ETHNOBIOLOGY FOR THE FUTURE

Linking Cultural and Ecological Diversity

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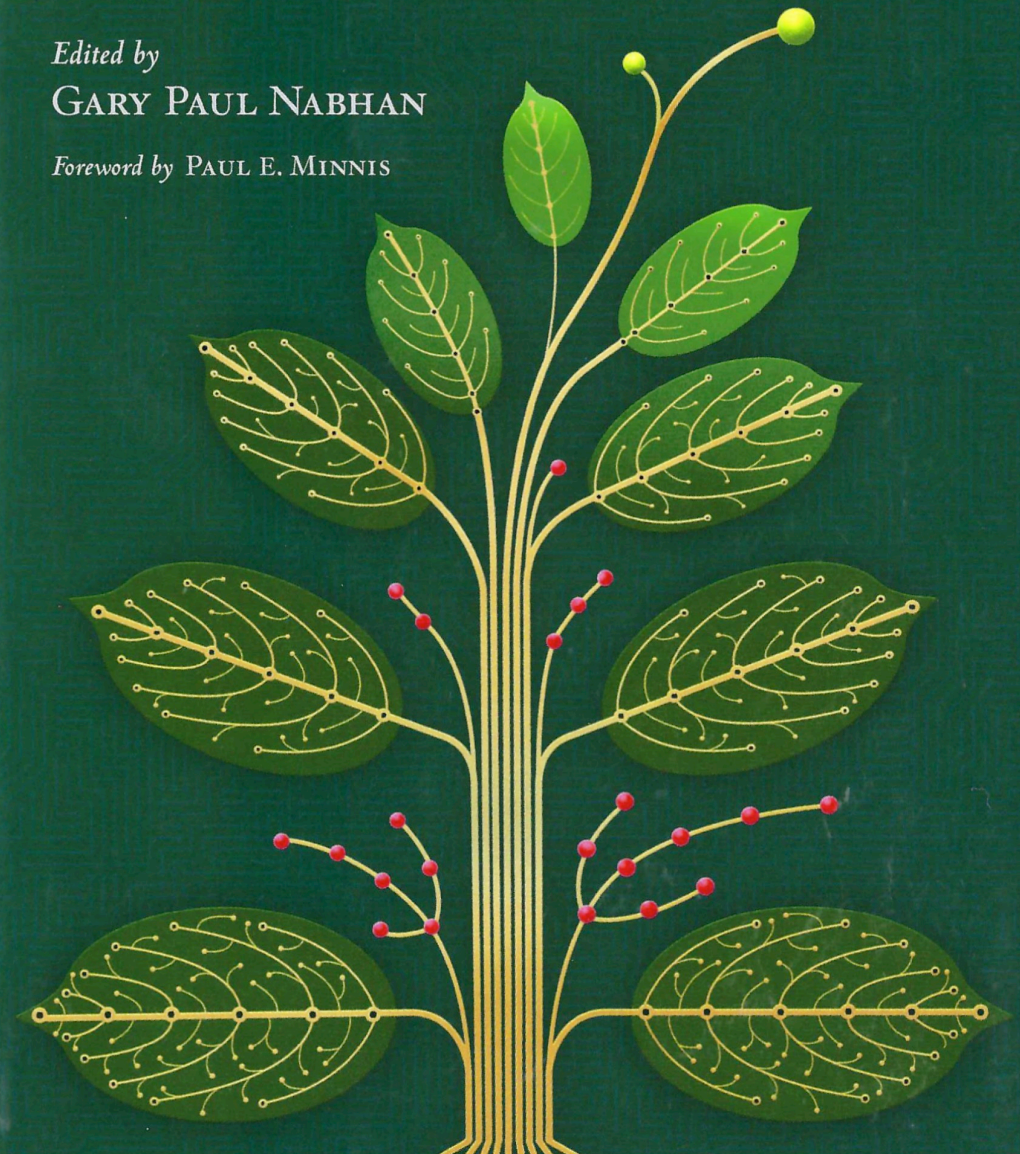

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ETHNOSCIENCE, THE "OLDEST SCIENCE"

A Needed Complement to Academic Science and Citizen Science to Stem the Losses of Biodiversity, Indigenous Languages, and Livelihoods

BENJAMIN T. WILDER, CAROLYN O'MEARA, LAURA MONTI, AND GARY PAUL NABHAN

WITH ACCELERATING LOSSES of biodiversity, habitats, and native languages, ethnoscience—including the study of traditional ecological knowledge of species and landscapes held by indigenous cultures—has become ever more significant. Globally, 20 percent of described species are likely to face extinction over the next two to three decades (Maffi 2001). Indeed, current extinction rates vastly exceed background rates among vertebrate taxa by 114 times under the most conservative of calculations (Ceballos et al. 2015). Simultaneously, Rogers and Campbell (in press) estimate that one language goes extinct every 3.5 months, and that 3,134 of the 6,901 known living languages are endangered. Linguistic and biological diversity are tightly coupled and face similarly grim futures (Gorenflo et al. 2011).

Collaborative efforts to adequately document local biological classifications and associated traditional knowledge of species distributions and habitats are, in a very real sense, time-sensitive. While indigenous knowledge of the natural world can arguably be honored as "the oldest science," since it predates the formal articulation of Western scientific tenets and organized citizen science by thousands of years, it is in many ways rapidly shifting, if not dramatically

A complementary discussion of this topic is in preparation with the journal *Bioscience* as this volume goes to press.

eroding. This is especially true among communities suffering from declining use of their indigenous languages. As such, there is an urgent need to support the communities attempting to revitalize their native tongues and maintain their traditional livelihoods based on natural resources. Fortunately, there are growing efforts among indigenous cultures to direct projects that restore habitats of declining species and resuscitate lost practices and knowledge.

Recently, citizen scientists' efforts to help inventory and monitor the world's declining biodiversity have been given the attention they have long deserved (Miller-Rushing et al. 2012). Laudable efforts are underway to reengage a broader segment of the population in making natural history observations of biodiversity imperiled by climate change, and discussing the moral implications of such changes (Nisbet et al. 2010; Miller-Rushing et al. 2012). Here we wish to direct comparable attention to the value of indigenous knowledge embedded in local taxonomies. Few scientists open to citizen science collaborations have found appropriate means of accommodating observations made by indigenous foragers, fishers, hunters, farmers, and artisans who have a particularly sophisticated grasp of place-based changes in biodiversity through time and space. Accommodating their knowledge should be of keen interest to those scholars working to bridge the environmental sciences with social sciences, arts, and religion to better engage the diverse constituencies in addressing the biological and cultural consequences of climate change (Nisbet et al. 2010). It may help us avoid a truncated approach to knowledge that limits the horizon of discovery and merely pays lip service to averting the loss of biocultural diversity.

INDIGENOUS SCIENCE AS COMPARED TO ACADEMIC AND CITIZEN SCIENCE

As never before, direct comparisons of relatively comprehensive treatments of species, habitats, and landscapes from Western and indigenous perspectives are now possible. The junction of different ways of perceiving and cataloguing biodiversity is a bountiful realm for collaboration and respectful learning across cultures. The nexus of diverse worldviews can be the departure point for future efforts to both document and conserve. However, we must consider that disparate cultures have not necessarily arrived at parallel typologies and classification structures for discerning the lives and habitats around them. Why are there widely heralded cases of one-to-one correspondences of Western and local

classifications, but intriguing divergences as well? Can indigenous names and mythology of the geographic origins of certain species serve as the basis of testable hypotheses, just as a scientist's observations have been utilized?

The knowledge base of most indigenous science is ancient yet dynamic. Place-based natural history observations gathered over centuries or millennia are distilled in the lexicon, calendars, place names or maps, and other practices of indigenous resource managers. Indigenous scientific knowledge is in many ways complementary to—not contradictory or redundant with—academic science and citizen science (Table 3.1). In fact, local taxonomies already bridge detailed place-based natural history observations with moral dimensions and artistic, effective communication strategies that some biodiversity and climate scientists are now striving to encompass in their own work (Nisbet et al. 2010).

As linguistic loss accelerates and traditional livelihoods decline, there is a concomitant loss of traditional ecological knowledge of biodiversity and habitats within which it is nested. This compromised knowledge base—as indicated by disuse of lexemes that refer to particular organisms—may hamper the indigenous community itself and humanity at large in gaining a more holistic understanding and management framework for dealing with imperiled species, habitats, and the stresses currently being placed on them (Berkes 2012). Nevertheless, the distributions, habitat needs, and behavior of locally declining or globally endangered species may remain better known by indigenous or local peoples who have long resided in their territories than by Western-trained scientists (Nabhan 2000). We desperately need such place-based knowledge to help guide both species recovery and habitat restoration efforts. These efforts may also be essential in supporting the persistence of resources on which livelihoods for indigenous fishers, foragers, or hunters are based (Berkes 2012).

Fortunately, for decades, individuals in the biological and social sciences have worked with leaders in indigenous communities to document the biocultural diversity still extant in First Nations' lands and waters (Maffi 2001). Until recently, only a small minority of studies were formally guided or directed by traditional tribal elders, with technical support being provided by professional or academic scientists (Gupta et al. 1993). But more than ever before, indigenous leaders are taking full leadership in documenting the diversity in their territory. Foremost among them are the ethno-ornithological and traditional medicinal plant inventories in the Kuna Yala homelands of the Kuna in Panama.

There remain creative tensions to deal with when attempting to integrate information, values, and cosmologies of distinct cultures. Perhaps there has

TABLE 3.1. Comparison of features of Western science, citizen science, and indigenous knowledge/ethnoscience, following Berkes (2012) and Miller-Rushing et al. (2012)

CHARACTERISTICS	WESTERN SCIENCE	CITIZEN SCIENCE	INDIGENOUS KNOWLEDGE/ ETHNOSCIENCE
Goals	Seeking universals and testing theories through experiments, analysis of data, and models	Offering local data to those seeking universals and testing theories	Usually offering data and pattern analysis specific to or bounded by a culturally-defined space and time
Participants	Largely done by academically trained professional technicians, some of them naturalists	Largely done by enlightened/committed "amateur" naturalists, often trained in other professions	Largely done by "proto-professional" naturalists: foragers, hunters, fishers, farmers, and shamans
Communication	Primarily transmitted through written works, graphs, and formal oral presentations	Primarily transmitted through field notes, social media, online databases, and informal oral presentations	Primarily transmitted orally in an indigenous language, also through song, story, maps, and art
Framework	Done by individuals, small teams, or cyber-networks for universal benefit	Done for pleasure by cohorts of volunteer participants in informal networks often guided by professionals	Done in multigenerational communities primarily for the community
Worldview	In most cases, wary of spiritual dimensions and ambivalent on ethical-moral context	Variable in directly addressing spiritual, moral, and ethical dimensions, depending on community	Seamlessly linked to spiritual dimensions and ethical-moral considerations
Methodological concerns	Insists on separation of object-subject	Ambivalent on object-subject dichotomy	Less object-subject dichotomy
Location/Scale	Increasingly done irrespective of place or focused on model systems	Preferably affectionately done as place-based inquiry	Embedded in cultural cosmology specific to place

been a prevailing ideological bias among linguists and biologists toward finding "universal principles" of classification embedded in folk biological taxonomies to which most, if not all known cultures have adhered to. Such apparent commonalities have been enough to convince some scientists that the prevailing one-to-one correspondences of folk and scientific taxonomies indicate that such taxa are "biologically real" entities and not just arbitrary constructs of human minds (Begossi et al. 2008). Such over-simplified use of universal principles risk ignoring the very essence of diversity itself. Instead, we must give particular attention to the anomalies, the unique cultural expressions, and the collisions of dissonant taxonomic structures. Historically, while linguists or taxonomists may have favored certitude over dissonance, we no longer wish to risk doing so at the expense of the very diversity we wish to honor.

PRIORITIZING ACTIONS

As Gewin (2002) has capably described, there are many new emerging collaborations to adapt taxonomic inventories for the Internet age. These innovative approaches often involve broader collaborations and participatory strategies to inventory the world's remaining biodiversity before it is too late. Some of these engage citizen scientists as "parataxonomists" to assist academic scientists with All Taxa Biodiversity Inventories (ATBI), such as those initiated in the Guanacaste Conservation Area of Costa Rica (Janzen 2004), the NaturaLista program spearheaded by the Mexican National Commission for the Knowledge and Use of Biodiversity (CONABIO, http://conabio.inaturalist.org), and in Great Smoky Mountains National Park in the United States. However, we wish to encourage comprehensive collaborative work toward documenting inventories of indigenous and Western knowledge for local biodiversity such as the case study we present below. We also stress that knowledge maintained in rural communities is equally valuable and in need of recognition and collaboration.

Given that the crisis in biocultural diversity is more complex and time-sensitive than what we can gain by merely inventorying species, we argue that before more species and languages (or merely lexical items) are lost, indigenous, rural, citizen, and professional scientists should collaborate to accomplish five tasks:

1. Document in understudied/minority languages not only the local names (simple or compound lexemes) for, but descriptive natural history knowledge about

as many plants and animals as possible, with particular focus on endangered and endemic species;

2. Document more precisely the convergence and congruency between local taxonomies and Western knowledge schemas, as well as which species appear to have culturally influenced distributions and abundances;
3. Attempt to discern the extent to which the very structures of local classification systems in languages now at risk appear to be aberrant or incongruous with the Western (or Linnaean) scientific classification system;
4. Engage indigenous or local communities in biodiversity documentation and stewardship through culturally driven intergenerational learning, using native language-based approaches as well as other ecological knowledge tools and strategies;
5. Empower and support indigenous or local communities that choose to develop their own programs for managing and recovering rare species in their homelands and waters, as a means to maintain or revitalize native languages and customs in order to sustain traditional livelihoods.

CASE STUDY INVOLVING THE COMCAAC OF THE GULF OF CALIFORNIA, MEXICO

Let us consider as a case study the progress made on these five tasks through long-term collaborations between the *Comcaac* (Seri People) of Sonora, Mexico, and a group of linguists, ethnobiologists, anthropologists, geographers, and conservation biologists who have gained momentum and diversity over the last quarter-century. The Comcaac are a seafaring and hunter-gatherer culture. They or their ancestors or predecessors have lived in the arid coastal region of the Sonoran Desert and Gulf of California for millennia (Bowen 2009). There are around 900 speakers of *Cmiique Iitom* (the Seri language) as of 2007 (Lewis et al. 2015), almost all of whom are bilingual in Spanish. *Cmiique Iitom* has been described as vibrant and its status as "vigorous" (Lewis et al. 2015), even while taking into consideration its status as an endangered language (Moser and Marlett 2010). *Cmiique Iitom* is not genealogically related to the neighboring cultures in the family of Uto-Aztecan languages, and it has been classified as a language isolate, meaning that we do not know with any precision its linguistic relatives.

A group of professional scientists from Mexico and the United States has been engaged with Comcaac community leaders and young "para-ecologists"

in what began *ad hoc*, but has emerged as an ATBI. It encompasses both landscapes and seascapes along the Sonoran Desert coast of the Gulf of California of Sonora and among the Midriff Islands. These efforts have documented several sets of taxa in *Cmiique Iitom* and Western or Linnaean scientific terminology to classify the biodiversity of that region.

In recent years, young Seri para-ecologists as well as elders have been coauthors or listed as contributors on several significant studies of biodiversity inventory, habitat conservation, and restoration published in a half-dozen refereed journals and four books from academic presses. Substantive collaborative studies have been completed with contributors who are Comcaac regarding vascular plants, marine invertebrates, fish, reptiles, birds, and mammals regarding species migration, endangered species recovery, habitat restoration, and indigenous (economic) uses.

These multicultural assessments of biodiversity serve as the departure point for a more refined grasp of a region, in this case, the remarkably diverse Gulf of California and the surrounding Sonoran Desert. Many researchers (e.g., Marlett and Moser 1995; O'Meara 2010) have considered the way that the Comcaac conceptualize and talk about their land and seascapes, containing abundant references to plants and animals, as well as other "affordances," or knowledge that conveys the interweave between humans and their environments. Examples include *Moosni Oofija* (lit. 'what the green sea turtles encircle'), which refers to a shoal in the ocean where *Chelonia mydas* individuals of certain age classes aggregate, and *Seenel Iitxo* (lit. 'where there are many butterflies') an aggregation site around scarce springs, seeps, or floral resources. The latter term may have offered human survival value, since it refers to a place where one would find fresh water after rains on the extremely arid San Esteban Island. These names clearly provide a context regarding biological resources located at culturally significant sites.

As such, the collective knowledge of biodiversity among the Comcaac that evolved over millennia is embedded in complex local linguistic expressions and cultural practices, which contributes new and often surprising information to regional conservation efforts, particularly with regard to endemic or endangered species (Nabhan 2003).

These efforts have often led Western taxonomists to populations of plant species previously uncollected in the region (Felger and Moser 1985). They also document observed behaviors and interspecific interactions not initially encountered by academic scientists (Nabhan 2000), such as an undocumented

overwintering population of sea turtles previously thought by scientists to migrate away from the region during cold periods (Felger et al. 1976).

Seri place names also encode biological knowledge that has otherwise been lost. The name in *Cmiique Iitom* for Rasa Island, a small yet globally important seabird island in the middle of the Gulf of California is *Tosni Iti Ihiiquet* (lit. 'where the pelicans have their offspring'). However, the island has not had breeding pelicans in the recent past (Anderson et al. 2013). Yet, translation of Italian naturalist Federico Craveri's journals from an 1856 voyage in the Gulf reveals the presence of young pelicans on Rasa Island and corroborates the accuracy of the Seri name (Bowen et al. in press).

Conversely, scholarly research can be incongruous with knowledge held by the Comcaac. Seri mythology and historical records supported a longstanding absence of desert bighorn sheep on Tiburón Island. The recent finding of 1,500-year-old dung of this herbivore on Tiburón demonstrates the presence of this species on the island prior to its unintentional rewilding to the island in 1975 (Wilder et al. 2014). This is a situation where science is finding something traditional knowledge has not preserved. We see opportunities to increasingly use Seri knowledge and mythology to inform scientific hypotheses to be tested through cross-cultural collaboration.

We equally value the contributions of professionally trained botanists and citizen scientists in refining the scientific taxonomy and geography of desert plants and animals in this region, especially when they attempt to correlate it with Seri knowledge. Nabhan (2003), Bowen (2009), and Davy et al. (2011) have refined our biological knowledge of which plant and animal taxa the Seri themselves culturally dispersed among islands and coastal habitats. O'Meara (2010) showed that the landscape domain conceptualized by the Comcaac (based on generic landscape terms) describes unique environmental characteristics. These landscape categorizations could lead to new understanding of distribution patterns of local species guilds.

Still other studies reveal major knowledge gaps, such as the names of mollusks that refer to species currently unidentified by scientists or that have possibly been locally extirpated already (Marlett 2014). Accounts of mythological sea creatures and reptiles also unknown to Western science are embedded within the songs and stories of their ancient navigation journeys throughout the Gulf of California (Monti 2002).

As any other source of knowledge, indigenous ecological knowledge is fluid and dynamic. Emerging medicinal knowledge of the Comcaac has been

demonstrated by Narchi et al. (2014) in their documentation of the recent adoption of a marine algae for medicinal purposes. Monti (2002) and her indigenous collaborators have also demonstrated how the Comcaac have adapted traditional knowledge to deal with emerging diseases and climate-driven environmental stresses affecting human health in their region. Climate change, loss of habitat, recently dispersed pathogens, and dietary changes have forced Comcaac herbalists to innovate new uses of medicinal plant species.

Active efforts are being made not merely to archive but also to share this knowledge within indigenous communities. With respect to language conservation and maintenance, Moser and Marlett (2010) have compiled and published a trilingual Seri-Spanish-English dictionary that defines and describes folk taxa documented over the course of a half-century. Their efforts also encompass the publication of numerous monolingual booklets of stories in *Cmiique Itom* for community use (Marlett 2013). Intensive courses and workshops on native language literacy have been offered in recent years, which support language maintenance and restoration that have involved dozens of younger Seri individuals. Thanks to these efforts, various Seri adults have some reading and writing ability in their own language. Now the younger generation can assure that traditional knowledge held by Seri elders is being documented, retained, and celebrated in their communities.

In short, strengthening intergenerational knowledge transmission processes in indigenous communities may be a necessary investment for engaging the next generation in biodiversity stewardship. The combined efforts of community and academic researchers over decades has led to both traditional knowledge and Western scientific knowledge being readily taught, accepted, and resulting in measureable benefits to species recovery and habitat restoration. Comcaac ecologists and researchers are gaining recognition in their community and throughout the world, as their impressive list of publications and on-the-ground achievements only hints.

Seri individuals who underwent para-ecologist training are now working for Mexico's Commission for Natural Protected Areas (CONANP), and the tribal natural resources program. The quality of their work has been recognized by the Smithsonian Institution's Museum of the American Indian, the National Geographic Society, the Cousteau Society, Conservation International, the Amazon Conservation Team, Slow Food International, and many other international organizations. Many of the participating researchers (academics and Comcaac alike) are now members of the Next Generation Sonoran Desert Researchers

(N-Gen; Wilder et al. 2013), a network of 300+ of the leading scholars in the region—50 percent based in the United States, and 50 percent based in Mexico. Indigenous leaders from different cultures together with academics in the region have convened the Biocultural Network of Sonora—an affiliate of the national Biocultural Network in Mexico—to address some of the most pressing ecological challenges confronting their communities. The next era of collaboration can increasingly support the Comcaac as leaders in science and conservation projects.

It is important to recognize the persistent external pressures not just on the Seri, their language and homelands, but also on those of other indigenous communities in rapid-changing coastal areas. The loss of their traditional livelihoods is strongly linked to economic pressures. Efforts to appropriate indigenous territory and natural resources by outside forces are unabated in many parts of the world. Strategies to conserve and honor traditional ecological knowledge must take into account the rights of indigenous communities for self-governance, intellectual property, prior informed consent, and maintenance of their language and culture, while seeking sustainable economic development options as affirmed in the United Nations Declaration on the Rights of Indigenous Peoples in 2008.

The complex nuances of local classification systems are intricately connected with the biocultural diversity that global actions aim to maintain. By not fully honoring the real and potential value of indigenous science, as society often does, our institutions risk ignoring the opportunity for consilience among the many funds of knowledge collected over the millennia. It is especially dangerous to do so in a time of paired and accelerated loss of biodiversity and traditional knowledge. We strive for a future in which academics, governments, and nonprofits working in civil society will document, honor, and value every bit of cultural information regarding biodiversity, whether or not it initially appears anomalous, incongruent, or not fitting with the prevailing opinion. Much may be at stake if we sweep such "messiness" under the rug.

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LITERATURE CITED

Anderson, D.W., Henny, C.J., Godínez-Reyes, C., et al. 2013. Size and distribution of the California Brown Pelican metapopulation in a non-ENSO year. *Marine Ornithology* 41: 95–96.

Begossi, A., Chauer, M., Figueiredo. J.L., et al. 2008. Are biological species and higher-ranking categories real? Fish folk taxonomy on Brazil's Atlantic coast and in the Amazon. *Current Anthropology* 49(2): 291–96.

Berkes, F. 2012. Sacred ecology. New York, NY: Routledge.

Bowen, T. 2009. The record of native people on Gulf of California Islands. Arizona State Museum Archaeological Series 201. Tucson, AZ: University of Arizona Press.

Bowen, T., Velarde E., Anderson, D.W., and Marlett, S.A. Federico Craveri and changes in nesting seabirds on Isla Rasa since 1856. *Southwest Naturalist.* In press.

Ceballos, G., Ehrlich, P.R., Barnosky, A.D., et al. 2015. Accelerated modern human–induced species losses: Entering the sixth mass extinction. *Science Advances* 1: e1400253.

Davy, C.M., Mendez de la Cruz, F.R., Latrop, A. et al. 2011. Seri Indian traditional knowledge and molecular biology agree: no express train for island-hopping spiny tailed iguanas in the Sea of Cortes. *Journal of Biogeography* 38(2): 272–84.

Felger, R.S., Cliffton, K., and Regal, PJ. 1976. Winter dormancy in sea turtles: independent discovery and exploitation in the Gulf of California by two local cultures. *Science* 191: 283–85.

Felger, R.S. and Moser, M.B. 1985. People of the desert and sea: ethnobotany of the Seri Indians. Tucson, AZ: University of Arizona Press.

Gorenflo, L.J., Romaine, S., Mittermeier, R.A., et al. 2011 Co-occurrence of linguistic and biological diversity in biodiversity hotspots and high biodiversity wilderness areas. *Proceedings of the National Academy of Sciences USA* 1209(21): 8032–37.

Gewin, V. 2002. Taxonomy: all living things, online. *Nature* 418: 362–63.

Gupta, M.P., Jones, A., Solís, P.N., et al. 1993. Medicinal plants inventory of Kuna Yala: part I. *Journal of Ethnopharmacology* 40: 77–79.

Janzen, D.H. 2004. Setting up tropical biodiversity for conservation through non-damaging use: participation by para-taxonomists. *Journal of Applied Ecology* 41: 181–87.

Lewis, M.P., Simons, G.F., and Fennig, C.D. (eds.). 2015. Ethnologue: languages of the world, eighteenth edition. Dallas, TX: SIL International. Online version: http://www.ethnologue.com. Viewed June 9, 2015.

Maffi, L. 2001. On biocultural diversity: linking language, knowledge and the environment. Washington, DC: Smithsonian Institution Press.

Marlett, C.M. 2014. Shells on a desert shore: mollusks in the Seri world. Tucson, AZ: University of Arizona Press.

Marlett, S.A. 2013. A bibliography for the study of Seri history, language and culture. http://www.und.nodak.edu/instruct/smarlett/Stephen_Marlett/Publications_and_Presentations_files/SeriBibliography.pdf. Viewed July 9, 2015.

Marlett, S.A. and Moser, M.B. 1995. Presentación y análisis preliminar de 550 topónimos seris. In: Gaxiola López, J., and Mendoza Guerrero, E. (eds.). Coloquio de toponimia: los nombres del pueblo del noroeste. Culiacán, Sinaloa: Colegio de Sinaloa.

Miller-Rushing, A., Primack, R., and Bonney, R. 2012. The history of public participation in ecological research. *Frontiers in Ecology and Environment* 10(6): 285–90.

Monti, L. 2002. Seri Indian adaptive strategies in a desert and sea environment: Three case studies. A navigational song map in the Sea of Cortes; the ironwood tree as habitat for medicinal plants; desert plants adapted to treat diabetes. (PhD dissertation). Tucson, AZ: University of Arizona.

Moser, M.B., and Marlett, S.A. 2010. Diccionario seri-español-ingles. Hermosillo, Sonora: Universidad de Sonora, Mexico D.F.: Plaza y Valdes Editores.

Nabhan, G.P. 2000. Interspecific relationships affecting endangered species recognized by O'odham and Comcáac cultures. *Ecological Applications* 10(5): 1288–95.

Nabhan, G.P. 2003. Singing the turtles to sea: Comcáac art and science of reptiles. Berkeley, CA: University of California Press.

Narchi, N.E, Cornier, S., Canu, D.M., et al. 2014. Marine ethnobiology a rather neglected area, which can provide an important contribution to ocean and coastal management. *Ocean and Coastal Management* 89: 117–23.

Nisbet, M.C., Hixon, M.A., Moore, K.D., et al. 2010. Four cultures: new synergies for engaging society on climate change. *Frontiers in Ecology and Environment* 8: 329–31.

O'Meara, C. 2010. Seri landscape classification and spatial reference (PhD dissertation). Buffalo, NY: State University of New York at Buffalo.

Rogers, C. and Campbell, L. Endangered languages. In: Aronoff, M. (ed.). Oxford research encyclopedia of linguistics. Oxford: Oxford University Press. 2015. doi:10.1093/acrefore/9780199384655.013.21.

Wilder, B.T., O'Meara, C., Medel, A., et al. 2013. The need for a next generation of Sonoran Desert researchers. *Conservation Biology* 27: 243–44.

Wilder, B.T., Betancourt, J.L., Epps, C., et al. 2014. Local extinction and unintentional rewilding of bighorn sheep (*Ovis canadensis*) on a desert island. *PLoS ONE* 9(3): e91358.