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INTERSPECIFIC RELATIONSHIPS AFFECTING ENDANGERED SPECIES RECOGNIZED BY O'ODHAM AND COMCÁAC CULTURES

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Abstract. Because certain indigenous peoples have lived in the same habitats for centuries, their languages often encode traditional ecological knowledge about interactions between plant and animal species that occur in those habitats. This local knowledge is sometimes complementary to more broadly derived knowledge accrued by academically trained field ecologists. In this analysis of recent ethnoecological studies from the Sonoran Desert, it is clear that O'odham and Comcáac foragers recognize, name, and interpret ecological interactions among locally occurring species, regardless of whether these species directly benefit them economically. It is demostrated how their knowledge of ecological interactions involving threatened species may offer Western-trained scientists and resource managers hypotheses to test, and to apply to endangered species recovery efforts. It is proposed that endangered species recovery teams include local para-ecologists from indigenous communities to aid in the integration of knowledge bases derived from various cultural perspectives.

Key words: biodiversity; Comcáac (Seri); conservation; deserts; ecological associates; endangered species; ethnoecology; indigenous peoples; interaction diversity; O'odham; Traditional Ecological Knowledge.

INTRODUCTION

Slowing the loss of diversity is currently a major preoccupation of both conservation biologists concerned with disappearing species (Wilson 1992) and linguistic anthropologists concerned with disappearing languages (Zepeda and Hill 1991, Hale 1992, Harmon 1995). Yet, the intervention strategies chosen will vary greatly depending on who one involves in defining these problems, what one considers to be the knowledge bases relevant to protecting biodiversity and linguistic diversity, and how one identifies proximate and ultimate threats that need to be curtailed (Nabhan 1994).

In practice, biodiversity has been discussed largely in terms of "species richness," although most conservation biologists recognize the contribution of other levels of biological organization (genetic variation with populations, variability between populations, habitat heterogeneity, ecosystem diversity) that are more difficult to monitor or measure (Office of Technology Assessment 1987, Harmon 1995). As Thompson (1996: 300) has recently argued, "the diversity of life has resulted from the diversification of species and the interactions that occur among them . . . nevertheless, the focus of studies on the conservation of biodiversity has often been primarily on species rather than interactions." In many cases, ignorance of biotic interactions has led to the decline of a particular plant or animal species that has lost its ecological associates, even though they may occur within a formally protected area such as a national park or forest (Suzan et al. 1994, Buchmann and Nabhan 1996, Tewksbury et al. 1999).

Similarly, most assessments of linguistic diversity focus merely on how many extant languages there are ("language richness"), on the declining abundance of living speakers of indigenous languages ("speaker richness"), or on the erosion of idiomatic vocabularies ("lexical richness"). Linguists have barely begun to consider the influences of interactions between cultures, let alone the influences of interactions among cultures and co-occurring species, although explorations of these topics are within the mission of a new professional organization, Terralingua. There is, however, an older tradition of inquiry that considers both cultural–linguistic and biological diversity: *ethnobiology,* the study of cultural perceptions and management of the earth's biodiversity. Unfortunately, most ethnobiological inventories only scratch the surface of indigenous knowledge about the biodiversity, by merely recording indigenous names for biota and by cataloguing their uses. Such descriptive, purely utilitarian ethnobotanical surveys tell us hardly anything about how the natural world works from an indigenous perspective, assuming perhaps, that indigenous people are not generally interested in interspecific relationships or ecological processes, but only in useful species.

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Thus, some evolutionary ecologists have remained skeptical when ethnobiologists speak of indigenous peoples as sources of "traditional ecological knowledge" because these scholars are unaware of any detailed examples from ethnobiological field studies that demonstrate any unique knowledge of interactions among species and their habitats. At first glance, many of the published inventories of useful plants and animals named in native languages typically appear to be lacking any ecological or evolutionary context. However, many ethnobiologists would argue that such empirical knowledge of interaction diversity is embedded in their work, although it is seldom presented in ways that biologists without linguistic or anthropological training can easily access.

I propose that more ethnobiologists should explicitly focus their inquiries on traditional ecological knowledge of interspecific interactions, and communicate their findings in formats that conservation biologists can understand and apply to endangered species recovery efforts. When the uninitiated read ethnoecological accounts, some of the indigenous observations recorded there may seem irrational or counterintuitive at first, but may, in fact, be linguistically encoded means of validly explaining certain relationships between plants and animals (Anderson 1996). I will demonstrate that, once understood, the O'odham and Comcáac oral traditions can be seen to include many insights about interspecific relationships that may have escaped notice by field biologists. In addition, some indigenous hypotheses about the nature of plant–animal interactions can be tested by Western scientific means, resulting in additional insights of significance to ecological and evolutionary theory. I will offer specific examples of how ethnoecological studies of interaction diversity can contribute to the conservation of biodiversity, particularly when the relationships recognized and described by indigenous peoples affect endangered or endemic species. Finally, I will suggest a few ways in which academically trained conservation biologists can foster collaborations with indigenous parabiologists to ensure cross-cultural involvement in species recovery programs.

Methods

I will use examples from just two cultural groups within the Sonoran Desert with whom I have studied for two decades: the Comcáac or Seri, a group of Hokan speakers in Sonora, Mexico; and the O'odham (Desert Papago, Sand Papago, River Pima, and Lowland Pima, groups of Uto-Aztecan speakers in Arizona, USA and Sonora, Mexico). The Comcáac or "Seri," as they are commonly called in Mexico, number fewer than 600 individuals residing in two permanent villages and several temporary fishing camps on the Sea of Cortez coast of Sonora, Mexico near Tiburón Island, which is also part of their aboriginal territory. The O'odham or Northern Piman speakers number 18 000–21 000 individuals living in south-central Arizona, United States, and 1000–2000 in adjacent Sonora, Mexico. I have interviewed between 50 and 100 individuals, among older generations, in each of these two linguistic communities. Interviews were typically accomplished in Spanish and English; native terms in *Cmique Iitom* (Seri) and *O'odham ha-neokĭ* (Piman) were used as prompts. When interviewing monolingual speakers, I was usually accompanied by bilingual relatives of the person(s), who translated and verified my understanding of the person's responses. On several occasions, sightings of the rare plant or animal elicited commentary; in most cases, however, because of the rarity of the organisms, photos and drawings of the organisms in question were utilized to elicit discussion. Folk taxonomic information for the O'odham and Comcáac was corroborated by consulting recently-completed linguistic and ethnographic works (Nabhan 1982, Rea 1983, 1997, Felger and Moser 1985) as well as my own Comcáac ethnoherpetological overview (Nabhan, *in press*).

Results

In Table 1, I have listed all plant and animal names that I have encountered in *O'odham ha-neokĭ* (Piman) that apparently refer to interspecific interactions, particularly those between plants and vertebrate animals, with birds and mammals given special emphasis. Table 2 provides a similar inventory for *Cmique Iitom* (Seri), including all names that apparently refer to interspecific interactions between plant species, between plants and reptiles, or between animal species. These lists were used as points of departure for asking Comcáac and O'odham elders about their knowledge of any ecological interactions described or implied by the names. In accomplishing these interviews, I also learned of additional interspecific relationships observed by the Comcáac and O'odham, but not codified in their lexicon of names for local biota. These interrelationships are discussed in the following sections, with selected examples interpreted in depth.

Discussion

One of the earliest definitions of ethnoecology was published by Harvard Botanical Museum ethnobotanists Robert Bye, Jr. and Maurice Zigmond (1976): "the area of study that attempts to illuminate in an *ecologically* revealing fashion man's interactions with and relationship to his environment." I prefer to broaden this definition by recognizing that ethnoecology "attempts to illuminate a cultural community's knowledge of ecological interactions among humans and other animals, plants, and their habitats, including its own influences on such interspecific relationships."

Despite the fact that hundreds of ethnobiological books and journal articles have been published since

TABLE 1. Interspecific relationships encoded in the biosystematic lexicon of the O'odham.

O'odham name	Translation	Species	Notes	Reference	Plant/ animal
Kakaicu e'es	quail's plant	*Heliotropium curassavicum*	possible forage	Nabhan et al. (1989), Rea (1983)	p
Kuidad	mesquite knocker	*Colaptes auratus*	frequent nesting habitat	Rea (1983)	a
Kuigam	mesquite owner	*Phainopepla nitens*	bird whose tree is host to parasitic mistletoe that is eaten and dispersed	Nabhan et al. (1989), Rea (1983)	a
Makkom ha-jew-ed, makkom je:j	sphinx moth's ground (or its other)	*Boerhaavia erecta, Boerhaavia intermedia*	larval host plant	Nabhan (1997); Rea (1997)	p
S-baban makam	coyote's eatings	*Calamospiza melanocorys*	possible predator–prey relationship	Rea (1983)	a
Vakoin ha:k	heron eagle	*Pandion haliaetus*	predator with parallel foraging strategies	Rea (1983)	a
Vipismal je:j	hummingbird's mother	*Justicia californica*	nectar source	Rea (1983)	p

Note: In the last column, p = plant; a = animal.

1976, few scholars have intentionally emphasized what kinds of ecological interactions indigenous communities recognize, name, interpret, or manage. Fewer still have chosen to focus their research on indigenous knowledge of interspecific relationships among plants and animals. The exceptional studies that have had such a focus, although few in number, suggest that indigenous recognition of, and interest in, biotic interactions is geographically widespread, from the temperate rain forests (Nelson 1983, Turner 1997), to arid coastal scrublands and mangrove lagoons (Felger and Moser 1985, Nabhan, *in press*), to lowland tropical rain forests (Hunn 1977, Vasquez-Davila 1995).

The kinds of interspecific relationships alluded to in O'odham and Comcáac lexicons (Tables 1 and 2) refer to the following ecological interactions and processes: (1) predator–prey; (2) ectoparasite–host; (3) forager–forage; (4) mimic–model (in camouflage); (5) dweller–dwelling (micro–habitat provider).

Embedded in any folk taxonomy are numerous references to interactions or analogies among taxa. In some cases, names may make evident a particular similarity in the color, texture, taste, or shape between two species. For example, the Comcáac liken the mottled color pattern of the fruit of *Sideroxylon occidentalis* to the beaded skin of the gila monster (*Heleoderma suspectum*); they refer to both by the name *paaza.* Yet, this does not imply that gila monsters eat the fruit. A superficial analysis of the folk taxonomy of the Comcáac (Felger and Moser 1985) might initially suggest that 10% of their names for specific plants, what linguists call terminal ethnotaxa, refer to interactions with fauna. However, my follow-up interviews with the Comcáac reveal that 4% of their terminal folk taxa specifically refer to interactions between local populations of native plants and animals, whereas many more names may have metaphorical or mythic meanings that also reinforce cultural ethics and values concerning wildlife.

A word of clarification on terms may be necessary here. One should keep in mind that a plant name might be a compound lexeme, that is, a multi-word term, such as one with an animal's name embedded within it, e.g., "Coyote's tobacco." Such a name refers to the inferior quality of *Nicotiania trigonophylla* for smoking brought about by the mythic trickster Coyote, and not to foraging on this plant by desert coyotes *Canis latrans* (Nabhan 1982). In contrast, at least 19 plant names used by the Comcáac refer to interactions between flowers and their pollinators, fruits and their seed dispersal agents, foliage and its herbivores or flailers, larval host plants and their larvae, brushy canopy-providers and dormant or reclusive animals, algae associated with sea turtle carapaces, and nest-providing canopies and their nesting birds (Table 2). In such cases, it is reasonable to assume that plant names that recognize their faunal associates are derived from empirical observations of plant–animal interactions.

Similarly, animal names may include reference to particular plants. For example, the O'odham call the Phainopepla (*Phainopepla nitens*) *kuigam,* meaning "mesquite dweller" (Nabhan et al. 1982, Rea 1983). Not only do Phainopeplas dwell in mesquite (*Prosopis* spp.), but also they are the major agents dispersing parasitic mistletoe (*Phoradendron californicum*) to mesquite.

In special cases, the same lexeme is polysemic for both a plant and an animal, usually when the relationship between the two is unusually robust. One such case of polysemy comes from the Chontal Maya, whose name for the Great Kiskadee (*Pitangus sulphuratus*) and for wild chile peppers (*Capsicum annuum*) is the same lexeme. The Chontales and their mestizo neighbors recognize the Giant Kiskadee as an important seed

TABLE 2. Interspecific relationships in biosystematic lexicon of the Comcáac.

Comcáac name	Translation	Scientific name	Notes	Reference	Plant/ animal
Hamisj catojoj	limberbush's hider	*Oxybelis aeneus*	snake mimicking vine	G. P. Nabhan, *unpublished data*	a
Hamooja ihap	pronghorn's tepary	*Phaseolus filiformis*	forage	Felger and Moser (1985)	p
Hap oacajam	mule deer antler's flayings	*Caesalpinia palmeri, Echinopterys eglandulosa, Thryallis angustifolia*	rubbing post for bucks	Felger and Moser (1985)	p
Hee imcat	jackrabbit's bitings	*Machaeranthera parviflora*	possible feeding deterrent	Felger and Moser (1985)	p
Hee xojat	jackrabbit's saiya	*Tiquilia palmeri*	possible forage	Felger and Moser (1985)	p
Hepem iheem	white-tailed deer's pencil cholla	*Opuntia versicolor*	possible habitat indicator	Felger and Moser (1985)	p
Hepem iicoa	white-tailed deer's globemallow	*Hibiscus denudatus*	possible forage	Felger and Moser (1985)	p
Hohr oohit	donkey's forage	*Nama hispidum*	forage	Felger and Moser (1985); G. P. Nabhan, *unpublished data*	p
Moosnil ihaqueepe	blue sea turtle, what it likes	*Asparagopsis taxiformis*	forage plant	Felger and Moser (1985)	p
Mossni ipnail	sea turtle's skirt	*Cryptomenia obovata, Halymenia coccinea, Padina durvillaei, Rhodymenia divaricata, Rhodymenia hancockii*	forage plant, carapace cover	Felger and Moser (1985); G. P. Nabhan, *unpublished data*	
Moosn-oohit	sea turtle's forage	*Asparagopsis taxiformis*	forage plant	Felger and Moser (1985)	p
Moosn yazj	sea turtle's membrane	*Gracilaria textorii, Padina durvillaei*	carapace cover	Felger and Moser (1985); G. P. Nabhan, *unpublished data*	p
Noj oopis	hummingbird's suckings	*Justicia californica*	nectar source	Felger and Moser (1985)	p
Xtamass-ija oohit	mud turtle's forage	*Nemacladus hispidus*	forage	Felger and Moser (1985); G. P. Nabhan, *unpublished data*	p
Xtamoosn(i) oohit	desert tortoise's forage	*Chaenactis carpoclinia, Fagonia californica, Fagonia pachyacantha*	forage	Felger and Moser (1985); G. P. Nabhan, *unpublished data*	p
Ziix hant cpatj oohit	flounder's forage	*Dictyota flabellata, Galaxaura arborea*	forage plant	Felger and Moser (1985)	p

Note: In the last column, p = plant, a = animal.

dispersal agent of wild chiles in secondary growth emerging after milpa (field) abandonment (Vasquez-Davila 1995, Nabhan 1997).

Hypothesis testing and verification of ecological interactions

As Western-trained scientists learn of plant–animal interactions recognized and named by indigenous peoples, they can potentially test hypotheses to elucidate the relative degree of connectivity or exclusivity in such relationships. As previously noted, the folk taxonomies of indigenous, Spanish-, and English-speaking peoples in the Americas often distinguish wild *Capsicum* chiles from domesticated chile peppers by using a term akin to "bird pepper," but the bird in mind varies from culture to culture and place to place (Vasquez-Davila 1995, Nabhan 1997). When asked, people of any region within the range of wild *Capsicum* will name only certain birds as consumers and dispersers of these bird peppers. The Lowland O'odham of central Sonora, Mexico associate Northern Cardinals and Pyrroloxias (*Cardinalis* spp.) as chile seed dispersers, whereas Chontal Mayans associate the Great Kiskadee with the same ecological process (Vasquez-Davila 1995). Some wild chile harvesters in various watersheds of the Sonoran Desert region also associate wild chiles with particular *madrinas* "godmothers" or *nodrizas,* "nurse plants" such as hackberries (*Celtis* spp.),

oaks (*Quercus* spp.), or mesquites (*Prosopis* spp.) believing that these trees provide sensitive chile seedlings with protection from various stresses.

Such perceived differences in floral and faunal associates of one ecologically variable species are a critical reason that ecological interactions should not simply be looked at within one locality alone, or through the lens of just one cultural community. As Thompson (1996:300) has argued, "Many species are composed of populations specialized to different interactions . . . some [of which]" can evolve rapidly under changed ecological conditions." To fully fathom a cultural community's understanding of such interactions, it is critical to go beyond mere taxonomic inquiries to interview indigenous specialists about certain plants and animals in the very habitats where those species occur. Ethnobiologists should not confine themselves to taxonomic inventories, but should devote more time to eliciting and testing ecological knowledge from folk practitioners.

In a series of experiments and quantified observations of avian foraging activity undertaken over the last several years, I have worked with colleagues to test whether there are any peculiar relationship between red-plumaged birds and wild chile peppers, as indigenous peoples suggest. In particular, we wished to determine whether the roosting and foraging behavior of any resident frugivores in particular tree canopies predicted the degree of association between wild *Capsicum* shrubs and their overstory nurse plants better than other parameters could. Our results (Tewksbury et al. 1999) demonstrate that Northern Cardinal activity in hackberries (*Celtis* spp.) is highly correlated with wild chile presence beneath hackberries, and better predicts chile distribution than do other characteristics of nurse plants or frugivorous birds. This, then, is a tangible example of how indigenous ecological knowledge can be used to guide empirical or experimental studies to learn more about plant–animal interactions.

Sometimes Western scientists claim that they have discovered an ecological interaction that was previously well known by indigenous peoples. Among the O'odham, this is true both for winter hibernation of poorwills (*Phalaenptilius nuttalii*) in the desert (Rea 1983) and for the intoxicating effects of thornapple (*Datura*) alkaloids on nectar-feeding hawkmoths (*Manduca* spp.).

Vern and Karen Grant (1965) were the first to report in biological literature that hawkmoth pollinators demonstrated intoxicated behavior after several visits to *Datura* flowers, a behavior that they attributed to the hallucinogenic alkaloids in this plant. University of Arizona neurobiologist Rob Raguso and pollination ecologist Stephen Buchmann are now attempting to verify this empirical observation experimentally, because alkaloid levels in *Datura* nectar itself should be minimum or negligible. However, neither the Grants nor the University of Arizona team were initially aware of the following O'odham song excerpt, no doubt about *Manduca* moths and their hornworms, recorded by Jose Luis Brennan in 1901, first published in translation by Russell (1908), and recently re-translated (Nabhan 1997):

Sacred datura leaves, sacred datura leaves,
eating your greens intoxicates me,
making me stagger, dizzily leap.
Datura blossoms, datura blossoms,
drinking your nectar intoxicates me,
making me stagger, dizzily leap.

It may well be worth further testing to determine whether or not both the larval and adult stages of sphingid moths are exposed to *Datura* alkoloids, and whether any noticeable behavioral effects occur under different conditions.

Conclusions: implications for endangered species recovery

It is clear from a number of studies, summarized in Nabhan (1992), that indigenous communities are reservoirs of considerable knowledge about rare, threatened, and endangered species; to date, these reservoirs have not been independently accumulated by Western-trained conservation biologists. What may be less obvious is that indigenous knowledge of biotic relationships involving rare plants or animals can help to guide the identification, management, protection, or recovery of habitats for these species. The Comcáac and O'odham are certainly aware of details of the diets, nesting, and refuge cover requirements of endangered species, and all of the ecological details that they have noticed have not necessarily been recorded in the literature of conservation biology.

Take as examples the following details regarding the autecology of four endangered animals: the desert tortoise, the green sea turtle, the Sonoran pronghorn antelope, and the desert bighorn sheep. For the desert tortoise (*Gopherus agassizii*), a key issue in its conservation management has been providing protected habitat where sufficiently diverse forages are available for its dietary use. Despite 60 years of incidental reports on desert tortoise feeding behavior, stomach contents, and fecal pellet analysis, knowledge of the species' dietary needs has, until very recently, remained fragmentary (Van Devender and Schwalbe 1998).

In contrast, there are four species of desert plants known for centuries to the Seri as *xtamoosn(i) oohit* "desert tortoise's forage." These include three species not otherwise identified in tortoise diets in the Sonoran Desert (*Chaenactis carphoclinia, Fagonia californica,* and *F. pachyacantha*), although another species of *Chaenactis* has been identified in Sonoran Desert tortoise diets, and *Fagonia* may be found in Mohave Desert tortoise diets (Van Devender and Schwalbe 1998; T. R. Van Devender, *personal communication*). The

fourth species cited by the Comcáac, *Chorizanthe brevicornu*, has only recently been verified as an important springtime component of desert tortoise diets, even though it is an inconspicuous, ephemeral wildflower (Van Devender and Schwalbe 1998). A fifth species (*Trianthema portulacastrum*) cited by the Comcáac is not formally called "desert tortoise's forage," but is nevertheless considered an important summer forage plant for tortoises in the Gulf Coast of Sonora. Although not yet found by field ecologists in fecal pellets of tortoises, this summer herb has morphological, ecological, and nutritional characteristics similar to those of several *Portulaca* species found in tortoise pellets (Van Devender and Schwalbe 1998).

A parallel story can be told for the Comcáac association of the endangered Sonoran pronghorn antelope (*Antilocapra americana sonoriensis*) with an ephemeral legume, *Phaseolus filiformis,* which they call *hamooja ihaap* "pronghorn its wild bean." Although this plant is occasionally abundant where the remnant pronghorn population lives in northwest Sonora, it is seldom abundant where the northernmost Comcáac families resided, ~60–80 km south, in a poorly documented Sonoran pronghorn range. To date, this forage has not been recorded by members of the Sonoran pronghorn recovery team in their dietary studies, although it is a likely candidate.

A wild onion (*Allium haemotochiton*) is called "desert bighorn what-it-eats," in reference to *Ovis canadensis mexicanus,* another threatened subspecies. Although this winter-blooming onion has not been recorded in Sonoran Desert bighorn diets to date, wildlife dietary ecologists consider it a good candidate (P. Krausmann, *personal communication*).

Several species of algae are noted by the Comcáac as habitat, carapace cover, or forage for *Chelonia mydas,* the endangered green sea turtle: *Cryptomeria obovata, Halymenia coccinea, Gracilaria textorii,* and *Rhodymenia divaricata.* The most intimate association is between the red alga *Gracilaria,* "sea turtle's membranes," which grows up to 30 cm tall on the carapaces of the endangered sea turtle population that overwinters, dormant, in a shallow channel of the Sea of Cortez adjacent to Comcáac villages (Felger and Moser 1985). Recently, one elderly Comcáac turtle hunter told me that he used to see bumphead parrotfish (*Scarus perrico*) visiting green sea turtles just after they had broken dormancy, coming to "eat the wool" of algae off their carapaces. Knowledge of this overwintering behavior among this *moosni hant koit* "sea turtle touching-down" population was once unique to the Comcáac, but once non-Indian fishermen learned of it, they rapidly wiped out this population (Felger et al. 1976).

Berlin (1992) recently used the Comcáac as the clearest counterexample to the hypothesis that only farmers "overclassify" economically important plants and animals into "folk species." The recognition that non-agricultural people associate a particular alga and fish with a named folk species (or distinct population) of sea turtles is even more remarkable. It is my impression that the Comcáac are interested in ecological interactions even when they are not directly useful to hunters in obtaining economically important wild species. Thus, the Comcáac ecological knowledge may counter two truisms: (1) that only farmers and herders are interested in intraspecific variation and subspecific taxonomy; and (2) that such interests among non-Western peoples are restricted to economic species. Unfortunately, my recent interviews with Comcáac sea turtle experts indicate that they almost never see individuals of this sea turtle population now, so knowledge of the population's ecological interactions may be in demise as well.

Proposal: involving indigenous para-ecologists as participants in species recovery programs

The Indian reservations in the United States and comparable indigenous reserves in Mexico and Canada collectively contain more wildlands than all of the national parks and Nature Conservancy areas in North America. They are undoubtedly important refuges for the extant biodiversity remaining on the continent. Yet, when Native Americans involved in wildlife management, hunting, fishing, and endangered species conservation are surveyed, they lament that so many culturally important species have been lost from their homelands during their own lifetimes. Some tribes are now formally legislating native plant protection and establishing tribal wilderness areas to slow the loss of endangered species.

Many Native Americans are also aware that most of their community members under 25 years of age have had diminished exposure to these endangered species, and to the oral knowledge about subsistence and ceremonial traditions concerning them. Although even the native names of common plants and animals are being forgotten by O'odham youth (Nabhan and St. Antoine 1993), the situation is much more complex among the Comcáac, where native names are retained, but direct participation in a dozen ceremonial and subsistence "indicator" activities has been reduced by 25% during the last generation alone (Nabhan, *in press*). This "extinction of experience" regarding endangered species breaks the mutually reinforcing connections between cultural and biological diversity that have functioned over the last 8–10 millennia in the Americas, and longer elsewhere (Nabhan and St. Antoine 1993). In general, it appears that traditional ecological knowledge about interspecific relationships is being lost far more rapidly than are the native names for these taxa.

Elsewhere, I have been among those who have made strong arguments to national park and wildlife refuge managers to involve Native American parabiologists in the management of not only cultural resources, but also

natural resources such as endangered species (Tuxill and Nabhan 1998). Recently, I have worked with the Comcáac council of elders and Mexican government officials to complete a twelve-month professional certification course for "para-ecologists" who wish to work as field technicians in endangered species inventory, monitoring, and threat assessment. The course has been taught to 15 members of the Comcáac community by five traditional elders as well as by conservation biology experts on rare plants, sea turtles, migratory birds, bats, reptiles, and marine invertebrates; students are expected to gain competency in both ways of knowledge about the natural world. Most endangered species translocations, reintroductions, and habitat restoration efforts require that some members of the recovery teams have detailed local knowledge of the habitats and habits of the species of concern; elderly indigenous hunters and foragers often retain such knowledge (Hunn 1977, Nelson 1983, Nabhan 1997).

It is critical that such local experts, indigenous or otherwise, be involved in endangered species recovery and habitat restoration in ways that value traditional ecological knowledge as well as Western science (Tuxill and Nabhan 1998). Academically trained conservation biologists should be open to considering these other perspectives, even when they may at first sound "foreign" to the realm of science. Scientists can foster such cross-cultural exchanges by asking open-ended questions and considering the ways in which each culture uniquely encodes its empirical knowledge and ethical values regarding wildlife. If the link between cultural and biological diversity is to be in any way maintained, strengthened, or restored, indigenous peoples must be included in the management and conservation of the world's remaining biological riches.

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