Sensory Ecology, Bioeconomy and the Age of COVID: A parallax view of Indigenous and scientific knowledge

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Abstract:

Drawing on original ethnobotanical and anthropological research among Indigenous peoples across the Amazon, we examine synergies and dissonances between Indigenous and Western scientific knowledge about the environment, resource use, and sustainability. By focusing on the sensory dimension of Indigenous engagements with the environment—an approach we have described as "sensory ecology" and explored through the method of "phytoethnography"—we promote a symmetrical dialogue between Indigenous and scientific understandings around such phenomena as animal-plant mutualisms, phytochemical toxicity, sustainable forest management in "multinatural" landscapes and the emergence of novel diseases like COVID-19. Drawing examples from our own and other published works, we explore the possibilities and limitations of a "parallax view" attempting to hold Indigenous and scientific knowledge in focus simultaneously. As the concept of "bioeconomy" emerges as a key alternative for sustainable development of the Amazon, we encourage a critical and urgent engagement between dominant Western conceptions and Indigenous Amazonian knowledge, practices, and cultural values. Cognitive science, which has long contributed to studies of Indigenous categorisation and conceptualisation of the natural world, continues to play an important role in building bridges of mutual communication and respect between Indigenous and scientific approaches to sustainability and biodiversity conservation.

Keywords: Amazonia, traditional ethnoecological knowledge, sustainability, development, bioeconomy

Introduction

Even with English as the shared global language of scientific publication, cultural anthropologists and natural scientists are barely able to communicate with one another. The theoretical premises and methodological habits of the social and natural sciences are not so much contradictory, as taking place on largely separate intellectual planes. For example, anthropologists working with Indigenous peoples of the Amazon have long been interested in how these diverse cultures conceptualise plants, animals and environmental processes. However, the results of these fascinating investigations rarely have any impact on mainstream research by ecologists and conservationists working in the same region (Fernández-Llamazares and Virtanen 2020). By the same token, the fascinating and often relevant work done by natural scientists on Amazonian environments and species is rarely taken into consideration in anthropological studies, which tend to focus on abstract, metaphysical conceptions of the natural world as found in myths, shamanism and ritual practices (Shepard and Daly 2022). The field of ethnobiology, deeply influenced by cognitive science, has long sought to bridge this gap (Berlin 1992; Nazarea 1999; Medin and Atran 1999). Adopting a paradigm strongly allied to the natural sciences, however, the interdisciplinary dialogue between ethnobiology and cognitive science has largely excluded contemporary anthropological insights emerging from multi-species approaches and the "ontological turn" (Daly et al. 2016; Ellen 2016; Furlan et al. 2020). While there are certainly powerful institutional forces at play in hampering interdisciplinary communication, these disciplinary divisions are themselves deeply rooted in the Cartesian divide between mind and body that lies at the very foundations of contemporary Western philosophy and science (for a useful discussion on this point, see Hornborg 2006).

Given the cascading social, environmental and climate crisis, it seems ever more urgent to build bridges of dialogue between the human and natural sciences, and even more importantly, between Western and non-Western conceptions about nature, humanity and the environment. To this end, we present our own efforts to build a symmetrical exchange between Indigenous Amazonian and Western scientific understandings of ecological processes and the burgeoning environmental crisis, in the hopes that these methods and concepts could inspire others. In the context of this special issue, we draw on our own case studies and the work of others to suggest avenues of methodological and theoretical exchange between contemporary Amazonian anthropology and cognitive science, building on but also transforming existing approaches from ethnobiology. Specifically, we present case studies drawn from own research in Amazonia into Indigenous and scientific understandings of ant-

plant mutualisms, toxic compounds used in traditional medicine and shamanism, the formation of domesticated forest landscapes and the COVID-19 pandemic.

In examining synergies between Indigenous and Western science while also acknowledging profound epistemological and ontological differences, we borrow Ruth Ginsburg's (1995) concept of the "parallax effect." In her analysis of the frictions between aboriginal and conventional approaches to film, Ginsburg uses the phenomenon of parallax, borrowed from the field of optics, as a metaphor for the new perspectives offered by Indigenous peoples' "slightly different angles of vision" (ibid: 65). In a similar way, we suggest that Indigenous and Western understandings of the natural world should be seen, not so much as in diametrical opposition, but rather in a productive tension that reveals new vistas and deeper insights into shared and urgent contemporary human dilemmas.

Indigenous and Western science: Possibilities and limitations of dialogue

Mind/body dualism is the foundation for what Latour (1993: 12) refers to as "the Great Divide" between the human (Culture) and nonhuman (Nature) realms that characterises modern Western thought. The mind/body dichotomy is not such a problem for Amazonian Indigenous peoples (e.g., Taylor 1996; McCallum 1996; Viveiros de Castro 1998; Barreto 2022), but it is for Western scientists, anthropologists and policy makers, who are constantly tripping over Cartesian dualism and the related nature/culture divide in their efforts to implement sustainable development goals. There is no doubt that the reductive, rationalist principles established by Descartes and other early Enlightenment philosophers and scientists contributed to the phenomenal growth and success of Western science and technology over the ensuing centuries. But as the global ecological crisis puts the very basis of civilisation under greater threat, we are witnessing the drastic, and perhaps unavoidable negative impacts of a philosophical viewpoint that objectifies non-humans and even other human beings, elevates humanity outside of the natural world, and commodifies everything.

Indigenous conceptual systems, by contrast, are built upon a more fluid ontology which incorporates 'natures' and 'cultures' into an integrated, relational whole. Perhaps the most important contribution of Amazonian anthropology to contemporary social theory has been its exploration of the subjectivity and fundamental humanity of non-human beings through the lens of Indigenous ontologies, mainly via the intellectual currents of "animism" (Descola 1994) and "perspectivism" (Viveiros de Castro 1996). The personhood of animals is central to Viveiros de Castro's formulation of perspectivism, where, according to Indigenous concepts, each species sees itself as a person with a human body and culture, while other

species are perceived according to their "cosmological perspective," as determined by predatory relationships: the peccary sees itself as a person, but regards human hunters as predatory jaguars, while the jaguar sees itself as a person, and regards humans as peccaries to be hunted (Viveiros de Castro 2002). In this "cosmos-as-ecosystem," predation is a central metaphor governing social, ecological and symbolic exchanges between humans, animals and spirits (Reichel-Dolmatoff 1976; Århem 1996; Fausto 2007).

In Amazonian life-worlds, the entire human life cycle, from birth and growth through senescence, death, and decay, including biological as well as social dimensions on individual as well as collective scales, includes vital non-human actors, whether biotic, abiotic, or spiritual (Shepard 2004; Santos-Granero 2012; Kohn 2013; Seeger et al. 2019[1979]; Zent and Zent 2022). Thus, the intertwined spiritual and ecological lifeworlds of Amazonian Indigenous peoples harness the agency of plants, animals, spirit-beings, landscape features, and other non-human persons in an integrated sphere of relationships. In these Indigenous Amazonian philosophies of life, the soul is embodied and the body is ensouled (Shepard 2018; Daly 2021). In contrast to Cartesian metaphysics and its dualistic ontology, then, Amazonian Indigenous peoples tend to see the physical and the spiritual, the material and the intangible, body and mind, and ultimately nature and culture, as intermingled and interdependent rather than opposed, though of course these categorical distinctions are themselves conceptually problematic (Descola 2013).

The practical result of these non-Cartesian philosophies is that Indigenous peoples of Amazonia and other parts of the world turn out to be better stewards of biodiversity than their non-Indigenous counterparts (Garber et al. 2022), even though these outcomes are not necessarily predicated upon explicitly conservationist practices. As humanity faces unprecedented social, ecological and epidemiological crises, a growing number of scholars suggest that active collaboration with Indigenous knowledge systems should be a significant part of global conservation and sustainability strategies (Chapin 2004; Franco-Moraes et al. 2019; Fernández-Llamazares and Virtanen 2020; Athayde et al. 2021; Estrada et al. 2022). Yet given the noted differences between Indigenous and Western scientific epistemologies, not to mention the inherent power asymmetries, what are the possibilities, risks and limitations inherent to such exchanges?

Comparing Native and Western science, Native American ethnobotanist Linda Black Elk has written, "Native science has at its foundation the very same scientific method that we, as researchers trained in the Western world, all hold so near and dear" – that is, detailed observation and experimentation – yet at the same time, "Native science also differs from

Western science in that it is based on *participation* with the natural world. We do not separate ourselves from the Earth's processes" (Black Elk 2016: 3, 4 – our emphasis). Indigenous worldviews tend to emphasise the holistic, relational connections between diverse elements of the biosphere, including plants, animals, rocks, landscape features, and importantly, human beings. These connections are often conceived as kindred relations (see, for instance, Rarámuri ethnobotanist Enrique Salmón on "kincentric ecology", 2000; see also ojalehto mays et al. 2020 on "folkcommunication" among the Ngöbe people of Panama).

Western and Amerindian knowledge systems have been in dialogue, in some sense, since the Age of Exploration, though it was hardly a fair or two-sided exchange. The influx of vast amounts of plant material from the New World and other tropical regions beginning in the 16th century caused a revolution in the botanical sciences, ultimately resulting in modern Linnaean taxonomy (Bartlett 1940; Ford 1978). Of course, this interest in new botanical material was hardly just academic: the original motivation for the "discovery" of the New World was European navigators' search for alternative routes in the lucrative spice trade. Early colonial explorers, physicians, missionaries and scientists received instructions to be on the lookout for "fruits and seeds, all kinds of spices, drugs, perfumes… trees, plants, herbs, fruits… and medicines" (Latorre 1914: 301). Important pharmaceutical and industrial products like quinine, strychnine, curare, ipecac, rubber, kapok fibers and many others represent direct appropriations of Indigenous Amazonian knowledge, though this intellectual debt is seldom even documented, much less acknowledged or compensated (Sanjad et al. 2021).

Beyond such crassly utilitarian interest, ethnographers and ethnobiologists have long marveled at the sophisticated taxonomic and ecological knowledge Indigenous peoples maintain about plant and animal species, ecological processes and forest habitats, including elements that may complement or even rival contemporary scientific understandings (H. Conklin 1954; Bulmer 1974; Parker et al. 1983; Boster et al. 1986; Fleck and Harder 2000; Shepard et al. 2001; Abraão et al. 2008; Kimmerer 2013; Bang et al. 2018; Franco-Moraes et al. 2019; ojalehto mays et al. 2020). Nonetheless, such ethnobiological studies tend to focus on practical, morphological and taxonomic questions that appear to show congruency or complementarity between Indigenous and scientific systems, while steering clear of deeper ontological questions that appear radically different, even incommensurate (Furlan et al. 2020; Sheldrake 2020; Prado et al. 2022).

To even begin to engage in a more productive, symmetrical and mutually beneficial dialogue between Indigenous and scientific knowledge, we must first acknowledge the

important differences in their ontological bases and social, philosophical, historical and practical functions. Viveiros de Castro (2004b: 8), for example, warns about the dangers of "silencing the Other by presuming a univocality—the essential similarity—between what the Other and We are saying." There is no question that Indigenous and scientific ways of acquiring, transmitting and acting on knowledge about the so-called natural world are fundamentally different in many ways, starting from the very definition of what comprises "nature" (Descola 1994; Rival 2012). Moreover, there is no homogenous, unified body of "Indigenous knowledge" on which to base such comparisons, since Indigenous people represent linguistically, culturally, historically, and internally diverse human groups spread across the globe in often dramatically different political, social and economic situations.

Indigenous peoples have been defined as "ethnic groups who are descended from and identify with the original inhabitants of a given region" (Reyes-Garcia et al. 2019). Indigenous and local knowledge, sometimes referred to as Traditional Ethnoecological Knowledge (TEK) by ethnobiologists (e.g., Hunn 1993), has been defined by the United Nation as follows (IPBES 2016: par. 5[a]):

> Indigenous and local knowledge systems are understood to be dynamic bodies of integrated, holistic, social and ecological knowledge, practices and beliefs pertaining to the relationship of living beings, including people, with one another and with their environment. Indigenous and local knowledge is grounded in territory, is highly diverse and is continuously evolving through the interaction of experiences, innovations and different types of knowledge (written, oral, visual, tacit, practical and scientific). Such knowledge can provide information, methods, theory and practice for sustainable ecosystem management. Indigenous and local knowledge systems have been, and continue to be, empirically tested, applied, contested and validated through different means in different contexts.

Although now codified in international law and development discourse (e.g., the UN Declaration on the Rights of Indigenous Peoples, 2007), the moniker "Indigenous" is a highly politicised category, replete with historical complexities and contestations in Amazonia and beyond (Ramos 2003; Kenrick and Lewis 2004; Carneiro da Cunha 2009). It would be difficult to attempt a general comparison of "Indigenous knowledge systems" with Western science (see Bang et al. 2018's discussion of Kimmerer [2002] on Traditional Ethnoecological Knowledge and Indigenous science), given that the scope of such a comparison would include vastly distinctive types of knowledge, from fully systematised bodies of professional practice such as Ayurveda or traditional Chinese medicine, codified in written texts for thousands of years, to the threatened and virtually unknown ethnobiological classification systems of isolated Indigenous peoples of the Amazon. Focusing on the Amazon region, however, certain general shared features of cosmology, ontology and

ethnoecological classification have been noted (Parker et al. 1983; Boster et al. 1986; Descola 1994; Viveiros de Castro 2004a; Abraão et al. 2008; Rival 2012). In this case, we hazard a general outline of major differences as well as some shared features as a preface to any further attempts at dialogue between Western and Indigenous knowledge systems.

Despite multiple revolutions in scientific thought over the past century, the Western scientific method, especially within disciplines allied to biodiversity conservation, remains largely rooted in a Newtonian paradigm based on stable, observable identities, the notion of a single Truth, the importance of measurement, and the primacy of language, especially mathematical language, as an objective description of reality. Despite the quantum revolution, many Western scientific disciplines remain firmly rooted in positivism, premised on a stark separation between observer and observed. The objectification of research subjects is associated with quantification, reductionism, universalism and statistical analysis aimed at discerning cause and effect. Such scientific methods are also closely allied with capitalist political and economic structures based on thoroughly naturalised assumptions about individualism, competition, accumulation, private ownership and the commodification of knowledge and nature itself (Latour and Woolgar 1986; Latour 1987; Tsing 2004; Helmreich 2016; Hartigan Jr. 2017). As Myers (2015) observes, Western science is also inextricably bound to its racist, sexist, economising and heteronormative history.

Indigenous Amazonian ways of knowing are associated with radically different social, epistemic, ontological and economic premises. Where Western science seeks to objectify that which is to be known, Amazonian knowledge systems take the opposite tack. As Viveiros de Castro (2004: 468) observes:

> Amerindian shamanism is guided by the opposite ideal. To know is to personify, to take on the point of view of that which must be known. Shamanic knowledge aims at something that is a someone—another subject. The form of the other is *the person*.

Rather than being reductionist, Amazonian and other Indigenous knowledge systems are *integral*, in the sense that technical aspects of hunting, horticulture and other environmental practices cannot be separated from the religious beliefs, rituals, myths and social organisation that make food production possible and meaningful. As Harold Conklin (1957: 2) remarked of the Hanunóo people of the Philippines, "One of the most significant considerations… is the extent to which the agricultural system is integrated with other systems in the sociocultural matrix." Though Amazonian and other Indigenous peoples are increasingly turning to text-based and even audiovisual and hyper-text technologies to

document and preserve their knowledge (Turner 1992; B. Conklin 2007; Shepard and Pace 2021), the basis of these knowledge systems throughout nearly all of their history has been through direct, oral transmission in hands-on, mostly non-formal learning contexts, very different from the highly formalised, mostly written and preferentially mathematical basis for communication and transmission in Western science.

Though not universally the case, much of Amazonian Indigenous knowledge about the natural world is widely shared throughout the population, though subject to strong segregation by gender and great variability across individuals and age groups. Some forms of specialised knowledge, however, such as that held by shamanic healers or midwives, may in fact be more private and reserved, and sometimes require significant economic investments to acquire through apprenticeship. While Western scientific knowledge at least attempts to be universal, Indigenous knowledge is closely tied to specific geographical and cultural regions and circumscribed territories. Combined with the active, lived nature of knowledge transmission, this gives local knowledge an intimate, embodied and highly detailed character that can be seen as different from, but also complementary to the universalising language of Western science.

Finally, there are clearly different religious, ethical and economic underpinnings to Indigenous Amazonian knowledge when compared with the Western scientific paradigm. Yanomami shaman Davi Kopenawa (Kopenawa and Albert 2013: 149) describes the ecological concept of *në rope*, translated as "value of growth," which represents the "invisible hand" regulating Yanomami economy:

> The value of growth remains abundant in the forest and if our gardens take the value of hunger, our shamans drink the *yãkoana* [psychoactive shamanic snuff] to bring it back home. And if need be we can also borrow the forest's fertility from a friendly house… When the forest's richness runs away, the game becomes skinny and scarce, for this richness is what makes game prosper… To live, their images must feed on the image of the forest's value of growth. This is why the shamans also bring down the image of the game's fat with that of the forest's fertility.

Such conceptions that bind ecology, economy, morality and spirituality present a stark contrast to Adam Smith's notions about the determinant role of supply and demand shaping Western capitalist markets. Closely tied to such economic and moral considerations, the thorny question of patenting nature, privatising and commodifying traditional knowledge and the elusive promise of sharing benefits from bioprospecting create additional barriers and justified resistance to exchanges between Indigenous and Western science (see, for example, B. Conklin 2002).

With such fundamentally distinctive ideological, epistemological, social, ethical and technological bases, it might appear that Indigenous and scientific knowledge would be entirely incommensurate, with no common ground on which to reach any form of dialogue. And yet time and again, ethnobiologists around the globe have commented on the sophistication of Indigenous taxonomic knowledge about plant and animal species, often rivaling or surpassing that of contemporary scientists (H. Conklin 1954; Bulmer 1974; Fleck and Harder 2000; Abraão et al. 2010). In one particularly noteworthy case from Amazonia, Boster et al. (1986) describe the remarkable congruities between Aguaruna Indigenous taxonomies for woodpeckers and the corresponding scientific classification.

In his foundational text on ethnobiology, Berlin (1992) draws on evidence from ethnography, linguistics and cognitive science to document apparently universal patterns observed in ethnobiological classification systems across the world and throughout history, including Western folk botanical traditions that gave rise to scientific taxonomy. While accounting for significant linguistic, geographical and individual variation, Berlin posits universally shared features of human cognition that, when confronted with the taxonomic disjunctions observed in the natural world, result in broadly similar folk biological systems. European folk biological classification systems, which reach back to Antiquity and laid the perceptual foundations of Linnaean taxonomy (see Bartlett 1940), are no exception, showing remarkable similarities to Indigenous folk taxonomies. Indeed, Bang et al. (2018) argue that Western (European and Euro-colonial) and Indigenous folk or "lay" knowledge systems are more similar to one another than to the peculiar ways of thought of trained Western scientists. On the other hand, Ingold (2000) suggests that scientific and Indigenous or "folk" ways of knowing are not entirely incommensurate. Beyond the overt similarities between scientific and folk taxonomies of species and ecosystems, Ingold also points out the sometimes hidden importance of hands-on, trial and error, "oral" knowledge transmission even in scientific apprenticeship. Ingold (2000: 20) draws attention to the ways in which close observation of the natural world can lead to transformative perceptions and insights, inviting human curiosity to follow cues and seek patterns (see also Black Elk 2016).

While heeding Viveiros de Castro's (2004) warnings about "silencing the Other," we provide here several examples from our own work and the literature that lay out a pathway for respectful, meaningful and mutually illuminating exchanges between Indigenous and scientific ways of knowing, which pay heed to points of alignment and convergence whilst also striving to take seriously the epistemological and ontological differences at play (see also Rival 2014). Crucially, various Latin American scholars have pointed out how such

ontological disjunctures and dissonances are imbued with asymmetrical power relations, and have called for a decolonisation and radical retheorisation of these politics (Blaser 2009; de la Cadena 2011; Rivera Cusicanqui 2012).

The Ant, the Shaman and the Scientist

Scientific discoveries often happen in unlikely situations. And so, deep in the tropical rainforest of Manu National Park, Peru, a discussion between a Matsigenka shaman and a Harvard ecologist led to a significant discovery about ant-plant mutualisms (Shepard 2011), while reviving a century-old debate in tropical ecology between Richard Spruce and Alfred Wallace (see Edwards et al. 2009). Douglas Yu, then working on his Ph.D. at Harvard University under the mentorship of E.O. Wilson, was visiting the Matsigenka community of Yomibato, where author Shepard was carrying out ethnobotanical research. Yu was studying the mutualistic relationship between several species of ants and the plant *Cordia nodosa*, a bristly tropical shrub related to borage (*Borago officinalis*). The *Cordia* plant offers the ants protective corridors of bristly hairs along its stems as well as large swollen branch nodes, which the ants hollow out to make nests. In return, the ants protect the host plants from other insect predators and in some cases, clear out competing vegetation, creating notable clearings in the understory. Local Quechua-speaking colonists refer to these clearings as "Devil's gardens" (*supay chacra*).

The Matsigenka people also recognise the mutualistic relationship between ants and the *Cordia* shrub. Indeed, the Matsigenka word for the plant is *matyagiroki*, which means "arboreal ant shrub," where *matyaniro* refers generically to a number of ant species frequently encountered on plants and leaves, like *Allomerus*, *Azteca*, *Myrmelachista* and the miniature fire ant, *Wassmania*. Ants and other insects involved in such mutualistic relationships with plants are referred to generically as *iriite*, "its (i.e., the plant's) larvae," a term otherwise reserved for the larval stage of insects, and generally implying multiplicity, i.e., not a single larva but a large, almost uncountable number. Thus, plant-insect mutualistic relationships for the Matsigenka are couched in ontogenic vocabulary, implying that the host plant is a kind of adult or "parent" to the fragile, multitudinous larval insect "children."

For the Matsigenka, the clearings found around *Cordia* plants are the work of spirit beings known as *Saankariite* (also written *saangariite*), a term which has previously been glossed as "pure" or "invisible ones" (Rosengren 1998; Shepard 1999, 2018), or "invisible beings, good spirits, angels" (Snell 2011). Indeed, *Saanka-* is a Matsigenka verb root referring to purity, cleanliness, transparency, invisibility and erasure, as in *saankiari* "clean,

transparent water" or *saankagantsi*, "to clean, purify, fade, erase, disappear." However, the word *Saankariite* also incorporates the noun suffix *-iite* noted above, referring to insect larvae and mutualistic plant-insect relations. Thus, the literal translation of the term is "invisible larvae", making a direct allusion to plant-insect mutualisms. A looser gloss might be "invisible swarm," highlighting their multitudinous nature.

Matsigenka shamans come to these spirit clearings and consume powerful psychoactive preparations such as tobacco paste, ayahuasca (*Banisteriopsis*), or the *Datura*-like toé (*Brugmansia*; Shepard 1998, 1999). With the aid of such visionary plants, the shaman perceives the true nature of these mundane forest clearings: they are the villages and swidden gardens of multitudinous, capricious, and powerful human-like spirit beings, who are unimaginably distant and inaccessible under ordinary states of consciousness. While in trance, the shaman enters the invisible village and develops an ongoing relationship with a spirit "brother" (*ige*) among the *Saankariite*, who can provide him or her with esoteric knowledge, news from distant places, healing power, artistic inspiration, auspicious hunting and even novel varieties of food crops or medicinal plants from their gardens (Shepard 1999).

As empirical proof of this hidden reality, the Matsigenka shaman Mariano Vicente Kiche pointed out tree trunks adjacent to the *Cordia* clearing, noting a profusion of swollen, scar-like nodules: "These are the burn marks caused by fires set by the *Saankariite* every summer to clear their gardens," he explained.

Yu, who had been researching the *Cordia* ant-plant relationship for years, had never observed this phenomenon. Dozens of trees around this large stand of *Cordia* were pocked with similar "burn marks." Intrigued, Yu cut into these formations with his pruning shears and found nests teeming with *Myrmelachista* worker ants that appeared to be galling the trunks to create additional housing, thus ensuring colony longevity. As detailed in *American Naturalist* (Edwards et al. 2009), this was the first recorded example of ants galling plants, thus resuscitating a pet theory of Spruce's that Wallace and later naturalists had rejected. This galling and colony-forming behavior, apparently unique to *Myrmelachista*—and as revealed by a Matsigenka shaman's keen insights—was also crucial in helping Yu fully characterise the ecological conditions shaping the mutualistic niche shared by three competing ant species.

In addition to such direct contributions to a scientific discovery, the striking Matsigenka conception of an "invisible swarm" of multitudinous spirits living in unseen villages suggests a fractal relationship between shamanic knowledge and observable ecological processes. Beyond abstract symbols or spiritual metaphors, these shamanic

observations appear to relate to the living world as through a cosmological microscope, drawing non-arbitrary connections between microcosm and macrocosm, and relating ecological to cosmological processes. There is a of course a clear ontological distinction between the scientific paradigm and the Indigenous view of these phenomena. However, by holding the ecological perspective in one eye and the cosmological perspective in the other, we can imagine bringing both views into overlapping focus onto a novel, stereoscopic vista, and thus unveil a richer, more comprehensive and interesting landscape, somewhat analogous to what Ruth Ginsburg (1995) has described as the "parallax effect" in Indigenous cinema (see above).

Magic Darts and Messenger Molecules

A similar parallax between Indigenous and scientific insights was revealed in a collaborative investigation by the authors into a category of "charm plants" known as *bina* by the Makushi people of Guyana. Daly describes an interview with Makushi elder John Samuels in a Makushi village on the Rupununi River concerning *waawî* spirit darts that shamans (*pia'san*) are said to acquire from *bina* plant-charms (Daly and Shepard 2019; see also Daly 2015; Van Andel et al. 2015). These spirit darts are fired during shamanic warfare and extracted from patients' bodies during healing rituals. Grandpa John described them as "tiny crystals… an arrow, but with macaw feathers" (Daly and Shepard 2019: 13). Shamans are able to shoot these darts at their enemies: "like a missile, like star-light. But it is invisible to us. That arrow shoots into your chest and kills you straight away" (ibid.). He made a miniscule drawing (about 8mm by 15mm) in Daly's field notebook showing a cluster of pencil lines to illustrate the spirit darts he observed during shamanic training in his youth. Having imagined something more elaborate, Daly was initially disappointed in the tiny sketch, attributing its poor quality to John's arthritis and failing eyesight.

Several years later, the authors worked together examining the botanical identification and chemical properties of different *bina* species for clues as to how the Makushi understand and use these plants. Although botanically diverse, the botanical group most frequently associated with *bina* is the Araceae, or calla lily family. Many Araceae species, including important *bina* varieties, contain toxic compounds known as raphides, which consist of needle-like, microscopic crystals of calcium oxalate that are responsible for the "stinging, irritating, and inflammatory activities of Araceae plant tissues," referred to in the medical literature as "the needle effect" (Kono et al. 2014). These microscopic needles can cause

severe bodily reactions in humans (and other herbivores) by facilitating the transmission of toxic phytochemicals through the skin or internal membranes within the body.

These phytochemical insights into the toxicity of *bina* plants led us to appreciate Uncle John's sketch of *waawî* spirit darts in a new light. Though Makushi shamans have never examined calcium oxalate crystals under a microscope, their detailed knowledge of the chemosensory qualities and physiological effects of these and other toxic, medicinal and bioactive plants have allowed them to understand these microscopic processes through the surprisingly accurate metaphor of the spirit-dart: in a revealing point of convergence between scientific and shamanic understandings, these plants are in fact riddled with pathogenic crystalline "needles" that are invisible to the naked eye. The example of Makushi spirit-darts demonstrates the multiscalar and integrated character of shamanic philosophy, which oscillates between—and sometimes inverts—the micro- and macroscopic in transiting the levels of the shamanic multiverse (see also Herrera 2018).

Raphide toxicology may also play an entirely overlooked role in the widespread phenomenon of attack sorcery or "dark shamanism" in the Guianas, known regionally as *kanaimà* (Butt Colson 2001; Whitehead 2002; Wilbert 2004; Daly and Shepard 2019). According to the Makushi, *kanaimà* are malevolent shamans who use a portfolio of secret *bina* plant-charms to obtain illness-inducing darts which are used to maim and kill their victims. *Kanaimà* are said to poison their victims before piercing their tongue with snake fangs, such that tongue and lips are swollen shut, and then scraping away the sphincter muscles of the rectum with an iguana or armadillo tail, leading to intestinal incontinence. Anthropologists have interpreted the specific symptoms of *kanaimà* sorcery as an inversion of ingestion—mouth swollen shut like a sphincter, rectum open like a mouth—associated variably with a structural inversion of shamanistic healing, a social response to envy, a vestige of colonial violence or a form of Indigenous resistance (Butt Colson 2001; Whitehead 2002). And yet these are also precisely the symptoms caused by ingesting significant doses of raphide-containing Araceae, which have particularly toxic effects on mucus membranes around the mouth and anus (Desphande 2002: 553; Hayes 2008: 990).

This is not to say that raphide chemistry obviates the essential historical, sociological and symbolic investigations by anthropologists on *kanaimà* sorcery in the Guianas, nor does it explain away the more widespread phenomenon of sorcery darts throughout Amazonia (see Chaumeil 1993). Rather, the unexpected congruence between Indigenous and scientific insights into *bina* toxicity reveals a striking chemosensory logic connecting Makushi ethnobotany with these broader cultural ideologies, enriching both anthropological and

pharmacological understandings of these complex biocultural practices. We have dubbed this approach "sensory ecology," and have described the attendant interdisciplinary methodology as "phytoethnography" (Shepard 2004; Daly and Shepard 2019).

Multinatural Landscapes of Amazonia

Moving beyond the scale of individual plants and substances and their "sensory ecologies" in Amazonian shamanism, we have also sought to apply a parallax view to Indigenous understandings of ecological processes shaping tropical forest biodiversity. Recent studies have pointed to persistent floristic legacies left by pre-colonial and historical Indigenous peoples through conscious and unconscious management practices, some of which are ongoing (Shepard and Ramirez 2011; Lins et al. 2015; Franco-Moraes et al. 2019; Levis et al. 2018; Fausto and Neves 2018). Amazonian Indigenous peoples appear to have invested their efforts in domesticating cultivated species in gardens as well as wild populations of plants in actively managed agroforests and surrounding forest landscapes (Clement et al. 2015). In this way, some Amazonian landscapes have been transformed into cultural or ancestral forests (Rival 1998; Balée 2013; Franco-Moraes et al. 2019), that appear natural to the eyes of colonisers, but are in fact anthropogenic in origin.

For example, Franco-Moraes et al. (2019) analysed floristic composition of mature, apparently primary forests located in the territory of the Baniwa Indigenous people of the northwestern Brazilian Amazon. Prior studies predicted that forests in the region would not show signs of significant anthropogenic alteration of species composition (Bush et al. 2015). However, working in old-growth forests near ancient village sites identified by the Baniwa, the authors encountered "ancestral forests" with as much as 57% of the tree biomass consisting of wild fruit trees managed by the Baniwa, compared to only 10% of such species "immemorial forests" with no memory of past habitation or management by the Baniwa. Participatory mapping and direct observations revealed ancestral forests to be widely distributed throughout the region, whereas old-growth forests are rare. Yet structural analysis reveals ancestral forests to be nearly indistinguishable from immemorial forests: to an ecologist or botanist, both would appear to be pristine and natural.

Such domesticated Amazonian forested landscapes represent the multispecies outcomes of intentional and unintentional practices, accumulated over countless generations. As such, they represent social spaces that have been harnessed for human purposes, yet without excluding the multitude of other species and their associated ecological functions. Thus, to call such modified forests merely "anthropogenic" simplifies Indigenous worldviews

and livelihood practices, which acknowledge the agency of multiple species and beings in their formation (Oliveira 2016; Oliveira et al. 2020). Moreover, the socioenvironmental processes that have generated cultural forests also act in the reverse direction, leading to the "forested" cultures of Indigenous Amazonian peoples (Franco-Moraes et al. 2019; Shepard and Daly 2022), for whom ecology and biodiversity are essential components of myth, ritual and cosmology (Reichel-Dolmatoff 1976; Århem 1996).

Borrowing from the work of Eduardo Viveiros de Castro (2002, 2004), we have developed the concept of "multinatural landscapes" in Amazonia. According to Amerindian concepts, all living beings are, fundamentally, persons, sharing a universal human culture, while the "natural" biological form varies from one species or being to another. Culture, here, is a trans-specific quality shared by all sentient beings (animals, plants and other beings), typically conceived of as "other-than-human persons" (Hallowell 1960). Viveiros de Castro describes this as a "multinatural" ontology, in contrast to the "multicultural" Western notion of a universal, biological nature underlying the myriad variations of human language and culture (1998, 2004b).

According to Viveiros de Castro, Amazonian ontologies imply not a single, unifying biological nature, but rather a multiplicity of natures that may vary according to diverse cultural conceptions about the nature/culture relationship. In this regard, the study by Lins et al. (2015) highlights an additional nuance to our concept of multinatural landscapes: namely, distinctive archaeological cultures in the central Amazon seem to produce measurably different floristic legacies, detectable a millennium after the sites were abandoned. In other words, cultural diversity in the past, acting through variable cultural habits, management practices and food preferences, can result in distinctive botanical signatures in the landscape that persist for centuries. Like a living tapestry, the forest bears the fingerprints of prior human activity, stretching back many generations and linking societies and their territories into a complex historical web of human-forest and other-than-human mutualism. Domesticated crops and other kinds of vegetal infrastructures undergird these cultivated landscapes, shaping them through historical time (Rival 1998; Daly 2021).

Indigenous peoples of the Amazon depend on standing forest for their livelihoods, and they have shaped these forests to suit their own needs through time, in parallel to the needs of multiple other species and beings. This realisation fundamentally transforms our understanding of biodiversity conservation and resource management in regions with long-term Indigenous occupancy. It is especially urgent to acknowledge the role of Indigenous peoples in shaping Amazonian biodiversity in the current context of the Anthropocene

(Lorimer 2012; Kawa 2016; Hornborg 2017; Latour 2017; Erickson 2022). Incorporating Indigenous knowledge and practices into the conservation framework is vital for both biodiversity conservation and Indigenous rights (Chapin 2004; Estrada et al., 2022).

Revenge of the Bat-People

The COVID-19 pandemic caught most of the world by surprise. However, Indigenous peoples of the Amazon have had centuries of experience dealing with deadly epidemics. While global emergency measures such as social distancing, travel restrictions and lockdowns were unprecedented in the recent history of Western public health, Indigenous peoples have long used the strategy of "voluntary isolation" to protect themselves from the immunological and existential threats of European colonisation (Shepard 2016). While some governments hesitated or struggled to impose such unusual restrictions on their populations, Indigenous peoples across the Amazon took the lead by declaring self-imposed quarantines and village lockdowns to avoid the introduction of this virulent new disease to their communities (Shepard 2021).[1] As Tuyuka priest Justino Sarmento Rezende (2020) of the Upper Rio Negro in Brazil, reflected on his own childhood:

> I was born far from the city, at "Jaguar-Creek." Whenever my father heard that a dangerous disease was coming, he took us to an even more isolated place. There, we waited until the latest news finally reached us: "the disease has passed." We had no doctors or nurses to take care of us. But we were watched over constantly by our sage grandparents who performed protective ceremonies using white pitch incense to fumigate the environment, the people and their pets… This current time with its current viruses, with their own proper names, it takes me back to the past and reminds me of the wisdom of my grandparents who helped to defend life.

In addition to their pro-active and in many cases effective responses to the COVID pandemic, Indigenous communities also developed their own understandings of the disease's origin in dialogue with evolving scientific information as it circulated through the news and social media. Anthropologist Els Lagrou (2020) was in communication with her Indigenous Huni Kuin friends in the Brazilian Amazon just before they went into their own self-imposed COVID isolation protocol in early 2020. She was struck with the prescient observation of Huni Kuin shaman Ibã Sales who was certain this new disease belonged to *nisun*, a traditional illness category. *Nisun* in the Huni Kuin language refers to illnesses produced by spiritual revenge of the non-human personifications of animal species who are upset at humans for overhunting, disturbing sacred places, sullying certain animal habitats or disregarding other behavioral norms (see also Shepard 2004; Read et al. 2010; Vieira et al. 2017). Despite

intensive research and public scrutiny, there is still no scientific consensus as to the precise origin of the novel coronavirus pandemic, or even whether it emerged from natural zoonotic contagion or from a laboratory leak in Wuhan. However, there seems to be a clear genetic association between the novel coronavirus and closely related pathogens found in bats commonly sold for medicinal purposes in Chinese markets. Ironically, a common ethnic moniker for the Huni Kuin people is Kaxinawa, which means "bat people" in their language, not because they consume bats, but because they consider them to have transformative powers. When she mentioned to her Huni Kuin friends that bats might be involved in the origins of the COVID-19 pandemic, they were not surprised: indeed, their shamans had already guessed as much.

As Lagrou (2020) observes:

> The ontologies of these minorities, however, speak a language that contains vital knowledge for the planet today, and that we need to translate urgently into the language of science… New scientific discoveries are moving closer and closer to what Amerindian philosophies have been trying to teach us for some time.

On a recent field trip to the Makushi community of Yupukari in January 2023, coauthor Daly saw how local healers (*taren esak*) similarly responded to COVID-19 using Indigenous epistemologies of healing and etiology incorporating microbiological pathogens, spirit projectiles, and shamanic plant remedies. Although many local people had been vaccinated against COVID, Makushi healers emphasised that the impact of the disease was eased locally by the use of traditional "bush medicine". In particular, healers cited the use of "bitter barks" (*mai' pi'pî*), gathered from large trees in the high rainforest (*yu'*) and consumed as tea-like infusions. These remedial infusions combine multiple native and introduced plant substances with intense sensory properties, including garlic, ginger and lime. According to villagers, it was Indigenous "high science" (a vernacular term for shamanic wisdom, as opposed to Western science and biomedicine), rather than pharmaceutical drugs, vaccines, or social isolation, that protected people against the full impact of this new disease. Local healers understood coronavirus to be a disease (*paran'*) brought by outsiders (*ratiko*), but for which their own traditional remedies gave them more protection than biomedicine in isolation. As evidence, healers contrasted local resilience to the lethal pandemic with the devastation it caused in other parts of the world. In these contrasting examples of Indigenous responses to COVID-19, native practices and epistemologies have been held up alongside Western medicine in a show of cultural resilience and pride.

Discussion: Parallax Vistas, Equivocations and the Emerging Bioeconomy

Increasingly, Amazonian biodiversity and the finely-tuned socio-ecological systems found in Indigenous territories are under threat from right-wing political movements, rampant resource extractivism, industrial monocultural agriculture, neocolonial ranching, and aggressive development projects. Accelerating deforestation coupled with climate change and extreme oscillations in rainfall are pushing Amazonia towards a "tipping point" that could have catastrophic implications for global climate stability (Lovejoy et al. 2018).

In describing their vision of green development in Brazil through the "Amazon 4.0" bioeconomy initiative, Nobre and Nobre (2019) ask the crucial question: "Is it possible to reconcile the economic development of the Amazon and the conservation of the rainforest?" Bioeconomy is a new approach to sustainable development that has been defined as "an economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences" (Abramovay et al. 2021: 9). Abramovay et al. further call attention to the importance of valorising Indigenous and traditional knowledge and providing economic opportunities for underprivileged forest peoples: "Bioeconomy has the ambition to guide social life towards the regenerative use of the biotic, material, and energy resources on which we all depend. The opportunities that open up for combating poverty and inequality with the sustainable use of forest biodiversity are immense" (ibid.: 3).

However, given the tremendous cultural, cosmological, moral and ontological differences between Western and Indigenous economies and forms of knowledge, it is essential that such bioeconomy initiatives approach Indigenous and traditional peoples as more than just sources of useful information or strategic links in the supply chain. Indigenous world views provide us with a template for a profound critical reevaluation of the reductive, objectifying philosophical and moral tenets that tacitly underpin the Western scientific tradition, which are in turn imbedded in the devastating ecological outcomes of capitalism.

Fernandez-Llamazares and Virtanen (2020: 24) argue, "the diverse cosmo-centric worldviews placing non-humans at the centre of life together with humans could help to promote innovative ways of operationalising, conceptualising and achieving sustainability from local to global levels." In bringing scientific and Indigenous perspectives into dialogue and productive tension, we emphasise the need to pay closer attention to Indigenous philosophies of life, vitality, and sustainability (e.g., Salmón 2000; Kopenawa and Albert 2013; Black Elk 2016). From an Indigenous Amazonian perspective, sustainability is a quality of life which ultimately emerges out of the relational dynamics of the multi-species,

multinatural shamanic multiverse. As we have pointed out elsewhere (Shepard 2018; Daly and Shepard 2019; Shepard and Daly 2022; Daly, in press), Indigenous life-worlds are immersed in the vivacious pulse of plant communication, mutualistic interactions, chemosensation and attendant processes of growth, death, and decay.

To develop the influential idea coined by anthropologist Eduardo Kohn (2013), if *forests think,* it is precisely through the kinds of embodied, sensorial, and substantial relationships that we have documented. If such research requires natural scientists to become more conversant in the anthropology of Amazonia (see Sheldrake 2020), it also requires anthropologists to become more conversant in botany, phytochemistry and biosemiotics. Indeed, institutions of "Indigenous conservationism" (Cepek 2011) are fundamentally 'biocultural' (a progressive concept in conservation, for sure, but one which still retains the dualistic opposition between the bio- and cultural, even if in a more integrated vision: see Bridgewater and Rotherham 2019), at one and the same time protecting tropical biodiversity and the cultural and linguistic traditions of Indigenous custodians. For this reason, conservation strategies need respect the rights of Indigenous peoples and recognise their historical role in the sustainable management of Amazonian forests (Carneiro da Cunha and Almeida 2000; Blaser 2009; Mentore 2011; Brightman and Lewis 2017; Franco-Moraes et al. 2019; Shepard and Daly 2022).

Cognitive and communication science contributes to contemporary debates around sustainability, biodiversity conservation and the climate crisis by examining how humans, both individually and collectively, perceive, understand and respond to environmental phenomena (Ostrom et al. 1994; Sewell et al. 2017; Kashima 2020; see also the contribution of Kashima et al. in this issue). However, much of this work has been carried out with European, and specifically, English-speaking subjects, leading several authors to question the broader applicability of these insights to other cultural and linguistic contexts (Heinrich et al. 2010; Majid et al. 2018; Blasi et al. 2022). In order to contribute to these debates, we have presented case studies from our own research into Indigenous Amazonian concepts about ecological processes and reviewed contemporary anthropological theories on the topic. Hoping to overcome the impasse between dichotomous thinking about Indigenous vs. Western perspectives, we suggest a "parallax" approach to dialogue between Indigenous and scientific knowledge. While acknowledging profound ontological differences, this approach does not rule out the possibility for complementary, or at least mutually illuminating, viewpoints.

Even when Western and Indigenous viewpoints appear contradictory, Furlan et al. (2020: 11) suggest that ethnobiologists and other scientists can take advantage of such misunderstandings or "equivocations" (after Viveiros de Castro 2004b) to ask paradigm-expanding questions: Do we make symmetric efforts to overcome the misunderstandings and at least partially peek into other worlds? What is the value of truth that we assign to these worlds? Such multidirectional, transdisciplinary and intercultural dialogue is especially important as prominent scientists and industry leaders develop bioeconomy projects and begin scaling them up as part of "Amazon 4.0." Such initiatives should pay close attention to existing collaborative research and commercial arrangements between Indigenous peoples, scientists, anthropologists and non-profit organisations that have been implemented in different parts of Amazonia and beyond (e.g., Shepard, da Silva and Brazão 2001; Carneiro da Cunha and Almeida 2000; Abraão et al. 2008; Hutukara Association 2015; Pimenta et al. 2018a, 2018b; Hopkins et al. 2019). The resulting multinatural exchanges, parallax vistas and ontological equivocations may prove crucial to global biodiversity and climate stability in the precarious era of the Anthropocene.

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[1] Unfortunately, many Evangelical Christian Indigenous communities fell prey to anti-vaccine disinformation that spread widely through social media in Evangelical circles.

References:

Abraão, M.B., B.W. Nelson, D.W. Yu and G.H. Shepard Jr. (2008) Ethnobotanical Ground-Truthing: Indigenous knowledge, floristic inventories, and satellite imagery in the Upper Rio Negro, Brazil. *Journal of Biogeography* 35(12): 2237–2248.

Abramovay, R., J. Ferreira, F. de A. Costa, M. Ehrlich, A.M.C. Euler, E.C.F. Young, et al. (2021) The New Bioeconomy in the Amazon: Opportunities and challenges for a healthy standing forest and flowing rivers. In C. Nobre, E. Anderson and F.H. Roca Alcazar (eds.), *Amazon Assessment Report 2021*. New York, NY: United Nations Sustainable Development Solutions Network, 30.1–30.52.

Århem, K. (1996) The Cosmic Food Web: Human-nature relatedness in the Northwest Amazon. In P. Descola and G. Pálsson (eds.), *Nature and Society: Anthropological Perspectives*, pp. 185–204. New York, NY: Routledge.

Athayde, S.F. de, G.H. Shepard Jr., T.M. Cardoso, H. van der Voort, S. Zent, M. Rosero-Pena, A.A. Zambrano, G. Surui and D.M. Larrea-Alcazar (2021) Critical Interconnections Between Cultural and Biological Diversity of Amazonian Peoples and Ecosystems. In C. Nobre, A. Encalada, E. Anderson, F.H. Roca Alcazar et al. (eds.), *Amazon Assessment Report 2021*. Scientific Panel for the Amazon. New York, NY: United Nations Sustainable Development Solutions Network: 10.1-10.34. https://www.theamazonwewant.org/spa-reports/

Bang, M., A. Marin and D.L. Medin (2018) If Indigenous Peoples Stand with the Sciences, Will Scientists Stand with Us? *Daedalus* 147(2): 148–159.

Barreto, J.P.L. (2022) *O Mundo em Mim: Uma Teoria Indígena e os Cuidados Sobre o Corpo no Alto Rio Negro.* Brasília, Brazil: Mil Folhas.

Bartlett, H.H. (1940) The Concept of the Genus. *Bulletin of the Torrey Botanical Club* 67(5): 1–13.

Berlin, B. (1992) *Ethnobiological Classification: Principles of Categorization of Plants and Animals in Traditional Societies*. Princeton, NJ: Princeton University Press.

Black Elk, L. (2016) Native Science: Understanding and respecting other ways of thinking. *Rangelands* 38(1): 3–4.

Blaser, M. (2009) The Threat of the Yrmo: The political ontology of a sustainable hunting program. *American Anthropologist* 111(1): 10–20.

Blasi, D.E., J. Henrich, E. Adamou, D. Kemmerer and A. Majid (2022) Over-Reliance on English Hinders Cognitive Science. *Trends in Cognitive Sciences* 26: 1153–1170.

Boster, J., B. Berlin and J. O'Neill (1986) The Correspondence of Jivaroan to Scientific Ornithology. *American Anthropologist* 88(3): 569–583.

Bridgewater, P. and I.D. Rotherham (2019) A Critical Perspective on the Concept of Biocultural Diversity and its Emerging Role in Nature and Heritage Conservation. *People and Nature* 1(3): 291–304.

Brightman, M. and J. Lewis (eds.) (2017) *The Anthropology of Sustainability: Beyond Development and Progress.* London: Palgrave MacMillan.

Bulmer, R. (1974) Folk Biology in the New Guinea Highlands. *Social Science Information* 13(4-5): 9–28.

Carneiro da Cunha, M. (2009) *"Culture" and Culture: Traditional Knowledge and Intellectual Rights.* Chicago, IL: Prickly Paradigm Press.

Carneiro da Cunha, M. and M. de Almeida (2000) Indigenous People, Traditional People, and Conservation in the Amazon. *Daedalus* 129(2): 315–338.

Cepek, M.L. (2011) Foucault in the Forest: Questioning environmentality in Amazonia. *American Ethnologist* 38(3): 501–515.

Chapin, M. (2004) A Challenge to Conservationists. *World Watch*, November/December 2004: 17–31.

Chaumeil, J. P. (1993) Del Proyectil al Virus: El complejo de dardos-mágicos en el chamanismo del oeste Amazónico. In C.E. Pinzon et al. (ed.), *Cultura y Salud en la Construcción de las Américas,* pp. 261–277. Bogota: Instituto Colombiano de Antropología.

Conklin, B. (1997) Body Paint, Feathers, and VCRs: Aesthetics and authenticity in Amazonian activism. *American Ethnologist* 24(4): 711–737.

Conklin, B. (2002) Shamans Versus Pirates in the Amazonian Treasure Chest. *American Anthropologist* 104(4): 1050–1061.

Conklin, H.C. (1954) *The Relation of Hanunóo Culture to the Plant World*. Doctoral dissertation: Yale University, New Haven, CT.

Conklin, H.C. (1957) *Hanunóo Agriculture, a Report on an Integral System of Shifting Cultivation in the Philippines*. Forestry Development Paper (Vol. 12). Rome: FAO.

Daly, L. (2015) *The Symbiosis of People and Plants: Ecological Engagements Among the Makushi People of Amazonian Guyana.* University of Oxford, Oxford, UK: Doctoral dissertation.

Daly, L. (2021) Cassava Spirits and the Seed of History: On garden cosmology in northern Amazonia. *Anthropological Forum* 31(4): 377–395.

Daly, L. (in press) Fragrant Ecologies: Aroma and olfaction in Indigenous Amazonia. In L. Stafford (ed.), *Smell, Taste, Eat: The Role of the Chemical Senses in Eating Behaviour*. London: Palgrave Macmillan.

Daly, L. and G.H. Shepard Jr. (2019) Magic Darts and Messenger Molecules: Toward a phytoethnography of Indigenous Amazonia. *Anthropology Today* 35(2): 13–17.

Daly, L., L. Nic Eoin, K. French and T. Miller (2016) Integrating Ontology into Ethnobotanical Research. *Journal of Ethnobiology* 36(1): 1–9.

De la Cadena, M. (2011) Indigenous Cosmopolitics in the Andes: Conceptual reflections beyond "politics". *Cultural Anthropology* 25(2): 334–370.

Descola, P. (1994). *In the Society of Nature: A Native Ecology in Amazonia*. Cambridge, UK: University of Cambridge Press.

Descola, P. (2013) *Beyond Nature and Culture.* Chicago, IL: University of Chicago Press.

Desphande, S. S. (2002) *Handbook of Food Toxicology*. New York, NY: Marcel Dekker.

Edwards, D.P., M.E. Frederickson, G.H. Shepard Jr. and D.W. Yu (2009) A Plant Needs Ants Like a Dog Needs Fleas: *Myrmelachista schumanni* ants gall many tree species to create housing. *American Naturalist* 174(5): 734–740.

Ellen, R. (2016) Is there a Role for Ontologies in Understanding Plant Knowledge Systems? *Journal of Ethnobiology* 36(1): 10–28.

Erickson, T.H. (2022) The Sustainability of an Anthropology of the Anthropocene. *Sustainability* 14(6): 3674.

Estrada, A., P.A. Garber, S. Gouveia, A. Fernández-Llamazares, F. Ascensão, A. Fuentes, S. Volampeno et al. (2022) Global importance of Indigenous Peoples, their Lands, and Knowledge Systems for Saving the World's Primates from Extinction. *Science Advances* 8(32): eabn2927. https://doi.org/10.1126/sciadv.abn2927

Fausto, C. and E.G. Neves (2018) Timeless Gardens: Deep Indigenous history and the making of biodiversity in the Amazon. In D. Rommens and J.P. Mata (eds.), *Exploring Frameworks for Tropical Forest Conservation: Integrating Natural and Cultural Diversity for Sustainability, a Global Perspective,* pp. 150–179. Mexico City: UNESCO Office in Mexico.

Fernández-Llamazares, Á. and P.K. Virtanen (2020) Game Masters and Amazonian Indigenous Views on Sustainability. *Current Opinion in Environmental Sustainability* 43: 21–27.

Fleck, D.W. and J.D. Harder (2000) Matsés Indian rainforest habitat classification and mammalian diversity in Amazonian Peru. *Journal of Ethnobiology* 20(1): 1–36.

Ford, R.I. (1978) *The Nature and Status of Ethnobotany.* Anthropological Papers, Museum of Anthropology, University of Michigan, Vol. 67. Ann Arbor, MI: University of Michigan Press.

Furlan, V., N.D. Jiménez-Escobar, F. Zamudio and C. Medrano (2020) 'Ethnobiological Equivocation' and Other Misunderstandings in the Interpretation of Natures. *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 84: 101333.

Ginsburg, F. (1995) The Parallax Effect: The impact of aboriginal media on ethnographic film. *Visual Anthropology Review* 11(2), 64–76.

Giraldo Herrera, C.E. (2018) *Microbes and Other Shamanic Beings.* London: Palgrave Macmillan.

Hallowell, A.I. (1960) Ojibwa Ontology, Behavior and World View. In S. Diamond (ed.), *Culture in History: Essays in Honor of Paul Radin,* pp.19–51. New York, NY: Columbia University Press.

Hartigan Jr., J. (2017) *Care of the Species: Races of Corn and the Science of Plant Biodiversity.* Minneapolis, MN: University of Minnesota Press.

Hayes, A.W. (ed.) (2008) *Principles and Methods of Toxicology*. Fifth edition. New York, NY: Informa Health Care.

Henrich, J., S.J. Heine and A. Norenzayan (2010) The Weirdest People in the World. *Behavioral and Brain Sciences* 33(2): 1–75.

Helmreich, S. (2016) *Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond.* Princeton, NJ: Princeton University Press.

Hopkins, D., T.L. Joly, H. Sykes, A. Waniandy, J. Grant, L. Gallagher, L. Hansen, K. Wall, P. Fortna and M. Bailey (2019) "Learning Together": Braiding Indigenous and western knowledge systems to understand freshwater mussel health in the lower Athabasca region of Alberta, Canada. *Journal of Ethnobiology* 39: 315–336.

Hornborg, A. (2006) Animism, Fetishism, and Objectivism as Strategies for Knowing (or Not Knowing) the World. *Ethnos* 71(1): 21–32.

Hornborg, A. (2017) Dithering While the Planet Burns: Anthropologists' approaches to the Anthropocene. *Reviews in Anthropology* 46(2/3): 61–77.

Hunn, E. (1993) What is Traditional Ecological Knowledge? In N.M. Williams and G. Baines (eds.), *Traditional Ecological Knowledge: Wisdom for Sustainable Development,*

pp.13–15. Canberra*:* Centre for Resource and Environmental Studies, Australian National University.

Hutukara Association (2015) *Manual dos Remédios Tradicionais Yanomami.* Boa Vista, Brazil: Hutukara Associação Yanomami and Instituto Socioambiental (ISA).

IPBES (2016) Indigenous and Local Knowledge Systems (Deliverable 1(c)). IPBES/5/4. Bonn, Germany: United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Service. Accessed August 2022 at https://www.ipbes.net/sites/default/files/downloads/pdf/ipbes-5-4-en.pdf

Kawa, N.C. (2016) *Amazonia in the Anthropocene: People, Soils, Plants, Forests.* Austin, TX: University of Texas Press.

Kashima, Y. (2020) Cultural Dynamics for Sustainability: How can humanity craft cultures of sustainability? *Current Directions in Psychological Science* 29(6): 538–544.

Kenrick, J. and J. Lewis (2004). Indigenous Peoples' Rights and the Politics of the Term "Indigenous". *Anthropology Today* 20(2): 4–9.

Kimmerer, R.W. (2002) Weaving Traditional Ecological Knowledge into Biological Education: A call to action. *BioScience* 52: 432–438.

Kimmerer, R.W. (2013) *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge and the Teachings of Plants.* Minneapolis, MN: Milkweed Editions.

Kohn, E. (2013) *How Forests Think: Toward an Anthropology Beyond the Human.* Berkeley, CA: University of California Press.

Kopenawa, D. and B. Albert (2013) *The Falling Sky: Words of a Yanomami Shaman.* Cambridge, MA: Belknap Press of Harvard University.

Lagrou, E. (2020) Nisun: A vingança do povo morcego e o que ele pode nos ensinar sobre o novo coronavirus. *Blog da Biblioteca Virtual do Pensamento Social*, 13 April 2020.

Latorre, G. (1914) Instrucción General o Parecer Sobre el Modo de Hacer Descubrimientos en las Indias. In *Congreso de Historia y Geografía Hispano-Americano, Actas y Memorias*. Madrid.

Latour, B. (1987) *Science in Action: How to Follow Scientists and Engineers through Society.* Cambridge, MA: Harvard University Press.

Latour, B. (2017) Anthropology at the Time of the Anthropocene: A personal view of what is to be studied. In M. Brightman and J. Lewis (eds.), *The Anthropology of Sustainability: Beyond Development and Progress,* pp. 35–49. London: Palgrave MacMillan.

Latour, B. and S. Woolgar (1986 [1979]) *Laboratory Life: The Construction of Scientific*

Facts. Princeton, NJ: Princeton University Press.

Lorimer, J. (2012) Multinatural Geographies for the Anthropocene. *Progress in Human Geography* 36: 593–612.

Lovejoy, T.E. and C. Nobre (2018) Amazon Tipping Point. *Science Advances* 4(2): eaat2340.

Majid, A., S.G. Roberts, L. Cilissen, K. Emmorey, B. Nicodemus, L. O'Grady, B. Woll, S.C. Levinson et al. (2018) Differential Coding of Perception in the World's Languages. *Proceedings of the National Academy of Sciences* 115(45): 11369–11376.

Medin, D. and S. Atran (1999) *Folkbiology*. Boston, MA: The MIT Press.

Mentore, L. (2011) Waiwai Fractality and the Arboreal Bias of PES Schemes in Guyana: What to make of the multiplicity of Amazonian cosmographies? *Journal of Cultural Geography* 28: 21–43.

Myers, N. (2015) Conversations on Plant Sensing: Notes from the field. *NatureCulture* 3:35–66.

Nobre, I. and C. Nobre (2019) "Amazon 4.0" Project: Defining a third way for the Amazon. *Medium: Fundação FHC,* 25 September 2019. São Paulo.

Nazarea, V.D. (ed.) (1999) *Ethnoecology: Situated Knowledge/Located Lives.* Tucson, AZ: University of Arizona Press.

ojalehto mays, B., R. Seligman and D.L. Medin (2020) Cognition Beyond the Human: Cognitive psychology and the new animism. *Ethos* 48(1): 50–73.

Oliveira, J.C. de (2016) Mundos de Roças e Florestas. *Boletim Do Museo Paraense Emílio Goeldi, Ciências Humanas* 11(1): 115–131.

Oliveira, J.C. de, M. Amoroso, A.G. Morim de Lima, K. Shiratori, S. Marras and L. Emperaire (eds.) (2020) *Vozes Vegetais: Diversidade, Resistências, e Histórias da Floresta.* São Paulo, Brazil: Ubu Editora.

Ostrom, E., R. Gardner and J. Walker (1994) *Rules, Games, and Common-pool Resources*. Ann Arbor, MI: University of Michigan Press.

Parker, E., D. Posey, J. Frechione and L.F. da Silva (1983) Resource Exploitation in Amazonia: Ethnoecological examples from four populations. *Annals of the Carnegie Museum of Natural History* 52(8): 163–203.

Prado, H.M., R.S.S. Murrieta, G.H. Shepard, T. de Lima Souza and M.N. Schlindwein (2022) Sympathetic Science: Analogism in Brazilian ethnobiological repertoires among Quilombolas of the Atlantic forest and Amazonian ribeirinhos. *Journal of Ethnobiology and Ethnomedicine* 18(1): 1.

Ramos, A.R. (2003) Pulp Fictions of Indigenism. In D.S. Moore, J. Kosek, and A. Pandian

(eds.), *Race, Nature, and the Politics of Difference,* pp. 356–379. Durham, NC: Duke University Press.

Read, J. M., J.M.V. Fragoso, K.M. Silvius, J. Luzar, H. Overman, H., A. Cummings, S.T. Giery, S. T. and L.F. de Oliveira (2010) Space, Place and Hunting Patterns among Indigenous Peoples of the Guyanese Rupununi Region. *Journal of Latin American Geography* 9(3): 213–244.

Reichel-Dolmatoff, G. (1976) Cosmology as Ecological Analysis: A view from the rain forest. *Man* 11(3): 307–318.

Reyes García, V., Á. Fernández Llamazares, P. McElwee, Z. Molnár, K. Öllerer, S.J. Wilson and E.S. Brondizio (2019) The Contributions of Indigenous Peoples and Local Communities to Ecological Restoration. *Restoration Ecology* 27(1): 3–8.

Rezende, J. S. (2020) Coronavirus Brings Back Memories. *Chacruna Institute*, 10 April 2020. https://chacruna.net/coronavirus-brings-back-memories/

Rival, L. (1998) Domestication as a Historical and Symbolic Process: Wild gardens and cultivated forests in the Ecuadorian Amazon. In W. Balée (ed.), *Advances in Historical Ecology,* pp. 232–250. New York, NY: Columbia University Press.

Rival, L. (2012) The Materiality of Life: Revisiting the anthropology of nature in Amazonia. *Indiana* 29: 127–143.

Rival, L. (2014) Encountering Nature Through Fieldwork: Expert knowledge, modes of reasoning, and local creativity. *Journal of the Royal Anthropological Institute* 20(2): 218–236.

Rivera Cusicanqui, S. (2012) *Ch'ixinakax Utxiwa:* A Reflection on the Practices and Discourses of Decolonization. *The South Atlantic Quarterly* 111(1): 95–109.

Rosengren, D. (1998) Matsigenka Myth and Morality: Notions of the social and the asocial. *Ethnos* 63(2): 248–272.

Salmón, E. (2000) Kincentric Ecology: Indigenous perceptions of the human-nature relationship. *Ecological Applications* 10(5): 1327–1332.

Seeger, A., R. Da Matta and E.B. Viveiros de Castro (2019[1979]) The Construction of the Person in Indigenous Brazilian Societies. *HAU: Journal of Ethnographic Theory,* 9(3): 694–703.

Sewell, D. K., P.J. Rayner, D.B. Shank, S. Guy, S.D. Lilburn, S. Saber and Y. Kashima (2017) Causal Knowledge Promotes Behavioral Self-Regulation: An example using climate change dynamics. *PLoS ONE* 12(9): e0228445.

Sheldrake, M. (2020) The 'Enigma' of Richard Schultes, Amazonian Hallucinogenic Plants, and the Limits of Ethnobotany. *Social Studies of Science* 50(3): 345–376.

Shepard, G.H. Jr. (1998) Psychoactive Plants and Ethnopsychiatric Medicines of the Matsigenka. *Journal of Psychoactive Drugs* 30(4): 321–332.

Shepard, G.H. Jr. (1999) Shamanism and Diversity: A Matsigenka perspective. In D.A. Posey (ed.), *Cultural and Spiritual Values of Biodiversity,* pp. 93–95. London: United Nations Environmental Programme and Intermediate Technology Publications.

Shepard, G.H. Jr. (2004) A Sensory Ecology of Medicinal Plant Therapy in Two Amazonian Societies. *American Anthropologist* 106(2): 252–266.

Shepard, G. H. Jr. (2011) The Ant, the Shaman and the Scientist. *O Eco Amazônia*, 22 November 2011. https://ethnoground.blogspot.com/2011/11/ant-shaman-and-scientist.html

Shepard, G. H. J. (2016) Ceci N'est Pas un Contacte: The festishization of isolated Indigenous people of the Amazon. *Tipiti* 14(1): 135–137.

Shepard, G.H. Jr. (2018) Spirit Bodies, Plant Teachers and Messenger Molecules in Amazonian Shamanism. In D. McKenna, G. T. Prance, B. De Loenen and W. Davis (eds.), *Ethnopharmacologic Search for Psychoactive Drugs II: 50 Years of Research (1967-2017),* pp. 70–81. Santa Fe, MN: Synergetic Press.

Shepard, G. H. J. (2020) Voluntary Isolation in the Age of Coronavirus. *Chacruna Institute*, March 2020. https://chacruna.net/voluntary-isolation-in-the-age-of-coronavirus/

Shepard, G.H. Jr. and L. Daly (2022) Sensory Ecologies, Plant-Persons, and Multinatural Landscapes in Amazonia. *Botany* 100: 83–96.

Shepard, G.H. Jr. and R. Pace (2021) Authenticity and Anthropophagy in Kayapó Film Production. *Current Anthropology* 62(3): 309–332.

Shepard Jr., G.H., D.W. Yu, M. Lizarralde and M. Italiano (2001) Rainforest Habitat Classification among the Matsigenka of the Peruvian Amazon. *Journal of Ethnobiology* 21(1): 1–38.

Snell, B.A., A. Collants, I. Chavez P., V. Cruz K. and J.E. Pereira C. (2011) *Diccionario Matsigenka-Castellano*. Serie Ling. Peruana No. 56. M.R. Wise (ed.). Lima: Instituto Linguistico de Verano.

Tom, M.N., E.S. Huaman and T.L. McCarty (2019) Indigenous Knowledges as Vital Contributions to Sustainability *International Review of Education* 65: 1–18.

Tsing, A.L. (2004) *Friction: An Ethnography of Global Connections.* Princeton, NJ: Princeton University Press.

Turner, Terence (1992) Defiant Images: The Kayapo appropriation of video. *Anthropology Today* 8(6): 5–16.

United Nations (2007) *Declaration on the Rights of Indigenous Peoples.* UN Office of the High Commissioner for Human Rights (OHCHR). Accessed 16 September at: https://www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf

Van Andel, T., S. Ruysschaert, K. Boven and L. Daly (2015) The Use of Amerindian Charm Plants in the Guianas. *Journal of Ethnobiology and Ethnomedicine* 11: 66.

Vieira, M.A.R. de M. and Shepard, G.H. (2017) "A Anta tem Muita Ciência": Racionalidade ecológica e ritual da caça entre ribeirinhos amazônicos. In G. Marchand and F.F. Vander Velden (eds.), *Olhares Cruzados Sobre as Relações entre Homens e Animais Selvagens na Amazônia (Brasil, Guiana Francesa),* pp. 17–32. Manaus: Editora da Universidade Federal do Amazonas (EDUA).

Viveiros de Castro, E.B. (1996) Os Pronomes Cosmológicos e o Perspectivismo Ameríndio. *Mana* 2(2): 115–144.

Viveiros de Castro, E.B. (2002) Perspectivismo e Multinaturalismo na America Indigena. In E.B. Viveiros de Castro (ed.), *A Inconstancia da Alma Selvagem e Outros Ensaios de Antropologia,* pp. 347–399. São Paulo, Brazil: Cosac and Na.

Viveiros de Castro, E.B. (2004a) The Transformation of Objects into Subjects in Amerindian Ontologies. *Common Knowledge* 10(3): 463–472.

Viveiros de Castro, E.B. (2004b) Perspectival Anthropology and the Method of Controlled Equivocation. *Tipiti* 2(1): 3–22.

Zent, E. and S. Zent (2022) Love Sustains Life: *Jkyo jkwainï* and allied strategies in caring for the Earth. *Journal of Ethnobiology* 42(1): 86–104.