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Alton C. Byers
University of Colorado Boulder, alton.byers@colorado.edu

Elizabeth Byers
WV Dept of Environmental Protection, appalachian.ecology@gmail.com

Milan Shrestha
Arizona State University, milan.shrestha@asu.edu

Dambar Thapa
The Partners Nepal, dthapachhetri@hotmail.com

Bidhya Sharma
Bangor University, info.bidhya@gmail.com

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Alton C. Byers
Elizabeth Byers
Milan Shrestha
Dambar Thapa
Bidhya Sharma

Around 2003, the highly valuable medicinal fungi *Ophiocordyceps sinensis* (Nepali: *yartsa gunbu*) began to be commercially harvested in the remote Barun valley of the Makalu-Barun National Park and Buffer Zone, eastern Nepal. Since then, an estimated 3,000 collectors per year have visited the valley each harvesting season, placing new pressures upon its subalpine and alpine landscapes. A review of the *yartsa gunbu* literature suggested that its harvesting throughout highland India, Nepal, Bhutan, and China has brought important economic benefits, but that it has often been accompanied by a corresponding increase in negative environmental impacts such as alpine shrub destruction, wildlife poaching, and improper garbage disposal. Adverse social impacts reported have included an increase in violence, occasional murder, and the erosion of traditional values. In an attempt to determine if similar phenomena were occurring within the Barun valley, east Nepal, we conducted a month-long study of *yartsa gunbu* harvesting practices between May and June of 2016. Unlike other regions of the Himalaya, we found that violence and social unrest due to harvesting competition were unheard of in the Barun, which we link to the (a) lower market value of *yartsa gunbu* harvested there when compared to other regions, and (b) the recognized role of *yartsa gunbu* as a supplemental and livelihood diversifying income generation opportunity instead of a sole source of new income. Since its collection and sale were legalized by the Government of Nepal in 2001, the concurrent development of locally responsive *yartsa gunbu* harvesting policies and practices can also be linked to the general absence of environmental disturbance that we found.

Keywords: *yartsa gunbu*, Barun valley, environmental impacts, alpine, livelihoods.

Introduction

Ophiocordyceps sinensis (Figure 1) is one of the most valuable medicinal fungi in the world, commanding prices of over $50,000 per pound in Chinese markets, depending upon size, color, aroma, and region of origin (Shrestha et al. 2014). Translated as "summer grass, winter worm," *yartsa gunbu* is a parasitic complex formed by the relationship of the fungus *Ophiocordyceps sinensis* with the larval stage of several species of moth of the genus *Thitarodes*, known as the "ghost moth" (Shrestha and Bawa 2013). It is found between the altitudes of 3,000 and 5,000 m. A telltale black stromata emerging from the soil indicates the presence of the mummified caterpillar body just below, which is either dug or pulled out by hand, or extracted with a small pick, depending upon soil type and compaction (Winkler 2008; Shrestha et al. 2014; Byers et al. 2016). Used to cure a variety of ailments as well as an alleged aphrodisiac, the harvesting and sale of *yartsa gunbu* can provide up to 65 percent of a rural Nepali's annual income (Shrestha and Bawa 2014a; Schultz 2016; Shrestha et al. 2017), and is said to be "contributing to economic and social transformations across the Tibetan Plateau and Himalayan region faster than any development scheme could envision" (Childs and Choedup 2014). At the same time, a range of negative ecosystem impacts resulting from the often large and unregulated numbers of *yartsa gunbu* collectors, for example, wildlife poaching, ecosystem disturbance, and improper waste management, have been reported for various harvesting regions throughout Nepal and Tibet (Devkota 2006; Cox 2008; Winkler 2008).

Around 2003, local people began to harvest *yartsa gunbu* commercially in the alpine zone of the remote Barun valley of the Makalu-Barun National Park and Buffer Zone, Nepal. Based upon a review of the literature, it seemed likely that the negative environmental impacts of its collection found elsewhere would be present in this little known and remote valley as well, a hypothesis which we attempted to test in the course of two research expeditions in June–July 2014 and May–June 2016. In the interest of broadening the knowledge base of *yartsa gunbu*, the following paper discusses our findings regarding the impacts of *yartsa gunbu* harvesting upon the vegetation, biodiversity, soils, wildlife, and landscapes of the alpine ecosystems of the Barun valley.

Background

Especially during the past decade, thousands of harvesters have lived and collected *yartsa gunbu* in the alpine valleys of highland Nepal, India, Tibet, and Bhutan each summer, areas that historically have seen only a handful of livestock herders per year. The majority of the *yartsa gunbu* literature is focused on its therapeutic uses (e.g., Shrestha et al. 2012), chemical analyses (e.g., Zhang et al. 2012), socio-economic benefits (e.g., Winkler 2008; Shrestha et al. 2014;

Figure 1. *Ophiocordyceps sinensis*, the 'caterpillar fungus' known locally as *yartsa gunbu*. Specimens collected in the Barun valley alpine zone tend to be smaller and of lower quality than those found elsewhere, particularly in western regions such as Dolpo.

(A. Byers, 2016)

Hansen 2011; Thapa et al. 2014; Childs and Choedup 2014), and sustainability (Winkler 2008; Negi et al. 2014; Shrestha and Bawa 2014b; Thapa et al. 2014; Shrestha 2012). Also frequently mentioned are a range of negative socio-economic impacts related to the high value of *yartsa gunbu* as a new source of income, such as concurrent increases in violence (Hansen 2011; Thapa et al. 2014), conspicuous consumerism (Budha 2015; Winkler 2008), erosion of traditional values, increases in gambling, and increased consumption of alcohol (Winkler 2008). The topic of harvesting techniques and impacts upon the alpine environments where the fungus is found, however, remains largely undocumented (Shrestha et al. 2014).

When the impacts of harvesting *yartsa gunbu* are mentioned, they are often negative in scope and rarely quantified. Cox (2008: 2), for example, writes of the "dire conservation problems...[of]...broad scale and intensive cutting of dwarf juniper and rhododendron (*Rhododendron leucoseptum* and *R. nivale*) shrub" in the Rukum and Dolpa regions of Nepal, resulting in slopes "...within a several kilometer periphery of main camps...being rapidly degraded." Negi et al. (2014: 886) write of the concurrent "...exploitation of herbaceous [medicinal and aromatic] plants whose roots and flowers the host larva thrives" in Pithoragarh district, India, and degradation of the lower reaches of *yartsa gunbu* harvesting sites on "account of the space being occupied [by collectors](p. 886)." Other references to the negative impacts of *yartsa gunbu* include those from Devkota (2006: 51), who mentions the "high use of fuel wood" in Dolpa; Dema (2013: 2), citing the degradation of alpine environments in Bhutan; and Shrestha et al. (2014: 12), who lament the "...impact of fuel wood [harvesting], open defecation, and amassing solid waste in the landscape..." in Dolpa that "...can be easily observed."

The problem of improper solid waste management has also been highlighted by Winkler (2008: 297), who writes that although permit fees in Dengchen County, Seda Xiang, Tibet were said to be used for the collection of garbage after the harvesting season, the "...campsites that I visited... were marked by empty and broken beer bottles, discarded instant noodle containers and plastic bags." Weckerle et al. (2010: 2694), writing of the Xueshan Nature Preserve in China report that in spite of regulations designed to keep harvesting camps clean, "...the main Shuong camp site after the 2007 season was covered in garbage." The widespread poaching of wildlife in Dolpa, particularly the Blue Sheep,[1] has been described by Cox (2008) and by Devkota (2006) and Lama (2017) in the case of musk deer, snow leopard, ghoral,[2] and other large mammals. Overgrazing and soil compaction by cattle is mentioned by Negi et al. (2014), and Shrestha et al. (2014) claim that large numbers of collectors also leads to soil compaction, now necessitating the use of a small hoe to extract the *yartsa gunbu* which could be easily pulled out by hand only a few years ago. The excessively large numbers of collectors that gather annually in many regions has been reported for Dolpa by Devkota (2010), for the Dhorpatan Hunting Preserve by Shrestha et al. (2013), and for eastern Tibet by Winkler (2008), among many others.

Collectively, the Fungal Red List (IUCN 2016) includes as threats to the alpine ecosystems in which *yartsa gunbu* is collected the (a) harvesting of alpine shrubs for fuelwood, (b) disturbance to ground-dwelling birds and charismatic fauna and (c) nitrogen pollution from increased human waste. Finally, the growing incidence of violence and corruption that can be associated with the highly valuable fungus has been mentioned by Hansen (2011), Shrestha et al. (2014), Thapa et al. (2014), and Childs and Choedup (2014), and is a featured and regular topic in the national press every monsoon season (e.g., Samiti 2016; Miya 2014).

Methods

We used an interdisciplinary approach that combined the social and physical sciences in order to generate more in-depth insights regarding the impacts of *yartsa gunbu* harvesting upon the environments and people of the Barun valley. Social science data were generated through ethnographic techniques such as in-depth interviews with key respondents and participant observations (Bernard 2002). A total of forty key respondents were interviewed using the chain referral technique (Penrod et al. 2003), which helped us identify and interview key respondents who were knowledgeable in their respective fields. Respondents represented harvesters (n = 20), middlemen (n = 2), national park personnel (n = 2), and lodge owners (n = 16). The interviews were informal and open-ended, with questions focused on harvesting methods, seasons, regulations, fuelwood use, solid and human waste problems, and other phenomena.

At the recommendation of local informants, we visited five of the Barun valley's sixteen different harvesting sites in the vicinity of Yangle Kharka (Figures 2 and 3) in May-June 2016. This included a one week stay camped at Asamasa (4,450 m), and day trips to Yak Desa (3,962 m), the fir-rhododendron forests near Yangle Kharka (3,610), Yangle Salix tall shrubland (3,765 m) and Langmale (4,510 m). The Makalu basecamp and vicinity, although not considered to be *yartsa gunbu* harvesting sites, were also visited to examine more recent impacts of lodges, trekking groups, and mountaineering teams upon the surrounding alpine and

subalpine ecosystems. A total of eighteen soil and vegetation sampling plots (5 m x 5 m) were established within the five *yartsa gunbu* harvesting sites visited, and sixty-eight plots were established in non-harvesting sites, but within the same elevation range, to gain a deeper understanding of the soil and vegetation characteristics of the harvest areas (Mueller-Dombois and Ellenberg 1974). A wildlife survey was conducted that included avian pellet counts, predator scat identification and collection and informal interviews to determine what, if any, the impacts of this new influx of harvesters might be upon wildlife populations. The growing problem of solid waste accumulations and landfills near lodges was noted, and prospective incentive systems for the better management and recycling of solid waste (glass, plastic, metal) was discussed with lodge owners and national park personnel (Byers 2005: 127-132). Fuelwood use was quantified by the direct measurement of harvested shrub juniper and dwarf rhododendron in camps and/or stacked outside of lodges, and by estimates provided by lodge owners and other informants.

The current study also benefitted from the results of our 2014 field work in the Barun valley that attempted to quantify contemporary impacts of adventure tourism upon the valley's alpine ecosystems (Byers et al. 2014). Fortunately, tourist impacts proved to be minimal compared to those found in other alpine regions of Nepal (Byers 2005, 2013, 2017), most likely a reflection of the Barun valley's low tourist numbers, wet and resilient environment, and use of propane for fuel in most alpine lodges and tea houses. At the same time, valuable information was collected regarding livestock populations, lodge and tourism growth since the end of the Maoist insurgency (1996–2006), vegetation dynamics and condition, and the new phenomenon of *yartsa gunbu* harvesting which collectively facilitated and enhanced the current study (Byers et al. 2014).

The Setting

For the present paper, the Barun valley is considered to be the 49 km river valley between Mt. Makalu and its confluence with the Arun river, which includes the trekking route between Shipton Pass (4,420 m) and the Makalu basecamp (4,870 m). Data for lodges, livestock, *yartsa gunbu* collecting, and fuelwood use are not included for villages along the trekking route from the village of Seduwa (1,530 m) to Shipton Pass (4,220 m).

The remote and beautiful Barun valley, known for centuries as a *beyul* (sacred valley) and pilgrimage site to both Buddhists and Hindus alike (Reinhard 1978; Bernbaum 1980), is located in the eastern part of Makalu-Barun National Park (Figure 2). The 476 km^2 watershed is 49 km in length from the eastern Barun/Arun confluence at 1,097 m to the summit of Makalu at 8,463 m to the west. Annual rainfall is at least 4,000 mm/year, the majority of it falling during the summer monsoon, based upon available records from the closest weather station at Num (1,497 m). The valley's seasonal residents are mostly Sherpa people from the villages of Navagaon and Tashigaon in the Kasuwa valley to

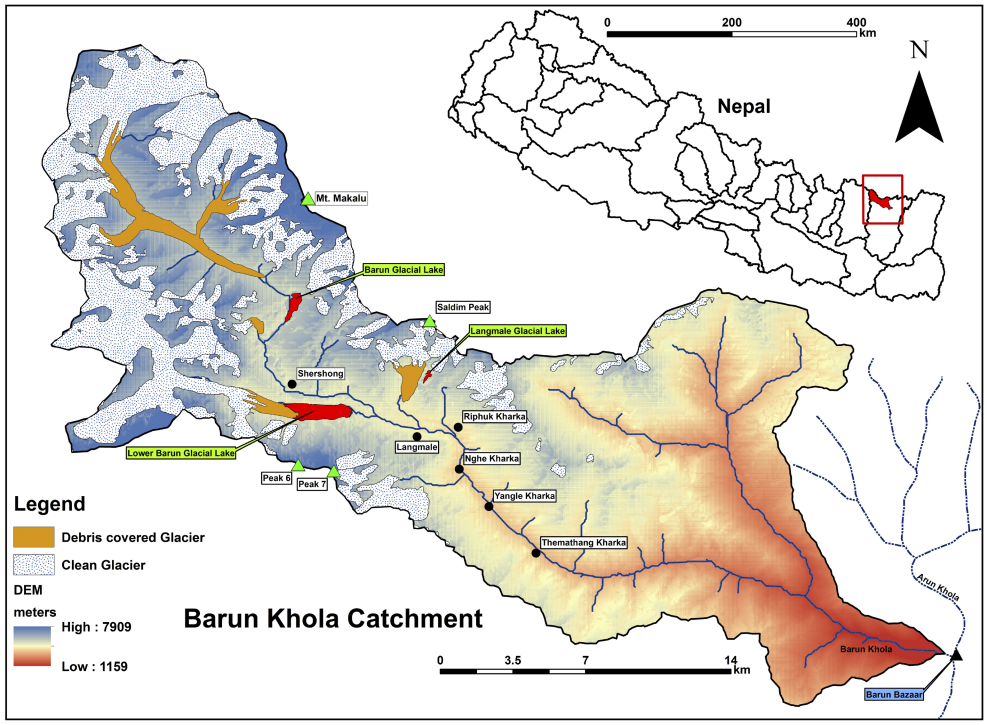

Figure 2. The Barun valley, located within the Makalu-Barun National Park.

(Rakesh Kayastha)

Figure 3. Yangle Kharka (3,610 m). *Yartsa gunbu* harvesting sites are located in the highest alpine pastures shown on the skyline in the photograph. This photograph was taken in 2016, a year before a devastating glacial lake outburst flood destroyed much of the riparian zone between Langmale (4,510 m) and Yangle Kharka.

(A. Byers, 2016)

the southeast, who migrated from the Solu Khumbu region sometime in the sixteenth or seventeenth century (Diemberger 1993a).

Formerly, an eleven day walk from the airstrip at Tumlingtar (400 m) was required to reach the Makalu basecamp. Trekking time has now been reduced by several days if the unpaved, fair weather road constructed from Tumlingtar to Num (1,505 m) is serviceable. Likewise, access to Tumlingtar is no longer restricted to flights, as road access from Dhankuta and Kathmandu was provided in the 1990s.

From Num, about nine days are still required to complete the trek to the Makalu basecamp, including acclimatization, climbing through six different ecosystems and vegetation zones that include hot and rain-drenched sub-tropical *Castanopsis/Schima/ Pandanus* forests (1,000–2,000 m), leech-infested and temperate *Quercus/Magnolia* forests (2,000–3,000 m), subalpine *Betula/Abies/Rhododendron* forests (3,000–4,000 m), high altitude dwarf rhododendron/shrub juniper/*Kobresia* alpine shrub-grasslands (4,000–5,000 m), discontinuous high alpine herbaceous vegetation and cushion plants (5,000 m–6,000 m), and the rock and perpetual ice zone (>6,000 m)(Cronin 1979). Within the valley itself, we identified twelve distinct vegetation communities (Byers et al. 2016). Wildlife includes the musk deer, barking deer, serow,[3] Himalayan black bear, and wild boar. Similar to the Sagarmatha (Mt. Everest) National Park to the northwest, snow leopards have made a significant comeback since the 1990s based upon the abundance of scat and tracks observed, and numbers of yak and sheep depredation recorded. The Barun valley has also received considerable international attention as a result of a number of international 'Yeti hunting expeditions' which have been conducted there since the 1970s (Cronin 1979; Taylor-Ide 2000; Taylor 2017).

The first Western visitors to the valley were the climbers Eric Shipton and Edmund Hillary, who glimpsed the valley from a pass above the Hongu glacier in 1951, returning in 1952 and 1954 to explore and climb in what they described as a "veritable paradise" (Hillary and Lowe 1957: 8). Thirty years later, the Barun was described as "the only major natural habitat in Nepal where the vegetation cover from subtropical to alpine (from 1,000 to 4,000 meters) may be seen in a single sweep of slope...," and "...Nepal's last pure ecological seed" (DNPWC and Woodlands Institute 1984: 1, 8). Likewise, the Makalu-Barun region was frequently described in the early to mid-1990s as being "...a wilderness area of unusual beauty," and recognized "...as one of the few remaining undisturbed natural environments in the Himalayan range" (Sherpa and Lama 1996: 3).

In fact, despite their apparently pristine appearances, forests and alpine ecosystems within the Barun have been extensively modified by humans and cattle over the course of hundreds of years of grazing and burning activity (Cronin 1979; Diemberger 1993b; Byers 1996). For example, between the Khongma (3,562 m) and Shipton Pass (4,178 m), south-facing slopes that are naturally covered with rhododendron shrubland above treeline have been cleared of up to 60 percent of their woody vegetation to promote grass and sedge growth. This is evidenced by the abundance of bright yellow cinquefoil (*Potentilla spp.)* and primrose (*Primula spp.)* flowers (both unpalatable species) that favor these sunny opening sites. Large burned areas of dwarf rhododendron were observed between Yangle Kharka (3,610 m) (Figure 3) and the Makalu basecamp, and hectare size clearings of recently cut shrub juniper were noted at Thulo Pokhari (4,020 m), Riphuk (3,930 m), Langmale (4,650 m), and the Makalu basecamp (4,870 m). A sample of three shrub juniper cross sections showed sixty-four rings at 7.1 cm, 187 rings at 8.2 cm, and 121 rings at 9.3 cm (Cook, E., pers. comm., 2017). Fire has clearly been used as a pasture expansion tool, as seen by charcoal layers found in soil profiles throughout the region that provide evidence of repeated burning (Byers 1996; Byers et al. 2014, 2016). One

profile in the alpine pastures of Langmale showed continual layering of charcoal at depths of approximately 3 cm, 4 cm, 5 cm, 7 cm, and 10 cm, each indicative of a fire that occurred perhaps hundreds of years in the past in the interests of short-term fuelwood supply and long-term pasture expansion. Exposed soils in cattle wallows and truncated slopes throughout the pasture showed similar charcoal layering. Given the exceptionally moist conditions of the valley, the fires were most likely set by humans following the cutting of the shrub the season before (Byers 1996, 2005). Similar conditions were found in 2017 in the nearby Apsuwa and Sankhwa river valleys, suggesting that much of the 'wilderness area' of the Makalu-Barun National Park has in fact been modified by humans and their livestock for centuries (Byers 2018).

Perhaps owing to the valley's high annual precipitation, most burned or cut over areas nevertheless appear to have suffered few adverse impacts, such as accelerated soil loss and degraded hillslopes, as compared to drier and less forgiving alpine ecosystems further to the west, for example, Sagarmatha (Mt. Everest) National Park (Byers 2005, 2013). Pastures along the entire trekking route, from Seduwa to the Makalu basecamp, are in generally good condition, with localized heavy impacts around herders' huts at Khongma (3,562 m), Kalo Pokhari (4,022 m), Mumbuk (3,550 m), Riphuk (3,930 m), and below Langmale (4,510 m). Goats and sheep appear to have had particularly strong impacts on the woody vegetation.

Much of the shrub *Cotoneaster* spp. encountered exhibited a trimmed, buzzcut appearance resulting from the constant browsing of new growth. Some palatable species were only present on cliff faces, boulder tops, or islands that are inaccessible to livestock. The shrub *Potentilla fruticosa* was nearly absent from the area grazed by sheep and goats, but was regenerating above the landslide which marked the upper elevation of browsing livestock. Sheep and goat herders do not take their flocks above the landslide because of the risk of increased predation. Yaks, which are grazers rather than browsers of woody vegetation, are larger in size and more resistant to predation, although losses still occur, primarily by snow leopards.

The Makalu-Barun National Park and Conservation Area (later Buffer Zone) in which the Barun valley is located was officially gazetted in 1992 and covers 2,330 km^2 within Solukhumbu and Sankhuwasabha Districts (Taylor-Ide et al. 1992). The park and adjacent regions have experienced considerable social, physical and demographic change since that time. For example, although hailed as a new model of participatory protected area establishment and management in the 1990s (HMG and WMI 1990), the Maoist insurgency of 1996-2006 totally destroyed the park's infrastructure while eliminating a range of innovative biodiversity conservation, applied research, community development and park management programs initiated by the program (Shrestha et al. 1990). Since about 2010, the demand for cheap labor in the Middle East has resulted in the outmigration of thousands of young Nepali men each year from the region, leaving behind villages that are largely populated by older people, children, and young wives (Sharma et al. 2014). Livestock populations have plummeted since the 1990s, which according to local herders interviewed is a result of the new labor shortage as well as changes in preferred lifestyles. Climate change has led to the formation of new and potentially dangerous glacial lakes, and a recent glacial lake outburst flood (GLOF) from the Langmale glacier destroyed much of the riverine landscape between Langmale and Tematang (Byers et al. 2018). The construction of dozens of new seasonal (unpaved) roads, primarily during the past decade, has brought a range of positive, negative, and uncertain environmental and social changes. Finally, the curious 'moth-plant' *yartsa gunbu* began to be commercially collected in the region around 2003, about ten years after the fungus gained international recognition (Stone 2015) and two years after its harvesting was legalized by the Government of Nepal. As no mention of *yartsa gunbu* can be found in the detailed botanical and socio-economic surveys conducted in the region in the late 1980s (e.g., Shrestha et al. 1990), there is reason to believe that its widespread collection began only once its high economic value became known sometime around 2003. Since that time, as many as 3,000 local (i.e., living within the Makalu-Barun Buffer Zone) and non-local collectors (i.e., living within Sankhwasabha District) visit the Barun and other inner valleys of the Makalu-Barun National Park each year between 15 May and 15 July.

As mentioned, livestock numbers within the valley have decreased significantly in recent years. In the mid-1990s, Lama and Sherpa (1995:26), citing Khadka (1988), reported that "...several hundred herders" graze "...more than 1,000 cattle [most likely *chauri*, or female yak and cow crossbreed] and 5,000 sheep from Hatiya, Pathibara, and Makalu villages that graze on 29 pastures of the Barun valley during the monsoon." The total number of livestock (sheep, goat, *chauri*, yak, and cow) in 2014 was 2,872, less than half of the 1996 estimate, and consisted of 2,020 sheep, 385 goats, 391 *chauri*, 86 yak/nak,[4] and ten cows (Byers et al. 2014). Yak and nak numbers have continued to decrease since then (Byers et al. 2016). The decreases are attributed by the herders we interviewed to the difficulty of finding people to take care of the livestock, with much of the young adult male population leaving for overseas jobs in Saudi Arabia or Malaysia. Young children, once a mainstay of the labor force, are now attending school on a

regular basis and are not available to work in the high pastures. Other contributing factors cited included the hard work involved in herding; the availability of alternative livelihood options such as tourism, medicinal plant and herb farming (e.g., *chiraito*, cardamom); new restrictions on cattle grazing on community forest land; and increased awareness of the importance of children's education. What impacts such decreases in livestock populations will have upon the ecology of the Barun valley, as well as upon future *yartsa gunbu* populations, is not known.

In spite of its spectacular biophysical and cultural diversity, the Barun valley has received relatively little tourism when compared to most other mountain parks in Nepal. Between 2010 and 2015, for example, the Government of Nepal records an average of only 1,027 trekkers and climbers per year to the entire Makalu-Barun National Park (GON 2015), with the majority attempting to climb Mera Peak (6, 476 m), Nepal's highest 'trekking peak.' Our interviews with lodge owners in 2014 suggested that on average a minimum of 175 and maximum of 225 tourists visit the Barun valley each year. Both numbers represent a fraction of the annual number of tourists visiting other parks (e.g., the 34,412 visitors in Sagarmatha (Mt. Everest) National Park in 2015 (GON 2015)), and are most likely linked to the Barun's remoteness, steep topography, lack of infrastructure and facilities, and reputation for being among the most difficult treks in Nepal (Lama and Sherpa 1996; Cox 1999).

Nevertheless, tourist infrastructure has grown considerably within the Barun valley since the mid to late 2000s, perhaps in anticipation of the return and growth of tourism following the Maoist insurgency between 1996 and 2006. As shown in Figure 4, only three lodges or tea houses existed in the Barun valley in the early to mid-1990s: two in Tashigaon (2,065 m) and one in Langmale (4,510 m). A lodge provides food, drink, and accommodation, while a teahouse provides only food and drink. Between 2007 and 2014, sixteen new lodges and teahouses were constructed in the valley, and a total of thirty-three if the entire trek from Seduwa (1,530 m) to the Makalu basecamp (4,870 m) is included. Although the Makalu trek can now be completed as a 'teahouse trek,' most lodges in the Barun valley are still quite rustic in nature, and food varieties are limited when compared to other trekking destinations such as Khumbu, Langtang, or Annapurna.

Corresponding to the presence of new lodges in the valley has been an increase in fuelwood consumption, i.e., 2,835 headloads of fuelwood (99,225 kg) were consumed annually by the lodges and teahouse in 2014. By comparison, the five *goThs* (stone livestock herder's huts with a woven bamboo or plastic tarp roof) in the valley consumed an estimated 1,050 headloads (36,750 kg) of fuelwood in 2014. This is most likely comparable to the level of fuelwood use prior to the construction of the new lodges and teahouses. Tree and tall shrub rhododendron is the most common type of fuelwood used, although lodges in Rephuk (3,930 m), Yak Kharka (4,120 m), and Langmale (4,510 m) burn an estimated 945 headloads (330,075 kg) of shrub juniper per year (Figure 5). Although shrub juniper is still abundant in the Rephuk region, its continued harvesting contributes to the historic practice of removing juniper from the landscape.

Rock exclosures containing plastics, glass bottles, aluminum beer cans and other non-biodegradable waste were observed at Thulo Pokhari, Yangle Kharka, and Langmale, and we also observed landfills at the Makalu basecamp. When the rock exclosure becomes full, it is covered with sod and a new one is constructed. Lodge owners interviewed said that *yartsa gunbu* harvesters purchase next to nothing in the way of alcohol (bottled beer and whiskey), canned goods and other imported foods, such that the vast

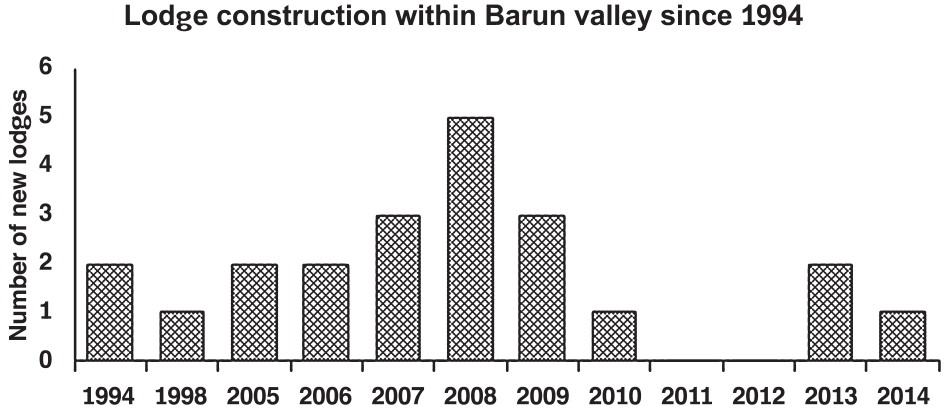

Figure 4. Number of lodges built in the Barun valley since 1994.

(Sharma)

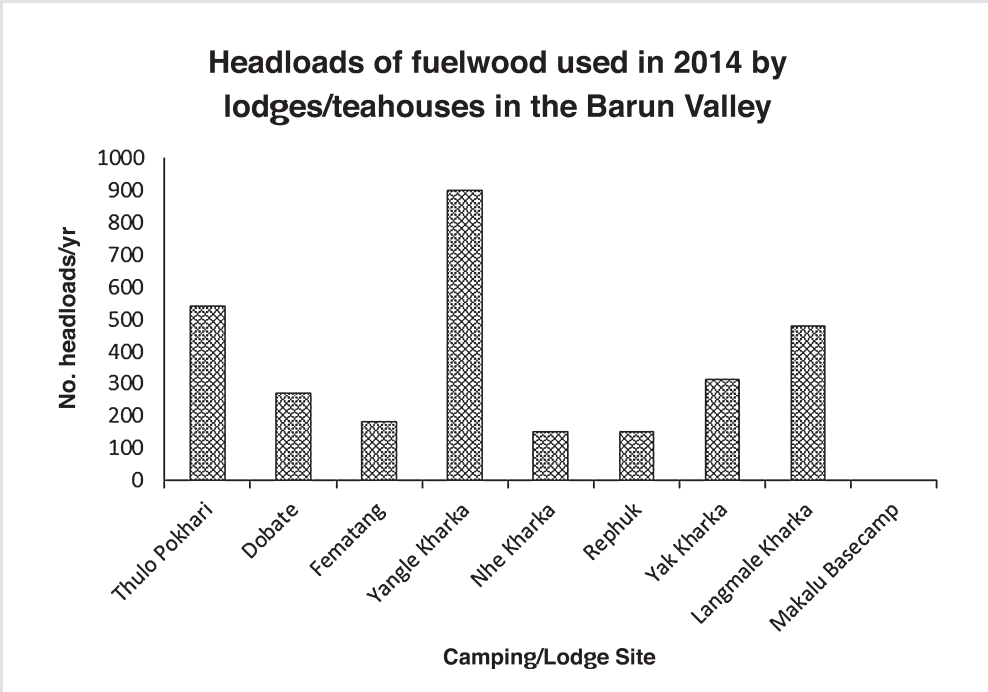

Figure 5. Headloads of fuelwood used in 2014 in the Barun valley.

(Sharma)

majority of the solid waste can be linked to western trekking and mountaineering groups. As no incentive systems exist for lodge owners to recycle, export or ban certain products from entering the valley (e.g., bottled beer and plastic water bottles), the Barun valley is experiencing the same problem of solid waste accumulation and disposal as found in other trekking destinations in Nepal, notably in the Sagarmatha (Everest) National Park. There, landfills and human waste disposal pits in the vicinity of villages along the main trekking routes are resulting in a growing health and safety concern for humans and livestock alike, as the landfills and leaking septic systems contaminate freshwater supplies and increase the incidence of gastrointestinal diseases among tourists and local people (Rogers and Aitchison 1998; Goldenberg 2011). While some progress has been made in recent years in community-based alpine ecosystem conservation and restoration initiatives, solutions to the problem of solid and human waste accumulations in Nepal's national parks remain chronically elusive, under-studied, and of concern.

Finally, the landscapes of the Barun valley were altered recently when on April 20, 2017 a massive glacial lake outburst flood (GLOF) from Langmale lake scoured the lush riparian ecosystem to bare rock and ground from Langmale to Yangle Kharka and beyond (Byers et al. 2018). Six bridges between Tematang and Langmale were washed away, at least 24 yaks and *dzo* (yak-cattle crossbreed) were killed, and Yangle Kharka suffered the loss of many hectares of valuable grazing land because of flood deposits of coarse sand and debris. Four structures were destroyed at Yangle Kharka, including the Makalu-Barun Hotel, an event that was dramatically captured in a video by a visiting trekking group (One Epic Adventure, "Mudflow/Landslide Yangle Kharka, Nepal - 20 April 2017," You Tube Video, May 20, 2017, 2:16, <https://www.youtube.com/watch?v=2VB1PRgb_Ic >). Villagers were deeply concerned that the coming tourist, pilgrimage, and *yartsa gunbu* harvesting seasons would be negatively impacted because of the damaged or destroyed trails, bridges, and dramatically altered landscapes. However, bridge reconstruction began almost immediately after the event, and as most *yartsa gunbu* harvesting sites are located hundreds of meters above the valley floor little impact on the 2018 season is expected. At least two other GLOFs are known to have occurred in the Barun valley during the past hundred years (USAID 2014), and it normally takes forty to fifty years for vegetation to become reestablished.

Results and Discussion

There are sixteen harvesting regions used by local people in the Barun region, from Shipton Pass (4,220 m) to Langmale (4,520 m) in the upper Barun valley. Unlike the comparatively flat steppes of the Tibetan plateau, the harvesting of *yartsa gunbu* in the Barun valley takes on a more vertical 'three-dimensional' approach owing to the region's extremely rugged, high altitude topography (Fig-

ure 6). Harvesters climb seemingly inaccessible cliffs, overhangs, and precipices in search of the fungus, and at least one death by falling was reported for the 2015 season in the Yak Desa harvesting region (Thapa, T. B., pers. comm., 2016; Caplins and Halvorson 2017).

Yartsa gunbu habitat is generally confined to high altitude alpine regions (> 4,000 m) characterized by *Kobresia* sedges, alpine forbs, and grasses. However, we also found fairly abundant populations in the subalpine fir-rhododendron forests and Salix tall shrublands near Yangle Kharka, a phenomenon that has, to our knowledge, yet to be reported in the *yartsa gunbu* literature. Within the alpine zone, the most abundant *yartsa gunbu* was reportedly found in the narrow strip of land between the alpine and beginning of the nival zones (snow and ice), usually above the last dwarf rhododendron stands. Soils in both the alpine and forest/woodland harvesting sites are typically moist and well-drained, with a peaty black O horizon (average depth: 10 cm) underlain by a sandier A horizon. *Yartsa gunbu* larvae were typically found feeding at the base of the organic horizon. These organic horizons are common on moist slopes with north-facing aspects, and also in wet areas where an abundance of water favors such soil formation processes. The organic horizons may provide a higher level of insulation than shallow mineral soils, protecting *Thitarodes* larva from freeze-thaw better than thinner, less-insulated soils, as well as providing an overall better habitat for growth and survival.

A possible reason why *yartsa gunbu* is not found in the upper valley locations, at the same elevation as the harvest areas but upstream of Langmale, is because the decrease in precipitation in the upper valley regions prevents the organic horizon from forming. Many of the vegetative host species for the fungus, which include alpine grasses (*Poaceae* spp.), bistorts (*Polygonum* spp.), bellflowers (*Cyananthus* spp.), and buttercups (*Ranunculus* spp.) are abundant in both the upper and lower Barun valley (Winkler 2017). Organic horizons have not been highlighted as habitat requirements in other parts of the *yartsa gunbu* range, and it may be that the particular species found in the Barun valley, which tend to be smaller and of lower value than those in Dolpo, have differing habitat preferences.

In the Barun valley, the official *yartsa gunbu* harvesting season is between 15 May and 15 July (Thapa, T.B., pers. comm., 2016). However, several factors can influence the actual start up dates, in particular snow cover and on-going employment. Most collection sites are still covered in snow or heavy frost throughout most of May and early June, a key reason why so few people go to the harvesting grounds until the middle of or even late June.

Harvesters fall into two main groups: (1) extended families, most often Sherpa people from the nearby Kasuwa valley to the southeast, who camp in the harvesting regions and (2) individual harvesters, usually of the Rai ethnic group living outside of the Kasuwa valley, who tend to stay in the

Figure 6. Searching for *yartsa gunbu* high above the Barun river valley.

(E. Byers, 2016)

valley teahouses and commute to the harvesting sites each day. Families with children ages eight to fifteen began appearing at our base camp in Yangle Kharka the first week of June to harvest *yartsa gunbu* in the lower altitude and nearby pastures, such as Yak Desa, moving to the higher elevations in late June. Children are in particular demand as *yartsa gunbu* harvesters because of their keen eyesight and ability to crawl and clamber close to the ground (Winkler 2008), and in fact young people make up the bulk of harvesters in the Barun. Young men traveling in groups of two or more began arriving in mid- to late-June and, depending upon the abundance of *yartsa gunbu* found, either stayed the rest of the season or migrated on to a different valley.

Yartsa gunbu harvesting permits are issued by Buffer Zone Management Committees, of which there are twelve in the Makalu-Barun National Park region. Fees are Rs. 500/- per household member if the family lives in the Buffer Zone; Rs. 2000/- if one lives in the Sankhuasabha District; and Rs. 3000/- if the harvester lives outside of the District. Half of the funds collected are turned over to the national park, and half are kept by the Management Committee and used for local development projects. Since the amount of funding collected is small, the projects tend to be small in scale as well.

Information on the opening of the national park for *yartsa gunbu* collection is broadcast on the radio both before and after the start of the harvesting season. A broadcast on the morning of 30 May, 2016 specifically mentioned that no dangerous weapons would be allowed to be carried by anyone, presumably to avoid conflict. According to national park authorities, neither wildlife hunting nor firewood collecting is allowed within the national park at any time.

Park officials in Seduwa reported that the recent phenomena of *yartsa gunbu* harvesting has only increased their workload in the face of scarce resources.

Normally, it takes between 8,000–10,000 *yartsa gunbu* to make a kilogram, which is then sold to a middleman, two of whom live seasonally in Yangle Kharka, with others based in Tashigaon and Seduwa. This amounts to between Rs. 600,000/- to Rs. 800,000/- (US$5,856.00 to $7,808,00). This is considerably lower than the prices paid for *yartsa gunbu* elsewhere in Nepal and reportedly reflects the generally poorer quality of *yartsa gunbu* from the Makalu-Barun region, at least by widespread reputation. As opposed to other regions where the value of *yartsa gunbu* is much higher, incomes derived from *yartsa gunbu* harvesting in the Barun are not too different from wages derived from trekking or portering, nor is its collection disruptive to the normal cycle of life, since the timing of the harvest coincides with down times in the trekking and agricultural calendar. In 2014, 45–50 kg of *yartsa gunbu* were reportedly collected from the Barun valley, with middlemen paying a royalty of Rs. 10,000/- (US$98.00) to the park (Thapa, T.B., pers. comm., May 2016). In sum, *yartsa gunbu* harvesting in the Barun valley is more of a supplementary income generation opportunity which neither competes nor interferes with other economic activities (e.g., tourism, farming, livestock). Nor does its harvesting require any substantial financial investments or specialized skills to commence. Those involved in *yartsa gunbu* harvesting view the recent introduction of its harvesting as simply one more livelihood diversification strategy, which is key to sustaining life in most remote and high altitude mountain regions of the world (Huber et al. 2014).

All informants interviewed reported that there have

Figure 7. Asamsa harvesting *kharka* (4000 m +), Barun valley.

(A. Byers, 2016)

been declines in the annual *yartsa gunbu* harvest since the early 2000s, particularly during the past three years (i.e., 2014–2016), a trend that is consistent with those seen elsewhere in Nepal (Shrestha and Bawa 2014c). The reasons for the decrease are not entirely clear, and the prospective impacts of climate change, grazing, soil compaction, and fires are unknown. However, most collectors generally attributed the decreased populations to over-harvesting pressures. In the summer of 2014, the typical harvester in Asamasa (Figure 7) could expect to collect between 100–150 *yartsa gunbu* per day, with the middleman paying Rs. 150/- per piece. In the summer of 2015, one could expect to collect between 30–50 pieces per day, with the price dropping to only Rs. 100/- per piece. In 2016, the harvests were so poor in Asamasa and elsewhere that most people reportedly left after only one or two days, trekking to the Hinku valley to the west where supplies were supposedly better.

In the Barun, entire families will spend several weeks camping and collecting in one or several of the Barun's alpine pastures during the *yartsa gunbu* season. Pemba Sherpa, Kongma lodgeowner, explained the process as follows:

> Hunting for yartsa gunbu is like hunting for any other mushroom in the Barun—some years are good, and there are lots of people, and some years are bad, and there aren't many people. In good years people go way, way up to the top of the mountains, like over there and there, hunting yarsa for two days, then moving on, sometimes staying in GoThs, sometimes in tents, covering as much of the alpine zone as they can during the harvesting season.

However, permanent camps are fairly rare in the Barun valley, and the number of campers is low (less than 200). Many dozens of harvesters commute each day to the harvesting sites from teahouses or lodges down in the main valley. Although the total number of harvesters varies from year to year depending on yields, lodge owners reported observing an estimated 3,000 harvesters throughout the course of the harvesting season, a figure we were unable to verify.

The alpine harvesting sites that we visited were remarkably free of garbage. Collectors explained that they tend to bring their own local rice, dal, potatoes, and other traditional foods as opposed to plastic packaged, canned, or bottled goods, burning the occasional noodle soup packaging in the fire. The absence of roads also discourages the importation of heavy beer bottles and cans, which is a chronic problem elsewhere (e.g., Winkler 2008). Fuelwood is packed in from the rhododendron tall shrublands below, and no damage to the shrub juniper and dwarf rhododendron within the alpine harvesting sites was found, in contrast to other alpine ecosystems studied in Nepal (e.g., Byers 2005, 2013). The taller, thicker shrub juniper stands found above 4,000 m in the main valley are, however, the source of fuelwood for tourist lodges and *goThs* in Riphuk and Langmale. Villages further downvalley (e.g., Yangle Kharka) have access to and use tree rhododendron, fir, or birch. Fuelwood usage in the *yartsa gunbu* harvesting regions was estimated at one headload per family (with the average extended family size assumed to be ten) every three to four days, which can be extrapolated to roughly fifty headloads per family during the month-long harvesting season. If the reported 200 campers per season is further extrapolated to twenty extended families, this suggests that approximately 1,000 headloads of tree rhododendron fuelwood are burned in the alpine pastures per *yartsa gunbu* harvesting season.

Unlike other parts of Nepal and Tibet where violence has occurred over perceived harvesting territories and ownership, there is reportedly little competition between families and harvesters (Pant et. al 2018), and violence is unheard of in the Barun valley. The families that camp in the harvesting regions are primarily local (i.e., living in villages from Seduwa to Kongma, gateway to the Barun trek over the Shipton La) and are well known to each other. Prices paid by middlemen for *yartsa gunbu* from the Makalu-Barun region are low when compared to other regions, for example Rs. 500,000/- (USD$ 4,800.00) to Rs. 900,000/- (USD$ 8,640.00) per kg in the Barun, compared with Rs. 1,200,000/- (USD$ 11,520.00) to Rs. 2,200,000/- (USD$ 21,120.00) in Dolpa (Lama, T., pers. comm., 2018). As opposed to other regions where the harvesting of *yartsa gunbu* can represent between 50 to 90 percent of a family's annual income (Childs and Chodep 2014; Shrestha and Bawa 2014a), livelihoods in the Barun are diversified and include livestock raising, tourism, portering, lodge running, and medicinal plant harvesting. A season's profits from *yartsa gunbu* harvesting are comparable to those generated from tourism, such that neither necessarily takes precedence. In fact, most harvesters interviewed reported that to them, *yartsa gunbu* harvesting is a source of fun, amusement, family time, and supplementary income.

The socio-economic and institutional arrangements of *yartsa gunbu* harvesting in the Barun Valley are also reflective of the somewhat different ecological and biophysical settings of the valley when compared to Dolpa and other parts of the Himalaya, where *yartsa gunbu* dominates the local economy. Although the value of *yarsta gunbu* has been known to local people for centuries, especially among Tibetan medical practitioners, its direct impacts on house-

hold as well as village income have grown considerably since both the market demand increased and the Government of Nepal lifted the ban on its harvesting in 2001 (Shrestha et al. 2017). As reported elsewhere (e.g., Childs and Choedup 2014), this change in institutional arrangements legitimized local resource management practices of *yartsa gunbu* harvesting, which in turn spurred much needed off-farm income generation opportunities for remote mountain villages in the Barun, many of which had been isolated from national development programs for decades.

In the Barun and other alpine valleys within the national park, the Makalu-Barun Buffer Zone Management Committee, consisting of village representatives, plays an important role in the linking of national park authorities with local communities. This committee is also responsible for the management of *yartsa gunbu* harvesting in the valley. It issues permits, collects revenues, coordinates the funding of local development programs and partners with the national park to regulate harvesting practices. This arrangement has proven to be locally more responsive than the conventional, top-down governance systems of the past, and overall has had a positive influence upon the physical and social aspects of *yartsa gunbu* harvesting in the Barun valley.

The numbers of harvesters from outside the region are also comparatively small when compared to the 50,000–60,000, largely non-local collectors reported for the Dolpa region each year, thus reducing the possibilities of conflict and widespread environmental degradation (Devkota 2010). In summary, we link the lack of violence and social unrest in the Barun, unlike other regions of the Himalaya, to the (a) lower value of *yartsa gunbu* in the Barun when compared to other regions, (b) the recognized role of *yartsa gunbu* as a supplemental and livelihood diversifying income generation opportunity, as opposed to an extremely high value and thus competitive income source, and (c) the development of more horizontal and adaptive governance systems of *yartsa gunbu* harvesting since its collection and sale were legalized by the Government of Nepal in 2001.

On the other hand, wildlife poaching in the Barun valley has reportedly accelerated. One young man from Seduwa said that *yartsa gunbu* harvesters will hunt most anything that they can find, focusing on pheasants (Blood Pheasant and Monal) and pikas. Local people interviewed said that nearly all of the young collectors between fourteen and eighteen years of age, the majority of harvesters, carry slingshots and kill Tibetan snowcock, Impeyan pheasant, Blood pheasant, Snow partridge, other birds, and small mammals when the opportunity presents itself.

In fact, our team observed a total of only seven Tibetan snowcock, and no pheasants or partridges, during both field seasons. This is in stark contrast to those reported by Cox (1999:65), who noted that in 1998 Tibetan snowcock were common and fairly tame in the upper Barun region, and that the "snowcock's abundance and behavior suggest that gamebirds were not being hunted." The killing of larger mammals, such as Blue Sheep in Dolpa as reported by Cox (2008), was neither observed nor reported. Park personnel, however, informed us that they were considering deploying the Nepal Army as patrollers throughout the Makalu-Barun National Park because poaching in general had become a major problem.

In summary, few of the negative environmental impacts reported for other *yartsa gunbu* harvesting regions in Nepal and elsewhere in the Himalaya were found to exist in the Barun valley. Alpine and subalpine ecosystems, although historically modified, were found to exhibit a resilience and healing capacity that most likely results from the valley's remoteness, low human densities, and abundance of moisture. Garbage in the alpine harvesting regions was practically non-existent, juniper and dwarf rhododendron formations were only moderately disturbed, cattle impacts were minimal, competition low, and violence unheard of. Additionally, human ecosystem use is spread throughout the year, with different seasons offering different economic opportunities, allowing the landscapes to rest in between. Increases in wildlife poaching, medicinal and aromatic plant collection, and solid waste accumulations near lodges are, however, of concern.

Conclusion

The Barun valley is located in a remote, high mountain region of Nepal that, in spite of historical and contemporary land use practices, is stressed, but not in crisis. Alpine ecosystems have been modified for centuries to increase pasture land by burning and shrub removal, but when compared to other regions of Nepal have suffered few adverse impacts. The commercial harvesting of *yartsa gunbu* that started in 2003 has resulted in a dramatic increase in the number of seasonal visitors to the valley, but when compared to other harvesting regions in Nepal, their overall impacts have been minimal. Alpine ecosystems were found to be in good condition in terms of the absence of large-scale shrub harvesting for fuelwood and resultant desertification and erosion processes. Harvesting sites were found to be largely garbage-free, primarily because of the difficulty of importing canned or bottled goods and the widespread use of local, non-packaged foods such as potatoes, rice, and dal. Unlike other regions of the Himalaya, violence and social unrest due to harvesting competition were unheard of, which we link to the (a) lower

market value of *yartsa gunbu* harvested in the Barun when compared to other regions, and (b) the recognized role of *yartsa gunbu* as a supplemental and livelihood diversifying income generation opportunity instead of a sole source of new income. Since its collection and sale were legalized by the Government of Nepal in 2001, the concurrent development of locally responsive *yartsa gunbu* harvesting policies and practices can also be linked to the general absence of environmental disturbance and social unrest.

However, poaching by *yartsa gunbu* harvesters of local pheasant, snow cock, and small mammal populations is a continuing problem. The harvesting and exportation of other medicinal and aromatic plants, also collected during the *yartsa gunbu* harvesting season, could become problematic in the long term, especially as roads are built closer to park boundaries and transportation to markets becomes easier and cheaper. Better management of solid waste accumulations near lodges along the main trekking route, and within the Makalu basecamp, is needed in order to avoid the problems experienced by other protected areas in Nepal, including water contamination, impacts upon human and animal health, and the degradation of cultural and physical landscapes.

Yartsa gunbu populations in the Barun are fluctuating and could be decreasing for reasons that are not entirely understood, and which may portend an uncertain future of *yartsa gunbu* as a reliable, although supplementary, income source. Regardless, the response of local people to future uncertainties would most likely be proactive and self-reliant, as befits a people who have lived and adapted to change for generations in a particularly remote and steep corner of the Nepal Himalaya.

Alton C. Byers, Ph.D. is a mountain geographer, conservationist, and mountaineer specializing in applied research, high altitude ecosystems, climate change, and integrated conservation and development programs. He received his doctorate from the University of Colorado in 1987, focusing on landscape change, soil erosion, and vegetation dynamics in the Sagarmatha National Park. Between 1990 and 2015 he worked for The Mountain Institute in the Himalayas, Andes, and Appalachians, and in 2015 joined the Institute for Arctic and Alpine Research (INSTAAR) at the University of Colorado at Boulder as Senior Research Associate and Faculty.

Elizabeth Byers, M.S. is a Senior Scientist with the West Virginia Department of Environmental Protection and the principal of Appalachian Ecology, an environmental consulting firm. Ms. Byers has a B.A. *magna cum laude* in geology from Brown University, an M.S. in hydrology from New Mexico Tech, and has completed additional graduate work in ecology at Oregon State University. Ms. Byers has 30 years of experience working on natural resource projects in the Himalayas, East African rift, Rocky Mountains, and Appalachians.

Milan Shrestha, Ph.D. is Assistant Research Professor and Senior Sustainability Scientist with School of Sustainability at Arizona State University. He is an environmental anthropologist with a background in smallholder agriculture and food systems, international development and geospatial analysis. His current research projects include climate change risks and vulnerability in mountains, urban-rural linkages of land system change, and societal transitions to green development.

Dambar Thapa, M.S. is a forester who worked at The Mountain Institute, Kathmandu, Nepal when the 2014 field research was conducted. He now works for The Partners Nepal, Kathmandu, Nepal.

Bidhya Sharma is a 2017-2018 recipient of the Chevening Awards 2017/2018 and recently completed her M.Sc. with distinction in wetland science and conservation at Bangor University, Wales.

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Endnotes

1. The Himalayan Blue Sheep (*Pseudois nayaur*), also known as *bharal* or *naur*, is found throughout the Himalayas at higher altitudes.

2. *Naemorhedus goral*, a goat-like bovid species found across the Himalayas.

3. A small, goat-like antelope (*Capricornis thar*) native to the eastern Himalayas.

4. "Nak" is a female yak, also called a "*dri*" (Brower, B. 1991: 104-105).

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