Rapid Vulnerability Assessment of Yartsa Gunbu (Ophiocordyceps sinensis [Berk.] G.H. Sung et al) in Pithoragarh District, Uttarakhand State, India

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Rapid Vulnerability Assessment of *Yartsa Gunbu* (*Ophiocordyceps sinensis* [Berk.] G.H. Sung et al) in Pithoragarh District, Uttarakhand State, India

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Any resource of high value and relevance to rural livelihoods is at risk of overexploitation. The anthropogenic pressure on the caterpillar fungus, Ophiocordyceps sinensis *(Berk.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora 2007, commonly referred to as* yartsa gunbu*, is intense, especially given the absence of traditional sustainable collection techniques. Stable harvests are the result of 2 factors: more people searching more intensely and extensively and the ongoing discovery of new areas for harvest. Increasing international demand and prices (presently around US$ 20,000 per kg) have resulted not just in overexploitation but also in the degradation of the fungus's habitat, thus endangering its future viability. This article reports on a rapid vulnerability assessment involving 2511 harvesters in 9 broad study sites and 110 villages in the Pithoragarh district in Uttarakhand state, India, in the central Himalaya, and recommends ways to lessen the pressure on this valuable species.*

Keywords: Ophiocordyceps sinensis*; rapid vulnerability assessment; sustainability;* yartsa gunbu.

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Introduction

Ophiocordyceps sinensis (Berk.) G.H. Sung, J.M. Sung, Hywel-Jones & Spatafora 2007, commonly referred to as *yartsa gunbu*, which translates from Tibetan as "winter worm, summer grass," and in Kumaun and Garhwal Himalaya as *keera ghaas*, referring to the larva (*keera*) and the emergent fruiting body that resembles sprouting grass (*ghaas*), is a genus of mostly entomophagous flask fungi (Pyrenomycetes, Ascomycotina) belonging to the family Ophiocordycipitaceae. The parasitic fungus grows on and derives nutrients from around 60 species of lepidopteran larva in the Himalayan and Tibetan Plateau (Chu et al 2004; Sung et al 2007; Wang and Yao 2011), primarily those belonging to the genus *Thitarodes* (previously *Hepialus*), a moth species belonging to the order Lepidoptera and the family Hepialidae, globally represented by 60 genera and 587 species (Nielsen et al 2000), often referred to as ghost moths. *Yartsa gunbu* consists of a completely mummified larva, filled and coated with mycelia, with a slender, brown, club-shaped fruiting body that usually emerges from the ground just above the eyes of the larva, reaching a total length of 8–15 cm (Figure 1A). The fruiting body emerges around mid-May, as soon as the snow melts. By mid-July, the collection season is over, but mature fruit bodies with low value are reported to persist until mid-August (Negi et al 2006; Negi et al 2014).

Ophiocordyceps sinensis contains a broad range of compounds that are considered nutritional (Hobbs 1995; Holliday et al 2004). The pharmacological qualities ascribed to the fungus include antitumor, antimetastatic, immunomodulatory, antioxidant, anti-inflammatory, insecticidal, antimicrobial, hypolipidemic, hypoglycemic, antiaging, neuroprotective, and renoprotective effects. Polysaccharides account for anti-inflammatory, antioxidant, antitumor, antimetastatic, immunomodulatory, hypoglycemic, steroidogenic, and hypolipidemic effects; cordycepin contributes to antitumor, insecticidal, and antibacterial effects; and ergosterol (a universal fungal compound) exhibits antitumor and immunomodulatory effects (Negi et al 2006).

Collection of *yartsa gunbu* (Figure 1B) is a recent activity that can be traced back 20–25 years. Over the past 2 decades, however, increasing international demand for *yartsa gunbu* and concomitantly increasing prices—presently between US$ 13,000 and US$ 20,000 per kilogram—have resulted in heavy exploitation and degradation of the prized species' habitat, endangering its future viability. Rapid vulnerability assessment (RVA) is an effective tool to assess the status of a species in the wild and its future viability (Aumeeruddy-Thomas et al 1999:17). While RVA has been conducted in Bhutan (Namgyel 2003), Tibet Autonomous Region (Winkler 2008), and Nepal (Aryal et al 2008), a similar exercise has not been conducted so far in India. This study, in addition to carrying out an RVA, conducted a comparative assessment of the different local livelihoods to inform efforts to lessen the pressure on the species.

FIGURE 1 *Yartsa gunbu*: (A) the pinkish-brown stroma (fruiting body) emerging from the soil; (B) after harvesting. The harvest is cleaned with a toothbrush in the field and often dried in the sun.

Methodology

Study area

The study was conducted in the district of Pithoragarh, Kumaun Himalaya, Uttarakhand, India. The study sites, all alpine meadows, are 3200–4700 m above mean sea level and lie at 80°15′–81°5′E longitude and 29°5′–30°32′N latitude (Figure 2). The sites exhibit considerable variation in precipitation, with an average annual rainfall of 150–200 mm. The survey, which lasted 2 years (2012–2013), covered 110 villages in 9 large study sites or landscapes (Johaar, Darma, Vyas, Gori Paar, Choudas, Kanar, Metali, Ranthi, and Jumma), 902 families, and 2511 harvesters.

Rapid vulnerability assessment

To assess the sustainability of wild plant harvesting, it is necessary to understand the natural distribution, abundance, population structure (density, age/size

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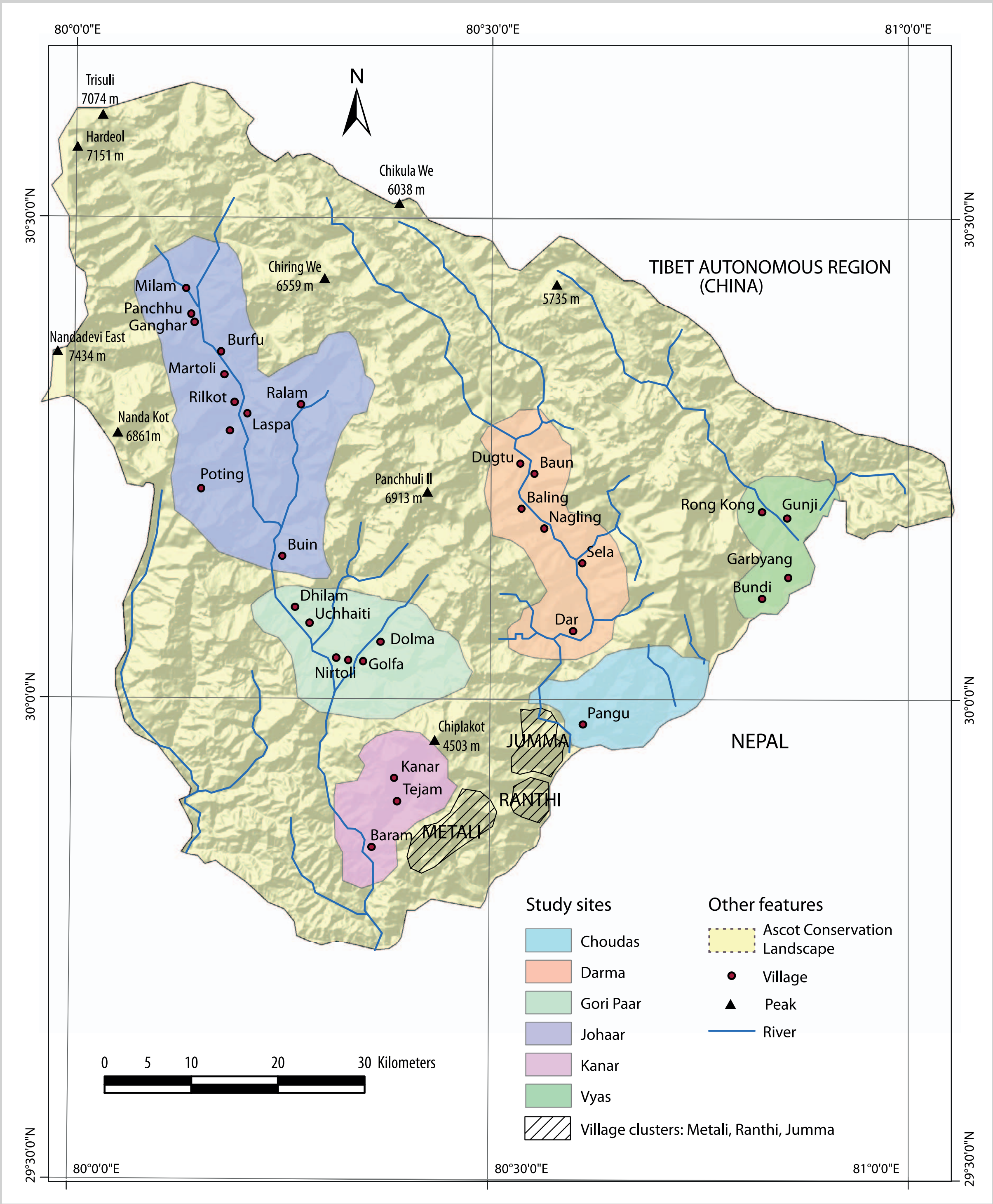
FIGURE 2 Map of the study area. The study sites are restricted to the alpine meadows (3100–4700 masl). (Map by Tarun Kumar)



distribution, number of mature individuals) and population dynamics (mortality, recruitment, growth, and reproductive rates) of the target species, and how these vary across space and time (Hall and Bawa 1993; Boot and Gullison 1995; Gould et al 1998).

RVA—primarily attributed to Cunningham (1994, 1996, 2001) but most specifically explored by Wild and Mutebi (1996) and Watts et al (1996)—builds on several methodologies and involves collecting information about characteristics that help determine whether a plant is

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TABLE 1 Factors studied in the RVA to assess the vulnerability of *yartsa gunbu*. Shaded cells represent the categories selected to derive the final vulnerability score.

	Vulnerability score		
	Low (1)	**Moderate (2)**	**High (3)**
Ecological factors			
Population density	High	Medium	Low
Distribution	Wide	Limited	Very restricted
Frequency	High	Medium	Low
Habitat range and specificity	Broad range	Restricted range or broad range but specific	Highly specific
Rate of growth	Rapid	Medium	Slow
Reproductive capacity	High	Medium	Low
Spore dispersal	Abiotic	Biotic (common, generalist)	Biotic (rare, highly specific)
Spore germination and sprouting ability	High	Medium	Low
Socioeconomic factors			
Whole plant–animal complex harvested	Common and fast growing	Intermediate	Rare, long living, or slow growing
Volume harvested or demand	Low	Medium	High
Habitat reduction or degradation	Low	Medium	High
Harvesting community nature and size	Small, local	Large, local	Large, inclusive of outsiders
Legal access to harvest	Restricted	Intermediate	Open
Market price	Low and static	Moderate	High
Commercialization	Low	Medium	High
Availability of substitutes	Available and affordable	Available but unaffordable	Not available
Traditional conservation practices	Strong or conspicuous	Weak or inconspicuous	Absent

vulnerable to overharvesting. Species vulnerability is evaluated according to a set of criteria of sustainability, including life-form, habitat specificity, abundance and distribution, growth rate, response to harvesting, growth stage at harvest, patterns of selection and use, demand, seasonal harvesting, traditional conservation practices, commercialization, and the availability of substitutes (Wild and Mutebi 1996; Wong et al 2001).

The integration of local knowledge with scientific data facilitates triangulation, makes it possible to collect information more quickly, and promotes cooperation between local communities and outside experts in making appropriate management decisions (Wild and Mutebi 1996). Further, the integration of ecological, social, and economic factors determines whether the species is vulnerable to harvesting (Wild and Mutebi 1996; Aumeeruddy-Thomas et al 1999).

Data collection

Information was elicited through an open-ended questionnaire with questions about *yartsa gunbu* as well as means of livelihood—agriculture, livestock raising, and gathering of medicinal and aromatic plants from the wild. RVA was adapted for use in the study.

The broad parameters used to assess the status of *yartsa gunbu* were as follows:

- For population size and frequency, phytosociology (Ralhan et al 1982) was conducted. For population

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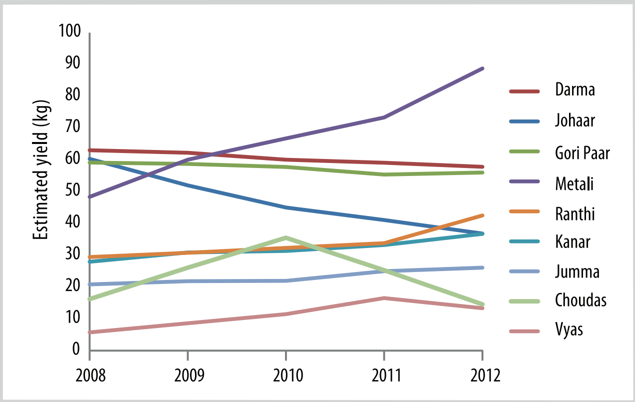
FIGURE 3 Estimated yield of *yartsa gunbu* in the 9 study sites, 2008–2012, according to study participants.



assessments of the host insect (*Thitarodes*), 1-cubic-foot ($0.028\ m^3$) pits were dug, and the larvae were counted by hand.

- For habitat specificity, life form, and reproductive biology (reproductive capacity, sporulation, spore dispersal, sprouting), the literature was consulted.
- For yield, habitat reduction, harvesting community, access, demand, market price, commercialization, and traditional conservation practices, interviews were conducted using an open-ended questionnaire, primarily with the head of the family, often jointly with village elders.

Based on the information collected through the RVA, an assessment of the vulnerability of 8 ecological and 9 socioeconomic factors was conducted, using scores from 1–3 for low to high vulnerability.

Results and discussion

The total vulnerability score for *yartsa gunbu* elicited through the RVA was 39 for 17 factors. Low vulnerability was scored in 3 parameters, moderate vulnerability in 6 parameters, and high vulnerability in 8 parameters (Table 1). The predominance of high vulnerability scores is enough to categorize the species as vulnerable.

Ecological factors determining availability

Population size: This is one of the most important factors affecting plant vulnerability and relates directly to the quantity of the material available for harvest (Wild and Mutebi 1996). The population size of *yartsa gunbu*, in terms of yield per hectare, is relatively low in the study area: on average 600, compared with 4200, reported from some good habitat sites in Tibet Autonomous Region 15 years ago (Chen et al 2000). The finding of a lower yield in the study area than in Tibet is strengthened by the finding that in Johaar, Darma, and Gori Paar valleys—where the harvest is strictly limited to local villagers and the number of harvesters remained about the same, thus leading to comparable results between the years—the yield declined from 2008 to 2012 (Figure 3).

This finding is similar to that reported by Shrestha and Bawa (2013, 2014), who showed that the harvest decreased significantly, from 261–212 pieces per person in 2006 to 126–97 in 2010, suggesting overexploitation. Yield decline by 70% from 1978 to 2001 has been reported in China (Tsim and Shao 2005). In Bhutan, 70% of harvesters viewed overexploitation and habitat destruction as major factors in the decline of the Chinese caterpillar fungus (Shrivastava 2010).

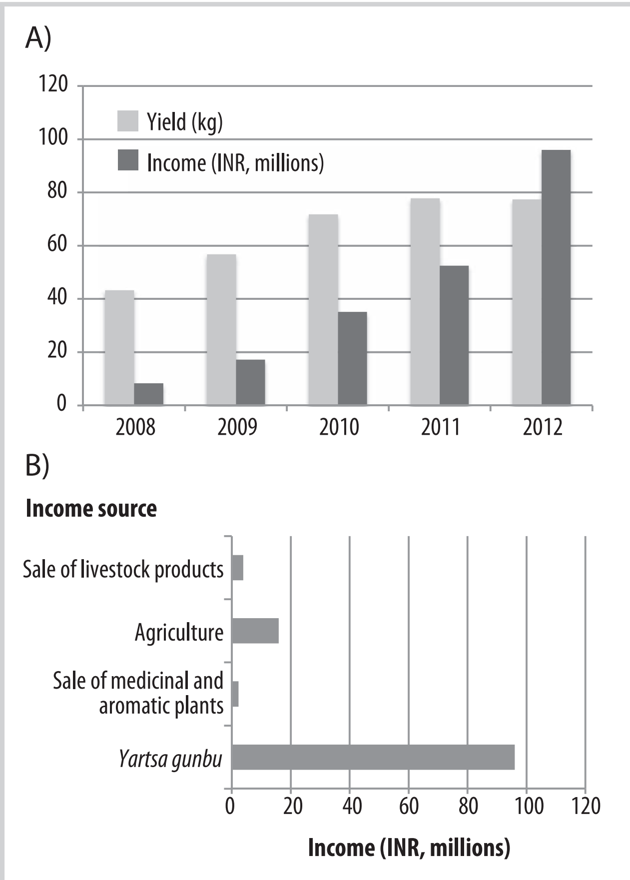
Distribution: A species with a wider distribution is obviously less vulnerable than one endemic to a small area (Stockdale 2005). Even though the *yartsa gunbu* yield per hectare has declined according to the information collected during the RVA, the overall yield has increased then remained more or less steady in the study period (Figure 4), because every year new harvest sites are added and existing sites are enlarged as harvesters explore more inaccessible patches.

Frequency: Frequency also affects the profitability of the harvest. Harvesting a highly scattered resource takes more time and may negatively affect the ecosystem in the search area (Peters 1996). In our study area, frequency of *yartsa gunbu* is higher than in other areas, and distribution is scattered. However, its availability with regard to frequency is likely to decline with the observed decline, not just in the overall habitat area but also in vegetation, including among woody species such as *Rhododendron campanulatum, R. anthopogon,* and *Juniperus communis*, on whose roots the *yartsa gunbu* host larva feeds.

The medicinal properties of *yartsa gunbu* are said to be enhanced by the close proximity of highly valued plants, including *Rhododendron setosum, R. anthopogon, Delphinium* spp, *Nardostachys jatamansi*, *Picrorhiza kurrooa*, and *Rheum* spp. (Wu 1997; Zang and Kinjo 1998). As plants and their seeds occur in the fungal colonized zone, it might be speculated that the fungus has a role in plant preservation and that it ultimately contributes to seed bank longevity (Chee-Sanford 2008). Whether the relationship is mutualistic has yet to be studied; however, during the *yartsa gunbu* harvest, a number of the aforementioned medicinal and aromatic plants are also harvested, as are fuelwood species. The fact that the *yartsa gunbu* harvesters now have to procure fuelwood from 100–200 m away in the forests below their camps substantiates the previous argument.

Habitat specificity: Yartsa gunbu occurs in alpine meadows at elevations of 3200–4700 m, a relatively wide zone. However, mountain topography, especially in the alpine zone, contains a great variety of microhabitats, which narrows the niche.

FIGURE 4 (A) *Yartsa gunbu* total yield and income generated for study participants, 2008–2012; (B) Study participants' main income sources in 2012 (INR 60 = US$ 1).



Life-form: A plant's life-form offers the possibility of easily ascertaining some of its ecological characteristics, such as growth rate, production to biomass ratio, reproduction, and longevity (Rutherford and Westfall 1986). A slow-growing, long-lived, slow-reproducing species is more vulnerable than a fast-growing, short-lived, or fast-reproducing species. The life-form of *yartsa gunbu* is a complex of 2 different species; while *Ophiocordyceps sinensis* (the fungal component) is fast growing, the emergence of the host species (*Thitarodes* sp) from its diapause condition may extend for a considerable period of time (2–4 years). In other words, ambient conditions that are favorable for the fungus may not be the favorable for the host.

Reproductive capacity and spore dispersal: Reproductive rate, in terms of number of spores shed per individual, remains an important criterion for vulnerability (Stockdale 2005). *Cordyceps* are well adapted for reproductive success, with each spore reportedly fragmenting into 100 or more part-spores, and each fungal fructification in turn produces 32 million propagules, thus increasing the odds of landing on a larva (Kendrick 1992). However, *yartsa gunbu* does not produce the part-spores, and thus the total number of propagules dispersed (and able to bring about the infective cycle) remains limited. Also, 70–80% of the harvested *yartsa gunbu* are immature, which accentuates the problem of the naturally low reproductive rate.

Further, *yartsa gunbu* requires the presence of the host insect (the obligate out-crosser) for the completion of its life cycle. This makes out-crossing an important vulnerability factor (Peters 1996). In other words, sustainable harvest of *yartsa gunbu* requires an adequate population of the host insect larva. A 14.8% decline in the host larva population was recorded within just 2 years (2012–2013), from 1218/ha to 1041/ha. Even though this decline cannot be taken as conclusive, this study does reinforce the estimation that greater anthropogenic pressure has a negative effect on the host larval population. However, results can only be conclusive if (1) similar studies are conducted across multiple sites where the intensity of harvest differs, (2) studies are undertaken over a longer time span, and (3) environmental variables affecting the population size of the host larva are recorded.

Spore germination and sprouting ability: *Ophiocordyceps* is an example of coevolution, wherein the precise liberation of spores coincides precisely with the presence of the larval (caterpillar) stage of the host insect, upon whose integument the spores then germinate to form hyphae, which then penetrate the larval soft tissue. The spores have little tolerance for adverse conditions (eg desiccation) and must germinate immediately. The availability of an obligate out-crosser, the host *Thitarodes* larva, is essential.

Socioeconomic factors determining vulnerability

Whole plant–animal complex harvested: One factor that greatly influences the rate of loss of individual plants from the population, and consequently the vulnerability of the species, is the plant part harvested (Shackleton 2001; Ticktin 2004; Stockdale 2005). Species with a single reproductive cycle (monocarpic) are likely to be more vulnerable, and this requires that enough individuals are left unharvested for adequate reproduction. Harvesting that includes mortality of the target plant, because it removes potentially reproductive individuals from the population, leaves a species more vulnerable (Cunningham 2001).

In the case of *yartsa gunbu*, the complete caterpillar and fungus, including the reproductive structure (the sporocarp), is harvested. The sustainability of removing whole individuals also depends greatly on the timing of harvesting (before or after fruiting) and the number of individuals remaining in the population for reproduction (Hall and Bawa 1993). In the case of *yartsa gunbu*, with 70–80% of the harvested lot consisting of immature samples, the inadequate number of spores dispersed by the smaller surviving population of mature individuals increases the vulnerability of the species. At the same time,

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the practice of harvesting immature *yartsa gunbu* could, paradoxically, serve as a means to sustain the population of the host moth (Stewart 2009; Winkler 2009). One can speculate that the declining population of the controlling agent (*Ophiocordyceps*) would result in resurgence of the population of the host insect (*Thitarodes* sp), which in turn would affect the ecology of the above-ground vegetation.

Volume harvested or demand for product: Greater demand and higher prices are likely to lead to increased intensity of the *yartsa gunbu* harvest and thus longer stays by harvesters in the harvest sites. The volume of a harvest consists of 2 basic factors: the quantity harvested and the frequency of harvest (Bennet 1992). In the area covered by this study, both factors were in play. With the declining yield of *yartsa gunbu* (average of 600/ha), the frequency and duration of stay in the harvest sites have increased.

While the amount harvested by this study's 2511 informants remained more or less stagnant during 2010–2012, the income earned nearly doubled (Figure 4A). In fact, the income generated by the 1.5-month *yartsa gunbu* harvest far exceeded the combined annual income from other sources (Figure 4B).

Habitat reduction or degradation: Increasing anthropogenic pressure has resulted in conspicuous reduction in habitat space, with the lower reaches (inhabited by the harvesters) showing no yield. The availability of *yartsa gunbu* is inversely related to the slope, with greater availability reported on 15° slopes, and declining availability as the angle of slope increases; the negative impact of harvesters is increased because their tents are erected on spaces with less slope. Exploitation of herbaceous (mostly medicinal and aromatic) plants as well as woody vegetation on whose roots and flowers the host larva thrives, soil compaction by harvesters (Shrestha et al 2014) and livestock, and prolonged stays in the habitat sites have resulted in the degradation of the habitat and declining numbers of *yartsa gunbu* and its host insect.

Nature and size of the harvesting community: Three factors have a major impact on harvest pressure on commercially exploited natural resources—the biology of the collected species, the regime governing access to it, and market prices (Weckerle et al 2010). Hardin's (1968) article on the "tragedy of the commons" concluded that open access in combination with increasing demand inevitably leads to overexploitation of a natural resource. *Yartsa gunbu* is an example of this phenomenon.

Lately, the village forest councils, which have jurisdiction over their respective alpine meadows harboring *yartsa gunbu* have demarcated sites that outsiders are strictly prohibited from entering. However, any resulting reduction in the number of harvesters has been offset by the greater number of women from the same village who now accompany the men to these sites. Notwithstanding, habitat sites within the jurisdiction of village forest councils are better off than sites within areas with a protection status. This is the case in the Ascot Conservation Landscape, which includes a minor portion of the adjacent Nanda Devi Biosphere Reserve merged with the Askote Wildlife Sanctuary. Harvesting in these areas, though legally prohibited, remains open to all because conservation rules are not enforced.

Regulation of the harvest: Regulation of access to resources is related to sustainable management (Hutton and Leader-Williams 2003). Five years ago, the first author successfully implemented a mechanism restricting people not belonging to the *van panchayat* (forest council) by issuing passes to village inhabitants only. Unfortunately, these passes, misappropriated by infirm and elderly people, are now being auctioned to outsiders at exorbitant prices (up to US$ 1166 per pass). Lately, the contracting of harvesters (mostly Nepalese) by powerful villagers who provide them with lodging in the alpine meadows in return for 50% of their harvest has increased anthropogenic pressure on the *yartsa gunbu* habitat in all the study area.

Market price: The price of *yartsa gunbu* increased from around US$ 3333 per kg in 2008 to US$ 20,000 per kg in 2012. The total yield across the study area in 2012 was just under 345 kg, worth US$ 7,500,000. This extreme price increase has increased the pressure on *yartsa gunbu*. The prices vary depending on the quality: there are 5 categories of produce—18, 22, 28, 32, and 38—corresponding to the number of individuals (in hundreds) per kg. While category 32 currently fetches about US$ 20,000 locally, category 18 may earn the harvester more than US$ 30,000.

Trafficking: There is a well-established network of local middlemen, brokers, and merchants in the border townships of Dharchula and Munsiari. Proximity to the porous border with Nepal and Tibet Autonomous Region makes it also accessible to trafficking. All efforts by the state forest department and other agencies to regulate the trade have failed, because the price offered through the legal auction system is far below that offered by the network mentioned earlier. During 2008–2012, amounts trafficked across the border increased from 309 kg to 345 kg.

Availability of substitutes: Although the species, more precisely the mycelia, has been successfully cultivated in liquid suspension (Lu 2003; Sheng et al 2011) and on solid substrate (Sung et al 1999; Lin et al 2006; Yue 2010), buyers still prefer the wild product consisting of larva and fruiting body. Attempts to generate the composite *yartsa gunbu* have not reached the stage of large-scale production.

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BOX 1: Sustainable harvesting of *Ophiocordyceps sinensis*

Bhutan

Bhutan's approach to managing the *yartsa gunbu* harvest includes (1) relaxing the laws on gathering *yartsa gunbu* in order to provide local people with an incentive to police their areas and protect natural resources, (2) delegating the power to restrict the number of harvesters to a few members per household, and (3) establishing a law that *yartsa gunbu* can only be sold at authorized auctions by authorized collectors and that buyers must be Bhutanese nationals. The government imposes a 4.9% levy on sales to cover the expenses of auctions and to support environmental protection programs (Cannon et al 2009).

Nepal

In Samagaun, Nubri Valley, Nepal, the village development council has devised and implemented a management regime for *yartsa gunbu*. A date is set for the commencement of the harvest, and in the weeks prior to it, every able-bodied resident must physically check in at the community meeting house 4 times daily (7 AM, 10 AM, 2 PM, and 6 PM); anyone caught venturing to the high pastures before the starting date incurs a heavy fine. Village leaders have the authority to postpone the harvest when conditions warrant. The right to gather *yartsa gunbu* is held only by bona fide residents of the village, a status defined through participation in a household taxation system. Each household must register its collectors with the village administration and pay a *yartsa gunbu* tax of NPR 100 (US$ 1.20) for the first household member and NPR 4500 (US$ 53) for each additional member; the money thus collected is spent on communal activities, such as inviting a lama to perform an empowerment ritual (*dbang*) (Childs 2005; Childs and Choedup 2014).

In Dolpa, in western Nepal, local people establish their camps 3–5 km from the collection area (Shrestha et al 2014). In Nubri and Tsum, Nepal, religious decrees (*chos khrims*) prohibit collection in certain sacred areas, ensuring that part of the landscape remains undisturbed (Childs and Choedup 2014). Lamas in Sama shield certain tracts of land on the slopes of sacred Gang Pungyen (Mount Manaslu, 8156 m), abode of *Yul Iha*, the resident deity, through "sealing decrees" (*shag rgya*) that prohibit people from cutting trees, gathering forest products (including *yartsa gunbu*), or hunting wildlife.

Traditional conservation practices: Until a few years ago, women were prohibited from entering the sacred alpine meadows and from collecting *yartsa gunbu*, which obviously restricted the number of harvesters. However, with the dramatic increase in the price of the commodity, the taboo system regarding collection has been discarded, and the same men who earlier enforced the religious prohibition now encourage women to harvest *yartsa gunbu*. Being religious, the female harvesters fear the wrath of the deity, more so when the stay in the sacred landscape lasts more than a month and when another, most religiously held taboo regarding menses, cannot be adhered to either. Thus, tension exists between moral-religious imperatives and the lure of economic benefits. Dilution of the traditional norms contributes to the vulnerability of *yartsa gunbu*.

Recommendations

Several scholars have argued that community-based management can ensure the sustainability of the *yartsa gunbu* harvest (Cannon et al 2009; Stewart 2009; Weckerle et al 2010; Shrestha and Bawa 2013, 2014). Measures for sustainable resource management can be effective when stakeholders are formally or informally integrated into policy-making and control mechanisms (Dietz et al 2003; Robbins et al 2009), but before that, communities must appreciate the problems arising out of commercial exploitation and institute mechanisms at the local level for the sustainable harvest of *yartsa gunbu*.

The use of more scientific techniques for harvesting, including spore dispersal immediately after collection or the use of burying pits after uprooting, could aid sustainable management of wild resources (Shrestha and Bawa 2013, 2014). Creating rest areas, imparting knowledge of the fungal reproductive cycle, and establishing an end date to the collection season might allow for sufficient spore dispersal to maintain sustainable populations (Baral et al 2015). Providing higher economic incentives to local harvesters who comply with harvesting guidelines might motivate sustainable harvest (Boesi 2003; Sharma 2004; Varghese and Ticktin 2008; Weckerle et al 2010); however, doubts remain when the commodity being harvested brings such high prices internationally. Fortunately, success stories exist in other countries (Box 1), which could be replicated by empowering the Biodiversity Management Committees, which are being constituted at the village level under the National Biodiversity Authority of India.

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Conclusion

Considering the large number of ecological and socioeconomic factors increasing the vulnerability of *yartsa gunbu*, this medicinal species should definitely be considered vulnerable. Among the factors leading to higher vulnerability, dependence on another species (obligate out-crosser) for the completion of the life cycle, increasing demand and high market prices, the reduction in and degradation of habitat, and abandonment of traditional conservation practices, raise concerns as to the viability of the species in the near future. Local communities' awareness of the problems arising out of commercial exploitation should increase. Moreover, it would be important to develop and implement effective institutional mechanisms at the local level for the sustainable harvest of *yartsa gunbu*. Such mechanisms should concern all ecological and socioeconomic factors that the present study has revealed as leading to greater vulnerability of the species.

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