Representing and Coordinating Ethnobiological Knowledge

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Abstract: Indigenous peoples possess enormously rich and articulated knowledge of the natural world. A major goal of research in anthropology and ethnobiology as well as ecology, conservation biology, and development studies is to find ways of integrating this knowledge with that produced by academic and other institutionalized scientific communities. Here I present a challenge to this integration project. I argue, by reference to ethnographic and cross-cultural psychological studies, that the models of the world developed within specialized academic disciplines do not map onto anything existing within traditional beliefs and practices for coping with nature. Traditional ecological knowledge is distributed across a heterogeneous array of overlapping practices within Indigenous cultures, including spiritual and ritual practices that invoke categories, properties, and causal-explanatory models that do not in general converge with those of the academic sciences. In light of this divergence I argue that we should abandon the integration project, and conclude by sketching a notion of knowledge coordination as a possible successor framework.

1. Introduction

Knowledge of the natural world has been created many times over by different communities in ways that reflect their distinctive characteristics. Viewed comparatively, this knowledge looks on the surface to be quite heterogeneous in its form and content. The categories picked out and the causal-explanatory networks they occupy depend on the particulars of a group's history, organization, needs, goals, and values. This fact comes into sharp focus when comparing knowledge produced within modern scientific, governmental, industrial, and development communities with traditional knowledge of nature held by Indigenous groups.[1] In

[1] "Indigenous" is a contentious and not easily defined term used variously across disciplines as a synonym for *local*, *traditional*, or *native*. An obvious problem is that none of these are synonymous with each other: *local* refers to a degree of geographic dispersion, *traditional* refers to a way of transmitting information and practices over time, and *native* refers to perceived or actual origins, historical precedence, and territorial/cultural possession. In lieu of disentangling this confusion here, I will follow the established norm of using the term to characterize groups, societies, and peoples that have some mixture of these qualities. These include the specific groups that I discuss, e.g., the Itza' Maya, the Jotï, the Ngöbe, the San, the many Surinamese and Brazilian groups that practice *Candomblé* and *Winti*, etc. The term is not, however, meant to imply that these groups are homogeneous or that there is something like a "universal Indigeneity" that they exemplify.

the latter, these social and technological institutions are to varying degrees absent. In recent years, traditional knowledge has been the focus of especially intense attention. This interest has several sources. One is the hope that it will prove useful in species conservation and resource management. Another is the desire to discover (and profit from) new drugs and medical treatments based on Indigenous remedies. Finally, there is scientific curiosity about the history and biota of Indigenous lands, and the need to preserve knowledge of them in the face of looming threats to its existence. These inquiries have a common overarching goal: to integrate traditional knowledge with scientific, corporate and industrial, and governmental/NGO-based knowledge of nature.

Here I argue that the prospects for this integration project, as it is often conceived, are not promising. Specifically, there are a large number of attested cases in which it fails, and these suggest a pattern that generalizes widely. The evidence I review does not decisively establish that integration, as it will be defined here, is impossible, but it does establish limits on its scope and motivates the search for alternatives. In what follows I first characterize the two varieties of knowledge that are the targets of these efforts (Sect. 2) and the ontological background of realism against which they are interpreted (Sect. 3). The core of the argument turns on the fact that the models of the world developed within the various specialized academic disciplines do not map uniformly well onto the models developed within traditional discourses and practices for coping with nature (Sect. 4).

Traditional ecological knowledge is not produced by a special-purpose epistemic community, but rather is distributed across a heterogeneous array of overlapping practices within Indigenous cultures (Sect. 5). These practices serve a diverse range of ends, including sustenance, building and crafting artifacts, creating medicines and other palliatives, explaining

and predicting natural phenomena, and facilitating spiritual and religious rites. As a result the categories this knowledge picks out are shaped by a wide range of concerns that do not necessarily align them with the categories of academic disciplines such as the life sciences. I conclude by proposing the ideal of knowledge coordination as a successor to the ideal of integration, and sketch some of its advantages (Sect. 6).

2. Two images of knowledge

There is no uncontested definition of traditional ecological knowledge (TEK), but it is useful to start with Berkes' widely adopted working definition:

> a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationships of living beings (including humans) with one another and with their environment. (Berkes, 2012, p. 7)

This proposal emphasizes several points: (1) TEK is an interweaving of beliefs and practices, hence something that is embodied not just in the mind but in action and material culture; (2) it is adaptive, hence persists in virtue of making some substantial contribution towards group survival and flourishing; (3) it is passed down by the mechanisms that ensure the replication of other aspects of culture, rather than in any special-purpose fashion; and (4) it takes as its subject matter the organization of the living world in the widest possible sense.

TEK is often contrasted with knowledge produced by various natural and life sciences: ecology, evolutionary and conservation biology, ornithology and mycology, hydrology and

pedology, etc. The product of these fields is *scientific* ecological knowledge. However, this makes an imperfect contrast with TEK, insofar as there are common forms of hypothesis testing, evidence gathering, causal explanation, and inductive generalization or ampliative inference in both formalized scientific practices and everyday cognition. If everyday cognition and scientific reasoning are continuous, then TEK itself might count as scientific because it shares an infrastructure of psychological processes with these more institutionalized disciplines.[2]

No doubt there is psychological overlap between what goes on in the minds of investigators carrying out institutionalized scientific investigations and those of Indigenous peoples coping with their natural environment. My focus here is primarily on bodies of knowledge shaped, transmitted, and used as part of collective enterprises. These may or may not be products of individual cognitive operations that are also deployed within the bureaucratically distinguished sciences.[3] Accordingly, I use the term "academic ecological knowledge" (AEK) to denote knowledge about living beings and their environment created and used by various named scholarly disciplines, understood as organized collectives whose activities are part of a larger socially recognized sphere dedicated specifically to knowledge production. By contrast with TEK, this knowledge is typically passed on via institutionalized pedagogy, and evolves subject to the distinctive epistemic norms and investigative constraints that regulate good practice within

[2] This view is taken by those who use the term "ethnoscience" to refer to TEK. One way of viewing the argument of this paper is that TEK can be represented within anthropological discourse, but not if it is approached from within the framework of ethnoscience, which constitutes a simultaneously powerful and highly limiting interpretive mode. I nevertheless persist in using "ethno-" prefixed names of sciences to ensure continuity with the existing literature.
[3] As Scott observes, there is always a tension between universal and local conceptions of "science": "If one means by science a social activity that draws deductive inferences from first premises, that these inferences are deliberately and systematically verified in relation to experience, and that models of the world are reflexively adjusted to conform to observed regularities in the course of events, then, yes, Cree hunters practice science—as surely all human societies do" (Scott, 1996, p. 69). Whyte (2013) also usefully distinguishes three ways the science-TEK relation can be conceptualized: they may be seen as entirely disjoint knowledge production practices, as complementary, or as indistinguishable (pp. 5-8). The argument of this paper is that none of these possibilities is true across the board; which one is realized depends on the particular dialogic circumstances (see Section 6).

these disciplines. AEK's native habitat is specialized social institutions. These knowledge-producing institutions include the modern university, but also allied sites such as research consortiums, the R&D divisions of private industry, and governmental organizations or NGOs.

Highlighting the institutional setting of AEK also draws attention to the sociopolitical context in which integration questions arise. Indigenous groups interact with scholars, conservationists, development agencies and aid organizations, state and government representatives, and private corporations (e.g., the pharmaceutical and oil industries). These interactions serve many goals, including ameliorating biodiversity loss and promoting ecological conservation, seeking and sharing the profits from natural resources, and studying TEK itself, as well as preserving it against its ongoing erosion. At these points of contacts, knowledge schemes as well as political and economic power relations are negotiated and realigned.

What these interactions often share is the aspiration of integrating TEK with AEK. Integration, as used in this discussion, presupposes that TEK contains categories and explanatory schemes that coincide with or can be intelligibly combined with those that exist in AEK (Ludwig, 2018; Ludwig & El-Hani, Forthcoming; Ludwig & Poliseli, 2018). This integration can take several different forms. *Category overlap* occurs when some representation or practice in TEK has (approximately) the same extension as one in AEK. Canonical examples involve discoveries that, e.g., named birds in an Indigenous language correspond well to distinct named Linnaean species. Category overlap constitutes a form of integration insofar as it ensures that both knowledge frameworks are making claims about the same types of things. *Property overlap* occurs when the qualities and powers that are ascribed to a category are similar in both TEK and AEK. For instance, Indigenous hunters of bowhead whales might know more about their migration patterns than do Western marine biologists, making it prudent to consult them when

designing population studies (Ludwig, 2016, p. 38). Property overlap allows integration of the sorts of generalizations and inferences that are made in the target domain. Finally, *explanatory overlap* occurs when a similar abstract causal or explanatory pattern is recurrently used in both TEK and AEK. For instance, according to Itza' Maya informants, spread of diseases among species follows routes defined by their relations of ecological connectedness (Atran & Medin, 2008, pp. 67–74). The same causal pattern manifests in scientific predictions of how such transmission will take place. Explanatory overlap allows integration of the types of processes that are paradigmatically used to guide reasoning and action. Where the same patterns of reasoning are present in both schemes, empirically successful bodies of information can be transferred from one to the other, can be evidentially assessed in the same ways, and can be similarly refined and improved.

Where overlap exists, we can say that two knowledge systems are talking about the same things, ascribing the same sorts of characteristics to them, and assigning them broadly the same roles in their explanatory schemes. Integration so defined is a matter of degree: it turns on how much overlap there is in categories, properties, and explanatory patterns. Its success turns on two conditions: (1) that TEK fundamentally shares epistemic ends and procedures of knowledge production with AEK; and (2) that its theoretical content has a sufficiently analogous form that it can be plugged into the explanatory schemata of AEK with little reframing and minimal distortion. If both are the case, TEK and AEK are, in principle, making similar types of contributions to a common body of knowledge.

3. The background of ethnobiological realism

Given the foregoing, determining the extent of overlap between AEK and TEK turns on elucidating their common epistemic and ontological commitments. Realism is the dominant framework for interpreting AEK, and it is habitually applied by default to other ways of understanding nature, including TEK. It comprises two claims. The first is the *referential assumption*: that a theory's ontology is wholly captured by its referential apparatus.[4] Ontological domains are constituted by how terms, concepts, and practices partition the environment into groups of organisms corresponding to the categories that they purport to pick out, and the properties that those category members have. The ontology of wildlife biology, for example, consists of a division of organisms (fish, insects, birds, etc.) into species, a catalogue of the causally and explanatorily relevant properties of those species, a division of environments into particular habitats characteristic of those organisms, and a model of how organisms and habitats make up larger ecological structures (e.g., energetic and resource webs and food pyramids).

From this perspective, the specialized lexicons of entomology, ornithology, forestry, mycology, etc., are tools honed for the purpose of making referential distinctions among *entities*, for ascribing significant clusters of *properties* to those entities, and for describing the structural and dynamic *relations* that hold among those entities in virtue of having the properties that they do. Realism reflects the notion that the function of scientific terms and taxonomies is to track natural kinds. There are a number of competing conceptions of natural kinds, but within the sciences of the living world, the homeostatic property cluster (HPC) theory is presently ascendant.[5] On an HPC conception, kinds are categories possessing stable property clusters that

[4] The importance of the referential claim to realism can be seen in Boyd's (1980, 1990) canonical formulations of the doctrine, e.g.: "By 'scientific realism' philosophers ordinarily mean the doctrine that non-observational terms in scientific theories should typically be interpreted as putative referring expressions" (1980, p. 613).

[5] The HPC conception is often contrasted with a distinct realist tradition that distinguishes natural kinds by their possession of essential properties (Bird, 2010; Ellis, 2001; Gelman, 2003; Wilson, Barker, & Brigandt, 2007). The relations between HPC and essentialism are complex, however, with some holding that the two are opposed and others claiming that HPC kinds do have essences, e.g., the underlying mechanisms or historical chains that hold the

contribute to a host of epistemic ends, including most prominently that of articulating causal-explanatory facts about the target domain (Boyd, 1999; Slater, 2015; Wilson, Barker, & Brigandt, 2007). Scientific terms refer to those clusters that best *accommodate* the explanatory demands made by each particular discipline. A species of fish—the Amazonian Piraiba catfish *Bracymentia filamentosum*, for instance—is distinguished from others by a property cluster including its morphology, metabolic and biochemical processes, geographic range, ecological niche, and evolutionary history.

The referential claim is compactly expressed, although not endorsed, by Hunn and Thornton (2010, p. 203): "cross-linguistic comparisons made use of an *etic grid* or meta-language to characterize the referential meanings of local terms… For comparative ethnobiological studies, the etic grid is the Linnean system of biological classification and nomenclature."[6] A statement of TEK's content makes use of (and is rendered intelligible in terms of) the referential apparatus of AEK. The objects of Indigenous knowledge are similarly taken to be classes of entities that the terms deployed within TEK refer to. Comparison between TEK and AEK becomes possible to the degree that the ontological domain of each body of knowledge overlaps (Ludwig, 2016, 2018). As noted above, this comparison (of categories, properties, and explanatory patterns) is what enables these distinct bodies of knowledge to be integrated.

The commitment to this claim can be seen in the many ethnobiological studies that give inventories of a culture's biological knowledge. Diamond and Bishop's (1999) survey of bird

property clusters together (Godman, 2018; Griffiths, 1999). Both of these, meanwhile, are distinguished from simple causal theories of kinds that carry fewer assumptions about the precise structure of causality that kind categories must have. I focus here on HPC kinds for expository simplicity, given that in the biological and ecological sciences this is, rightly or not, typically taken as the default view.

[6] The use of the Linnean etic grid also accounts for the emphasis on searching for hierarchical taxonomic structure in TEK, as potentially revealed through lexical analysis, naming, and sorting paradigms. This search is one distinctive form that the integration project can take, in which distinctions in nature made by Indigenous groups are aligned with those made by academic classifications.

names among the Ketengban people is exemplary. The researchers spent three weeks trekking among camps for 8-11 hours a day in the company of local guides, eliciting the names of birds seen or heard along the way, along with other details about the bird's appearance, song, diet, and typical location in the forest. The resulting inventory maps 169 vernacular bird names onto 143 ornithological binomial species names, along with approximate English vernacular names. The high degree of co-reference found between AEK and TEK is evidence that "their and our shared classification describes a mutually perceived reality in the biological world" (p. 41); in other words, an ontological convergence.

The second realist assumption is that ethnobiological taxonomies are *autonomous*. The autonomy claim holds that a group's biological beliefs and practices can be separated and assessed apart from the larger cultural matrix that they are embedded in. This assumption lies behind the notion that the natural world (or, more narrowly, the living world) constitutes its own conceptual or semantic domain. The autonomy of biological knowledge implies that its content is more or less modular with respect to other cultural representations. This possibility makes specifically *ecological* knowledge into a distinct object of study for ethnobiologists, something that can be cogently and without undue distortion extracted from the other knowledge structures that make up Indigenous culture.

Not coincidentally, autonomy is highly suited to describe the organization of AEK. Part of the story of modernity is the self-conscious development of the institutionalized sciences as a cluster of increasingly specialized knowledge-generating enterprises (Tambiah, 1990). For example, the history of natural history from the Renaissance onward is in part a tale of its attempts to separate itself from more utilitarian disciplines such as medicine (Anderson, 2013; Ogilvie, 2006; Ritvo, 1997). Early herbals classified plants principally by their medicinally

useful parts and agricultural manuals described the habits farmers needed to cultivate them, while bestiaries painted the animal kingdom as a gallery of morally uplifting lessons and cautions. Not until the 16th century did classification became regarded as an end in itself, as botanists developed their own disciplinary identity, dedicated to the separation of taxonomic knowledge from both folklore and more directly useful applications of that knowledge. The development of disciplines as separate knowledge-seeking enterprises goes hand-in-hand with the placement of epistemic ends above others.[7]

Commitment to autonomy is explicit, for instance, in Boyd's view that terms in scientific theories refer to those parts of the natural world that best advance the epistemic goals established by the discipline that they are drawn from. These goals include generating explanations and maximizing the potential for inductive inferences. Scientific fields are associated with proprietary disciplinary matrixes (families of explanatory and inductive practices, along with sets of concepts and terms that underlie them), and a category constitutes a natural kind for that field to the degree that reference to it advances the epistemic goals set forth in the matrix (Boyd, 2000, p. 57). This captures two key notions of autonomy: first, that epistemic goals take priority over others in scientific classification; and second, that each discipline determines its own kinds and classifications with respect to the accommodation demands of its inferential architecture. Non-epistemic aims, or aims drawn from outside of the disciplinary matrix, have no bearing on how accommodation is achieved between a scientific theory and the world.[8]

[7] As Tsing (2005, pp. 88–95) incisively notes, these developments also rested on concealed foundations of Indigenous knowledge, including botanical samples, plant inventories, and all manner of instructions in how to tame the variety of imported flora.

[8] Note that even theorists who reject Boyd's theory that kinds are homeostatic property clusters often retain a commitment to autonomy in this sense; see, e.g., Ereshefsky & Reydon (2015). Recent work on kinds and classification often weakens or abandons the autonomy requirement, and is to that degree non-realist in the current sense; for examples, see the papers in Kendig (2016).

Ethnobiological realism, then, is the conjunction of the referential and autonomy claims. Realism of this sort claims that biological and ecological knowledge is a distinct body of information that taxonomizes the natural world into categories of entities bearing causal-explanatory property clusters (that is, kinds), and that the epistemic principles by which this taxonomy is built and populated are largely independent of wider cultural goals, values, and practices. The assumption that realism is true undergirds the possibility of integrating knowledge systems through finding ontological overlaps between them, since overlap depends precisely on the existence of a common referential framework.[9]

Despite the utility of realism as a scheme for understanding AEK, I argue that it misrepresents the structure of TEK. In particular, the autonomy claim is false: ecological knowledge is inextricably entwined with other, "non-natural" beliefs about the world. Rejection of autonomy gives rise to the *alterity thesis*: the ontological inventory of TEK often consists of entities or properties that are ontologically alien from the perspective of AEK. Alterity here is restricted to the level of reference: the domains of categories, properties, and causal-explanatory patterns picked out by the two schemes do not overlap. In many cases, including those to be discussed, even the broad *types* of categories and properties referred to may not be shared. The method of filling in the empirical content of TEK by finding elements in the domain of reference which best accommodate a set of beliefs and practices leads, in a wide range of cases, to ontological divergence rather than convergence. I now turn to illustrations of ontological alterity in action.

[9] For a history of how these assumptions about metaphysical convergence among knowledge systems have risen and fallen in recent ethnobiology, see Ludwig (2018). Ludwig and Weiskopf (2019) also discuss several possible strategies for achieving ontological convergence. For discussion of integration within the sciences, see Mitchell (2003).

4. Three aspects of alterity

The alterity thesis is supported by close analysis of how natural categories are understood by various forms of TEK. The aspects of culture that I focus on here are those that are sometimes relegated to the domain of spirituality, ritual, or myth. These cases aim to illustrate that knowledge of the natural world does not constitute a domain comparable to those claimed by the various branches of AEK.

In particular, I argue that the *causal models* invoked by TEK are not typically convergent with those of AEK. A causal model has three components: (1) a set of entities, (2) their properties, and (3) the connections among them, particularly those relationships of causation and dependency that bind these entities into larger structures and processes. These models represent part of the causal structure of the world in a simplified, tractable way, enabling us to manipulate, understand, and predict how things will behave. The highly skilled coping with nature enabled by TEK can be understood, without undue distortion, by representing it in terms of such models.

4.1. Ontologically novel entities

First, TEK can differ from AEK in the *kinds* of things that it posits. Indigenous causal understanding is often pervasively agentive: it posits beings such as spirits (ancestral or natural) with agent-like qualities, and it ascribes these qualities both to familiar entities like plants (Hall, 2011) and nonliving beings such as rocks (Dean, 2010). This latter point has been particularly highlighted by the so-called "New Animist" movement (Harvey, 2014). Because of these notions' familiarity, my description here will be brief.[10]

[10] For challenges to the cogency of animist discourse in anthropology, see, inter alia, Wilkinson (2017) and Willerslev (2013).

Consider one well-studied case, that of the Itza' Maya of lowland Guatemala (Atran & Medin, 2008; Le Guen, Iliev, Lois, Atran, & Medin, 2013). The Itza' traditionally believe in guardian forest spirits known as *arux*. *Arux*, while having a host of striking powers, are nevertheless concrete beings held to be "things of the forest," on a par with everyday living animals. They are both tricksters and helpers, but their prime ecological role is to patrol the use of forest resources, to encourage the protection of species and discourage their overuse. The *arux* mediate between the Itza' and the forest, and impose norms backed by threats of supernatural punishments.

Crucially, belief in these spirits is not idle, but plays a role both in shaping ecological behavior and in structuring ecological knowledge. Evidence for this can be found in the simultaneous decline of both spiritual and ecological knowledge. A series of catastrophes in recent decades has shattered the Itza' way of life. These include the threat of imminent language extinction, overextraction of resources (including cedar and mahogany, and the clearcutting of forests for cattle), civil war and narcotrafficing, and waves of religious conversion. Among older generations of Itza', beliefs about what the spirits want align with traditional understandings of forest ecology, of the behavior and role of culturally central plant species such as copia resin trees, and so on. Younger Itza' lack the sort of consensus knowledge of the *arux* possessed by their elders, but also lack deep knowledge of particular plant species and their ecological relations.

The notion that ontological commitment to spirits has a concrete role in ecological practice is strengthened by several examples of plant animism. Consider the Ngöbe, an Indigenous people living in Panama who subsist on agroforestry, fishing, and diving. Ngöbe adults systematically attribute to plants traits such as goal-directed action, helping their offspring,

and feeling the pain of other plants (ojalehto, Medin, & García, 2017b, 2017a). The same broadly social orientation towards the natural world that produces these agency ascriptions also plausibly serves the epistemic function of directing attention towards, and generating expectations about, plant behavior. Similar findings concerning the highly social treatment of maize among the Kayapó (Miller, 2011) and the copaíba tree in southern Bahia (DeVore, 2017) suggest that the extension of cognitive, perceptual, communicative, and broadly agentive qualities to plants serves not only to forge affective bonds with them, thereby reinforcing their cultural centrality, but also to encourage their adaptive use.

4.2. Ontologically novel properties

Second, TEK can differ from AEK in the *properties* that it posits. Many traditional worldviews represent nature as permeated by magical powers. Herbs and the parts of trees and bushes such as roots, bark, berries, leaves, and flowers, play an especially prominent role here, but so do animals and their bones, claws, skin, feathers, and organs. These parts of nature are the locus of powers that can be tapped by knowledgeable initiates. Indigenous medicine is rife with lore concerning the power of magical substances to bless (cure and protect against disease, ease pain, or strengthen and straighten the body) or curse (sicken, enfeeble, and kill) targeted individuals. Beyond the realm of medicine, hunters invoke magical powers in order to achieve success, ensure that game are retrieved in an appropriately respectful way, and preserve the cyclical exchange of energies that sustains wild populations. Planting and cultivation, too, involve a set of distinctive ritual invocations to ensure fecundity and repel rot and insects.

Consider the ways that these magical powers are pervasively invoked throughout the ecological practices of the Jotï, an Indigenous group numbering around 900 people inhabiting the

Venezuelan Guayana. Prior to contact in 1969 the Jotï were primarily trekking hunter-gatherers. In recent decades, horticulture and fishing have become important activities as they have settled in more permanent mission communities. They divide their time between foraging (81%) and agriculture (19%) (E. L. Zent, 2005, p. 39), and cultivate 67 plant species for food (n=36), magic and medicine (n=20) and making artifacts and technology (n=11), an inventory similar to other regional horticulturists' (S. Zent & Zent, 2012, p. 312).

For the Jotï, plants, rather than animals, are central within their ideological universe: they are conceived of as "subjects that assume multiple characters, acting contextually and locally as hypostatic beings, tricksters, predators, immanent beings, or diacritics that potentially perpetuate or end life dynamics" (p. 12). This centrality is exemplified by the causal roles that plants and fungi take in ritual practices. The Jotï have extensive mycological knowledge that goes beyond the simple edible/inedible (or poisonous) distinction. They commonly use fungi in hunting rituals, both in preparation for a hunt and for purification and restoration of a hunter's skills after they have committed a transgression. Preparatory rituals involve boiling specific fungal parts (flesh, pilea, hymenia) as well as arthropods and tree bark, leaves, and roots to create brews that are bathed in, inhaled, or imbibed as potions (E. L. Zent, 2005, p. 46). These "inductors" include 107 folk botanical species and 7 distinctive types of fungi. The mode of action of inductors involves a transfer of properties from the magic-containing preparations to the hunter, who gains heightened sensory capabilities and motor skills as a result. These preparations can be general in their effects or highly specific, with fungal species often being selected for their effects on particular species (e.g., for ensuring that arboreal monkeys hunted with curare-tipped darts will reliably fall when struck).

Purification rites become necessary when a hunter suffers a run of ill luck, such as being unable to track or hit an animal. Impurities arise most commonly because a hunter makes an error in handling the body of a slain animal (E. L. Zent, 2005, p. 51). Many game animals are held to contain a bile-like yellowish-green substance called *waya*, the location of which is variable but that is believed to contain a magical force capable of adhering to and affecting other living beings. If *waya* is spilled, or not buried appropriately after the animal is butchered, it will adhere to the hunter and contaminate his luck until it can be purged. Specific fungi are employed as *waya* purgatives, often because of their morphological resemblance to the *waya* of the target species (E. L. Zent, Zent, & Iturriaga, 2004, p. 223).[11]

These practices draw on a set of causal processes known as "essence interpenetration" (E. L. Zent, 2009, pp. 13–15). Essence interpenetration is a type of causal process that involves the transfer of conjoined material and immaterial qualities from one lifeform to another. This transfer is effected by close physical contact: inhaling, imbibing or eating, or bringing material in contact with the skin directly or indirectly (e.g., as a component of a bath or ingredient in body paint). Transfers of qualities are exploited for a variety of purposes beyond hunting magic, including properly developing the bodies and minds of newborn Jotï, preventing or curing illness, and communicating with spirits.

The essence interpenetration schema underpins a host of natural practices. For example, plants are held to be essential to the development of the *jnamodi*, the invisible aspect of human beings that accounts for their cognition, will, and perception as well as bodily integrity. Fathers fabricate a newborn's *jnamodi* in part from botanical compounds that transfer their qualities to the child, binding them permanently with those plant species (E. L. Zent, 2005, p. 42, 2009, p.

[11] This principle is an instance of the "doctrine of signatures"; see Section 4.3 for further discussion.

21). This ritualized transfer of specific qualities from plants to humans contributes to the creation of a more general "biospheric link" that winds through landscape and ecology, technological fabrication and deployment, the organization of society, and cosmological and spiritual belief (E. L. Zent, 2009, p. 28).[12]

With respect to commitment to essence interpenetration, the Jotï are far from unique. This same type of causal schema occurs, throughout the Amazon and beyond, in many traditional medical and magical uses of plants.[13] One survey of the Guianas numbered 366 distinct plant charms, most of which pertained to hunting, but which also included charms for protection, love charms, fishing, luck in general, and protection from snakes (van Andel, Ruysschaert, Boven, & Daly, 2015, p. 4). These charms are typically applied by direct physical contact, e.g., rubbing the tuber *Caladium bicolor* on the hunter's body and gun while he performs an elaborate mimicry of his tapir prey's behavior and vocalizations (p. 9). The earliest attested version of these rituals involved burning or otherwise incorporating organs from the target species, suggesting that their intent is the transfer of specific qualities by contact with a material vector.

Similar practices occur among adherents of Afro-Caribbean religions such as *Winti* in nearby Suriname and *Candomblé* in Brazil. *Candomblé* medicine, derived from Yoruba beliefs brought to the New World by enslaved peoples, conceptualizes disease as the product of an imbalance in a vital force known as *axé*. Material and spiritual beings are able to move and act in virtue of their *axé*, which is "a fluid and dynamic force, transferrable between objects and

[12] There is another class of spirits, *jkyo aemo*, that have the role of protectors or guardians and are particularly invoked in horticulture and whose magical uses focus on shielding from predatory magical attacks (S. Zent & Zent, 2012, p. 304).

[13] Against the idea that these two uses can be sharply distinguished, Voeks (1997, p. 97) comments that "[t]he distinction between organically and spiritually derived illness is fuzzy for Bahians in general, and even more so for those who are serious followers of *Candomblé*. In principle, all illness is believed to be derived from imbalance with the other world and, hence, within the purview of spiritual divination and treatment." Moreover, flora are often multifunctional, possessing distinct spiritual and organic healing roles. In Surinamese *Winti*, for instance, 73% of magical plants surveyed also had a medical use (van Andel, Ruysschaert, Van de Putte, & Groenendijk, 2013, p. 9).

entities by which it is possessed" (Voeks, 1997, p. 73). Plants must be harvested correctly in order to activate this spiritual energy, which is further awakened by a series of preparations including kneading, speaking incantations, and placement in proximity to the shrine of the plant's corresponding deity (pp. 93-95). Once prepared, the *axé*-bearing plants are ready to transfer their qualities via bathing or imbibing.

Even the most practically oriented everyday activities, then, commonly have some magical aspect that is believed to be an ineliminable part of their successful performance. These magical interventions tap into seemingly novel causal powers in the world, understood both in terms of what they can bring about and in the mechanism of their operation. While in some cases magical effects result from the intervention of a spirit, ancestor, or deity (that is, an entity of the type discussed in the Section 4.1), in other cases such as *waya* and *axé* they appear to be powers that are inherently possessed by natural objects themselves, even if they need to be "activated" by the intervention of a skilled practitioner. As we will see, everyday appeals to similar patterns occur within both Indigenous and Western contexts.

4.3. Ontologically disjoint explanatory schemas

Third, TEK and AEK may differ in the *causal pathways* and other structural/dynamical elements that they posit. Here we find several kinds of causal-explanatory patterns that do not have the right form to be integrated with AEK.[14]

[14] It has often been argued that explanations in TEK are holistic, while those in AEK are mechanistic (Ludwig & Poliseli, 2018). The formal distinction drawn here is not between holism and mechanism; rather, it is a distinction among local (non-holistic) causal structures that have the *wrong mechanistic form* to be integrated with AEK.

Sympathetic magic provides many examples.[15] There are three core principles that define sympathetic magic: the law of contagion, the law of similarity, and the law of opposites (Nemeroff & Rozin, 2000; Rozin & Nemeroff, 2002). Contagion holds that a thing can permanently transfer some essential quality of itself to another via physical contact. Similarity holds that "like causes like," or that causes will resemble their effects. Opposites, by contrast, holds that causes are dissimilar from their effects.[16] The first two of these are particularly important in analyzing TEK.

Consider similarity first. The idea that causes and effects resemble each other is ethnobiologically embodied in the so-called "doctrine of signatures" (Durant, 2017; Voeks & Greene, 2018). The doctrine holds that morphological features of plants and animals correspond with the particular diseases and conditions that they can be used to treat. The resemblance can serve a sign of this relationship because the similarities themselves are caused by underlying "essential" factors that are related as disorder and cure. The shape of lungwort (*Pulmonaria officinalis*) signals its usefulness for respiratory infections. In Gabon, the heart-shaped leaves of *Geophilia afzelii* are sought after for their love-attracting properties (Quiroz, Sosef, & van Andel, 2016). Even parts of slow-moving animals such as tortoises are used in *Candomblé* remedies that produce a calming effect (Alves, Rosa, Léo Neto, & Voeks, 2012). While the doctrine is on its face a causal-explanatory principle, it is not one that is given credence within scientific botany,

[15] The category and the term derive from Frazer. Subbotsky (2010, p. 5) usefully distinguishes sympathetic magic from three other forms of magical causality: mind-over-matter (direct mental control of objects), animation (acquisition of agency by non-agent objects), and nonpermanence (violations of object permanence) magic. My use of the term "magic" here is to denote these sorts of causal processes, not as a term of derision or dismissal.
[16] The fact that both similarity and opposites are principles of sympathetic magic suggests that it is not a consistent, universally applicable explanatory scheme, since those principles are in tension with one another.

ecology, or ethology. It nevertheless provides a way of interpreting and making connections between empirical events, and of guiding new interventions into those events.[17]

Contagion-based causality has been widely studied with respect to feelings of disgust and contamination (Rozin, Millman, & Nemeroff, 1986). An unclean lifeform such as a cockroach, even if it has been sterilized, seems to transfer its negative properties to foodstuffs through the slightest contact. Transmitted properties can be physical, intentional, or moral; thus, participants are reluctant to wear a sweater worn even once by someone with undesirable traits (having an infectious disease, being an unlucky accident victim, being a murderer), even if it has been thoroughly cleaned of any physical residue (Rozin, Markwith, & McCauley, 1994). Reluctance, manifested in disgust, rests on a tacit belief that negative moral qualities can be "caught" by contact. The essence interpenetration scheme sketched in Section 4.2 clearly exemplifies this contagion-like causal pattern. *Waya* handled improperly (a moral violation) is capable of contaminating the hunter, requiring the performance of purification rites.

Backwards contagion is perhaps the form of sympathetic magic least able to be assimilated into AEK's causal understanding of the world. In backwards contagion, a vehicle (*exuviae* such as a lock of hair or nail clipping, or images such as a photograph) travels from a source agent to a target agent, who then acts on it. The target's action is usually a negative one—burning a lock of hair or cursing an article of clothing—which then sympathetically propagates "backwards" to affect the subject themselves. Gell (1998) refers to this practice as "volt sorcery," an appropriate term given the way that witchcraft and sorcerous practices often exploit this sort of causal relation (Whitehead & Wright, 2004).

[17] The extent to which the doctrine of similarities is truly held within TEK is debated, however. Bennett (2007) argues that it is a post-hoc gloss whose function is to aid memory and information transmission, rather than a discovery heuristic or metaphysically explanatory principle.

Commitment to sympathetic and other forms of magical causality are hardly restricted to Indigenous worldviews. Instead, they appear to belong to a cross-culturally pervasive mode of thinking that is always, consciously or unconsciously, available. Backwards contagion-style reasoning, for example, shows up in American participants, who will evince strong discomfort at the prospect of personally intimate substances (blood, hair, one's diary) falling into the hands of others, particularly if they are specific nemeses or generically nefarious individuals (Rozin, Dunn, & Fedotova, 2018).[18]

An underlying commitment to magical causality may nevertheless be modulated by cultural narratives and practices that rationalize and make it acceptable to express. Legare and Gelman (2008) find that among Sesotho-speaking South Africans, biological explanations for illness co-exist with culturally accepted witchcraft-based explanations, even though the former will dominate unless the context is expressly welcoming of magical causality. And Subbotsky argues that while Western adults overtly disavow belief in magic, implicit measures suggest a more ambivalent attitude (Subbotsky, 2011; Subbotsky, Mitchell, & Riggs, 2000). Magical cognition tends to be stakes-sensitive. When the stakes are even mildly elevated, attitudes of British adults come to more closely resemble those of adults from central Mexico, where the dominant culture is more permissive with respect to "anomalous" causal entities and phenomena

[18] In general, commonsense thinking in Western cultures (i.e., non-academic reasoning deployed as part of everyday life rather than as part of an institutionalized community or practice such as scientific research) may share some properties with the types of Indigenous knowledge production described here. Such commonalities would not be surprising, given that what gets called "commonsense" is a patchwork cobbled together for coping with daily problems and challenges. Just as with TEK, the ontology of commonsense may conflict with the deliverances of AEK; but unlike most systems of TEK, Western commonsense knowledge is extremely poor when it comes to giving guidance on how to understand and navigate the biological world (Atran, Medin, & Ross, 2004; Ross, Medin, Coley, & Atran, 2003). And as McCauley (2011) argues, the cognitive underpinnings of commonsense may be much more well-suited to religious and spiritual thought than to contemporary science. Thanks to an anonymous reviewer for noting this connection.

(Subbotsky & Quinteros, 2002). The sciences may have systematically exiled magical cognition, but it retains a hold on everyday life despite the lip service paid to materialism.

5. The distributed nature of ecological knowledge

The commitment to a set of spiritual entities and powers that shape, interpenetrate, and can be affected by the living world, that tap into emotions and systems of value, and that can be manipulated in specific ways, challenges the view that TEK is an Indigenous correlate of the "disenchanted" nature that AEK posits.[19] Spiritual or magical powers and the means of manipulating them are not sharply or systemically distinguished from the rest of nature. Rather, they are just other forces set alongside the known powers of living things such as their abilities to reproduce, seek nutrition, avoid predation, and communicate and coexist as social peers. These forces can be tapped by those who know the correct preparations and invocations, just as with the more prosaic manipulations involved in planting and harvesting crops, or preparing curare.

This is just to say that "ecological knowledge" does not name a discrete package of information possessed by members of a culture. Knowledge of nature is *distributed* across a host of practices that overlap in the categories that they deal with but differ in how they engage with them. From the internal perspective of the culture there is no obvious way to pry these practices apart, and their reciprocal causal interactions and dependencies make any such dissections implausible. This failure of autonomy, combined with consistent adherence to the method of accommodation, undermines the prospects for convergence between AEK and TEK. The reason is that the accommodation demands that TEK is responsive to are not ones that lead it to pick out only, or perhaps even predominantly, the ontological divisions made within academic biology.

[19] Although it is also unclear how "disenchanted" contemporary science is; see, e.g., (Josephson-Storm, 2017).

The referential apparatus of TEK is responsible for accommodating a body of non-epistemic needs, values, and claims, and these systematically exert pressure towards divergence.

As an example, a category such as caribou may, among the Cree, participate in:

1. A system of naming and nomenclature, in which the category is distinguished from others and divided into subcategories;
2. A set of culturally significant narratives, which may take the overtly mythic or historical form;
3. A set of ways of interacting with and using them for group-specific ends; this may include tracking and hunting, preparing kills for consumption, or using their hides as materials;
4. A body of information about their life cycle, typical habits and behavior, relations to the land and other kinds of living things;
5. A set of rituals that prescribe and proscribe how they are to be treated and place them within a network of spiritual attitudes, and ascribe to them various spiritual properties and explanatory roles

This list is meant to highlight the diversity of these practices, not to be exhaustive. All contain information about the same category, viz., caribou—but which of them, we might ask, is *purely* ecological? Within the practices themselves, there is no answer, or rather, the question arguably can't even be posed. What we have is not a set of discrete components, but a weave of interlocking practices that are equally ontologically committal.

These practices are heterogeneous but structured. Knowledge of migration patterns, for instance, contributes to choices made while in the field hunting, and culturally significant narratives depend on naming practices. Crucially, though, none are *fundamental*. Lexical

information will plausibly be most widely shared, but that does not imply that it is the most important for coping with nature, since it is possible to know the names of things without knowing how to use them fluently (Casagrande, 2016; Gatewood, 2011). Some substantive information is widely acquired by an early age: e.g., Q'eqchi' Maya children can by age 9 identify 85% of the plants growing in their homegardens (Zarger, 2011). But more specialized information, such as how to brew medicine, may be held only by particular marked groups within the larger population. A subgroup that knows how to hunt monkeys with blowpipes may not know how to weave garments from barkcloth, and vice-versa, but they partially constitute the culture's TEK despite their lack of overlap and relative epistemic independence.

The alterity thesis defended here should not be confused with any sort of incommensurability claim. Incommensurability concerns the difficulty (or impossibility) of translating the claims made within one system of concepts with those made within another—hence the lack of a common "conceptual measure." Whether it is possible to express TEK's ontological distinctions within an alternative representational scheme is one thing. Whether those ontological distinctions *converge* with the ones made in AEK is another. An ethnography of the uses of animal parts in ritual decoration, an inventory of frequently cultivated palms, a lexical analysis of a people's floristic vocabulary, or a controlled study of how ornithological inferences are made can all shed light on how TEK is deployed in various contexts. The literature is rich in such descriptive studies (Hunn, 2006). The fact that anthropologists, cultural psychologists, and ethnobiologists produce such detailed and compelling descriptions of Indigenous worldviews in itself attests that ontological bridge-building is possible.

But the fact that TEK and its unfamiliar ontological distinctions can be cogently described does not imply that its integration with AEK is similarly possible. Integration requires

more than translation across cultural-linguistic boundaries. As noted in Section 2, it also requires overlap in the significant ontological commitments of both TEK and AEK, including their core explanatory categories, properties, and causal patterns. These ontological elements must not merely be described, but also have a place within the classificatory, inferential, and causal-explanatory dynamics of AEK itself. To the extent that the sorts of alien (in the sense of "non-overlapping") elements described in Section 4 are prevalent, integration will remain out of reach.

6. Coordination without integration

So far I have argued that the notion of TEK appealed to within the integration project misrepresents what Indigenous peoples know by imposing a structure that this knowledge does not have within its everyday habitat. The fact that TEK can for certain purposes be systematized in this way does not show that this structure is implicit in the practice of group members themselves. I turn now to assessing the non-integrative prospects for framing knowledge encounters among Indigenous peoples and academic, conservation, and other stakeholders.

I suggest we can best regard TEK as emerging piecemeal out of many delicately organized but highly artificial interactions. TEK is essentially a *dialogic* product of a conversational setting, experimental task or procedure of interviewing, and an environment of testing, questioning, observing, cataloguing, and writing. These ways of probing knowledge by development officials, ethnographers, cognitive psychologists, and field linguists promote the retrieval and construction of information in a form that can be assembled into something that is legible to academic investigators. They produce selected and structured knowledge that can be assessed for its fit with AEK, even if it constitutes only a part of what is embodied in the total set of Indigenous practices.

This dialogic production (or co-authorship) is elegantly captured in Anna Lowenhaupt's Tsing's (2005) evocation of the fraught pleasures of listmaking with her Meratus Dayak friend and collaborator: "The list is self-consciously globalist: an entry into a world-making millennial project. It is self-consciously localized: following the contours of local geographies and their plant and animal residents… The list offers the pleasure of making a widely circulating form come to life in the terrain around one's home place, and for foreigners as well as local folks" (p. 170). A dialogic conception also resembles Whyte's (2013) notion of TEK as a "collaborative concept" that "should be invoked to invite non-indigenous parties to learn more about how particular indigenous communities approach fundamental questions of the nature of knowledge and how it fits into their visions of environmental governance" (p. 10).

Precisely because TEK is dialogically created, though, we cannot separate issues of power from those of knowledge (Nadasdy, 1999, 2005). The act of representing TEK *as* an intelligible body of knowledge, and thus as a possible candidate for integration, is one that at the same time imposes epistemic asymmetries that mirror the power differentials between the parties. This is nowhere more clear than in the fact that, for all the talk of integration, it is TEK that characteristically ends up being trimmed and tied to fit the epistemic mold of AEK. Witness, for example, the persistent emphasis on "validating" the claims of TEK as a precondition of securing its credentials. One would be hard pressed to find a case in which the reverse demand for legitimation was made, let alone acknowledged.

This validation challenge occurs frequently in medical bioprospecting, where a causal network described one way within Indigenous TEK may be modeled in a quite different way within AEK. Even if phenomenal generalizations concerning how high level properties are connected may be preserved, the underlying or supporting causes differ radically. The complex

meaningful, situational relations among a shaman, a plant, and a patient can be conceptualized either as effecting a cure via a negotiation with and purgation of restless spirits, or as a physiologically mediated interaction between a psychoactive molecule and neurotransmitter uptake sites (McGonigle, 2017; Nigh, 2002). The shamanic healer's procedures are held to be really effective only if they are backed by the *right sorts* of mechanisms. To call this "knowledge integration" is an exaggeration: only the phenomenal relationship between plant compounds and healing is preserved.

Proponents of integration may argue that enriching AEK by selectively importing knowledge that is embedded within Indigenous practice is faultless, since this transfer leaves TEK itself fundamentally unchanged. But this is far from clear. The process of making culturally significant categories palatable to AEK normally involves "flattening" them, stripping away especially those properties connected with their distinctive evaluative and affective roles. Consider the marketing of Hoodia, a plant traditionally used by the San people of southern Africa as an appetite suppressant. Following a commercial pharmaceutical agreement, the plant was harvested and processed to extract its active ingredients, which were sold as a slimming aid. The San themselves are profoundly ambivalent about this development. In a telling study, Vermeylen (2008) reports that, to some community members, Hoodia itself has lost its former meaning and efficacy as a result of this commodification. One interviewee says, pointedly, "You can not experience these powers and energies of the Hoodia in pills; we gave the power away for money. Everything what we had here is gone because we traded the supernatural powers for money, for simple things […] but the Hoodia was so good for us" (p. 231).

Not all epistemic transfers are faultless, then. There are significant perils for Indigenous knowledge-holders in becoming *too* legible, *too* potentially subsumable into systems of

administrative management (Bryan, 2009). Crafting an understanding between two asymmetrically positioned knowledge communities that respects the distinct values and epistemological strictures that they impose requires delicate negotiation. The normative point that I am urging here is that the pervasive structural risks of harm that arise in seeking integration should be considered in addition to the possibilities that it will not prove successful on purely epistemic grounds.

In light of these considerations, I suggest it is more promising to discard the rhetoric of integration, and with it the need for all natural knowledge to fit into a seamless whole. *Coordination*, by contrast with integration, does not require a merging of two communities' knowledge, but negotiation of ways in which they can work together for mutual benefit despite the parties having potentially divergent goals.[20] The passion for unification is arguably a one-sided obsession in any case. Many Indigenous groups may be syncretic and fundamentally pragmatic about these matters, freely adapting Western tools and methods on their own terms in an epistemically porous and eclectic way (Briggs, 2005, p. 104). I briefly sketch four main characteristics that distinguish coordination from integration.

First, coordination fundamentally rests on the possibility of *grasping* the other's ontology without sharing or importing it. Its success turns on facility at working with alternative worldviews, which falls short of fitting them into your own. Success in this descriptive task, as we have seen, is a matter of degree. But there is also an important reflexive aspect to coordination that has so far gone unmentioned. A glimpse of an alternatively structured world is always also a partial mirror into one's own. The reason is that taking note of ontological difference inherently involves an operation of comparison, and the view that this provides can be

[20] See again Whyte's (2013) notion of collaborative concepts as "invit[ing] people to engage in a process of respectful learning about significant differences" (p. 10).

a defamiliarizing one. Some, like Viveiros de Castro (2004), hold that this ontological destabilization is not just an uncanny intermittent phenomenon but rather the fundamental method of anthropology.

Coordination, then, requires an element of humility, but also a significant degree of irony about one's worldview and epistemic commitments. This may not be a precondition for undertaking coordination, but rather an attitude whose cultivation is integral to successfully carrying the project out. An attitude of irony also holds out the prospects of *mutual alteration* to the parties' worldviews (Wagner, 1981). Built into the idea of coordination is that it is a reciprocal process. As noted above, a feature picked up on by many critics of integration is the one-sidedness and inflexibility it can, at times, display in practice. Because the categories of AEK are created to serve the needs of institutional actors and agencies, they tend to have historical inertia as well as authority behind them. An inquiry that situates these categories within a wider space of alternatives may loosen their grip by highlighting the fact of their contingency.

Second, coordination is *local* and *provisional*. This is true in a trivial sense since, like all encounters, it occurs in a geographic, social, and political context that is circumscribed in space and time. More significantly, though, it holds because the processes that enact coordination are inherently fragile ones. There is no guarantee that a stable coordination achieved between two or more groups in one situation will carry over to another, even if the same parties and topics are involved. Successful coordination requires establishing a foundation of trust among the specific individuals involved (a research team at a fieldwork site, a particular group of healers or hunters), which is an inherently personal connection not easily transferred or generalized (Davidson-Hunt & O'Flaherty, 2007). The questions and stakes involved may have changed, or

the underlying power dynamics shifted. The process centrally turns on openness to renegotiate the terms of exchange as the participants and their relationships change.

Third, coordination is *partial* and often *shallow*. Processes of coordination are always limited in their scope to a particular set of questions or problems to be addressed, namely ones to which both parties can make some contribution and from which both parties stand to benefit. Coordination only brings to bear those aspects of the parties' knowledge that contribute to the restricted problem set under consideration. At most they may make contact at a particular constellation of points, and these points may hover near the surface of what is known rather than plumbing its deeper recesses. Indigenous hunters, for example, may share their extensive historical observations of caribou migration patterns without delving into how these observations fit into a larger pattern of value. Healers may share knowledge of pairings between plants and the diseases they treat, without adverting to the underlying causal mechanisms that sustain these relations. Shallowness may court misunderstandings or confusion, but it also allows all parties to avoid raising questions that cannot productively be debated.

The partial, shallow nature of coordination is one of the core marks that distinguish it from integration. While integration can end up being partial, its regulative ideal is that of maximizing overlap between ontologies. Coordination explicitly encourages productive syncretism. This means finding the degree of overlap appropriate to each discursive context, and allowing the parties to selectively ignore or reformulate parts of one another's worldviews. The attempt to give biomedical explanations for the effectiveness of shamanically employed plant compounds illustrates this phenomenon well. Spiritual powers that are ascribed efficacy by healers are "flattened" into (possibly unknown) biochemical agents in AEK. But this case also usefully illustrates the reciprocity of coordination, since the Indigenous knowledge that many of

these compounds are effective only given the right set and setting may encourage the search for non-molecular mechanisms of action (e.g., presence of a supportive social group) within AEK itself.

Fourth and finally, coordination is neutral with respect to the question of *convergence*. It neither aims at consensus nor dissensus, by contrast with integration, which has convergence as its fixed endpoint. Within coordination there may be different and even conflicting endpoints, together with diverging narratives of what the encounter meant to each party. Tsing (2005) celebrates this as one of the primary morals of the community-managed forestry project that she documents. While the forest near Manggur was the "common object" that served as a focus for all parties (village leaders, activists from Jakarta, local nature-lovers groups), none could agree on a coherent narrative of what *happened* as a result of their coordination. Instead, "[c]ollaboration was not consensus making but rather an opening for productive confusion" (p. 247). Coordination between two knowledge production practices may result in their unification, in partial borrowings taking place at varying degrees of depth, in their participants reflecting on and refining their own practices as a result of seeing how others are organized, or in indefinitely many other outcomes.

These points give an outline of how the coordination-based approach differs from one centered on integration. In brief, knowledge coordination is a fragile, potentially destabilizing, sometimes contradictory enterprise that nevertheless may thrive precisely because it facilitates exactly the right degree of contact while leaving space for parties' independence and pursuit of their own goals. Its default ontological attitude is a broadly pluralistic one. Islands of convergence are welcomed if and when they emerge out of these encounters, but convergence per se is not a goal except insofar as it is selected as one in the context of some particular episode

of coordination. The endpoint of coordination may be two knowledge systems that have syncretically incorporated elements from each other, but not necessarily in the same ways or with the same result.

Finally, it is worth briefly considering how ethnobiological realism fares on a coordination-based approach. Nothing said here challenges the claim that realism may be the appropriate framework for interpreting AEK. Rather, the challenges to integration presented in Section 4 all involve a failure of overlap between AEK and TEK arising from attempts to interpret TEK within the same realist scheme. From within the home perspective of each knowledge system, there will be categories, properties, and processes belonging to the target system that, at a minimum, cannot be coherently fit with the rest of the home elements. There is no place for the *arux*, or for *waya*, within contemporary forestry and physiology, nor any clear way that activity in cellular metabolic pathways fit into a shamanic account of guided spirit journeys.

Given its failure to capture TEK itself, the framework of realism similarly may not apply to the products of coordination between AEK and TEK. Local negotiations may settle on a particular overlapping subset of their ontologies, but elements may also be coordinated through processes of modification, such as flattening or being treated as a phenomenological placeholder. These operations involve an agreement by the negotiating parties to suspend judgment about the reality of certain things that the other is committed to in order to bring about some otherwise desired ends. The degree and depth of commitment to each coordinated element may also vary between the parties. Consequently a patchwork of realism, pragmatic instrumentalism, and

empiricism may be the appropriate ontological attitude to take in coordination, particularly given that it is meant to be just such a bridge between distinct knowledge schemes.[21]

7. Conclusion

Common thinking has it that traditional and academic knowledge of nature both can and should be integrated, and that doing so will repay all participants both epistemically and materially. Without downplaying the real achievements derived from encounters carried out under this banner, I have tried to cast doubt on whether integration is the right way to think of the enterprise and its goals. The model of knowledge integration is one on which both bodies of knowledge come together into a single overarching whole that nevertheless, in practice, often ends up being dominated by the most politically and economically powerful party. Shifting away from integration, by thinking explicitly in terms of the coordination agenda sketched here, replaces this model with one in which both bodies briefly come into contact and separate, each having been changed but neither having been subsumed. This approach promises a more accurate representation of traditional knowledge and of the ways that asymmetrically positioned communities negotiate these exchanges.

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[21] Even an advocate of global scientific realism like Boyd is willing under the right conditions to accept realism restricted only to certain domains. Realism, he thinks, holds just in those areas that "unproblematically share a common methodology with the natural sciences" and "unproblematically exhibit a level of instrumental reliability of method appropriate to the abductive argument for realism" (1990, p. 190). Both of these conditions may fail to hold in coordination between AEK and TEK. For a description of a range of cases where we are justified in adopting realism towards ethnobiological and commonsense categories, see Weiskopf (2020).

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