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Environmental Linguistics

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Abstract

Environmental linguistics is an emerging field at the intersection of linguistics and natural sciences. It recognizes the mutual relationship between cultural and ecological diversity, documenting linguistic structures and verbal practices by which speakers conceptualize, encode, and transmit knowledge about the natural world. It surpasses the largely metaphorical and narrative program of ecolinguistics to position language as the preeminent conceptual framework and channel for environmental knowledge. Natural phenomena—as Indigenous experts explain—cannot be understood apart from the languages that encode them, and vice versa. Language diversity is thus the key to safeguarding biodiversity and a balanced human relationship with nature. Environmental linguistics helps decolonize linguistics as our field evolves to prioritize knowledge coproduction over data extraction. Examples from my fieldwork in Tuva cover six domains of knowledge: landscapes, lifeforms, time, sound, memory, and survival. This article reviews recent literature from many cultures, emphasizing works by Indigenous authors.

1. LIVING WITH NOMADS

> Indigenous languages come from the land, and the land is expressed and understood through these languages.
>
> —Parker (2012, p. 46)

A year living with yak herding nomads in the Republic of Tuva transformed my understanding of language. My goal was to learn Tuvan and collect data for my doctoral thesis (Harrison 2000). A secondary motivation was my fascination with nomadic pastoralists, and a desire to live among them. Having few useful skills in a nomadic society, I began with basic chores—herding goats and collecting yak dung—as I started to get a handle on the language. I learned to greet people with "Are your sheep fat?" and to ask their age with "How many snows do you have?" My training in linguistic anthropology had primed me to seek an emic perspective, or, as Bronisław Malinowski (1922, p. 24) put it, "the final goal, of which an Ethnographer should never lose sight. . .to grasp the native's point of view, his relation to life, to realize his vision of his world."

My host, Kara-ool Monguš, and his family patiently helped me learn Tuvan by immersion. I daily observed members of my host family communicating not only with other persons but also with animals (using sung vocables), the landscape (which they view as sentient), and spirits present in the landscape. After a few months I was able to converse, eventually progressing to more abstract topics such as animism and Buddhism. The Tuvan worldview manifested itself to me in daily interactions. No matter what topic I broached, my Tuvan interlocutors—aged 5 to 95—tended to guide our conversation to nature-related themes: domestic animals, food, landscapes, and material culture at their seasonal campsites in Möngün-Taiga. They possessed what I now understand to be a holistic and "ecocentric" worldview (Leopold 1968), which contrasted starkly with my own cultural upbringing, mostly disconnected from nature. Tuvans see themselves and all their actions as part of nature, an integrative orientation observed in many other cultures. As communication theorist Young Yun Kim (2013, p. 406) puts it: "From the Eastern perspective, the entirety of the universe is viewed as a vast, multidimensional, living organism consisting of many interdependent parts and forces." From a Native American Indigenous perspective, Gilio-Whitaker (2019, p. 138) writes: "The very thing that distinguishes Indigenous peoples from settler societies is their unbroken connection to ancestral homelands. Their cultures and identities are linked to their original places in ways that define them; they are reflected in language, place names, and cosmology or religion." These perspectives contrast with those of Western cultures, which historian William Cronon (1995, p. 80) critiques for their "dangerous dualism that sets human beings outside of nature." For Tuvans, nature is the unifying theme of their art, language, and lifeways. Their intellectual efforts have been applied over the centuries to fathom and adapt to nature's patterns; they are astute observers and skilled naturalists. Learning to converse with Tuvans about nature was thus a transformative experience for me, both as a person and as a scientist.

Tuvans' nature-centric worldview is clearly manifested in their speech and paralinguistic behavior, or what Küžüget (2017) calls their "linguistic world map." Environmental knowledge may be found at every level of language, from single phonemes used in sound mimesis to oral epic tales that extend to more than 10,000 lines. Tuvans have exceptional acuity to the ambient soundscape (Levin & Süzükei 2018), which they encode linguistically using a large and productive repertoire of ideophones. They have achieved world renown with their art of *xöömei* (overtone singing), a repertoire of vocal techniques and aesthetics derived from nature sounds (van Tongeren 2002; Kyrgys 2003; Levin & Süzükei 2011, 2018; Beahrs 2019). Tuvans also practice a wide range of verbal arts, including riddles (Dugaržap 2011), shamanic chants (Kenin-Lopsan 1997), animal domestication songs (Smithsonian Folkways 1990), protective rituals (Ooržak &

Bavuu-Sürün 2020), fairy tales (Dongak 2018), toponymic legends (Dongak 2015), and epic hero tales (Turguskan et al. 1957). All these genres are saturated with environmental knowledge, serving as guides for proper human behavior vis-à-vis animals, fellow humans, sentient landscapes, and spirits. Tuvan society thus provides one possible answer to the apt question posed by the sociologist Frans Verhagen (1993, p. 117): "How can language be used to shape a biocentric worldview away from an excessively anthropocentric and mechanistic worldview?"

Tuvans constantly directed my attention to the unifying theme of the environment, encompassing animals, humans, spirits, earth, and heaven. As a linguist, I maintained my interest in Tuvan phonology and morphology, and collected data on these. As a language learner, I sensed the world around me constantly expanding as I became aware of linguistic structures that are often marginalized. I began to notice how Tuvan uniquely encodes the environment in ways that may be experienced and lived but not easily translated. The lexicon is an obvious starting point, and Tuvan has highly elaborated nomenclatures for types of domestic animals, topographic features, weather phenomena, and so forth. But encoded environmental knowledge is not confined to the lexicon; it extends to aphorisms, mimetics, metaphors, storytelling, personal names, place-names, and verbal morphology. My shift in attention to the environment also required a shift in my methodology, from the standard data extraction techniques we refer to as "field methods" to a more active, participatory, and nature-attuned style of communicating. I had to live pastoralist lifeways, however ineptly, and be situated within the landscape in order to understand the grammar of the Tuvan language.

2. WORLDS OF KNOWLEDGE

Starting with the Tuvan premise of unity between language and environment, I summarize six domains of knowledge that first came to my attention in Tuva. I then expand the data set with examples from many other languages, citing recent (since 2010) scholarship, with an emphasis on Indigenous authors. The diverse works reviewed here explore the environmental dimensions of language and are inspired by or collaborative with Indigenous science. Much of the scholarship I review references the concept of traditional ecological knowledge (TEK), a term that is evolving in meaning (Houde 2007, Kimmerer 2013). As linguistic anthropology is a field with "expanding boundaries" (Monaghan 2011), the works reviewed here intersect with many adjacent fields:

1. **Landscapes.** Speakers of many Indigenous languages—including Tuvan—perceive a deep unity and interdependency between their land and their language. The two are mutually constituting and reciprocally shaped. Biophysical features such as caves, mountain passes, streams, trees, and rock formations possess spiritual significance and are worshiped through linguistic and ritual praxis on the land (Fridman 2004, Forbes-Boyte 2011, Hou 2017).
2. **Lifeforms.** Plants and animals not only are alive but also may enter into reciprocal relations and communication with humans. Detailed folk taxonomies in botany and zoology reflect ancient adaptations for survival (Conklin 1968, Hunn 1982, Ulicsni et al. 2016).
3. **Time.** Cultural understanding of time can be qualitative as well as quantitative, and can be expressed not only as numbers but also as effort, distance, metaphorical space, and alignment of diverse natural cycles. Ecological calendars facilitate survival by tracking patterns in vegetation, astronomical events, animal life stages, and seasonal activities (Kassam et al. 2016, Kelso et al. 2022).
4. **Sound.** An important way of knowing the environment is by active listening and cultural attunement to the ambient soundscape (e.g., animals, echoes, plants, rocks, water, winds). Tuvans construct their music, verbal, and vocal arts on a foundation of nature sound mimesis (Levin & Süzükei 2011, 2018).

5. **Memory.** Individual and generational memories are not contained solely within the mind but are also emplaced and located in the landscape. Oral poetics—often requiring prodigious memorization and virtuosic performance—are the most valued artistic–cognitive ability in a pastoralist society, where people have relatively few possessions and are highly mobile (Reichl 2016).
6. **Survival.** Life in a challenging environment, and sustainable stewardship of it, is possible only with the concepts and practices encoded in the language (Ly 2020, Benner et al. 2021), which mostly defy translation into other languages. These concepts underlie Native conservation practices, for, as Kassam et al. (2016, p. 137) note, "[i]n pastoral societies, economic and ecological aims are not necessarily in conflict."

All of these ideas have been explored within linguistic anthropology and the history of sciences more broadly, but they were new to me when I began my fieldwork in Tuva. I benefited from encountering them all at once, presented as a unified worldview by my Tuvan teachers. This web of knowledge transformed both my understanding of language and my approach to documenting it. In this review, I first provide examples that foreground Tuvan experiences. I then summarize recent scholarship on TEK or "Native science," which Tewa scholar Gregory Cajete (2018, p. 18) defines as

> processes of perceiving, thinking, acting, and 'coming to know' that have evolved through human experience with the natural world. Native science is born of a lived and storied participation with the natural landscape. [. . . It] is the collective heritage of human experience with the natural world.

I conclude with a challenge to apply these ways of knowing to decolonize linguistics and other sciences.

2.1. Landscapes

Unity of land and language is reflected in Tuvan grammar. For example, Tuvan verbs for 'go' encode the speaker's trajectory relative to a nearby river—with, against, or across the current—even if that river is distant or out of sight. Tuvan thus requires that speakers attend to topography when describing motion events. This unity is further reflected in named topographic features that have no counterpart in English, in anthropomorphizing of the landscape, and in veneration of land-based spirits (Arakchaa 2018, Peemot 2021). Language not only encodes the landscape but also arises out of it, and they are reciprocally shaped. This unity is expressed in both direct and subtle ways in all Tuvan verbal genres, such as the rich shamanic lexicon (Simčit 2010) and shamans' curative incantations (Kenin-Lopsan 1993, p. 45):

> As my moon, my sun began to rise
> I burned the golden herb of my wondrous mountain—
> the six-jointed juniper—
> fumigating myself.

Mountains and trees are not only sentient but also potentially hosts for spiritual forces, which must be respected. Environmental knowledge is encoded at every level of the grammar, from phonemes to morphemes to syntax; to metaphors; to the lexicon, prosody, and texts of all lengths, ranging from 1-line riddles (Dugaržap 2011) to 10,000-line oral epics (Harrison 2006).

As Tuvan anthropologist Victoria Peemot (2021, p. 9) writes: "Tuvan pastoralists acknowledge sentiency of landscapes in numerous practices: food offerings, asking for help, prohibition on activities which could be offensive (e.g., leaving trash, speaking ill about them), and

understanding some nonhumans (in the steppe ecologies—horses and wolves) as communicative bridges between homelands and human-livestock communities." This analysis fits not only Tuvans but also their neighbors, the Altais, Dukhas, Monchaks, Tofas, and others inhabiting the Altai, "one great and sacred organism in which every mountain, river, lake, spring, tree, or plant is its living part, each of which has its spiritual host, and where a human is only one of many beings inhabiting this entity. . .and where the physical landscape cannot be separated from its spiritual agency" (Rozwadowski 2021, p. 4). Anthropologist Morten Pedersen (2016, p. 222), who lived in Mongolia with the Dukha people (whose language is mutually comprehensible with Tuvan), describes nomads' interactions with landscapes by which "meaning is 'drawn' or 'elicited' from the landscape via a continual engagement with it in the form of both everyday and more ritualized nomadic practices."

The land–language connection first described to me in Tuva has since been explained to me many times by speakers of minority languages around the world. Near Broome, Australia, as we walked through the outback in 2007, Neil MacKenzie—a speaker of Yawuru—told me: "I want to show you the land, because if you don't see the land you can't understand the language." This view is reinforced in much Native scholarship. As Washoe elder Alan Wallace explains: "When the land speaks, it'll speak in a native tongue. So if you want to understand the land you have to speak the language. And if you speak your language to the land it will understand" (Christensen 2006). Parker (2012, p. 46), a linguist working with the First Peoples' Cultural Council, notes: "Together, language and land both embody and express the Indigenous worldview as a whole."

Andrea Lyall (2017), of the Kwakwa̱ka̱'wakw people, explains:

> Our language expresses a connection to the land through words, stories, and ceremonies, which describe the patterns of the seasons, traditional use, important places, and cultural and spiritual values. . . . Literal translations from Kwak̓wala clearly demonstrate that the Kwakwa̱ka̱'wakw have a complex and intimate knowledge of land, ecology, and forests and of the interconnectedness between plants, animals, environment, people, and spirituality.

Jerilynn Webster, a hip-hop artist and youth educator from the Nuxalk and Onondaga nations, explains: "If you look at different languages, languages are what the land looks like. So it's according to what your environment is. If you're not in that environment, you're displaced. Cut. That's why the language isn't happening, because. . .[w]e can't feel our Mother, we can't feel our language" (Baloy 2011, pp. 537–58). Kapyrka & Dockstator (2012, p. 98) emphasize that "Indigenous knowledges inherently include environmental or land-based knowledge because they stress the importance of the holistic connection of all living beings to Creation and the Earth as well as all relationships between these forces—relationships of humans to humans, to animals, to plants, to the elements, to the spirit world, and to the cosmos." Okanagan poet Jeannette Armstrong (1998, p. 178) writes: "[T]he land as language surrounds us completely just like the physical reality of it surrounds us. Within this vast speaking, both externally and internally, we as human beings are an inextricable part—though a minute part—of the land language."

Such statements describe not only a way of knowing and worldview but also an Indigenist research paradigm. Awareness of the land–language connection among linguists leads to better science—such as the exemplary work by Grenoble et al. (2019) exploring "landscape linguistics" in Greenland. It also provides tools for decolonizing landscapes through Indigenous countermapping, as Rose-Redwood et al. (2020, p. 151) explain: "One of the primary threads that binds together 'land and life' within Indigenous traditions is the ancestral knowledge embedded within Indigenous toponymies, or place-naming practices." The decolonization of mapping thus seeks to "restor[e] Indigenous toponyms, land boundaries, mapping styles, navigational guidance, and

A SIBERIAN KNOWLEDGE GAP

Siberia provides historical examples of the knowledge gap revealed in early Indigenous–European encounters. When eighteenth-century European explorers and scientists first encountered Siberian Indigenous cultures (and similar examples may be drawn from around the world), they knew they were confronting sophisticated knowledge systems that enabled survival in harsh environments (Castrén 1857). They recorded parts of these, in some cases creating the only record of now-vanished languages such as Kott (Castrén & Schiefner 1858). But they often failed to grasp that they were encountering a divergent scientific paradigm and a rational, relational worldview that defied the standard European categories of analysis, instead seeming to consist of magical or primitive thinking. In some cases, it is evident that ideas from Indigenous Siberian science influenced the thinking of European scholars—such as geographer Johannes Granö (1882–1956)—who were either unaware of or unwilling to credit this influence.

environmental knowledge" (pp. 152–53). Example alternate cartographies of land may be based on birdsongs, stars, weather, songs, and sacred sites. As Hirt (2012, p. 108) writes, "Indigenous cartographic traditions are orally or performance-based, and. . .expressed through poetry, dance, songs, painting, and dreaming." Finally, respect for the land–language connection leads to more ethical engagement and advocacy by scientists. Hunn (2008, p. 1) explains: "We should support communities with deep roots on the land, [and] defend their communal tenure in land and sea; their cultural and linguistic distinctiveness follows from their collective ties to the land" (see the sidebar titled A Siberian Knowledge Gap).

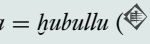
2.2. Lifeforms

In addition to being skilled hunters and animal domesticators, Tuvans expertly use plants for medicinal and ritual purposes. Each morning my host family in Tuva would burn *artyš* (juniper) to purify inside and outside the yurt. When a child had a cough, she was treated with an infusion of herbs. Invited to participate in a ritual, I witnessed shaman Aldyn-Čaa Xüresh-ool using a liquid infused with three different plants, which he sprinkled on the fire as a spirit offering. Tuvan plant nomenclature is extensive, often naming with metaphors; for instance, feather grass (*Stipa lessingiana*) is called *aza ogu*, meaning 'devil's arrow'. Tuvans are now decolonizing their botanical knowledge, after centuries of research carried out on their territory, but using standard botanical nomenclature. In their critique of past methods and knowledge gaps, Bavuu-Sürün et al. (2018) argue that future botanical research in Tuva must adopt Tuvan names and taxonomies as the unit of analysis and then correlate them with other naming systems, rather than the reverse. These authors worry that gaps and mistranslations in the prior literature may lead to misuse of medicinal plants. For example, three wood fern varieties grow in Tuva, each named differently, but only two have known medicinal uses. But in published plant guidebooks and dictionaries, they report, these three have been inexactly translated into Russian under a single name, thus incorrectly conflating medicinal with nonmedicinal plants (see the sidebar titled Early Environmental Linguistics).

Listing and taxonomizing lifeforms are among the oldest attested scholarly and linguistic pursuits. An ancient knowledge base that begins with the Babylonian *urra* = *ḫubullu* Sumerian and Akkadian tablets from the first millennium BCE (Kilmer et al. 2005) is currently being expanded through lexicography and ethnosciences. Much of this work is being carried out by or in collaboration with local experts, who, as Ulicsni et al. (2016, p. 2) explain,

> have long possessed unified, systematic knowledge, including folk taxonomies, about phenomena that were of importance to them. The use and management of natural resources was based on

EARLY ENVIRONMENTAL LINGUISTICS

The earliest known work of lexicography is also a compendium of environmental knowledge. The ancient Babylonian *urra* = *ḫubullu* ()—bilingual Sumerian and Akkadian tablets from the later first millennium BCE—enumerates many animals, birds, plants, star names, and stones (Kilmer et al. 2005). Taxonomies also figure prominently in the *urra* = *ḫubullu*: There are 60 lexemes for types of sheep; 44 for camels, donkeys, and horses; 74 for types of beer; and 68 for types of bread and flour. Other tablets from the same period include 46 lexemes denoting time and weather terms and 20 names for winds (Civil 1988). Lexical gaps are apparent, as are some many-to-one mappings between Sumerian and Akkadian.

> centuries-old, often millennia-old ecological experience, on multi-generational knowledge passed down from generation to generation.

Here, I review several recent and exemplary works.

In India, the Solega people are bee experts who avidly gather honey. Si (2013; 2015, p. 202) presents richly detailed data showing "that the Solega's understanding of the natural history of honeybees—exploited, but not managed, wild organisms—is at least as good as that of societies that have indulged in beekeeping for centuries." Furthermore, the Solega know to sustainably harvest honey, leaving the brood and hive intact. Solega honey-gathering knowledge is encoded in the lexicon (which names and taxonomizes four bee species and two varietals); in songs describing implements, actions, and places; and in descriptive narratives. The knowledge base is robust, as Si (2015, p. 208) observes:

> All the Solega speakers interviewed in the field were able to provide detailed information on various aspects of the biology of the four bee species: this included their life histories, hive architecture, migration schedules, preferred nesting sites, and times of high honey flow. Most were also able to identify the tree species on which certain kinds of bee were most likely to be found.

Moreover, the Solega discern features of bees invisible to the eye:

> Individual worker honeybees are called *kunni* in Solega, which is also the word for 'girl', while the 'leader' of the hive is called *ra:ṇi*, or 'queen'. This is consistent with the fact that at any given time, most, if not all, the insects in a honeybee colony, including the queen, are biologically female. Already, it is clear that certain basic facts that eluded the beekeeping societies of Europe are known to the honey-gathering Solega, even in the absence of technological developments such as microscopes and observation hives. (Si 2013, p. 81)

Alongside their insect expertise, the Solega have deep botanical knowledge. They are now coping with collapsing plant diversity in their forest habitat. An invasive grass species has caused the local extinction or endangerment of 125 Solega plant ethnotaxa that are of nutritional, cultural, and medicinal value (Agnihotri et al. 2021). Agnihotri et al. (2021, p. 6) include first-person narratives, with accompanying translations, that foreground Solega expertise, for example: "The grass grows weakly now. Our people say that there used to be 10, 15 types of grass. There's no grass now, and so what happens as a result? The animals move elsewhere." Si (2015, pp. 215–16) argues that "a proper appreciation of Solega TEK requires that it be understood as a coherent and independent system of knowledge—one that exists not in relation to other knowledge systems, but is instead founded on the very observations that Solega speakers repeatedly make in the everyday lives, and the mental categories that their language provides."

Linguists and (ethno)botanists are expanding collaborations with Indigenous knowledge keepers, often as coauthors (e.g., Bussmann et al. 2018, Paniagua-Zambrana et al. 2018, McAlvay et al.

2021). Botanists are increasingly adding Indigenous scholars to their field and lab teams, and vernacular names to their herbaria databases, often aided by linguists or botanists trained in linguistics (e.g., Salick et al. 2020, Ranker et al. 2022). When our research team from the New York Botanical Garden, consisting of four botanists and one linguist, visited Vanuatu's Futuna Island in 2018, we were met by local culture expert Takaronga Kuautonga (Dixon Keller & Kuautonga 2008). He listened patiently as we described our plan to collect on Futuna Island specimens of endemic plants that may be "new to science." He agreed to share his knowledge, admonishing us that "we have names for all these plants." Our team collected many specimens on Futuna and published a botanical paper documenting 10 species of lycophytes and 88 species of ferns, along with the vernacular names and uses in eight local languages, with two Indigenous experts as coauthors (Ranker et al. 2022). Among the documented fern uses were body or head decoration, clothing, construction, communication, food, handicrafts, magical, medical, spiritual, and ornamental. But botanical science alone was insufficient to describe the plants of Futuna. Only by coproduction of knowledge with the Futuna people could we aptly describe botanical diversity on the island.

Some biologists understand how Native knowledge augments the scientific record. In a 2016 study (Fleck & Voss 2016), biologists consulted the Matses people—Amazonian hunter-gatherers of whom a majority are monolingual speakers of Matses—about the greater long-nosed armadillo, *Dasypus kappleri* (Xenarthra: Dasypodidae). They first established that the armadillo has multiple names, indicating its cultural importance: "The greater long-nosed armadillo is known by several Matses names, which include a principal term (*tsawes*), one archaic synonym, a ceremonial term (used only in the now-discontinued *komok* ceremony), and three lexicalized hyponyms (names for overdifferentiated varieties)" (p. 2). The authors then recorded 66 armadillo facts that the Matses shared, only 21% of which were previously known to biologists; 79% were completely new, comprising "previously unrecorded aspects of its natural history, including numerous details of foraging behavior, burrow architecture, nest construction, diet, reproduction, and predation" (p. 6).

As with Matses armadillo lore or Futuna plant expertise, Indigenous knowledge of animals and plants typically surpasses what science knows, and is organized in ways that do not map neatly onto Western taxonomic categories. Future studies in the life sciences—especially studies that aim to create species checklists—can aspire to accuracy and completeness only if they respect local knowledge.

2.3. Time

Tuvans possess an impressive ability to look at the moon on any given night and precisely state, according to its shape, which numerical day of the lunar calendar is coming next. "It's fifteening" means that the moon is in its fourteenth day. They mark daytime intervals with precision, as Küžüget (2017) explains, by the progression of the sun's rays across yurt-interior spaces and furnishings. At night Tuvans track the position of constellations visible through the yurt's upper lattice. This regularity is possible because interior arrangements of yurts, and the south-facing orientation of the door, are uniformly and predictably ordered, such that a blind person could enter a stranger's yurt and know the exact location of the lasso, cooking pots, bed, altar, and so forth. Tuvans accurately measure units longer than the lunar month with carefully observed stellar, phenological, and meteorological changes.

Though Tuvans no longer rely on ecological calendars, many other Siberian peoples do. The reindeer-herding Tofa have months named 'birch collecting month' and 'sable hunting month', and the hunting and fishing Ös (Chulym) name months after crow and fox (Falck 1785/1786, Harrison 2007, Ståhlberg & Svanberg 2021). When Johan Peter Falck (1732–1774), a Swedish botanist, ethnographer, linguist, and zoologist, visited the Ös, a people then virtually unknown to the outside world, in the 1770s, he noted in detail their lifeways, including environmental calendars

(Falck 1785/1786). Falck recorded Indigenous Siberians' cultural, social, and cognitive relationships to their forest ecosystem. Among thousands of pages of his field notes kept in Russian and other archives, many still unpublished, Falck's key finding from Siberia was that "human relationships with the biodiversity were very complex. . . . They included emotions, knowledge about their characteristics, habits and behavior, myths, personal stories and experiences, sensorial aspects such as color or smell, and awareness about their seasonal presence in the landscape" (Ståhlberg & Svanberg 2021, p. 113).

When I visited the Ös in the 2000s, they were long settled in Russian-style villages but still avidly fishing, gathering, and hunting. Despite these ongoing rich interactions with the forest, Ös calendars existed only as remnants. Elders Ivan Skoblin, Anna Baydasheva, and Mikhail Gabov allowed me to record their lively dialogue about the lunar month names, but in the end could recall only 4 out of 13. Where ecological calendars persist, or are being revitalized, for example, in Mongolia or the Pamirs, "they provide a potentially effective adaptation strategy to anticipate seasonal variation resulting from anthropogenic climate change, because they are grounded in the local ecology and cultures of local peoples" (Haag et al. 2019, p. 26).

Apart from lunar cycles, ecological calendars may correlate plants, birds, or other natural indicators to mark time. Speakers of Arandic languages of Australia know that "the spotted nightjar calls when dingo pups are born" (Turpin et al. 2013, p. 7) and use this event to track seasonal cycles. As Turpin et al. explain: "Indicator events can be described as the presence or behavior of a particular species or phenomenon that signals some other species or phenomenon. Arandic people group these into five broad domains: indicators of food, water, weather, danger and news" (p. 7). In Australia's Daly River region, Kitty Kamarrama—a speaker of the Nangikurrunggurr language (also called Ngan'gi)—explained to me: "When the kapok tree blooms, it is time to gather crocodile eggs." Molly Yawalminy, also a Ngan'gi speaker, added: "When gum tree bark peels easily, river sharks are fat and may be hunted."[1] An exemplary Ngan'gi dictionary by Reid & McTaggart (2008) is especially rich in species names (*adirrminmin* 'lesser wart-nosed horseshoe bat', *Hipposideros stenotis*), animal part terms (*afinyi* 'emu's wing'), animal life-stage descriptors (*afil-filmuy* 'hairless pouch-bound baby kangaroo or wallaby'), meteorological terms (*amiden* 'the fainter rainbow that you see outside the inner brighter rainbow'), calendrical season names (*memenyir* 'season name for that time of the year when pig-nose turtles incubate their eggs in the hot sand'), and topographic terms (*fekiweri* 'deep water').

The Meriam people of Australia's Torres Strait use stellar scintillation as a seasonal clock and predictor of weather patterns, encoding these observations in songs. As Hamacher et al. (2019, p. 24) describe in a paper coauthored by Indigenous experts, "Indigenous people around the world observe the twinkling of stars and incorporate this into their knowledge systems to forecast weather and predict seasonal change." George Passi explains (p. 26) how his people, the Meriam,

> also know the right seasons to engage in such [preparation] activities by observing the behavior of the stars and constellations in the sky. In fact, it is the stars or constellations that are seen to govern the behavior of plants and animals, which in turn influences the subsistence activities of the Islanders. The stars and constellations act as important guides to such activities.

[1]Molly Yawalminy and Kitty Kamarrama of the Nauiyu Nambiyu community, Northern Territory, Australia, were interviewed in August 2007 by the author and linguist Gregory Anderson for the National Geographic Society's Enduring Voices Project. Nangikurrunggurr, which Molly and Kitty explained as meaning "language of the swamp people," is one of three dialects of Ngan'gityemerri (also called Ngan'gi), which may have 150–200 speakers total. Nangikurrunggurr was estimated at the time of the 2007 interview to have approximately 26 speakers.

At least a dozen native Pacific Island societies anchor their calendars to the swarming cycle of the palolo worm (Fowler 2018). In a paper written with Indigenous coauthors from Vanuatu, Kelso et al. (2022, p. 1) explain: "[T]he annual appearance of the palolo worm is a signal event within very complex systems that incorporate wild plants, animals, agriculture, celestial bodies, the ocean, and human health for the purposes of organizing human activities." The Vureas-speaking people of Vanua Lava Island have a strong connection with the palolo worm, known as *būn*. When they see the leaves of a she-oak species (*Casuarina equisetifolia*) turn red and a specific seabird appear in the village, it is the month *Voromal*, or October. From the first day in *Voromal* when the moon appears during daylight, Vanua Lava people begin to count the days. On the night of the sixth day, they know it is time to harvest the palolo worms in the sea.

Environmental calendars—whether based on birds, fish, moon, plants, or worms—are essential to survival and constitute a rich but now threatened legacy of time-correlated environmental knowledge (Harrison 2007). The anthropology of time (Munn 1992) is a field that will yield many newly documented systems (Kassam 2021), if they can be recorded before they vanish.

2.4. Sound

On a daily basis in Tuva, I heard people imitating ambient sounds. Tuvans and their neighbors, including Altaians and Mongolians, perceive landscapes as soundscapes. They employ rich repertoires of mimesis, and of vocal and instrumental music, by which they sonically interact with the landscape. Tuvans use mimetic sounds, or spoken or sung vocables, to express distance, emotion, luminance, motion, objects, shapes, velocity, and so forth. They also use these in practical ways to lure animals in hunting, to induce desired psychological states in their domestic animals, to wayfind, to invoke spiritual entities, and to induce mental states such as a shamanic trance (Simčit 2010). The linguistic and paralinguistic resources Tuvans draw upon are productive in that speakers can, following a few principles of iconicity (Svantesson 2017), create new sound-mimetic terms and be understood by their hearers.

There has been a surge of studies of sound symbolism, once relegated to the periphery of the grammar but now increasingly understood to be a core feature on the basis of comparative studies. Tuvan provides evidence that iconicity is a general property of language (Perniss et al. 2010) and partly answers Perlman et al.'s (2015) question about "the extent to which people can also generate vocal communication systems by this same process of iconic creation." Tuvan provides the kind of evidence sought in Perlman et al.'s study, "indicating that the vocal modality holds more potential for iconicity than is often realized" (p. 3). In this study, participants performed vocal charades/mimesis on the fly, creating vocalizations intended to convey antonyms (e.g., *fast/slow*, *many/few*) which their experimental partner then had to guess the meanings of. The authors found that native-English-speaking participants were successful at communicating a set of 18 different meanings in a vocal charades game (p. 12). While this result is novel and promising, it is not unexpected in a Tuvan context.

In a global survey of 6,452 languages, Blasi et al. (2016) found robust sound/meaning correspondences. Tuvan shows three of these patterns: The words for 'tongue' tend to have [l] or [u], 'round' often appears with [r], and 'small' often appears with [i]. But Tuvan goes much further, having a very large repertoire of sound-mimetic words and productive processes by which speakers can create new mimetic words on the fly and be understood (Harrison 2004). The overwhelming majority of such words refer to natural phenomena, such as animal sounds, water sounds, wind, echoes, rocks, and vegetation. Mongolian, a language long in contact with Tuvan, also has a rich vocabulary of "onomatopoeia and iconopoeia" (Oberfalzerová 2011) that expresses features of the landscape and natural events experienced by pastoral nomads. For example, *pad/ped* represents "the sound *pad* of a not too heavy object falling on the ground, while *ped* is the sound of a light

object falling on the ground, or drops of rain. The latter may be metaphorically extended to mean 'to attain a good living standard'" (p. 46). Oberfalzerová notes:

> [T]hough to a certain extent these depicting words exist in every language, in Mongolian communication they represent a very large group of words, which go hand in hand with the necessities of the nomads' life, where they must be well oriented in the surrounding wild natural environment, and with their ability to perceive it and reflect it in great detail in words. (p. 53)

Tuva is renowned for its musical aesthetic, and Levin & Süzükei (2018, p. 205) explore "timbre-centered listening as an enculturated practice among Tuvan pastoralists, whose perceptual focus on timbral qualities of sound correlates with exceptional acuity to ambient soundscape." This acuity is encoded in the lexicon and expressed both vocally and with musical instruments: "Tuvan pastoralists' prioritization of timbre as a locus of interest extends to human-made sound and music and is reflected in the timbre of two-stringed fiddles strung with horsehair strings, metal jaw harps, and the widespread vocal practice of *xöömei*, whose performers selectively reinforce harmonics naturally present in the voice" (p. 215). This cultural ability also shapes the lexicon:

> Enculturated listeners can describe the timbral qualities of sound with great precision using an ideophonic vocabulary consisting of onomatopoeia and other forms of sound symbolism, cross-modal sensory associations (e.g., the depiction of sound in visual and haptic terms), and affective words, which comprise a rich lexical resource. The central role of timbre in Tuvan music and its depiction in discourse about sound and music suggest a culturally specific and pervasive form of timbre-centered listening. (p. 205)

Ambient sounds, hearing, speech, and music all fall along a perceptual–aesthetic continuum, without sharp breaks in between. Songs are a key vehicle for transmitting environmental knowledge, connected to specific landscapes and the cultural memories anchored to those sites. Thornton et al. (2019, p. 392) find that, in Tlingit society, "[a]s potent expressions of individual and collective identity, heritage, and destiny, songs encapsulate ethnobiological, social, and geographic knowledges in a melodious, interspecific lingua franca." Recent research in ethno-acoustemology supports the premise that cultures—inspired by the landscapes they inhabit—may prioritize acoustic perception and production. Simonett (2014) explores how the Indigenous cosmovision of the Yoreme people of Mexico integrates perception of sound and human–animal–environment relationships. According to Yoreme origin stories, mouse and bird calls first inspired humans to create music and musical instruments as a way of recreating ambient nature sounds, while dancers' motions and postures imitate animal movements. Entering into inspired trance states while performing, Yoreme dancers also experience a shift in perspective: "[I]n the ritual, the mountain landscape is seen through the animal whose song or canto (song) is being ensounded" (pp. 113–18). Simonett's work is yet another example of the thesis proposed by Feld (1990, p. 118), and fully instantiated by Tuvans, that "the natural environment conduces to the cultural shaping of a musical system."

The Tuvan understanding of landscape as an acoustic domain has influenced and been extended by geographers Johannes Granö (1882–1956), a noted explorer of Siberia, and his son, Olavi Granö (1925–2013) (Uimonen 2008). Johannes Granö (1997), positing what he called "pure geography," conceived of the landscape as a complex of phenomena perceived by the senses, with particular attention to sounds of rivers, birds, and the rustling of grass in the wind. After spending time in Tuva and the Altai, he brought these ideas back to Europe and revolutionized the science of geography with the notion that the real object of geographical research is the environment as perceived by the senses, in other words, that "[l]andscapes exist primarily as a form of human experience possessing symbolic meanings and significance" (Käyhkö et al. 2004, p. 248). Granö thus gave a cognitive orientation to the landscape, defining it as a perceptual entity in the minds

of speakers, apprehended by all the senses, but especially hearing. There is no doubt that these concepts emanated from Tuva to influence European geography.

2.5. Memory

Visiting the Tuvan village of Arıg-Uzyu, I met epic storyteller Šojdak-ool Xovalyg (1929–2010), a composer of verbal arts such as blessing songs, riddles, and poems. By vocation a tractor driver on a collective farm, he used the hours spent plowing fields to practice the patterned mnemonics and creative flair needed to tell epic tales. Storytelling was once an esteemed avocation and profession in Tuva. An itinerant storyteller (*tooldžu*) would visit a nomadic encampment to tell an epic story in installments over successive evenings. A story would typically begin at evening teatime, once outdoor chores were completed and the animals safe in the stockade. Older Tuvans recall childhood storytelling sessions that began with the formulaic *Šıjaan am!* ('Once upon a time') and extended late into the night. A single tale—which might stretch up to 10,000 lines—might be accompanied by the *igil*, a bowed horsehead fiddle made of wood, or a *bızaančı*, a bowed four-stringed instrument with a skin-covered resonator. Šojdak-ool allowed me to record his version of *Boktu-Kiriš*, *Bora-Šeelei*, the story of a shape-changing shamaness on a quest to bring her deceased brother back to life. Advised by her talking horse, Bora-Šeelei disguises her gender; metamorphizes into various animals; and outwits, outruns, and outwrestles opponents to succeed in her quest (Harrison 2006).

As documented in many oral traditions, Tuvan versification shows intricate patterns, both small and large, of alliteration, numerical sequences, metaphor, parallelism, and repetition (Dongak 2006, Mižit & Voinov 2019). Tuvan stories express cultural values, humor, spirituality, and above all environmental knowledge. For Šojdak-ool, the body and physical environment provided mnemonics and brain-external sites for oral traditions to be stored. He could anchor lines and episodes within the tale to fields, forests, or mountains. These became physical memory aides, as well as sites of events featuring mythical protagonists. In addition to serving as an intergenerational memory bank, Tuvan tales are a wellspring of information about animals, landscapes, plants, and spirits. As Seredkina & Smolina (2018, p. 229) note, Siberian Indigenous epics promote ecological awareness via a "syncretic model of the universe," and especially "[w]hen performed in the language of the indigenous peoples in the appropriate conditions in the homeland."

Many oral traditions are endangered, but some are thriving, carrying cultural memory into the twenty-first century. Reichl (2016) examines the "surprising vitality" of the Kyrgyz heroic epic tale *Manas*, celebrated as the cornerstone of Kyrgyz national identity. He notes that social conditions are crucial to its continuity: "Where oral epics of such proportions flourish, there must be talented singers and oral poets and a cultural milieu in which a high premium is placed on verbal art" (p. 331). Tale-tellers—in Kyrgyz called *manaschy*—are typically called to their vocation in a dream or vision. They embark on rigorous training, learning the tale by hearing it from others, not from written texts. While every *manaschy* has access to the same basic building blocks of plot and style, the *Manas* makes less use of repeated formulaics than do other epic traditions, and allows for greater improvisation or "composition in performance" (Jumaturdu 2016). As Reichl (2016, p. 339) explains, "prerequisites for a successful *manaschy* consist in a good memory and in having fully absorbed the meter and poetic idiom of the epic." In addition, there is room for innovation, whereby "master-singers put their own creative stamp on their versions of the epic." The Kyrgyz tale, like Tuvan epics, is also rich in sound symbolism (Koshueva et al. 2020) that expressively depicts animals, the landscape, and natural phenomena. Storytellers may also enter a state of transcendence during the telling, making contact with ancestral spirits, thus opening up a connection through which healing energy emanates to their listeners (van der Heide 2008).

Among the Hup people of Colombia, as Epps & Ramos (2020, p. 235) report, the verbal genre of shamanic incantations "provide[s] an encyclopedic ontology of social, cosmological, and ecological knowledge." A 208-line Hup incantation they explicate names 30 species, such as swamp eel (*Symbranchus marmoratus*), rufous-collared sparrow (*Zonotrichia capensis*), tobacco caterpillar (*Manduca* sp.), imbauba (*Cecropia* sp.), ocelot (*Leopardus* sp.), cebus monkey (*Cebus* sp.), passionflower (*Passiflora acuminata*), and mussurana snake (*Clelia clelia*). This Hup genre, recited only by shamans or incantation specialists, is now by the community's own estimation endangered: "Hup elders were concerned that the young men of their community were not mastering the incantations as the older generation felt they should, putting the future health and safety of the village at risk" (p. 235). The authors further note that "there is likely a two-way relationship between the compromised transmission of incantation and a waning familiarity with traditional territory and activities" (p. 235).

On Micronesia's remote Poluwat Island, memorization of songs and chants is crucial for navigation and survival at sea. As Diettrich (2018, p. 18) explains:

> Specialized knowledge of and experience with the sea in Micronesia is codified largely in recitations, chants, and songs. . . . [R]ecitational mapping. . .includes the names of stars, sightings at sea, the seaways and star courses between islands, sea creatures that surround islands and inhabit sea lanes, the seasonal calendar, winds, currents, swells, clouds, birds, and the channels in island reefs.

In Aboriginal Australia, Curran et al. (2019, p. 354) demonstrate how "songs and their performance practices interact with techniques of seed production and knowledge systems connecting people to biota, the land, and their totemic religion." Looking at songs across many cultures, we find "an untapped library of rich ethnobiological knowledge and biocultural memory, embedding important social, physical, emotional, and spiritual ties to local ecologies" (Fernández-Llamazares & Lepofsky 2019, p. 337). Spoken or sung oral genres thus play crucial roles both in transmitting detailed knowledge of the environment and in maintaining people's spiritual connection to it. They also reveal diverse techniques for exercising and training memory, which may lack any counterpart in literate societies.

2.6. Survival

Adaptation for survival is deeply encoded in languages. Tuvans live alongside their domestic animals; a typical nomadic family owns some combination of camels, cows, horses, goats, reindeer, sheep, and yaks. They have intimate knowledge of the animals' anatomy, behavior, life cycle, psychology, and uses. The Tuvan language is capacious and precise in describing animals and animal-centered human activities. Participating in a ritual sheep slaughter allowed me to learn not only anatomical parts but also names for foods made from blood and entrails, food-handling taboos, gendered division of labor, and prayers and songs that accompany the ritual. Many different manual skills accompany the sheep and its by-products (e.g., hide, rope); these too require a special lexicon.

Tuvans use complex taxonomies to classify domesticated animal subtypes. Reindeer, for example, are categorized and named according to age, fertility, gait, personality, and sex. The terminology, as Tuvan anthropologist Tayana Arakchaa (2018, p. 143) explains, arises because herder-hunters' "lives completely depend on the reindeer in the taiga. The reindeer. . .becomes a personified being, contributing to the hunting of game due to its superb internal navigating capabilities and capacity to cooperate with its human counterparts. The reindeer is the heartbeat of the remote taiga because the reindeer-human connection is intimate and inextricably mutual." Domesticates such as goats, horses, sheep, and yaks also bear many labels describing color and pattern combinations (Darža 2014, Peemot 2021).

When Falck (1785/1786) visited Tuva in the 1770s, he was impressed by Tuvans' holistic, multisensory perception of the environment as expressed in their language. He found, as Ståhlberg & Svanberg (2021, p. 113) summarize, that "[p]lants were not just edible or nonedible, and animals not only satisfied the need for blood, fat and meat. . . . Naming was also an important aspect of the intricate set of relationships." Among the Nenets and Norwegian Sámi, neighboring reindeer herding peoples of the Arctic, scholars have compared deer slaughtering and processing terms. They find that the Sámi and the Nenets have different methods of slaughtering deer and cutting the carcass and also differ in their use of the blood, meat, and organs for food. Scholars documenting Nenets and Sámi reindeer knowledge conclude that "the culture of nutrition is intellectual knowledge. . .developed for centuries, preserved in the culture of the ethnos, reflected in the economy and life, passed on from generation to generation, used in ritual ceremonies and material culture. . . . All traditional actions and objects have their names in the Nenets and in the Sámi languages" (Serotetto & Lyublinskaya 2018, p. 21).

In circumpolar regions, knowledge not only of animals but also of snow and ice is critical to survival. As Eira et al. (2013, p. 117) show, traditional Sámi snow terminology is "more holistic and integrated into the ecology of the herd and pastures than the international standard snow terms." Sámi snow and ice terminology may denote "snow types, temperatures, wind, snow density, snow depth, snow layers, physical snow processes on the ground and on trees" (p. 118). The terms are highly practical and "imply characteristics needed to communicate conditions relevant to reindeer husbandry and ecology, such as access to food, water, and space; physical activity, shelter, and rest; mobility; visibility of tracks; and visibility of animals and the environment" (p. 118). Sámi herders have many untranslatable concepts that describe the accessibility of pastures for reindeer grazing in winter; for example, "the meaning of the word *guohtun* encompasses both the snow conditions and the lichen" (Roturier & Roué 2009, p. 1960). As lichen is essential for reindeer survival, it is not surprising that Sámi nomenclature encodes not only nutrient value but also different lichen species' regrowth patterns after fire (Kendig 2020). Sámi snow terminology models stratigraphy, the layers of the snowpack, using concepts such as *čearga* which lack an equivalent term in the scientific snow classification system. By painstakingly aggregating herders' narratives, Eira et al. (2013, p. 121) are able to define it:

> [W]ind is an important modifier of snow crystals and the snowpack. It leads to the development of *čearga* conditions. When strong cold winds transport the snow, snow particles are broken down in turbulent drift. These broken particles often form a strong and dense snowpack. *Čearga* can be so hard that neither reindeer nor people can dig through the snow. In areas with *čearga*, reindeer are "locked out" from grazing on the plants beneath the snow. This causes poor feeding conditions for the reindeer. The thickness of a *čearga* layer can be from 5 cm to one meter deep. *Čearga* conditions affect the mobility of both reindeer and humans as it is easy to travel on this type of snow. Consequently the herders have to be very careful not to lose individual reindeer to neighbor herds. However, in terms of tracking capabilities, *čearga* is unfavorable. It is difficult to see where individual reindeer have been walking. *Čearga* is at the top of the snowpack, but may include as much as half the snowpack when grazing conditions are poor. The term *čearga* is used in winter, from January to April.

Snow terminology—long a linguistic curiosity, yet still not fully appreciated—arises out of lived Sámi experience, and directly facilitates survival.

Beyond mere survival, language enables long-term sustainability of habitats. Indigenous societies have their own concepts of caring for their land, in both its practical and sacred dimensions. The Zapotec communities in Oaxaca, Mexico, inhabit a biodiversity and language hotspot (Kelso 2019). For them, "conservation is a new word that implies an exclusive space since it forbids the daily use of the territory" (Peña Azcona et al. 2020, p. 178). Native Zapotec terms that roughly

correspond to 'conservation' are more holistic and usage-based. In Mazahua, the Zapotec word *Gapanu* means "to care, to have, relating to use. They acknowledge the importance of taking care of the hills and mountains because they are a source of subsistence; water comes from there and wood can be obtained for the construction of their housing" (p. 177). In El Morrito, people "refer to conservation in Zapotec as '*Yapani Shaa*', which means 'to care for', 'to have it', and '*Que iruti caa ni valla*', which means 'no one should touch it'" (p. 177). Zapotec linguist Moises García Guzman (personal communication, 2019) explains how harvesting cycles and taboos encoded in Zapotec facilitate sustainability:

> An example is the exploitation of thin bamboo. There is a bush that people use to make their brooms. We have two sets of forests that are used to exploit wood as well. Specifically for that thin bamboo there are cycles of seven years that people follow to ensure that it never disappears from either of the forests. We collect it from one side of the forest for seven years, after that we collect it from the other side, that way we have it always available.

In Micronesia, Isebong Asang (2019, pp. 206–8) explains how the Palauan language socializes its speakers to live sustainably:

> Palau is historically an oral society; its values. . .are embodied in the language of *omelengmes*, the language of social and economic order for Palauans. . . . Omelengmes is and continues to define the relationship between Palauans and their natural environment. It determines the boundaries of personal consumption and limits each Palauan's harvest from the environment. It is an essential control that ensures a continuous supply for all and recognizes that nature is not as quick to replenish its largesse. . . . Omelengmes is woven into the Palauans' respect for other living beings. This ensures the survival of the species. . . .

Indigenous concepts of sustainability, briefly discussed here, must be included in any equitable discourse about conservation. But these voices cannot be fully appreciated without the linguistic expertise that can help interpret them for a wider audience. Linguistic methods are thus an essential element of conservation science.

3. DECOLONIZING SCIENCES

Environmental linguistics helps decolonize the sciences. It relies on coproduction of knowledge with Indigenous experts, ideally as coauthors but minimally as acknowledged collaborators and intellectual property owners. Linguists were long accustomed to treating languages as extractable and copyrightable data; this is now changing. We have an opportunity to help decolonize biological sciences ranging from botany (McAlvay et al. 2021) to entomology (Si 2015) to zoology (Walsh 2021). Many sciences remain stuck in a colonial mode that touts "discoveries" by Western scientists while ignoring ancient and sophisticated local knowledge. It is still distressingly common to see headlines such as "Hundreds of new and unusual insects discovered in the Amazon's canopy" (Gililand 2021) or "Yale researchers create map of undiscovered life" (Hathaway 2021). Biologist Walter Jetz, a coauthor of the "map of undiscovered species" (Moura & Jetz 2021), opines: "At the current pace of global environmental change, there is no doubt that many species will go extinct before we have ever learned about their existence and had the chance to consider their fate. . . . I feel such ignorance is inexcusable, and we owe it to future generations to rapidly close these knowledge gaps" (Hathaway 2021).

A trio of taxonomists (Costello et al. 2013), writing in *Science*, wonder: "Can we name Earth's species before they go extinct?" They further opine: "We argue that the number of species on Earth today is 5 ± 3 million, of which 1.5 million are named" (p. 413). Some naturalists use the phrase "new to science," which seems to signal faint awareness that many species are already known to humans, but does not yet demonstrate an interest in Indigenous science or species

nomenclature. Entirely absent from this perspective is the fact that humans everywhere know species with which they cohabit. These species are mostly not awaiting discovery by humans, nor are they "lost in ignorance" (Moura & Jetz 2021, p. 631). They are often known, aptly named, taxonomized, and used by Indigenous experts. Accepting this reality exposes knowledge gaps in Western science, as Robin Wall Kimmerer (2013, p. 47) explains:

> The language scientists speak, however precise, is based on a profound error in grammar, and omission, a grave loss in translation from the native language of these shores. My first taste of the missing language was the word *Puhpowee* on my tongue. I stumbled upon it in a book by the Anishinaabe ethnobotanist Keewaydinoquay, in a treatise on the traditional uses of fungi by our people. *Puhpowee*, she explained, translates as "the force which causes mushrooms to push up from the earth overnight." As a biologist, I was stunned that such a word existed. In all its technical vocabulary, Western science has no such term, no words to hold this mystery. You'd think that biologists, of all people, would have words for life. But in scientific language our terminology is used to define the boundaries of our knowing. What lies beyond our grasp remains unnamed.[2]

As anthropologist Roy Ellen (2006, p. 64) writes: "Scientific and folk classifications have coevolved in recent global history, and the relationship between folk knowledge and instituted scientific knowledge can be modeled as two interacting and mutually reinforcing streams."

The environmental turn is thus more accurately a return to themes found in classic works in linguistics, especially in lexicography. There is a long tradition in both linguistics and anthropology of taking seriously Indigenous (folk) biological nomenclature and taxonomics. As Ellen (2006, p. 65) notes: "Anthropological studies of biological knowledge emerged from the Boasian ethnolinguistic tradition associated with Edward Sapir and Benjamin Lee Whorf. Initially, this was concerned with demonstrating what people knew and how they organized that knowledge at the level of individual 'cultures'. The prime exponent of this approach within ethnobiology was Harold Conklin." In this earlier ethnographic era, "universal knowledge was the fashion" (Ståhlberg & Svanberg 2021, p. 114). The later universalist turn in linguistics led to a neglect of Indigenous knowledge. As Knopf (2015, p. 180) points out, many scientific fields manifested "a legacy of colonial and neocolonial relations, where Indigenous social and political structures, knowledges, religions, and world views were seen as inferior, insignificant, and even barbaric by the Western standards." Now our field—guided by Indigenous scholars—is taking a welcome "turn toward the indigenous" (p. 179) while establishing linguistics as a key environmental mode of knowing. This turn should be welcomed and accelerated. It will have broad implications for our field, especially in three areas.

First, and most germane to this review, an Indigenous turn requires us to take seriously and literally (not just metaphorically) conceptualizations of language and environment as a unified network of relations, reciprocally constructed. We can no longer approach language documentation as something that can be done adequately without equitable collaboration, reciprocity, or in settings separate(d) from the natural environments in which the languages are spoken.

Second, it requires us to take seriously memory and orality as the natural modalities for languages, thus helping us overcome our literacy bias. This may temper our overreliance on capturing languages in symbolic systems and in abstract representations that lack interpretability and relevance to speakers. We need not discard linguistic theory. Rather, we can elevate speaker-centric genres such as narrative, poetics, rhetoric, sound symbolism, language play, song, and taxonomics (to name a few) to an equally respected place in our theory, no longer subordinate to more linguist-centric concerns such as universals of grammar or abstract theoretical constructs. Emphasizing orality will also shift the focus to key individuals who transmit knowledge. As Ly (2020, p. 225)

[2]Keewaydinoquay Pakawakuk Peschel (1919–1999) was an Anishinaabe author, ethnobotanist, and scholar.

explains, "indigenous culture depends a lot on local leaders, gatekeepers such as the elderly, chiefs, shamans. . .because they are who maintain and transmit beliefs to the next generation."

Third, an Indigenous turn exposes power relations in the academy, with implications for recruitment, training, and hiring of linguists, scholarly collaboration, coauthorship, publishing, intellectual property, and research ethics. Papers coauthored with Indigenous scholars—who own their languages—will become a norm (many such papers are referenced herein). Native speakers will assume their proper role as our teachers and collaborators, not our consultants or data sources. Collaborations by linguists with botanists and other scientists, and with Indigenous experts, will increase. These nascent partnerships make it an exciting time to be a linguist, and will positively influence our methods. For example, many language activists explicitly state that the preservation and protection of their environmental–spiritual knowledge—and the lands therein defined—are not only a primary goal of their revitalization efforts but also their key methodology. As Richard Littlebear (1997, p. 2) explains: "Our land base and sacred practices are passed on through our languages, not by English. . . . The passage of time and the continuing loss of our languages separates us from our sacred references and our sacred sites. We have to refer to them constantly. We need to see that our languages continue to refer to our sacred sites." This perspective will help those of us who engage with Indigenous communities to better align our priorities with theirs.

As a long-standing yet emergent field, environmental linguistics brings together many strands of inquiry and exploration while centering local perspectives that link land with language. It has intellectual merit, social impact, and global relevance in both applied praxis and theory. Perhaps the greatest contribution linguistic science can make to human well-being and the health of the planet lies not in our discovery of abstract grammatical patterns, or in hypotheses about universal grammar, but rather in the unique doorway linguistics opens into the natural world, illuminating our precarious place within it as eloquently articulated in more than 7,000 tongues. Linguistics must therefore count among the key sciences that will allow us to advance conservation, protect biodiversity, and ameliorate effects of climate change (Raygorodetsky 2011). Native science, as Gregory Cajete (2016, p. 18) notes, helps us "face the challenges of climate change and begin to attempt to create a more sustainable way of living on the Earth."

Most of what humans know about plants, animals, weather, and diverse natural phenomena is found not in scientific databases or scholarly publications but in minority and often endangered languages. Indigenous worldviews, which emphasize holism and interconnectedness, stand in contrast to specialized fields of science that may be deep yet siloed. As Lyall et al. (2019, p. 402) explain: "Kwakwala language about plants demonstrates complex and intimate knowledge of land, ecology, ocean, forests, and the interconnectedness between plants, animals, environment, and people." Yet access to the Kwakwala, Solega, and Tuvan knowledge bases is possible only through the generosity of the speakers, with respect for their ownership of the languages and with appreciation for the complex linguistic encoding of knowledge. Environmental linguistics shares and promotes these values. If we have the humility to listen to the experts, it is a way of knowing that may help save the planet.

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