



Research

Biocultural diversity: a Mongolian case study

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ABSTRACT. Although conceptual frameworks describing biodiversity and cultural keystone species have been widely accepted over the past 15 years, there remains a need for an overarching framework that covers the various components of biocultural diversity. We present a conceptual framework to enable the better understanding, monitoring, and maintenance of biocultural diversity across a range of spatial scales, from the landscape and ecosystem level to the species and gene/meme level. This is done by combining the concepts of biological diversity and cultural diversity, including cultural values and symbols, ethnoscientific approaches, as well as power relations and institutions, to form a biocultural diversity framework. To illustrate the framework, we use a systems diagram and practical examples from a case study on the ethnoveterinary knowledge and practices of Mongolian pastoralists. Ethnoveterinary knowledge is an example of traditional ecological knowledge and therefore offers valuable insight into biocultural diversity. Using the conceptual framework as a tool, our investigation of biocultural diversity in the Mongolian pastoralist context strongly suggests that an understanding of the historical, political, and cultural contexts, as well as the interrelatedness of cultural processes and ecological systems, is essential for maintaining biocultural diversity. More specifically, our results indicate that retaining a mobile herding way of life as well as the associated balance and communication with nature, is vital for both the continued transmission of ethnoveterinary knowledge and the sustainable use of ecological resources that Mongolian pastoralists rely on. There is a need for national policies that acknowledge, support, and maintain the important and complex processes underlying the Mongolian landscape and the associated worldviews, knowledge, and practices. The development of a coherent framework for biocultural diversity therefore allows for a clearer understanding of the various components and the selection of appropriate indicators for monitoring biocultural diversity.

Key Words: *biocultural diversity; cultural keystone species; ethnoveterinary knowledge; Mongolia; pastoralists*

INTRODUCTION

The relationship between human culture and nature, and the connections between cultural and biological diversity, are encapsulated in the term “biocultural diversity” (Maffi and Woodley 2010). This is defined by Loh and Harmon (2005:231-232) as “the sum total of the world’s differences, no matter what their origin. It includes biological diversity at all its levels, from genes to populations to species to ecosystems; cultural diversity in all its manifestations ..., ranging from individual ideas to entire cultures; and, importantly, the interactions among all of these.” Notably, the consolidation of biological diversity and cultural diversity into a single concept reflects the development of social-ecological science, and echoes the worldview of many cultures, where people and nature are viewed not as separate entities, but as an interconnected whole (Berkes 1999). This interconnected “whole” can be viewed as a system with emergent properties that are not necessarily evident when parts are viewed in isolation.

The links between biological and cultural diversity are increasingly recognized as important constituents of social-ecological systems (Sutherland 2003, Loh and Harmon 2005, Maffi and Woodley 2010, Agnoletti and Rotherham 2015). Consequently, in 2010, the Convention on Biological Diversity (CBD) and the United Nations Educational, Scientific and Cultural Organization (UNESCO), launched a “Joint Programme on the Links between Biological and Cultural Diversity” (Agnoletti and Rotherham 2015). The interconnectedness between biological and cultural diversity also forms a fundamental ethos of the IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services) framing (Díaz et al. 2015). Important issues concerning biocultural research activities were

addressed in the “Florence Declaration” (UNESCO and SCBD 2014) and include, among others, indications that landscapes (including seascapes) rich in biocultural diversity are often those managed by traditional pastoralists, peasant farmers, and small-scale fishermen.

As traditional pastoralists, Mongolian herders actualize a social-ecological system that represents a working example of biocultural diversity. For centuries they have lived in close connection with their livestock and the steppe ecosystem they inhabit, with a worldview that includes themselves, their livestock, and the landscape they live in as a strongly interrelated unit (Humphrey et al. 1993). Because landscapes are products of both biological and cultural processes (Taylor 2009), understanding cultural knowledge and practices associated with a particular place is crucial for the conservation of both cultural and biological diversity associated with that specific landscape, eloquently encapsulated by Cuerrier et al. (2015) in the term “cultural keystone places.” For example, in a case study of the Dongba culture among the Naxi in Yunnan Province, China, Geng et al. (2017) found that understanding symbolic plant use and places of ritual potency can help to better understand both communities and the conservation of natural resources. Interactive, cross-cultural approaches to conservation that include a focus on indigenous knowledge and cultural values thus contribute to conserving both biodiversity and traditional knowledge associated with biodiversity (Xu et al. 2005).

Ethnoveterinary knowledge and practices can be described as a form of traditional ecological knowledge (TEK) and in this study, as in Berkes (1999:6), TEK is used in the same way that aboriginal people from the Canadian North refer to their “knowledge of the

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land.” This dynamic body of knowledge, practices, and beliefs about the relationships between living beings and their environment is a characteristic of societies that have for generations been dependent on resource use of specific lands (Berkes 1999), such as the Mongolian pastoralists. In addition, ethnoveterinary knowledge is embedded in a complex social-ecological system and is built upon specific cultural beliefs, customs, traditions, as well as the relationship of herders to the land and to their animals, and therefore, contains both cultural and biological elements (Wanzala et al. 2005).

Within the Mongolian pastoralist context, we use a study on the ethnoveterinary knowledge of Mongolian herders (Seele 2017) as a case study to identify and better understand the components of biocultural diversity, and to illustrate how this information contributed to the development of a two-part conceptual framework for biocultural diversity. We refer to ethnoveterinary knowledge and practice as a living example of TEK that connects biological and cultural diversity, and includes the use of medicinal plants, fungi, and remedies of mineral and animal origin (Seele 2017), as well as specific herding techniques that are closely linked to ecological markers (Fernández-Giménez 2000). The TEK of Mongolian herders has been the focal point of various studies, including herders’ observations of rangeland change (Bruegger et al. 2014), herders’ perceptions of climate change (Marin 2010), perceptions of vegetation threshold changes caused by grazing (Kakinuma et al. 2008, 2014), and pastoralists’ ecological knowledge in rangeland management (Fernández-Giménez 2000). To date, however, no other studies have focused on the ethnoveterinary knowledge of Mongolian herders as a form of TEK. Using this knowledge as a starting point, we suggest that the Mongolian pastoralist social-ecological system offers a real-world example of the importance of understanding biocultural diversity. As Reading et al. (2006:2) pointed out, “adequately conserving Mongolia’s rangelands requires a sound understanding of the ecological, social and cultural context and values of these rangelands.”

The Mongolian context

Mongolia’s vast grasslands represent one of the largest contiguous rangelands in the world (World Bank 2003). Roughly a quarter of Mongolia’s 3 million inhabitants are pastoralists, caring for a total of 66 million head of livestock (FAOSTAT 2017, National Statistics Office of Mongolia 2018). In terms of formal conservation, two Worldwide Fund for Nature (WWF) Global Ecoregions lie partly within Mongolia’s borders (Reading et al. 2006), and as of 2002, Mongolia’s protected areas cover 13% of the country’s land surface, or 20.68 million hectares.

The characteristic Steppe rangelands, together with the biodiversity they support, are central to livestock health and therefore, herder livelihoods. A long history of pastoralism together with a low human population density and strong cultural connections to the land, are some of the reasons that Mongolia has the capability to maintain its biodiversity (Reading et al. 2006). Many Mongolian herders still follow a nomadic or seminomadic lifestyle, largely influenced by the quality and availability of natural pastureland, water sources, and family ties. Ethnoveterinary medicinal (EVM) plants are harvested in the wild by herders and their families, mostly during the autumn months,

dried in their felt homes (*gers*), and stored for use during the harsh winter and spring months.

Mongolian pastoralists have a wealth of traditional ecological knowledge on rangeland management (Fernández-Giménez 2000) as well as ethnoveterinary practices and beliefs (Seele 2017). As Berkes (1999) points out, damage is done when traditional ecological knowledge is separated from its cultural and historical context. *Baigal*, the Mongolian term for nature, is closely related to *baidal*, “the way things are” or a “state of being” and includes animals, plants, the landscape, weather, human existence, and the ways in which they affect each other (Humphrey et al. 1993, Humphrey and Sneath 1999:2). Reciprocity applies to human-animal and human-landscape relationships (Humphrey et al. 1993). For example, herders believe that if they treat other beings and the landscape around them with respect, their extended family will remain strong and healthy (Fijn 2011), however, if harmed, nature could retaliate (Humphrey et al. 1993, Charlier 2015).

During the Soviet era in Mongolia (1920s–1980s), traditions and spiritual norms regarding interactions with nature were suppressed (Bawden 1986, as cited in Upton 2010), and a more scientific, state-led nature conservation approach was implemented based on species identification and enumeration (Reading et al. 2006). Since the end of the Soviet era, conservation programs and practices were largely influenced by donor agencies, e.g., WWF, United Nations Development Program (UNDP), and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), together with the adoption of key global conventions such as the Convention of Biological Diversity and the passing of new environmental legislation in Mongolia (Mearns 2004, Upton 2010). Recently, however, Western conservation structures and programs have become more community-orientated, often driven by sustainable livelihood approaches or community-based conservation efforts (Fernández-Giménez et al. 2015, Ulambayar et al. 2017). Interestingly, there has also been a re-emergence of spiritual beliefs as the foundation for interactions with nature (Upton 2010).

METHODS

Within the context of the Mongolian pastoralist social-ecological system, we used a conceptual framework that describes the different components of biocultural diversity and facilitates the better understanding, monitoring, and maintenance of biocultural diversity across a range of spatial scales. This two-part framework represents both biological and cultural diversity. Biological diversity is represented using the framework developed by Noss (1990) that reflects structural, functional, and compositional components of biodiversity and follows a nested hierarchical approach (Franklin et al. 1981, Noss 1990). Because there was no parallel and convenient way to investigate cultural diversity, we used Noss’s (1990) conceptual figure for biodiversity as a departure point from which to develop a framework for cultural diversity. This represents three major components of cultural diversity that also influence biocultural diversity, namely cultural values and symbols, ethnoscientific approaches, and power relations and institutions. Following Noss’s (1990) hierarchical structure, these are presented along four levels of organization. In combination, the figures for biodiversity and cultural diversity provide a new framing to assist with the investigation of biocultural diversity.

To illustrate the conceptual framework, we populated both parts (representing biodiversity and cultural diversity) with practical examples from the Mongolian pastoralist context and used these to illustrate the connection between both halves of the framework through a systems diagram. Examples were sourced from the literature pertaining to traditional ecological knowledge and practices of Mongolian herders, notably *Wolf Totem* (Rong 2009), and from a recent study on the ethnoveterinary knowledge of Mongolian herders (Seele 2017). Observations of culturally significant sites at different spatial scales from the landscape level to the microscale within people's homes (Fig. 1) were recorded during the course of this two year MSc research study, four months of which was spent in Mongolia.

Fig. 1. Continuity and change in the Mongolian pastoralist context: Culturally significant sites at different spatial scales (from the landscape level to the microscale within people's homes [*gers*]) reflecting biocultural change. (A) the location of the ger homestead is carefully chosen according to livestock needs and cultural significance; (B) changes to a more sedentary lifestyle can affect cultural traditions, for example, limiting access to culturally significant sites; (C) certain landscape features, such as lakes, hold both cultural and livelihood significance; (D) an *ovoo* (rock cairn) signifies a landmark of cultural value; traditionally shrines are also built in more remote locations of ritual or mythical value, such as secret valleys and forests, but are not shown here because of cultural sensitivities; and (E) the inner ger architecture and arrangement holds cultural significance. Photo credits: A, C: B. Seele; B, D, E: H. Wiese.



Preliminary field work was done in the autumn of 2014 to establish research contacts and to pretest methods. This was followed by an intensive field study in the north-central part of Mongolia during the summer and autumn of 2015. Data for the field study were collected using a mixed methods approach that included participant observation, semistructured interviews with open- and closed-ended questions, as well as personal observations and reflections recorded on detailed observation schedules. Insights were also acquired through informal discussions, journeying on horseback, and staying with herder families.

To explore ethnoveterinary knowledge and the concept of biocultural diversity, interviews were conducted with 22 men and 26 women, representing 48 herder family units. The average age of respondents was 52 years (range: 27 to 78 years), with an average of 33 years of herding experience. During the data gathering months, most herders were located in the summer pastures of their migratory cycle, with a few being in special pre-*Naadam* (traditional festival in Mongolia centered on horse racing) grazing areas. With regard to seasonal migration patterns, 81% of respondent families ($n = 39$) moved two or more times per year, whilst 15% ($n = 7$) of families interviewed had stopped seasonal migrations and followed a sedentary pastoralist lifestyle.

Upon meeting the families, cultural formalities were observed (as recorded in Sternberg 2008), followed by introductions by a local interpreter and/or horse guide. Background to the project was given, together with a subject information sheet (written in Mongolian) explaining the study aims and objectives. A copy of this information sheet was given to respondents as a reference of their consent and to allow them to contact the researcher should they so wish. Interviews were conducted in Mongolian, with the help of a local interpreter, if and after prior informed consent was given. Likewise, audio recordings (35) and photographs of the interviews were only taken if consent was given. Ethical clearance for this research project was obtained from Stellenbosch University (DESC/Seele/Feb2015/1) and the National University of Mongolia (17132015-17).

During the interview, specific open-ended questions were asked that were developed to gain an understanding of herders' perceptions of the threats to medicinal plants, the dynamics and transfer of medicinal plant knowledge, and the perceived threats to the continuation of this knowledge (see Appendix 1). These questions were designed to explore the possible links and common influencing factors between biodiversity and cultural diversity within the Mongolian pastoralist context.

Being aware of research context and the possible influence of positionality of power forms a foundation for conducting good social-ecological-systems research (Shackeroff and Campbell 2007). Prior to the MSc study, the lead author participated in the Mongol derby (a 1000 km self-supported endurance horse-ride); this in combination with a personal background in livestock farming helped to gain an understanding of the pastoralist research context. In addition, conducting fieldwork on horseback as a means of travel between interviews, working together with local interpreters and guides, together with using a fieldwork journal and daily observation schedules, allowed for a deeper understanding of the research context.

Both men and women were interviewed and the research team comprised both men and women. The experience of using first female, then male interpreters, allowed insight into gender-related knowledge and gender differences in the particular Mongolian context. In designing and implementing more inclusive, gender-neutral research, Pfeiffer and Butz (2005) suggest using a mixed-gender team because this lessens the likelihood of experiencing cultural restrictions in data gathering. As in many pastoralist societies, the Mongolian women of herder families have many roles and duties to fulfil from preparing food and medicinal plants for the colder months and looking after children, to preparing daily meals, milking the animals, and seeing to sick livestock. To consider the busy lives of women in a patriarchal society, interviews held with women were mainly conducted in the ger whilst cooking and preparing food, whereas interviews with men were often conducted outside the ger.

Because livestock herding is done mainly by men and young children, men have wider access to grazing lands, forests, hard-to-access mountainous areas, and other sacred sites where medicinal plants grow and are harvested, than women whose daily roles are more home-based. However, women are directly involved with the use of medicinal plants, as they are responsible for sick animals. Treatment occurs close to the ger, especially in winter where herds are kept close to the homestead. In addition, because most medicinal plants are dried and stored for later use, women are directly involved with the preparation and storage of the plants. Although interviews, participant observations, and informal discussions gave valuable insight into the ethnoveterinary knowledge held by women, only two interviews were held where only women were present (respondent and research team) and it is possible that sensitive topics were not mentioned and that the full wealth of knowledge held by Mongolian herder women was not recorded. We therefore refrain from analyzing the ethnoveterinary data gathered in terms of gender. We acknowledge that our findings reflect the respondents involved with this study, and cannot be extrapolated to the entire Mongolian nomadic pastoralist society and culture. It should also be remembered that gender roles, expectations, and taboos, as with any cultural realm, are dynamic and constantly changing because of internal and external influences.

Several methods were used to balance the position of power between researcher and respondents. These included arriving at interviews on horseback, participating in culturally important activities such as tea ceremonies, eating meat (even though the primary researcher had been a vegetarian for over 20 years), and by beginning discussions about ethnoveterinary medicinal plants with a free listing opportunity. This was done to allow respondents to feel more at ease with a more balanced position of power. Because of the primary researcher's background and interest in horses, a certain bias toward interviewing herders that were known for their horses and horse-care could have been present, although the use of snowball sampling may have reduced this. Although bias cannot be completely eliminated, measures were taken to counteract and reduce bias, including the taking of three separate trips to Mongolia, living in Mongolia for four months, the lead author being personally involved in all aspects of the field study, and discussions (both formal and informal) with various members of the community, academics residing in Mongolia (both foreigners and locals), and with boundary organizations.

In addition, following an approach from the social sciences, written reflections were used to reflexively question and explore various experiences from the field study, recognizing limitations and areas for improvement (Seele 2017). Despite these methods and approaches, we acknowledge that with the primary researcher being a woman and a foreigner participating in Western research on indigenous knowledge in a patriarchal system, certain gender-related nuances may have been at play that we were unaware of and certain imbalances of power were inevitably present. A critical review of all methods and methodology used for the field study, as well as a more detailed discussion of the importance of understanding the research- and gender-related context can be found in Appendix 2 and in Seele (2017:67-68,74-76).

Interview data were analyzed using the qualitative data analysis software package Atlas.ti (v. 7.5.15). Interviews were transcribed and imported into the package, and quotations from answers were iteratively coded using an inductive or open-coding approach based in grounded theory (Glaser and Strauss 1968). This allowed for a better understanding of herders' perceptions of medicinal plants and gave insight into the transmission and dynamics of medicinal plant knowledge. Codes were arranged into broader family codes and further analyzed according to major concepts or themes that emerged. The co-occurrence of codes within quotations (certain responses can be assigned to more than one code) was then investigated in order to gain an understanding of the connections and associations between codes (Hopping et al. 2016). For example, "We should educate everyone about how to communicate with nature," falls under the codes of "education" and "connection with nature," and indicates a possible relationship between the two codes. The co-occurrence of codes across the broader themes of "medicinal plants" and "medicinal plant knowledge" was used to investigate the links between biological and cultural diversity that contribute to a more integrative concept of biocultural diversity and therefore, to our conceptual framework.

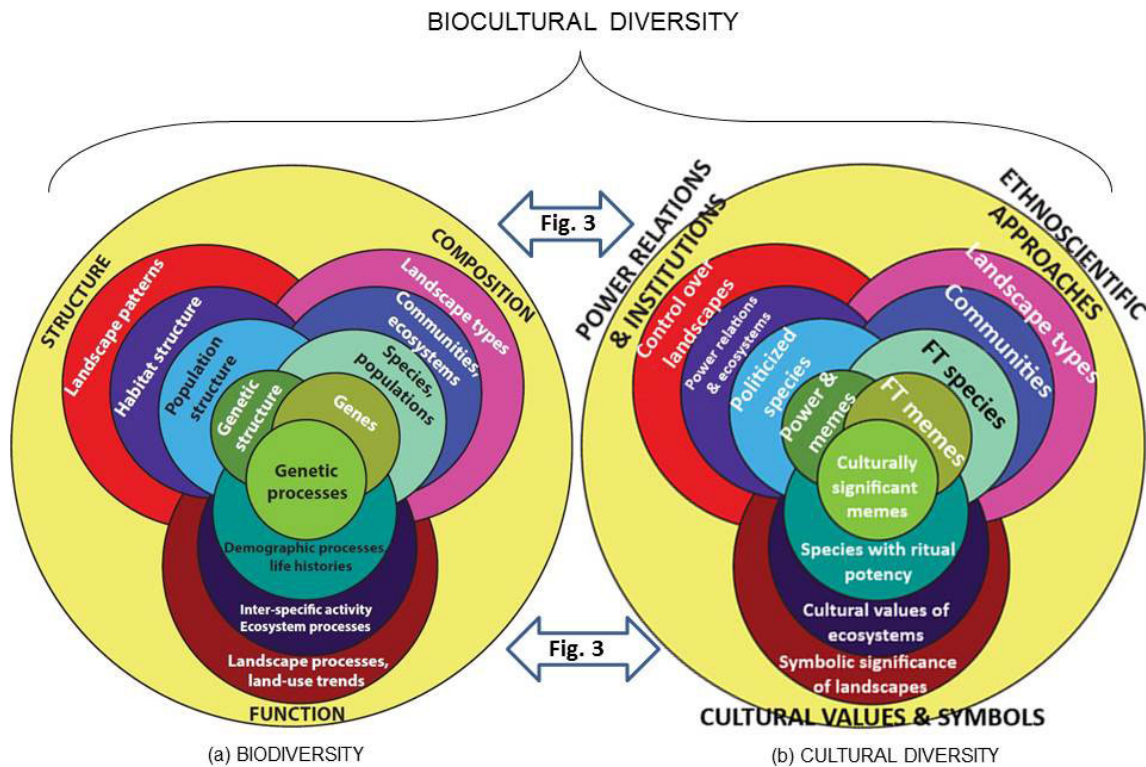
Although interview data reflects perspectives, qualitative rigor for the analysis of interview data was ensured by pretesting interview methods during preliminary fieldwork, having interviews conducted through an interpreter, and having audio recordings transcribed and translated by an official translation company (with a signed confidentiality agreement) to account for interpreter bias. Within our framework, we link interview data with relevant literature on ecology and the TEK of Mongolian pastoralists by using a systems diagram to illustrate the links between biological diversity and cultural diversity.

RESULTS

Biocultural diversity framework

To make biocultural diversity a more practical and workable concept, we developed a two-part, interrelated conceptual framework for biocultural diversity (Fig. 2). This consists of the biodiversity framework by Noss (1990) (Fig. 2a) and a cultural diversity framework (Fig. 2b). Whereas the biodiversity component represents the compositional, structural, and functional aspects of biodiversity along a scale of organization levels (Noss 1990), the equivalent cultural diversity component represents the cultural (shared cultural values and symbols), social (ethnoscience), and political aspects (power relations and

Fig. 2. A conceptual framework for biocultural diversity, consisting of (a) a biodiversity component (Noss 1990), and (b) a cultural diversity component, indicating cultural values and symbols, ethnoscientific approaches (including folk taxonomy [FT]), and power relations and institutions that influence biocultural diversity as interrelated spheres along four levels of organization. The links between the two spheres are presented in Figure 2.



institutions) of cultural diversity. These three aspects not only influence cultural diversity, but also influence biocultural diversity as a whole. The two components of the framework are interlinked and together form an interwoven concept for understanding biocultural diversity along various levels of organization.

The genetic level of organization (Noss 1990) has been adapted to incorporate meme theory as described by Dawkins (1976). In doing so, we concur with Burman (2012) that the meaning of “memes” has been misunderstood and has shifted over time. In this paper, we follow Dawkins (1976:192) definition of a meme as a “unit of cultural transmission” because this is a useful analogy to illustrate the parallels between the transmission of cultural information versus genes. Using language and customs as examples of cultural evolution, Dawkins (1976) suggests that coadapted meme-complexes evolve in a similar way as coadapted gene-complexes. In the same sense, Drout (2006) describes traditions as a combination of several smaller memes and describes memes as atoms and their combinations as molecules of culture.

The two-part interlinked framework is further explained and anchored by populating it with examples from the Mongolian pastoralist case study (Seele 2017). Examples of factors that affect terrestrial biodiversity in the Mongolian context are presented at

four levels of organization, from regional landscape and ecosystem-community to population-species and genetic levels (Noss 1990; Table 1). To better understand the influence of cultural elements on biocultural diversity, Mongolian examples of ethnoscience, cultural values and symbols, and political factors that influence biocultural diversity are presented along similar levels of organization: regional landscape, ecosystem, species, and meme-levels (Noss 1990; Table 2). Visual examples of the various dimensions of change and influence on biocultural diversity are depicted in Fig. 3, taken from a study on the ethnoveterinary knowledge of Mongolian herders (Seele 2017).

Links between biodiversity and cultural diversity

The connections between biodiversity and cultural diversity were visualized using a systems diagram where the relationships between the two components of biocultural diversity are graphically illustrated using the Mongolian pastoralist context (Fig. 4). Existing literature on ecology and the TEK of pastoralists in Mongolia, as well as interview data from the case study were used to develop the systems diagram. Pastoralists’ responses to four specifically designed open-ended questions on ethnoveterinary medicinal plant use and ethnoveterinary knowledge (Appendix 1) were iteratively coded using inductive codes that emerged from the data. Codes were grouped under two general themes: “Medicinal plants” and “Medicinal plant knowledge.” These were broadly viewed as examples of biodiversity and cultural diversity,

Table 1. Examples of factors that influence biodiversity in the Mongolian pastoralist context, using compositional, structural, and functional elements of biodiversity along four levels of organization, based on the conceptual framework for biodiversity developed by Noss (1990).

	Composition	Structure	Function	Inventory and monitoring tools
Regional landscape	Ecoregions of Mongolia: high mountains, taiga, forest steppe, steppe, desert-steppe, and desert (Marin 2010). Grasslands cover 80% of Mongolia (Reading et al. 2006). Approximately 3000 vascular plant species (Nyambayar et al. 2011).	Mongolian steppe: one of largest contiguous grasslands in the world (World Bank 2003). Habitat loss and fragmentation by anthropogenic factors, e.g., mining (Ito et al. 2013). Patterns of pastoral land use have changed (Sneath 2003). Seasonal and <i>otor</i> (short) rotation of livestock and herder families determined by water sources and grazing quality.	Sixty-six million livestock graze Mongolian rangelands (National Statistics Office of Mongolia 2018). Seasonal rotation, with reserve pastures set aside for spring and winter. Grazing exerts relatively smaller influence on vegetation than high interannual precipitation variability in southern Mongolia (Stumpp et al. 2005). Regional climate change predictions: increase in frequency of extreme events, e.g., <i>dzud</i> (harsh winter conditions where animals cannot forage) and in area affected by drought (Assessments of Impacts and Adaptations to Climate Change 2006, as cited in Marin 2010). Declining mobility could lead to overgrazing and a decline in pasture quality (Sternberg 2008). Levels of grazing vary geographically, higher around settlements and lower in dryer region. Wells have run dry/not maintained (Stumpp et al. 2005). Livestock numbers have increased since decollectivization.	Occurrence of drought and <i>dzud</i> . Ease of mobility. Distance and frequency of seasonal moves. Aerial photographs. Interpretation of repeat photography (e.g., Hoffman and Rohde 2007). Climate data. Remote sensing and GIS.
Ecosystem/ community	Important ethnoveterinary ecoregions: inland salt lakes, forests, mountains. Ethnoveterinary medicinal (EVM) plants often collected in forests and mountain areas, but also occur in grasslands. More than 150 endemic vascular plant species in Mongolia, 200 subendemics; 148 of ~3000 vascular plants are on the IUCN Red List (Nyambayar et al. 2011).	Threat that good soils (where medicinal plants grow) will be used for agriculture. Increase in fencing of winter pastures and haymaking may threaten medicinal plants. Water availability: Soviet era water wells, many in need of repair (Tanaka et al. 2005). Snow cover extensive over winter months.	Life history of EVM plants. Flowering phenology. Possible effect of EVM harvest on fertility, growth rate and population fluctuation?	Aerial photographs, remote sensing, vegetation mapping, GIS, orthographic images, livestock data. Interpretation of repeat photography (e.g., Hoffman and Rohde 2007). Species cover percentage and grazing activity (Stumpp et al. 2005).
Population/ species	Specific medicinal plants and remedies of animal origin used for EVM. E.g., <i>Paemonia anomala</i> L. listed as vulnerable in the Mongolian Red List of plants (Nyambayar et al. 2011). Different livestock species are herded: cattle, goats, sheep, horses, camels.	Various EVM plant parts are used: leaves, flowers/inflorescence, root/ bulb, and/or bark. Possible effect of EVM harvest on dispersion. Seasonal wild harvest of EVM plants mainly in autumn. Morphological variability of herd animals.	Life history of EVM plants. Flowering phenology. Possible effect of EVM harvest on fertility, growth rate and population fluctuation?	Medicinal plant market data. Interviews with medicinal plant users. Population observations and counts. Livestock census.
Genetic	Local Mongolian breeds of livestock. Mongolian and Russian yak populations should be considered as distinct genetic entities for conservation and breeding purposes (Xuebin et al. 2005). Presence of rare alleles, e.g., alleles unique to <i>Equus przewalskii</i> (Breen et al. 1994). Genetic profiles of <i>Artemisia frigida</i> found to differ between different environments, with drier environments showing the highest genetic diversity (Liu et al. 2012). Quality and quantity of essential oil from <i>Artemisia gmelinii</i> varies with genetic makeup of taxa and prevalent environmental factors (Haider et al. 2012).	Effective population size: e.g., Mongolian Bactrian Camel (<i>Camelus bactrianus</i>) populations have severely reduced over last 20 years, threat of reduced genetic variability that could affect adaptive potential (Chuluunbat et al. 2014). Heterozygosity: e.g., crossing cattle with yak: F1 hybrid male is sterile, F1 hybrid female is sterile (Tumennasan et al. 1997).	Rate of genetic drift, gene flow: e.g., domesticated and Przewalski's horses split ~45,000 years ago, but remained connected by gene flow thereafter (Der Sarkissian et al. 2015). Female mediated gene-flow among Argali sheep (<i>Ovis ammon</i>) populations in Mongolia (Tserenbataa et al. 2004). Gene flow between populations of <i>Artemisia frigida</i> (Liu et al. 2012).	Genetic analyses, DNA sequencing, morphological analysis.

respectively. The co-occurrence of codes across these themes suggests possible links between the themes (Foster et al. 2007). Six similar codes occurred across both themes of medicinal plant conservation and ethnoveterinary knowledge: nature connection/ balance with nature, loss of knowledge around correct harvesting of plants, education (of children and herders), political support, research/recording and sharing knowledge, and mobility/keeping herding traditions and practices alive (Table 3). This co-occurrence of codes across the two general themes representing biological and cultural diversity suggests common links between these concepts and indicates the relatedness of these two concepts

within the unified concept of biocultural diversity (Pretty et al. 2009, Hopping et al. 2016).

DISCUSSION

Biological diversity is crucial to ecosystem health because it increases ecological resilience to disturbance and often buffers against environmental shocks and stresses (Gadgil et al. 1993, Peterson et al. 1998, Folke et al. 2004, Stolton et al. 2008). Similarly, cultural diversity is central to the health of a social system because it has the capacity to increase the resilience and adaptability of the system (Gunderson et al. 2002, Berkes and Turner 2006, Dudgeon 2008, Pretty et al. 2008). Together,

Fig. 3. Examples of biocultural diversity and change in the Mongolian pastoralist context (Seele 2017). Although the ger and homestead remain at the center of pastoralist life, pivotal changes in material culture, the mobility of livestock, and knowledge exchange reflect the interplay between changes in biodiversity at multiple scales and changes in the cultural uses of the environment. (A) The shift from horses to trucks and motorbikes has stimulated biocultural change; (B) A decrease in nomadic mobility and pasture rotation can mean having to bring in fodder by truck, and (C) fewer opportunities for harvesting fresh medicinal plants in different areas. As a result, (D) the storage of medicinal plants in plastic bags is now common and (E) herbal medicines can also be bought in larger settlements; (F) Although changes in dress between generations is clear, the effects of changes in intergenerational knowledge transfer are less so. Photo credits: A-E: B. Seele; F: H. Wiese.



biological and cultural diversity thus contribute significantly to the resilience of social-ecological systems (Persic and Martin 2008).

Although acknowledging the philosophical view that biocultural diversity cannot be viewed from a purely scientific perspective, it is crucial that the discussion of biocultural diversity includes methods drawn from, amongst others, psychology, anthropology, and sociology. Our study offers a first step in this direction in that the study is multidisciplinary in nature and that both natural and social science-methods were used (Appendix 2; Seele 2007).

Managing and conserving ecosystems within cultural landscapes requires a transdisciplinary and integrated approach. In addressing this and the need for tools that assist in understanding

biocultural diversity, the links between people and nature, and their implications for conservation (Ommer et al. 2012, Poe et al. 2013), we developed a framework of biocultural diversity that allows for the hierarchical framing of different perspectives, while accounting for change at both spatial and temporal scales. This encourages us to see the bigger picture, acknowledges that the whole is greater than the sum of the parts, and allows for the emergence of new insights through a structured yet integrated approach. Rather than just being an inventory, the framework offers multiple inventories, organized hierarchically, that take into account processes and change, and allow for the monitoring of biocultural diversity.

Biocultural diversity and ethnoveterinary knowledge

Livelihoods and practices that link biological and cultural diversity across scales of reference were investigated through the case study. Ethnoveterinary practices of Mongolian herders include, among others, the harvesting of wild (uncultivated) medicinal plants, mainly in autumn, and the subsequent storage for use during the challenging winter and spring months (Seele 2017). The wealth of botanical and plant use knowledge held by Mongolian pastoralists in terms of plant growth form, fodder, and medicinal use, as well as palatability is indicative of the close connection between herders, their livestock, and the environment (Fernández-Giménez 2000).

Twenty-six of the herders interviewed (54%), perceived that medicinal plants (including medicinal fodder plants) are becoming more difficult to find. When prompted for possible reasons for scarcity, climatic stress, e.g., drought, increased livestock numbers and overgrazing, reduced mobility, incorrect harvesting methods, the effects of the modern way of life, mining, agriculture, as well as a loss of balance and communication with nature were mentioned: “We don’t use the world as it is supposed to be used,” “Herders are not migrating anymore, that is why [the] pasture is becoming damaged.”

Herders’ perceptions and ideas around actions to ensure future medicinal plant supplies included the importance of “correct” harvesting, herder and livestock mobility, reduced livestock numbers, political support, and the connection with nature. Merely possessing traditional ecological knowledge does not mean that a group will live in harmony with nature, and there are many cases of environmental mismanagement by traditional societies (Berkes 1999). Instead this knowledge must be used, adapted, and passed on between generations. Therefore, understanding the dynamics of knowledge transfer and exchange is crucial to maintaining the values and cultural beliefs associated with the knowledge (Persic and Martin 2008).

As discussed by Berkes (1999), many traditional groups rely on a spectrum of resources for their livelihoods, and therefore traditional resource use practices often tend to conserve biodiversity, for example, by maintaining sacred areas and other ecological refugia. For example, in Mongolia, forests and mountains that harbor medicinal plants are seen as sacred places. Through interactions with many herders during our field study, it became clear that medicinal plants are often protected through certain taboos and the protection of particular plant life history stages. From this, we suggest that the knowledge and practices associated with the sustainable use of ethnoveterinary medicinal plants could play a role in maintaining herders’ relationship and

Table 2. Examples of cultural factors that influence biocultural diversity in the Mongolian pastoralist context, using ethnoscientific approaches, cultural values and symbols, and power relations and institutions along four levels of organization. Adapted from Noss (1990).

	Ethnoscientific approaches	Cultural values and symbols	Power relations and institutions	Inventory and monitoring tools
Cultural landscape	Ethnotaxonomy of landscapes. <i>Baigal</i> : nature (to be) <i>Khaan</i> : mountain (king) <i>Gobi</i> : desert differentiation of rain (Marin 2010): <i>Shirun boro</i> : hard rain <i>Shivree boro</i> : soft rain <i>Torgnii hee boro</i> : silk embroidery rain (rain that occurs over small patches of land, more frequent, could be indicative of climate change). Mongolian pastoralists use <i>Uul shig khun</i> (man like a mountain) to describe senior male power (Murphy 2014).	Cultural landscapes. Often represented by cultural keystone places (Cuerrier et al. 2015). “Emotional geography” (Kearney 2009). Ancestral connections to the landscape, e.g., landscape represented by shamanic gown (Humphrey 1995). Mountains and rivers described metaphorically using the human body, e.g., <i>gol</i> (river) means aorta/blood vessel of life (Humphrey 1995). Local knowledge and observations of climate change (Marin 2010). <i>Tengger</i> (sky) is the most important natural power.	Power, value of landscapes, e.g., Mongolian rangelands: Han Chinese viewed them as opportunity for development (Rong 2009); during the Soviet era collectives managed and controlled rangeland use; opportunity of resource mining for present democratic government; herders are against privatization of rangelands (Fernández-Giménez 2000).	Participatory mapping (superimposed on aerial photographs). Interpretation of repeat photography (Moseley 2006). Participatory photomapping (Bennett and Lantz 2014). Ethnoarcheology (Kearney 2009). Ethnocartography (Chapin and Threlkeld 2001). Vitality index of traditional environmental knowledge (VITEK; Zent and Maffi 2009).
Cultural perception of ecosystem	Ethnotaxonomy of ecosystems. Ethnopedology. Mongolian names for specific ecosystems: <i>Nuur</i> : lake <i>Gol</i> : river (blood vessel) <i>Khujir</i> : saline lake/salt deposits. Classification of grazing territories: <i>Seruun nutag</i> : cool pastures <i>Khaluun nutag</i> : hot pastures (Fernández-Giménez 2000, Fijn 2011).	Cultural ecosystems. Emotional geography: human engagement with significant, cultural places (Kearney 2009). Particular communities of plants and animals, and geographic features linked to a specific place (cultural keystone places; Cuerrier et al. 2015). Ecosystems/places of mythical potency. Sacred areas such as forests and valleys. <i>Ovoo</i> : Rock cairn and ceremony on mountain top. Shamanism more powerful in forested mountain areas (Humphrey 1995; <i>personal communication</i>). Protection of Mongolian grasslands: balance between wolves and antelope (Rong 2009).	Power relations and ecosystems. Protected areas, e.g., <i>Khaan ul</i> reserve. Political control of access and use of sacred areas/areas of ritual potency. Political influence (presocialism, collective, postcollective) on mobility, grazing regime, stocking intensity, and herd composition of Mongolian pastoralists (Fernández-Giménez 2000, Sternberg 2008).	Ecosystem knowledge expressed through stories, poems, and paintings about ecosystems. Interpretation of repeat photography (e.g., Hoffman and Rhode 2007). VITEK (Zent and Maffi 2009). Photovoice (e.g., Bennet and Dearden 2013). Place identity (visual qualities; Fry et al. 2009). Levels of land use intensity (Bürgi et al. 2015). Monitoring access to spiritually important places.
Ethnospecies	Ethnospecies. Categorizing plants by ethnospecies takes folk nomenclature into consideration (Hanazaki et al. 2000), e.g., <i>tavan salaa</i> is used for <i>Plantago media</i> , <i>Plantago major</i> , and <i>Plantago depressa</i> (Plantaginaceae). <i>Yumduujin</i> (<i>Dianthus</i> spp.), also classified according to humoral properties. Horses classified according to age, coat-color, gender, use, and temperament.	Species of mythical or ritual potency. Cultural keystone species (Garibaldi and Turner 2004). All entities in nature have their own majesty (Humphrey 1995). Rocks should not be moved carelessly or taken away (<i>personal communication</i>). Wolf: spirit animal (Fijn 2011), connection to <i>Tengger</i> , grassland steward (Rong 2009), strength of a wrestler linked to that of a wolf (Fijn 2011). <i>Morin khuur</i> : horse head fiddle.	Power and politicized species. Politics and the conservation of particular species (Carolan 2008). Politicization of particular species, e.g., wolf (Rong 2009). Descriptions of Mongolian herders as wolves (Mongolians) and Han Chinese as sheep (Rong 2009).	Depth, breadth, and detail of knowledge about species and how this knowledge is changing (Casagrande 2002). Particular attention needs to be given to cultural keystone species (Garibaldi and Turner 2004). VITEK (Zent and Maffi 2009). Free listing (Martin 2004, Quinlan 2005).
Local knowledge of genetic variety below the ethnospecies level	Folk taxonomic memes. Varieties recognized and named beyond the ethnospecies level. Herd animals are identified at the individual level by physical appearance, age, sex, and individual characteristics, e.g., <i>tsogio mor</i> , horse that is a galloper (Fijn 2011). Red flowers of <i>altan gamuur</i> (<i>Rhodiola</i> spp.) used to treat muscle injuries, yellow flowers for bone injuries (Seele 2017).	Culturally relevant memes. Worldviews, and the process of transferring knowledge of varieties below the ethnospecies level across generations. In the Mongolian context, the wolf has various meanings, symbolism, metaphors, and modes of existence: The wolf can be a metaphor for success, fortune, and morality, but also for excess and animality (Charlier 2015). For horses, family lineage is interpreted through branding marks (Waddington 1974).	Power and memes. Political and economic ideologies or ideas that influence tenure and ownership. Political processes that influence the meme level, e.g., access to sacred valleys, mountains, or areas where medicinal plants grow. Political regulations that favor certain species or breeds of livestock over others, e.g., species of livestock kept changed during Soviet times (Humphrey 1978, Fernández-Giménez 1999).	Focus on ethnospecies that are overdifferentiated (Martin 2004), where a monitoring approach similar to Casagrande (2002) is used to understand change in relation to folk names, e.g., songs that illustrate variations below the ethnospecies level. VITEK (Zent and Maffi 2009). Free listing (Martin 2004, Quinlan 2005).

connection to the landscape. In addition, the collection of medicinal plants (and grazing of medicinal food plants) could play a role in increasing the mobility of pastoralists and their herds as they search for specific medicinal plants and pastures.

Local knowledge about medicinal plants (used for livestock) among Mongolian herders is largely transferred between generations, as lived knowledge (from herding and life experience), through active teaching (show and tell) and

experiential learning (by collecting medicinal plants together). Knowledge is also gained through following the “herding way of life.” This everyday folk instruction in animal husbandry forms part of *khar ukhaan*, folk knowledge or common sense (literally: black knowledge) that builds the traditional Mongolian herder identity (Marzluf 2015). Maintaining this traditional ecological knowledge therefore requires the continuation of herding practices and culture, and a family structure that allows for

Table 3. Co-occurrence of similar codes is indicated by corresponding letters in superscripts across the themes of “medicinal plants” and “medicinal plant knowledge” in the Mongolian pastoralist context. Groundedness values (in brackets) indicate the number of times each code was used throughout all interviews. Codes relate to perceived threats regarding the availability of medicinal plants and continuation of local medicinal plant knowledge as well as ideas around conserving this knowledge.

Threats to: Medicinal plants (biodiversity)		Threats to: Medicinal plant knowledge (cultural diversity)	
(12)	Weather/climate related	(9)	Younger generation: loss of medicinal plant knowledge (use and collection) ^a
(5)	Loss of balance and communication with nature ^b	(5)	Modern medicine replacing medicinal plants
(5)	Anthropogenic causes	(5)	Education: children do not learn about medicinal plants
(4)	Increased livestock numbers	(5)	Loss of herding knowledge and practices ^b
(3)	Way of nature	(3)	Younger generation is disconnected from nature
(3)	Incorrect harvesting of medicinal plants ^a	(3)	Urbanization
(2)	Decreased mobility	(2)	Political and social changes
(2)	Agriculture	(2)	Decrease in medicinal plant availability ^a
(1)	Overgrazing	(2)	Loss of culture and knowledge
(4)	Other (unknown, fires, mice, general decrease in plants)	(2)	Other (loss of land, willingness to learn)
How to conserve: Medicinal plants (biodiversity)		How to conserve: Medicinal plant knowledge (cultural diversity)	
(17)	Correct harvesting	(12)	Teach children ^c
(11)	Protection of medicinal plants/soil/grazing/nature	(10)	Keep herding traditions and practices alive ^d
(9)	Nature knows how to recover	(7)	Nature (including livestock) connection ^f
(7)	Government assistance ^e	(5)	Record and share plant knowledge ^e
(6)	Mobility ^d	(5)	Transfer knowledge between generations
(4)	Communication and connection with nature ^f	(4)	Children should spend time in countryside
(3)	Reduce livestock numbers	(4)	Medicinal plant books
(3)	Education ^f	(4)	Formal school education ^c
(2)	Human activity and mining	(3)	Need teachers ^c
(2)	Prevent pasture degradation	(2)	Government support: prepare and teach herders ^e
(2)	Research ^e	(2)	Responsibility of the younger generation
(6)	Other (cultivation [for and against], fences, unknown, prevent fires)	(4)	Other (unknown, social interaction, awareness, motivation)

intergenerational connections through space and time. This was also identified by respondents: “We should teach our younger generation and save this knowledge. City children should come to the countryside for summer and they will interact with nature and learn to love.”

Most herders (70%, n = 44) indicated that traditional ethnoveterinary knowledge is in danger of disappearing. Associated threats and concerns include a decrease in abundance of medicinal plants and in medicinal plant knowledge, the development of modern medicine and the perceived convenience thereof, urbanization and resulting changes in education, and a loss of connection to livestock and to nature. The following quotes illustrate the interrelatedness of (ethnoveterinary) medicinal plant knowledge, ecological changes, and socio-political developments:

The problem is that many young people are moving to (Ulaanbaatar), destroying the culture and knowledge; if they are here then the knowledge will stay alive and the culture will continue.

People ... prefer medicines to plants. Modern young children are not living close with nature, they don't communicate with nature, mostly they use TV, phones, these things separate them from nature. ... Also plants are becoming hard to find and only growing in the mountains. People are not going further to collect them.

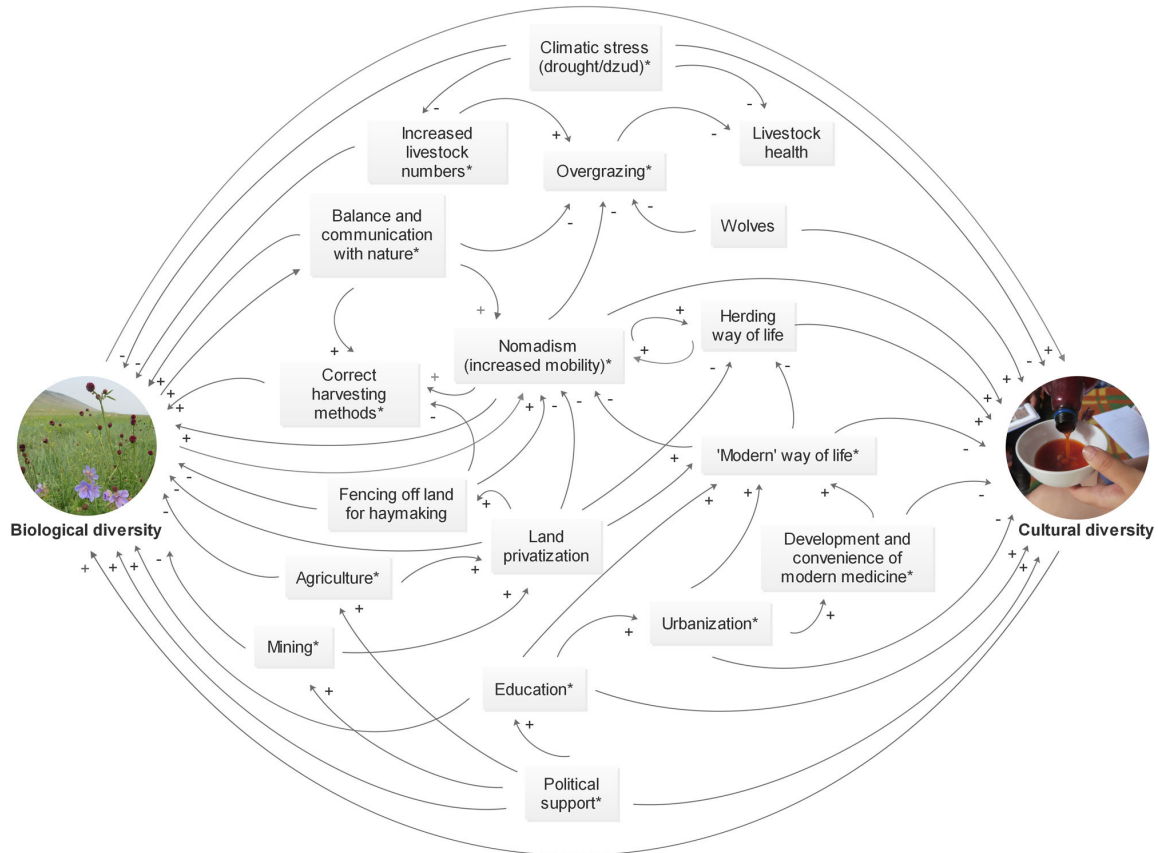
The perception that the modern education system results in children learning less about the environment, was also recorded by Hopping et al. (2016) in a study on the local knowledge of Tibetan herders.

As Tang and Gavin (2010) indicate, the TEK of pastoralists can play an important role in resource management. Although the ethnoveterinary knowledge recorded in this study cannot be extrapolated to the entire Mongolian pastoralist population, it is an example of traditional ecological knowledge and practices that offer valuable insights into the maintenance of biocultural diversity. Essential to the continued existence and use of this knowledge and practice is an understanding of the historic, political, and cultural contexts, and the interrelatedness to ecological systems and processes. Our investigation of biocultural diversity, in a Mongolian pastoralist context, suggests that maintaining a mobile “herding way of life,” and the associated balance and communication with nature, is vital for the ecological resources that herders rely on and the continued transmission of traditional ecological knowledge.

Cultural values and symbols

Cultural values, symbols, and processes, or learning systems, that are involved in the continual shaping and adapting to the environment can influence and describe the relationship between humans and nature (Pretty 2002). Processes involving cultural values and symbols include moral and religious belief systems and are further explored as religious, ritual, or mythical perspectives of landscape, including the connections to particular places and species of mythical potency (Upton 2010). To understand people's connection to the land and behaviors that are linked to resource conservation, it is important to understand the worldviews and associated beliefs and rituals that people have (Berkes 1999, Cunningham 2001). It is through these connections that cultural values, symbols, and processes such as cultural and spiritual norms, taboos, and rituals can influence local resource

Fig. 4. A systems diagram illustrating the links, relationships, and feedback loops between biological and cultural diversity in the Mongolian pastoralist context. Polarity signs on the arrow heads indicate whether the relationship leads to an increase (+) or a decrease (-) in the various elements. The * refers to concepts that were guided by the coding of interviews (see Table 3). Photo credit: B. Seele, H. Wiese.



use, for example, the grazing of seasonal pastures (Colding and Folke 2001, Upton 2010).

Mongolian pastoralists, like many other traditional societies, have a “community-of-beings” worldview, a cosmology whereby they see themselves, and their actions, as an inherent and interconnected part of nature (Humphrey et al. 1993, Berkes 1999:79). This is reflected in the ancestral connections to the landscape (Humphrey 1995), and in the belief that all entities in nature have their own powers (Humphrey et al. 1993). Many Mongolian pastoralist traditions are deeply connected to cultural keystone places (see Cuerrier et al. 2015 for a detailed description of cultural keystone places) with Mongolian pastoralists having a strong connection to the land, from the landscape level and particular places within the landscape, through to individual relationships with specific mountains, valleys, or trees (Humphrey 1995). Because forests and high mountains are often revered as places of mythical potency and sacredness, they form the sites of ceremonial practices, and medicinal plants are frequently collected from these areas because the potency extends through to the plants that are viewed as a resource and as a gift from powerful spirits (Fijn 2011).

As reflected on by Humphrey (1995), cultural values and symbols related to the landscape are closely linked to behaviors and

landscape use. This in turn can influence biodiversity as is also reflected in the findings from our study: herders’ perceive the “connection with nature” to be important for both medicinal plant and knowledge conservation. Fundamental to the discussion around biocultural diversity, therefore, is the acknowledgment and understanding of the value of cultural keystone places (Cuerrier 2015). This can be done using toponymy (the study of traditional place names) across different scales, from the landscape to below the species level because local names are often defined through a holistic view, considering not only biological factors (topography, fauna, and flora) but also social and spiritual aspects (Mathez-Stiefel et al. 2007) thereby recognizing the cognitive or symbolic connections to the landscape and elements in the landscape through time and space.

Ethnoscience approaches

Ethnoscience approaches are represented by ethnobiological classification systems as described by Berlin (1992) along all levels of organization, and refer to the classification of landscapes, ecosystems (for example, ethnopedology), species (for example, ethnospecies), and folk taxonomic memes. Knowledge bases and language are one of the bridges connecting biodiversity and cultural diversity (Pretty et al. 2009), and are directly linked to ethnoscience approaches. These approaches offer valuable

insight into the historic and cultural understanding of the environment (Berlin 1973), as well as resource use and value (Hunn 1993).

At a landscape level, ethnoscience offers information that allows for a better understanding and description of the landscape, its value, and management (Krasilnikov and Tabor 2003). At a community level, ethnopedology, for example, the study of indigenous soil knowledge and names, can provide insight into the local value of particular areas and soils (Krasilnikov and Tabor 2003).

At the ecosystem level, an example of ethnoscience is offered by the local classification of grazing land. Pastures can be classified as “warm” *khaluun nutag*, such as desert steppes, waterless pastures, and south-facing slopes, or as “cool” grazing lands *seruun nutag*, which include mountain-steppe pastures and pastures near rivers, on mountaintops, and north-facing slopes. This classification system is incorporated in herder’s ecological knowledge of plant-animal-environment interactions and consequent grazing practices, where “cool-muzzled” livestock are best suited to “warm/hot” grazing lands, while “hot-muzzled” animals are better adapted to “cool” pastures (Fernández-Giménez 2000).

At a species level, categorizing plants by ethnospecies takes folk nomenclature into consideration (Hanazaki et al. 2000). For example, the *Yumduujin* is the local name used for both *Dianthus superbus* and *Dianthus versicolor*. In addition, plants are also classified according to their humoral properties. The local and cultural importance of a particular species is often reflected in overdifferentiation of the species in local terms, compared to the Linnaean classification (Hunn 1993, Martin 2004). An example of this is reflected in the many names used to describe horses of different ages, colors, and temperaments in Mongolia, indicative of the fact that horses are central to herding life and the highly valued connection between herders and horses (Fijn 2011).

In the Mongolian context, it is important to acknowledge and maintain the unique ethnoscientific (and folk taxonomic) classification systems and the rich vocabulary that reflects a sense of identity and a strong connection to the landscape. On a broader scale, understanding local taxonomic systems can be critical in maintaining sustainable resource management, especially in ecologically fragile areas of the world (WinklerPrins and Barrera-Bassols 2004).

Power relations and institutions

The aspects of power relations and institutions consider the effect that political institutions and decisions have on communities and their interactions with nature, for example, through land tenure decisions and rights (Cunningham 2001, Upton 2010). The political element of biocultural diversity includes the political (mis)perceptions of landscape value, ecosystem value, and species’ value (Freemuth and McGregor Cawley 1998, Nie 2002). Political decisions can have a direct influence on a community’s sense of place and possible dislocation of sense of place (Williams and Stewart 1998) and furthermore, power relations and institutions can influence biocultural diversity through the bridge of local norms and institutions (Pretty et al. 2009), as illustrated by the following example of Mongolian pastoralist’ mobility:

Over centuries of herding and through acute observations, Mongolian pastoralists developed sophisticated animal husbandry and herding systems, based on the accumulated knowledge of climate, animal behavior, and plant ecology (Fernández-Giménez 1999, Fijn 2011). By developing a nomadic way of herding, pastoralists used the rangelands both efficiently and sustainably (Fernández-Giménez 1999). However, during the Soviet era (1924–1990), traditional social organization was disrupted and a system enforced whereby all herders had to become members of collectives (*negdel*) and almost all livestock became state owned. In addition, decisions around where and when to move were controlled by collectives (Fernández-Giménez 1999). The disruption of traditional social organization, mobility, and reduced decision-making power, together with the “modernization” of livestock herding and healthcare, led to a loss of important traditional knowledge and skills (Sokolewicz 1982, Fernández-Giménez 1999), and the specialization of livestock to large single-species herds played a role in the overuse of pastures (Mearns 1993). The extensive influence of power relations and institutions on biocultural diversity is highlighted by the example of Mongolian herder mobility.

In 1990, Mongolia began the transition from socialism to a market economy. Although herders’ decision-making power was largely reduced during the Socialist time, the end of the collective-system brought new challenges that directly influenced the herders’ use of the steppe rangelands. After the collapse of the Soviet era, and subsequent dismantling of *negdel* (herding collectives), although rangelands remained state property, almost all livestock herds were privatized, but the infrastructure and support provided by collectives (which herders had been relying on since the 1960s) was not replaced (Fernández-Giménez 1999, Murphy 2014, Fernández-Giménez et al. 2015). Following privatization, a rise in poverty led to an increase in both the number of herding households (urban to rural migration) and livestock. This influx of new herders, together with a lack of formal regulatory institutions responsible for herding decisions, and reduced government support regarding transport, water sources, and securing of grazing lands and campsites, led to a change from coordinated seasonal movements to an increase in year-round grazing of seasonal pastures (Fernández-Giménez 1999, 2000, Sternberg 2008, Murphy 2014). This decline in mobility intensified grazing pressure and has had a “detrimental effect on rangeland that, when paired with reduced water sources, serves to create a positive feedback loop as human action exacerbates natural forces in affecting the environment” (Sternberg 2008:1300). The decrease in herders’ ability to migrate according to seasonal or ecological conditions includes a decrease in both the frequency and the range of herder mobility, which has important ecological implications (Fernández-Giménez 2000, Sternberg 2008).

Along with the many impacts on biodiversity, the reduction in mobility influences herders’ connection to the land and landscape entities, indicating how essential mobility is for rangeland use to be sustainable (Fratkin and Mearns 2003, Ykhanbai et al. 2004). Correctly interpreting these trends in mobility requires an understanding of the historical and political context thereof (Fernández-Giménez 1999), what Murphy (2014:764) calls the “landscapes of rule.”

Further effects of power relations and institutions are reflected by complex and multifaceted land tenure concerns because governance and land access are often entangled with political issues of power and inequalities (Poe et al. 2013) as seen in the Mongolian pastoralist context. In 1993, together with decollectivization, a policy of decentralization resulted in resource management being handed to local administrative bodies, without much government support. This then led to pastureland and campsite (dis)organization with little acknowledgement of customary norms (Murphy 2014). As a result, a complex myriad of different forms of territory evolved, influenced by, among others, kinship-connections, “underlying moral economies of mutual aid and obligation, and spiritual economies of ritual aid” (Murphy 2014:765, Ahearn 2016). From 1999 to 2002 a number of extreme weather related events (*dzud*) combined with a lack of policy support led to large loss of livestock (Fernández-Giménez et al. 2015). Although studies have found herders to be against the privatization of rangelands, and have articulated the need to keep access to pastureland unrestricted by one person, in a simplified view of blaming pastoralist mismanagement as the reason for *dzud*-related losses and rangeland degradation (e.g., Dashnyam 2003), government as well as local and global advisors have hailed land privatization as a remedy for further land degradation (Fernández-Giménez 2000, Sternberg 2008, Murphy 2014). However, this approach has led to a further decentralization of resource management, and does not consider the complexity of power relations, cultural dynamics, the previous disempowerment of herders, and climate change (Murphy 2014). Stump et al. (2005), for example, found that grazing has a relatively smaller influence on vegetation than high interannual precipitation variability in southern Mongolia, demonstrating the importance of scale and how intense local effects can lose their significance when aggregated into a larger scale.

Land tenure reform that includes privatization threatens two important norms of pasture use, formed from herder’s perceptions and observations of resource use. First, all herders must refrain from out-of-season grazing of the pastures reserved for winter and spring, and second, based on reciprocity, no herding group may deny another group access to their grazing in times of need (Fernández-Giménez 2000). This highlights the need for local and international policy advisors and decision makers to see tenure and property rights in a cultural context (Cunningham 2001), and represents a link between cultural and biological diversity, because privatization not only threatens the land, but also threatens pastoral identity and resource management that is based on land as a common resource (Marzluf 2012). This is also reflected in herders’ perceptions, recorded during our field-study, of the government being responsible for the conservation of both medicinal plants and associated knowledge, pointing toward the disempowerment of herders, especially regarding decision-making power, through various government cycles.

In the Mongolian context, correctly interpreting and understanding rural politics and political economies requires a contextualization of cultural dynamics, historical legacies, and resource politics across various scales and role players, from kin to government (Murphy 2014, 2018). This emphasizes the need for a greater perspective, where factors are not viewed in isolation,

but rather across scales and across both biodiversity and cultural diversity.

Linking it all together: cultural keystone species

Cultural keystone species, a concept developed by Garibaldi and Turner (2004), describes species that play a specific role in shaping the identity of the people who rely on them and feature prominently in language, ceremonies, and narratives. Cultural keystone species are therefore an example of the link between biological and cultural diversity, and offer an important way to evaluate the connections between ecological integrity and cultural well-being (Poe et al. 2013).

An example of a cultural keystone species is represented by the Mongolian grey wolf (*Canis lupus*). The importance of the wolf for Mongolian herder identity and culture as well as grassland ecology becomes clear in the semiautobiographical novel *Wolf Totem* written by political scientist and former activist Lu Jiamin, under the pseudonym Jiang Rong (2009). Although *Wolf Totem* is an autobiographical novel, it is of academic value, as illustrated by Varsava (2011), Meng and Omar (2011), and Huang (2016). The novel combines biological, anthropological, and political perspectives on the ecological state and past situation of the grasslands of Inner Mongolia and Mongolia. It helps us to understand the current context and offers a valuable account of political drivers of cultural change. *Wolf Totem* is based in the Inner Mongolia Autonomous Region of China, which borders directly with Mongolia, and is set during the Chinese Cultural Revolution (1966–1976). Rong (2009) describes how the Han Chinese introduce sedentary agriculture and industrial animal and land management practices to the nomadic pastoral grasslands of Inner Mongolia, with devastating consequences (Bürgi et al. 2015). Amongst others, the wolf population is destroyed, causing an increase in grass-eating marmots, gazelle, and mice. The disregard of nomadic Mongolian pastoralism and rangeland stewardship ultimately leads to degradation of the grasslands and the associated cultural patterns (Varsava 2011). In contrast to the Han Chinese ideas of agricultural “development,” Rong (2009) describes the traditional Mongolian pastoralist view of ecology and the symbiotic relationship of wolves and herders:

...wolves are sent by Tengger to safeguard the grassland. Without them, the grassland would vanish. And without wolves, we Mongols will never be able to enter heaven.
(p. 123)

Wolves maintain both the ecological balance (by controlling gazelle and livestock numbers) and a cultural-spiritual balance as the Mongolian primary totem (Varsava 2011). Wolf populations, in turn, are controlled by the herders and therefore, both Mongolian herders and wolves can be seen as stewards of the grassland. In a similar example, the reintroduction of wolves in Yellowstone National Park, USA, has had a positive effect on ecosystem structure and biodiversity (Ripple and Beschta 2003, 2004).

CONCLUSIONS

It is clear that biocultural heritage needs to be at the center of conservation strategies (Agnoletti and Rotherham 2015). We set out to conceptualize the interrelationships between people and nature by developing a framework for biocultural diversity that

considers and explores the cultural factors that influence diversity. In addition, we use a systems diagram to graphically illustrate how biocultural diversity emerges from the framework, offering a visualization of the connections between biological diversity and cultural diversity using examples from the Mongolian pastoralist context. Looking forward, a direction for further theory building could be to focus on the links and specific feedback mechanisms between biodiversity and biocultural diversity.

Within the context of biocultural diversity, the Mongolian case study indicates the need for national policies that understand, acknowledge, and maintain the important and complex processes underlying the landscape and the associated worldviews, traditional knowledge, and practices. Currently the use of herders' traditional ecological knowledge is constrained by various factors, which are connected to larger socioeconomic causes. As suggested by Fernández-Giménez (2000), a lack of access to transport and key pasture areas combined with a lack of pasture use regulatory systems are limiting herders' ability to use their traditional ecological knowledge. This leads to behaviors that transgress widely held rules of pasture use, and calls for a re-establishment of strong local institutions to regulate the way grasslands are used. Furthermore, herders' concerns around the privatization of land need to be incorporated in policy discussions and decisions concerning land tenure.

There is no specific formula that ensures a particular community or society will successfully conserve a resource, particularly in the face of rapidly changing social, political, and economic variables (Cunningham 2001). Nevertheless, the development of a framework for biocultural diversity that takes factors and processes into account across a range of scales, from the landscape- to the genetic level, allows for a clearer understanding of the variables at play. A coherent framework can guide the choice of appropriate indicators to monitor and assess biocultural diversity at various scales.

Responses to this article can be read online at:
<http://www.ecologyandsociety.org/issues/responses.php/11207>

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Appendix 1.

Theme	Question
Medicinal plants	Are there any medicinal plants that are becoming more difficult to find/get hold of? If yes, why have they become more difficult to find/get hold of?
	How do you think medicinal plant supplies can be ensured in the future?
Medicinal plant knowledge	Is this indigenous plant knowledge in danger of disappearing? Please explain any threats/future concerns regarding this knowledge?
	How should we conserve this knowledge?

Appendix B

Table 1. Theory versus practise: a review of the methods and approaches used for ethnoveterinary research conducted in Mongolia.

Methods used (chronologically ordered)	Theoretical Approach	Practical Reality	Comments on outcomes
Participation in the Mongol derby (1000 km self-supported endurance horse ride)	Establish rapport with local knowledge holders (Martin 2004). Understanding the 'human context' in which the traditional knowledge is embedded (Shackeroff and Campbell 2007).	Riding Mongolian horses and staying with local herder families allowed me to gain insight into Mongolian herder way of life, especially in terms of livestock.	Highly beneficial: increased my understanding of the context in which ethnoveterinary knowledge is embedded. Enabled the establishment of important relationships with knowledge holders, interpreters and local guides.
Collaboration with local university	Establish local research partners (CBD 1992, International Society of Ethnobiology 2006).	Administrative benefits (research visa and local university affiliation), but little fieldwork and data collection support. Use of university herbarium was very helpful.	Although more about administrative steps, this was a crucial part of the research process, and it is hoped it will play a role in dissemination of findings in Mongolia.
Ethical clearance and prior informed consent	Prior informed consent (International Society of Ethnobiology 2006, Nagoya Protocol 2010).	Obtained from two universities. This was instrumental in explaining intention and motivation of the research project. Proof of ethical clearance offered protection from a false accusation of biopiracy.	It proved invaluable to receive ethical clearance from a local institution, as it offers protection to both respondents and researchers.
Employing a local vehicle driver and local interpreters	Local involvement in research team and research logistics (International Society of Ethnobiology 2006).	There was a dependence on the driver, and cultural sensitivity was misused by him. The driver became aggressive. Good interpreters are in high demand and easily find other jobs. The interpreter also brought her personal agenda into interviews. There was some interpreter bias towards research and respondents.	The importance of a driver is often underrated, especially where a language barrier exists. The driver used in this study made the experience more difficult. 'The mere fact that interviewers, enumerators or extension agents are from the local area does not mean they have that requisite local knowledge, language skills and cultural sensitivities for studying local knowledge systems' (Grandin and Young 1996).
Recording	Use of recorder during interviews (Martin 2004), only if consent was given.	Seventy percent (n=35) of interviews were recorded. In retrospect, the manner in which the interpreter explained the recording influenced respondents' reaction towards recording.	Transcription and translation of recordings gave insight into interpreter bias.

Snowball sampling	A nonprobability sampling method, often employed in field research, whereby each person interviewed may be asked to suggest additional people for interviewing (Babbie 2004).	Mongolian pastoralists have an extensive social network, which was key to locating knowledge holders and to establishing trust. Both contacts from the Mongol derby and from the horse guide assisted with snowball sampling.	Suggestion from respondent translated incorrectly due to personal agenda of driver and interpreter (n=1).
Free listing	Free listing can provide insight into culturally important plants and ailment categories (Martin 2004). Because free lists are not exhaustive (Quinlan 2005), where possible, inventories from free listing were supplemented and cross-checked using a plant reference book (see following row).	Free listing allowed respondents to become comfortable with the interview situation and encouraged a more balanced positionality of power between researcher and respondents.	Using position of mention and frequency of mention also enabled the researcher to ascertain, through an emic approach, what categories and plants are seen as important and useful.
The use of photographs in a reference book <i>Flowers of Mongolia</i> (Hauck and Solongo 2010) for ethnoveterinary medicinal plant inventories	Interviews held <i>ex situ</i> with plant photographs as a reference tool (Thomas et al. 2007).	A high adult literacy rate of 97.8% in Mongolia (Yembuu and Munkh-Erdene 2006) substantiated the use of the reference book method. In general herders reacted positively and with much interest to the book. However, four respondents mentioned having poor eyesight and chose not to use the reference book.	In the reference book, two species of the same genus are frequently shown on one page. Respondents often indicated (by vaguely pointing at all photographs on the page) that both species (sharing the same common name) were used, although not both voucher specimens could be collected.
Voucher specimens	Good quality herbarium specimens are crucial to ethnobotanic (and ethnoveterinary) studies (Alexiades 1996, Cunningham 2001, Martin 2004). Researchers must take into account sensitivity to conservation and local cultural concerns (Cunningham 2001).	In general, voucher specimens were difficult to collect for all mentioned plant species due to an ongoing drought (FAO 2016), herders being too busy, distance between interview location and medicinal plant location and cultural objections.	Concerns were raised about the use of a GPS to mark voucher specimen coordinates, possibly due to suspicions related to similar technology used by geologists prior to mining, and possible fears around bioprospecting.
Use of GPS	Used to determine geographical distance and to record interview and voucher specimen location.	Not everyone uses the 'western' approach to map reading and direction. Locally, time and distance measures were done taking horseback travel and jeep tracks into consideration. Compass directions can be interpreted in different ways. Concerns were raised around the use of a GPS to record voucher specimens, based on fears of bioprospecting.	One needs to be flexible in terms of when and how to get to a specific area, and prepare for cultural differences in map reading. Cultural sensitivity around voucher specimen location needs to be considered. The horse guide was fascinated with the GPS after time was taken to explain to him how it works.

Interviews	Semi-structured interview with open- and closed-ended questions (Martin 2004).	Conducting interviews of good ethical, social and scientific quality is challenging, especially when dealing with non-interview related issues that come up during the interview. Questions around herd size and demographic information made some respondents feel uncomfortable (also briefly reported by Heffernan et al. (1996) and, in this case, were left out.	Researchers should receive specific training, from the social sciences, in conducting interviews.
Travelling on horse back	Establish rapport with local knowledge holders and participant observation (Alexiades 1996, Martin 2004). Reduce imbalance in position of power (Shackeroff and Campbell 2007).	Although this meant a decrease in the daily distance covered, it soon became clear that this was the appropriate mode of transport, with respondents feeling more at ease. This led to naturally stimulated conversation around livestock care. It enabled the research team to establish good rapport with herders and allowed for valuable insight into life on the steppes.	This had a very positive effect on the success of the project. It allowed me to place ethnoveterinary knowledge in the context of Mongolian herders (Shackeroff and Campbell 2007).
Local horse guide as part of research team	Place ethnoveterinary knowledge in context (Shackeroff and Campbell 2007). Local involvement in research team and research logistics (International Society of Ethnobiology 2006); Establish rapport with local knowledge holders (Martin 2004).	The horse guide was a well-known and respected community member. He suggested which families to visit, and introduced the research team and project to these families. He also assisted with voucher specimen collection.	The assistance of the horse guide with horse-care, logistics and introductions to knowledge holders was invaluable during field work.
Support of having my partner as field assistant.	Ensuring researcher health and well-being (Moncur 2013, Kara 2015). Partner was introduced as my husband.	Help and support from my partner during the often strenuous fieldwork provided crucial support, motivation and understanding. The presence of my 'husband' prevented any untoward responses, increased my status in a patrilineal society and reduced vulnerability associated with doing fieldwork as a foreigner.	Gender issues (Howard 2003) and vulnerability are important to consider before and during fieldwork. Especially the vulnerabilities associated with alcohol, untoward advances and general safety of a young female foreign researcher should be considered.
Keeping a journal and observation schedules	Daily entries into a fieldwork journal, and observation schedules (Appendix C) for interviews and other noteworthy experiences (Martin 2004).	This allowed me to record and keep track of finer, often crucial, details. In addition, time spent on this offered an opportunity to de-brief and reflect on fieldwork.	This proved to be instrumental for later analysis. However, it was challenging to add qualitative data to a largely quantitative research project in a meaningful way.

Market surveys	Interviews were conducted with market sellers at two major markets following guideline described by Martin (2004) and Cunningham (2001).	Market sellers reacted with suspicion to questions relating in any way to plant sales and popularity. The <i>ca.</i> 60 years of being a Soviet satellite state could be a factor in suspicions related to interviews and questions. A relationship was established with only one market seller.	Performing market-related research can be difficult due to the informal, varied and somewhat hidden nature of the medicinal plant trade (Etkin et al. 2011). I needed more time to establish relationships prior to conducting market research.
Assistance from boundary organisations	Boundary organisations bridge the gap between research and practise (Guston 2001, Cook et al. 2013) and are familiar and experienced with the local context.	Staff from the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Biodiversity and Adaptation of Key Forest Ecosystems to Climate Change Programme, offered valuable support in terms of interpreters, horses and fieldwork logistics.	It is important to identify and receive support from the correct and genuinely supportive boundary organisations. This takes time and should be factored into research planning.
Support	There is a need for researchers, especially young and novice researchers, to have support systems in place that offer support before fieldwork commences and to allow for debriefing after the fieldwork period (Hallowell et al. 2005, Kara 2015).	Academic and motivational support was received from my supervisors before, during and after fieldwork. Professional psychological support was sought after fieldwork had been completed. The help from a psychologist in dealing with post-traumatic stress (main sources of stress: problems with driver, politicization of the intellectual property rights issue) played a critical role in finishing the research project.	From my experience, I recommend that researchers performing ethnobotanical studies in a foreign country for the first time, receive psychological support (of some form) pre- and post-fieldwork.

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