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Trends in Ecology & Evolution



Series: Local and Indigenous ecological knowledge

Science & Society

Towards richer knowledge partnerships between ecology and ethnoecology

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Indigenous and traditional practices based on ethnoecological knowledge are fundamental to biodiversity stewardship and sustainable use. Knowledge partnerships between Indigenous Peoples, traditional local communities, and ecologists can produce richer and fairer understandings of nature. We identify key topical areas where such collaborations can positively transform science, policy, and practice.

Towards more equitable knowledge partnerships

Indigenous peoples and traditional local communities (IP&LC) hold valuable, place-based ethnoecological knowledge about nature (also referred to as traditional ecological knowledge), including knowledge of complex species interactions, cause–effect relationships, ecosystem dynamics, and history, as well as how to live

with, care for, and manage nature and its contributions to people (NCPs) [1–3]. Ecosystems managed, used, and/or owned by IP&LCs, although under increasing pressure from the expansion of industrial and extractive frontiers, are less degraded and their biodiversity is declining less rapidly than ecosystems under other management systems [4].

Beyond biophysical factors and lower densities of human populations and infrastructure, the main reason for high biodiversity in areas inhabited by IP&LCs is that their culturally based practices contribute to their well-being and sustain nature. These practices, based on long-term, in-depth, and dynamic ethnoecological knowledge, directly or indirectly contribute to sustaining nature and biodiversity through their interaction with natural processes, co-producing high-biodiversity cultural landscapes that constitute their territories [5] (Figures 1 and 2).

However, and despite being firmly recognised in international instruments for biodiversity conservation, ethnoecological knowledge is often invisible to ecologists seeking to understand how managed ecosystems and organisms function, and how to ensure biodiversity conservation and sustainable use in such ecosystems [7]. Furthermore, IP&LC territories, people, and related ethnoecological knowledge are today facing unprecedented threats, particularly ongoing social injustices [8,9].

We argue that the lack of recognition and understanding of the knowledge of IP&LCs, due to epistemological issues deeply rooted in the histories of scientific disciplines as well as social stigma as irrelevant, have made it difficult for ecologists to create fruitful partnerships with IP&LCs¹. The global environmental crisis

we face today highlights the need for new partnerships to address critical social–ecological needs. In this paper, we advocate for the co-production of knowledge through just and equitable partnerships as a way to generate richer and fairer understanding of how nature functions, and how to steward it in a rapidly changing world.

IP&LCs contributions to biodiversity management and the underpinning ethnoecological knowledge

Existing research highlights the benefits from ecological–ethnoecological knowledge partnerships in three different contexts, as follows.

Ostensibly unchanged, natural landscapes

Through mobile grazing, transplanting and tending species, controlled burning, conscious modification of species composition, and culturally mandated avoidance of places and species, among many other practices [2,3], IP&LCs have managed landscapes for millennia that scientists have traditionally considered to be untouched, wild, or pristine [10] (Figure 1). IP&LCs use knowledge of disturbances, regeneration processes, and accompanying ecosystem dynamics to maintain biodiversity. Additionally, IP&LCs often endeavour to prevent species and ecosystem loss in these areas by restricting access, and thus preventing unsustainable practices (see Appendix III in supplemental information online for a collection of key references).

Transformed biodiverse landscapes

Some landscapes heavily altered by IP&LCs, often subjectively and incorrectly identified as degraded because of anthropogenic transformation, are now recognised as being managed for diversity and resilience [11]. These landscapes typically provide a wide range of NCPs: multispecies tropical forest gardens, domestic forests, hay meadows, wood pastures, and clam

¹ We acknowledge that ecologists and IP&LC knowledge holders, as used in this paper, are not mutually exclusive categories.



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Figure 1. Ethnecological knowledge in a traditionally managed cultural landscape. Arnhem Land stone country is a centre of endemism in Northern Australia that has been managed by the Warddeken people for many millennia. However, most people left the region during a hiatus in occupation following colonisation. As a result, extensive wildfires frequently swept the region in the hottest months of the dry season. The fine-scale mosaic of burning histories that had characterised traditional fire management was obliterated, and many species and plant communities were threatened. A return to homelands by the owners and managers of Country (there is a traditional division of responsibilities) is now leading to a renaissance in the reproduction and application of traditional knowledge. One reason for the change has been a partnership with scientists who have recognised that traditional burning reduces greenhouse gas emissions. The combination of traditional knowledge with scientific knowledge made traditional burning profitable in the wider monetary economy, helping provide jobs for Warddeken people and allowing them to continue traditional practices using modern technologies, such as the latest remote sensing data. The altered fire regime is also delivering benefits to the biodiversity that had previously relied on Warddeken land management. The region remains a cultural landscape in which nature and culture are inseparable. The success of the partnership between traditional owners and scientists rests on a mutual respect for contrasting worldviews (based on [6], and references therein, see Appendix I in supplemental information online for more details about this case example; photo credit Emma Masters/ABC).

gardens, among other examples. They also sustain diverse ecological communities with increased NCPs, and some have even become biodiversity hotspots [5,12] (Figure 2). The management of these landscapes requires an intimate understanding of multispecies interactions, degradative and regenerative processes,

and short- and long-term ecosystem dynamics [9]. Fine-scale ethnecological knowledge and IP&LC monitoring underpin such cultural practices, nurture ecosystem renewal, initiate successions, avoid overuse, promote restoration, maintain remnant 'natural' patches, and generate locally adapted breeds and

varieties. The sophisticated knowledge of IP&LCs of the behaviour, population distribution and dynamics, and habitat needs of species often contributes to prevent overuse [3]. Some management practices (e.g., burning and grazing) may replace disturbances that no longer occur naturally but which are needed to



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Figure 2. Ethnoecological knowledge in a highly modified biodiverse cultural landscape. Gyimes in the Eastern Carpathians (Romania) is famous for its semi-natural mountain meadows rich in colourful flowers and rare species, the beauty of its landscape, and the richness of its folk culture. The species-rich and diverse habitat mosaic of the cultural landscape has developed under a regime of fine-scale and fine-tuned attention-intensive succession management, and nurturing of ecosystem renewal and nature's contributions to people by the local Hungarian Csángó community. Co-production with nature is explicit: 'the better you care (i.e., take care of your meadows, arable fields), the more benefit you get (from them).' Long-term experimentation by the Csángós resulted in an in-depth local understanding of short- and long-term population and ecosystem dynamics, and provides a firm knowledge base for extensive ways of farming. Long-term partnership and knowledge co-production between scientists and Csángó knowledge holders helped enrich the understanding of the complex functioning of this cultural landscape, especially the direct and indirect ecological and social impacts of external agricultural and conservation regulations. These regulations are often exclusively based on Western European scientific evidence, ignoring and disrespecting local knowledge, values, and contexts. Establishing and strengthening fair and equitable collaborations could increase respect and acknowledgement for the Csángó's nuanced, biodiversity-friendly cultural landscape management, hardly understood previously by ecologists, and could lead to a fairer and more efficient protection of the Csángó's biocultural heritage (based on [9] and references therein, see Appendix II in supplemental information online for more details about this case example; photo credit Ábel Péter Molnár).

allow species persistence (see Appendix III in supplemental information online for a collection of key references).

Domestication and agrobiodiversity

Domestication selects for specific traits which are then integrated into social-

ecological niches that differ from those in which species evolved. IP&LCs have developed structured knowledge on how to propagate and maintain local varieties and breeds of plants, animals, fungi, and bacteria; such knowledge facilitates dynamic adaptation to environmental and

social changes. For example, knowledge of crop traits combined with social practices, such as seed exchange networks, can increase farmers' capacity to adapt to changing socioecological conditions (see Appendix III in supplemental information online for a collection of key references).

Equitable IP&LC—ecologist knowledge partnerships as the basis for a richer understanding of nature

A partnership is not the integration of the knowledge of IP&LCs into science (which may potentially result in loss of context, undermining the holistic basis of ethnoecological knowledge), but rather bridging and weaving across knowledge systems [13,14] so that emergent new knowledge is produced. Co-production, whereby collaborators work together to generate knowledge, requires partnerships based on mutual respect that recognise the complexities that can arise from trans-disciplinary engagement across knowledge systems [12,14]. Partnerships among ethnoecological knowledge holders and ecologists have provided fruitful areas of mutual understanding in four intellectual domains (cf. [3]) (Table 1).

Knowledge of species and ecosystems

Ethnoecological knowledge can inform ecological science on aspects of biodiversity through folk taxonomy, functional ecology, and spatial and temporal distribution of taxa; oral histories can help identify direct and indirect drivers of ecological change (Figure 1). Knowledge co-production can provide understanding for IP&LCs of why ecologists are interested in specific scientific questions and result in coproduced new understandings (see Table 1 for corresponding scientific categories).

Knowledge of management and stewardship practices

Ecologists can gain appreciation of ethnoecological knowledge and its rationale for management practices. For example, the local categories of NCPs, or the practices IP&LCs use to modify the environment and thereby enhance NCP provision, to mitigate adverse impacts or to restore damaged populations and ecosystems, are often linked to locally developed sets of indicators and monitoring approaches (Figure 2). Ecologists and IP&LCs may

gain new insights together by learning about other rationales, IP&LC human-to-non-human connectedness, practices that sustain nature, and multiple values. Diverse knowledge lenses may transform mainstream ecological hypotheses, research and monitoring methodologies, to produce results that integrate local practices and worldviews and thus transform ecological understanding of human–nature interactions [7,10].

Social institutions (rules-in-use), governance

Appreciation and recognition of the social institutions and governance underpinning IP&LC management can be as important a benefit of partnership as understanding the biological/ecological aspects. IP&LC institutions manage biodiversity using a diverse range of social, economic and political instruments including local rules, taboos, norms, social structures, and power relationships [3,15]. Ecologists can also benefit from understanding IP&LC approaches to learning from and about nature, pathways for inter- and intragenerational knowledge transmission, and ways of coping with and adapting to the ecological and social consequences of environmental change, including new difficulties and limits. IP&LCs may also benefit from partnering with ecologists on specific management issues based on strong common understandings of changes underway.

Values, worldviews

Partnerships for knowledge co-production need and can lead to mutual respect for different worldviews, values, and mentalities [12,13]. The reason IP&LCs have managed to resist ongoing pressures to alter or abandon their cultural practices is often firmly rooted in the way relationships among various elements of biodiversity are viewed and strongly connected to their identities. This relates to the continuity and unity of nature and culture, the influence of teachings and customs on behaviours and attitudes towards biodiversity, the roles of kinship and reciprocity with various elements

of nature, the relationships among humans, and the influence of spirituality on management [3,15,16]. Such collaborations can enable ecologists, and the wider society, to understand that sustainable use and management by IP&LCs are as much an emergent property of culture and social organisation as is the massive consumption of biodiversity by other societies.

Although many individual studies focus on one or several of these domains of ethnoecological knowledge, their rationales and their ecological consequences, the ethnoecology of these social–ecological systems has only been documented and analysed across all four domains in a handful of sites and for only a few ecosystems. Much remains to be done.

Knowledge partnerships for a liveable future

Ecologists can assist IP&LCs through recognition and knowledge partnerships to ensure that IP&LC knowledge and practices and the rationale behind them not only persist, but can form the basis of wider sustainability efforts globally. Collaborations that increase understanding of IP&LC practices by ecologists constitute a critical step for the sustainable management and stewardship of landscapes that have evolved under IP&LC stewardship. Evidence from existing partnerships shows that mutual respect for the differences between knowledge systems; support and understanding of indigenous sovereignty; participatory decision-making on research questions, design, and outputs; and acknowledgement of different priorities for outputs, including data-sharing and dissemination, are crucial to success. A key priority is how such efforts can be sustainably funded, particularly for Indigenous scholars and IP&LC-led research. Furthermore, knowledge partnerships can strengthen recognition of IP&LC knowledge and practices, especially when faced with declines in knowledge transmission and, through this, contribute to a more



Table 1. Some key subject areas of ethnoecological and scientific knowledge of socio-ecological systems to help design knowledge partnerships (see related references in Appendix IV in supplemental information online).

Ethnoecological knowledge domains	Ethnoecological subject areas	Corresponding scientific ecological subject areas
Land/seascapes, ecosystems, plant and animal species	<ul style="list-style-type: none"> Local categories, folk names, characteristics, taxonomy and uses of wild and domestic plants, animals and fungi, soil, rock, water, snow, ice, wind etc.; distinguishing parts of a landscape into macro-, meso-, and microscale habitats Local categories and knowledge of ecological needs and modes of interactions of species and wider ecosystems and/or landscapes; spatial distribution, patchiness, dynamics (incl. trends and fluctuations) of elements of biodiversity at different spatial and temporal scales Trends over time in the local environment, conceptualisation regarding direct and indirect drivers of change or status, including climate; local knowledge of extinct and new arriving (potentially invasive) species 	<ul style="list-style-type: none"> Categories and classifications of biotic and abiotic elements of nature Physiology, molecular ecology, phylogenetics, phenotypic and genetic diversity Spatial and temporal patterns and dynamics of populations, ecosystems and landscapes, coexistence of various elements of nature Functional ecology: traits, flows of resources, productivity, ecosystem health (biological, chemical, physical characteristics) Landscape ecology, maps (vegetation, edaphic, topographic) and types of partitioning proposed, changes of species pools Flora, fauna, ecosystem, and landscape histories, history of land-use, and of internal and external drivers of change
Land and biodiversity management practices and related ethnoecological knowledge	<ul style="list-style-type: none"> Categories of NCPs related to biodiversity, practices that modify patterns and processes in the environment to enrich NCP provisioning Trends and changes in various management practices and their short- and long-term perceived impacts on biodiversity and interactions between species Monitoring processes related to degradation or regeneration of biodiversity under various management practices and intensities; practices to mitigate adverse impacts or restore damaged populations/ecosystems Locally developed indicators and their use to monitor impacts of practices Management decisions, linked to ethnoecological understanding of changes and their drivers for the management of biodiversity 	<ul style="list-style-type: none"> Identifying formal categories of NCPs and ecosystem services Short and long-term impacts on ecosystem structure and function, biogeochemical and physical flows, productive capacity at fine and coarse scales in relation to changes and adaptation of the local management system to internal and external drivers etc. Local management processes applied to regeneration or active restoration, or protection of individuals, selected species, life history stages or entire habitats, and the ecological impacts of these Species, ecosystem and landscape-level indicators and monitoring of ecological change Landscape mosaics and complexities: biodiversity flows between agroecosystems, forests and other habitats Developing experimental set ups in field (or in labs) simulating local practices and monitoring with ecological approaches
Social institutions underpinned by ethnoecological knowledge	<ul style="list-style-type: none"> Explanations of indirect (social, economic, political) drivers of ecological change at multiple scales, and actors driving these changes Assessment of the impact of rules, social taboos, norms, social structures, power relationship on management decisions, and their ecological consequences Ways of learning from and about nature and its changes, and pathways of inter- and intragenerational knowledge transmission Ways of coping with and adaptation to the ecological and social consequences of environmental changes, such as maintaining the resilience of the socio-ecological system Well-tested principles and mechanisms for collective allocation of labour at multiple levels of the socio-ecological system Institutions of nature stewardship 	<ul style="list-style-type: none"> Drivers of change which affect customary rules, e.g., access to spaces, where, when, and what amount to hunt, collect, where to cultivate or bring herds, and ecological monitoring of impacts (spatial/temporal changes in spaces and associated biodiversity) Norms of social behaviour (not elaborated rules): limiting overuse at the expense of others within a community, sharing, giving and receiving (e.g., seeds, propagules), and the ecological consequences of these on reshuffling (mixing) of biodiversity and agrobiodiversity and on the potential resilience to climate and yield stability Exchanges and mobility of humans and biodiversity impacting environmental management: land and/or biodiversity transmission or exchanges between communities, ecological impacts of and risk management for evolving wild and domestic species or genetic resources Trade and exchange practices: exchange of products and know-how leading to incorporation of new land races and varieties Ecological monitoring of new communities of species, agrobiodiversity created through exchanges Impact of conventional schooling on social institutions, transgenerational knowledge transmission and land management, and their ecological impacts

(continued on next page)

Table 1. (continued)

Ethnoecological knowledge domains	Ethnoecological subject areas	Corresponding scientific ecological subject areas
Worldviews and values, and their ecological dimensions	<ul style="list-style-type: none"> • Relational values towards elements of nature (staple foods, sacred elements etc.) • Role of humans as part of nature, and more-than-humans (other living beings than humans and non-living geo-physical objects such as rocks, climate etc.) in worldviews • Understanding of kinship with various elements of nature, supranatural creatures' impact on management decisions, degree of the nature-culture divide • Application of well-tested principles of use and management of biodiversity in order to increase social capital and affecting behaviour, attitude towards nature (cf. Nature stewardship) 	<ul style="list-style-type: none"> • Worldviews and how they link humans to non-humans (mutualism, reciprocity or predation) and their direct or indirect consequences on biodiversity, habitat protection, ecosystems management • Principles of coexistence that favour equilibrium between elements of biodiversity and abiotic elements (e.g., water, fire, wind) or disequilibrium linked to changes • Ecological monitoring (e.g., on plant–animal–soil relationships and on the coexistence of elements of ecosystem mosaics that favour NCP provisioning and their resilience) • Multiple values linked to biodiversity-rich food systems, food sovereignty, local crop diversity, locally-protected forests, pastures, rivers vs larger external destruction approaches; assessing the impacts on biodiversity, and linkages to related worldviews and values • Multiple values expressed in major situations of controversies (what people want and do not want) and linked to local ecology and biodiversity that are threatened; assessing how identity and indigenous rights protect nature, vis à vis destructive external drivers

equitable future locally and globally. Context-specific discussions and knowledge co-production with or led by IP&LCs on topics relevant to both IP&LCs and science can enrich the knowledge basis for science, for IP&LCs, and for the safeguarding of nature.

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