THE PALM HAS ITS TIME: AN ETHNOECOLOGY OF *SABAL URESANA* in Sonora, Mexico[1]

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Joyal, Elaine (Department of Botany, Arizona State University, Tempe, AZ 85287-1601 USA). THE PALM HAS ITS TIME: AN ETHNOECOLOGY OF *SABAL URESANA* (ARECACEAE) IN SONORA, MEXICO. *Economic Botany 50(4):446–462. 1996. Participant observation and formal interviews were used to learn what local people understood of palm natural history and how palms were managed. Ecological and ethnographic methods were combined to assess traditional ecological knowledge (TEK) and traditional resource management (TRM). Palm workers understood TEK and TRM for palms. This knowledge was not general in the population, however. Residence, harvester status, and gender were strongly correlated with TEK and TRM. Harvest practices included limiting access, "sparing," controlling harvest times and levels, and choice of leaf age and palm size. "Alpha" management is proposed as practices which maintain populations long-term. In this case, sparing was the single most important practice. "Beta" management is shorter term and important for obtaining good quality product in sufficient quantities. Although the impacts are more subtle, it can affect population structure over time. This study provides one prototype for identifying practices which function as de facto conservation traditions for wild-harvested species.*

La Palma tiene su Tiempo: Una Etnoecológica de *Sabal uresana* en Sonora, México. *Observación participante y entrevistas formales fueron los métodos utilizados para aprender cómo la gente local entendió la historia natural y manejo de las palmas. Métodos ecológicos y etnográficos fueron combinados para valorar el conocimiento tradicional de la ecología (TEK) y el manejo tradicional de los recursos (TRM) para las palmas. Aunque los palmeros entendieron TEK y TRM para las palmas, este conocimiento no era generalizado entre la población. La residencia, y el estatus y el género del palmero fueron correlacionados fuertemente con TEK y TRM. Las prácticas de cosecha incluyeron: acceso limitado a las poblaciones, uso moderado de grandes palmas, tiempos y niveles controlados de cosecha, selección del tamaño de la palma y edad de la hoja. El manejo "alpha" es un manejo a largo plazo para el mantenimiento de las poblaciones, en este caso a través del uso moderado de las palmas grandes. El manejo "beta" es un manejo a corto plazo e importante para la obtención de productos de buena calidad en suficientes cantidades. Aunque su impacto sobre las poblaciones es más sutil, si puede afectar la estructura poblacional con el tiempo. Este estudio provee un modelo para valorar las especies silvestres e identificar las prácticas tradicionales que de hecho funcionan en la conservación de estas especies.*

Key Words: *Sabal uresana*; Arecaceae; Sonora; Mexico; ethnobotany; traditional ecological knowledge; traditional resource management.

Before there can be sound development of a wild-harvested resource we must first understand it. Unfortunately, most wild-harvested species are poorly known to science. Ethnobiologists generally agree that people who live in close proximity to a wild-harvested resource develop a knowledge of the species' natural history and how to manage it for sustained yield (e.g., Balée 1994; Hecht, Anderson, and May 1988; Posey et al. 1984). This belief has become a dominant paradigm for many (e.g., TEK TALK 1992). In contrast, some researchers believe that traditional people are just as likely to mismanage resources as are modern societies (e.g., Rambo 1985). Relatively few have taken a balanced view, that is, "scientific knowledge systems have received increasing criticism within the social science literature while indigenous knowledge systems are over-optimistically presented as viable alternative ways of knowing" (DeWalt 1994). A careful evaluation of traditional knowledge systems may allow us to more

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rapidly assess wild-harvested species and also to test if traditional people manage these resources sustainably. Although an increasing number of studies are quantifying the value of wild-harvested plant resources and traditional knowledge for them (e.g., Phillips and Gentry 1993; Posey et al. 1984; Prance et al. 1987), few studies have quantitatively evaluated traditional knowledge systems for individual wild-harvested species (e.g., Anderson 1991; Cunningham and Milton 1987; Fong 1992).

If a species is harvested on a regular basis there must be an impact on its populations (Getz and Haight 1989). This effect can be dramatic to subtle depending upon the plant part harvested, how the species responds to harvest, and harvest practices. The relative value and abundance of a plant resource in a given culture determines whether it can be harvested to simply satisfy needs (Jochim 1976; Nonacs 1993) or if it must be managed to optimize the resource (Nonacs 1993; Pyke 1984). That is, the more important the resource the more one would expect to find practices in place which ensure a sustained supply, especially if it is scarce (Hunn 1982). Likewise, if the quality of the resource is affected by harvest, practices which guarantee a quality product would be expected to be present. Given these conditions, one would predict management to conserve and/or enhance resources.

While there have been numerous papers published on sustainable harvest during the past 10–20 years, there is still no consensus on defining it. On the surface the problem appears simple. Population matrix models have been developed, especially in fields such as forestry and fisheries, to determine maximum and optimal levels of resource extraction (Getz and Haight 1989). However, most of these models are of necessity simplistic and cannot adequately predict the sum of stochastic processes, whether ecological and/or anthropogenic, which will affect a species through time (Lande, Engler, and Saether 1994). Furthermore, detailed demographic data that are required for matrix models do not exist for most wild-harvested species. A better understanding of traditional knowledge systems of wild-harvested species can help in assessing their sustainability and in promoting in-situ conservation for them among cultures lacking such traditions (e.g., Hall and Bawa 1993; Martin 1995; Peters 1994). Ethnoecological methods offer potentially useful techniques in such endeavors (Berkes 1993; Williams and Baines 1993).

Ethnoecology has been defined as the study of "the interaction between and relationship of humans and their ambient environment from an ecological perspective" (Bye 1976). If one were to undertake concurrent studies of the interaction of a people with a given resource and an ecological study of the species, the data should converge into a recognizable set of natural history knowledge and harvest practices for the resource, i.e. TEK and TRM. TEK is "the knowledge base acquired by indigenous and local peoples over hundreds of years through direct experience and contact with the environment. . . ." (Inglis 1993). While there have been several definitions proposed for TRM (e.g., Schmink, Redford, and Padoch 1992), I consider "good" TRM to be all activities by humans that enhance natural resources, i.e. activities that serve to maintain or increase the yield and quality of the product while minimizing negative impacts on the resource. TRM may or may not be explicitly stated as having a beneficial effect on the resource by the people employing it.

Unlike most woody tropical plants, palms (Arecaceae) lend themselves to demographic studies because of their well-organized form of growth, discrete method of flowering, and easily determined age (Sarukhán 1978). Moreover, palms are one of the most utilized plant families worldwide, especially in the tropics (e.g., Balick and Beck 1990; Uhl and Dransfield 1987). Wild populations of many species are harvested by traditional people for local use and a few species are harvested from the wild as major cash crops (e.g., Balée 1988; Balick 1988; Fox 1977; Hecht, Anderson, and May 1988). Management and conservation of wild-harvested palms has only begun to be addressed, and many are endangered, threatened, rare or depleted in all or part of their range (Johnson 1988).

The type and intensity of harvest and land-use as well as the biology of the target species must be factored into management of wild-harvested species. Generally, subsistence use of a plant resource results in relatively low levels of extraction (per plant, population, or unit time) whereas commercialization leads to increased rates of extraction. The use of various plant parts have different consequences on populations (Peters 1994). The removal of logs or whole plants for ornamental use can have an immediate impact on a population, with specific size-classes affected (Pinard and Putz 1992; Suzán et al. 1989). Leaf harvest, while more subtle in its effect, can modify a population over time. Both the level and timing of leaf removal alters a plant's energy stores (Chabot and Hicks 1982). Most studies have reported increased leaf production following the removal of mature leaves from adult palms (e.g. Chazdon 1991; Oyama and Mendoza 1990). Mendoza, Piñero, and Sarukhán (1987) found reduced leaf production in young palms in response to defoliation, however. It is the newly-unfolding leaves (cojoyos) of juvenile palms that are used for weaving in most cultures.

After preliminary study (Joyal 1996), *Sabal uresana* Trelease was selected for ethnoecological study. It is an important non-timber resource (leaves employed in weaving, thatching, and broom-making), and the most widespread and valuable of six regional endemic Sonoran palms. The Mexican government has designated *S. uresana* as a "rare, endemic" in its most recent list of endangered, threatened, and rare species (SEDESOL 1994). Two questions are addressed: (i) how good are Sonoran palm workers as observers of natural history? and (ii) how effective are they as resource managers?

Although the terms "indigenous" and "traditional" are both found in the literature (e.g., DeWalt 1994; Williams and Baines 1993) and there has been debate as to which is the most appropriate, I use "traditional" because it is the best term available at present to collectively refer to indigenous and local peoples who have lived in a given area for a long time and whose knowledge is a combination of that passed down to them from previous generations and/or learned by their own observation with little or no formal education and input from western science.

Study Areas

Study sites included the range of *S. uresana* utilization and people using palms in the Sonora (Joyal 1996). They were located in four areas within eastern Sonora: Ures (north central), Buena Vista (northeastern), Onavas-Yécora (east central), and Alamos (southern). The best developed stands are in the first two areas.

Methods

The methods in this study are similar to those described in Joyal (1996). Only techniques that differ from those are included here.

Ethnobotany

Participant observation with key informants and other palm workers was used to learn how palms were managed and what people understood of palm natural history. During formal taped interviews in 1993, palm workers was asked about their knowledge of palm natural history and harvest practices and personal demographic data (Joyal 1996).

Harvest Measurements

Relative harvesting pressure on a given palm was estimated by recording petiole width and number of cut petioles and green leaves present in populations censused across Sonora (Joyal 1995). Each population was categorized according to leaf age and size-class harvested and harvest levels. Cluster analysis was used to examine size-class structure and harvest patterns among populations. Petiole widths were measured for harvested versus unharvested palms from all populations to test for differences between the two. Experimental manipulations at one population were used to test harvest impacts (Joyal 1995).

To examine selectivity among harvesters, petiole width and leaf length were measured for all intact cojoyos present in palm workers' homes. I also noted if each cojoyo had been cut properly, i.e. below the hastula (juncture of petiole with blade). While size-class regressed on petiole width was significant, leaf length regressed on petiole width was not (Joyal 1995). Therefore, petiole width was used as a measure of cojoyo size and thus the size of the palm from which it was likely cut. A nested Analysis of Variance (ANOVA, fixed effects) and Tukey tests were used to test for differences in cojoyo size among harvesting "events" and between the two areas in which measurements were made. Given a significant difference among events, I tested if the harvester who had cut cojoyos larger than other harvesters chose only large cojoyos or if he cut cojoyos from populations with larger palms. Petiole widths for the cojoyos harvested by him were compared with those for the population from which the cojoyos had been cut and for which I had transect data for the source population. This was repeated for a second harvester who had cut smaller cojoyos and for which correponding transect data were also available. (T)-tests were used to determine if the cut cojoyos were representative of their populations or not.

Ecological Measurements and Matrix Model

Ecological methods are described in Joyal (1995). Briefly, these included demographic surveys across palm populations to establish patterns of size-class structure and associated species; estimation of growth (e.g., number of leaves produced/yr), survival, and fecundity rates; and construction of matrix models to estimate population sustainability. Simulations of the matrix model were used to assess the impact of harvest practices on palm populations, e.g., reduced growth of juveniles due to increased leaf harvest. These results were also used to assess the long-term impacts of harvest practices and thus to explain size-class structures observed in palm populations.

Synthesis

Informant responses from formal taped interviews were compared with ecological data, and against the range of responses given by all informants to any one query, to determine palm workers' "cultural competence" in TEK (Javier Caballero, pers. comm. March 1995; Bernard 1988). Twelve palm TEK variables (terrain, associated species, abundance, direction, age, leaf production, leaf time, flowering, fruiting, fruiting regularity, other palm species, other weaving plants) were coded. A scale comprising five response categories was used for each variable: no knowledge (0); minimal (1); basic and sometimes incorrect (2); good and correct (3); and the most accurate and perceptive (4). For example, responses for annual leaf production for "palma del suelo" (juvenile palms) included: (0) "who knows?;" (1) "very few" (no specific number); (2) "one a month therefore 12;" (3) "one a month in the growing season thus four or five;" (4) "one a month in the growing season hence four or five, except it depends upon if it is harvested a lot." Questions such as flowering time could only be sorted into three levels: no knowledge, general idea but imprecise, or correct and precise. A weighted mean of the variables was calculated for each informant (maximum = 3.33). Principal Components Analysis (PCA) and ANOVA were used to examine patterns between TEK variables and demographic factors and to test the relationship between them (SAS 6.1/WIN -SAS Institute 1989).

A correlation matrix of informants' scores for six TRM variables was used to examine the relationship among variables. A second correlation matrix was used to evaluate the relationship among the number of palm products made/used, the number of products known, and TEK and TRM scores. These were compared with six demographic factors (harvester status, gender, residence, ethnic identity, age, and formal education) to examine how each was related to palm knowledge. ANOVAs coupled with Tukey tests were used to test for differences between residence and harvester status and among male harvesters, female harvesters, and female non-harvesters (there were no male non-harvesters) for TEK scores.

Results

Ethnobotany

The following sections are based upon responses from the most knowledgeable informants and are supported by concurrent ecological research. They also draw upon data of Joyal (1996).

Natural History

Palm workers had a limited view of the geographic distribution of palms, as might be expected by people who do not travel much nor often meet others who do. Many could name the general direction from their homes and say whether palm grew near or far away. Palms were most often cited as growing in drainages (arroyos, bajíos, faldas) or low rolling hills (lomas, planos), often in rocky places (pedregoso), and with woody Fabaceae, especially mesquite (*Prosopis* spp.), and with encino (*Quercus chihuahensis* Trelease). Responses were divided about equally for palms being more abundant, about the same, or less abundant now than in the past. Those who differentiated between palma del suelo (juvenile) and palma del taco (adult palms) said that the former were more abundant now and the latter declining. A few talked about changes in specific populations, e.g., one elderly Buena Vista woman said that palms grew plentifully in the Nácori [Chico] valley (there are a few isolated palms still) when she was young but that people now ride (horseback) several hours to cut cojoyos. Several people specified that livestock eat seedlings during the spring drought when *S. uresana* is one of the few green plants at ground level. Others talked about natural cycles of growth and death. People often added that palms were "not like other plants," and that there were enough, especially palma del suelo.

Estimates of annual leaf production ranged from very few (1–3/yr) to one a month all year (12/yr) to one a month during the monsoon season (4–5/yr). The last estimate, reported by several informants, is supported by ecological data (Joyal 1995). Seven interviewees added that harvesting cojoyos decreased leaf production and slowed palm growth, an observation consistent with results from experimental manipulations (Joyal 1995).

The most common responses to palm age were that they "grow slowly," "are very old," "older than people [live]," or "older than 100 years." Tall adults have been calculated to be 100–200 years old (Joyal 1995). A few people related how individual palms had grown or not grown during their lifetime. Some said that palms grow slowly when they are small and faster as they get larger. One woman said that robust juveniles with long petioles (palma real) never produce trunks. Several informants noted that because harvesting cojoyos slows growth it can be difficult to age a palm. Others talked about variation in growth rates due to habitat or natural differences that exist among individual plants.

Most people who knew when palms flower and fruit were accurate in the time of year reported. Flowering was reported to occur from February to August, but most often March to June. I saw flowers most often in May. Fruits were reported to ripen from June through December, with August through October the most common responses. I have observed ripe fruit in September and October in the sierra and in August only in the desert. Fruiting was said to be abundant but when questioned further many people said that there were good and bad years. Cold temperatures, including late [March] frosts, extremes in rainfall [too much or not enough], or wind, were given as probable causes for poor fruit production. A few people correlated low fruit production in palms with poor fruit set in other species, e.g., mesquite (*Prosopis* sp.) and igualama (*Ficus* sp.).

Chulos (ring-tail cat = *Bassariscus astutus*) were said to eat the fruit of *B. elegans* (Franceschi ex Beccari) H. E. Moore preferentially in the Sierra Aconchi northeast of Ures; coyotes (*Canis latrans*), and zorros (gray fox = *Urocyon cinereoargenteus*) were the major consumers of *S. uresana* fruits in the Río Sonora valley. Zorillos (skunk = *Mephitis* sp?) was also mentioned and ardillas (squirrel) and culebras (snake) were reported to climb the palms to reach the fruits. Palm fruit foragers specified in the mountains included chulugos (coati = *Nasua narica,* similar to matepi), batetis [vatepies = ring-tail cat (Pfefferkorn 1949:114–115)], zorras, coyotes, zorillas, ardillas, javelin(a)s, and cattle.

"Babiso" was a name frequently given to a second palm that grew in north central (*Brahea elegans*) and northeastern (*B. nitida* André) Sonora. Several informants knew its natural history well. *Brahea elegans,* which grows in east central Sonora, was not used much. Questions about other palms in this area seldom elicited it or other names. In southern Sonora, the common thatch palm "coguegue" or palmilla (*B. aculeata*) was often mentioned. Sotol (*Dasylirion wheeleri* Wats.) and palmilla (*Nolina matapensis* Wiggins), palm-like monocots used for weaving (Joyal 1996), were said to grow at higher elevations, usually at some distance from the weavers' homes (nearby only for Mountain Pima).

Harvest Practices

Harvest practices which contribute to overall palm management include limiting access to populations, sparing, and harvesting according to lunar cycles. There is no statewide policy for limiting access to palm populations for harvest. The local offices of the Secretaría de Agricultura y Recursos Hidraulicos (SARH) sometime issue permits to harvest pencas (mature leaves) from the Ures and Alamos areas to construct beach cabins (palapas) along the coast near Bahía Kino and Huatabampo, respectively. A less formal system of "permiso" limits access to many palm populations and hence regulates harvest levels, especially in northeastern Sonora. Cojoyos are sometimes cut by the weaver but are usually obtained by a (male) family member. Palmeros (palm harvesters) request permission from the land owner, either each time or by general permit depending upon their relationship (frequently related by birth or marriage), before harvesting from a population that is not their own. A few informants stated that any one can harvest cojoyos and payment is not required (they are sometimes bought) since there are lots of palms (an exchange of goods and services and/or compadrazgo (family ties) is customary). Some palm workers stressed that asking permission ensures that a palmero knows how to harvest properly. For example, an Ures broom-maker recounted how his cousin felled a tall palm to reach its leaves because he didn't know better. Many populations occur on remote ranches. In areas where access is not easily regulated, e.g., along highways, harvest levels are high. Several informants stated that palms were harvested opportunistically at these locations. For example, another Ures broom-maker stated that he cut from the more vulnerable populations and that he went hidden because few land owners would give him permission to cut pencas (mature leaves).

There are about 15 palm populations in the vicinity of Nácori Chico (northeast). La Ciénaga El Palmar, a three hour ride on horseback, has the largest, densest population of palma del suelo with good quality cojoyos. It is an additional three hour ride past the palms to obtain permission at the ranch house. The owner rarely denies permission to harvesters from Buena Vista but insists that he be asked each time. Consequently, although La Ciénaga is regarded as one of the best sources of cojoyos, the effort required results in people harvesting there less often. In this same area, the infrequent use of babiso was attributed in part to the distance of its populations relative to *S. uresana.*

Palms are spared when clearing land for conversion to pasture or croplands (milpa) in Sonora. The dead trunks are harvested but live palms are seldom or never cut (this is changing) even though they are valued for construction, especially in the desert areas. The most common reason given was "that's how it's always been done." Occasionally, people added that palms were very slow-growing. Sparing is adhered to in much of the state, but less so in the central area. For example, the SARH forester stationed at Sahuaripa reportedly did not permit cutting of live palm trunks. Guisamopa informants reported that some people were cutting live palms and added that SARH could do little to regulate this activity in such remote areas when the inhabitants decided otherwise. In contrast with sparing practices are those which kill or remove entire palms. The harvest of palm hearts kills single-trunked species. This was practiced in northeastern Sonora during the eighteenth century (Nentvig 1977) and in southern Sonora in the 1930s (Gentry 1942:66, 1963:98) but has apparently ceased. Palms are rarely transplanted for horticultural purposes.

As is common in other parts of Latin America (e.g., Joyal 1994), many palm workers restrict harvest according to lunar cycles to insure the longevity and quality of the products. Palm leaves harvested when the moon is less than half full reportedly would not last, would be full of holes, infested with insects, and would not be good quality (tiernita). At several locations, e.g., Rancho El Palmer de Onavas (east central), a rancher clarified that it was the petioles, and not the blades, that were attacked by insects if thatch were cut at the wrong time. Guarihios and mestizos in southern Sonora more often stated that the season of harvest was unimportant but that the moon was; seven days from the new moon was bad. At Rancho Santa Barbara, in the sierra east of Alamos, younger people stated that they probably should adhere to lunar cycles more strictly, but that they didn't except when cutting wood for building or palm for thatch. When questioned further about men seen cutting *B. aculeata* along the road when the moon was less than half full, they said that the men had to be harvesting for sale and not for their own use or else they would have been more careful. When provided an opportunity to harvest, some people pay strict attention to the lunar phase and others relax their standards.

Palmeros obtain the best quality and quantity of fiber by harvesting a leaf that is at the right stage of development for an intended use from the best size palm at the proper time. Hence, leaf harvest is regulated by choice of palm size and leaf age, by controlling harvest times and levels, and also by the effort required to obtain leaves. Taller palms produce the largest leaves with the longest fibers (there was some disagreement about their quality). However, it is the largest juvenile palms, which have long fibers and are easily reached, that are generally harvested for weaving (Fig. 1A). The large leaf size of mature palms and the greater number of leaves produced by them (Fig. 1B) make them preferable for thatching roofs and for broom manufacture.

A cojoyo is harvested only after its petiole becomes visible because its fibers have reached

Fig. 1. Leaf harvest: A) cojoyo harvest from palma del suelo, Rancho Santa Barbara, Mpio. Alamos. Petiole has emerged. B) palma del taco harvested for thatch, R. Las Cabras, Mpio. Alamos. This palm was recently harvested as evidenced by the presence of only two new leaves. The dead leaves below the crown indicate that it was not harvested in the previous year.

their maximum length at this stage. It is also easier to carry because the leaflets cannot accordion-out from the hastula. According to Manuel Silva (Buena Vista), the heart can be damaged and the palm killed if the petiole has not emerged when the cojoyo is cut. Depending upon their precise developmental stage, cojoyos vary in suppleness and color. These properties dictate whether each can be woven into a hat, basket, or mat, or if it can be used only for a broom. Pencas are large but tough and green and are used only for thatching and for making brooms.

The major harvest time for cojoyos is during the summer monsoon season, when the earth is "warm and wet," or shortly before it. Cojoyos harvested at this time are easier to work and therefore the best quality. Indeed, palm workers such as Guadalupe Valencia (Buena Vista) prefaced their responses to questions about harvest with a general statement that "palms have their time," ("tiene su tiempo la palma, sí . . ."). An open question about harvest time, not which months or what time of the moon, most often (51%) elicited the response that cojoyos are harvested only in the late spring or summer (15% said anytime but spring or summer best; 32% said anytime) and close to the full moon (71%). Approximately 75% responded with season first and added the lunar cycle as a secondary qualifier, with or without prompting from me. Pencas were harvested during the spring (or fall) dry season. In the Alamos area, this was specified as after the summer rains and before palms flowers, i.e. late fall through spring.

Given the above practices only one cojoyo per year is harvested from juvenile "palma del suelo." More astute harvesters stated that cutting cojoyos hurts palms, that it slows or stunts their growth, and that palms need to rest between harvests. The standing crop of pencas, i.e. all leaves except the cojoyo, are removed from adult palms once or twice a year.

Palmeros will go to great effort to obtain cojoyos. Gathering trips may be arranged specifically to harvest cojoyos or they may be cut opportunistically in conjunction with other activities. An average yield for an organized foray is 30 cojoyos per burro. On the other hand, harvesting done in conjunction with other activities usually results in fewer than ten cojoyos. Carlos Luna, an elderly Guarihio, recalled how he spent five to seven days travelling one way by foot or donkey in the mountains of Chihuahua (between the Sierras Oscura and Loreto) to gather cojoyos in central Sonora (Rancho Tarahumaris, NNE of Nuri). Likewise, Rogelio Apoderado, the oldest Ures area broom-maker (d. 1994), said that when he lived in Batuc, in the sierra, he had regularly led packtrains to harvest palms near Ures even though *S. uresana* grew near his home. He explained that the desert palms produced better quality cojoyos than those near Batuc (Joyal 1996). Villagers in central Sonora reported that the Mountain Pimas regularly travelled a long distance and down in elevation to harvest cojoyos in this area until recently. They now mostly rely on intermediates to harvest for them. Some people have access to only a single palm population while others have two or more choices. Tepoca informant Cuca Valenzuela (d. 1993) harvested from two populations, Ranchos Yerbanis and El Palmar de Onavas. She maintained that the former had better quality cojoyos. However, her ranch was near El Palmar, which was on the main highway, and her compadre worked there. Thus, she almost always cut cojoyos at El Palmar rather than Yerbanis. In contrast, leaves for thatch are difficult to transport and are used only when they are readily accessible and easily transportable.

Harvest Measurements

Cluster analysis identified two major harvest patterns among 16 populations censussed statewide, those with a small number of contiguous size-classes harvested, e.g., only palma del suelo, and those with all except seedlings harvested (see Joyal 1995). Within these clusters, harvest levels varied from zero to very high percentages. For example, palma del suelo was harvested for cojoyos at Ranchos La Noria (north central), La Ciénaga (northeast), and Los Bajíos (south). The first, a protected population, was lightly-harvested; the second, a remote population with regulated harvest, moderately so; and the third, a small population near a Guarihio village, very heavily. The most accessible populations had all size-classes harvested. For example, pencas had been heavily harvested for broom-making from all except seedlings at Rancho La Raja (north central), located near a major road. Rancho El Palmar, located on a major highway, was likewise heavily harvested. Given the low number of palma del taco there, the major harvest was of cojoyos from palma del suelo. In contrast, at Rancho Las Cabras, a short walk from Alamos (south), the population was comprised largely of palma del taco which was cut for thatch on a regular basis.

Palm leaf production and size gradually increases with size-class, a rough estimate of age. Experimental manipulations found that both traditional and over-harvest of cojoyos reduced annual leaf production significantly but that penca harvest did not. Response to harvest was also greater for smaller size-classes across all harvest types. A trend toward decreased petiole width following harvest was noted, i.e. new leaves were smaller than leaves produced prior to harvest. Moreover, when the petiole widths for harvested and unharvested palms from the 16 population transects were compared, the former were significantly smaller than those of the latter. This supports the trend observed in the experimental harvest and strengthens claims made by several palm workers that harvesting palms reduces growth.

One hundred and twenty-six cojoyos that had been cut at 10 different populations and that were present in eight weavers' homes in northeastern and east central Sonora were measured (Table 1). The number of improperly cut cojoyos varied from 0 to 53% per harvesting event. Petiole width averaged 3.2 cm (13.5% < 2.5 cm wide) and mean leaf length was 114.1 cm. No difference in petiole widths between the two areas was detected using a nested ANOVA (it would be significant using a random effects model). There were differences among the 11 harvesting events within these areas (fixed or random effects), however (Table 2). Two harvesting events (harvester MS at two different populations) differed from five other harvesting events (Tukey test). The mean petiole width (2.68 cm) cut by BC at Rancho El Palmar was less than those harvested by MS at Rancho Los Pescados (3.66 cm). However, the mean size cut at Los Pescados was 1.27 cm larger than the population mean (2.39) while those harvested at El Palmar averaged 0.25 cm less than the population mean (2.92) there (Table 3; Fig. 2). It appears that MS was a highly selective harvester, cutting only the largest cojoyos at Los Pescados, whereas BC cut cojoyos representative of the population at El Palmar.

Ecological Measurements and Matrix Model

Results of the concurrent ecological research have been introduced in the preceding sections, e.g. leaf production rates; details are described in Joyal (1995). A summary of results from the matrix model is given here in order to better understand palm workers' responses and the implications for TEK and TRM. The model produced $\lambda \geq 1.0$ for 1992 and 1993 for the Ures population, i.e. it is stable but almost static (λ is defined as the finite rate of growth of a population). Elasticity analysis (a method to determine the relative contribution to λ of each parameter by size-class) indicated that survival, especially of the larger size-classes, accounted for ca. 90% of elasticity. The stable-stage distribution projected over 256 years differed from the present size-class distribution, most notably in the low number of immature palms at present.

A simulation which reduced juvenile growth as a response to increased harvest lowered λ slightly. The new projected stable-stage distribution had more juvenile and fewer immature palms than the original model. This supports the idea that leaf harvest has a subtle, long-term impact and offers an explanation for the bimodal size-class structure observed in some populations. Simulating increased mortality for juvenile palms as a response to incorrect or overharvest decreased λ still further. Its projected stable-stage distribution had even fewer immature palms than the original model and the first

TABLE 1. HARVESTED COJOYO MEASUREMENTS[1] FROM NORTHEASTERN AND EAST CENTRAL SONORA.[2]

Area	Weaver, date & population	# cojoyos cut	Mean cojoyo length (cm)	Mean petiole width (cm)	Cut petioles
Buena Vista/Bacadéhuachi (Mpios. Nacori Chico and Bacadéhuachi)	MS, 6/13/92, Los Pescados	8	114.0 (17.0)	3.7 (0.59)	0
	MS, 6/15/92, El Alamo	2	109.0, 112.0	4.0, 4.2	0
	JC, 6/17/92, El Palmar	6	113.5 (9.0)	3.4 (0.36)	0
	MS, 8/23/93, Napopa	21	112.9 (9.6)	4.2 (0.59)	6
	VM, 8/26/93, El Alamo	19	114.2 (8.5)	2.9 (0.59)	6
	ED, 8/26/93, El Saucito	15	114.3 (16.0)	3.2 (0.86)	8
	RM, 8/29/93, La Ventana	16	109.4 (11.4)	3.1 (0.82)	5
East central (Mpios. Yécora and Sahuaripa)	BC, 7/11/92, El Palmar	20	118.5 (7.3)	2.7 (0.46)	1
	MT, 7/13/92, Yerbanis	2	110.0, 120.0	3.3, 3.5	0
	GC, 10/20/93, Sahuaripa?	9	110.0 (6.6)	2.6 (0.22)	2
	JC, 10/24/93, Guisamopa	8	120.6 (9.8)	3.3 (0.31)	1
Buena Vista total		87	112.7 (11.5)	3.5 (0.8)	25
East central total		39	116.0 (8.4)	3.0 (0.5)	4
Total		126	114.1 (10.8)	3.2 (0.77)	29

[1] Measured below hastula, at top of petiole where it joins leaf blade.
[2] Cojoyos measured in weavers' homes whenever available.

simulation and suggests yet another explanation for bimodal size-class distributions.

SYNTHESIS

Ten of the 12 variables identified from 47 formal taped interviews were highly inter-correlated ($r \geq 0.29$). Using a weighted mean of the variables, the average score for Buena Vista palm workers area was higher (2.08/3.33 max) than those from all other areas combined (1.32). These differences were significant only between Buena Vista and east central Sonora, however (Tukey test). In a Principal Components Analysis of these data, the first factor appears to represent overall palm TEK (Fig. 3). It explains 52.3% of the variance and the same ten variables fall here, thus reinforcing the results from correlation. The second factor ($s^2 = 10.3\%$) is mostly explained by knowledge of other palms and weaving plants. People with higher scores (> 2.50) fall in the tightest cluster to the right and scores decrease to the left. If residence, harvester status, or gender are superimposed on these points, more people from Buena Vista, harvesters and men fall in this cluster.

Six harvest practices (time of year, lunar phase, palm size, cojoyo size, petiole, permiso) were all positively correlated; seven of 15 pos-

TABLE 2. DIFFERENCE IN PETIOLE WIDTHS FOR HARVESTED COJOYOS BETWEEN AREAS USING A NESTED ANALYSIS OF VARIANCE.

Area	F	d.f.	*P*
Buena Vista/Bacadéhuachi	2.6377	1, 11.60	0.1312
East central	6.5983	9, 115	0.0001

TABLE 3. COMPARISON OF MEAN PETIOLE WIDTHS OF COJOYOS CUT BY TWO HARVESTERS AT DIFFERENT RANCHES.

Harvester	Population	Mean petiole width/pop. (cm)	Mean petiole width cut (cm)	t	t_{crit}[1]
BC	El Palmar de Onavas	2.92	2.68	−4.26	2.01
MS	Los Pescados	2.39	3.66	1.76	1.98

[1] $\alpha = 0.05$ (2); d.f. = 50.

sible comparisons were significantly so ($r \geq 0.29$) (Table 4). The highest correlations were between time of year harvested and palm size harvested (0.54), adherence to lunar phases (0.48), and cutting cojoyos with petioles (0.43). This suggests that there is a suite of practices that are either adhered to by palm workers or not. For example, those who said that they harvested only during a specified time were more likely to say that they also cut only certain size palms with petioles. Cojoyo size was the most weakly correlated factor not because it was unimportant ($r^2_{\text{petiole width, size-class}} = 0.78$) but because there was not enough variation in response to separate it well.

The highest positive correlations for four areas of palm knowledge were for the manufacture of palm products and knowledge of them and for TEK and TRM and products known (Table 5). In other words, making palm products is related to knowledge of the range of palm products made, but it may or may not have anything to do with whether a person is involved in palm harvest or if they have opportunities to observe palms. Thus, making palm products was only weakly correlated with TEK and TRM (but see residence below).

The three most important demographic variables associated with people's knowledge of palms were residence, harvester status, and gender (Table 6). Age and formal education had no significant effect on scores. However, those who scored higher were often older and none had more than a primary school education. Residents of northeast Sonora scored higher than the three other areas for knowledge of palm products,

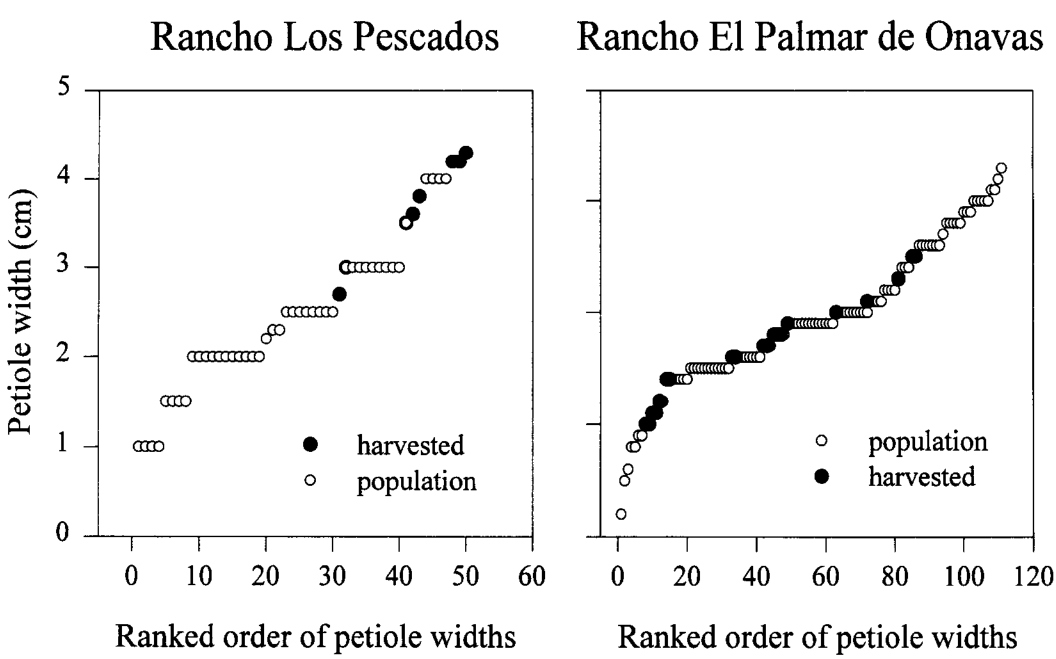

Fig. 2. Cojoyo harvest: harvester selectivity, harvested cojoyos vs population measurements for MS at Los Pescados, Mpio. Nácori Chico, and for BC at El Palmar de Onavas, Mpio. Yécora.

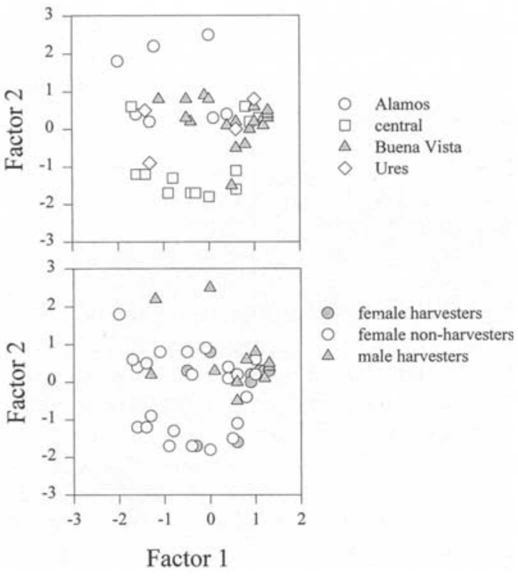

Fig. 3. Knowledge of palm natural history: principal components analysis by residence and by gender/harvester status.

higher than the southern and north central areas for number of products made, and higher than central Sonora for TEK (Tukey test). Harvesters scored better than nonharvesters on TEK, TRM, and knowledge of palm products. There were differences in TEK both by residence and by harvester status (2-way ANOVA; Table 7). Residents of the northeast scored higher than those in the east central and south areas but not the north central area (probably due to small sample size) (Tukey test). Northeastern harvesters scored similarly to harvesters from other areas and higher than nonharvesters from the northeast for TEK (Tukey test, harvester status by each residence area separately). Scores for non-harvesters from the northeast were similar to harvesters and higher than non-harvesters else-

TABLE 5. PALM PRODUCTS MADE/USED, KNOWN, TRM, AND TEK: CORRELATION MATRIX.[1]

	Products made	Products known	TRM	TEK
Products made	1.00			
Products known	**0.51**	1.00		
TRM	0.27	**0.43**	1.00	
TEK	0.24	**0.57**	**0.58**	1.00

[1] $r_{0.05(2), 45} = 0.288$; n = 47; significant correlations are boldfaced.

where, however. The pattern between residence and harvester status held for TRM scores but was not significant (ANOVA main effects: northeast > other areas; harvesters > non-harvesters).

Men scored higher on TEK than women (t = 4.30, $t_{crit, \alpha = 0.0017 (2), d.f. = 45} = 2.01$, p = 0.0001). There were significant differences among male harvesters, female harvesters, and female non-harvesters (there were no male non-harvesters) (1-way ANOVA, Table 8). Female harvesters scored higher than female non-harvesters but there was no difference between male and female harvesters (Tukey test). A 2-way ANOVA of residence and gender was not run because the overlap of gender and harvester status by residence area was such that it would likely produce results similar to those obtained for residence and harvester status. Still, northeastern women would most probably score similar to men elsewhere and higher than women elsewhere on TEK.

"Sonoran" mestizos scored better than indigenous palm workers for all four areas of palm knowledge. This may be due in part to the low number of indigenous palm workers interviewed (two Guarihio and no Mountain Pima men) coupled with the confounding relationship of gender and harvester status. Both indigenous groups also lived far from palms. There is a stand of *S.*

TABLE 4. COJOYO HARVEST PRACTICES AND RESTRICTIONS: CORRELATION MATRIX OF RESPONSES.[1]

	Time of year	Lunar phase	Palm size	Cojoyo size	Petiole	*Permiso*
Time of year	1.00					
Lunar phase	**0.48**	1.00				
Palm size	**0.54**	**0.29**	1.00			
Cojoyo size	0.21	0.20	0.01	1.00		
Petiole	**0.43**	**0.34**	0.20	0.12	1.00	
Permiso	0.23	**0.29**	**0.39**	0.03	**0.34**	1

[1] $r_{0.05(2), 45} = 0.288$; n = 47; significant correlations are boldfaced.

TABLE 6. RELATIVE SCORES FOR PALM TEK, TRM, PRODUCTS KNOWN, PRODUCTS MADE/USED, AND HARVESTER STATUS BY SELECTED DEMOGRAPHIC FACTORS: SUMMARY FROM INTERVIEWS. THE DEMOGRAPHIC FACTOR WHICH PRODUCED THE HIGHEST MEAN FOR EACH VARIABLE IS LISTED FIRST (TOP), THEN THE SECOND LARGEST MEAN, ETC. MEANS THAT ARE SIGNIFICANTLY DIFFERENT THAN THE OPPOSING VALUE (E.G., GENDER = MALE VS. FEMALE) USING T-TESTS ($\alpha = 0.05$) ARE ITALICIZED (E.G., *GENDER = MALE*); THOSE THAT ARE DIFFERENT USING A BONFERRONI CORRECTION FACTOR FOR MULTIPLE T-TESTS ($\alpha/30 = 0.0017$) ARE IN BOLD ITALICS (E.G., ***GENDER = FEMALE***).

Relative mean score	TEK	TRM	Products known	Products made/used	Harvester
high	***gender = male***	residence = BV	***residence = BV***[2]	***residence = BV***[3]	***gender = male***
	harvester = yes	*harvester = yes*	education = 1–5 yrs	***gender = female***	ethnic = mestizo
	residence = BV[1]	***ethnic = mestizo***	*harvester = yes*	education = 1–5 yrs	residence = BV
	ethnic = mestizo	gender = male	***ethnic = mestizo***	age = ≥60 yrs	education = 1–5 yrs
	education = 1–5 yrs	age = ≥60 yrs	gender = male	ethnic = mestizo	age = <60 yrs
low	age = ≥60 yrs	education = 1–5 yrs	age = <60 yrs	harvester = no	

Tukey tests for residence: [1] BV > central Sonora; [2] BV > all other areas; [3] BV > Ures, Alamos.

uresana a short walk from Los Bajíos but it consists of a mere 24 heavily-harvested juveniles and the next closest population is a full day's walk. Most indigenous weavers said that they had rarely, if ever, seen a palm and that a male relative or acquaintance harvested afar and did not discuss palms. The Mountain Pima travelled to east central Sonora to harvest cojoyos in the past but now more often rely on intermediates to harvest for them. The one indigenous palm worker with the highest TEK score was a Guarihio man who had recently relocated from the Chihuahuan sierra and who for many years had travelled for days to harvest cojoyos in east central Sonora.

DISCUSSION

While harvest practices were most often stated as managing for the quality and quantity of palm fiber, and not for population maintenance, it may be that the former contributes to the latter. Harvest practices appear to be effective at maintaining and/or increasing the yield and quality of palm products while minimizing negative impacts on the resource. Management can be divided into two components which function at very different levels in Sonora: "alpha," or long-term practices, and "beta" practices, which function on a shorter term.

Given that survival accounted for about 90% of elasticity, sparing, the practice of not cutting live palms, is the single most important contributor to alpha management. Sparing of palms ensures that populations will be there in 100 or 200 years or more, similar to the "seventh generation" concept (Clarkson, Morrissette, and Regallet 1992). It functions more or less as a taboo in Sonora, i.e. "a prohibition imposed by social usage or as a protective measure" (Webster's Seventh New Collegiate Dictionary 1971). A number of populations appear to be "living dead," i.e. they do not appear to be reproductively viable (Janzen 1988). While the adults have been spared, seedlings and juveniles cannot establish under present land-use. However, due to their long life span, these populations might be recovered if practices such as restricting spring grazing were used to protect establishing young palms. Also, maintaining these populations may reduce harvest pressure on other populations.

Growth and fecundity, the two remaining parameters in the model, are affected by harvest

TABLE 7. TWO-WAY ANALYSIS OF VARIANCE OF RESIDENCE AND HARVESTER STATUS FOR TEK SCORES.

Factor	d.f.	F	*P*	Tukey
Residence	3	4.82	0.0060	BV vs. central
Harvester status	1	31.19	0.0001	
Residence*harvester status	3	1.37	0.2650	

practices. While more subtle, the model simulations demonstrated that changes in growth rates could alter population structure over time. A suite of harvest practices, including restricting palm size and leaf age, and regulating harvest times, levels, and access, (and land-use) thus contribute to overall population maintenance, or beta management.

By cutting cojoyos from the more robust palma del suelo a harvester not only gets more fiber (larger quantity and longer fibers) for less effort, s/he also restricts harvest to larger individuals which respond less adversely to leaf removal. Thus, selective harvesters who cut only the largest cojoyos have less impact on a population than those who harvest whatever they can find. There is less impact from harvest on palma del taco because it produces more leaves per year than palma del suelo and, like other palm species (Pinard and Putz 1992), appears to respond favorably to removal of the standing crop of pencas.

Given the small number of leaves produced each year, a large share (ca. one-fifth to one-third) of palma del suelo's annual energy expenditure is invested in each cojoyo. If it is removed just as the palm is about to recoup its investment in leaf production (through photosynthesis), it represents a high cost to a young palm. If this happens frequently the palm may not grow or it may even decline. Penca harvest removes leaves after three to nine months of peak photosynthetic activity (they last about two years). Because leaves photosynthesize most efficiently when they are young (Chabot and Hicks 1982), the palms are able to recoup their initial energy investment in the leaf and then some prior to harvest. Thatch harvesters in Yucatan maintain the height of adult *S. mexicana* Martius by regulating harvest levels (Caballero 1994). This suggests that although palms may produce the same number of leaves, or more, in response to harvest there may be a trade-off. I have no information to suggest that this is done deliberately in Sonora.

TABLE 8. ONE-WAY ANALYSIS OF VARIANCE OF HARVESTER STATUS AND GENDER FOR TEK SCORES.

Factor	d.f.	F	*P*
Harvester status and gender[1]	2	12.20	0.0001

[1] Three groups: female non-harvesters (weavers), female harvesters (harvester/weavers), and male harvesters.

Most leaves are produced during the summer rainy season, the major harvest time for cojoyos. While the photosynthetic potential of the cojoyo is lost, another arises in a month or so. This is likely important for minimizing energy deficits in young palms which produce very few leaves each year. By restricting thatch harvest time to the spring dry season, the most productive young leaves can photosynthesize for several months before they are removed. Although the effect of lunar cycles has not been studied much, it may be that it reduces harvest pressure by adding yet another restriction to harvest.

An important element in regulating a common-pool resource is to clearly identify who can extract resources under what conditions (Ostrom 1990). The system of "permiso" in place for palm harvest in Sonora regulates harvest levels by limiting the number of people who have access. It also protects palms because only people who know how to harvest correctly are allowed to do so. While there were many people who stressed the importance of asking permission, this system breaks down in areas where there is no way to limit access to the palms. For example, the highest harvest levels were found in roadside populations or within a short walk of villages. Not all people consider asking permission to be important. In east central and southern Sonora people who cut cojoyos without permission said that they did so simply because the palms were there and the owner was not. At Los Bajíos anyone from the village was free to harvest cojoyos from the tiny population of palma del suelo nearby since the land was an ejido (collectively-owned lands). All palms were heavily harvested. Because more vigilant ranchers in the Ures area will not allow local broom-makers to harvest pencas, some broom-makers now cut without permission at more accessible populations where they know it is unlikely that they will be caught. Thus, while the potential yield of some populations may go unrealized, preferential harvest in easily accessible locations threatens the extinction of other populations (Bodley and Benson 1979).

During the course of interviews, Sonoran palm workers were able to relay information on palm TEK and TRM that were well supported by concurrent ecological studies. This knowledge, however, was not general among palm workers. Much of what constitutes management in this system appears, in hindsight, to be little more than "common sense." The term is a misnomer because common sense is in fact learned behavior, a way of integrating information and applying it to new situations that is so basic that we forget that it had to be learned. For instance, it "makes sense" that younger palms respond more adversely to harvest. Then why did Ures broom-makers insist that the size of a palm didn't matter (except that larger palms produce more and larger leaves) while Buena Vista weavers said that it did? It is these types of practices that are easily overlooked and apt to be lost as a result of acculturation and changing market demands on resources. Both are modifying traditional use of palms, resulting in the over-exploitation of many species (e.g., Uhl and Dransfield 1987). For example, in Botswana, a sharp increase in demand for the Mokola palm (*Hyphaene petersiana* Klotzsch) for basket-weaving due to its shift from subsistence use to commercialization has led to over-harvest (Cunningham and Milton 1987).

Every culture has its natural scientists, but the average person is not one, i.e. it takes a certain aptitude and training to become a good scientist (Berlin, Breedlove, and Raven 1974). By being able to predict who understands TEK and TRM, it should be easier to identify individuals who can work with scientists, bureaucrats, and the local-community to develop effective conservation measures (DeWalt 1994). Several demographic factors appeared to play a role in what people knew about the palm resource. Palm workers from northeastern Sonora on the average understood more about palms than those from the other three areas. Why might this be so? While rural households across Sonora relied upon palms for part of their livelihood and took an interest in palms, Buena Vista was the only town whose focus was palms. There seemed to be a general underlying interest in palms. People talked about palms more and asked returning "palmeros" how the palms appeared on a particular trip. They lived close to the palms, physically and otherwise, and they maintained an active oral tradition.

Harvesters have more opportunities to observe natural history and harvest impacts on palms. Because they provide the raw materials, it makes sense that they would also know more about which products are made from palms. While it appears that being a harvester is more important than gender for TEK, harvester status is strongly influenced by gender. Overall, men scored higher on TEK because they were always harvesters yet women who harvested scored similar to men. Residence played a role in what non-harvesters knew about TEK. In the northeast non-harvesters scored lower on TEK than harvesters, but scored similar by to harvesters and higher than non-harvesters elsewhere. The same pattern holds for gender and residence. It appears that the difference in TEK scores among areas can be explained more by the relatively high scores of non-harvesters and of women in the northeast than by the high scores of harvesters and men there.

That Sonoran mestizos scored better than indigenous people is undoubtedly related to their distance to palms, the gender/harvester issue, and sample size. Two other possible explanations involve communications. One may be cultural, i.e. while I met several Guarihio and Mountain Pimas that I communicated with easily, as a whole they were more reserved than most mestizos. There also seemed to be a lack of oral tradition for palms among these people.

That palm workers came only from the ranks of the formally un-educated and under-educated is noteworthy. Many young people now go to school in the larger cities. Few return. Those who do usually do not want anything to do with palm weaving. While the finished craft is admired, the socio-economic status of the person creating it most often is not. This has led to an increasingly older population of palm workers. However, that the younger half of palm workers did not score differently on TEK than the older half suggests that the transfer of traditional knowledge is still passing from one generation to the next.

CONCLUSIONS

First, the perception of management in the western scientific tradition may be different from how it is perceived in another culture. The net result, however, may be the same. Local beliefs and practices which we do not understand need to be evaluated quantitatively. As an ethnoecologist, sparing was a practice that I recognized as having management implications. Nevertheless, the impact of this practice could not be assessed until the population models were run.

Second, identifying who is likely to know the right answers rather than assuming who we think should know them is an important first step in documenting traditional knowledge systems for wild-harvested plant resources. Much to my surprise, the people who understood TEK and TRM well were more often mestizos, albeit descended from indigenous peoples. Being a member of an extant indigenous group may not be as important as maintaining a good oral tradition is, no matter how this is accomplished. Mestizos, who until recently have been mostly forgotten by ethnobotanists, are the inheritors and developers of regional native traditions (Benz et al. 1994; Mejia 1988).

Third, many traditional cultures are in a rapid stage of transition. Those who are closest to the land and understand it the best are usually the poorest and have the least formal education. Slowly, their knowledge of the world around them, accumulated through countless generations, is eroding. They are admired, on the one hand, for their knowledge of the land, and on the other hand, looked down upon for their old-fashioned ways. When they die their grandchildren may keep a palm "guari" in the living room. Most want no reminder of a life of poverty. The people left in the countryside, or relocated into towns by poverty or "narcotraficos," look for ways to earn extra money and decide to weave articles for tourists. With so much demand and so little experience, the palms are soon over-harvested. Could it have been otherwise? TEK and TRM, developed in subsistence economies and combined with western scientific methods, offer the best approach to future management of wild plant resources made scarce by changing cultures and economies.

Finally, the ecological and ethnographic methods employed in this study were not new. It was their combination, using descriptive, experimental, and modelling techniques, that was. This study may serve as one prototype for the more rapid assessment of the conservation status of scientifically poorly-known but economically important wild-harvested plant resources, their management, and the role of traditional people in this process.

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