
This is the **accepted version** of the journal article:

Mattalia, Giulia [et al.]. «Stewardship practices enhance nature's contributions to people». *BioScience*, Vol. 76, Num. 6 (2026), p. 491-500 DOI 10.1093/biosci/biag047

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Stewardship practices enhance nature's contributions to people

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Abstract

Humans shape landscapes through the management of organisms and ecosystems, either degrading or sustaining biodiversity. Despite their essential role in sustaining biodiversity, stewardship practices have been overlooked by conventional conservation research and action. To improve our understanding of biophysical stewardship practices, we propose a classificatory framework and illustrate it by applying it to the stewardship of cultural keystone species, rich in examples due to their

high value to people. We identified 19 types of biophysical stewardship practices with impacts at population, community, and ecosystem levels. Through a review of English literature providing examples of cultural keystone species, we identified 343 reports of biophysical stewardship practices directed toward almost 1000 cultural keystone species and 1652 reports of nature's contributions to people associated with these species. Integrating stewardship practices into biodiversity conservation frameworks would facilitate consideration of both biodiversity and its stewards. Strengthening Indigenous, local and other place-based stewardship practices within scientific and policy settings could contribute to more effective and inclusive conservation.

Keywords: Biodiversity conservation, ecosystem management, Indigenous Peoples, Kunming-Montreal Biodiversity Framework, Local communities, Local ecological knowledge

Stewardship practices: connecting biodiversity conservation and nature's contributions to people

Anthropogenic drivers have contributed to an unprecedented decline of nature and its contributions to people (Díaz et al. 2019, Jaureguiberry et al. 2022). At the same time, human actions also hold promise for curbing these threats (Díaz et al. 2020, Ojeda et al. 2022, Levis et al. 2024). Human societies have transformed landscapes for millennia through land use, and by managing other organisms at the population, community, and ecosystem levels (Clement 2006, Ellis et al. 2021). For example, contrary to prevailing views, ecosystems in western Canada are shaped primarily by natural processes and elements such as wildfire, soils, and climate, place-based knowledge holders have been actively managing their territories to foster the abundance and quality of preferred plant and animal species since before European colonisation (Christianson et al. 2022). Indigenous Peoples and other place-based knowledge holders (i.e., small-scale farmers, amateur foragers, and hunters; hereafter

place-based knowledge holders¹) have developed and maintained mosaic landscapes comprising different ecosystems (Ellis and Ramankutty 2008, Ellis et al. 2021). These mosaic landscapes are of high cultural value. They are often characterized by absent or low chemical inputs but high levels of human attention (Agnoletti and Rotherham 2015, Levis et al. 2024), and at the same time that harbor high levels of biodiversity (Halada et al. 2011, Balée et al. 2020, Ingty 2021, Molnár et al. 2024). In light of this, there is a growing recognition of the need to appreciate and incorporate the roles of place-based knowledge holders and their stewardship practices in managing ecosystems and maintaining their health (Garnett et al. 2018, Artelle et al. 2019, Tardella et al. 2020, Heller et al. 2023). Stewardship practices (often named management practices), defined as “actions taken by individuals, groups or networks of actors, with various motivations and levels of capacity, to protect, care for or responsibly use the environment in pursuit of environmental and social outcomes in diverse social-ecological contexts” (Bennett et al. 2018; p. 597), offer invaluable insights for ethical and effective biodiversity conservation.

Stewardship practices span individuals and communities taking responsibility for maintaining and enhancing nature's contributions to people (Díaz et al. 2018, Díaz and Pascual 2025; hereafter nature's contributions) through voluntary actions of conservation, management, monitoring, advocacy for, and education about landscapes (Campbell et al. 2011, McLain et al. 2017). At the individual level, stewardship practices manifest personal attitudes and behavioural preferences (Lehnen et al. 2022); at the community level, they can materialize as customary guidelines or be embedded in cultural practices and customs (Loring 2022). They can have both positive and detrimental effects on different levels of ecological organization, and their contribution to

¹ The term "place-based knowledge holders" is used in this manuscript to inclusively refer to both Indigenous Peoples and local communities with a long-standing connection to specific lands and ecosystems. While the terminology is intended to encompass the diverse knowledge systems tied to these groups, it is important to acknowledge that the use of terms like "Indigenous Peoples" and "local communities" can be contentious. Some Indigenous groups object to the terminology that lumps them with settler communities. Additionally, exclusively focusing on Indigenous communities risks excluding Afrodescendant communities and other non-Indigenous groups that hold significant place-based knowledge and have longstanding ties to their environments. This terminology, therefore, should be understood as a broad and inclusive descriptor for any group that has longstanding connection to and knowledge about their landscapes. Each place-based knowledge holder belongs to a sociocultural group which we define using language as distinctive characteristic.

maintaining and enhancing ecosystems and species depends on multiple dimensions of stewardship (social, spiritual, and political). Stewardship practices are expressions of knowledge systems that are modulated by specific historical, social, cultural, linguistic, ecological, political, and economic contexts (Berkes et al. 2000), and can be grounded in intrinsic, instrumental, and relational values (Chan et al. 2016). In this sense, stewardship practices have to be understood as pluralistic, including diverse views and perspectives in different contexts. Guided by knowledge and regulated by place-based formal and informal guidelines and rules, these practices are manifestations of people's relationships with other components of nature aligned with cultural identity and diverse worldviews (Berkes et al. 1994, Maffi and Woodley 2010, Gavin et al. 2015).

Here, we present a classification framework for the biophysical dimension of stewardship practices to facilitate their integration into research and decision-making, where they remain largely underrepresented. We used the literature on classifications of stewardship practices to draft a classification that was then refined and illustrated by mobilizing a corpus of cultural keystone species literature (CKS; species that hold a high cultural value and significance; Garibaldi and Turner, 2004). The resulting synthesis highlights the widespread prevalence of stewardship practices for almost 1000 cultural keystone species worldwide, and their fundamental role in co-producing nature's contributions to people. Recognizing and incorporating stewardship practices and their knowledge holders into conservation efforts can enhance social-ecological resilience.

A classificatory framework of biophysical stewardship practices

As part of the growing recognition of the importance of stewardship practices, in the last two decades, scholars have developed various classifications for stewardship practices (Supplementary Information 1). For example, Ticktin (2004) classifies them differentiating between harvesting, management, and land use practices and describes the different impacts of these practices at genetic,

species, community, and ecosystem levels. Comberti et al. (2015) mimic the structure of ecosystem services classifications and differentiates practices according to four services to ecosystems (i.e., protection, enhancement, restoration, and support services). McLain et al. (2017) propose a two-dimensional classification of practices: those that maintain species or habitats and those that enhance them. Most literature distinguishes practices that are intended to maintain biodiversity from those practices that actively manage it to enhance some elements. Additionally, previous works have also identified and classified stewardship practices for specific taxa (e.g., palms; Bernal et al. 2011), groups of taxa (e.g., non-timber forest products; Ticktin 2004), ecosystems (e.g., rainforests; Comberti et al. 2015, Levis et al. 2018), or practices specific to social groups (e.g., urban foragers; McLain et al. 2017). While all these classifications partly overlap, they do not include the same practices or follow a consistent classification logic. This lack of reporting coherence in the literature hampers the clear identification and comparability of those practices and the understanding of their effects across scales.

Drawing on existing literature about environmental management practices and utilizing the literature on cultural keystone species as empirically-grounded examples, here we propose and illustrate a comprehensive and coherent classification to identify the biophysical dimension of stewardship in specific environments. We focus on the biophysical dimension as an entry point to unpack the tangible ways in which people steward, or have stewarded, specific elements of nature. Our approach proceeds in two steps. We first reviewed and synthesized previous classifications of stewardship practices (Box 1, Supplementary Information 1) to draft a classification that was then refined by comparing and complementing it with categories emerging from the CKS literature coded using an inductive approach. Once we had the final classification, we used it to categorize stewardship practices CKS dataset, which includes domesticated and wild animal, plant, and fungi species and associated sociocultural groups (Box 1, Supplementary Information 2). We also coded nature's

contributions to people mentioned in this corpus according to Díaz et al. 2018. We selected eight illustrative case studies worldwide to exemplify the stewardship practices carried out by some of the place-based knowledge holders we work with (see Figure 2, Table 1).

BOX 1 Methods

In February 2024, we performed a literature review to identify existing classifications of stewardship practices (12 articles; Supplementary Information 1). Fourteen documents were selected and screened to retain only those that included a classification of practices that people carry out to support species (n=12; Supplementary Information 1). Existing categories of stewardship practices, along with their classification structure (e.g., protecting, enhancing, restoring, supporting practices), focus (e.g., reciprocity), and labelling of practices (e.g., management practices) were extracted and grouped by similarity (e.g., watering, irrigating, drip irrigation) to come up with a first classification draft.

In parallel, we performed a second literature review for documents in English containing the wording "Cultural Keystone Species" in Web of Science, Scopus, and Google Scholar published before December 2023 (242 articles). From each article, we extracted (1) the name of the species and (2) the sociocultural group forming the CKS (when available), (3) species contributions to the sociocultural group, and (4) stewardship practices carried out by the sociocultural group. This approach is grounded on the concept of reciprocity (i.e., reciprocal contributions; Ojeda et al. 2022). Due to the cultural significance of CKS, its literature provides details about both nature's contributions and stewardship practices. To identify the stewardship practices, we did not look for specific keywords but we thoroughly read the articles identifying activities that expresses protection, care, or responsibility regarding the CKS, CKS-associated species, or the environment in which they live. We organized these data into two tables.

In the first table, we classified CKS contributions according to Díaz et al.²⁰. An “economic value” category was added to indicate when the CKS was traded or bartered for other goods as this appeared frequently in the literature and could be an important element for the associated sociocultural group but not explicitly classified as such in Díaz et al.²⁰. We then calculated how many times each CKS contribution was reported per continent.

In a second table, text describing stewardship practices was copied and coded using an inductive approach, defining categories according to practices repeatedly mentioned in the CKS literature. Each entry could receive several codes to cover the full range of practices documented. This resulted in over 90 codes that were subsequently homogenised (e.g., “transplantation”, “transporting and planting”, “translocation”, and “transplanting individuals” were all coded as “translocation”) and grouped into broader categories. For example, “selective harvest (based on seasonality)” and “selective harvest (based on phenological stage)” were all coded as “sparing individuals”.

Then, we compared the categories obtained through the scoping literature review of classifications stewardship practices (Supplementary Information 1) with the categories defined through this bottom-up approach. We fine-tuned our list of categories to build a classification that was comprehensive and coherent (Supplementary Information 2). Reporting these practices can be done with different levels of detail, leading to labels that can be nested into one another or cases of partial overlaps between labels. In developing our classification, we focused on identifying the actual practices rather than the motivations for doing them. For instance, instead “trait selection”, we coded “sparing individuals”, which is one of various practices to carry out trait selection. The stewardship practices and their groupings have been named as broadly as possible to allow for the classification to be used for plants, animals, fungi, and other species. This led to the identification of 19 stewardship

practices (Figure 1) that we then used to classify the full CKS corpus and further illustrate with eight qualitative case studies (Table 1, Supplementary Information 3). **END OF THE BOX**

We identified 19 types of stewardship practices across three levels of ecological organization to which these practices apply (Figure 1). Some practices address a target species (e.g., a CKS, but also other culturally important species), others address assemblages of species (community level, often including groups of species, including target and non-target species, but not always the whole community), and still others address whole ecosystems (where the target species lives). Although this classification focuses on biophysical stewardship practices, we acknowledge that these human actions towards nature span multiple dimensions, including spiritual ones.



Figure 1. Stewardship practices organised by the level of ecological organization they target (See Supplementary Information 2 for definitions and examples).

Stewardship practices are not mutually exclusive from one another. For example, irrigation and drainage practices contribute to creating micro-topography changes and influencing soil moisture, all resulting in changes in biodiversity composition. We recognized the importance of burning and classified it as a practice itself. Yet, fire is a tool that can be used to achieve several stewardship practices simultaneously (e.g., “maintaining or adding companion species” and “removing/disfavoring competing and predating species”). Stewardship practices aimed at specific components of nature, as for example target elements such as CKS, often ripple through trophic webs and across other ecological interactions, affecting multiple biotic and abiotic components. For example, ensuring and enhancing the reproduction of herring (*Clupea pallasii*, a CKS for Haida People in Canada) through the conservation of spawning grounds (maintaining or adding companion species) ensures food for salmon and seals (Thornton 2015). Similarly, controlled burning by Ma’dān People in Iraq to enhance the growth of reeds also maintains prairie habitats that support many other species (Al-mudaffar Fawzi et al. 2016). While stewardship practices are intentional to specific elements, unintentional effects on other elements of nature other than the focal ones are not rare. For example, in the Ecuadorian Amazon, the Waorani People mention that they “plant the forest” by selecting seeds of particular species and dispersing or sowing them into the forest. They also translocate seedlings in specific forest places where they know they can grow to provide food and attract animals for hunting (Montúfar *pers. obs.*). At the same time, during their long hunting trips, they carry with them cooked fruits of *Oenocarpus bataua* (*patawa*) or raw fruits of *Mauritia flexuosa* (*moriche* palm), whose seeds are then dispersed in the forest. Therefore, stewardship practices often affect wider social-ecological systems even when geared toward promoting a single species. These types of management are often invisible to academics (Denevan 1992, Molnár et al. 2023). The wider social-ecological system is reflected in the classification that we propose, where practices not only target culturally valuable species but their biotic and abiotic environments. Because of these

complementary levels of action, the classification can also be used when stewardship is directed to specific places rather than species (e.g., cultural keystone places; Cuerrier et al. 2015).

Given the diversity and complexity involved, classifications of stewardship practices are best understood as a working framework, not a rigid structure. Still, by focusing on the actual actions and the targeted levels of nature to which they are applied, classifying stewardship practices can facilitate dialogue between stewards and scientists focusing on biological conservation. Nonetheless, each stewardship practice may be intertwined with cultural, spiritual, psychological, social, educational, and political aspects. For instance, the CKS literature often reported the concept of "harvest only what you need and use it all" (e.g., Maxwell et al. 2018, Clapcott et al. 2018, Cram et al. 2022). While it does not represent a specific biophysical practice, the concept inherently limits the harvest amount for individual or community needs, and presumably does so without including commodification (i.e., harvest to trade). This seems related to foundational values (such as reciprocity) of many Indigenous Peoples and has important implications for the stewardship of nature (Kimmerer 2013).

Illustrating the stewardship practices classificatory framework: the example of the CKS literature

Cultural keystone species are often the target of stewardship practices (Lukawiecki 2024). CKS are defined as "culturally salient species that shape in a major way the cultural identity of a people, as reflected in the fundamental roles these species have in diet, materials, medicine, and/or spiritual practices" (Garibaldi and Turner 2004 p. 4). An important aspect of CKS is that the relations between people and CKS are reciprocal (Ojeda et al., 2022). That is, not only do CKS play important material, spiritual, or relational roles for people, but people steward CKS in return (Table 1; Nabhan and Carr 1994, Mattalia et al. 2024). For instance, reindeer (*Rangifer tarandus*) play a crucial role among the Saami People of Northern Scandinavia, exceeding the cultural salience of any other species Saami relate with (Mustonen 2022). Reindeer contribute to Saami livelihood and culture (e.g., food,

materials, etc.), who in turn care for reindeer (e.g., supplementary feeding and mobility for high-quality grazing), thus establishing relations of reciprocity (Markkula, Turunen, and Rasmus 2019). Similarly, in the Andes of southern South America, the seeds, adult individuals, and forest stands of the *pewen*, or the monkey-puzzle tree (*Araucaria araucana*) have key economic, ecological, social, and spiritual roles for the Mapuche-Pewenche Indigenous People (Ibarra et al. 2022). Thanks to Mapuche-Pewenche traditional practices of seed dispersal, planting seedlings, conserving the habitat, and engaging in political organisation to defend these trees, many *A. araucaria* forests continue to thrive in their ancestral lands (Ibarra et al. 2024). These acts of care and protection have influenced evolutionary and ecological processes in the forests of the southern Andes (Reis et al. 2014, Speziale et al. 2018, Cockle et al. 2019). In the CKS literature (242 articles), we found evidence for 343 reports of stewardship practices (in 90 articles) representing all 19 types of stewardship practices. Most stewardship practices concerned plants (46 plant species were targeted in 231 reports of stewardship practices), followed by animals (40 animal species were targeted in 109 reports of stewardship practices) and fungi (one species was targeted in three reports of stewardship practices). Sixty per cent of all stewardship practices were reported from North America, and among them burning represented 30% (n = 62; Figure 2). However, burning was little mentioned in other continents, with only five mentions in Oceania and two in Asia. Instead, sparing individuals (e.g., selective harvest) was the most salient stewardship practice in reports from all the other continents, accounting for 60% of the total in Oceania and 24% in Europe. The literature reported more than one stewardship practice per CKS (in 130 out of 206 CKS for which stewardship practices were documented at all). Stewardship practices were distributed across all the levels of our classification (respectively 138 at target species [population and meta-population] level, 133 at the community of species level, six at the ecosystem level).

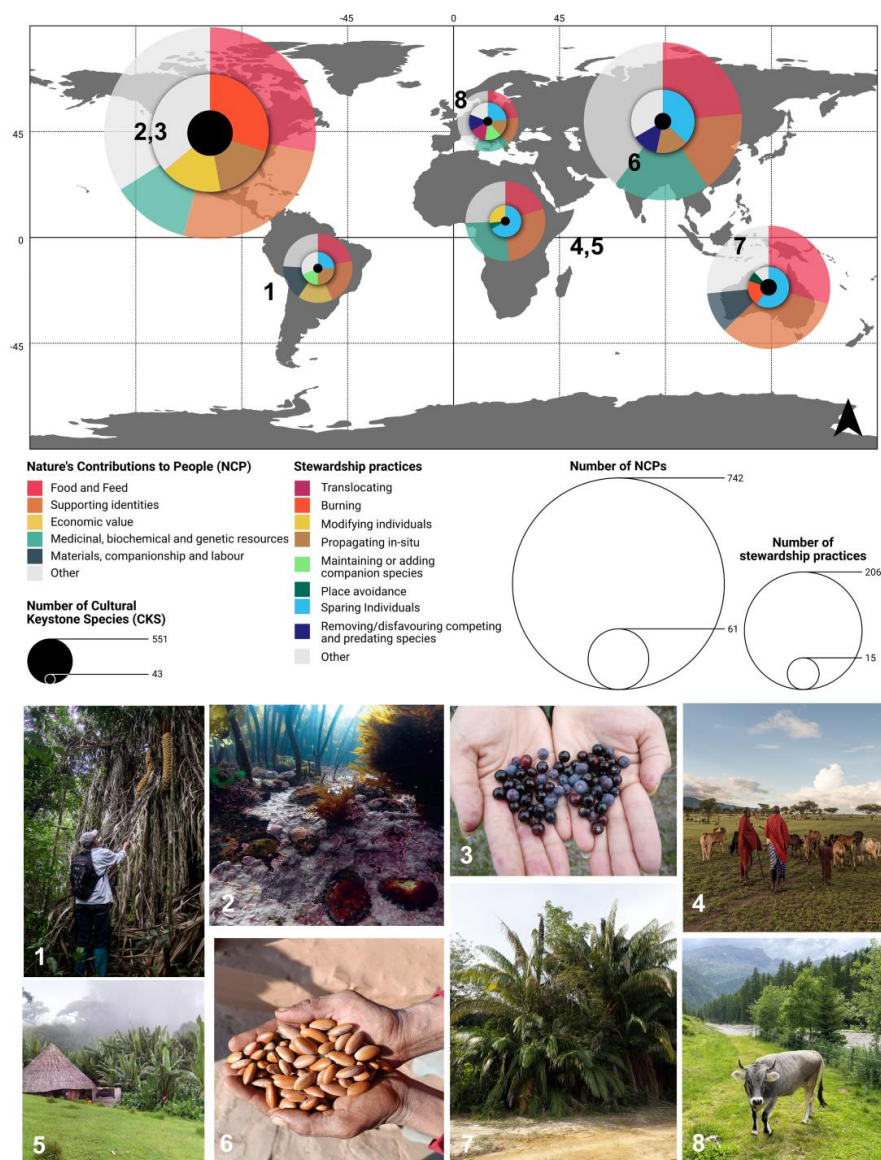


Figure 2. Number of CKS per continent (inner black circles) documented in this review. Number and proportion of nature's contributions (outer circles) and stewardship practices (middle circles). Largest and smallest numbers per continent are indicated as rounds in the bottom of the map. Figure made by Téo Barbetti. Out of 982 CKS reported in the English language literature (collected from 453 articles that mention the CKS concept and, more specifically, in the 242 articles that describe a specific CKS, see Box 1), we identified 1652 mentions of nature's contributions (177 articles; Figure 2). We found that the majority of nature's contributions concerned plants (182 species and 1099 nature's

contributions), followed by animals (104 species and 545 nature's contributions), and fungi (two species and eight nature's contributions). About 45% of the nature's contributions were documented in North America. The most reported nature's contributions was food and feed in Asia, Europe, and North and South America (representing 22 to 27% of all nature's contributions mentioned for these continents), while the most reported nature's contributions in Africa and Oceania was "supporting identities", and food and feed in South America (representing 22 to 34% of all nature's contributions in these continents). Other frequent nature's contributions are the provision of medicinal, biochemical, and genetic resources (especially in Africa, Asia, Europe, and North America) and materials, companionship, and labour (especially in Oceania and South America). Numbers (1-8) indicate the continent of the eight case studies summarized in table 1, illustrated below the map through a photo collage: (1) *Phytelephas aequatorialis* (Tagua) and Huancavilca People (Ecuador) © Gabriela Loayza. (2) *Haliotis kamtschatkana* (Northern abalone) and Haida People (Canada) ©Lynn Lee, Tll.aal, Haida Gwaii. (3) *Vaccinium membranaceum* (huckleberry) and Gitksan and Wet'suwet'en People (Canada) © Nancy Turner. (4) *Bos taurus* (cattle) and Maasai People (Kenya and Tanzania) © Tim Bruijninx - VSF. (5) *Ensete ventricosum* (enset) and Gurage and Sidama People (Ethiopia) © Zemedet Asfaw. (6) *Diploknema butyracea* (chiuri) and Chepang People (Nepal) © Yadav Uprety. (7) *Eugeissona utilis* (wild sago palm of Borneo) and Penan People (Malaysia and Indonesia) © F. Merlin Franco. (8) *Bos taurus* (cattle) and Walser People (Switzerland) © Giulia Mattalia.

Our synthesis indicates that the CKS literature more often documents nature's contributions to people than stewardship practices of people towards species. Only half of CKS articles that report nature's contributions also document stewardship practices. This could reflect the CKS definition proposed by Garibaldi and Turner (2004), which specifically focuses on nature's contributions, overlooking stewardship practices. Based on our collective decades of field experience, we have observed that stewardship practices are present when elements of nature are culturally or

individually valued and used (e.g., Table 1, Supplementary Information 3). However, these practices and other aspects of people-nature relations are not always investigated or reported. The academic underreporting of these practices may lie in a paradigm - the notion of wilderness - anchored in Eurocentric perspectives, increasingly criticized by some scholars, including Indigenous ones (Anderson 2005, Denevan 2011, Turner 2020, Ellis et al. 2021, Fletcher et al. 2021, McMichael et al. 2023). Indeed the “Western” positivistic epistemology promoted the idea of “command and control” grounded on the belief that elements of nature are either valuable to people or to the ecosystem but not both, in stark contrast with Indigenous holistic perspectives where elements of any social-ecological system are deeply interdependent (Loring 2020, Reid et al. 2021). The lack of reporting of stewardship practices is not easily identifiable because they are often found under various terms, which hampers literature searches. Another reason for this may be that much of the literature in social sciences and ethnography is written in languages other than English. While this can indicate cross-continental differences, this may also be due to reporting biases in the literature, as CKS documentation is much more abundant in North America (Figure 2; Mattalia et al. 2024).

Table 1 A summary of the eight case studies detailing the main stewardship practices, nature's contributions, and threats (further details in Supplementary Information 3).

CKS	Region	Key Stewardship Practices	Main nature's contributions	Main Threats

1. <i>Phytelephas aequatorialis</i> and Huancavilcas	Ecuador, South America	Sparing individuals, in-situ propagation, modifying individuals, removing/disfavouring competing and predating species, translocation	Supporting identity, food, medicine, income	Deforestation, overharvesting, market instability, knowledge erosion
2. <i>Haliotis kamtschatkana</i> and Haida	Canada, North America	Sparing individuals, translocating	Food, supporting identity	Overharvesting, poaching, climate change, limited rights
3. <i>Vaccinium</i> spp. And Gitksan, Wet'suwet'en,	Canada, North America	Burning, fertilizing, modifying individuals, translocating	Food, medicine, income, supporting identity	Climate change, herbicide use, colonial bans on burning

other First Nations				
4. <i>Bos</i> spp. and Maasai	Kenya/ Tanzania, Africa	Grazing, burning	Food, Income Physical and psychological experiences	Land privatization, sedentarization, climate change
5. <i>Ensete ventricosum</i> and Gurage, Sidama, Gedeo, others	Ethiopia, Africa	Sparing populations, fertilizing, translocation	Food, medicine, Physical and psychological experiences, supporting identity	Market changes, cultural erosion, gender role shifts
6. <i>Diploknema butyracea</i> and Chepang	Nepal, Asia	Sparing individuals, burning, in-situ propagation	Trade, supporting identity	Economic shifts, regeneration failure, market opportunity

8. <i>Bos taurus</i> and Walsers	Switzerland, Europe	Mowing and grazing, fertilizing	Food, Supporting identity	Depopulation, abandonment of practices
7. <i>Eugeissona utilis</i> and Penans	Malaysia, Southeast Asia	Sparing individuals, removing/disfa vouring competing and predating species,	Food, Supporting identity	Logging, social change, external pressures

Relevance of stewardship practices for global policy

The global impact of place-based knowledge holders' stewardship is yet to be fully understood. However, place-based knowledge holders are increasingly considered in international scientific and policy fora (Carmona et al. 2023). For example, the IPBES Thematic Assessment of the Sustainable Use of Wild Species acknowledges that biodiversity loss should be always addressed "while respecting the rights of Indigenous Peoples and local communities" (IPBES 2022), but does not acknowledge Indigenous and local stewardship practices that do contribute to managing and maintaining biodiversity. Stewardship practices are likely included in the "biodiversity-friendly practices" mentioned in KMGBF Target 10 and their consideration is necessary "for effective and equitable governance" (KMGBF Target 21). Stewardship practices are especially relevant to Target 9 (Manage

wild species sustainably to benefit people²) as many conventional colonial forms of conservation and sustainable use governance, such as some parks and protected areas or endangered species regulations, protect biodiversity but criminalize use and stewardship by place-based knowledge holders. Examples include cultural burning or the harvesting of plants and animals (Christianson et al. 2022). Another example are policies that restrict pastoral mobility, resulting in increased grazing pressure in specific localities, while mobile grazing *per se* is beneficial to many ecosystems (Manzano 2023). Many interactions between people and other components of nature are context-specific and therefore difficult to scale up and articulate to outsiders (Daniel et al. 2012, Sterling et al. 2017, Díaz et al. 2018, Ibarra et al. 2023). Transdisciplinary theoretical frameworks used to inform policy-making, to which the classification of stewardship practices presented here can be integrated, offer an opportunity to articulate the various visions of people-nature relations (Díaz et al. 2015, Hill et al. 2021, Díaz and Pascual 2025).

Stewardship practices and their effects on both nature and human quality of life can be interpreted using the IPBES conceptual framework (Díaz et al. 2018, Díaz et al. 2015), itself emerging from a transdisciplinary process. Stewardship practices contribute to co-producing nature's contributions and can also be interpreted as direct anthropogenic drivers that influence nature (Díaz and Pascual 2025). An emphasis on stewardship would create meeting points between instrumental and relational-oriented conservation strategies for more effective biodiversity conservation (Mulyoutami et al. 2023). Hence, policies should carefully and holistically interpret these practices with the people performing them, as their beneficial or detrimental impact will not only depend on the governance and the value system of the people implementing them (see IPBES conceptual framework (Díaz et al.

² *TARGET 9: Ensure that the management and use of wild species are sustainable, thereby providing social, economic and environmental benefits for people, especially those in vulnerable situations and those most dependent on biodiversity, including through sustainable biodiversity-based activities, products and services that enhance biodiversity, and protecting and encouraging customary sustainable use by indigenous peoples and local communities.*

2015)) but also on the value systems assessing them (IPBES 2022). Benefits from stewardship may be perceived and evaluated differently by place-based knowledge holders, scientists, and managers (Reo et al. 2017, Moore et al. 2024, Menzies 2024, Bell et al. 2025). Identifying and incorporating multiple values into policymaking, as argued by the KMGBF, provides leverage for transformative change toward just and sustainable futures (IPBES 2024). The classification framework presented here can contribute to transdisciplinary research approaches by offering a tool to analyze whether, when, how, and why stewardship practices are beneficial to people and nature.

Our article sheds light on the ubiquitous contributions of place-based knowledge holders that through stewardship practices offer the opportunity to connect biodiversity conservation and nature's contributions to people. However, to realize this potential and thus, integrate stewardship practices into conservation policy and practice, a better systemic understanding was missing (Ibarra et al. 2023). Here we developed a framework for stewardship practices and applied it to a corpus of literature on cultural keystone species. Our synthesis indicates an unbalance in researchers' focus on the reciprocal relation, with a stronger focus on nature's contributions to people, and much less attention posed to stewardship practices. Integrating stewardship practices into biodiversity conservation research and practice would facilitate consideration biodiversity stewards along with biodiversity itself.

Acknowledgements

GM acknowledges funding from the Margarita Salas grant MGSC2022-13; SD Red Federal de Alto Impacto CONATURAR (CONVE2023-102072649-APN-MCT), Argentina, and the Oxford Martin School, Oxford University, UK; JTI and JC thank ANID/FONDECYT Regular 1240070, CIIR

(ANID/FONDAP/15110006), CAPES (ANID PIA/BASAL AFB240003), and CHIC (ANID PIA/BASAL PFB210018); NCB was supported by the Social Science and Humanities Research Council of Canada, the Natural Sciences and Engineering Research Council of Canada, and the University of Victoria; YU received support from the UGC-IOST start-up grant at Tribhuvan University; I.T.T. has received financial support from the IRD ANR-CPJ contract number 402299/00 and from the French government under the France 2030 investment plan, as part of the Initiative d'Excellence d'Aix-Marseille Université – A*MIDEX (AMX-22-CPJ-05). This work contributes to ICTA-UAB “María de Maeztu” Programme for Units of Excellence of the Spanish Ministry of Science and Innovation (CEX2024-001506-M funded by MICIU/AEI /10.13039/501100011033).

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