.

In January 1999, further interviews with focus groups were carried out in Ipeti in order to establish consensus on six key questions: (1) How much plant material is used for each species? (2) How often is the plant harvested? (3) Which part of the plant is most commonly used? (4) How is it collected? (5) What is the gender difference in work regarding these plants? (6) Which species should be targeted for conservation action? For questions one and two, the informants played a pile-sorting game (Bernard 1995) in which a series of cards representing the 22 species were ordered according to the quantity and frequency they were perceived to be harvested. For question six, informants were asked to put together the species that were abundant, species for which they foresaw a problem of supply, and the species that were absent from the Tierras colectivas. The result recorded was the consensus reached among all participants of one sex as they arranged the cards.

In Nurna, structured interviews were used to obtain information on the most important questions identified from the Ipeti interviews. (1) How frequently is the species used? (2) In what quantities is it collected? (3) Has the abundance of this species changed over your lifetime? Informants were asked to identify each species orally in the following categories: frequently/not frequently used, large quantity/small quantity, declining/not declining. Interviews were carried out in Kuna by three researchers from Fundación Dobbo-Yala during a one-week period in October 1999. Because people (particularly women) in Nurna were more wary of participating in household surveys, the team worked with informants with whom they had closer relationships and who represented a range of ages. One interview was carried out by S. Dalle with one of the two men who worked in the ecological inventory. Fifteen male informants (30% of the male population) were interviewed, half of whom were over 40 years of age.

Participant observation was used to obtain additional information on the plant part used and methods of harvest in Nurna. Opportunities for observation included witnessing harvesting and agricultural activities during field work for the ecological inventory, occasional outings with both men and women to collect firewood or work in agricultural fields, and living with two different families. For both Ipeti and Nurna we used participant observation and informal interviews to determine whether harvest for each species was non-destructive or not, and whether species were managed through cultivation or sparing. Harvest was considered non-destructive when the individual (e.g., ramets for clonal species) survived the harvest episode.

Statistical Analysis

Multivariate statistics were used to explore the relationships of use and ecological variables with their perceived conservation status. To prepare the data for analysis, a matrix of species versus use and ecological traits was developed. For Ipeti, variables concerning conservation status and use characteristics were derived from the consensus reached in the card-ordering games. For most analyses, men's and women's perceptions were pooled. In the case of disagreement between the sexes, the perception of the gender with most experience with the species was used; when one gender claimed ignorance, the perception of the other gender was employed. For Nurna, consensus was defined as a significantly ($P < 0.10$) non-random distribution in interview responses, as assessed by chi-square tests. Abundance was estimated from the ecological inventory as the total number of individuals recorded, and was transformed using the equation ln(abundance + 1), in order to achieve a normal distribution and minimize outliers. Ecological guild, for the purposes of our study, was defined as pioneer, mid-successional/disturbance tolerant or late successional. These classifications were derived from canonical ordinations of species versus habitat from the ecological inventory (Dalle et al. 2002), as well as information in the literature and communication with other ecologists working in the region. A list of the codes used in the data matrix is included in Appendix 1.

Stepwise discriminant analysis was used to examine which variables from the use/ecology matrix best predicted the perception of conservation status in both Ipeti and Nurna. The procedure was conducted using the program CANOCO for Windows v.4 (ter Braak and Smilauer 1998), which provides Monte Carlo permutation tests for tests of significance. The ethnobotanical characteristics considered were plant part used, frequency of harvest, quantity harvested, mode of harvest (destructive or not), and degree of management (cultivated and/or spared or not). The ecological characteristics included were life-form (woody or not), guild, and ln(abundance). Relationships between the frequency of harvest and conservation status with other variables in the use/ecology matrix were examined by means of Pearson correlation coefficients (Systat v.9 for Windows, SPSS Science, Chicago).

To examine whether the frequency of harvest of species was related to characteristics of the habitats where they occur, the Fourth Corner method (Legendre et al. 1997) was also used. This method allows correlations between habitat and species characteristics to be calculated, based on the presence/absence of species at a range of sampling stations. Here, the habitat characteristics of interest were successional stage and the distance from the village of plots in the ecological inventory (used as an estimate of resource availability), whereas the species characteristic examined was the frequency of harvest. The significance of the Pearson corre-

TABLE 2. SIMILARITY OF USE CHARACTERISTICS FOR THE TEN PLANTS COMMON TO IPETI AND NURNA. DIFFERENCES BETWEEN VILLAGES ARE CODED AS ''0'' AND AGREEMENTS AS ''1''.

	Plant part	Abundance	Conservation status	Principal use	Harvest frequency	Total
Carludovica palmata	1	1	1	1	1	5
Genipa americana	1	1	1	1	1	5
Ochroma lagopus	1	1	1	1	1	5
Oenocarpus mapora	1	1	1	1	0	4
Sabal mauritiiformis	1	1	1	1	0	4
Socratea exorrhiza	1	0	1	1	0	3
Aechmea magdalenae	1	0	0	0	1	2
Dalbergia retusa	1	1	0	0	0	2
Heteropsis oblongifolia	1	0	1	0	0	2
Astrocaryum standleyanum	0	1	0	0	0	1
Total	9	7	7	6	4	

lation coefficient between these variables was tested using a Monte Carlo permutation test (method 1, following Legendre et al. 1997) with 9999 permutations.

As discussed by Hall and Bawa (1993), comparison of population structure between harvested and unharvested sites can provide an initial assessment of the impact of harvest on plant populations. Here this analysis was carried out using data on eight species from the ecological inventory in Nurna. To determine harvested and unharvested zones, maps of harvesting activity were examined by means of visualization in the GIS program Arcview, version 3.1 (ESRI, California). Plots were coded as 1 (harvest occurs) or 0 (no harvest known to occur) for each species, and a surface of harvest intensity was interpolated using a second-order Inverse Distance Weighting (IDW) algorithm, based on the 12 nearest neighbors. These were compared with maps of harvest areas drawn with the two field assistants. Harvest zones were then determined for each individual species in relation to its distribution. To do this, the occurrence of each species was overlaid on the corresponding harvest intensity map and a ''harvest'' and ''control'' zone defined. In the case of *Sabal mauritiiformis*, a third zone, ''past harvest,'' was defined for plots near the village where the species occurred but was no longer harvested.

To compare population structures among harvest zones, a series of canonical correspondence analyses (CCA) were conducted on the population structure matrix (sites × species abundance in each size class) to evaluate the relationship with (a) harvest zone and (b) environmental variables. Forward selection was used to select the most important environmental variables for the CCA of population structure versus environment. Finally, a partial CCA served to evaluate the relationship between population structure and harvest zone, controlling for the effect of the environmental variables. In the case of one species (*Sabal mauritiiformis*) for which we found a significant effect in this last analysis, we also calculated the amount of variance attributable to harvest zone, environmental variables, and a combination of these two, following the method proposed by Borcard et al. (1992).

RESULTS

RESOURCE USE

Thirty-five species from 20 families were selected for their cultural importance in the two villages (Table 1). Of these, 10 were common to the two villages. These were most similar in terms of the plant part used, abundance, and conservation status, and least similar in terms of the frequency of harvest and principal use (Table 2). Of the 10 species, the main use differed for *Astrocaryum standleyanum, Heteropsis oblongifolia, Aechmea* spp., and *Dalbergia retusa*. The first two species are used for basket weaving in Ipeti, but in Nurna serve primarily as latching for house construction and for food, respectively. However, historical or minor uses converge in some cases. In Nurna, for example, *H. oblongifolia* is occasionally used for basketry, while one man in Nurna reported that *A. standleyanum* was employed for weaving of hammocks in the past. Similarly, according to oral history, ''Oa'' (*Aechmea magdalenae*) was used by the Kuna for thread (Salvador 1997), corresponding to the Embera use. The species for which the main use converged were primarily used for construction (e.g., *Sabal mauritiiformis*, *Socratea exorrhiza*), basketry (e.g., *Carludovica palmata*, *Oenocarpus mapora*), and rituals (*Ochroma lagopus*, *Genipa americana*).

The frequency of harvest varied substantially among species in both Ipeti and Nurna. For Ipeti, the most frequently harvested species were *Calathea latifolia* and *Carludovica palmate*, both on a weekly basis (Table 3). *Ochroma lagopus*, *Dalbergia retusa*, *Genipa americana*, *Astrocaryum standleyanum*, and ''Tinta roja'' were reported to be harvested on a monthly basis. In Nurna, seven species were considered to be ''frequently'' harvested (at least several times a year), whereas nine species were classified as infrequent (Table 3). The most frequently harvested species were *Carludovica palmata* and *Sabal mauritiiformis.* The chi-square analysis revealed significant agreement ($P < 0.10$) among respondents on the frequency of harvest of 16 of the 23 species. The lack of consensus for the remaining seven species likely reflects differences in preference for, or experience with, particular products (e.g., *Genipa americana* and *Bactris coloradonis* are not harvested by everyone). In subsequent analyses these species were considered to be used with ''moderate'' frequency.

To examine the relationship between harvest frequency and availability, we evaluated the correlation of harvest frequency with species abundance, distance from the village, and species habitat. The frequency of harvest in Ipeti correlated significantly with species abundance as well as with guild (Table 4), suggesting that in Ipeti the most frequently harvested species tend to be abundant, early successional species. These relationships hold up when the seven species absent in the ecological inventory are removed from the analysis (data not shown). In Nurna, however, no significant correlation was detected between frequency of harvest and either of these variables (Table 5). Results from the fourth corner analysis revealed marked differences between the two villages in the relationship of harvest frequency with habitat characteristics. In the case of Ipeti, a significant relationship was found between frequency of harvest and the successional stage ($r = -0.15$, $P = 0.0001$), but no correlation existed with the distance from the village. The negative sign on the r-value indicates that early successional habitats had more frequently harvested species, which is consistent with the correlation analysis above. In Nurna, a significant relationship was found only for distance ($r = -0.083$, $P < 0.0002$), but not for the stage of succession. Thus, closer but not necessarily early successional sites were more likely to have frequently harvested species.

Local Perception of Conservation Status

In Ipeti, women's perception of the resources was statistically correlated with that of men (Table 4). In addition, both sexes' perception of species status was negatively correlated to the frequency of harvest and abundance. Men's perception of status was more strongly associated with ecological guild than the women's, although the latter showed a similar trend (Table 4). These results suggest that both sexes perceived plant status in a similar way. Overall, nine species were identified as being absent from the Tierras Colectivas, and seven as priorities for conservation efforts (Table 6). In Nurna, statistically significant consensus on perceived changes in abundance was reached among the 15 informants on a total of 11 species: six species were considered declining, while no decline was perceived for five species (Table 6).

Stepwise discriminant analysis was performed to identify which ethnobotanical and ecological characteristics of species could best predict their perceived status. For Ipeti, three variables were found to be significant in the forward selection procedure: ln(abundance) ($F = 9.1$, $P = 0.005$), non-destructive harvest ($F = 9.47$, $P = 0.005$), and harvest frequency ($F = 9.1$, $P = 0.005$). The discriminant functions based on these three variables produced a significant classification ($F = 11.8$, $P = 0.001$) and successfully classified all but one of the species into the three groups: ''abundant,'' ''danger,'' and ''absent.'' The relationships among the three explanatory variables and the categories of perception are shown in Fig. 1. Here, the first axis (which represents the first discriminant function) serves to separate the ''abundant'' species from the ''absent'' species. In addition, species perceived to be ''abundant'' tended to be frequently but non-destructively harvested. The group ''danger'' is positioned in the positive portion of the second axis, 4?

TABLE 3. FREQUENCY OF HARVEST FOR SPECIES IN NURNA AND IPETI, AS REPORTED IN INTERVIEWS. NURNA: LEVEL OF CONSENSUS AMONG INFORMANTS ANALYZED WITH CHI-SQUARE TESTS. IPETI: RESULTS FROM PILE-SORTING GAMES WITH FOCUS GROUPS. SPECIES COMMON TO BOTH VILLAGES APPEAR IN BOLDFACE.

	I. Nurna						II. Ipeti	
Species	% Informants reporting frequent harvest	N	Chi-square statistic	*P*-value	Frequency code*	Species	Frequency of harvest**	Last harvest***
Carludovica palmata	100.0	16	—	—	3	*Calathea latifolia*	4	1
Sabal mauritiiformis	100.0	17	—	—	3	***Carludovica palmata***	4	1
Oenocarpus mapora	94.1	17	13.235	<0.001	3	***Genipa americana***	3	1
Heteropsis oblongifolia	93.8	16	12.25	<0.001	3	*"Tinta roja"*	3	1
Arrabidaea chica	87.5	16	9	0.003	3	***Ochroma lagopus***	3	2
Ochroma lagopus	82.4	17	7.118	0.008	3	***Dalbergia retusa***	3	2
Oxandra sp.	75.0	16	4	0.046	3	***Astrocaryum standleyanum***	3	3
Genipa americana	64.7	17	1.471	0.225	2	***Oenocarpus mapora***	2	3
Socratea exhorriza	62.5	16	1	0.317	2	*Xylopia fructescens*	2	3
Cordia alliodora	60.0	15	0.6	0.439	2	*Oenocarpus bataua*	2	4
Bactris coloradonis	54.5	11	0.091	0.763	2	*"Motete"*	1	3
Myroxylon balsamum	41.2	17	0.529	0.467	2	*Cedrela odorata*	1	3
"Puarsip"	40.0	15	0.6	0.439	2	*Bombacopsis sp.*	1	3
Dalbergia retusa	37.5	16	1	0.317	2	***Sabal mauritiiformis***	1	3
Peltogyne purpurea	26.7	15	3.267	0.071	1	***Socratea exorrhiza***	1	3
Swietenia macrophylla	26.7	15	3.267	0.071	1	***Heteropsis oblongifolia***	0	3
Aechmea magdaleneae	25.0	16	4	0.046	1	*"Chiru"*	0	5
Astrocaryum standleyanum	18.8	16	6.25	0.012	1	*Manettia sp.*	0	5
Apeiba tibourbou	17.6	17	7.118	0.008	1	*Manilkara sp.*	0	6
Gustavia superba	17.6	17	7.118	0.008	1	*Aechmea sp.*	0	6
"Bunur"	16.7	12	5.333	0.021	1	***Aechmea magdalenae***	0	6
"Sianele"	13.3	15	8.067	0.005	1	*Bactris sp.*	0	6
Symphonia globulifera	6.7	15	11.267	0.001	1			

* Codes for Nurna: 1 (infrequent), 2 (moderate), 3 (frequent).
** Frequency of harvest Ipeti: 0 rare or never, 1 (>2 years apart), 2 (yearly), 3 (monthly), 4 (weekly).
*** Last harvest codes Ipeti: 1 (days or weeks ago), 2 (2–6 months ago), 3 (1–2 years ago), 4 (>2 y ago), 5 (sp. not present), 6 (don't know).

TABLE 4. PEARSON CORRELATION COEFFICIENT FOR PERCEIVED STATUS AND FREQUENCY OF HARVEST WITH VARIOUS ECOLOGICAL AND USE INDICES, IPETI. N = 15–22 SPECIES.[1] STATISTICAL SIGNIFICANCE: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

	Status (women)	Status (men)	Harvest frequency	Quantity	Trunk	Guild	Ln Abun-dance
Status (women)	1						
Status (men)	0.821***	1					
Frequency	−0.672**	−0.716**	1				
Quantity	.055	−.013	.179	1			
Trunk	0.101	0.268	−0.320	−.244	1		
Guild	0.400	0.649**	−0.444*	−.352	0.324	1	
Ln.Abundance	−0.509*	−0.803***	0.493**	0.209	0.096	−0.510*	1

[1] Pairwise deletion was used to accommodate missing values for men's perceived status (3 species) and quantity harvested (4 species).

indicating its association with destructively harvested species. Both the groups ''danger'' and ''abundant'' are associated with higher abundance in the ecological inventory than the ''absent'' category; abundance, however, does not serve to distinguish between ''danger'' and ''abundant'' groups.

For Nurna, the forward selection procedure resulted in three variables being significant with 199 permutations: frequency of harvest (F = 4.71, P = 0.01), non-destructive harvest (F = 4.14, P = 0.01), and guild (F = 2.34, P = 0.13). The resulting classification correctly classified 18 of the 23 species (78%) and was statistically significant (F = 4.2, P = 0.003, 999 permutations). The first two variables (frequency and non-destructive harvest) served to separate the groups ''decline'' and ''no decline'' along the first axis, such that species perceived to be declining tended to be frequently as well as destructively harvested (Fig. 1). The third group (''no consensus'') held an intermediate position with respect to this first axis, and was negatively associated with successionary stage (''guild'') along the second axis. Consensus tended to be lacking, therefore, for species that were either early successional and destructively harvested (e.g., *Cordia alliodora*, *Apeiba tibourbou*) or later successional species with non-destructive harvest and/or moderate harvest frequency (e.g., *Oenocarpus mapora*, ''Bunur''). It is interesting to note that frequency of harvest appears to correlate with different processes in the two communities. In Nurna, the most frequently harvested species were perceived to be in decline, whereas frequent harvest was associated with the ''abundant'' group in Ipeti. In both villages, however, destructive harvest appears to be associated with species perceived as in ''danger'' or ''declining,''

POPULATION STRUCTURE ANALYSIS

In Nurna, visualization of harvest zones (Fig. 2) as well as sketch maps revealed significantly different patterns of harvesting among forest products. Timber products harvested for construction and firewood were reported to be harvested close to the village, whereas harvesters

TABLE 5. PEARSON CORRELATION COEFFICIENT FOR PERCEIVED STATUS AND FREQUENCY OF HARVEST WITH VARIOUS ECOLOGICAL AND USE INDICES, NURNA. N = 23 SPECIES. STATISTICAL SIGNIFICANCE: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

	Status	Harvest frequency	Quantity	Trunk	Guild	Ln abundance
Status	1					
Frequency	0.462*	1				
Quantity	0.234	0.539**	1			
Trunk	0.313	−0.1	−0.469*	1		
Guild	0.143	−0.238	−0.081	0.04	1	
Ln.Abundance	0.055	0.107	0.191	−0.091	−0.526*	1

TABLE 6. LOCAL PERCEPTION OF CONSERVATION STATUS AND ABUNDANCE FROM THE ECOLOGICAL INVENTORIES. NURNA: LEVEL OF CONSENSUS AMONG INFORMANTS ANALYZED WITH CHI-SQUARE TESTS. IPETI: CLASSIFICATIONS FROM FOCUS GROUPS. THE NAMES OF SPECIES COMMON TO THE TWO COMMUNITIES ARE IN BOLDFACE, TO FACILITATE COMPARISON. ABUNDANCE IS THE TOTAL NUMBER OF INDIVIDUALS RECORDED IN 50 TRANSECTS.

	I. Nurna							II. Ipeti			
Species	% informants perceiving decline	N	Chi-square ratio	*P*-value	Status code*	Abundance	Species	Status** (women)	Status (men)	Status (pooled)	Abundance
Heteropsis oblongifolia	100	15		<0.001	3	71	*Oenocarpus bataua*	3	3	3	0
Sabal mauritiiformis	100	15		<0.001	3	373	"Chiru"	3	3	3	1
Swietenia macrophylla	100	15		<0.001	3	33	***Heteropsis obongifolia***	3	3	3	0
Socratea exorrhiza	86.7	15	8.067	0.005	3	205	*Manettia reclinata*	3	3	3	0
"Puarsip"	78.6	14	4.571	0.033	3	0	"Tinta roja"	3	3	3	0
Oxandra sp.	71.4	14	2.571	0.109	3	328	***Dalbergia retusa***	3	3	3	0
Oenocarpus mapora	66.7	15	1.667	0.197	2	102	*Aechmea magdalenae*	3	?	3	55
Myroxylon balsamum	60	15	0.6	0.439	2	204	*Aechmea* sp.	3	?	3	0
Carludovica palmata	53.3	15	0.067	0.796	2	337	*Manilkara* sp.	2	3	3	0
Dalbergia retusa	53.3	15	0.067	0.796	2	1	*Cedrela odorata*	3	2	2	70
Arrabidaea chica	46.7	15	0.067	0.796	2	2	***Astrocaryum standleyanum***	2	2	2	466
"Sianele"	53.8	13	0.077	0.782	2	0	***Sabal mauritiiformis***	2	2	2	361
Apeiba tibourbou	40	15	0.6	0.439	2	172	***Socratea exorrhiza***	2	2	2	644
Astrocaryum standleyanum	40	15	0.6	0.439	2	455	*Bombacopsis quinata*	?	2	2	32
Bactris coloradonis	54.5	11	0.091	0.763	2	338	*Xylopia frutescens*	1	2	2	56
Ochroma lagopus	42.9	14	0.286	0.593	2	199	"Motete"	1	2	2	13
"Bunur"	41.7	12	0.333	0.564	2	33	***Oenocarpus mapora***	1	1	1	92
Cordia alliodora	38.5	13	0.692	0.405	2	61	***Genipa americana***	1	1	1	9
Aechmea magdalenae	26.7	15	3.267	0.071	1	2380	***Ochroma lagopus***	1	1	1	504
Gustavia superba	26.7	15	3.267	0.071	1	865	*Bactirs* sp.	1	1	1	2071
Genipa americana	20	15	5.4	0.02	1	2	*Calathea latifolia*	1	1	1	272
Peltogyne purpurea	21.4	14	4.571	0.033	1	1	***Carludovica palmata***	1	1	1	553
Symphonia globulifera	13.3	15	8.067	0.005	1	12					

* Conservation status for Nurna: 1 not declining, 2 no consensus, 3 declining.
** Conservation status for Ipeti: 1 abundant, 2 locally endangered, 3 absent.

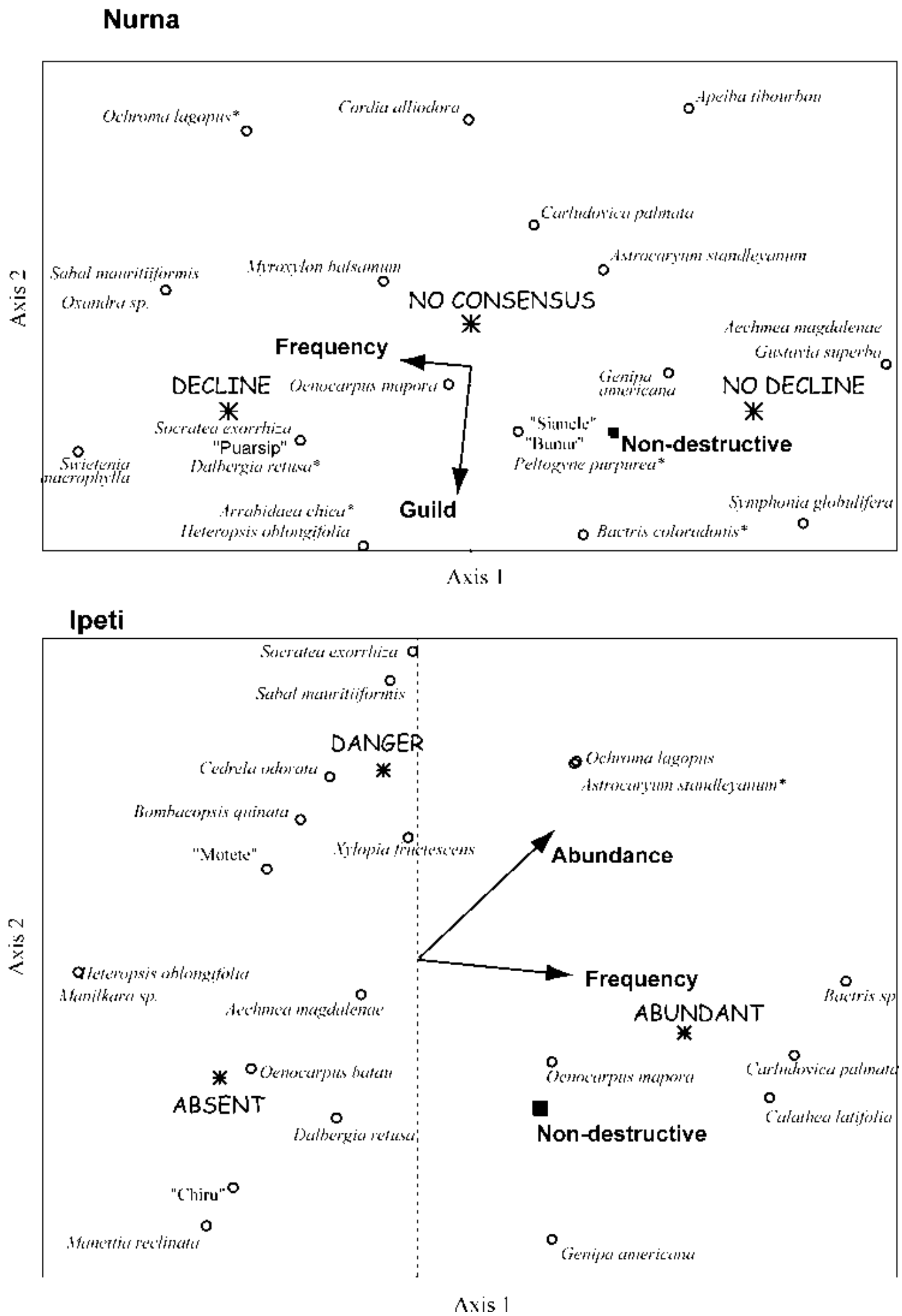

Fig. 1. Correlation biplots representing discriminant analysis classifications of conservation status based on use and ecological variables. Species (circles) were assigned by the analysis to the closest group (stars). The names of mis-classified species are followed by an asterisk. Quantitative predictors (e.g. frequency of harvest) are represented by vectors (arrows) while nominal precitors (e.g. non-destructive harvest) are represented by squares. The projection of species, groups, and nominal predictors at right angle onto the discriminant axes or the predictor vector approximates the value of that object on the axes/vector. The angle between the predictor vectors and the discriminant axes reflects their correlation (the smaller the angle, the greater the correlation).

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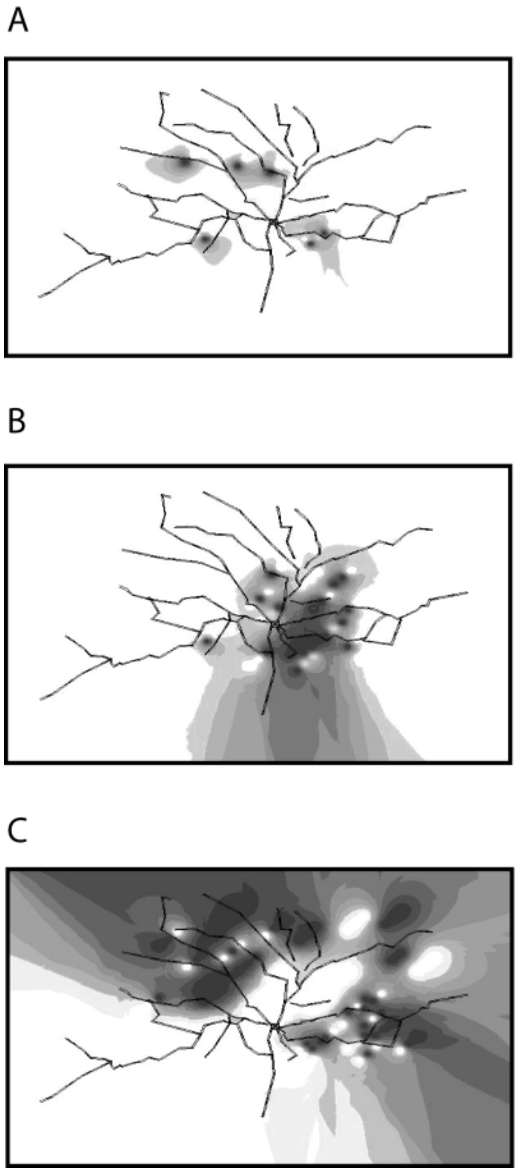

Fig. 2. Harvest intensity maps for Nurna illustrating a range in harvest patterns: a) localized harvest—*Socratea exorrhiza,* b) regional harvest—construction materials, and c) widespread harvest—*Heteropsis oblongifolia.* The village is represented by a square, at the centre of the maps. Darker tones represent a higher density of plots in the ecological inventory for which harvesting for the product was reported to occur.

actually range quite far to harvest species such as *Sabal mauritiiformis* and *Heteropsis oblongifolia,* required in large quantities for house construction. *Heteropsis oblongifolia* is often opportunistically harvested during hunting excursions or other outings, which might also explain the distribution of harvest activities for this species. Finally, a number of other products are harvested in more localized regions, including *Socratea exorrhiza, Oenocarpus mapora,* and *Gustavia superba.* In general, harvest ranges depend on a variety of factors, including the distribution and quality of the resource, the quantities required, the difficulty of transport or handling, and the harvesting strategy (e.g., opportunistic or deliberate, individual or collective). This variation in the spatial patterns of harvest meant that we could not identify a single ‘‘harvest’’ zone in Nurna. Instead harvest zones were determined according to product type. In Ipeti, on the other hand, it was not possible to define harvest zones at all due to the differing system of land tenure, in which people do not have much communal forest available to them. Instead, people in Ipeti usually harvest forest products specifically on their own ‘‘parcelas.’’ Any unharvested lands, therefore, would in theory exist within individual ‘‘parcelas’’ as opposed to outlying communal lands as in Nurna.

Population structure analysis, therefore, was conducted only for Nurna, and only on the eight species that were sufficiently abundant and for which information on harvest activities was available. The objective here was to evaluate whether population structure varied among harvest zones. CCAs of population structure versus harvest zone revealed significant relationships for *Sabal mauritiiformis, Myroxylon balsamum, Apeiba tibourbou,* and *Gustavia superba* (Table 7). However, once the relationships between species and environment were accounted for, only *Sabal mauritiiformis* retained a significant effect of harvest intensity. These results are consistent with the hypothesis that declining species would exhibit significantly different population structures among harvesting zones for six of the eight species: *Sabal mauritiiformis* and the five species considered ‘‘not declining’’ or for which no consensus was reached. The hypothesis is not supported in the case of the other two species perceived to be declining (*Socratea exorrhiza* and *Oxandra* spp.).

In the case of *Sabal mauritiiformis,* variance partitioning revealed that 10.7% of the variation in the population structure data was explained by harvest zones alone, 18.4% by environment only, and 10.7% by covariation of environmen-

TABLE 7. RESULTS FROM CANONICAL CORRESPONDENCE ANALYSES OF POPULATION STRUCTURE VS. HARVEST ZONES AND ENVIRONMENTAL VARIABLES, NURNA. SIGNIFICANCE TESTS ARE MONTE CARLO PERMUTATION TESTS, PERFORMED WITH 999 PERMUTATIONS. *P*-VALUES < 0.05 ARE SHOWN IN BOLDFACE.

		Population structure vs. harvest				Population structure vs. environmental variables			Population structure vs. harvest controlling for environment			
Species	No. of sites	% variation explained	F-ratio	P-value	No. enviro. variables selected	% variation explained	F-ratio	P-value	% variation explained	F-ratio	*P*-value	Local perception of conservation status
Sabal	75	21.3	9.749	**0.001**	10	29.1	2.63	**0.002**	15	5.516	**0.001**	decline
Socratea	27	3	0.77	0.528	3	30.7	3.393	**0.001**	3.8	0.854	0.495	decline
Oxandra	89	2.1	1.924	0.144	1	2.2	1.979	0.136	0.8	0.724	0.498	decline
Oenocarpus	37	6.3	2.342	0.086	5	31.1	2.797	**0.003**	6.6	2.172	0.11	no consensus
Myroxylon	54	5.1	2.788	**0.038**	5	16.1	1.848	**0.052**	1.9	0.913	0.417	no consensus
Apeiba	42	7.4	3.208	**0.019**	5	30.7	3.186	**0.002**	1.6	0.57	0.645	no consensus
Astrocaryum	127	0.6	0.7	0.571	2	4.7	3.041	0.064	0.2	0.189	0.925	no decline
Gustavia	84	7.4	6.425	**0.008**	6	23.3	3.918	**0.001**	1.2	0.899	0.409	no decline

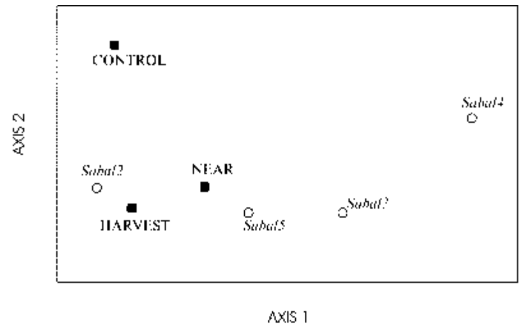

Fig. 3. Biplot from the CCA of *Sabal mauritiiformis* population structure vs. harvest zones, controlling for environmental variation. Size classes are represented by circles, harvest zones by squares. The projection of either size class or harvest zones at right angle onto the axes approximates the value of that object on the axis.

tal variables and harvest zones together, for a total of 39.8% of variation in population structure explained. In the biplot of *Sabal mauritiiformis* population structure versus harvest intensity, controlling for environment (Fig. 3) the first axis is dominated by a gradient of distance from the village, with SC2 being abundant in the harvest and control zones, having apparently been reduced near the village. In addition, the size class 4 is more closely associated with the control zone. For this species, the size classes that are most frequently harvested are SC2 and SC3 (non-destructively) and to a lesser degree SC4 (destructively).

DISCUSSION

COMPARISON OF CONSERVATION STATUS AND PATTERNS OF PLANT

In the present study, six of the 23 species in Nurna were perceived to have declined in abundance within living memory, whereas in Ipeti seven of the 22 study species were considered as conservation priorities. Thus villagers perceived a third of the species examined as potentially threatened. These species are predominantly used for construction in the local economy (e.g., houses, canoes), whereas three species provide products sold on regional or national markets (such as *Swietenia macrophylla* in Nurna and *Astrocaryum standleyanum* and *Dalbergia retusa* in Ipeti). In general, the pressure resulting from commercialization of forest products is well recognized, but less attention has focused on subsistence products (Pinedo-Vasquez et al. 1992), despite the fact that subsistence products represent the majority of species harvested from the forest (Pinedo-Vasquez et al. 1990; Prance et al. 1987). Species used for construction were also reported declining for a savannah in Senegal (Lykke 2000) and in one montane village in Chiapas, Mexico, studied by Hellier et al. (1999). In the latter study, firewood and fenceposts predominated among declining use categories for a second montane village.

In both villages, a combination of ecological (abundance, guild) and use (frequency, mode of harvest) variables was necessary to predict perceived conservation status. The interaction of use and ecology is seen especially in Nurna, where the ability of the early successional species to tolerate disturbance seemed to buffer the impact of use. However, our results do not suggest any dichotomy between timber and non-timber products in terms of conservation status in either village. This is indicated by the lack of any relationship with the plant part harvested. Instead, the destructiveness of harvest emerges as the most consistent predictor of conservation status between the two villages. Although it is often assumed that harvest of NTFPs is non-destructive, as discussed by Peters (1996), NTFPs are indeed sometimes destructively harvested, as is the case here for *Sabal* in Nurna and *Astrocaryum* in Ipeti. Demographic studies have found that survival of adult life stages is often crucial to maintaining palm and other long-lived plant populations (Joyal 1996; Pinard 1993).

The intensity of use of a species, as noted by Peters (1996), is important for understanding human impacts on resources. From an ecological standpoint, the more frequently a resource is harvested, the greater the impact should be. We found that the frequency of harvest was related to species perceived as declining in Nurna, but with those species in Ipeti that were considered ‘‘abundant.’’ We thus examined the hypothesis that harvest frequency is related to resource availability. It has been suggested that for medicinal purposes, people tend to rely more on species from early successional/disurbed than late successional habitats (Frei et al. 2000; Kohn 1992; Stepp and Moerman 2001; Voeks 1996). Species in early successional habitats are thought to be more available due to the high densities at which they occur (Stepp and Moerman 2001) or because such habitats are often found closer to human settlements (Frei et al. 2000). In both Ipeti and Nurna we found that accessibility is indeed related to the intensity of use, yet in different ways. In Ipeti, frequently used species were abundant early successional species, but these did not occur closer to the village. On the other hand, in Nurna the opposite was found, with frequency of use being related to distance only.

These results appear to stem from the contrasting ecological and cultural contexts of the two villages. Perhaps the most evident are the contrasting ecological contexts: Ipeti has a lower percentage of forest cover (44.6% of plots in the ecological inventory vs. 76% in Nurna), higher population density, and is situated in a highly fragmented landscape as compared to Nurna. This suggests that reduced or degraded forest cover may have led inhabitants in Ipeti to rely more heavily on early successional species than in Nurna. In contrast, in Nurna where mature forest is still abundant, villagers appear to rely on species whose distributions make them more accessible rather than on early successional habitats. The lack of major land-use change as yet in Nurna (Lopez and Dalle 2001) would appear to lead to a situation where harvest pressure is still the major conservation concern, as opposed to land-use change apparently being the major pressure on plant populations in Ipeti. It cannot be discarded, however, that cultural and historical differences in plant use may be another possible explanation. In Ipeti, where a much higher level of cultural and economic change as compared to Nurna has been experienced, several of the plants studied have fallen into disuse and many younger people no longer know how to use them (e.g., *Aechmea* spp., ‘‘Chiru,’’ *Manettia* spp.). These species are all found in late successional habitat and could at least in part explain the trend for frequent use of early successional species in Ipeti.

In examining the 10 species common to both case studies, we found that cultural differences appear to exist in the use of plant resources between the two villages, particularly in terms of the frequency of harvest. Some of these differences can be attributed to different uses (e.g., *Astrocaryum standleyanum*, *Heteropsis oblongifolia*, *Dalbergia retusa*). On the other hand, the more frequent use of *Sabal mauritiiformis*, *Socratea exorrhiza*, and *Oenocarpus mapora* (used in house construction) in Nurna may be due to the more widespread use of non-traditional building materials in Ipeti as compared to Nurna. However, another reason may be that in Nurna house construction and maintenance is carried out collectively, whereas in Ipeti it is organized by household. In Nurna, then, a man will harvest materials such as *Sabal mauritiiformis, Heteropsis oblongifolia, Socratea exorrhiza*, and *Oenocarpus mapora* every time a house is built or repaired in the village (two to three times a year during our research), whereas in Ipeti harvest events will be linked to each family's needs (every 8–10 years). This difference was not accounted for in our interviews. Further studies on the comparative ethnobotany and historical ecology of the Embera and Kuna are necessary to elucidate the dynamics of resource use in these communities.

Local Perception as a Tool for Conservation

At the onset of this study we chose to focus on useful plants, since we assumed that local people would be most likely to have interest in conserving species of importance to them. This was certainly the case in Ipeti, where the community quite readily expressed interest in initiating efforts to restore and/or enrich populations of useful species. In Nurna, the participatory nature of the research stimulated discussion in the village regarding the state of their resources, and by the end the community decided to continue mapping parts of their territory, and to experiment with planting of *Sabal.* To what extent can such initiatives contribute to conservation?

In the conservation literature, considerable attention has been focused on rare species and/or small populations, since these are thought to be more susceptible to extinction (Groombridge 1992). In our study, nine species were reported to be absent from the territory. These species could be the focus of restoration efforts with the local community. However, apart from these ''absent species,'' it is important to note that conservation status did not correlate with abundance. Thus the species prioritized for cultural purposes were not necessarily rare and may not be threatened on a regional level. From a local perspective, however, some important resources are required in high abundance (e.g., thatch) and may be prioritized for this reason. From a scientific viewpoint, conservation efforts aimed at such species can nonetheless have an ecological basis. For example, abundant species often provide important ecosystem services, such as nutrient cycling (O'Hara 1998), and play crucial roles in many plant-animal interactions (Redford 1996). Furthermore, conservation measures aimed at locally important resources can also lead to the protection of a threatened habitat (Ticktin et al. 2002).

In addition to stimulating local participation, the involvement of local people in conservation can be a valuable source of knowledge (Gadgil et al. 1993). Here we compared the local perceptions of species declines with population structure analysis, a rapid-assessment method that has been used for evaluating the effect of harvest pressure (Hall and Bawa 1993; Murali et al. 1996). We expected that species declining due to harvest pressure would exhibit significantly different population structures among harvesting zones, whereas non-declining species would not. This was corroborated for one of the three ''declining'' species (*Sabal mauritiiformis*) and all five of the ''non-declining'' species.

In the case of *S. mauritiiformis*, the lower density of the most frequently harvested size classes of *S. mauritiiformis* near the village is consistent with a hypothesis of over-harvesting for this species. However, for *Oxandra* spp. and *Socratea exorrhiza* (perceived as declining but no significant difference in population structure), it is possible that population structure is not a good indicator for their status. In a previous paper, we found that the occurrence of these two species increased with distance from Nurna, independently of environmental variation, and that all size classes tend to co-occur (Dalle et al. 2002). These species may therefore be influenced by land-use or other changes that affect the establishment or maintenance of entire populations rather than influencing specific size classes, as is expected with harvesting.

Our experience indicates that local knowledge may have several advantages for rapid-assessment of plant resources. First, it is possible to collect data on large numbers of species. In the case of population structure, sampling in the field is much more labor intensive, particularly for less abundant species that may require additional sampling (e.g., Murali et al. 1996). In addition, non-harvested sites may not be available, as in the case of Ipeti. A second advantage of local knowledge is that it does not assume *a priori* any specific cause of the decline itself. On the other hand, a hypothesis for the cause of decline is necessary in order to determine what should be the ''control'' for population structure analysis (e.g., harvested vs. unharvested or between different land-uses). Controls are necessary because trends in populations cannot be deduced from the population structure alone (Condit et al. 1998, but see Lykke 1998). Based on these advantages, we suggest that local knowledge may be best used as an initial assessment of a large number of species. Population structure analysis may then be used as an initial test of the hypothesis of harvest pressure for selected species in regions where unharvested (or other control) sites exist. To this end, the method used here to map harvest activities and factor out environmental variation can be employed.

Directions for Future Research

The two case studies presented here illustrate how assessments of multiple species can be conducted to improve our understanding of conservation priorities on indigenous territories. Our results suggest that certain characteristics, such as the destructiveness of harvest, may be common to many declining species, whereas others such as species abundance or the intensity of harvest may depend on the type of resource use or the specific ecological and cultural context. Further studies comparing a range of different ecological, cultural, and socio-economic situations are needed to better evaluate the consistency of these patterns and to elucidate causal relationships. Similar studies could also examine the conservation status of species within specific use classes (e.g., construction materials), permitting a more detailed comparison of plant use patterns in relation to conservation status and ecological characteristics.

A better understanding of harvesting patterns is imperative for ethnobotany to address issues of sustainable plant use. From our study it appears that a number of cultural, ecological, and historical factors may influence which species are more frequently used. These will need to be teased out through more comparative studies. In human ecology, optimal foraging theory has been used to examine hunting practices (e.g., Winterhalder and Lu 1997). In this study, switching between alternative resources was modeled according to the abundance and quality of the resource. Such a framework, in combination with historical approaches (e.g., Balee 1998), may be of value in understanding why certain plants are used more than others, and how plant use responds to changes in the landscape. We have also noted differences in Nurna and Ipeti in the use of the landscape, with early successional habitats versus proximate habitats having more frequently harvested species. This result suggests that a better description of the structure of the landscape, in terms of the abundance and spatial distribution of habitat types, could potentially increase our understanding of how and why plants are used.

Finally, the use of local knowledge as a tool for rapid assessment requires a closer examination of how perceptions regarding trends in biodiversity are actually constructed, and how cognitive, socioeconomic, or cultural factors may affect such perceptions. In Ipeti, women and men seem to have similar perceptions of status, which was the case in Lykke's (2000) study. However, Hellier et al. (1999) suggest that the perceived importance of a given product, memory, and experience with the resource may influence informants' ability to report species declines. Further studies of the use of local knowledge, where possible, should be carried out in areas where long-term ecological data (e.g., abundance over time) are available. This could then be used to assess local knowledge.

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APPENDIX 1. CODING USED FOR THE MATRIX OF ECOLOGICAL AND USE VARIABLES.

Variable	Type	Codes
Perceived status	Ordinal/Qualitative	Ipeti: 1 (abundant), 2 (danger), 3 (absent)
		Nurna: 1 (no decline), 2 (no consensus), 3 (decline)
Plant part used	Qualitative	Leaves, Trunk or Fruits
Quantity harvested	Ordinal	Ipeti: 1 (little), 2 (medium), 3 (large)
		Nurna: 1 (small), 2 (no consensus), 3 (large)
Frequency of harvest	Ordinal	Ipeti: 0 (never, I don't know, or species does not exist here), 1 (more than 2 years apart), 2 (annually), 3 (monthly), 4 (diurnally or weekly)
		Nurna: 1 (infrequent harvest), 2 (no consensus), 3 (consensus on frequency)
Mode of harvest	Binary	0 (destructive), 1 (non-destructive)
Ecological guild	Ordinal	1 (pioneer) 2 (mid-successional/disturbance tolerant), 3 (late successional)
Management	Binary	0 (no management), 1 (cultivated and/or spared)
Life-form	Binary	0 (not woody), 1 (woody)