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Societal Recognition of Ecosystem Service Flows From Red Panda Habitats in Western Nepal

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The biologically and culturally diverse mountain habitats of the red panda (Ailurus fulgens) *produce numerous ecosystem goods and services of global significance and satisfy the daily sustenance requirements and wellbeing of poor and vulnerable local communities. Most studies of ecosystem services conducted in Nepal have investigated community forest management and protected areas, largely in the lower hills and plains of the country. However, to conserve red pandas and associated biodiversity, knowledge is needed of the services instrumental to the livelihoods and wellbeing of people living in and around their Himalayan mountain habitats. Using case studies of 6 remote villages nearest to known red panda habitats inside and outside a protected area in western Nepal, this study reports on key informant interviews, focus group discussions, informal interactions, and participant observations to identify and categorize the goods and services provided by these habitats. Among the provisioning and cultural ecosystem goods and services obtained from red panda habitats, local people prioritized seasonal grazing in high-altitude pastures, plant materials for medicines and food, wild plants for energy, transhumance culture, and religious interaction with nature. Their dependence on these services varied with season and location, with greater reliance on the services outside the protected areas. Some services used for valuing ecosystems, such as carbon storage and improved air and water quality and biodiversity, were only ever mentioned in a manner that would characterize them as cultural services provided by mountain deities. They only appear to be acknowledged as services with a use value by people from outside the region. This study suggests that understanding the value of the services provided to local communities could allow development of a policy that would also help conserve red pandas, particularly if income can be obtained for providing services to outsiders who have no perceived local economic benefit.*

Keywords: *mountain habitat; livelihoods; transhumance culture; highland rangeland; traditional medicinal herbs; governance.*

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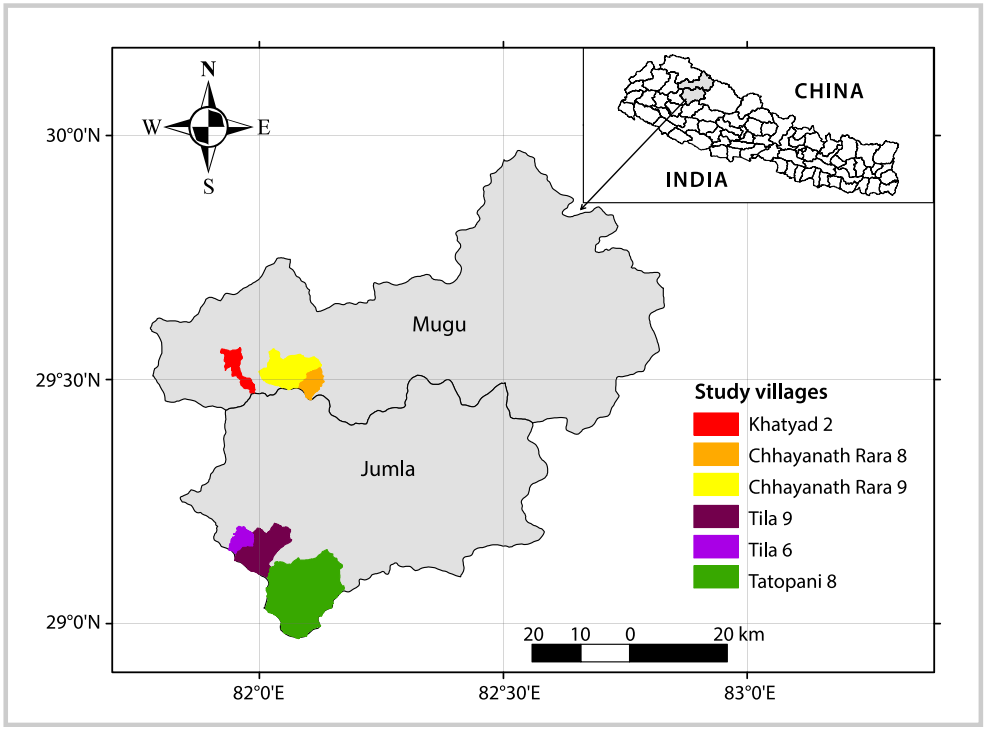
Introduction

Although mountains cover only about 22% of the Earth's land surface area and are home for only about 13% of the population (Romeo et al 2015), well over half of all humans rely directly or indirectly on mountain resources (Rodríguez-Rodríguez et al 2011; Maselli 2012). Mountains provide provisioning services such as food, timber, fiber, and medicine, regulating and supporting services including water purification, climate regulation, nutrient cycling and soil formation, and cultural services such as aesthetic, symbolic, and religious values (MEA 2005; Macchi and ICIMOD Team 2010; Molden and Sharma 2013; Hamilton 2015). They are also biologically diverse and home to 25% of global terrestrial biodiversity (Sharma et al 2019).

Among the species relying on mountain habitats are the red panda (*Ailurus fulgens*). Red panda habitats are found between 2500 and 4800 masl across the mountains of Bhutan, China, India, Myanmar, and Nepal (Glatston et al 2015). In Nepal, of which three-quarters is mountainous (Thapa 1996), potential habitats of red panda cover 24,000 km^2 in 24 districts (Bista et al 2016; DNPWC and DFSC 2018) in which there are numerous threatened plant and animal species (Måren et al 2015). Red panda habitats also sustain local livelihoods (Chaudhary et al 2009), based on livestock and non-timber forest products (NTFPs) (BPP 1995). However, population growth, overexploitation, and land fragmentation are all altering traditional practices of resource usage and degrading these mountain habitats (Adhikari et al 2007; Tiwari and Joshi 2015; Everard et al 2019). Current policies, regulations, and practices and demand for goods and services also tend to overlook or undervalue the benefits obtained from nature and lead to suboptimal investment in conservation and management of ecosystems (MEA 2005; Rasul et al 2011).

While people have long obtained services from mountain ecosystems, the articulation of ecosystem services (ES) as an idea is comparatively new. Quantifying, classifying, and understanding ES has now become a significant field of investigation (Fisher et al 2009), and several frameworks, approaches, tools, and research (Leemans and De Groot 2003; Sukhdev 2008; Rasul et al 2011; Haines-Young and Potschin 2011, 2018; Peh et al 2013; Bennett et al 2015; Díaz et al 2015; La Notte et al 2017) have been proposed to gain insight into the goods and services that nature produces, how they should be categorized and classified, how their

FIGURE 1 Map of the study area showing study villages in Mugu (inside RNP) and Jumla district (outside the PA). (Map by Saroj Panthi)



value should be quantified, and how the linkages between ES, livelihoods, and wellbeing can be understood (Carpenter, DeFries, et al 2006; Tallis et al 2008). However, apart from studies of community forest management systems and lower-altitude protected areas (Lamsal et al 2018), there is little understanding of ES instrumental to the livelihoods and wellbeing of people living in mountainous Nepal or how those services benefit the many animals, such as the red panda, with which mountain communities coexist.

This study identifies the services provided by red panda habitats that contribute to the quality of life and wellbeing of the remote communities living in and around a protected area (PA) in western Nepal. First, we categorize the benefits derived from red panda habitats using a recent ES framework, the Common International Classification of Ecosystem Services (CICES; Haines-Young and Potschin 2018). Then we analyze the ecosystem goods and services obtained from red panda habitats that local people value the most, the services people use, and their interdependencies. In doing so, we aim to improve understanding of nature–human interactions in the region to help develop a policy that will potentially improve local livelihoods and wellbeing but also ensure sustainable management of ES derived from red panda habitats.

Materials and methods

Study area

The research was undertaken in Jumla and Mugu districts, 2 remote, mountainous districts of Karnali province in the northwest corner of Nepal (Figure 1). Karnali province is the largest (24,453 km^2) of Nepal's seven federal provinces but has the smallest population (1.6 million). Jumla district (2500 km^2, population 109,000; CBS 2012) ranges from 2100 to 6400 masl (DDC 2013), annual temperature is generally between 1.3 and 13.0°C, and it receives about 860 mm of rain annually (DHM 2017). Mugu district to the north (3500 km^2, 55,000 people; CBS 2012) is equally mountainous (1200–6600 masl; DDC 2016) but a little cooler (–0.1 to 10.8°C) and slightly drier (800 mm; DHM 2017).

The study was conducted in the 6 villages nearest to known red panda habitats in Rara National Park (RNP), the adjacent buffer zone of Mugu district (Jnawali et al 2012), and an additional area in Jumla district outside both (Bhatta, Shah, et al 2014). Most people in the area depend on agriculture for their livelihoods but are often short of food because there is little arable land and agricultural productivity is low. Economic activity in the villages is largely limited to traditional occupations such as agriculture, animal husbandry, the collection of medicinal herbs and high-value NTFPs, home trade industries, and seasonal outmigration for employment. Within this traditional economy, the mountains of the study area constitute core resources for both local people and globally threatened species, such as red panda, snow leopard (*Panthera uncia*), musk deer (*Moschus chrysogaster*), and Himalayan tahr (*Hemitragus jemlahicus*).

Data collection

Data were collected from November 2017 to January 2018 using qualitative research methods including Key Informant Interviews (KIIs; Holloway and Galvin 2017), Focus Group Discussions (FGDs; Morgan and Spanish 1984), informal interactions, and participant observation (Kawulich 2005; Musante and DeWalt 2011). Participants in KIIs and FGDs were selected on the basis of their intimate knowledge of and experience in the region and its environments. Informants'

knowledge was based on their social role, professional expertise, or experience in the sector of our research interest. KIIs ($n = 15$) were conducted with the District Forest Officer of Jumla district, the rangers of RNP, members of the RNP buffer zone management committee and community forest user groups, the customary village chief (*Mukhiya*) of each of the study villages, representatives from the mothers' groups (*Ama Samuha*), school teachers, senior citizens, and herders. A total of 6 FGDs, 3 inside and 3 outside the PA, were also carried out in the study area. For most FGDs, village leaders nominated people they thought would increase the likelihood of obtaining reliable information relevant to the research questions. A discussion with 8 to 10 participants was then conducted for a period of around 2 hours. Relevant information was also collected from various governmental administration bodies, line agencies, and nongovernmental organizations and international nongovernmental organizations. Informal community consultation was first established with customary village heads, elders, and other local leaders who further facilitated KIIs and FGDs.

The purpose of the research project was explained to all groups with a description of the methods to be employed and the affiliations of the researchers. Information during the individual interviews and group discussions was gathered by using a semistructured questionnaire (Longhurst 2003; Baumbusch 2010) that had been designed to elicit information about the ecosystem goods and services provided by red panda habitats that contribute to the livelihoods and wellbeing of the local people. The FGD participants then ranked the 5 main ES perceived as most important to their livelihoods and wellbeing. Relevant information was collected by taking notes and through digital recordings in the local language.

Data presentation and analysis

The information was transcribed, translated into English, imported in Qualitative Data Analysis (QDA) software, NVivo 11, and then categorized and classified using CICES, version 5.1 (www.cices.eu). The CICES classification allows translation among various alternative ES classification schemes (Haines-Young and Potschin 2018). Such schemes include the Millennium Ecosystem Assessment (MEA; Leemans and De Groot 2003), The Economics of Ecosystems and Biodiversity (TEEB; Sukhdev 2008), and the Intergovernmental science policy Platform on Biodiversity and Ecosystem Services (IPBES; Díaz et al 2015). Under CICES's hierarchical structure, the 3 major categories ("sections") of provisioning, regulating, and cultural services are divided into more precise "divisions," "groups," and "classes" (Haines-Young and Potschin 2012; Potschin and Haines-Young 2016; Czúcz et al 2018) into which users can place the services they are assessing (Czúcz et al 2018). In contrast, the MEA, the first large-scale ecosystem assessment framework (EC 2013), had no structured classification at lower levels. To aid interpretation of the information (Miley and Read 2011), a visual representation of the responses from the FGD participants inside and outside RNP was encapsulated in word-clouds using the online word-cloud generator WordArt (https://wordart.com), based on those words that occurred with highest frequency (Heimerl et al 2014) after they had been translated.

Results

Major benefits obtained from red panda habitats

The ES provided by remote red panda habitats were categorized into 4 sections, 6 divisions, 9 groups, and 17 classes (Table 1), according to CICES version 5.1 (Haines-Young and Potschin 2018). Consumptive uses included terrestrial wild plants, animals, and surface water, for nutrition, materials, or energy, and seasonal transhumanism; productive uses included direct use goods such as medicinal herbs, bamboo products, and the products of beekeeping; goods and services with nonconsumptive uses identified were recreational activities, research, aesthetic experiences, and symbolic and religious interactions with nature. Nonuse ES were also recognized in the red panda habitats, including existence, option or bequest values, and cultural abiotic services in the form of religious sites, caves, and high-altitude rangelands.

Contribution of ES from red panda habitats to local communities

The main source of income for all villagers was the collection and sale of traditional medicinal herbs and seasonal transhumant pastoralism. FGD participants described how most villagers depend on red panda habitats, although the level of dependency varies. Some villagers rely primarily on transhumant sheep and goat pastoralism, others on harvesting of medicinal herbs, and some on both. After herb collection and grazing on highlands in summer, villagers generally look for alternative sources of income during winter, including short-term employment in India, weaving baskets using bamboo collected from the forest, making wool rugs, etc. The men were responsible for transhumant pastoralism and for picking medicinal herbs while women undertook household (domestic) work and collected firewood, fodder, and bedding for animals.

Provisioning contributions: The FGD participants identified edible wild fruits, flowers, mushrooms, green leafy vegetables, wild birds, and freshwater fish as supplementary sources of nutrition derived from red panda habitats.

Red panda habitats also supplied medicinal and aromatic plants used directly by villagers in traditional remedies, conventional therapies, and income generation. Medicinal plants were used for traditional health benefits and generated relatively high financial returns. FGD participants described how leaves, shoots, flowers, fruits, seeds, bark, resin, tubers, roots, rhizomes, or whole plants were all utilized to prepare traditional medicine and for trade.

Plant resources from red panda habitats also provided forage and bedding for domestic stock. Forests supported beehives for honey production, flowers were used in religious and traditional rituals, and the fibrous inner bark of *lokta* bushes (*Daphne* spp.) provided raw materials for handmade *lokta* paper. Some species had many uses: for example, bamboo (*Drepanostachyum* spp.) was used for fencing, roofing, construction of cattle sheds, weaving of mats and baskets, and fodder for animals. A major forest good was firewood, the primary means of energy for cooking and heating with timber, and lumber was also used for household construction and creation of agricultural implements. Slates from these habitats were used as a roofing

material. Red panda habitats also supplied potable water through pipelines, brooks, and springs, as well as for various other domestic uses, for crop irrigation, and to operate traditional mills. Streams and rivulets were also used to generate micro- and pico-hydropower.

Cultural contributions: Red panda habitats in the study area provided biotic and abiotic cultural benefits on a local, regional, and global scale. Seasonal transhumance culture has been practiced in these habitats for as long as any of the FGD participants could remember with livestock—mainly sheep and goats—taken to high-altitude rangelands where NTFPs were also collected. Not only does this generate income, but it is also seen as integral to local culture.

FGD participants also explained how deities were worshiped every year following traditional rituals at religious temples, holy sites, lakes, and caves inside the red panda habitats. These places also provided active or passive interactions with nature through their aesthetic value to both local people and visitors, while endangered flora and fauna in the region provided a range of existence, option, or bequest values.

The cultural values also provide economic benefits to local communities through provision of services to tourists, including homestays, horseback riding, boating, tourist guides, etc. Scientific investigation on the status and biology of mammals, birds, fish, and forests regularly occurred inside the PA. These areas also provided a venue for local and regional educational opportunities through field excursions and research training. Study sites were also used for making films and documentaries.

ES important to the local communities

Participants' preferences for the "5 goods and services from red panda habitats most important for your livelihood?" were consistent among the 6 FGDs, but their priority varied according to the respondents' accessibility and availability of resources and services. Respondents outside the PA gave highest priority to the seasonal grazing highland pastures and plant materials, with transhumance culture next and wild plants for energy and religious interaction with nature as the least important (Figure 2A). Respondents inside the PA, however, put greater emphasis on plant materials, with less importance to the other 4 attributes (Figure 2B).

As shown in Figure 3, key ecosystem goods and services identified by focus group discussants in all 6 villages were those that contributed directly to their livelihoods (eg wild plants for energy, seasonal grazing highland pastures, and plant materials) and cultural values (eg transhumance culture, religious interaction with nature, and recreation activities and ecotourism). Participants outside the PA prioritized seasonal grazing highland pastures, while plant materials were more important to respondents inside the PA (Figure 3A, B). The FGD in one community inside the PA identified recreational activities and ecotourism in the top 5 ES from red panda habitats (Figure 3B).

Discussion

The novelty of this study lies in its identification and categorization of the major goods and services that people living in the locality obtain from the remote mountain habitats of the red panda. The study demonstrates the important contribution of these services to sustaining the livelihoods of the communities residing inside and outside the mountain PA. Most research in Nepal relevant to red pandas has so far focused on the status, distribution, habitat preferences, diet, diseases, conservation threats, and ecology of the species (Yonzon 1989; Bhatta, Shah, et al 2014; Sharma et al 2014; Lama et al 2015; Panthi et al 2015, 2017; Acharya et al 2018; Thapa et al 2018; Bista et al 2019). To date no research has focused on how these habitats are contributing to the daily needs of the human communities with whom the pandas coexist, both inside and outside PAs. ES-related studies in Nepal, which could have covered this gap, have largely neglected the mountainous parts of the country (Lamsal et al 2018). Our work has showcased the people's understanding of services that they obtain from these mountain areas. Determining the dependency of villagers on the diverse resources from these habitats can inform development of relevant policies and plans and can help to conserve red pandas while simultaneously improving the sustainability of resource management by local people.

Identifying contributions of ecosystem goods and services from red panda habitats

In this study, we identified 51 types of ES from 17 different classes that were recognized by people as provided by the panda's mountain habitats (Table 1), including 23 provisioning and 28 cultural goods and services. By way of comparison using a categorization broadly similar to our own, 42 ES were identified in the Chure region in central Nepal (Acharya et al 2019), 37 in the Panchase mountain ecological region of western Nepal (Adhikari et al 2018), 10 from the Chure region of western Nepal (Bhandari et al 2016), 24 in the Jagadishpur reservoir catchment area of western Nepal (Baral et al 2016), 15 from the Koshi Tappu wildlife reserve of eastern Nepal (Sharma et al 2015), and 19 from the community-managed forests in central Nepal (Paudyal et al 2015). The higher diversity of services provided by red panda habitats may be because the communities who provided the information have a greater reliance on the diverse mountain resources and stronger cultural interconnections with nature than at other sites, as there are few alternatives to support their livelihoods. Respondents also claimed more cultural benefits than provisioning services from red panda habitats, possibly because people living in and around red panda habitats consider these places to be holy sites bearing spiritual power, a belief common to many of the religions practiced in the area (Bernbaum 2006: 306). The ancient practice of seasonal transhumant pastoralism also draws on a wide range of services that are then transformed into economic goods—in Nepal's western mountains a herder can make about US $200 a year from this custom (Gentle and Thwaites 2016).

Communities near Rara Lake inside the National Park also engaged in tourism activities such as homestays, horseback riding, and boating and were aware that the red panda habitats inside the park are providing platforms for scientific research, guided tours, films, and documentaries. Overall, the panda habitats inside the PA tended to provide more cultural services, while those outside offered more provisioning services. This may be because park regulations limit access to the resources, so people have started seeking

TABLE 1 Categories of key ecosystem goods and services from red panda habitats; the classification typology including sections, divisions, groups, and classes was adapted from CICES version 5.1 proposed by Haines-Young and Potschin (2018). (Table extended on next page.)

Ecosystem goods and services categories (modified from CICES version 5.1)			
Section	**Division**	**Group**	**Class**
Provisioning (biotic)	Biomass	Terrestrial wild plants for nutrition, materials, or energy	Terrestrial wild plants, including fungi, and algae used for nutrition
			Fibers and other materials from wild plants for direct use or processing (excluding genetic materials)
			Terrestrial wild plants used as a source of energy
		Wild animals (terrestrial and aquatic) for nutrition, materials, or energy	Terrestrial and aquatic wild animals used for nutritional purposes
	Other types of provisioning service from biotic sources	Other	Other
Provisioning (abiotic)	Water	Surface water used for nutrition, materials, or energy	Surface water for drinking
			Surface water used as a material (nondrinking purposes)
			Freshwater surface water used as an energy source
Cultural (biotic)	Direct, in situ, and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment	Characteristics of living systems that enable activities promoting health, recuperation, or enjoyment through active/passive or immersive/observational interactions
		Intellectual and representative interactions with natural environment	Characteristics of living systems that enable scientific investigation, education, and training
			Characteristics of living systems that are resonant in terms of culture or heritage
			Characteristics of living systems that enable aesthetic experiences
	Indirect, remote, often indoor interactions with living systems that do not require presence in the environmental setting	Spiritual, symbolic, and other interactions with natural environment	Elements of living systems that have symbolic meaning
			Elements of living systems that have sacred or religious meaning
			Elements of living systems used for entertainment or representation
		Other biotic characteristics that have a nonuse value	Characteristics or features of living systems that have an existence, option, or bequest value
Cultural (abiotic)	Direct, in situ, and outdoor interactions with natural physical systems that depend on presence in the environmental setting	Physical, experiential, intellectual, and representative interactions with abiotic components of the natural environment	Natural, abiotic characteristics of nature that enable active or passive physical, experiential, and intellectual interactions

[a] Mode of use of goods and services: Use services: direct (C: consumptive, P: productive use), indirect (NC: nonconsumptive use); nonuse services: NU. Service locations: O: outside the protected area (Jumla District), I: inside the protected area (Mugu District).

TABLE 1 Extended. (First part of Table 1 on previous page.)

Services/goods and services from red panda habitats	Use of services[a]	Services locations[a]
Edible wild fruits and flowers, bamboo shoots, mushrooms, green leafy vegetables	C	O and I
Medicinal plants/herbs, wood and wood products, roofing slate, bamboo species and products, handmade paper, forage, fodder and bedding for animals, flowers for religious offerings	C and P	O and I
Firewood, pine sticks	C	O and I
Birds, fishes	C	O
Beekeeping, highland pastures	C and P	O and I
Potable water through pipelines, spouts, brooks, springs	C	O and I
Water for domestic uses, agricultural uses, traditional mills	C	O and I
Micro-hydropower, pico-hydropower	C	O and I
Traditional walking routes, roads, tourist activities, hiking, horseback riding, boating, and other recreational activities in and around Rara Lake inside the red panda habitats	NC	O and I
Research/studies on biological diversity or forest resources, bird watching, mammal inventory, fishery research, educational tours	NC	O and I
Seasonal transhumance culture	C and P	O and I
High-altitude rangelands, picturesque landscapes, Rara Lake ("the queen of lakes")	NC	O and I
Himalayan monal ("national bird of Nepal"), rhododendron ("the national flower of Nepal"), endemic fish species	NC	O and I
Presence of temples, holy sites, lakes, caves inside the red panda habitats	NC	O and I
Documentaries and films	NC	I
Threatened flora and fauna, biological diversity inside the RNP	NU	O and I
Presence of caves, lakes, religious sites, temples, scenic views, mountains	NU	O and I

alternatives sources of livelihood. For some people, cultural services, specifically ecotourism in the effectively managed region, are progressively being accepted as a substitute for traditional livelihoods (Fleming and Fleming 2009).

Our study presents the understanding of the use and non-use ES obtained from mountain red panda habitats that are crucial for the welfare of local communities. Respondents stated that, in keeping with many rural communities in developing nations (Vira and Kontoleon 2012), there is significant reliance on forest ES, with productive uses including medicinal herbs, bamboo products, transhumant practices, and ecotourism still being the major sources of income for them. Indeed, forest ecosystems are critical to the national Nepalese economy, providing food, fiber, freshwater, and medicine to 80% of the Nepalese population and contributing almost 90% of all energy usage (DNPWC and BCN 2012).

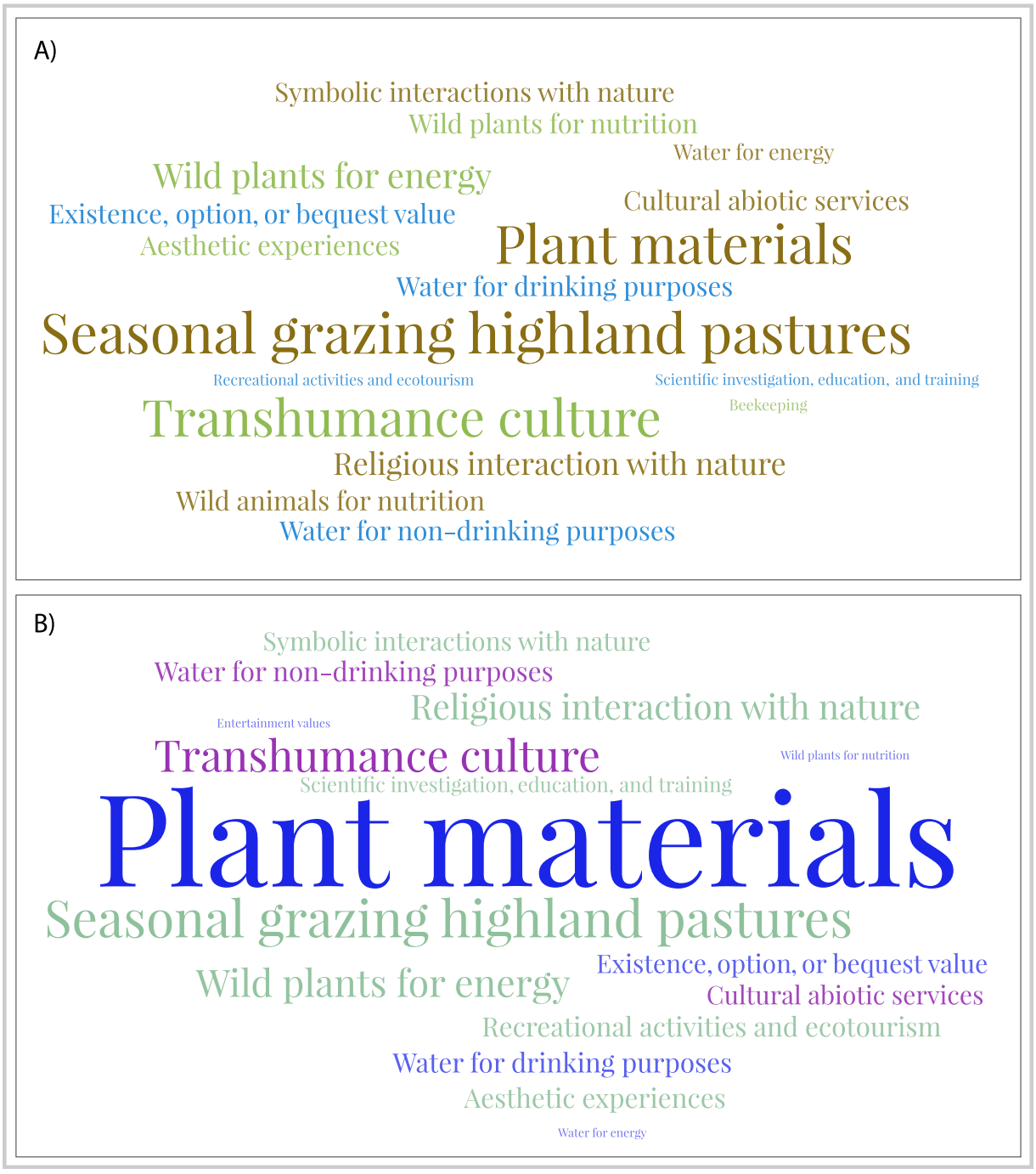
High-value ES

The top 5 ES for livelihoods and cultural significance are similar to those identified from the community-managed forests in central Nepal (Paudyal et al 2015), but they are influenced by local context (Daw et al 2011; Chaudhary et al 2018). Thus, as noted by He et al (2018) in southeast China, proximity to a PA limited access to the forest resources but provided opportunities to draw on other services such as ecotourism and associated recreational activities. Likewise, in the Chure region of Nepal (Acharya et al 2019), proximity to the forest, socioeconomic status, and forest management systems influenced ES priorities. Although local communities in our study area needed to travel a whole day to reach the important high-altitude rangelands, these areas were still valued highly. Such preferences may be because of a greater reliance on these services for livelihoods than others. This may also be because of the priority given to religious sites—such as temples and holy sites inside the red panda habitats—as also noted in China (He et al 2018). Firewood from these forests was also vital as a source of energy regardless of the distance, in keeping with many rural communities (Muhamad et al 2014; Ahammad et al 2019). About 64% of houses in Nepal use firewood as the primary means of energy for cooking (CBS 2012), and globally, around 2.4 billion population use firewood for cooking, heating, and boiling water (FAO 2018).

Gaps in the identification and classification of ES

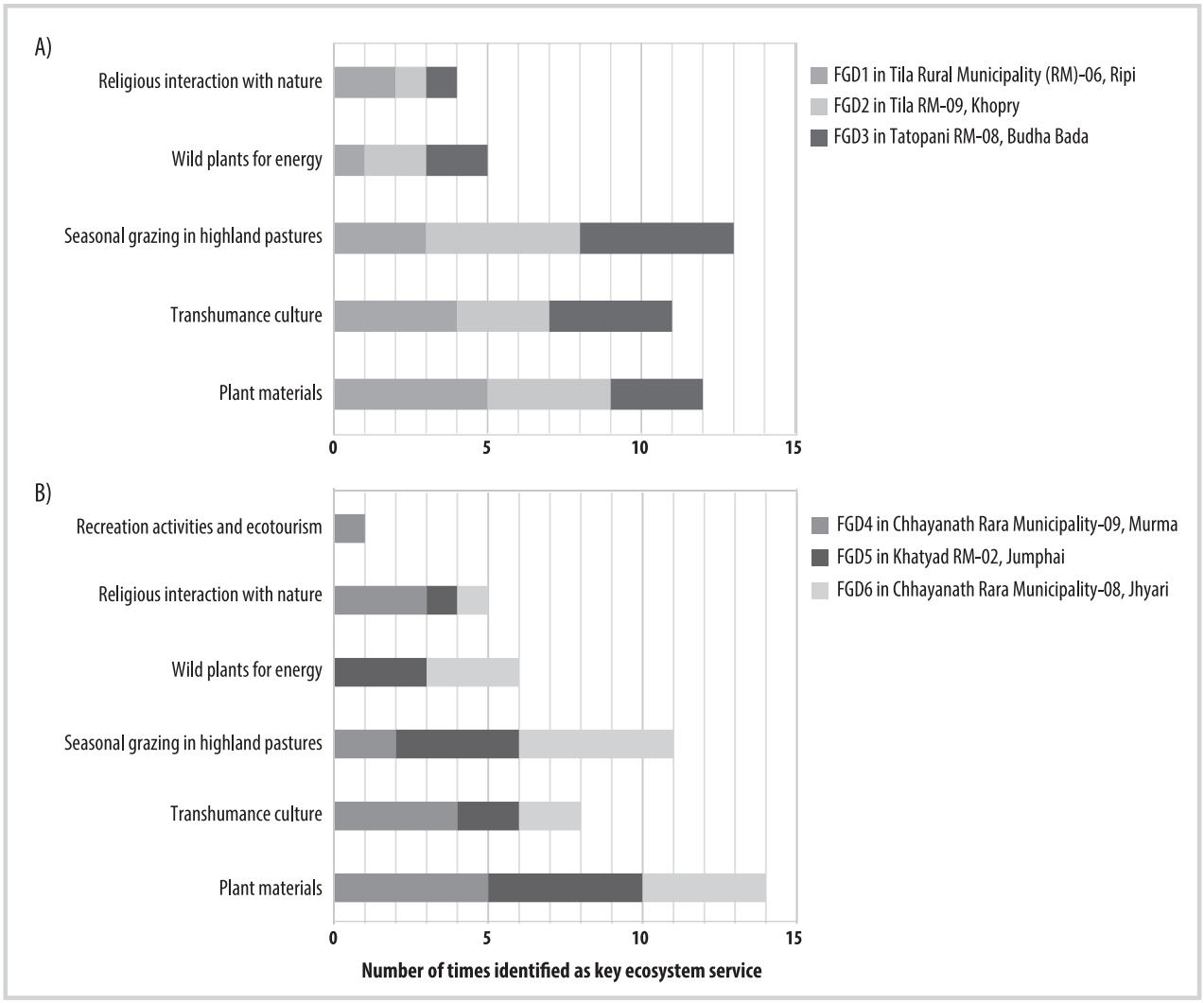
We broadly categorized the ES described in the FGDs and KIIs according to the CICES. However, some services listed could not readily be described, while some services known to be produced by the panda habitats were never mentioned. The two gaps are related. The CICES classification categorizes religious services, cultural services, and spiritual services as potential ES but does not spell out what might be included, or excluded, from these categories. As in the study of the Panchase mountain ecological region of western Nepal (Adhikari et al 2018), we found it difficult to find concordance between the CICES classification and what was described in the FGDs and KIIs as included within these categories. On the other hand, FGDs and KIIs universally omitted mention of regulating and maintenance services as use values.

FIGURE 2 Word clouds illustrating the priority given to ecosystem goods and services among the local users of red panda habitats (A) outside and (B) inside Rara National Park. The larger the word size, the higher the priority given to the service and vice versa.



We think this was at least partly because of the ontological framing of the concepts. It became evident in the FGDs and KIIs that many aspects of nature are not considered separately from the gods and goddesses who are embodied in the mountains. These deities regulate and maintain the services western science has categorized as climate control, carbon storage, natural hazard reduction, and maintenance of air, water, and soil quality. If the environment is thought of as sentient, which seemed to be the case from the way in which people spoke of the mountains, then people have little control of the services provided, even if, to outsiders, the ongoing provision of many of these services is critical to wellbeing and livelihoods beyond the mountains. This means that many regulating and maintenance services can be categorized most readily as cultural and spiritual services rather than use services. This finding is consistent with other research exploring the application of the ES framework to spiritual services provided by the natural environment (Cooper et al 2016), particularly where there are interrelationships between people and nature (Pascua et al 2017). It highlights a need to explore more deeply ways in which these different

FIGURE 3 Key ecosystem services identified by stakeholders in (A) outside and (B) inside the PA. FDG: Focus Group Discussion.



worldviews can be accommodated into the largely utilitarian ES framework (Sangha et al 2019).

Management implications

Identification and classification of ES benefits accruing to local communities from red panda habitats provide an evidence base and the first step toward supporting more sustainable resource management. There are 5 steps that logically follow this exercise (constituting the first step). The second step will be to quantify the goods and services that we have identified as required to support local livelihoods, including ways of incorporating cultural and spiritual values (Sangha et al 2019). The third is to estimate their value to different sectors of the community, including to communities beyond the region that draw on the regulating and maintenance services provided by the panda habitats. The fourth is to assess the status and trends in the availability of the ES, identifying factors that might lead to negative trends. The fifth step is to explore the policies, regulations, and governance regimes that will be most effective in sustaining provision of the ES from red panda habitats at healthy levels.

Understanding the level and trends in resource use and the distribution of benefits among the stakeholders would help reveal the extent to which these habitats address poverty and equity issues in the region. Research on trends in the availability of resources is required to explore not just current uses but also how future service provision is likely to be affected by a range of drivers such as climate change and changes in socioeconomic trends. Assessments of ES can help to accumulate a knowledge base on the benefits from ES, which, in turn, can promote sustainable biodiversity conservation and help raise community awareness, build local capacity, engage communities and line agencies in decision-making processes, and ensure alignment of management with national conservation policies (Thapa et al 2016).

Trade-offs between current and prospective uses of the same ES (Carpenter, Bennett, et al 2006; Rodríguez et al 2006), as may happen in our study area from overharvesting of medicinal herbs or the excessive extraction of Himalayan bamboo species (the sole food for red panda), need not always have negative consequences (Bennett et al 2009; Turkelboom et al 2016). This is apparent in RNP, and elsewhere in the red panda's range (Bista 2018), where reduction in delivery of one ES (transhumant pastoralism) is

resulting in an increase in another (ecotourism), as has happened in other areas where there have been synergies between improving wildlife habitats and enhancing prospects of recreation and ecotourism (Lindsey et al 2007; Baral et al 2017).

A thorough assessment of the values and trends of ES in red panda habitats can also potentially form the basis for development of a payments for ecosystem services (PES) scheme (Bhatta, van Oort, et al 2014; Baral et al 2017). However, carefully planned and locally defined incentive-based mechanisms for maintaining ES (Jack et al 2008; Patterson et al 2017) can often be more effective than a market-based PES mechanism (Sydee and Beder 2006). This, however, requires an effective governance system, particularly of the ES that are being overexploited. The national policy environment for such governance is already in place. As a party to the Convention on Biological Diversity, Nepal has formulated a National Biodiversity Strategy and Action Plan (NBSAP) 2014–2020 as a policy instrument focusing on effective conservation of biological diversity, sustainable utilization of natural resources, and mainstreaming biodiversity into policies and plans (MoFSC 2014b). Realizing the gaps and major constraints in sustainable mountain ecosystem management and the urgency of incorporating the values of mountain ES into governmental planning and decisions, the NBSAP has addressed mountain biodiversity as a separate thematic area for the purpose of strategic planning. The declaration of PAs can also help safeguard the future delivery of ES (Thapa et al 2016). Nepal has already satisfied Aichi Target 11, which requires conservation of at least 17% of terrestrial areas, by gazetting 23% of the country as PAs (MoFSC 2014a), including 84% of mountain areas (MoFSC 2014b). However, deep-rooted poverty-induced human pressure and human-induced climate change means protected mountain sites are not yet improving the status of Nepal's biological diversity (Bhattarai and Kindlmann 2013). Also, many areas with high biodiversity value, including 70% of red panda habitats, fall outside the PAs (MoFSC 2014b). This suggests that a community-based, landscape-level approach (Lindenmayer et al 2008; Sayer 2009; Arts 2017) to ES governance is needed to build a positive nexus between preservation of mountain habitats, species conservation, and sustainable livelihoods of deprived communities.

While community-based management approaches to strengthen ecosystems and conserve landscapes are gaining popularity in Nepal (Bhatta, van Oort, et al 2014), and a conservation intervention by the Red Panda Network in red panda habitats of eastern Nepal underpins community-based red panda conservation (MoFSC 2014a), if these initiatives are to succeed there is a need to focus on sustainability both of ES from these habitats and of the ways in which use of the ES supports societal livelihoods and wellbeing. Similarly, policy instruments targeted at red panda conservation should include detailed habitat-level studies focusing on identification, quantification, valuation, and the interrelationship between ES obtained, human disturbance, and alternatives to reducing the human pressure. The information obtained could drive more equitable and sustainable policies. Thus, conservation of this charismatic priority species could simultaneously safeguard the wellbeing and sustainability of associated biodiversity, ecosystems, and local communities.

Conclusions

This study describes provisioning and cultural ecosystem goods and services perceived by local people as supporting rural livelihoods in the habitats of the red panda in the mountains of western Nepal, including their significance for local subsistence. Identification of ecosystem goods and services from these mountain landscapes provides an evidence base that may inform policy reform for the sustainable conservation of biodiversity and equitable management of ES in the region. Understanding the nature and scale of such services can help to emphasize the need for effective ES governance. Overall, knowledge of ES flowing from the mountain habitats of the panda can help to regulate their use and management for the current and future delivery of needed and desired goods and services.

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