

# *Cognitive Aspects of Intergenerational Change: Mental Models, Cultural Change, and Environmental Behavior among the Lacandon Maya of Southern Mexico*

Norbert Ross<sup>1</sup>

The life of the Lacandon Maya of Mensäbäk (Chiapas, Mexico) has undergone tremendous changes in the last 30 years. These changes are manifested in a generational split in social relations, household location, and economic behavior. The changes affecting social life as well as decision-making processes are paralleled by changes in environmental cognition among the adult members of the community. Older individuals reveal a systematic awareness of the ecological complexity involving animals and plants of the rainforest. The data suggest that the emerging patterns of change are not due to different stages of development—from novice to expert—nor do they seem to be reversible. Rather, they indicate an intricate system that closely links culture, cognition, and behavior.

**Key words:** culture, cognition, intergenerational change, agricultural decision making, Maya, Mexico

In a very general sense, one of the central goals of anthropology has been to understand how groups of individuals perceive and construct their social and natural environment and how they interact with it. Within the realm of ethnoecology much work has been done to explore how different cultures perceive the order of plants and animals (i.e., living kinds, including humans) surrounding them (see Berlin et al. 1973, 1974; Berlin, Breedlov, and Raven 1992; Atran 1998). Most of these studies report a wide universal agreement in how people order living kinds with respect to a general “multipurpose taxonomy” (Berlin 1992; Atran 1998; López et al. 1997).

While these findings might seem surprising at a time when terms like “indigenous knowledge” are in vogue, they seem to depend at least in part on the perspective taken. For example, comparing Michigan students and lowland Itzaj Maya, López et al. (1997) show both cross-cultural similarities in the respective folk taxonomies and clear differences in how members of each group reasoned about the species

themselves. These differences, as well as related findings (see Medin et al. 1997; Medin et al. n.d.<sup>1</sup>), urge us to go beyond simple models of semantic domains to explore the content of the knowledge, both across and within cultures (see also Hunn 1985). Cross-cultural studies are very instructive for our theories, but they often fail to address issues such as cross-cultural variations in expertise and ignore the conditions causing the differences under exploration (Medin et al. n.d.<sup>2</sup>). Interviewing different kinds of tree experts in the Chicago area, Medin et al. (1997) found clear differences in reasoning patterns and taxonomical sortings according to kinds of expertise and individual goals. These intracultural differences open new insights into basic processes of knowledge formation and transmission in changing contexts, such as globalization.

Unfortunately, these topics receive little attention in ethnoecology, and in environmental anthropology in general they are treated superficially. This is even more surprising given the attention local resource management has received in the last decades. While indigenous knowledge systems receive increasing attention (see Zent 2001), they are almost never explored as complex systems of knowledge. Instead, they are treated as static cultural resources and referred to as a natural resource (Warren 1991).

If we ignore the processes leading to the formation, deformation, and changes within these knowledge systems, we may not understand their very nature and fail to see possible sources of conflict or even mismanagement. For example, Atran et al. (1999) showed that the Itzaj Maya of lowland

---

Norbert Ross is a research assistant professor in the Program in Culture, Language and Cognition, Northwestern University, Evanston, IL 60208. I thank Professors U. Köhler and D. Medin for their comments on drafts of this paper. This research was partially supported by the German “Studienstiftung des Deutschen Volkes,” the German Academic Exchange Service (DAAD), the Mexican Foreign Ministry, as well as NSF grants SBR-9422587 and SBR-9707761 awarded to Scott Atran and Douglas Medin. I thank the people of Mensäbäk.

Guatemala manage their commons sustainably despite the obvious lack of rules and communal institutions (see Ostrom 1990, 1992). It appears that the cultural models individuals hold about species interaction influence their agricultural decisions. The Itzaj Maya perception of ecological centrality predicts, for example, which trees are protected and thus found most frequently in individual land plots. This strategy is furthermore supported by an Itzaj Maya belief in *aruxes*, forest guardians, that seem to appreciate (and protect) exactly those trees that are important for the survival of the rainforest (Atran et al. n.d.). Obviously, this has very important implications for local resource management strategies.

The Itzaj Maya in this study were all older individuals who actually spoke Itzaj Maya, a dying language. Arguably, this sample is more connected with traditional values and beliefs than the “average Itzaj.” However, if these models change from one generation to the next, the original system of resource management may cease to function properly. For example, if younger Itzaj Maya lack an understanding of the complex forest ecology and the corresponding belief in the *aruxes*, who often punish a person for abuse of the forest species, then they might no longer protect those species. In turn, such cognitive changes might require a change of previously well-adapted institutions and rules.

Given the relatively recent but pervasive changes that have affected indigenous people all over the world, it is urgent that we explore the dynamics of indigenous knowledge in detail, with a particular focus on the potential loss of knowledge and consequences for resource management (see Zent 2001). Understanding these knowledge systems as dynamic implies a need to address the differences among individuals (Boster 1987). In this view, culture is seen as a distribution of individual cognitions linked through causal chains (Strauss and Quinn 1997). These causal chains can consist of similar input conditions, exchange of ideas (see Boster 1986), and common goals and activities leading to similar mental representations (Medin et al. 1997; Medin, et al. n.d.<sup>1</sup>). This approach clearly sees culture as a constant process of creating and (less than perfect) sharing of knowledge, ideas, and values that takes place within a certain environment (see Boster 1987 and Garro 1986, 2000 for similar points). Such a view allows classification of different types of cultural knowledge (independent facts versus facts based on a set of rules) as well as different forms of knowledge acquisition (active construction versus passive reception) (Boster 1987:153).

The focus of this paper is on recent changes that occurred from one adult generation to the next among the Lacandon Maya of Chiapas, Mexico. These changes are interesting on several accounts. First, they allow us to better understand the variability and flexibility of cultural knowledge and folk ecological knowledge in particular. Because these changes are relatively recent, comparing the two living adult generations allows us to examine the actual process of change. Second, the observed changes did not occur in a vacuum; they are embedded in a wider system of

interrelated changes in the social and economic spheres of the community.

The final argument of this paper is based on converging data that demonstrate clear differences between the members of the two living adult generations. Members of the two generations are clearly separated by age, and the members of the younger generation are the children of the older generation. While the older generation founded the community in the 1960s, their sons (and sometimes grandsons) grew up in Mensäbäk or were born there. These differences are salient in personal conversations about the community and the Lacandon way of life, where older individuals often complain about the changes their sons introduced. On the other side, younger Lacandones often try to convince their fathers to give up their lifestyle and move into the center village to take advantage of conveniences such as piped water and electricity. Younger Lacandon Maya are socially more active than members of the older generation. This can be seen in both their social networks and in the distribution of households within the community. Younger Lacandones in the village center live close to each other (Ross 2002). As a trade-off for living closer to each other, younger Lacandones establish their households farther away from their *milpas*, their agricultural plots. This causes them to visit the milpa less frequently and to plant fewer crops in their fields. These differences are statistically significant and capture the elders' complaints that the younger folks abandon much of the traditional Lacandon way of life, including the proximity to the forest and the importance of the agricultural work (see Ross 2001, 2002).

The differences reported in this paper not only refer to factual knowledge but also to differences in broader framework theories—rules that help individuals to establish the framework within which facts and generalizations are used to generate and order new knowledge (see Boster 1987). While factual knowledge could be an effect of differential experience, it is difficult to conceptualize fundamentally different frameworks as an effect of gradual differences in expertise. Members of the two generations have very different understandings of the *why* and *how* of their actions. For example, I could observe older Lacandones cut a tree to get to some honey. The very same individuals, however, rejected the idea of cutting a similar tree to sell the wood, which would allow them to buy much more honey. They conceptualize their behavior not in terms of outcome with respect to concepts such as “ecology” and “sustainable management,” but rather in terms of “the right behavior,” within a framework guided by tradition and the creation story evolving around *hächäkyum*, the Lacandon Maya creator god. This religious embeddedness is lost, or at least different, for the second generation Lacandones, with successive differences in the behavior of the individuals. The forest species and their interactions are detached from religious views and young Lacandones perceive restrictions to their actions based mostly in ecological (scientific) reasoning. This reasoning (don't cut trees unless absolutely necessary) often puts them in opposition to the views of their elders.

While factual knowledge might increase gradually with an increase in expertise, fundamental differences in the underlying framework theories are unlikely to occur gradually and less so at an advanced age (>34 years). Therefore, the differences seem to be best explained as the effect of a rupture in the social context of learning caused by changes in the life of the Lacandones.

To be sure, all this is not to argue that second-generation Lacandon Maya do not know the forest. Compared to neighboring Tzeltal Maya migrants they might still be regarded as experts. However, they do not possess the knowledge of their fathers and likely they won't acquire it. All this should have some impact for the applied social sciences as well as policy making. At a time when local and indigenous groups are more and more in the focus of policy strategies, we have to be careful to include the loss of knowledge in our considerations, rather than blindly celebrating indigenous knowledge. Furthermore, understanding the processes leading to the loss of knowledge might help design projects countering these undesired effects.

### The Lacandon Maya of Mensäbäk

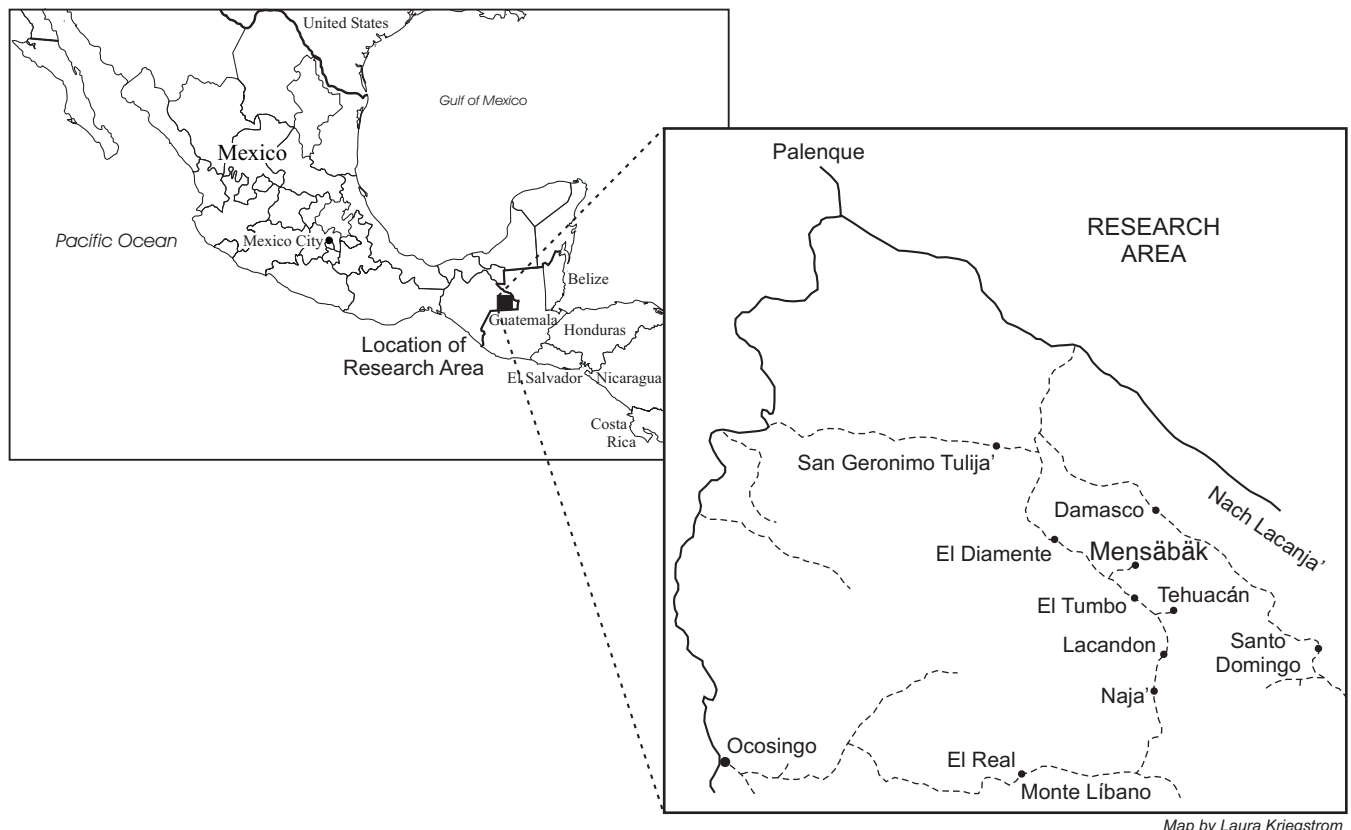
The Lacandones live in an area called the Selva Lacandona, a tropical lower montane rainforest (Breedlove

1973:149) located between the state of Tabasco and the highlands of Chiapas, the southernmost state of Mexico. The area is made up of tropical lowlands as well as pine stands at elevations up to 1,000 meters (Singer 1991:79). The major cities are Ocosingo and Palenque, both located in the state of Chiapas (Figure 1).

Today's Lacandones are descendents of refugees who fled the Spanish and the Itzaj Maya of neighboring Petén, Guatemala (see de Vos 1980:213; Nations 1979:84). The earliest description dates back to 1786 (Nations 1979:90; Barlow 1943). Dwelling near their cultivated fields, these Lacandones cultivated corn, beans, tobacco, manioc, and sweet potatoes; they also hunted, fished, and gathered wild plants. The initial description of their material culture, houses, clothing, and hairstyles closely fits the ethnographic description of modern Lacandones (Boremanse 1998:5).

Traditionally, Lacandones settled in dispersed households, often miles apart. This lifestyle was increasingly interrupted by governmental encroachment during the postcolonial era. Shortly after Mexico's independence in 1821, the new government declared all uninhabited land national property. Part of this plan, as stated by Benito Juarez, was to open up land for the benefit of private enterprise (see Ross 1997:181). Land used by Indians was declared national property and sold, depriving them of agricultural land and

Figure 1. Location of Research Area in Chiapas, Mexico



Map by Laura Kriegstrom

areas previously occupied for hunting and gathering. Land sales often preceded logging and chicle operations, which brought new settlers to the area and led to deforestation (Arizpe, Paz, and Velázquez 1992).

In 1972, with deforestation at its height, the government handed over 614,324 hectares to 66 Lacandon households (Nations 1979:110; de Vos 1980:22; Singer 1991:83). In 1974, the land was declared a protected area with usufruct rights (under governmental control) given to the Lacandones (Arizpe, Paz, and Velázquez 1992:78). Thus, the *comunidad lacandona* was created, including several immigrant villages. The area was extended in 1975 to include the two northern Lacandon communities (Nations 1979:113).

In exchange for land titles, the Lacandon families were required to relocate to stable villages, and in 1972, the villages of Lacañja', Naja', and Mensäbäk were founded. Only families living in these villages were entitled to money from timber licenses (Boremanse 1998:17) or aid from governmental and nongovernmental organizations (NGOs) (see Nations 1979:111).<sup>2</sup>

Mensäbäk is the smallest of the three villages; at the time of my research it consisted of 16 households with 34 adults. Development has had a huge impact on the economic situation and social organization of the people of Mensäbäk. Road connections not only provided new goods and information but also new income opportunities, such as handcraft production for tourists. Government and NGOs provide further financial and material support, making Lacandon families increasingly independent of agriculture (see Ross 2001). During my three years in the community, several families did not bother to plant enough corn to bring them through the year. Additional cash income and the security of emergency support from NGOs (in the form of cornmeal) allowed those families to spend their time in nonagricultural endeavors. This attitude was not found among first-generation Lacandones.

All this tells us that the changes were not equally assimilated by members of the two adult generations and that the difference can be seen in a variety of realms. It is in part this pervasiveness of change that leads me to interpret these changes as irreversible. The milpa has lost importance for second-generation Lacandones; for example, they recall and plant fewer crops and they have moved their houses away from the milpa to be close to one another (Ross 2001, 2002). As housing plots are freely available, household location can be seen as the physical manifestation of a new lifestyle, in which village life plays a greater role and the milpa is pushed in the background.

Given these differences, I expected a clear difference in ethnoecological knowledge between members of the two generations as a consequence of difference in exposure and interest. This would represent an extension of the finding that milpa and forest species are more salient to members of the first generation than to members of the second (Ross 2001, 2002). It extends into the actual models individuals hold about the environment—the tropical rainforest—and relates to

research conducted by Atran et al. (1999). This research shows that different cultures in the neighboring Petén (Guatemala) hold different beliefs and models about the interrelation of forest species. If the two generations differ in their models, one has to look at the quality of the differences for an interpretation of the data.

## Research Setting and Methodology

The research was conducted over a four-year period from 1994 to 1998. All interviews were conducted in Lacandon Maya by the author. The work included forest walks, work in the milpa, informal interviews, and formal elicitation of social networks. Therefore, the research combined methods from both anthropology and cognitive psychology. This approach allows statistical comparison of individual cognitions within an approach that is sensitive to contextual aspects (meaningful design) and comparable across different sets of data. Rather than intuitively assuming shared models and differences therein, this approach explores individual responses with respect to patterns of agreement and aggregates them statistically into a common model. Although data collection takes place within a formal setting, the tasks provided ample space for the telling of stories or more informal information related to the question at hand.

The cultural consensus model (CCM) (Romney, Weller, and Batchelder 1986) was used to assess the agreement pattern. CCM is a factor-analytic method for computing levels of agreement and disagreement in the structure and distribution of information within and across populations. The model assumes that widely shared information is reflected in high concordance, or cultural consensus, among individuals. Principal-component analysis was used to determine if a single underlying model holds for all informants. A strong group consensus exists if: 1) the ratio of the latent root of the first to the second factor is high; 2) the first eigenvalue accounts for a large portion of the variance; and 3) all individual first factor scores are positive and relatively high. If this is the case, then the structure of the agreement can be explained by a single-factor solution—the consensual model. In this case, first factor scores represent the agreement of an individual with this consensual model.

Within-group differences can be explored by: 1) comparing first and second factor scores of each individual; or 2) analyzing patterns of residual agreement. Residual agreement is calculated by subtracting predicted agreement (equal to the product of 1st factor scores) from the observed agreement (Boster 1986; López et al. 1997). To the extent that within-group residual agreement is larger than across-group residual agreement, one has evidence of reliable group differences.

The data on ethnoecological models are based on all male adults of the community (with the exception of a deaf person). Several interviews were conducted with the informants over the course of the three years of research. Of course, during this time I also had uncountable encounters with these

men, providing ample opportunity for observation and informal interviews.

### Lacandon Maya Ethnoecological Models and Informant Agreement

I report here on individual Lacandon models of species interaction. This paper extends a previous study, in which I asked informants to recall all the species that come to their mind (Ross 2001, 2002). It goes beyond previous studies on taxonomy to explore the relations of elements in a given domain rather than their similarities. The domain is the living kinds inhabiting the natural environment of the Lacandones—the Selva Lacandona. Similar tasks have proved effective in exploring cross-cultural differences as well as in describing cognitive models that helped to predict actual behavior (Atran et al. 1999, n.d.; Medin et al. n.d.<sup>1</sup>). The data provide information about the conception of the species themselves, but, more importantly, they give us further insights into the local perceptions of the ecological system in general and the distribution of these perceptions in particular.

The species included in this research were elicited by asking informants to list the most important plants and animals ecologically. On average members of the first generation did mention more species in the listing; however, no content difference could be detected. For research interest, I added the bat and cultivated corn, beans, chile, and coffee to the list used in the interaction task (note that cultivated plants do not appear in Table 1).

Animals on the list were represented on picture cards and plants on written name cards. Plant pictures are rather hard to administer because plant recognition often depends on differences that are not easily captured in a picture. Names were written in Lacandon Maya but served much more as a mnemonic device. As plants were introduced one at a time, this did not create any problems for the informants. For each plant the informants were individually asked to name all the animals that look for this particular plant. The question was repeated several times, pointing at and asking for each animal in particular. Each informant was then asked why the particular animal looks for the plants and if the plant helps or hurts the animal. This last question might seem awkward at first sight; however, it emerged during informal conversations with younger Lacandones who often guided the conversations toward the harmful or helpful effects of certain species (including humans) on the forest and particular plants.

The same questions were also asked with respect to the effects of each animal on each plant. Types of relations as well as justifications were recorded, as were stories and additional information that emerged during the interviews. For example, a typical response was that *chäk ak'*, a vine, helps the parrot, *aj kacho'*, which is the only animal that eats its small fruits. The parrot in turn helps the vine by distributing its seeds. Again, this final evaluation was introduced after informal interviews proved this to be a meaningful way of looking at the species.

### Informant Agreement on Plant-Animal Relations

Informant agreement was calculated (over the 420 responses of each person) and adjusted for guessing. A principal-component factor analysis produced a single factor solution (ratio 1st/2nd factor: 16.47; variance explained by 1st and 2nd factor: 87.6%; average 1st factor loadings: 0.915), confirming the existence of one underlying model of plant-animal interactions as perceived by the Lacandon Maya of Mensäbäk. This represents the “cultural model” (confidence level > 99%) (Romney, Weller, and Batchelder 1986:326).

The distribution of the factor loadings, which represent the agreement of each informant with the cultural model, reveals two clearly separated clusters of informants. The two respective groups of individuals are separated by both their first and second factor loadings (one-way ANOVA,  $F = 25.509$  and  $p = 0.007$ ;  $F = 14.669$  and  $p = 0.019$  respectively), indicating that the two clusters represent individuals holding different submodels.<sup>3</sup> This indicates the existence of a strong consensus among all male adults of Mensäbäk, further differentiated, however, in two subgroups of informants.

The fact that the first factor loadings correlate negatively with the age of the informants ( $r = -0.8$ ) indicates that the two groups differ in age (average age of group A is 65 years versus 34 years for group B). In fact, a closer look at the informants reveals that the two groups represent the first and second generation of adults. The higher first factor scores of the second-generation adults (average 0.934 versus 0.899) indicate they agree more strongly with the general cultural model than older members do.

Older informants (group A) reported on average 104 relations, compared to 67 relations perceived by the members of group B, the younger Lacandon men (one-way ANOVA,  $F = 19.22$ ;  $p = 0.012$ ).

On average, the younger men agree in 86 percent of relations with each other (compared to 79% for members of the group of older informants). This explains their higher first factor loadings. However, their higher agreement is based on the absence of reported relations.

Members of both groups agree with each other on the responses in 78 percent of all cases. For the younger adults, however, only 6 percent of the agreed responses refer to actually reported relations (72% are nonrelations). In contrast, older informants agree in 12 percent of actually reported relations (compared to 66% nonrelations).

If we separate the cultivated plants added to the set from the forest plants, the agreement pattern for the two sets of plants looks very different. For the cultivated plants alone (their relation to animals), a strong consensus emerges (ratio of 1st and 2nd factor eigenvalue: 20.62; variance explained by 1st and 2nd factors: 93.8%; average 1st factor score: 0.944). This shows that informants agree more strongly on this subset of species than they do for the forest plants. In fact, for the cultivated species alone the described group difference disappears. This makes sense, as agriculture is still

**Table 1. Forest-Plant Species and Indices**

Lacandon	Scientific Name	Common Name	Experts	Nonexperts
Oox	<i>Brosium alicastrum</i>	ramón	0.80	0.61
Ya'	<i>Manilcara spec.</i>	chicle	0.70	0.65
Ts'us	??; "Bejuco de Uva"	grapevine	0.53	0.42
Ja'as	<i>Calocarpum mannosum</i>	mamey	0.51	0.47
Ak' jun	<i>Ficus spec.</i>	amate	0.42	0
Pajok	<i>Chamaedorea spec.</i>	pajok	0.32	0.07
Wäch'	<i>Dialium guianense</i>	wild tamarind	0.30	0.32
Ch'ib	<i>Chamaedorea tepejilota</i>	pacaya	0.26	0.05
Bo'oy	<i>Chamaedorea spec.</i>	xate	0.18	0
Ak'te'	<i>Astrocarpum mexicanum</i>	chapay	0.18	0.09
Chäk ak'	<i>Cnestidium rufescens</i>	colored vine	0.12	0.05
Su'uk	Cyperaceae/Poaceae	grasses	0.11	0.07
Puna'	<i>Swietenia macrophylla</i>	mahagony	0.09	0
Pukte'	<i>Bucida buceras</i>	pukte'	0.07	0.12
K'uche'	<i>Cedrela odorata</i>	cedar	0	0
	<i>C. mexicana</i>			
Yajche'	<i>Ceiba pentandra</i>	ceiba	0	0
Nikte'	??; "Bejuco de Pimienta"	pimienta vine	0	0
Yuij	<i>Vitis tiliifolia</i>	water vine	0	0

an important feature in Lacandon society and hence the knowledge about animals feeding on crops is essential. The importance of this knowledge is also reflected in the fact that no submodels are found, indicating that this knowledge is widespread and basically common to all adult males. As a logical consequence, the difference of knowledge only occurs with respect to the forest species.<sup>4</sup>

To further understand the distribution of expertise and knowledge within the community, a social network task was conducted in which all women and men were asked to list the seven living individuals they regard as forest experts. Although no restrictions applied, only Lacandon men were nominated. All members of the first-generation Lacandones were described as forest experts and the informants often added that these men not only have more experience but also more interest in the forest. On average members of this group received 73 percent of the possible nominations compared with 40 percent for the members of group B. Surprisingly, an ANOVA failed to indicate this difference was reliable. However, this is due to the limited social activity of women in Mensäbäk (see Ross n.d., 2001). No woman nominated the oldest man in the community, who lives 30 minutes walking distance from the village center. If we only look at the judgments of the male adults, the difference in nominations for the two groups is highly significant ( $F = 10.8$   $p = 0.039$ ).

For the men, age plays an important role in the decision of "who is an expert and who is not." However, their decisions are not based on age alone. Among younger men, the youngest individual is rated the most expert—this makes

sense because he is the only person who owns a hunting rifle. Age plays a further role in that all Lacandon men readily acknowledge the different role the forest plays for the members of the two generations.

The Lacandon model of who are the experts correlates strongly with the two groups of informants that emerge from the above task. This lends extra support to the empirical data, and I will henceforth refer to older informants (group A) as forest experts.

### Models of Plant-Animal Interactions

As indicated in the strong consensus, both the expert and the nonexpert models share several features: 1) no individual mentioned a plant hurting an animal; and 2) for forest species alone, all informants agree on 21 (6%) individual plant-animal relations. These relations include six different plants and ten different animals. To explore the differences between experts and nonexperts, the general model was calculated for each group, taking the average responses for each pair of species.

In a first analysis an index was calculated (percentage of possible responses) for each species that describes: 1) the extent to which a plant is seen as helping all the animals; and 2) the extent to which an animal is seen as profiting from all the plants. For a plant a high index (range from 0 to 1) means that it helps many animals; for an animal a high index indicates that many plants help this animal.

Tables 1 and 2 show the indices for both experts and nonexperts, using the rankings of the expert indices as an

**Table 2. Animal Species and Indices**

Lacandon	Scientific Name	Common Name	Experts	Nonexperts
Ma'ax	<i>Ateles geoffroyi</i>	spider monkey	0.39	0.26
Ba'ats'	<i>Allouata pigra</i>	howler monkey	0.39	0.26
	<i>A. palliata</i>			
Pan	<i>Ramphastos sulfuratus</i>	tucan	0.39	0.11
Kox	<i>Penelope purpurascens</i>	cojolita	0.37	0.20
Sek	Stenodermatinae	bat	0.37	0.24
K'ambul	<i>Crax rubra</i>	pheasant	0.35	0.28
Bach	<i>Ortalis vetula</i>	chachalaca	0.35	0.11
Aj kacho'	<i>Amazona farinosa</i>	parrot	0.31	0.26
Jaree	<i>Agouti paca</i>	paca	0.30	0.20
Tsub	<i>Dasyprocta spec.</i>	agouti	0.30	0.22
Chäk k'ek'en	<i>Nasua narica</i>	coati	0.28	0.15
Juan	<i>Crypturellus cinnamomeus</i>	perdiz	0.24	0.13
Kitam	<i>Tayassu tajacu</i>	collared peccary	0.24	0.17
Yuk	<i>Mazama americana</i>	small deer	0.20	0.15
Kej	<i>Odocoileus virginianus</i>	big deer	0.09	0.15
Wech	<i>Dasyus novemcintus</i>	armadillo	0.07	0.06
Jach kän	<i>Bothropos asper</i>	nauviaca	0.07	0.07
Aach kän	<i>Boa constrictor</i>	boa	0.07	0.07
Jach barum	<i>Panthera onca</i>	jaguar	0.04	0

ordering system. All individuals knew all plants and animals in the list. (Cultivated plants are not included.)

These indices reflect the role of each species in the ecological structure of the rainforest, according to the informants of each group. As expected, the data describe a higher rate of animal-plant interactions reported by the experts (0.25) than the nonexperts (0.16) ( $F = 7.05$ ;  $p = 0.012$ ). In other words, experts mention significantly more relations than nonexperts (see above), and they ascribe a more important role in animal life to plants and ecology in general than nonexperts do.

Plant rankings (according to the indices) of both groups correlate significantly ( $r = 0.88$ ), reflecting the high agreement mentioned earlier. Basically, all Lacandon men describe the ramón tree, *jach oox*, the chicle tree, *ya'*, the *ts'us*-vine, as well as the *ja'as* tree as the most important plants for the animals because of their fruits. At the same time, the cedar tree, the ceiba tree, as well as the two vines, *nikte'* and *yuij*, were never mentioned as being of use to animals.

Expert and nonexpert rankings are lower ( $r = 0.77$ ) with respect to the animals of the set. This indicates that knowledge about plants is more accessible and salient than knowledge about animals. This is supported by the fact that only a few men had actually seen all the animals in the list. Only older men have ever seen a jaguar, and due to the recent population increase (and the subsequent loss of corridors in the general area) even the spider monkey, the peccary, and the big deer (white-tailed deer) are rarely observed.

### Experts and Nonexperts View of Forest Life

To explore the structure of this knowledge a correspondence analysis was performed (see Weller and Romney 1990:55). This form of matrix analysis looks at the agreement of variables (columns), putting them in relation to the cases (rows), by the use of factorial analysis. For this study, this means that in a two-dimensional representation, animals (columns) that use the same plants (rows) are close to one another and to the plants they use in common.

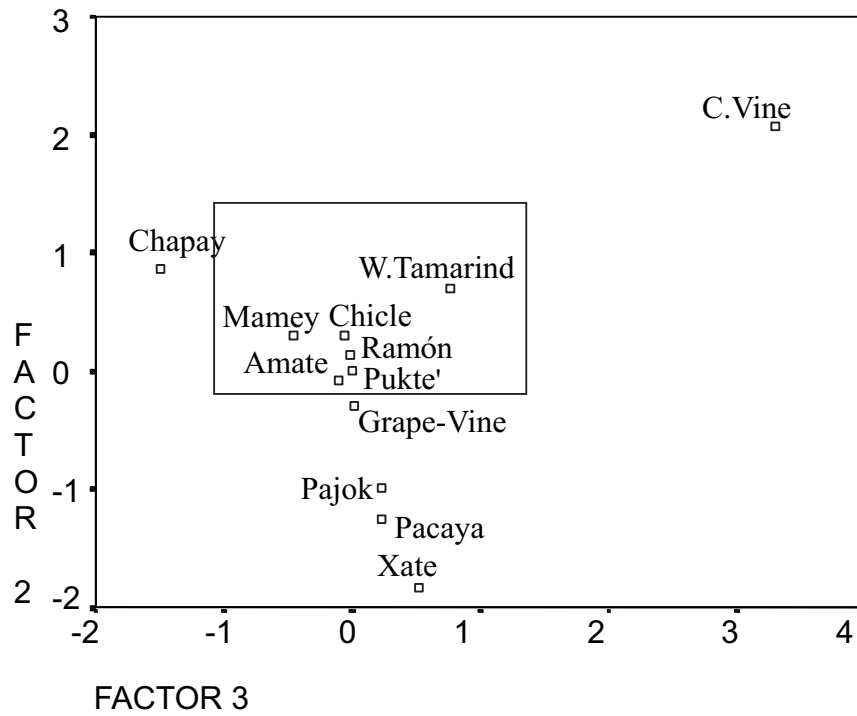
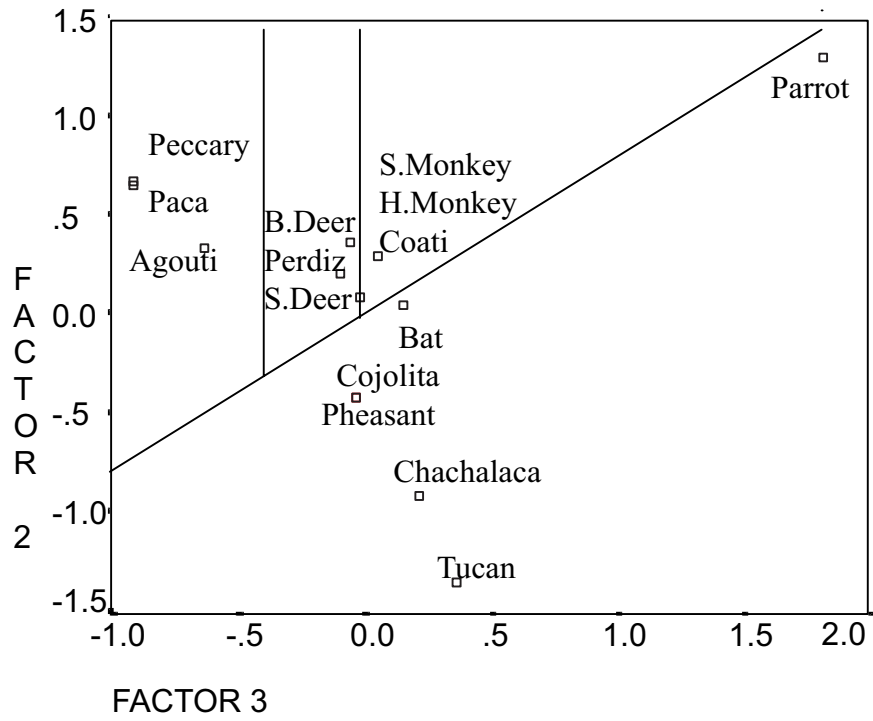
This depiction reflects the interaction structure of the forest as reported by informants. For experts and nonexperts, separate group matrices (animal by plant) were calculated, indicating existing and missing relations. A relation was assumed if reported by at least 33 percent of the members of a group.

Results are plotted for animals and plants separately, as the number of species does not allow a clear analysis of the data structure. However, the coordinates of both graphs are the same.

For the expert group, plotting was done using the second and third factor scores. Only the snakes (1st factor loading = 6.16) and the jaguar and armadillo (1st factor loading = 0) differ in their loadings on the first factor. Across kingdoms, the snakes share the same coordinates with the grasses and only with them. The latter do not help any other animal, and snakes do not profit from any other plant in the set. Snakes also hide in the grass.

The mahogany, cedar, and ceiba trees as well as the *nikte'* and *yuij* vines do not help any animal and have the respective

Figure 2. Correspondence-Analysis; 2nd and 3rd Factor Loading, Experts



first factor loadings of 0, which are the same for the jaguar and the armadillo, who do not profit from any of the plants used in the set. None of these species are included in the graphs.

The fact that all the remaining plants and animals have the same first factor loadings indicates that most of the plants help all the animals. This feature is ignored in the plotting of the second and third factor loadings, where more specific relations can be explored.

Plants that help all or most of the animals can be found in the center of the graph in Figure 2. These are the same plants at the top of the index ranking in Table 1, including the ramón tree and the *bejuco de uva*, which translates as “grapevine,” referring to the grapelike fruits this vine produces.

While the plants in the center help most animals in the graph, they have a special relation to the tree-dwelling mammals in the set: spider monkeys, howler monkeys, and coatis. Also the perdiz, a ground-dwelling bird, as well as the two deer species cluster around these plants, searching for their fallen fruits.

Other species’ relations are quite peculiar, depending on special properties of the plants and animals involved. The chapay palm illustrates this. Strong spines protect the trunk of this palm; therefore, only animals with strong teeth, such as the collared peccary (*kitam*), the agouti (*tsub*), and the paca (*jaree*) have access to this food source. Although these animals also feed on the plants in the center, it is this special relationship that clusters them close to one another and to the chapay palm. The same is true for the birds of the set that cluster around the palms—pajok (*pajok*), pacaya (*ch’ib’*), and xate (*bo’oy*). It is interesting to note that the bat (*sek*) is located between the tree-dwelling mammals and the birds.

Apart from the ground-living bird, perdiz (*juan*), only the parrot (*aj kacho’*) is separated from the other birds. This is due to its special relation with the colored vine (*chäk ak’*). The fruits of this vine are so small that, according to the Lacandon experts, only the parrots feed on them.

These descriptions should suffice to show the intricate ecological knowledge Lacandon Maya forest experts hold. Ecological and physiological properties are taken into account, creating a clear structure of forest life, separating palms, trees, and vines as well as tree-living mammals, ground-living mammals, and birds. A similar structure was found for the Itzaj Maya experts of the neighboring Petén, Guatemala (Atran et al. 1999).

For nonexperts, too, most of the plants and animals share the same first factor loading, indicating the general interaction described for the experts. Exceptions are the following species:

- 1) Animals and plants with no relations (1st factor loading = 0): jaguar, armadillo, big deer, chachalaca, and tucan; the mahogany, cedar, ceiba, and amate trees; the xate and chapay palms; and the pimienta and water vines. No species in this set has any relation to another.

- 2) Snakes and grasses (1st factor loading = 4.243) are again seen only as interacting among themselves.

These data show that the knowledge of the nonexperts is less specific and revolves around fewer species than that of the experts.

Again, a plotting of the second and third factor loadings (separated for animals and plants) is used to illustrate and analyze the structure of nonexpert knowledge (Figure 3).

If we compare the data for experts and nonexperts several differences emerge.

- 1) Experts see more animals profiting from plants and more plants helping animals than do nonexperts.
- 2) For the two birds—chachalaca and tucan—nonexperts do not describe any particular relation with any plants, while experts report they feed off little palm fruits, a property they share with other birds. These two birds are among the highest-ranked animals with respect to their activity index (Table 2) according to the experts, while nonexperts rank them rather low. Nonexperts often did not even know about the fruits produced by the palms in question.
- 3) Nonexperts do not see a special relation for the big deer (*kej*), which experts clearly group with the second deer species of the region. This difference might be explained by the fact that younger Lacandonones do not have much experience with this particular species. In fact, most of my younger informants have never seen a big deer.
- 4) Nonexperts in general use the strong spines of the chapay as an indicator that no animal would feed on this palm.

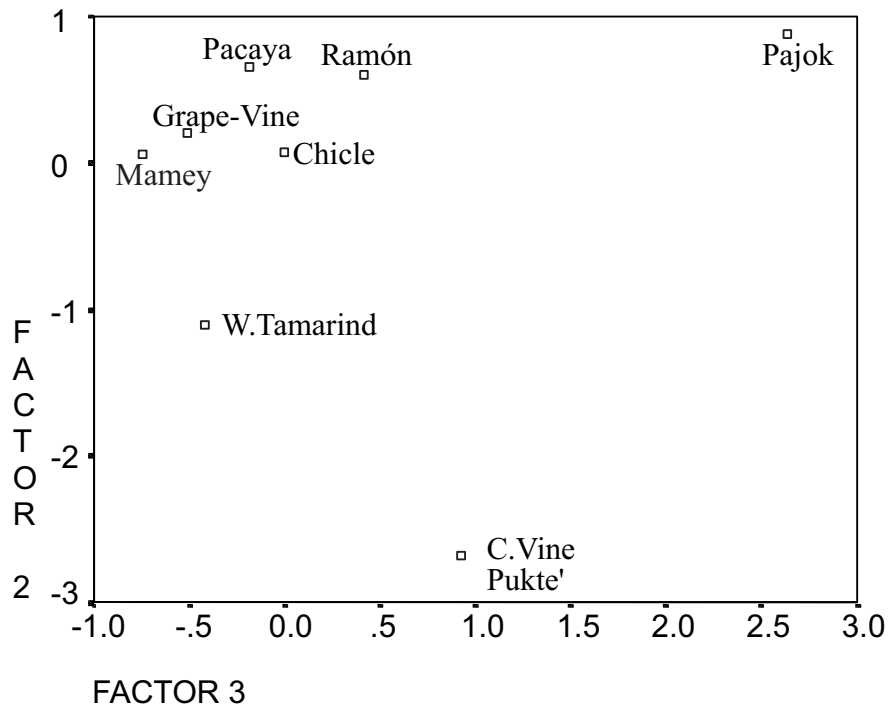
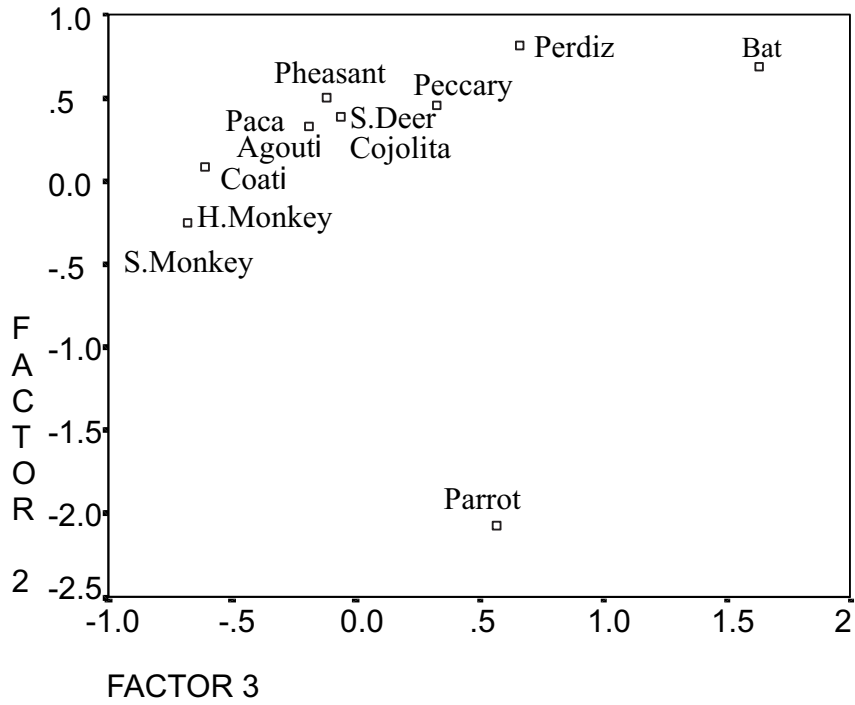
Some of these differences can be seen already in the distribution of the first factor loadings. However, the differences become even more detailed in the distribution of the loadings of the second and third factors.

For the experts, the distribution of the second factor loadings divides the animals into *bäk*, “meat-animals, mammals” and *ch’ich’*, “flying animals” (the only exception is the perdiz, a ground-living bird). Based on the distribution of the third factor loadings, ground-living mammals and tree-mammals are further separated. This differentiation contrasts strongly with the perception of nonexperts, for whom we do not find any structure at all. This already indicates a significant lack of knowledge on the part of younger Lacandonones. Although there is evidence that they are less engaged with the forest than their fathers, they may be in the process of acquiring the relevant knowledge to create the structured representation of forest species their fathers have. However, the evidence presented above suggests that younger Lacandonones will not acquire this knowledge as a consequence of their lack of general interest and lack of opportunity, since some of the animals are no longer observable in the area.

## Animal-Plant Relations

The same interview allowed further analysis of how animals interact with plants of the set. Again, a general consensus

Figure 3. Correspondence Analysis, 2nd and 3rd Factor Loading, Non-Experts



emerged across all informants, but since only 4 percent of all the possible animal-plant relations were reported (explaining the high agreement between the informants) no further analysis of informant agreement was performed (see Table 3).

It is interesting to note that the two oldest informants did not report any effect of animals on plants. Looking at the whole set of informants, there was a significant negative correlation between the age of an informant and the number of relations reported ( $r = -0.679$ ,  $p = 0.047$ ). Given that almost no positive relation was reported, this means that younger informants are more likely to recognize the damaging effects of animals on the forest (such as the parrot or monkeys playing with unripe fruits).

The following rules could be extracted from justifications given by the informants:

- 1) Eating an unripe fruit most often hurts the plant, as the seed cannot germinate. The same is true for playing with unripe fruits, as reported for the parrot and both species of monkeys.
- 2) Eating a seed might hurt the plant if it is a large seed that has to be opened. If it is a small seed it might actually help the plant, since it is swallowed whole and distributed over a wider area.
- 3) The above depends on the properties of the species involved. For example, the seed of the mamey tree (*ja'as*) is very hard and big. It cannot be swallowed whole, but some animals, such as the paca or the peccary, are able to open the seed with their teeth. Therefore, only they have a negative impact on the plant.

These rules seem to rely on fine observation of nature. In part, this reaffirms the fact that even younger Lacandonese are quite expert with respect to the forest. At first glance it might be surprising that younger adults report more of those harmful relations than older members of the community. Older informants do see the same relations as their younger peers, however. For example, they also recognize that the paca opens the seed of the mamey tree, which prevents the seed from germinating. They do not describe this action as harmful, since in their view the paca only does what *hächäkyum* created it to do; therefore, it cannot possibly hurt the plants.

This framework also applies to human beings and their use of the forest. As long as humans use the forest

in accordance with Lacandon traditions, they cannot hurt it. This explains the earlier example: a Lacandon man can cut a tree to get to some honey without hurting the forest, in the view of the older members of the community, but he hurts the forest if he cuts it to sell the wood. This view is supported by Lacandon mythology, which often describes the conversion of human beings into animals as a punishment for overhunting or hurting species for reasons other than (traditional) subsistence. It describes a relational perspective in which humans, animals, and plants exist in a religious framework put into place to defend the Lacandon traditional way of life.

Just as this traditional way of life gave way to new forms of living, so does the broader framework of perceiving living kinds (including humans) and their relations. Younger Lacandonese do not share a framework that supports a traditional lifestyle. To the contrary, rather than seeing the forest and human beings as relational entities, they separate them into unrelated species without further purpose. As independent entities, both animals and humans can harm or help each other. In fact, young Lacandon men are very concerned about human impact on the forest.

## Conclusion

### Plant-Animal and Animal-Plant Relations

The plant-animal data presented above show a knowledge distribution according to generation. First-generation adults not only reported significantly more relations than adults of the second generation, but the resulting structure of these interactions also proved to be much more sensitive to ecological and physiological properties of the species. While the statistical results show the meaningfulness of splitting up informants into separate cohorts, the results of an independent social-network task indicate that the Lacandonese themselves perceive the very same differences among their adult males. Members of the first generation are much more likely to be regarded as experts than members of the younger generation. (Note that the data showed an interaction of age and experience and not age alone.)

The average age of the group of young informants was 34. This already seems to rule out the possibility that the differences described represent a static picture in an ongoing development process from novice to expert. Furthermore, recent deforestation and the loss of corridors through newly established communities caused several species to disappear from the area. Therefore, many of the younger informants never saw some of the animals involved in the study. These animals seem to be out of reach for future observations and an important source of information seems to have vanished from the scene. As a consequence, older Lacandonese believe their younger peers will never learn all the intricate knowledge of the forest. While this could be just another statement about the "good old days, when the grass was greener," younger Lacandonese have less interest in both the forest and

**Table 3. Consensus Data, Animal-Plant Relations**

	1st/2nd Eigenvalue	Variance Explained by 1st & 2nd Factor	Average 1st Factor Scores
All plants	40.21	95.1%	0.96
Forest plants	34.90	94.9%	0.96
Milpa plants	27.89	96.8%	0.97

forest-based agriculture. The younger generation show a clear shift in their social life, which ties them closer together and at the same time distances them from the forest and the milpa. In fact, one could argue that while their parents moved to Mensäbäk, it was this second adult generation that actually created the village. They have abandoned the traditional pattern of establishing households at a distance from one another and close to milpas. This residential pattern has implications for how often one visits the milpa and even the number of crops planted; implications of which both generations are well aware.

This conclusion is supported by the findings described for the animal-plant relations. Members of the two generations subscribe to different underlying models of the world. It seems highly unlikely that these worldviews are subject to change as the younger generation matures. Rather, they seem to represent different framework theories (Welman and Gelman 1992); theories that represent a conceptual change from one generation to the next that is part of a larger process of cultural change. Only older Lacandonones have experience with the traditional Lacandon gods. Upon arrival in Mensäbäk all of them established their households including the traditional god-house. These god-houses are the ceremonial site of a traditional Lacandon household (sometimes shared among several households). In the god-house, the god-pots, the seats of the gods, are stored, and it is here that ceremonies are performed. Influenced by missionaries, many older Lacandonones abandoned these god-houses. Still, their experiences and models are heavily shaped by this aspect of Lacandon religion. Rather than abandoning the god-pots, all of my informants buried these pots in sacred shrines and caves, often in combination with prayers.

None of the younger informants ever built a god-house. Although some of them participated in ceremonies, they grew up in an environment in which traditional Lacandon religion was already contested by missionary efforts. As a (poorly studied) consequence, their relation to the Lacandon gods is largely restricted to knowing some of their names. Therefore, it seems almost impossible that these men will recover a religious framework they never learned in the beginning and that stands in contrast to many of their current beliefs, including the role of animals and humans in the forest.

### **Cognitive Aspects of Intergenerational Change**

Ethnographic and experimental evidence showed that members of the two adult generations adjusted differently to recent changes. Forced settlements as well as missionary activities and increasing contact with outside communities led younger Lacandonones to adopt a lifestyle different from their parents. These differences can be seen in the social and economic spheres, where younger adults created a community by consciously choosing to live next to each other and farther away from their agricultural fields. Young Lacandonones not only pay less attention to their agricultural fields, but also

to the forest, which has ceased to be a central part of their life and living environment.

This paper started out to explore intergenerational differences in environmental cognition and ethnoecological knowledge. The ethnoecological model of older Lacandon Maya proved not only to be more complex than that of their children, but also showed a structure that is completely missing in the model of the younger generation. Both on an individual species level and on a more abstract level, older Lacandonones seemed to have a better understanding of the complex forest ecology of plant-animal interactions. This seems to be in part a consequence of lack of interest and learning opportunity for younger Lacandonones. Not only do they lack the interest needed to acquire the necessary knowledge; they also lack the opportunity to observe many of the animals that once inhabited the area. Furthermore, younger adults interpret their observations through a different framework than their elders. Older Lacandonones demonstrate a complex picture of ecological knowledge and religious beliefs, with the latter providing the rationale for and description of proper behavior. Species, including human beings, are linked to one another through their purposeful creation by hächäk'yum, the Lacandon creator god. The relation to the forest and the species are very different for second-generation Lacandonones. Rather than a system of purposefully linked entities, species appear to be seen as isolated and potentially endangered (and not protected by the creator god). Rather than having a worldview that prescribes the right behavior, younger Lacandonones follow the model of NGO and extension workers who interpret individual observations with respect to their impact. Such a framework provides younger Lacandonones with a very different model for proper behavior than that of their elders.

The data in this paper provide converging evidence that the differences between the members of the two generations do not represent different stages in the development from novice to expert. The differences seem to reflect a rupture in the acquisition of cultural knowledge among the Lacandon Maya of Mensäbäk, which forms a part of a wider cultural change. This evaluation is based on several points. 1) Similar generational changes can be observed in related domains, indicating a much larger process of which folk ecological knowledge is but one piece. 2) These changes in part led to a significant decrease of interest among the younger Lacandonones in learning about the forest. 3) Recent environmental changes led to a decrease in learning opportunities, including deforestation and the disappearance of species. 4) Finally, differences found in framework theories seem to imply changes in general models that are unlikely to be subject to change in the course of increasing expertise.

Relating this to previous findings (Atran et al. 1999), the data provide further evidence for the existence of an intricate and complex system that connects culture, cognition, and behavior. Unfortunately, in this case the connecting line consists of ongoing change and the loss of knowledge. As

the forest becomes depleted and disappears, so does the knowledge about it among the Lacandon Maya of Mensäbäk.

All this has practical implications on several levels. For example, young Lacandones often use governmental farmer support to hire wage laborers to attend their fields (leaving them both with free corn and cash benefits). In a similar vein, “emergency aid” is often planned for, thereby affecting the size of the milpa planted in a given year. All this comes as a consequence of the decreasing interest in and dependence on the milpa.

These data should also alert us to possible consequences of development projects on a wider scale. In the case of the Lacandones, changed circumstances led to the development of different templates and shared experiences for second-generation adults. Still cherished as the *k'axil winik*, the people of the forest, younger Lacandones are no longer as familiar with the forest as their fathers, nor do they have the same interests. These differences in interests and knowledge have to be considered by projects targeting the community.

On a more theoretical level, the data indicate that we have to constantly question our ideas of “indigenous people” and “indigenous resource management.” The example given in this paper makes it clear that local institutions—often rightfully cherished as safeguards of sustainable resource management—are not fixed entities and are often in peril of erosion due to outside influences and internal adjustments. For example, older Lacandon Maya still have a clear framework that ties species (including human beings) into an intricate web of meanings and purposes, guided by their creation stories. This, however, no longer applies for younger Lacandones, and as a consequence new institutions and guiding principles must be established. The difficulty is to detect the differences between “applied frameworks” and “known traditions.” All of the younger Lacandon informants knew the creation stories evoked by their elders, but these stories no longer guide their behavior.

Many of the changes described here are irreversible and voluntarily chosen by the second-generation Lacandones, and one has to worry about their impacts for the future. Important knowledge has been lost, and unless it is replaced by a workable alternative both Lacandon society and the forest are endangered.

### Notes

<sup>1</sup>In my German publications my name is spelled Roß.

<sup>2</sup>None of the Lacandon farming families who do not live in one of the main communities receive any recognition by the government or NGOs.

<sup>3</sup>Residual Agreement (observed – predicted agreement) correlated positively ( $r = 0.37$ ) with the observed agreement, confirming the existence of submodels not explained by the general cultural model.

<sup>4</sup>It is therefore not surprising that the consensus for this subset is weaker than for the milpa plants. (Ratio of 1st and 2nd factor eigenvalues: 12.5;

variance explained by 1st and 2nd factors: 85.6; average 1st factor loadings: 0.89.)

### References Cited

- Arizpe, Lourdes, Fernanda Paz, and Margarita Velázquez  
1992 *Cultura y Cambio Global: percepciones sobre la deforestación en la Selva Lacandona*, Mexico. Mexico City: Fondo de Culturas.
- Atran, Scott  
1998 *Folkbiology and the Anthropology of Science: Cognitive Universals and Cultural Particulars*. *Behavioral Brain Sciences* 21:547- 609.
- Atran, Scott, Douglas Medin, Norbert Ross, Elizabeth Lynch, John Coley, Edilerto Ucan Ek', and Valentina Vapnarsky  
1999 *Folkbiology and Commons Management in the Maya Lowlands*. *Proceedings of the National Academy of Sciences* 96:7598-7603.
- Atran, Scott, Douglas Medin, Norbert Ross, Elizabeth Lynch, Valentina Vapnarsky, Edilerto Ucan Ek', John Coley, Christopher Timura, and Michael Baran  
n.d. *Folkbiology, Cultural Epidemiology, and the Spirits of the Commons: A Garden Experiment in the Maya Lowlands, 1995-2000*. Unpublished manuscript. Authors' files.
- Barlow, Robert  
1943 *The Lacandon of the 1790s*. *Tlalocan* 1:158-159.
- Berlin, Brent  
1992 *Ethnobiological Classification*. Princeton, N.J.: Princeton University Press.
- Berlin, Brent, Denis Breedlove, and Peter Raven  
1973 *General Principles of Classification and Nomenclature in Folkbiology*. *American Anthropologist* 74:214-242.  
1974 *Principles of Tzeltal Plant Classification*. New York: Academic Press.
- Boremanse, Didier  
1998 *Hach Winik: The Lacandon Maya of Chiapas, Southern Mexico*. Austin: University of Texas Press.
- Boster, James  
1986 *Exchange Varieties and Information between Aguaruna Manioc Cultivators*. *American Anthropologist* 88:428-436.  
1987 *Introduction: Intracultural Variation*. *American Behavioral Scientist* 31:147-162.
- Breedlove, Denis  
1973 *The Phytogeography of Chiapas*. In *Vegetation and Vegetational History*. Alan Graham, ed. Pp. 149-165. Amsterdam: Elsevier.
- de Vos, Jan  
1980 *La paz de Dios y del Rey: La conquista de la Selva Lacandona por los Españoles, 1525-1821*. Mexico City: Fondo de Culturas.
- Garro, Linda C.  
1986 *Intracultural Variation in Folk Medical Knowledge: A Comparison Between Curers and Non-curers*. *American Anthropologist* 88:351-370.  
2000 *Remembering What One Knows and the Construction of the Past: A Comparison of Cultural Consensus Theory and Cultural Schema Theory*. *Ethos* 28:275-319.

- Hunn, Eugene  
1985 The Utilitarian Factor in Folk Biological Classification. *In* Directions in Cognitive Anthropology. Janet Dougherty, ed. Pp. 117-140. Chicago: University of Illinois Press.
- López, Alejandro, Scott Atran, John Coley, Douglas Medin, and Edward Smith  
1997 The Tree of Life: Universals of Folk Biological Taxonomies and Inductions. *Cognitive Psychology* 32:251-295.
- Medin, Douglas, Elizabeth Lych, John Coley, and Scott Atran  
1997 Categorization and Reasoning among Tree Experts: Do All Roads Lead to Rome? *Cognitive Psychology* 32:49-96.
- Medin, Douglas, Norbert Ross, Scott Atran, Douglas Cox, John Coley, and Elizabeth Proffitt  
n.d.<sup>1</sup> The Role of Culture in the Folkbiology of Freshwater Fish. Unpublished manuscript. Authors' files.
- Medin, Douglas, Norbert Ross, Scott Atran, Russ Burnett, and Sergey Blok  
n.d.<sup>2</sup> Categorization and Reasoning in Relation to Culture and Expertise. *The Psychology of Learning and Motivation*. Vol. 41. In press.
- Nations, James  
1979 Population Ecology of the Lacandón Maya. University Microfilm International, No.GAX 79-20363. Ann Arbor: University of Michigan.
- Ostrom, Elinor  
1990 Governing the Commons: The Evolution of Institutions for Collective Actions. Cambridge: Cambridge University Press.  
1992 Crafting Institutions for Self-Governing Irrigation Systems. Oakland, Calif.: ICS Press.
- Romney, Kimball, Susan Weller, and William Batchelder  
1986 Culture as Consensus: A Theory of Culture and Informant Accuracy. *American Anthropologist* 88:313-333.
- Ross, Norbert  
1997 Nutz Lok'el li Kaxlane: die Vertreibung der Ladinos aus San Andrés Larraínzar, Chiapas, Mexiko. Münster, Ger.: Lit Verlag.  
2001 Bilder vom Regenwald: Mentale Modelle, Kulturwandel und Umweltverhalten bei den Lakandonen von Mexiko. Münster, Ger.: Lit Verlag.  
2002 Lacandon Maya Intergenerational Change and the Erosion of Folkbiological Knowledge. *In* Ethnobiology and Biocultural Diversity. John Stepp, Felicitas Wyndham, and Ruth Zarger, eds. Pp. 585-592. Athens: University of Georgia Press.  
n.d. Lacandon-Maya Intergenerational Change: Social Relations, Household Location and Economic Behavior. Unpublished manuscript. Author's files.
- Ross, Norbert, Douglas Medin, John Coley, and Scott Atran  
n.d. Cultural and Experiential Differences in the Development of Folk Biological Induction. Unpublished manuscript. Author's files.
- Singer, Marie-Odile  
1991 Los Hombres de la Selva. Un estudio de tecnología cultural en medio selvático. Mexico City: Conaculta.
- Strauss, Claudia, and Naomi Quinn  
1997 A Cognitive Theory of Cultural Meaning. Cambridge: Cambridge University Press.
- Warren, Darron  
1991 Using Indigenous Knowledge in Agricultural Development. World Bank Discussion Paper 127. Washington, D.C.: World Bank.
- Wellman, Henry, and Susan Gelman  
1992 Cognitive Development: Foundational Theories of Core Domains. *Annual Review of Psychology* 62:1070-1090.
- Weller, Susan, and Kimball Romney  
1990 Metric Scaling: Correspondence Analysis. London: Sage.
- Zent, Stanford  
2001 Acculturation and Ethnobotanical Knowledge Loss among the Piaroa of Venezuela. *In* On Biocultural Diversity. Luisa Maffi, ed. Pp. 190-211. Washington, D.C.: Smithsonian Press.