Supplemental material for

“Nature and People in the Andes, East African Mountains, European Alps, and Hindu Kush Himalaya: Current Research and Future Directions”, by Davnah Payne, Mark Snethlage, Jonas Geschke, Eva M. Spehn, and Markus Fischer, published in *Mountain Research and Development* 40(2), 2020. (See https://bioone.org/toc/mred/40/2)

TABLE S1 Ecosystem services (Nature’s Contributions to People) details.

Explicit wording	Wording used in the text and figures
Habitat creation and maintenance	habitat
Regulation of air quality	air & climate
Regulation of climate	
Regulation of ocean acidification	water & ocean
Regulation of freshwater quantity, location and timing	
Regulation of freshwater and coastal water quality	
Formation, protection and decontamination of soils, and sediments	soil & hazards
Regulation of hazards and extreme events	
Pollination and dispersal of seeds and other propagules	pest & pollination
Regulation of organisms detrimental to humans	
Food and feed	food & medicine
Medicinal, biochemical and genetic resources	
Materials and assistance	energy & materials
Energy	
Learning and inspiration	cultural
Physical and psychological experiences	
Supporting identities	
Maintenance of options	

TABLE S2 Search strings used for the literature selection.

Nature and biodiversity	biodiversity OR ecosystem OR habitat OR "natural capital" OR "natural asset" OR "Mother Earth" OR "system of life"
Geographic scope	**Andes**: Andes OR Andean **East African Mountains**: kilimanjaro OR virunga OR mitumba OR rwenzori OR ruwenzori OR "mount kenya" OR "mt kenya" OR "mt. kenya" OR "mount elgon" OR "mt. elgon" OR "mt elgon" OR aberdare OR itombwe OR "cherangani hills" OR "mount meru" OR "mt. meru" OR "eastern arc mountains" OR "imatong mountains" OR "lenkiyio hills" OR "cherangani hills" OR "marungu highlands" OR "kipengere range" OR "rungwe mountains" OR "makutu mountains" OR "vipya mountains" OR (("east africa" OR "eastern africa") AND (afromontane OR mountain OR alpine)) **European Alps**: "European Alps" OR (Europe AND Alps) **Hindu Kush Himalaya**: Himalaya OR "Hindu Kush" OR "Hindukush"
State of and trends in biodiversity	"conservation state" OR "conservation status" OR "ecological condition" OR trend
Direct drivers	"direct driver" OR "anthropogenic driver" OR "natural driver" OR "land use change" OR "climate change" OR pollution OR "invasive* species" OR overexploitation
Indirect drivers	"indirect driver" OR "economic driver" OR "institutional driver" OR "cultural driver" OR "religious driver" OR "demographic driver" OR "scientific driver" OR "technological driver"
Ecosystem services	"ecosystem service" OR "nature's benefit" OR "nature's contribution" OR "material service" OR "non-material service" OR "cultural service" OR "regulating service" OR "supporting service" OR "provisioning service"
Human wellbeing	"human wellbeing" OR "human well-being" OR livelihood OR "quality of life" OR "Living in harmony with nature"
Responses	governance OR institution OR institutional

TABLE S3 Values used in coding abstracts.

DIMENSIONS	VALUES
Species	Bacteria / algae; plants; invertebrates; vertebrates; agrobiodiversity
Ecosystems	above the treeline; forest; grassland; freshwater; agricultural land, highly modified (urban)
Ecosystem services (general)	regulating, material, non-material
Ecosystem services (details)	see Table S1
Human wellbeing	Livelihoods; material wellbeing; physical wellbeing; social wellbeing; security; freedom of choice
Interactions	State; trend; trade-off; synergy; teleconnections
Direct drivers	land use change; climate change; pollution; invasive species; overexploitation; other
Indirect drivers	Institutional; demographic; scientific and technological; economic; cultural and religious
Responses	Legal, regulatory and policy instruments; economic and financial instruments; social and information based instruments; rights based instruments and customary norms; research and monitoring; education, training and capacity building; planning; ecosystem and species management; climate change adaptation and mitigation; other
Sustainable Development Goals (SDGs)	SDG 1: No Poverty; SDG 2: Zero Hunger; SDG 3: Good Health and Well-being; SDG 4: Quality Education; SDG 5: Gender Equality; SDG 6: Clean Water and Sanitation; SDG 7: Affordable and Clean Energy; SDG 8: Decent Work and Economic Growth; SDG 9: Industry, Innovation and Infrastructure; SDG 10: Reduced Inequality; SDG 11: Sustainable Cities and Communities; SDG 12: Responsible Consumption and Production; SDG 13: Climate Action; SDG 14: Life Below Water; SDG 15: Life on Land; SDG 16: Peace and Justice Strong Institutions; SDG 17: Partnerships to achieve the Goal
Aichi targets	1. People more aware of biodiversity values; 2. Biodiversity integrated into development; 3. Perverse incentives and subsidies removed; 4. Sustainable production and consumption; 5. Rate of loss of natural habitats halved; 6. Sustainable harvests of fisheries; 7. Sustainable agriculture, aquaculture and forestry; 8. Pollution brought to safe levels; 9. Invasive species control; 10. Climate impacts on biodiversity minimized; 11. Protected areas cover 17% of terrestrial and inland water, 10% of coastal and marine; 12. Extinction of threatened species prevented; 13. Genetic diversity of cultivated biota maintained; 14. Ecosystem services restored and safeguarded; 15. Ecosystems resilience and contribution to carbon enhanced; 16. Nagoya Protocol enforced; 17. National biodiversity action plans implemented; 18. Traditional knowledge respected, full participation of indigenous and local communities; 19. Science and knowledge shared; 20. Sufficient finances mobilized

APPENDIX S1 Literature-based assessment for the article "Nature and People in the Andes, East African Mountains, European Alps, and Hindu Kush Himalaya: Current Research and Future Directions", by Davnah Payne, Mark Snethlage, Jonas Geschke, Eva M. Spehn, and Markus Fischer, published in *Mountain Research and Development* 40(2), 2020. (See https://bioone.org/toc/mred/40/2)

1 Contents

1. Biodiversity and ecosystems

1.1 The Andes

The Andes follow the entire west coast of South America across a wide range of latitudes, and is thereby the longest mountain range on Earth (Campetella & Vera, 2002). On the highest elevations, even at tropical (lower) latitudes, glaciers represent some of the most distinctive feature. Ecosystems surrounding the glaciers above the treeline consist primarily of fragile grassland and tundra. These so-called *páramo* and *puna* occur along the full length of the Andes (Arroyo and Cavieres 2013; Peyre et al. 2015; Benavides et al. 2018; Calderón-Hernández and Pérez-Martínez 2018; Rodríguez et al. 2018). They often co-occur with high altitude wetlands (peat bogs and mires), locally known as *bofedales*, which accumulate high levels of soil organic carbon. Lower down the altitudinal gradients, between the mountains and the Amazon, forests such as the *yungas* in Bolivia (Estado Plurinacional de Bolivia 2015) prevail.

Species diversity and levels of endemism are very high. This is likely due to the Andes' geological history, including mountain-building events (Sanín et al. 2016), as well as their diversity in elevations, past and present climates, past colonization events (Bacon et al. 2018), and in their soils (Ministerio del Ambiente 2015; Ministerio del Ambiente del Ecuador 2015; Benham and Witt 2016; Muñoz-Mendoza et al. 2017). Both species diversity, including lizards, birds, pollinating insects, and large mammals (e.g. the threatened Andean Condor (*Vultur gryphus*), Mountain Tapir (*Tapirus pinchaque*), and Andean Bear (*Tremarctos ornatus*)) (IPBES 2018a), and levels of endemism are particularly high in the *páramo* and the *puna*, which are supposedly also home to the world's richest alpine flora (Sklenář et al. 2014; Padilla-González et al. 2017). Despite a noticeable tendency towards the conversion of the *páramo* and *puna* into forest plantations and agricultural fields in certain parts of the northern Andes, these high elevation habitats remain the least transformed of the American biomes (IPBES 2018a). However, the local reduction in the extent of the *páramo* can be significant, especially where human population is high and depends on the *páramos'* ecosystem services. Other regions of high endemism include the much smaller Tucuman-Bolivian forest, which is in need of urgent conservation (Perger and Guerra 2016), whereas species richness is also very high in the mountain forests. Forests occupying the altitudinal gradient towards the Amazon as well as in the Chocó forests on the Northwestern Coast are particularly rich in species (Palomino-Ángel et al. 2019). However, many native mountain forests have sharply declined in extent, such as in Chile (Ministerio del Medio Ambiente 2014) and in in the lower reaches and intra-montane valleys of Colombia (de Luna and Link 2018; Murillo-Sandoval et al. 2018). In Ecuador, changes are more pronounced in the number of plant species in forests, with high extinction rates in patches of Andean forests characterized by high biodiversity and endemism (Pitman et al. 2002). High Andean peatlands are also considered oases of biodiversity (Izquierdo et al. 2015; Cochi Machaca et al. 2018), with notably a high diversity of (wetland) bird species in locations where hydrological conditions (water levels) are good (Tellería et al. 2006).

Water quality of the Andean rivers is generally highly variable and tends to worsen during droughts (Ministerio del Medio Ambiente 2014). This represents a considerable environmental issue, in particular for so-called "white waters", such as the western Orinoco tributaries, that are nutrient rich and support rivers rich in fish and fertile floodplains (Lasso et al. 2016).

1.2 The East African Mountains

The East African Mountains consists of isolated mountain massifs, of which three (Mount Kilimanjaro, Mount Kenya, and the Rwenzori Massif) are the highest mountains of the African continent (Alweny et al. 2014). These massifs are embedded within the dry lowland savannas, cloud forest remnants typically cover their peaks and ridges (Habel, Cox, et al. 2013), and many of the major rivers in the region, such as the Nile, originate there. In spite of their location around the Equator, many of the mountains and highland areas in the region experience frost during part of the year (Kotikot and Onywere 2015). The region is part of the Eastern Afromontane biodiversity hotspot (Myers et al. 2000) and home to two major mountain areas of biological rich highland forest and moorland habitats: the Albertine Rift and the Eastern Arc Mountains (IPBES 2018b). Further mountains include the volcanoes of the Kenyan and Tanzanian Highlands (e.g., Mount Kilimanjaro, Mount Meru, Mount Kenya, Mount Elgon, and the Aberdares Range). Yet, unlike these younger mountains typically support less biodiversity than their more ancient counterparts (IPBES 2018b). The East African Mountains are rich in species, many of which are endemic, with about 500 mammal (including 100 endemics), 1300 bird (including 157 endemics), 350 reptile as well as 323 amphibian species (Mittermeier et al. 2004). Species richness is particularly high in the mountain cloud forests, which are surrounded by heavily encroached lowland savannas (e.g., Habel et al. 2013; Musila et al. 2019). These species-rich forests are particularly at risk, with rapid declines in both area and condition (Marije Schaafsma et al., 2014; Mairal et al., 2017). Between 1908 and 2000, forest cover declined by 74% in the Eastern Arc Mountains (Willcock et al. 2016), reaching 98% at lower altitudes in some areas (Burgess et al. 2017). Accordingly, recent literature estimates the current forest cover in the Eastern Arc Mountain to represent only 20% of the original one (IPBES 2018b). With the designation of most of the remaining forests as protected in 2000, much smaller declines have been observed than when intensive logging was happening in the mid-19th (Hall et al. 2009) and even indications of recovery exist. However, while these protected areas play an important role for forest recovery, their network does not adequately cover the distribution areas of many species (Meng et al. 2016). In addition, protected area downgrading (e.g., Virunga National Park for oil and gas exploration, Qin et al. 2019), downsizing, and degazettement as well as illegal activities within designated protected areas remain a threat to these East African Mountain ecosystems, with extensive and severe degradation, such as in the Volcanoes National Park (Derhé et al. 2019).

Besides natural ecosystems such as protected mountain forests, various land use types ranging from agroforestry to fallows are also important habitats for plants and vertebrates of conservation value (Vihemäki et al. 2013). Ecosystems above the treeline play an important role as well but are relatively rare, as in the Eastern Afromontane region only a few mountains have a treeline. Such ecosystems can be found at altitudes of 3400 m.a.s.l. and above (McGinley 2009) on the highest mountains such as Mount Kenya, Mount Kilimanjaro, and the Ruwenzori, which all have glaciers (NEMA 2014). With their strong altitudinal gradients, these mountains are particularly species richness (Mairal et al. 2017; Zhou et al. 2018; Capitani et al. 2019) and have even witnessed the arrival of new plants colonizing the space left open by retreating glaciers (Detsch et al. 2016; Courtney Mustaphi et al. 2017). Although still largely intact due to their inaccessibility (Republic of Kenya 2015), ecosystems above the treeline have undergone significant changes over the last decades. Further habitats of importance are freshwater habitats, such as those found in the Rwenzori and Albertine Rift area of Southwest Uganda. To date, these habitats are still in good condition in the higher reaches of the uplands but rapidly deteriorating on the mountain lower slopes (Musonge et al. 2019).

The East African Mountains already offer several refugia associated with long term climate stability in the quaternary and current mild climate (Barratt et al. 2017) and are likely to gain in importance as climatic refuge in a warmer future (Marshall et al. 2012).

1.3 The European Alps

The European Alps have a long history of cultural landscapes, including pastures as well as hay and wooded meadows. These cultural landscapes, which result from an extended process of social-ecological coevolution (Schwörer et al. 2015; Gretter et al. 2018), have significantly changed over time, together with their associated high cultural and biological diversity (Ianni et al. 2015). Over millennia, human agro-silvo-pastoral activities have lowered the treeline, altered grasslands (Pansu et al. 2015), and modified the composition of forests notably in the Northern Swiss Alps, where Norway Spruce (*Picea abies*) has gradually replaced the European Silver Fir (*Abies alba*) (Schwörer et al. 2015). Accordingly, landscapes are increasingly homogeneous at the local scale (Lavorel et al. 2017) and polarized at the larger scale (Ringler and Grabherr 2017). Declines in trends and condition are observed across all landscapes, including many wooded pastures (Kiebacher et al. 2017), species rich semi-natural grasslands (Umweltbundesamt 2014; Fedrigotti et al. 2016; Fondevilla et al. 2016; Barros et al. 2017), as well as traditional mixed-use (multifunctional) landscapes. These latter landscapes are typical of the Alps and include Larch grasslands (Nagler et al. 2015) and grassland patches in forested areas (Orlandi et al. 2016).

The richness of vascular plant, fungus, mosses, lichen, and insect species (particularly butterflies) is high in the Alps (Direction de l'Eau et de la Biodiversité 2014). It is particularly high at the transitions between mountain ecosystems (around the treeline, forest shrub ecotone), which makes them particularly important for species conservation (Jähnig et al. 2018). The high climatic and topographical heterogeneity is important in explaining high species diversity. Additional factors include centuries old land use patterns, such as wooded pastures (Kiebacher et al. 2017). However, as landscapes change, many species and functional groups are threatened. The emblematic Mountain Hare (*Lepus timidus*) for example is projected to experience a contraction of its distribution range, but trends of suitable habitat differ, with the greatest losses occurring at the Northern and Southern edges of the Alps (Bisi et al. 2015; Rehnus et al. 2018). In the case of birds, threats levels are particularly high in the Northern and Western Alps. Yet, breeding bird species inhabiting open and treeline habitats are threatened across all the Alps (Chamberlain et al. 2016) and high alpine birds such as the Black Grouse (*Tetra tetrix*, Viterbi et al. 2015; Marti 2018) and the Rock Ptarmigan (*Lagopus mutus*, Furrer et al. 2016; Ferrarini et al. 2017) show different trends across species and regions. Typical farmland birds have shown signs of decline, although later in the Alps than in large parts of Western Europe. Hedge breeders and southern European species, on the other hand, have shown signs of increase. This increase correlates with widespread changes in the vegetation (Korner et al. 2018). These changes include the greening of the vegetation in high alpine habitats (Carlson et al. 2017), which is indicative of longer and warmer growing season, increased biomass, and colonization of previously bare habitats. They also include the increase in vegetation cover (Rogora et al. 2018) and in forested areas (FOEN 2014; Ianni et al. 2015) at the expense of grasslands on mountain slopes (Guidi et al. 2015), and changes in the treeline position (Thöle et al. 2016). Forest cover is projected to continue expanding under various land-use change scenarios, for instance in the Polish Carpathians and Swiss Alps (Price et al. 2017). The treeline in turn, which is largely conditioned by human use and has shifted downwards from its natural elevation (Körner 2012), is predicted to shift upwards under various future scenarios, thereby reducing the area of lower alpine grasslands by about 20% and the high alpine and nival zone by more than 50% (Pellissier et al. 2013).

In alpine ecosystems, diversity of vascular plant species (Lamprecht et al. 2018) has been found to increase over the last decade. However, plant species diversity and distribution are predicted to decline in the medium-term. For example, in the French Alps, declines of 10-23% in the beta taxonomic diversity of plant species are expected by 2050 (Thuiller et al. 2014) and as much as 150 high mountain plant species might see their range contract by as much as 44-50%, including various endemics (Dullinger et al. 2012). Several of these species that are predicted to be particularly affected in the future (Guerrina et al. 2016) are already declining (Stanisci et al. 2016). However, local conditions such as nutrient availability and timing of snowmelt may enable certain species to persist (Little et al. 2016). For example, in the short term, debris covered glaciers may persist below the treeline and support cold adapted plant life (Tampucci et al. 2016). Topographic complexity might also provide ectothermic insects such as alpine butterflies (Kleckova and Klecka 2016) and plants (Gentili et al. 2015) with microclimates in which to survive under warming climates. For certain species, (e.g., Crested Porcupine *(Hystrix cristata*) in Italy, Mori et al. 2018), current observations indicate range extensions from lower areas into the mountains, which is in line with predictions of an increase in species turnover preceding a possible extinction (extinction debt) (Engler et al. 2009). Forest composition in turn is predicted to change towards thermophilous species (Thöle et al. 2016).

Above the treeline, glaciers lost almost 50% of their total area between 1850 and 2000 (Zemp et al. 2006). Concomitantly, alterations have also happened to the hydro-morphological regimes of mountain rivers and to freshwater systems (Simoni et al. 2017; Mazzorana et al. 2018), including important changes to water quality in alpine lakes over the past millennia (Bajard et al. 2018). These changes are accelerating because of increased human pressure, from the western Alps in France (Bajard et al. 2018) to the Eastern Alps in Slovenia (Ravnikar et al. 2016). The expected impact of glacier retreat on ecosystems and species are numerous, ranging from the opening up of vast areas for vegetation establishment and growth (Tampucci et al. 2015), soil formation (D'Amico et al. 2015) and carbon accumulation in the soil, to effects on cold freshwater ecosystems species such as diatoms (Fell et al. 2018).

1.4 The Hindu Kush Himalaya

The Hindu Kush Himalaya region is the world's largest and most diverse mountain region. It notably harbours extensive cold deserts above the treeline and in the rain shadow (IPBES 2018c) but also a diversity of ecosystems, including alluvial grasslands and subtropical broadleaf forests in the foothills, temperate broadleaf forests in the middle elevations, mixed conifer and conifer forests higher up, and alpine meadows above the treeline (Ministry of Environment and Forests 2014). It is the region of all records, with the highest peaks in the world (IPBES 2018c) and the largest volume of ice and snow outside the Arctic and Antarctica. Because of the high ecosystems diversity, levels of biological diversity are extremely high, notably in the Himalayas biodiversity hotspot. Species diversity is also particularly high due to Pliocene and Pleistocene geological and glacial histories (Lei et al. 2015) and a great heterogeneity in environmental conditions (Paudel and Heinen 2015).

The Eastern Himalaya has approximately 9000 plant species, of which 39% (3500) are endemic (Ministry of Environment and Forests 2014). Of all ecosystems, alpine grasslands are particularly rich in (endemic) species (Barthlott et al. 2005). The Eastern Himalaya is also home to species-rich forests, including dry deciduous and cloud forests, which are among the most threatened high biodiversity terrestrial ecosystems (IPBES 2018c). Large predators such as Grey Wolf (*Canis lupus*), the Asian Black Bear (*Ursus thibetanus*) or the Snow Leopard (*Panthera uncia*) have been decreasing in the Himalayas although in certain protected areas and following the introduction of a livestock insurance scheme local recoveries have been observed (Subba et al. 2017). To date, many alpine plant species in the Nepalese Himalayas are found to increase in frequency and relative abundance, yet with an unexpected overall downhill shift of species assemblages (Bhatta et al. 2018).

Given the extent of the Himalayas, large variations are observed in the status of and trends in biodiversity and ecosystems. Patterns of greening for example are complex, with differences between lower and higher elevation and between the Western and the Eastern Himalaya (Mishra & Chaudhuri, 2015). Large variations across the Hindu Kush Himalaya region occur also in the status of and trends in forest condition and extent, although forest loss from 2000 to 2010 has been generally high up to an altitude of 2400 m a.s.l. (Das et al. 2017). Indications for an upward shift of the treeline by about 300 m since the 1980ies also exist across most of the Himalayas (Prakash Singh et al. 2018). However, limited losses in forest cover (7.4% since 1976) are reported in the Indian Western Himalaya as well as in Bhutan, where cover is about 60% and long term trends are stable to positive (Bruggeman et al. 2016). Yet, while losses might be low (e.g., Western Himalaya, Chakraborty et al. 2017) to moderate (e.g., 9% decrease between 1990 and 2009 in the Nepalese part of the Kailash Sacred Landscape), fragmentation can be high (Uddin et al. 2015; Prakash Singh et al. 2018). In the Sikkim, large undisturbed forest cores have been diminishing in size, while open forests changed to dense forests and alpine meadows changed to alpine shrub (M. Sharma et al. 2016).

The Himalayas have a wide range of traditional agro-pastoral systems and of traditional agroforestry land-use practices. These cultural landscapes are important for biodiversity conservation (Singh et al. 2017) and have consistently more species than adjacent forest in the Central Himalaya (Sharma and Vetaas 2015). Yet, the condition of many rangelands in the subalpine zones has been declining with losses in grasslands productivity (Qamer et al. 2016). The condition of freshwater habitats is deteriorating as well, notably due to eutrophication (Pandit et al. 2016). This is true also for the approximately 17% of the Hindu Kush Himalaya covered by high altitude wetlands (Gupta and Shukla 2016).

2. Ecosystem services

2.1 The Andes

In the Andes, the highly diverse mountain ecosystems provide a wide range of ecosystem services (Ministerio del Ambiente 2015) that support about 105 million people in and around the mountains (FAO 2012; Ministerio del Ambiente 2015; Mills-Novoa et al. 2017). This is particularly the case for the *páramos*, *puna*, and associated peat bogs (Izquierdo et al. 2015) due to their high soil organic content (Valderrama et al. 2017). This organic content confers them exceptional hydrological properties that regulate water flows and increase their resilience against droughts (Iñiguez et al. 2015). This in turn determines their capacity for water regulation and supply (Gil Morales and Tobón Marín 2016; Guio Blanco et al. 2018; Quiroz Dahik et al. 2018). The carbon they store is also a sink that helps mitigate climate change (Forero Ulloa et al. 2015; Valderrama et al. 2017). In addition to water regulation and grazing land for livestock (Farley and Bremer 2017), other ecosystem services include recreation and tourism, cultural services, pollination, as well as seed dispersal (Ministerio del Ambiente 2015). Mountain ecosystems are also an important source of plants used for medicine, food, firewood, and domestic tools (Rodríguez et al. 2018). The use of medicinal plants in Southern Ecuador (e.g., Rios et al. 2017) and the wider Andes region is still prevalent among people of all socioeconomic levels, in urban as well as in rural areas (Tinitana et al. 2016). Besides the high elevation ones, other ecosystems that provide an exceptional range of important services are the

Andean forests (Ministerio del Ambiente 2015), glaciers, and freshwater habitats. Services provided by forests include carbon sequestration (Jumbo-Salazar et al. 2017), pollination (Tinoco et al. 2018), and especially water regulation and provision (IPBES 2018a). Glaciers in turn also fulfil important ecological and socioeconomic functions (Young 2015), notably for the water resources they represent, and their disappearance bears multiple risks (Drenkhan et al. 2018). Freshwater habitats, including wetlands, lakes, and rivers are a source of protein for many Andean communities such as in Colombia (Olaya Rodríguez et al. 2017) but fulfil a much wider range of ecosystem services including pastures, water supply, recreation, and cultural services (Gandarillas R. et al. 2016). The central Andes (Bolivia, Peru) is also one of the seven key areas for the preservation of genetic diversity of crops (about 4300 known varieties of potato) and their wild relatives (Estado Plurinacional de Bolivia 2015).

2.2 The East African Mountains

From a continental perspective, the East African Mountains make the biggest relative contribution to the wellbeing, livelihoods, and socio-economic development of populations in and beyond mountains (IPBES, 2018a) by providing ecosystem services to millions of people (Vice President's office 2014; IPBES 2018b; Capitani et al. 2019). They are especially important for water regulation (Shaban et al. 2016), which in turn affects the hydrology of the lowland wetlands upon which many communities depend (Näschen et al. 2018), ground water recharge, soil conservation, climate regulation, as a resource for tourism, and for their cultural values (Republic of Kenya 2015). In Tanzania, for example, more than 600 sacred groves exist in the North Pare Mountains (IPBES 2018b). Due to their key role in water regulation, management of the mountains water resources must be considered in a holistic way that integrats the needs of communities and sectors far beyond the mountain regions alone (Baker et al. 2015; Nyongesa et al. 2016). Although the East African region contributes moderately to global greenhouse gas emissions (Omambia et al. 2017), forest carbon stocks - and in particular above-ground stocks (Ensslin et al. 2015) - in East African Mountains are essential to mitigate climate change (Adhikari et al. 2017). Agroforestry systems at mid elevations on mountains such as Mount Kilimanjaro also store significantly higher amounts of soil organic carbon and above ground biomass than the surrounding lowland savannas (Mathew et al. 2016). At a regional scale, the Eastern Arc Mountains provide a wide range of regulating and material ecosystem services including water regulation and provision, energy - including hydroelectric power (Omambia et al. 2017), agricultural products (in particular vegetables, spices, and fruits), and non-timber forest products (NTFPs) (Vice President's office 2014). Its natural forests and woodlands specifically are an important source of hardwood, which contributes to national revenue. However, declining plank size and shifts to lower quality timber suggests unsustainable hardwood harvesting (Schaafsma et al. 2014), which might be caused by the fact that the benefits from hardwood trade go to people who do not depend on other (regulating) ecosystem services provided by these forests. Besides the hardwood of mountain forests, many ecosystem goods and services are paramount to individual regions' and countries' economic development. For example, Uganda's mountains are the water towers feeding the nation's energy supply, fisheries, irrigation agriculture, and industry. In the Albertine Rift, rich volcanic soils support a thriving agriculture, mainly tea and coffee, of which much flows into the international market (IPBES 2018b). Also NTPFs play an important role in the East African Mountains, as construction material, as well as for consumption, health, and as fuel. On Mount Kilimanjaro alone, the total number of useful plants is estimated at 563 (Mollel et al. 2017). Traditional agroforestry systems typical of the lower reaches of the East African Mountains (such as the Chagga homegardens on Mount Kilimanjaro) promote soil fertility and are thus more appropriate for agriculture than mono-cropping systems such as maize (Mganga et al. 2016; Pabst et al. 2016). Their promotion around mountain protected areas (e.g., Virunga National Park) can considerably lower the pressures on ecosystems and promote biodiversity (Dumont et al. 2019). Coffee agroforestry systems in the Aberdare ranges in turn provide a range of ecosystem services, and increase resilience against climate change as they can incorporate a wide variety of native tree species (Gram et al. 2018; Rahn et al. 2018; Lamond et al. 2019). Under business as usual, projected climate change and overexploitation of natural resources will severely affect the provision of these ecosystem services (Omambia et al. 2017; Capitani et al. 2019).

2.3 The European Alps

In the European Alps, ecosystems have evolved over many centuries as a product of the interplay between human and ecological processes, and have resulted in heterogeneous cultural landscapes (BMU 2014) delivering multiple ecosystem services to mountain communities (Cantiani et al. 2016; Kohler et al. 2017; Lavorel et al. 2017). These resilient and complex social-ecological systems and the ecosystem services they deliver are nowadays under pressure from intense socio-economic changes coupled with changes in land use and climate (Fedrigotti et al. 2016). Changes in the growth conditions at the ecotones for instance have important consequences for the provision of ecosystem services in mountain regions with high population densities such as the European Alps (Jochner et al. 2017). As a result, over the course of the last century, the type of ecosystem services delivered by Alpine landscapes has changed from primarily material services to mainly regulating services (Egarter Vigl et al. 2016) and changes are also expected in the future, notably in response to climate change (Schirpke et al. 2017). However, different regions have had specific trajectories: some regions developed from single to multifunctional ecosystem service provision, some reduced the variety of services, and other remained rather stable. These dynamics reveal trade-offs between regulating and cultural services within the provisioning bundle. A significant change in the type of ecosystem services also comes from societal evolution and an increasing demand for cultural services, such as long vistas, with glaciers or lakes and open landscape, and options for tourism and recreational activities, of which the demand is particularly strong in urbanized areas (Schirpke et al. 2018). For example, the value of the Swiss landscape (mainly the Alps) for tourism is of approximately CHF 70 billion per year (FOEN 2014). Accordingly, this value is taken into consideration in land use planning, in particular in areas where reforestation for instance decreases the aesthetic perception of visitors (Schirpke et al. 2016). This value and the natural value of biodiversity hotspots also represents an important factor in the planning of renewable energy infrastructures such as for hydropower production, which are a key measure in climate change mitigation in the Alps. Preserving natures whilst intensifying the production of renewable energies is expected to increase conflicts over land use (Hastik et al. 2015). Iconic species present another important symbolic cultural ecosystem service across the Alps, with clear spatial patterns associated with high elevations, slopes that are steep, open land cover, and naturalness (Schirpke et al. 2018). Whereas these species are typically wild, local livestock breeds also offer an untapped potential for marketing and branding local products (Marsoner et al. 2018), and are the subject of targeted policies in some countries such as Germany (BMU 2014). Interestingly, different types of cultural ecosystem services are occasionally located in different parts of the landscapes: for example in South Tyrol (Italy) areas of aesthetic beauty, spirituality, or leisure are mainly located in traditionally managed landscapes between 100 and 2200 m a.s.l whereas cultural heritage values are concentrated in the valley (Zoderer et al. 2016).

Despite ongoing changes, many traditional alpine landscapes such as Larch grasslands still provide a variety of ecosystem services including timber, forage, but also space for recreation, biodiversity conservation, as well as carbon storage (Nagler et al. 2015). Timber otherwise comes mostly from alpine forests (Maroschek et al. 2015), which hold stocks that are among the largest in Central and Western Europe (IPBES 2018d). Additional services provided by these alpine forests (Irauschek et al. 2017), especially uneven-aged ones (Lafond et al. 2017) with high biodiversity and structural heterogeneity (Dupire et al. 2016a) include non-timber services such as the protection against natural hazards (Vacchiano et al. 2015; Winter et al. 2015; Dupire et al. 2016b; Lega et al. 2018). The vulnerability of these ecosystem services and of their provision to climate change is largely unknown (Irauschek et al. 2017) but their relative provision is likely to depend on the disturbance regime affecting the forests (e.g., fire, bark beetle infestations or avalanches), and the subsequent regeneration stages through which the forest has to go (Vacchiano et al. 2015). Protections against soil erosion and natural hazards is an important ecosystem services. As an example, half of Switzerland's forests serve to protect inhabitants and infrastructure from natural hazards (FOEN 2014). Yet, measurements in the Swiss Alps show that the current rates of soil erosion exceed the rates of soil formation, putting the future capacity of soils for protection, but also food production, at risk (Meusburger et al. 2018). Managing these ecosystem services under ongoing and future change is a challenge that will require taking into consideration the valuation of services and the trade-offs between them. For example, as the productivity of protection forests increases, protecting against natural hazards, carbon sequestration and timber extraction have to be weighed against each other in making management decisions (Irauschek et al. 2017; Jandl et al. 2018).

2.4 The Hindu Kush Himalaya

In the Hindu Kush Himalaya, the natural systems provide a wide range of ecosystem services to approximately one fifth of the world's total population (Das et al. 2017). Important regulating services include the regulation of water flow (Jana et al. 2017) and the regulation of climate through carbon storage. Carbon storage is particularly important in the high altitude dry temperate land use systems of the Indian Himalaya and in forest pastures, which store a particularly high amount of total biomass (Chisanga et al. 2018). While such higher altitudes land cover types can be considered a sink for soil organic carbon, improved management practices are needed at lower altitudes to sequester and stabilize more carbon in soils (Dinakaran et al. 2018). Possible improvements include the restoration of degraded barren and cultivated land to grasslands and forests and a decrease in land use intensity, which both have served to increase carbon and nitrogen storage and support climate change mitigation in the Indian Himalayas (Meena et al. 2018). For example, community-managed forests in the Gharwal Himalaya and Sikkim can participate in REDD+ mechanisms to control forest degradation as a measure to capture carbon and mitigate climate change (Chettri et al. 2015; Mahato et al. 2016). Similar to climate, the importance of water regulation extends way beyond the Himalayas. For example, the crucial inland fisheries in Bangladesh depend on the freshwater provided by the Ganges, Brahmaputra, and Meghna, which all come from the Himalayas (Department of Environment 2015).

Besides regulating services, the Himalayas also provide a great diversity of key provisioning ecosystem services to the communities (M. Sharma et al. 2016). These services include fodder, firewood, as well as timber and NTFPs. Fodder for livestock production is provided by various ecosystems, including protected (Thapa et al. 2016) and non-protected forests, such as in Jammu and Kashmir (Ahmad et al. 2015). Timber (for example *Pinus gerardiana*) is a particularly important provisioning ecosystem service for local communities, but in many places in North-Western Indian Himalaya for example, valuable trees are overexploited and cannot regenerate fast enough for the harvesting to be sustainable (Kumar et al. 2016). Timber is also important in Bhutan, where about

60% of the energy provision in rural areas comes from firewood (Royal Government of Bhutan 2014). NTFPs are important provisioning services supporting rural livelihoods in the Himalayas (Aryal et al. 2018). They are used for more than 20 different purposes, the most important being medicine and food (Singh et al. 2015; Rawat and Nagar 2017). In the Kailash Sacred Landscape (China, India and Nepal) for example, 85% of households depend on the wild plants they collect for their nutrition for at least one month a year (Aryal et al. 2018). However, the level of reliance on forest products depends to a certain degree on forest type, with oak forests providing more resources than pine forests (Chakraborty et al. 2017; Naudiyal and Schmerbeck 2018). A strong reliance on forest products (e.g., the tasat tree (*Arenga obtusifolia Griff*) to prepare traditional food and beverages in case of drought (Singh et al. 2015) or the Seabuckthorn (*Hippophae salicifolia*) (Chettri et al. 2018) is an important coping mechanism in the event of climate related adversities such as droughts, floods, and landslides (Rawat et al. 2018). Other coping mechanisms to face environmental uncertainties include the reliance on traditional agroforestry systems (Yadav et al. 2019). Agroforestry, including Pecan Nut (*Carya illinoinensis*), is widespread in the Indian Himalaya and provides a wide range of ecosystem services of local significance (such as food, timber, firewood) in addition to carbon sequestration for climate change mitigation (Yadav et al. 2017). Pecan Nuts are one of many agroforestry and crop-wild relatives that contribute to people's livelihoods and resilience as well as to the economy (Pandey et al. 2017). For example, in Bhutan alone, more than 100 species of agricultural crops are found, and the variety of grown races (e.g,. 384 races of rice and 32 races of barley) is an important resource for climate change adaptation (Royal Government of Bhutan 2014). The use of NTFPs is also widespread in medicine and as fodder and food, for example (Kanwal and Joshi 2015). However, much of the knowledge about the use of NTFPs in medicine has gradually been lost and is now mainly limited to the older generations. Medicinal and aromatic plants (MAPs) often represent an important source of income and livelihoods. The very renown Chinese Caterpillar Fungus (*Ophiocordyceps sinensis*) for example provides up to 65% of the income of poor households in Nepalese mountain villages (Shrestha et al. 2019) and its harvest represents a key livelihood strategies for Gharwal communities in Northern India, regardless of the villagers economic standing and social status (Caplins et al. 2018). This is true despite ongoing declines in response to overharvesting and climate change (Hopping et al. 2018). Encouraging the cultivation of MAPs represents a development tool for rural communities in the Indian Himalaya for instance, and simultaneously contributes to their conservation (Phondani et al. 2016). Fodder in turn is important in supporting traditional nomadic livelihoods and livestock-based livelihoods throughout the extensive rangelands of the Hindu Kush Himalaya region, including the Indian Himalaya (Thakur et al. 2017).

Cultural services, such as landscapes and ecosystems that attract tourists (e.g. Rhododendron forests in Sikkim), can provide alternative income sources for local communities (Chettri et al. 2018) if they are well managed (Badola et al. 2018). In the natural landscapes of the Himalaya region for instance (e.g., the Kailash Sacred Landscape of India and Nepal), many worshippers visit the numerous cultural and religious sites, thereby contributing to the local economy (Nepal et al. 2018). In Bhutan in turn, the health of two main sectors of the economy - hydropower and "high value, low impact" tourism - is attributed to the sustained provision of ecosystem services (water regulation and scenic pristine landscapes). There, forests, and in particular the community forests, also play an important role in the socio-economic development and good governance (Sears et al. 2018). However, the equitable sharing of the tourism related benefits among the different stakeholders is a constant challenge (Badola et al. 2018).

Ecosystem services often come in so-called bundles. Such bundles, including provisioning (food) and regulating (e.g. conservation and water regulation) services are for instance provided by traditional agroforestry landscapes based on land sharing principles. These landscapes typically contribute to biodiversity conservation, complementing the protected area network (Sharma and Vetaas 2015) by providing alternative habitats, refugia, and landscape connectivity for different species of plants and animals. Stages of natural succession from grasslands to forests are associated with particular bundles of ecosystem services, which typically increase in number towards later successional stages. They include ecosystem services of both local (fuelwood, food and fodder) and global value (climate mitigation and biodiversity conservation), whose prioritization often results in trade-offs that need to be included in local management plans (Naudiyal and Schmerbeck 2017). However, examples exists where conservation and local economic development can go hand in hand, such as in the tea plantations of Darjeeling, which support important and diverse bird communities (Cettri et al. 2018). In large-scale development projects, the ecosystem services delivered by the affected habitats are rarely considered during decision-making (Murali et al. 2017). The concept of ecosystem services could be part of a framework for sustainable development in the Himalayas, where conservation efforts and improvement of livelihoods (including poverty reduction) are often still considered as irreconcilable objectives (Sandhu and Sandhu 2015).

While ecosystems are mostly described for providing beneficial services, ecosystem disservices are reported as well. These disservices take primarily the form of human wildlife conflicts resulting from the damage caused by wildlife to crops around protected areas (e.g., Shivapuri Nagarjun National Park of Nepal), and which require adapted management strategies for people and protected species to live together (Pandey et al. 2016).

3. Direct drivers of change

3.1 The Andes

3.1.1 Land-use change

In the Andes, land-use change plays the most important role in driving environmental change (Ministerio del Ambiente 2015), in particular through deforestation (Bendix and Beck 2015), changes in agricultural practices (grazing and conversion to pastures, cultivation, and to a lesser extent conversion to cropland (Iñiguez-Armijos et al. 2018)), and rapid urbanization (Ministerio del Medio Ambiente 2014). Inappropriate forestry practices, such as the planting of exotic species, is another form of land-use change with negative effects. Oil palm (*Elaeis* sp.) is one example of species that represents a major threat, in particular because the most suitable areas for its expansion do not necessarily coincide with the areas of highest conservation priority (Ocampo-Peñuela et al. 2018). In parts of the Andes, these changes in land use result in land degradation (soil erosion and salinization) and desertification (Ministerio de Ambiente y Desarrollo Sostenible 2014). Afforestation and agriculture are forms of land-use change that particularly affect the high mountain grasslands (*páramo* and *puna*) and their capacity to deliver ecosystem services (Benavides et al. 2018; Rolando et al. 2018). In Bolivia as in other Andean countries, a clear correlation exists between the rate of deforestation and the distance to the nearest road (Fernández-Llamazares et al. 2018). Where forests are cleared, the impact on the hydrological cycle reduces the base flow of rivers (Buytaert and Breuer 2013) and increases the likelihood of landslides (Vanacker et al. 2003). Forest clearing for urban extension also affects carbon storage capacities, in particular in the tropical Andes where peri-urban forests have a high storage potential (Clerici et al. 2016). Water extraction for the growing mining industry is also a strong driver of change, specifically for Andean wetlands (Ministerio del Medio Ambiente 2014; Aitken et al. 2016). Other land-use related threats to mountain wetlands and aquatic ecosystems include the conversion to cropland and drainage, and the construction of roads and dams, which severely disrupts their hydrology (Salvador, F. et al. 2014; Matthews-Bird et al. 2017). Infrastructure construction such as hydroelectric dams also affects mountain rivers by causing severe losses in river connectivity (Finer and Jenkins 2012; Anderson et al. 2018). River sediment loads in turn are affected by changes in catchment areas, with downstream effects reaching as far as the Caribbean coral reef ecosystems (Restrepo et al. 2016).

3.1.2 Climate change

Climate change is another important driver, which interacts in complex ways with biodiversity because of altitudinal, latitudinal, and humidity gradients (Herzog et al. 2012). It represents a threat for all ecosystems, and not the least for the Andean cloud forests, which depend on specific atmospheric conditions (Herzog et al. 2012), and for small patches of relict forests (Ministerio del Ambiente 2015). Indications of climate change come primarily from increasing temperatures (Vuille et al. 2015). Increasing temperatures particularly affect the glaciers (Quenta et al. 2016) and *páramos* and the dynamics of freshwater ecosystems that depend on them (Barros et al. 2015; Labaj et al. 2018). Yet, while putting at risk the long-term provision of freshwater, glacier retreat also offers some short-term opportunities and options for human livelihoods (Drenkhan et al. 2018). These opportunities include transient increases in water flow and the opening up of new grasslands or wetland habitats for colonization by species such as amphibians (Dangles et al. 2017; Seimon et al. 2017; Young et al. 2017). However, projected temperature increases are also expected to cause faster soil carbon oxidation, in particular in the *páramos*, *puna,* and associated wetlands, which in turn would lead to an increase in the release of greenhouse gases (Buytaert et al. 2011) and a deterioration of the wetlands' favourable hydrological properties. Further temperature-related effects include a decrease in the extent of the *páramos* due to the climate-induced upward movement of the treeline. Patterns and trends in precipitations are less clear and predictions differ between the North (expected increase) and the South (expected decrease) (Sklenář et al. 2014). Decreases in rainfall are likely to mostly affect high mountain wetlands (Otto and Gibbons 2017) and freshwater fauna species through changes in the flow regimes of rivers as well as in the water renewal of mountain lakes and increasing risks of hypoxia (e.g., Yusseppone et al. 2018 in the Patagonian Andes).

Beyond their effects on ecosystems, changes in climate also affect species distribution (Crespo-Pérez et al. 2016), with a predicted upward shift from the Amazonian foot slopes to the Andes under different climate change scenarios (Sales et al. 2017). Individual examples of range modifications include that of the Shiny Cowbird (*Molothrus bonariensis*), which recently expanded its range from about 2000 to 2800m in the Ecuadorian Andes (Crespo-Pérez et al. 2016). Global warming and changes in precipitation also interact with ecological processes such as pollination (Arroyo et al. 2017), and the functioning of agroecosystems, forcing famers to adopt adaptation strategies such as return to traditional practices, technical advice from state agencies, and farmers associations (Barrucand et al. 2017).

The effects of climate on forests and the *yungas* (Carón et al. 2018) or on the *páramo*s (Buytaert et al. 2011) rarely happen alone. Observed trends often result from interactions between climate - and land-use change.

3.1.3 Invasive species

Invasive species are an increasing problem in at least parts of the Andes. They are currently mostly encountered in ecosystems below the treeline (with some exceptions such as *Ulex europaeus* in the Colombian *páramo*), including forests, which are increasingly exposed to the propagules of planted exotic trees (such as *Pseudotsuga menziesii* and *Fraxinus uhdei*) (Saavedra-Ramírez et al. 2018; Salgado Salomón et al. 2018). A typical example is that of the tropical ash (*Fraxinus uhdei*). This species, which is native to México, has been largely introduced to Colombia and other countries for various usages including timber, live fences, and urban greening. It is now common in various tropical mountain areas and is expanding into native forests, notably in Colombia (Saavedra-Ramírez et al. 2018). Introduced species are also an increasing problem in Andean freshwater ecosystems (Ministerio del Ambiente 2015) and in agricultural areas, with invasions of the Argentine Ant (*Linepithema humile*) in the vineyards of Cafayate for instance (Schulze-Sylvester et al. 2018). In freshwater ecosystems, the combined effect of trout introductions and more invasive fishing techniques has resulted in declines in endemic native fish species (Vila et al. 2007).

3.1.4 Pollution

Pollution remains essentially a local issue affecting freshwater ecosystems, mainly around settlements, but the expanding mining sector represents an increasing threat (Ministerio del Medio Ambiente 2014; Ministerio del Ambiente 2015) together with the runoff of pesticides and fertilizers in agricultural areas, such as the Colombian Andes (Ruiz et al. 2017).

3.2 The East African Mountains

3.2.1 Land-use change

In the East African Mountains, land-use change happens at an accelerating rate (Winowiecki et al. 2016). Deforestation and the degradation of forests and woodlands, including protected forests (Finch et al. 2017), represents a particularly important threat, which causes noticeable declines in forest area and condition (Schaafsma et al. 2014; Burgess et al. 2017). Deforestation is systematically reported notably in the Eastern Arc Mountains (Schaafsma et al. 2014), on Mount Kilimanjaro, and in the Albertine Rift Mountains, where it has already destroyed about 38% of the habitat of 162 endemic plant and vertebrate species (Ayebare et al. 2018) . Deforestation is often accompanied by, associated with, or the result of a number of other anthropogenic disturbances, which all affect mountain ecosystems, and lower mountain forests (Malonza 2015; Molina-Venegas et al. 2019) and grasslands in particular. These include the expansion of intensive crop cultivation and commercial plantations (e.g., coffee and tea), overgrazing, fire (Downing et al. 2017), mineral exploitation, large-scale commercial investments (e.g., Eckert et al. 2017 for Mount Kenya), the expansion of settlements, and renewable energy infrastructure, such as hydroelectric power (Musonge et al. 2019) and wind-based infrastructure of high potential in African mountains (Mukasa et al. 2013).

Consequences of anthropogenic disturbances are numerous, including logging-induced landslides on Mount Kilimanjaro (Vice President's office 2014) and negative impacts on the community size and relative abundance of large mammal species (Rovero et al. 2017). In Eastern DRC, increasing bushmeat hunting associated with small-scale mining in mountain forests threatens the survival of critically endangered species such as Grauers Gorilla (*Gorilla beringei graueri*) and Eastern Chimpanzee (*Pan troglodytes schweinfurthii*) inside the national parks (Spira et al. 2019). Around Mount Kilimanjaro, the loss of wildlife habitat to agriculture increases the incidence of human wildlife conflicts, in particular with elephant (Mmbaga et al. 2017). Additional consequences of land-use change and changes in land-use intensity (cultivated versus semi natural) include high levels of fragmentation, such as in the remaining areas of the Eastern African montane forest (Ojoyi et al. 2016), decreases in soil organic carbon and carbon stabilization (e.g., Becker and Kuzyakov 2018 on Mount Kilimanjaro), accelerated ecosystem cycles (Becker et al. 2015) and increasing water-related conflicts (Eckert et al. 2017). Increased fragmentation of lowland habitats between individual mountain ranges in turn significantly reduces ecological connectivity and isolates formerly connected mountain wildlife populations (Mbane et al. 2019), thereby reducing their chances of survival (Newmark et al. 2017).

Yet, although changes in land use have an overall negative effect on ecosystems and their biodiversity, different species groups respond either differently to land use or more readily to changes in land-use intensity. For example, on Mount Kilimanjaro and in the Eastern Arc Mountains, land-use change primarily affects vertebrate forest specialists, while forest generalists are often able to thrive in modified environments such as agroforestry (Helbig-Bonitz et al. 2015; Norfolk et al. 2017). Orthoptera on the lower slopes of Mount Kilimanjaro in turn respond to land-use intensity with a higher biodiversity of grasshopper in mosaics of agricultural landscape, areas of savanna, and extensively managed ruderal areas (Kuppler et al. 2015). Similarly, lightly to moderately grazed montane forests on Mount Kilimanjaro show higher plant species diversity than ungrazed and heavily grazed areas (Kikoti and Mligo 2015).

3.2.2 Climate change

Climate change increasingly affects the coupled socio-ecological systems of the Eastern African Mountains, because of steep environmental gradients, demographic growth, and geographical isolation (Capitani et al. 2019). With the predicted increase in the frequency of severe droughts in arid and semi-arid mountain areas (Munishi et al. 2015), their vulnerability is likely to increase even more. Climate change particularly affects ecosystem above the treeline (Downing et al. 2017) and other high montane ecosystems through increasing temperatures as well as glacier retreat and increased wildfires. However, it also affects the lower montane ecosystems through changes in rainfall patterns (Omambia et al. 2017). Effects of climate change on species vary, notably in birds along elevation gradients of Mount Kilimanjaro (Dulle et al. 2016). As a result of climate change, human populations are projected to move to higher elevations and put additional pressure on the remaining ecosystems (Capitani et al. 2019). Pressure on ecosystems, their functioning, and their ability to provide ecosystem services comes also from the combined effect of climate change and land-use change (Detsch et al. 2016).

3.2.3 Invasive species

Invasive alien species such as the *Eucalyptus* spp. and *Acacia mearnsii* are common exotic tree species in eastern Africa. They are described as increasingly invasive, reaching remote locations such as the high altitude remnants of native forest in the Taita Hills (Piiroinen et al. 2018). In Kenya, eucalyptus species introduced in 1907 and now naturalised are considered invasive in the Highlands (Republic of Kenya 2015). Besides trees, invasive species also include alien fish reported in some freshwater ecosystems such as Chala Lake on Mount Kilimanjaro (Moser et al. 2019).

3.3 The European Alps

3.3.1 Land-use change

In the European Alps, land-use change and land-cover change have extensively changed over the past century (Egarter Vigl et al. 2016). Land-use intensification and land abandonment (land-use polarization) have caused the degradation, loss, and fragmentation of many ecosystems, including semi-natural grasslands (Stanchi et al. 2015; Ringler and Grabherr 2017), wooded pastures, and Larch grasslands, with adverse effects on biodiversity (Löffler and Fartmann 2017). Land abandonment is described as one of the main threats on alpine bird populations, together with leisure, forestry, and urbanization, which is mainly concentrated in the mountain valleys (Direction de l'Eau et de la Biodiversité 2014; FOEN 2014), (Chamberlain et al. 2016). Unlike elsewhere so far, leisure or tourism have become a major driver of change. The transition away from rural economies has had important effects on the alpine landscape, primarily as a result of forest expansion at the expense of semi-natural grasslands at intermediate altitudes (1500 to 2150 m asl) along steep slopes (Fedrigotti et al. 2016; Fondevilla et al. 2016). However, the impacts of tourism, and of the ski tourism industry in particular, also result from the direct disturbance of ecosystems and their species (e.g., typical high mountain birds, Brambilla et al. 2016), and from all the associated infrastructure, including roads, hotels, high tension wires, and the water and energy used by snow canons (Direction de l'Eau et de la Biodiversité 2014). Other forms of infrastructures and land-use changes, such as those associated with the production of renewable energies, also affect alpine biodiversity and ecosystems (Hastik et al. 2016), notably freshwater ecosystems, including riverbeds and riverine ecosystems, which are profoundly altered though engineering works for increasing flood safety (Simoni et al. 2017).

3.3.2 Climate change

A systematic increase in temperatures is the most noticeable effect of climate change in the Alps (FOEN 2014), whereas trends in precipitations are less consistent. Increases in temperature (Fell et al. 2018) are influencing alpine vegetation and ecosystems (Direction de l'Eau et de la Biodiversité 2014), both at high and at lower elevations (Gritsch et al. 2016). They drive alpine plant species to higher elevations (Dainese et al. 2017; Rumpf et al. 2018), increase their abundance and affect their ranges, with the ranges of thermophilic species increasing and that of cold adapted species contracting (Rumpf et al. 2018). Together with changes in precipitations, they are also influencing vegetation phenology (Asam et al. 2018) by affecting the snow cover dynamics above the treeline (Nicolet et al. 2018). Temperature increases are further predicted to change the composition of tree species in forests, such as in Slovenia where the commercially desirable pine is predicted to be gradually replaced with less desirable beech, calling for alternative management strategies (Mina et al. 2017). Other evidence for pervasive effects of increasing temperatures on biodiversity come from birds such as Black Grouse (Marti 2018), Rock Ptarmigan (Furrer et al. 2016; Novoa et al. 2016; Ferrarini et al. 2017), White-winged Snow Finch (Montifringilla nivalis, Brambilla et al. 2017), and Boreal and Pygmy Owl (*Aegolius funereus* and *Glaucidium* sp, Brambilla et al. 2015). All these species are likely to face a decrease in their distribution range because of climate change. However, the effect of climate is often combined with the effects of land-use change, such as in farmland bird populations (Korner et al. 2018). Such combined effects also apply to species-rich semi-natural grasslands and forest grassland ecotones, where climate change together with land abandonment, the encroachment by woody plants (Umweltbundesamt 2014; Fedrigotti et al. 2016; Barros et al. 2017), and the upward movement of invasive species (Petitpierre et al. 2016) lead to changes in species composition. Other forms of climate change include droughts, which are affecting grassland forest ecotones (Barros et al. 2017), and increased frequency, magnitude, and intensity of heatwaves and other extreme climate events (Rosbakh et al. 2017). At higher altitudes, heatwaves may have positive effects due to early snow release. However, the effects at lower altitudes are mainly negative due to increased evapotranspiration (Jolly et al. 2005) or to anomalies in the discharge of rivers. Such anomalies impact on water quality and availability, which in turn affects ecosystems through impaired growth conditions in mountain forests for instance (Obojes et al. 2018), but also the industry and transport across all of Europe (Zampieri et al. 2016). Beyond the local scale, both the changes in climatic conditions at high altitude themselves and their effects on ecosystems (e.g., vegetation dynamics) depend on larger scale climate processes (Desai et al. 2016). The impacts of climate changes are also expected to affect different organismic groups differently in different locations, for example as a result of differences in mobility (Winkler et al. 2018).

Changes in climate also affect entire ecosystems. Increasing temperatures lead to glacier retreat and the melting of permafrost, which in turn affects freshwater ecosystems quality as well as their associated biota (Rotta et al. 2018) and reduces slope stability, increasing the risk of natural hazards (landslides, avalanches, floods) (Spehn and Körner 2017). Climate change also affects alpine river discharge (Zampieri et al. 2015) and temperature (Cianfrani et al. 2015), which in turn affects habitat suitability for fish such as Brown Trout (*Salmo trutta*, Viganò et al. 2016).

3.3.3 Invasive species

The Alps have so far been largely spared from alien species invasions and the expansion of non-native plant species and populations is small (Petitpierre et al. 2016; Seipel et al. 2016). However, in the face of climate change and land abandonment, and with the development of tourism and the increasing trade in ornamental species, the barriers to invasions (Petitpierre et al. 2016; Carboni et al. 2018) and to the upward migration of non-native plant species are gradually weakening. The threat is particularly high for some of these non-native plant species, which express functional traits that enable them to spread upwards approximately twice as fast as native species (Dainese et al. 2017). Although few, examples of invasive species exist. They include the killer shrimp (*Dikerogammarus villosus*), which represents an increasing threat in freshwater ecosystems (Rewicz et al. 2017), and the Bark Beetle (*Ips typographus*). Bark Beetle outbreaks represent a challenge for the management of Alpine forests, although they do occasionally facilitate the regeneration of more natural, diverse, and resilient forests (Winter et al. 2015).

3.3.4 Pollution

Atmospheric deposition of Nitrogen oxides from agriculture results in the overfertilisation of many ecosystems, including Alpine pastures and moorlands, putting at risk the many species adapted to habitat with low nutrient (FOEN 2014). Persistent organic pollutants (PCBs) in turn have accumulated in the Alpine glaciers and are now present in the meltwater, where they represent a risk for human health and the environment (Miner et al. 2018). They are also found in mountain lakes that tend to act as net sinks, receiving most of their input from spring snowmelt (Nellier et al. 2015).

The main direct drivers of change in mountain ecosystems typically interact in complex ways, either dampening or reinforcing their respective impacts. For example, fire risk in alpine mountain forests is typically a result of complex interactions between land-use (forest management) and climate change (trend in number of dry and hot “fire weather” days) (Dupire et al. 2017). The local persistence of species such as the Dwarf willow (*Salix herbacea)*, in turn, is determined by the interplay between climate change and human-induced nitrogen deposition (Little et al. 2016). Experiments in the Alps further reveal that ongoing land-use change in grasslands might profoundly influence the impacts that climate extremes might have on the carbon dynamics of grasslands (Ingrisch et al. 2018).

3.4 The Hindu Kush Himalaya

3.4.1 Land-use change

In the Hindu Kush Himalaya*,* land-use change takes a number of different forms and represents an important factor in the gradual modification of mountain ecosystems. In the Western Himalayas for instance, changes in land use and land cover in the form of marked increases in agriculture, scrubland, and urban areas (Maan et al. 2016) are among the main drivers of change in vegetation cover and productivity (Mishra and Chaudhuri 2015). In the Nepalese part of the Kailash Sacred Landscape, demand for agricultural land and forest products are the main drivers of forest cover decline (Uddin et al. 2015). As a result of the progressive integration into globalized markets and better infrastructure results, mountain societies are shifting progressively from subsistence to market-orientated agriculture (IPBES 2018c). Unsustainable agricultural practices are typically accompanied by the expansion of agriculture to steep slopes, which results in large-scale soil degradation and landslides (Royal Government of Bhutan 2014). Market-oriented production also drives increasing rates of forest conversion such as in the Eastern Himalayas, where conversion to oil palm plantations affects in particular selectively logged tropical forests wrongly considered to be of low conservation value (Srinivasan et al. 2015).

Besides a shift in agriculture, the Hindu Kush Himalaya is also experiencing increasing tourism, which, if not well managed, represents a major threat to the landscapes and ecosystems on which it depends (P.K. Chettri et al. 2018). In Sikkim for instance, tourism-related activities, such as opening footpaths, represents a considerable threat for the Rhododendron (*Ericaceae* sp) forests (P.K. Chettri et al. 2018). Concomitantly, also urbanization and infrastructure development are increasing, causing noticeable impacts on fragile mountain environments. Infrastructure development (e.g. hydroelectric power projects, road construction) in particular appears as an important contributor to ecological degradation throughout the entire Himalayas (Ministry of Environment and Forests 2014; Royal Government of Bhutan 2014; Nandy et al. 2015), with hydropower development reducing access to medicinal plants in the Indian Western Himalaya for example (Kanwal and Joshi 2015). Additional forms of land-use change include the abandonment of agricultural land, which, together with the insufficient tree cover, may result in a decrease in soil water retention and in the drying up of springs and streams at lower altitudes in Sikkim (G. Sharma et al. 2016). On the other extreme, the excessively intensive use of the grassland-oak forest continuum (fire, grazing, and lopping) hinders the natural regeneration of late-successional oak community in the Central Himalaya (Naudiyal and Schmerbeck 2018). Effects of land use change pertain to all mountain ecosystems and regions of the Himalayas, including the cold deserts of the Transhimalaya mountains (IPBES 2018c), and freshwater ecosystems such as high altitude wetlands (Gupta and Shukla 2016; Khan and Baig 2017; Rashid et al. 2017). There, land use change is associated with diffuse pollution (Rather et al. 2016).

3.4.2 Climate change

Climate change is associated with different phenomena. Those include increases in temperatures, in ozone concentrations on the highest peaks (Semple et al. 2016), in extreme events such as extreme precipitation and increases in flooding events from melting glaciers (IPBES 2018c), and in the variability in precipitation, with more unpredictable and shorter rainfall season in Sikkim for example (Sharma et al. 2016). Increases in temperatures vary across the region, with an increase of about 0.2

to 1.6 degrees Celsius per decade in the Northeast Indian Himalaya (Chakraborty et al. 2017) for instance, which is more rapid than the global average (Prakash Singh et al. 2018). Ongoing and predicted changes in climatic conditions are expected to have far-reaching consequences on natural ecosystems including glaciers, on ecosystem services (food production, water supply), and thus also on the health of both humans and animals as well as on overall human wellbeing (Aukema et al. 2017; Negi et al. 2017). Expected effects on species and ecosystems are numerous. For example, although in many places the treeline is depressed by anthropogenic factors (Bobrowski et al. 2017), climate change is predicted to cause a Northward and upward shift of treeline forming species and an advance of forested areas, which in turn will decrease the extent of alpine ecosystems (Chhetri et al. 2018). Changes in climate are also predicted to affect the climatic envelopes and the habitat distribution of many key conservation species, such as the Snow Leopard (Panthera uncia, Li et al. 2016) and the Blue Sheep (Pseudois nayaur, Aryal et al. 2016), as well as key species for mountain people, such as the Yak (*Bos grunniens*, Krishnan et al. 2016). The consequences of climate change, including the increased variability in water discharge due to melting glaciers, are in turn likely to have strong impacts on species such as the bumblebees (*Apidae* sp) in the Western Tibetan Plateau, which depend on a steady flow in arid areas (Williams et al. 2015). In the Eastern Himalaya region (Yunnan), climate change is further predicted to profoundly affect mountain forests (Saikia et al. 2017) and to substantially alter the bioclimatic conditions by 2050. Specifically, 45% of protected areas are predicted to coincide with entirely different bioclimatic conditions, signalling a period of intense ecological perturbation and questioning how effective the network of protected areas is (Zomer et al. 2015). Climate change, particularly in alpine areas, is also a threat for trophic interactions between primary producers, herbivores (such as the Pika, *Ochotona* sp.) and the predators that prey on them, which in turn could initiate a trophic cascade in the Himalayan ecosystem (Bhattacharyya et al. 2019). Finally, the melting of ice and snow, the thawing of the permafrost, and events of extreme precipitation are also likely to increase soil erosion and greenhouse gas emissions (IPBES 2018c). Examples of the effects of climate change on human wellbeing include increasing risks to traditional health care and food security caused by changes in the phenology of medicinal and agricultural plants (Sharma et al. 2016; Maikhuri et al. 2018).

3.4.3 Invasive species

Invasive plant species (such as *Lantana camara* and *Cassia tora*) are being recorded and are spreading in the Himalayas, posing threats to the native flora (Khare et al. 2018), notably by suppressing the floral biodiversity of herbaceous species in forests (Khan and Arya 2017). Major effects are on native scrublands and subtropical needle-leaved forests in the Western Himalayas (Thapa et al. 2018). These effects are predicted to increase with climate change (Khan and Arya 2017). In the Indian Himalaya, the advance of invasive species is recorded along riparian areas and areas grazed by cattle (Mandal and Joshi 2015). It is also recorded in freshwater, where the fifteen alien species of fish (three of them highly invasive) identified to date pose a severe threat (Gupta and Everard 2017) by eating the eggs of economically valuable fish species and by preying on endangered rare indigenous species of fish and invertebrates (Ministry of Environment and Forests 2014). Invasive insects such as ants (*Formicidae*) are also increasingly recorded in the lower reaches of the Himalayas, and predicted to move to higher elevations as temperatures increase (Bharti et al. 2016). Himalayan urban areas are centres of human induced biological invasions (Mehraj et al. 2018).

3.4.4 Pollution

Levels of pollution from point sources and diffuse atmospheric deposition levels in the Himalayas are generally low (Magnani et al. 2018), but differ greatly among locations, with urban areas showing higher levels of diffuse atmospheric deposition (Gupta et al. 2017). In Bhutan, solid waste is a major source of terrestrial pollution, while domestic sewage and effluents from industry contaminate the water ecosystems (Royal Government of Bhutan 2014). Pollution is an increasing threat for high altitude wetlands (Khan and Baig 2017) and in part ascribed to ill-managed tourism. Eutrophication is an important source of pollution of freshwater ecosystems in Kashmir (Pandit et al. 2016) and the wider Himalaya (Rather et al. 2016). In freshwater rivers in the Central Himalaya, water quality decreases downstream and water must be treated before drinking (Singh et al. 2019). Higher CO_2 concentrations and atmospheric Nitrogen deposition in turn have been suggested to cause the positive greening trend observed in certain regions of the Himalaya, along with the introduction of sustainable forestry practices, agricultural fertilization, and irrigation (Mishra and Mainali 2017).

3.4.5 Overexploitation

Overexploitation through bird hunting, fishing, collection of medicinal plants and timber, and retaliatory killings of predators such as the Grey Wolf and Asian Black Bear following livestock depredation are threatening the biodiversity of many high altitude wetlands (Gupta and Shukla 2016; Khan and Baig 2017) and forests (Royal Government of Bhutan 2014), including the sub canopy vegetation (Bisht et al. 2015). Given that many communities depend on livestock for their livelihoods (Syed and Khan 2017), overgrazing is also a widespread driver of change in different ecosystems including forests and above. Pastoralism and overgrazing affect native plant species but also the wild herbivores that compete for limited resources (Syed and Khan 2017) and other wild species, such as the Red Panda (*Ailurus fulgens*) who tend to avoid suitable habitats used by livestock (Dendup et al. 2017; Acharya et al. 2018). Overexploitation, combined with deforestation, habitat fragmentation, the introduction of exotic species (see below) (e.g., Rahman et al. 2016) and increasing trade as a source of additional income (Sher et al. 2017), also affects specific biological resources with a cultural and local consumption value (Negi et al. 2015) or a high market value. These resources include the Chinese Caterpillar Fungus, which is one of the most expensive biological resources of the world (Negi et al. 2015; Shrestha and Bawa 2015), the wild berry *Myrica esculenta* (Gusain and Khanduri 2016), and other MAPs. In the Indian Himalaya as in other parts of the Hindu Kush Himalaya, overharvesting and habitat loss are the main drivers of decline in a number of MAPs used in traditional medicine (Negi et al. 2018).

3.4.6 Interactions

Climate and land-use change interact in many ways and places. For example, they interact dynamically to impact alpine flora in Nepal (Bhatta et al. 2018) and high elevation wetlands (Bhatta and Vetaas 2016; Khan and Baig 2017). In the Eastern Himalayas, interactions between factors such as the loss and fragmentation of habitats, hunting and trapping, unsustainable practices of natural resources extraction, invasive alien species, unregulated tourism and climate change modify bird diversity and populations (Kandel et al. 2018). In Bhutan, road construction eases the access of poachers to forests areas, resulting in the overexploitation of timber and other high value forest species (Royal Government of Bhutan 2014).

4. Institutions, governance, and indirect drivers

4.1 Indirect drivers of change

The main indirect driver of change across the Andes, the East African Mountains (e.g., NEMA 2014; Näschen et al. 2018) and the Hindu Kush Himalay (Sharma et al. 2017; Singh et al. 2018) is demographic growth. In the Andes, additional factors include rapid environmental changes (Flores-López et al. 2016), economic development (cash cropping and market prices) (Quintero-Gallego et al. 2018), and the lack of environmental education and awareness of the general population and the local authorities (Ministerio del Ambiente 2015). Economic development in the form of market prices for instance is also an important factor, for instance in the Himalaya, where the conservation and sustainable management of wild species, such as the Chinese Caterpillar Fungus is often compromised by inadequate marketing (Uprety et al. 2016).

4.2 Legal and regulatory instruments

Legal and regulatory instruments consist primarily in national policy and legal documents. In the Andes, for example, and in particular in Ecuador and Bolivia, the relation between nature and people is acknowledged and reflected in major national policy and legal documents and in the notion of "living well" (*Buen Vivir* or *Sumak Kawsay* in Quechua). This notion is based on a concept and vision of the world that originated in the old indigenous societies of the Andes in which the social idea of solidarity and redistribution is linked to the wider concept of progress – as opposed to growth (SENPLADES 2013). Other countries such as Peru apply a more utilitarian view on the link between nature and people, which is based on the concept of ecosystem services flows that can be valued and compared (Ministerio del Medio Ambiente 2014). In the European Alps, the national conservation and development efforts are mostly pursued in the framework of the implementation of the Alpine Convention (BMU 2014; Direction de l'Eau et de la Biodiversité 2014). This includes the creation of a transboundary ecological network as well as coordinated reintroduction efforts of large predators.

4.3 Economic and financial instruments

Economic and financial instruments and measures take different forms. In the Andes, finance-based models for ecosystem conservation and restoration are applied at different scales. An example is the Socio Bosque Programme (SBP)[1] in Ecuador. This program, which is established by the government, directly provides economic incentives to rural families and local as well as indigenous communities that have agreed to comply with certain conservation activities on a voluntary basis (Cuenca et al. 2018). The SBP reduced deforestation by 1.5% in those forests that received the SBP's direct payment (Cuenca et al. 2018). Payments for Ecosystem Services (PES) represent another form of financial instrument. In Andean high mountain and forest environments, several PES schemes have been implemented to encourage land management practices that contribute both to ecosystem services related to water, carbon, and biodiversity, as well as to livelihoods at a local scale (Pagiola et al. 2002; Bremer et al. 2016; Farley and Bremer 2017). An improvement of the connection of local perceptions and ecological science can be achieved through an active involvement of the local stakeholders, and a better understanding of how the benefits people can obtain from *páramos* are perceived, and how local participation in PES is likely to affect those uses and values (Farley and Bremer 2017). Such collective processes are a prerequisite for an effective integration of local and scientific knowledge and for the coordination between the relevant societal actors, which in turns can help the process of successfully implementing a public policy for conservation (Rubio et al. 2017).

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[1] https://theredddesk.org/countries/initiatives/socio-bosque-program

Ecosystem services, the support of basic needs, security, health, as well as social relations are some of the values typically associated with the *páramo*. While local perceptions may at times align with research on the ecological outcomes of PES, expectations of PES participants are sometimes also unrealistic (Farley and Bremer 2017). PES in the form of payments for watershed services and direct payments for Reducing Emissions from Deforestation and forest Degradation (REDD), for example, are also co-developed with stakeholders in the Eastern African mountains. In the Eastern Arc mountains for instance, scenarios and models for the identification of areas candidate for REDD payments and voluntary carbon projects were co-created with multiple stakeholders and both the acceptance and legitimacy of the proposed options achieved through such a co-design process were high (Fisher et al. 2011; Swetnam et al. 2011). Yet not all attempts to introduce PES schemes have been successful and the overexploitation of forest resources for example continues in many places. In the European Alps, financial instruments consist primarily of direct payments in the form of subsidies to mountain farmers. These subsidies typically need to take into account the impacts of changing farming practices on farmland biodiversity, such as farmland birds (Korner et al. 2018).

4.4 Social and information-based instruments

Social and information-based instruments consist primarily in education and capacity building such as in Peru, and in training and awareness raising, such as in Pakistan where such instruments helped communities sustainably manage and trade medicinal and aromatic plants (Sher et al. 2017).

4.5 Rights-based approaches and customary laws

Rights-based approaches and customary laws represent other forms of institution and governance tools that are important in driving the relationship between nature and people. In many regions of the Andes, and particularly in the Central Andes, indigenous communities have conserved or are rediscovering their traditional knowledge and practices of living and interacting with mountain ecosystems. This traditional ecological knowledge and its application take different forms such as indigenous territories, community forests, or sacred natural sites. They help sustain ecosystem services and are perceived as efficient instruments towards the mitigation (Ricketts et al. 2010) and towards adaptation to (Magrin et al. 2014) climate change, and as effective means to reconcile biodiversity conservation and human development (Hoffmann et al. 2011; Marinaro et al. 2015). In various countries, most notably in Ecuador and Bolivia, such initiatives are firmly rooted in philosophy, policy, and laws such as the *Ley Orgánica de Tierras Rurales y Territorios Ancestrales del Ecuador* (Ministerio del Ambiente del Ecuador 2015), which is the Framework Law of Mother Earth and Integral Development for Living Well[2] (Estado Plurinacional de Bolivia 2015). These integrated, holistic approaches to biodiversity conservation and human wellbeing also consider and reflect the need to adapt to future climate change through the conservation of agrobiodiversity (Estado Plurinacional de Bolivia 2015). Important sources of traditional ecological knowledge are also important in the development of governance approaches and adaptation pathways in the Eastern African mountains. In the Eastern Afromontane for instance, local and indigenous knowledge (e.g., about traditional coffee farming (Capitani et al. 2019)) and coping mechanisms could be incorporated in conventional measures of climate change adaptation (Omambia et al. 2017). A vast amount of (indigenous) local knowledge about coping with and adapting to climate variability and extreme events exists also among the communities in the Himalayas (Ingty 2017) and could be integrated in climate adaptation strategies (Negi et al. 2017; Pandey et al. 2018). Traditional knowledge (e.g.,

[2] Spanish: *La Ley Marco de la Madre Tierra y Desarrollo Integral para Vivir Bien*
https://en.wikipedia.org/wiki/Framework_Law_of_Mother_Earth_and_Integral_Development_for_Living_Well

selection of planted tree species to safeguard plant richness in the Himalaya traditional land use systems (Singh et al. 2017)) can help provide efficient, appropriate, and timely ways of responding to climate change especially in remote communities. Other forms of right-based approaches include citizen mobilizations to defend basic rights and access to natural resources. For example, citizen movements have started in response to the expansion of mining in the *páramos* of Perú (Ministerio de Ambiente y Desarrollo Sostenible 2014) and conflicts have arisen due to the inadequate governance of water resources (Vuille et al. 2018) and to an increase in social and political problems associated with the allocation of water for subsistence farming.

4.6 Management based instruments

Finally, management based instruments also offer tools towards supporting a sustainable relationship between nature and people. One example of such instrument is ecosystem-based adaptation, where the sustainable use of biodiversity and ecosystem services supports and enhances the adaptive capacity of mountain socio-ecological systems in the face of anticipated changes (Egan and Price 2017). Restoration ecology is another approach, which is applied in the context of rural development objectives in the Andes, and has been shown to reduce rural to urban migration in Bolivia (Hartman and Cleveland 2018). In the Eastern African mountains, examples of management-based instruments include reforestation projects and support to agroforestry (e.g., the establishment or extension of Chagga homegardens in regions such as the Kilimanjaro).

5. References

Acharya KP, Shrestha S, Paudel PK, Sherpa AP, Jnawali SR, Acharya S, Bista D. 2018. Pervasive human disturbance on habitats of endangered red panda Ailurus fulgens in the central Himalaya. *Global Ecology and Conservation* 15:e00420. doi:10.1016/j.gecco.2018.e00420.

Adhikari H, Heiskanen J, Siljander M, Maeda E, Heikinheimo V, K. E. Pellikka P. 2017. Determinants of aboveground biomass across an Afromontane landscape mosaic in Kenya. *Remote Sensing* 9(8):827. doi:10.3390/rs9080827.

Ahmad S, Singh JP, Khan PA, Ali A. 2015. Pastoralism and strategies for strengthening rangeland resources of Jammu & Kashmir. *Annals of Agri-Bio Research* 21(1):49–54.

Aitken D, Rivera D, Godoy-Faúndez A, Holzapfel E. 2016. Water scarcity and the impact of the mining and agricultural sectors in Chile. *Sustainability* 8(2):128. doi:10.3390/su8020128.

Alweny S, Nsengiyumva S, Gatarabirwa W. 2014. Africa mountains status report. Africa Sustainable Mountain Development technical report. Kampala, Uganda.

Anderson EP, Jenkins CN, Heilpern S, Maldonado-Ocampo JA, Carvajal-Vallejos FM, Encalada AC, Rivadeneira JF, Hidalgo M, Cañas CM, Ortega H, et al. 2018. Fragmentation of Andes-to-Amazon connectivity by hydropower dams. *Science Advances* 4(1):eaao1642. doi:10.1126/sciadv.aao1642.

Arroyo MTK, Cavieres LA. 2013. High-elevation Andean ecosystems. In: Levin S, editor. Encyclopedia of Biodiversity. New Jersey, USA: Elsevier Science and Technology. p. 96–110.

Arroyo MTK, Pacheco DA, Dudley LS. 2017. Functional role of long-lived flowers in preventing pollen limitation in a high elevation outcrossing species. *AoB PLANTS* 9(6). doi:10.1093/aobpla/plx050.

Aryal A, Shrestha UB, Ji W, Ale SB, Shrestha S, Ingty T, Maraseni T, Cockfield G, Raubenheimer D. 2016. Predicting the distributions of predator (snow leopard) and prey (blue sheep) under climate change in the Himalaya. *Ecology and Evolution* 6(12):4065–4075. doi:10.1002/ece3.2196.

Aryal KP, Poudel S, Chaudhary RP, Chettri N, Chaudhary P, Ning W, Kotru R. 2018. Diversity and use of wild and non-cultivated edible plants in the Western Himalaya. *Journal of Ethnobiology and Ethnomedicine* 14(1):10. doi:10.1186/s13002-018-0211-1.

Asam S, Callegari M, Matiu M, Fiore G, De Gregorio L, Jacob A, Menzel A, Zebisch M, Notarnicola C. 2018. Relationship between Spatiotemporal Variations of Climate, Snow Cover and Plant Phenology over the Alps—An Earth Observation-Based Analysis. *Remote Sensing* 10(11):1757. doi:10.3390/rs10111757.

Aukema JE, Pricope NG, Husak GJ, Lopez-Carr D. 2017. Biodiversity areas under threat: overlap of climate change and population pressures on the world's biodiversity priorities. *PLOS ONE* 12(1):e0170615. doi:10.1371/journal.pone.0170615.

Ayebare S, Plumptre AJ, Kujirakwinja D, Segan D. 2018. Conservation of the endemic species of the Albertine Rift under future climate change. *Biological Conservation* 220:67–75. doi:10.1016/j.biocon.2018.02.001.

Bacon CD, Velásquez-Puentes FJ, Hinojosa LF, Schwartz T, Oxelman B, Pfeil B, Arroyo MTK, Wanntorp L, Antonelli A. 2018. Evolutionary persistence in Gunnera and the contribution of southern plant groups to the tropical Andes biodiversity hotspot. *PeerJ* 6:e4388. doi:10.7717/peerj.4388.

Badola R, Hussain SA, Dobriyal P, Manral U, Barthwal S, Rastogi A, Gill AK. 2018. Institutional arrangements for managing tourism in the Indian Himalayan protected areas. *Tourism Management* 66:1–12. doi:10.1016/j.tourman.2017.10.020.

Bajard M, Etienne D, Quinsac S, Dambrine E, Sabatier P, Frossard V, Gaillard J, Develle A-L, Poulenard J, Arnaud F, et al. 2018. Legacy of early anthropogenic effects on recent lake eutrophication (Lake Bénit, northern French Alps). *Anthropocene* 24:72–87. doi:10.1016/j.ancene.2018.11.005.

Baker T, Kiptala J, Olaka L, Oates N, Hussain A, McCartney M. 2015. Baseline review and ecosystem services assessment of the Tana River Basin, Kenya. Colombo, Sri Lanka.

Barratt CD, Bwong BA, Onstein RE, Rosauer DF, Menegon M, Doggart N, Nagel P, Kissling WD, Loader SP. 2017. Environmental correlates of phylogenetic endemism in amphibians and the conservation of refugia in the Coastal Forests of Eastern Africa. *Diversity and Distributions* 23(8):875–887. doi:10.1111/ddi.12582.

Barros C, Guéguen M, Douzet R, Carboni M, Boulangeat I, Zimmermann NE, Münkemüller T, Thuiller W. 2017. Extreme climate events counteract the effects of climate and land-use changes in Alpine tree lines. Mori A, editor. *Journal of Applied Ecology* 54(1):39–50. doi:10.1111/1365-2664.12742.

Barros VR, Boninsegna JA, Camilloni IA, Chidiak M, Magrín GO, Rusticucci M. 2015. Climate change in Argentina: trends, projections, impacts and adaptation. *Wiley Interdisciplinary Reviews: Climate Change* 6(2):151–169. doi:10.1002/wcc.316.

Barrucand MG, Giraldo Vieira C, Canziani PO. 2017. Climate change and its impacts: perception and adaptation in rural areas of Manizales, Colombia. *Climate and Development* 9(5):415–427. doi:10.1080/17565529.2016.1167661.

Barthlott W, Mutke J, Rafiqpoor D, Kier G, Kreft H. 2005. Global centers of vascular plant diversity. *Nova Acta Leopoldina* 342:61–83.

Becker J, Pabst H, Mnyonga J, Kuzyakov Y. 2015. Annual litterfall dynamics and nutrient deposition depending on elevation and land use at Mt. Kilimanjaro. *Biogeosciences Discussions* 12(13):10031–10057. doi:10.5194/bgd-12-10031-2015.

Becker JN, Kuzyakov Y. 2018. Teatime on Mount Kilimanjaro: assessing climate and land-use effects on litter decomposition and stabilization using the Tea Bag Index. *Land Degradation & Development* 29(8):2321–2329. doi:10.1002/ldr.2982.

Benavides IF, Solarte ME, Pabón V, Ordoñez A, Beltrán E, Rosero S, Torres C. 2018. The variation of infiltration rates and physical-chemical soil properties across a land cover and land use gradient in a Paramo of southwestern Colombia. *Journal of Soil and Water Conservation* 73(4):400–410. doi:10.2489/jswc.73.4.400.

Bendix J, Beck E. 2015. Environmental change and its impacts in a biodiversity hotspot of the south Ecuadorian Andes – monitoring and mitigation strategies. *Erdkunde* 70(1):1–4. doi:10.3112/erdkunde.2016.01.01.

Benham PM, Witt CC. 2016. The dual role of Andean topography in primary divergence: functional and neutral variation among populations of the hummingbird, Metallura tyrianthina. *BMC Evolutionary Biology* 16(1):22. doi:10.1186/s12862-016-0595-2.

Bharti H, Bharti M, Pfeiffer M. 2016. Ants as bioindicators of ecosystem health in Shivalik Mountains of Himalayas: Assessment of species diversity and invasive species. *Asian Myrmecology* 8(1):65–79. doi:http://doi.org/10.20362/am.008023.

Bhatta KP, Grytnes J-A, Vetaas OR. 2018. Downhill shift of alpine plant assemblages under contemporary climate and land-use changes. *Ecosphere* 9(1):e02084. doi:10.1002/ecs2.2084.

Bhatta KP, Vetaas OR. 2016. Does tree canopy closure moderate the effect of climate warming on plant species composition of temperate Himalayan oak forest? Kikvidze Z, editor. *Journal of Vegetation Science* 27(5):948–957. doi:10.1111/jvs.12423.

Bhattacharyya S, Dawson DA, Hipperson H, Ishtiaq F. 2019. A diet rich in C 3 plants reveals the sensitivity of an alpine mammal to climate change. *Molecular Ecology* 28(2):250–265. doi:10.1111/mec.14842.

Bisht VK, Kuniyal CP, Nautiyal BP, Prasad P. 2015. Integrated analysis of the trees and associated under-canopy species in a subalpine forest of western Himalaya, Uttarakhand, India. *Journal of Mountain Science* 12(1):154–165. doi:10.1007/s11629-013-2785-3.

Bisi F, Wauters LA, Preatoni DG, Martinoli A. 2015. Interspecific competition mediated by climate change: which interaction between brown and mountain hare in the Alps? *Mammalian Biology* 80(5):424–430. doi:10.1016/j.mambio.2015.06.002.

BMU. 2014. Fifth National Report Convention on Biological Diversity - Germany. Berlin, Germany.

Bobrowski M, Gerlitz L, Schickhoff U. 2017. Modelling the potential distribution of Betula utilis in the Himalaya. *Global Ecology and Conservation* 11:69–83. doi:10.1016/j.gecco.2017.04.003.

Brambilla M, Bergero V, Bassi E, Falco R. 2015. Current and future effectiveness of Natura 2000 network in the central Alps for the conservation of mountain forest owl species in a warming climate. *European Journal of Wildlife Research* 61(1):35–44. doi:10.1007/s10344-014-0864-6.

Brambilla M, Cortesi M, Capelli F, Chamberlain D, Pedrini P, Rubolini D. 2017. Foraging habitat selection by Alpine White-winged Snowfinches Montifringilla nivalis during the nestling rearing period. *Journal of Ornithology* 158(1):277–286. doi:10.1007/s10336-016-1392-9.

Brambilla M, Pedrini P, Rolando A, Chamberlain DE. 2016. Climate change will increase the potential conflict between skiing and high-elevation bird species in the Alps. *Journal of Biogeography* 43(11):2299–2309. doi:10.1111/jbi.12796.

Bremer LL, Farley KA, Chadwick OA, Harden CP. 2016. Changes in carbon storage with land management promoted by payment for ecosystem services. *Environmental Conservation* 43(04):397–406. doi:10.1017/S0376892916000199.

Bruggeman D, Meyfroidt P, Lambin EF. 2016. Forest cover changes in Bhutan: revisiting the forest transition. *Applied Geography* 67:49–66. doi:10.1016/j.apgeog.2015.11.019.

Burgess ND, Malugu I, Sumbi P, Kashindye A, Kijazi A, Tabor K, Mbilinyi B, Kashaigili J, Wright TM, Gereau RE, et al. 2017. Two decades of change in state, pressure and conservation responses in the coastal forest biodiversity hotspot of Tanzania. *Oryx* 51(01):77–86. doi:10.1017/S003060531500099X.

Buytaert W, Breuer L. 2013. Water resources in South America: sources and supply, pollutants and perspectives. In: Proceedings of H04, IAHS-IAPSO-IASPEI Assembly, Gothenburg, Sweden, July 2013 (IAHS Publ. 3 61, 2013) Understanding Freshwater Quality Problems in a Changing World. p. 106–113.

Buytaert W, Cuesta-Camacho F, Tobón C. 2011. Potential impacts of climate change on the environmental services of humid tropical alpine regions. *Global Ecology and Biogeography* 20(1):19–33. doi:10.1111/j.1466-8238.2010.00585.x.

Calderón-Hernández M, Pérez-Martínez LV. 2018. Seed desiccation tolerance and germination of four Puya (Bromeliaceae) high-andean tropical species from Colombia. *Caldasia* 40(1):177–187. doi:10.15446/caldasia.v40n1.67740.

Cantiani M, Geitner C, Haida C, Maino F, Tattoni C, Vettorato D, Ciolli M. 2016. Balancing economic development and environmental conservation for a new governance of alpine areas. *Sustainability* 8(8):802. doi:10.3390/su8080802.

Capitani C, Garedew W, Mitiku A, Berecha G, Hailu BT, Heiskanen J, Hurskainen P, Platts PJ, Siljander M, Pinard F, et al. 2019. Views from two mountains: exploring climate change impacts on traditional farming communities of Eastern Africa highlands through participatory scenarios. *Sustainability Science* 14(1):191–203. doi:10.1007/s11625-018-0622-x.

Caplins L, Halvorson SJ, Bosak K. 2018. Beyond resistance: a political ecology of cordyceps as alpine niche product in the Garhwal, Indian Himalaya. *Geoforum* 96:298–308. doi:10.1016/j.geoforum.2018.08.019.

Carboni M, Guéguen M, Barros C, Georges D, Boulangeat I, Douzet R, Dullinger S, Klonner G, van Kleunen M, Essl F, et al. 2018. Simulating plant invasion dynamics in mountain ecosystems under global change scenarios. *Global Change Biology* 24(1):e289–e302. doi:10.1111/gcb.13879.

Carlson BZ, Corona MC, Dentant C, Bonet R, Thuiller W, Choler P. 2017. Observed long-term greening of alpine vegetation—a case study in the French Alps. *Environmental Research Letters* 12(11):114006. doi:10.1088/1748-9326/aa84bd.

Carón MM, De Frenne P, Ortega-Baes P, Quinteros A, Verheyen K. 2018. Regeneration responses to climate and land-use change of four subtropical tree species of the southern Central Andes. *Forest Ecology and Management* 417:110–121. doi:10.1016/j.foreco.2018.02.006.

Cettri A, Sharma K, Dewan S, Acharya BK. 2018. Bird diversity of tea plantations in Darjeeling Hills, Eastern Himalaya, India. *Biodiversitas Journal of Biological Diversity* 19(3):1066–1073. doi:10.13057/biodiv/d190339.

Chakraborty A, Ghosh A, Sachdeva K, Joshi PK. 2017. Characterizing fragmentation trends of the Himalayan forests in the Kumaon region of Uttarakhand, India. *Ecological Informatics* 38:95–109. doi:10.1016/j.ecoinf.2016.12.006.

Chakraborty Anusheema, Joshi PK, Sachdeva K. 2017. Capturing forest dependency in the central Himalayan region: Variations between Oak (Quercus spp.) and Pine (Pinus spp.) dominated forest landscapes. *Ambio*. doi:10.1007/s13280-017-0947-1.

Chakraborty D., Saha S, Singh RK, Sethy BK, Kumar A, Saikia US, Das SK, Makdoh B, Borah TR, Nomita Chanu A, et al. 2017. Trend analysis and change point detection of mean air temperature: a spatio-temporal perspective of North-Eastern India. *Environmental Processes* 4(4):937–957. doi:10.1007/s40710-017-0263-6.

Chamberlain DE, Pedrini P, Brambilla M, Rolando A, Girardello M. 2016. Identifying key conservation threats to Alpine birds through expert knowledge. *PeerJ* 4:e1723. doi:10.7717/peerj.1723.

Chettri A, Pradhan A, Sharma G, Pradhan BK, Chhetri DR. 2018. Habitat distribution modelling of seabuckthorn (Hippophae salicifolia D. Don.) in Sikkim, Eastern Himalaya, India. *Indian Journal of Ecology* 45(2):266–269.

Chettri PK, Chhetri B, Badola HK. 2018. Rhododendron diversity along the Kusong-Panch Pokhari transect in Khangchendzonga Biosphere Reserve, the eastern Himalaya: a conservation perspective. *Journal of Threatened Taxa* 10(1):11192. doi:10.11609/jott.3728.10.1.11192-11200.

Chettri S, Krishna AP, Singh KK. 2015. Community forest management in Sikkim Himalaya towards sustainable development. *International Journal of Environment and Sustainable Development* 14(1):89. doi:10.1504/IJESD.2015.066900.

Chhetri PK, Gaddis KD, Cairns DM. 2018. Predicting the suitable habitat of treeline species in the Nepalese Himalayas under climate change. *Mountain Research and Development* 38(2):153–163. doi:10.1659/MRD-JOURNAL-D-17-00071.1.

Chisanga K, Bhardwaj DR, Pala NA, Thakur CL. 2018. Biomass production and carbon stock inventory of high-altitude dry temperate land use systems in North Western Himalaya. *Ecological Processes* 7(1):22. doi:10.1186/s13717-018-0134-8.

Cianfrani C, Satizábal HF, Randin C. 2015. A spatial modelling framework for assessing climate change impacts on freshwater ecosystems: Response of brown trout (Salmo trutta L.) biomass to warming water temperature. *Ecological Modelling* 313:1–12. doi:10.1016/j.ecolmodel.2015.06.023.

Clerici N, Rubiano K, Abd-Elrahman A, Posada Hoestettler J, Escobedo F. 2016. Estimating aboveground biomass and carbon stocks in periurban Andean secondary forests using very high resolution imagery. *Forests* 7(12):138. doi:10.3390/f7070138.

Cochi Machaca N, Condori B, Pardo AR, Anthelme F, Meneses RI, Weeda CE, Perotto-Baldivieso HL. 2018. Effects of grazing pressure on plant species composition and water presence on bofedales in the Andes mountain range of Bolivia. *Mires and Peat* 21(15):1–15. doi:10.19189/MaP.2017.OMB.303.

Courtney Mustaphi CJ, Gajewski K, Marchant R, Rosqvist G. 2017. A late Holocene pollen record from proglacial Oblong Tarn, Mount Kenya. *PLOS ONE* 12(9):e0184925. doi:10.1371/journal.pone.0184925.

Crespo-Pérez V, Pinto CM, Carrión JM, Jarrín-E RD, Poveda C, de Vries T. 2016. The Shiny Cowbird, Molothrus bonariensis (Gmelin, 1789) (Aves: Icteridae), at 2,800 m asl in Quito, Ecuador. *Biodiversity Data Journal* 4:e8184. doi:10.3897/BDJ.4.e8184.

Cuenca P, Robalino J, Arriagada R, Echeverría C. 2018. Are government incentives effective for avoided deforestation in the tropical Andean forest? *PLOS ONE* 13(9):e0203545. doi:10.1371/journal.pone.0203545.

D'Amico ME, Freppaz M, Leonelli G, Bonifacio E, Zanini E. 2015. Early stages of soil development on serpentinite: the proglacial area of the Verra Grande Glacier, Western Italian Alps. *Journal of Soils and Sediments* 15(6):1292–1310. doi:10.1007/s11368-014-0893-5.

Dainese M, Aikio S, Hulme PE, Bertolli A, Prosser F, Marini L. 2017. Human disturbance and upward expansion of plants in a warming climate. *Nature Climate Change* 7(8):577–580. doi:10.1038/nclimate3337.

Dangles O, Rabatel A, Kraemer M, Zeballos G, Soruco A, Jacobsen D, Anthelme F. 2017. Ecosystem sentinels for climate change? Evidence of wetland cover changes over the last 30 years in the tropical Andes. *PLOS ONE* 12(5):e0175814. doi:10.1371/journal.pone.0175814.

Das P, Behera MD, Murthy MSR. 2017. Forest fragmentation and human population varies logarithmically along elevation gradient in Hindu Kush Himalaya - utility of geospatial tools and free data set. *Journal of Mountain Science* 14(12):2432–2447. doi:10.1007/s11629-016-4159-0.

Dendup P, Cheng E, Lham C, Tenzin U. 2017. Response of the endangered red panda Ailurus fulgens fulgens to anthropogenic disturbances, and its distribution in Phrumsengla National Park, Bhutan. *Oryx* 51(4):701–708. doi:10.1017/S0030605316000399.

Department of Environment. 2015. Fifth National Report of Bangladesh to the Convention on Biological Diversity. Dhaka.

Derhé MA, Tuyisingize D, Eckardt W, Emmanuel F, Stoinski T. 2019 May 16. Status, diversity and trends of the bird communities in Volcanoes National Park and surrounds, Rwanda. *Bird Conservation International*:1–20. doi:10.1017/S0959270919000121.

Desai AR, Wohlfahrt G, Zeeman MJ, Katata G, Eugster W, Montagnani L, Gianelle D, Mauder M, Schmid H-P. 2016. Montane ecosystem productivity responds more to global circulation patterns than climatic trends. *Environmental Research Letters* 11(2):024013. doi:10.1088/1748-9326/11/2/024013.

Detsch F, Otte I, Appelhans T, Hemp A, Nauss T. 2016. Seasonal and long-term vegetation dynamics from 1-km GIMMS-based NDVI time series at Mt. Kilimanjaro, Tanzania. *Remote Sensing of Environment* 178:70–83. doi:10.1016/j.rse.2016.03.007.

Dinakaran J, Chandra A, Chamoli KP, Deka J, Rao KS. 2018. Soil organic carbon stabilization changes with an altitude gradient of land cover types in central Himalaya, India. *CATENA* 170:374–385. doi:10.1016/j.catena.2018.06.039.

Direction de l'Eau et de la Biodiversité. 2014. Cinquième rapport national de la France à la Convention sur la Diversité Biologique. Paris, France.

Downing TA, Imo M, Kimanzi J, Otinga AN. 2017. Effects of wildland fire on the tropical alpine moorlands of Mount Kenya. *CATENA* 149:300–308. doi:10.1016/j.catena.2016.10.003.

Drenkhan F, Guardamino L, Huggel C, Frey H. 2018. Current and future glacier and lake assessment in the deglaciating Vilcanota-Urubamba basin, Peruvian Andes. *Global and Planetary Change* 169:105–118. doi:10.1016/j.gloplacha.2018.07.005.

Dulle HI, Ferger SW, Cordeiro NJ, Howell KM, Schleuning M, Böhning-Gaese K, Hof C. 2016. Changes in abundances of forest understorey birds on Africa's highest mountain suggest subtle effects of climate change. Beggs J, editor. *Diversity and Distributions* 22(3):288–299. doi:10.1111/ddi.12405.

Dullinger S, Gattringer A, Thuiller W, Moser D, Zimmermann NE, Guisan A, Willner W, Plutzar C, Leitner M, Mang T, et al. 2012. Extinction debt of high-mountain plants under twenty-first-century climate change. *Nature Climate Change* 2(8):619–622. doi:10.1038/nclimate1514.

Dumont ES, Bonhomme S, Pagella Ti, Sinclair FL. 2019. Structured stakeholder engagement leads to development of more diverse and inclusive agroforestry options. *Experimental Agriculture* 55(S1):252–274. doi:10.1017/S0014479716000788.

Dupire S, Bourrier F, Monnet J-M, Bigot S, Borgniet L, Berger F, Curt T. 2016a. Novel quantitative indicators to characterize the protective effect of mountain forests against rockfall. *Ecological Indicators* 67:98–107. doi:10.1016/j.ecolind.2016.02.023.

Dupire S, Bourrier F, Monnet J-M, Bigot S, Borgniet L, Berger F, Curt T. 2016b. The protective effect of forests against rockfalls across the French Alps: Influence of forest diversity. *Forest Ecology and Management* 382:269–279. doi:10.1016/j.foreco.2016.10.020.

Dupire S, Curt T, Bigot S. 2017. Spatio-temporal trends in fire weather in the French Alps. *Science of The Total Environment* 595:801–817. doi:10.1016/j.scitotenv.2017.04.027.

Eckert S, Kiteme B, Njuguna E, Zaehringer J. 2017. Agricultural expansion and intensification in the foothills of Mount Kenya: a landscape perspective. *Remote Sensing* 9(8):784. doi:10.3390/rs9080784.

Egan PA, Price MF. 2017. Mountain ecosystem services and climate change: a global overview of potential threats and strategies for adaptation. Paris, France: UNESCO.

Egarter Vigl L, Schirpke U, Tasser E, Tappeiner U. 2016. Linking long-term landscape dynamics to the multiple interactions among ecosystem services in the European Alps. *Landscape Ecology* 31(9):1903–1918. doi:10.1007/s10980-016-0389-3.

Engler R, Randin CF, Vittoz P, Czáka T, Beniston M, Zimmermann NE, Guisan A. 2009. Predicting future distributions of mountain plants under climate change: does dispersal capacity matter? *Ecography* 32(1):34–45. doi:10.1111/j.1600-0587.2009.05789.x.

Ensslin A, Rutten G, Pommer U, Zimmermann R, Hemp A, Fischer M. 2015. Effects of elevation and land use on the biomass of trees, shrubs and herbs at Mount Kilimanjaro. *Ecosphere* 6(3):art45–art45. doi:10.1890/ES14-00492.1.

Estado Plurinacional de Bolivia. 2015. Quinto Informe Nacional ante la CBD - Vivir Bien en armonía con la Madre Tierra.

FAO. 2012. Why the Andes matter. Sustainable mountain development. From RIO 2012 and beyond. Lima – Perú.

Farley KA, Bremer LL. 2017. "Water Is Life": Local Perceptions of Páramo Grasslands and Land Management Strategies Associated with Payment for Ecosystem Services. *Annals of the American Association of Geographers* 107(2):371–381. doi:10.1080/24694452.2016.1254020.

Fedrigotti C, Aschonotis V, Fano EA. 2016. Effects of forest expansion and land abandonment on ecosystem services of alpine environments: case study in Ledro valley (Italy) for the period 1859-2011. *Global NEST Journal* 18(4):875–884. doi:10.30955/gnj.001770.

Fell SC, Carrivick JL, Kelly MG, Füreder L, Brown LE. 2018. Declining glacier cover threatens the biodiversity of alpine river diatom assemblages. *Global Change Biology* 24(12):5828–5840. doi:10.1111/gcb.14454.

Fernández-Llamazares Á, Helle J, Eklund J, Balmford A, Mónica Moraes R, Reyes-García V, Cabeza M. 2018. New law puts Bolivian biodiversity hotspot on road to deforestation. *Current Biology* 28(1):R15–R16. doi:10.1016/j.cub.2017.11.013.

Ferrarini A, Alatalo JM, Gustin M. 2017. Climate change will seriously impact bird species dwelling above the treeline: A prospective study for the Italian Alps. *Science of The Total Environment* 590–591:686–694. doi:10.1016/j.scitotenv.2017.03.027.

Finch J, Marchant R, Courtney Mustaphi CJ. 2017. Ecosystem change in the South Pare Mountain bloc, Eastern Arc Mountains of Tanzania. *The Holocene* 27(6):796–810. doi:10.1177/0959683616675937.

Finer M, Jenkins CN. 2012. Proliferation of hydroelectric dams in the Andean Amazon and implications for Andes-Amazon connectivity. *PLoS ONE* 7(4):e35126. doi:10.1371/journal.pone.0035126.

Fisher B, Turner RK, Burgess ND, Swetnam RD, Green J, Green RE, Kajembe G, Kulindwa K, Lewis SL, Marchant R, et al. 2011. Measuring, modeling and mapping ecosystem services in the Eastern Arc Mountains of Tanzania. *Progress in Physical Geography: Earth and Environment* 35(5):595–611. doi:10.1177/0309133311422968.

Flores-López F, Galaitsi S, Escobar M, Purkey D. 2016. Modeling of Andean Páramo ecosystems' hydrological response to environmental change. *Water* 8(3):94. doi:10.3390/w8030094.

FOEN. 2014. Switzerland's Fifth National Report under the Convention on Biological Diversity. Bern, Switzerland.

Fondevilla C, Àngels Colomer M, Fillat F, Tappeiner U. 2016. Using a new PDP modelling approach for land-use and land-cover change predictions: A case study in the Stubai Valley (Central Alps). *Ecological Modelling* 322:101–114. doi:10.1016/j.ecolmodel.2015.11.016.

Forero Ulloa FE, R. C, Germán E, Palacios Pacheco LS. 2015. Dinámica del Páramo como espacio para la captura de carbono. Tunja, Colombia.

Furrer R, Schaub M, Bossert A, Isler R, Jenny H, Jonas T, Marti C, Jenni L. 2016. Variable decline of Alpine Rock Ptarmigan (Lagopus muta helvetica) in Switzerland between regions and sites. *Journal of Ornithology* 157(3):787–796. doi:10.1007/s10336-016-1324-8.

Gandarillas R. V, Jiang Y, Irvine K. 2016. Assessing the services of high mountain wetlands in tropical Andes: A case study of Caripe wetlands at Bolivian Altiplano. *Ecosystem Services* 19:51–64. doi:10.1016/j.ecoser.2016.04.006.

Gentili R, Bacchetta G, Fenu G, Cogoni D, Abeli T, Rossi G, Salvatore MC, Baroni C, Citterio S. 2015. From cold to warm-stage refugia for boreo-alpine plants in southern European and Mediterranean mountains: the last chance to survive or an opportunity for speciation? *Biodiversity* 16(4):247–261. doi:10.1080/14888386.2015.1116407.

Gil Morales EG, Tobón Marín C. 2016. Hydrological modelling with TOPMODEL of Chingaza páramo, Colombia. *Revista Facultad Nacional de Agronomía* 69(2). doi:10.15446/rfna.v69n2.59137.

Gram G, Vaast P, van der Wolf J, Jassogne L. 2018. Local tree knowledge can fast-track agroforestry recommendations for coffee smallholders along a climate gradient in Mount Elgon, Uganda. *Agroforestry Systems* 92(6):1625–1638. doi:10.1007/s10457-017-0111-8.

Gretter A, Ciolli M, Scolozzi R. 2018. Governing mountain landscapes collectively: local responses to emerging challenges within a systems thinking perspective. *Landscape Research* 43(8):1117–1130. doi:10.1080/01426397.2018.1503239.

Gritsch A, Dirnböck T, Dullinger S. 2016. Recent changes in alpine vegetation differ among plant communities. Wulf M, editor. *Journal of Vegetation Science* 27(6):1177–1186. doi:10.1111/jvs.12447.

Guerrina M, Conti E, Minuto L, Casazza G. 2016. Knowing the past to forecast the future: a case study on a relictual, endemic species of the SW Alps, Berardia subacaulis. *Regional Environmental Change* 16(4):1035–1045. doi:10.1007/s10113-015-0816-z.

Guidi C, Cannella D, Leifeld J, Rodeghiero M, Magid J, Gianelle D, Vesterdal L. 2015. Carbohydrates and thermal properties indicate a decrease in stable aggregate carbon following forest colonization of mountain grassland. *Soil Biology and Biochemistry* 86:135–145. doi:10.1016/j.soilbio.2015.03.027.

Guio Blanco CM, Brito Gomez VM, Crespo P, Ließ M. 2018. Spatial prediction of soil water retention in a Páramo landscape: Methodological insight into machine learning using random forest. *Geoderma* 316:100–114. doi:10.1016/j.geoderma.2017.12.002.

Gupta N, Everard M. 2017. Non-native fishes in the Indian Himalaya: an emerging concern for freshwater scientists. *International Journal of River Basin Management*:1–5. doi:10.1080/15715124.2017.1411929.

Gupta S, Rai H, Upreti DK, Gupta RK, Sharma PK. 2017. Lichenized fungi Phaeophyscia (Physciaceae, ascomycota) as indicator of ambient air heavy metal deposition, along land use gradient in an Alpine habitat of Western Himalaya, India. *Pollution Research* 36(1):150–157.

Gupta SK, Shukla DP. 2016. Assessment of land use/land cover dynamics of Tso Moriri Lake, a Ramsar site in India. *Environmental Monitoring and Assessment* 188(12):700. doi:10.1007/s10661-016-5707-3.

Gusain YS, Khanduri VP. 2016. Myrica esculenta wild edible fruit of Indian Himalaya: Need a sustainable approach for indigenous utilization. *Ecology, Environment and Conservation* 22:267–270.

Habel JC, Cox S, Gassert F, Mulwa RK, Meyer J, Lens L. 2013. Population genetics of the East African White-eye species complex. *Conservation Genetics* 14(5):1019–1028. doi:10.1007/s10592-013-0492-9.

Habel JC, Weisser WW, Eggermont H, Lens L. 2013. Food security versus biodiversity protection: an example of land-sharing from East Africa. *Biodiversity and Conservation* 22(6–7):1553–1555. doi:10.1007/s10531-013-0479-3.

Hall J, Burgess ND, Lovett J, Mbilinyi B, Gereau RE. 2009. Conservation implications of deforestation across an elevational gradient in the Eastern Arc Mountains, Tanzania. *Biological Conservation* 142(11):2510–2521. doi:10.1016/j.biocon.2009.05.028.

Hartman BD, Cleveland DA. 2018. The socioeconomic factors that facilitate or constrain restoration management: Watershed rehabilitation and wet meadow (bofedal) restoration in the Bolivian Andes. *Journal of Environmental Management* 209:93–104. doi:10.1016/j.jenvman.2017.12.025.

Hastik R, Basso S, Geitner C, Haida C, Poljanec A, Portaccio A, Vrščaj B, Walzer C. 2015. Renewable energies and ecosystem service impacts. *Renewable and Sustainable Energy Reviews* 48:608–623. doi:10.1016/j.rser.2015.04.004.

Hastik R, Walzer C, Haida C, Garegnani G, Pezzutto S, Abegg B, Geitner C. 2016. Using the "Footprint" approach to examine the potentials and impacts of renewable energy sources in the European Alps. *Mountain Research and Development* 36(2):130–140. doi:10.1659/MRD-JOURNAL-D-15-00071.1.

Helbig-Bonitz M, Ferger SW, Böhning-Gaese K, Tschapka M, Howell K, Kalko EK V. 2015. Bats are not birds - different responses to human land-use on a tropical mountain. *Biotropica* 47(4):497–508. doi:10.1111/btp.12221.

Herzog SK, Martínez R, Jorgensen P, Tiessen. H. 2012. Cambio climático y biodiversidad en los Andes Tropicales. Paris, France: Instituto Interamericano para la Investigación del Cambio Global (IAI), Sao José dos Campos, y Comité Científico sobre Problemas del Medio Ambiente (SCOPE).

Hoffmann D, Oetting I, Arnillas CA, Ulloa R. 2011. Climate change and protected areas in the Tropical Andes. In: Herzog K, Martínez R, Jørgensen PM, Tiessen H, editors. Climate Change and Biodiversity in the Tropical Andes. São José dos Campos, Brazil & Paris, France: Inter-American Institute for Global Change Research (IAI) & Scientific Committee on Problems of the Environment (SCOPE). p. 311–325.

Hopping KA, Chignell SM, Lambin EF. 2018. The demise of caterpillar fungus in the Himalayan region due to climate change and overharvesting. *Proceedings of the National Academy of Sciences of the United States of America* 115(45):11489–11494. doi:10.1073/pnas.1811591115.

Ianni E, Geneletti D, Ciolli M. 2015. Revitalizing traditional ecological knowledge: a study in an alpine rural community. *Environmental Management* 56(1):144–156. doi:10.1007/s00267-015-0479-z.

Ingrisch J, Karlowsky S, Anadon-Rosell A, Hasibeder R, König A, Augusti A, Gleixner G, Bahn M. 2018. Land use alters the drought responses of productivity and CO2 fluxes in mountain grassland. *Ecosystems* 21(4):689–703. doi:10.1007/s10021-017-0178-0.

Ingty T. 2017. High mountain communities and climate change: adaptation, traditional ecological knowledge, and institutions. *Climatic Change* 145(1–2):41–55. doi:10.1007/s10584-017-2080-3.

Iñiguez-Armijos C, Hampel H, Breuer L. 2018. Land-use effects on structural and functional composition of benthic and leaf-associated macroinvertebrates in four Andean streams. *Aquatic Ecology* 52(1):77–92. doi:10.1007/s10452-017-9646-z.

Iñiguez V, Morales O, Cisneros F, Bauwens W, Wyseure G. 2015. Analysis of the drought resilience of Andosols on southern Ecuadorian Andean páramos. *Hydrology and Earth System Sciences Discussions* 12(11):11449–11484. doi:10.5194/hessd-12-11449-2015.

IPBES. 2018a. The IPBES regional assessment report on biodiversity and ecosystem services for the Americas. Rice, J., Seixas CS, Zaccagnini, M. E., Bedoya-Gaitán, M. and VN, editors. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPBES. 2018b. The IPBES regional assessment report on biodiversity and ecosystem services for Africa. Archer E, Dziba L, Mulongoy KJ, Maoela MA, Walters M, editors. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPBES. 2018c. The IPBES regional assessment report on biodiversity and ecosystem services for Asia and the Pacific. Karki M, Senaratna Sellamuttu S, Okayasu S, Suzuki W, editors. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

IPBES. 2018d. The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia. Rounsevell, M., Fischer, M., Torre-Marin Rando, A. and Mader A, editor. Bonn, Germany: Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Irauschek F, Rammer W, Lexer MJ. 2017. Evaluating multifunctionality and adaptive capacity of mountain forest management alternatives under climate change in the Eastern Alps. *European Journal of Forest Research* 136(5–6):1051–1069. doi:10.1007/s10342-017-1051-6.

Izquierdo AE, Foguet J, Ricardo Grau H. 2015. Mapping and spatial characterization of Argentine High Andean peatbogs. *Wetlands Ecology and Management* 23(5):963–976. doi:10.1007/s11273-015-9433-3.

Jähnig S, Alba R, Vallino C, Rosselli D, Pittarello M, Rolando A, Chamberlain D. 2018. The contribution of broadscale and finescale habitat structure to the distribution and diversity of birds in an Alpine forest-shrub ecotone. *Journal of Ornithology* 159(3):747–759. doi:10.1007/s10336-018-1549-9.

Jana P, Dasgupta S, Todaria NP. 2017. Impact and ecosystem service of forest and sacred grove as saviour of water quantity and quality in Garhwal Himalaya, India. *Environmental Monitoring and Assessment* 189(9):477. doi:10.1007/s10661-017-6173-2.

Jandl N, Jandl R, Schindlbacher A. 2018. Future management options for cembran pine forests close to the alpine timberline. *Annals of Forest Science* 75(3):81. doi:10.1007/s13595-018-0760-4.

Jochner M, Bugmann H, Nötzli M, Bigler C. 2017. Among-tree variability and feedback effects result in different growth responses to climate change at the upper treeline in the Swiss Alps. *Ecology and Evolution* 7(19):7937–7953. doi:10.1002/ece3.3290.

Jolly WM, Dobbertin M, Zimmermann NE, Reichstein M. 2005. Divergent vegetation growth responses to the 2003 heat wave in the Swiss Alps. *Geophysical Research Letters* 32(18):L18409. doi:10.1029/2005GL023252.

Jumbo-Salazar CA, Arévalo Delgado CD, Ramirez-Cando LJ. 2017. Medición de carbono del estrato arbóreo del bosque natural Tinajillas-Limón Indanza, Ecuador. *La Granja* 27(1):51–63. doi:10.17163/lgr.n27.2018.04.

Kandel P, Thapa I, Chettri N, Pradhan R, Sharma E. 2018. Birds of the Kangchenjunga Landscape, the Eastern Himalaya: status, threats and implications for conservation. *Avian Research* 9(1):9. doi:10.1186/s40657-018-0100-2.

Kanwal KS, Joshi H. 2015. The impact of hydroelectric project development on the ethnobotany of the Alaknanda river basin of Western Himalaya, India. *EurAsian Journal of BioSciences* 9:61–77. doi:http://doi.org/10.5053/ejobios.2015.9.0.8.

Khan AH, Arya D. 2017. Impact of climate change on the proliferation of invasive alien plant species in almora district of Uttarakhand Himalaya. *Indian Journal of Ecology* 44(2):295–299.

Khan H, Baig S. 2017. High altitude wetlands of the HKH region of northern Pakistan – status of current knowledge, challenges and research opportunities. *Wetlands* 37(2):371–380. doi:10.1007/s13157-016-0868-y.

Khare S, Latifi H, Ghosh SK. 2018. Multi-scale assessment of invasive plant species diversity using Pléiades 1A, RapidEye and Landsat-8 data. *Geocarto International* 33(7):681–698. doi:10.1080/10106049.2017.1289562.

Kiebacher T, Scheidegger C, Bergamini A. 2017. Solitary trees increase the diversity of vascular plants and bryophytes in pastures. *Agriculture, Ecosystems & Environment* 239:293–303. doi:10.1016/j.agee.2017.01.034.

Kikoti IA, Mligo C. 2015. Impacts of livestock grazing on plant species composition in montane forests on the northern slope of Mount Kilimanjaro, Tanzania. *International Journal of Biodiversity Science, Ecosystem Services & Management* 11(2):114–127. doi:10.1080/21513732.2015.1031179.

Kleckova I, Klecka J. 2016. Facing the heat: thermoregulation and behaviour of lowland species of a cold-dwelling butterfly genus, Erebia. *PLOS ONE* 11(3):e0150393. doi:10.1371/journal.pone.0150393.

Kohler M, Stotten R, Steinbacher M, Leitinger G, Tasser E, Schirpke U, Tappeiner U, Schermer M. 2017. Participative spatial scenario analysis for Alpine ecosystems. *Environmental Management* 60(4):679–692. doi:10.1007/s00267-017-0903-7.

Körner C. 2012. Alpine treelines: functional ecology of the global high elevation tree limits. Basel, Switzerland: Springer.

Korner P, Graf R, Jenni L. 2018. Large changes in the avifauna in an extant hotspot of farmland biodiversity in the Alps. *Bird Conservation International* 28(02):263–277. doi:10.1017/S0959270916000502.

Kotikot SM, Onywere SM. 2015. Application of GIS and remote sensing techniques in frost risk mapping for mitigating agricultural losses in the Aberdare ecosystem, Kenya. *Geocarto International* 30(1):104–121. doi:10.1080/10106049.2014.965758.

Krishnan G, Paul V, Hanah SS, Bam J, Das PJ. 2016. Effects of climate change on yak production at high altitude. *Indian Journal of Animal Sciences* 86(6):621–626.

Kumar R, Shamet GS, Mehta H, Alam NM, Kaushal R, Chaturvedi OP, Sharma N, Khaki BA, Gupta D. 2016. Regeneration complexities of Pinus gerardiana in dry temperate forests of Indian Himalaya. *Environmental Science and Pollution Research* 23(8):7732–7743. doi:10.1007/s11356-015-6010-5.

Kuppler J, Fricke J, Hemp C, Steffan-Dewenter I, Peters MK. 2015. Conversion of savannah habitats to small-scale agriculture affects grasshopper communities at Mt. Kilimanjaro, Tanzania. *Journal of Insect Conservation* 19(3):509–518. doi:10.1007/s10841-015-9772-7.

Labaj AL, Michelutti N, Smol JP. 2018. Cladocera in shallow lakes from the Ecuadorian Andes show little response to recent climate change. *Hydrobiologia* 822(1):203–216. doi:10.1007/s10750-018-3681-1.

Lafond V, Cordonnier T, Mao Z, Courbaud B. 2017. Trade-offs and synergies between ecosystem services in uneven-aged mountain forests: evidences using Pareto fronts. *European Journal of Forest Research* 136(5–6):997–1012. doi:10.1007/s10342-016-1022-3.

Lamond G, Sandbrook Li, Gassner A, Sinclair FL. 2019. Local knowledge of tree attributes underpins species selection on coffee farms. *Experimental Agriculture* 55(S1):35–49. doi:10.1017/S0014479716000168.

Lamprecht A, Semenchuk PR, Steinbauer K, Winkler M, Pauli H. 2018. Climate change leads to accelerated transformation of high-elevation vegetation in the central Alps. *New Phytologist* 220(2):447–459. doi:10.1111/nph.15290.

Lasso CA, Machado-Allison A, Taphorn DC. 2016. Fishes and aquatic habitats of the Orinoco River Basin: diversity and conservation. *Journal of Fish Biology* 89(1):174–191. doi:10.1111/jfb.13010.

Lavorel S, Grigulis K, Leitinger G, Kohler M, Schirpke U, Tappeiner U. 2017. Historical trajectories in land use pattern and grassland ecosystem services in two European alpine landscapes. *Regional Environmental Change* 17(8):2251–2264. doi:10.1007/s10113-017-1207-4.

Lega M, Casazza M, Turconi L, Luino F, Tropeano D, Savio G, Ulgiati S, Endreny T. 2018. Environmental data acquisition, elaboration and integration: preliminary application to a vulnerable mountain landscape and village (Novalesa, NW Italy). *Engineering* 4(5):635–642. doi:10.1016/j.eng.2018.08.011.

Lei F, Qu Y, Song G, Alström P, Fjeldsa J. 2015. The potential drivers in forming avian biodiversity hotspots in the East Himalaya Mountains of Southwest China. *Integrative Zoology* 10(2):171–181. doi:10.1111/1749-4877.12121.

Li J, McCarthy TM, Wang H, Weckworth B V., Schaller GB, Mishra C, Lu Z, Beissinger SR. 2016. Climate refugia of snow leopards in High Asia. *Biological Conservation* 203:188–196. doi:10.1016/j.biocon.2016.09.026.

Little CJ, Wheeler JA, Sedlacek J, Cortés AJ, Rixen C. 2016. Small-scale drivers: the importance of nutrient availability and snowmelt timing on performance of the alpine shrub Salix herbacea. *Oecologia* 180(4):1015–1024. doi:10.1007/s00442-015-3394-3.

Löffler F, Fartmann T. 2017. Effects of landscape and habitat quality on Orthoptera assemblages of pre-alpine calcareous grasslands. *Agriculture, Ecosystems and Environment* 248:71–81. doi:10.1016/j.agee.2017.07.029.

de Luna AG, Link A. 2018. Distribution, population density and conservation of the critically endangered brown spider monkey (Ateles hybridus) and other primates of the inter-Andean forests of Colombia. *Biodiversity and Conservation* 27(13):3469–3511. doi:10.1007/s10531-018-1611-1.

Maan A, Kumar R, Thakur SN, Kahlon S, Bhutani S. 2016. Human - environment relations and climate change in Western Himalaya. *International Journal of Environmental Sciences* 7(2):220–244. doi:10.6088/ijes.7020.

Magnani A, Ajmone-Marsan F, D'Amico M, Balestrini R, Viviano G, Salerno F, Freppaz M. 2018. Soil properties and trace elements distribution along an altitudinal gradient on the southern slope of Mt. Everest, Nepal. *CATENA* 162:61–71. doi:10.1016/j.catena.2017.11.015.

Magrin GO, Marengo JA, Boulanger J-P, Buckeridge MS, Castellanos E, Poveda G, Scarano FR, Vicuña S. 2014. Central and South America. In: Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, et al., editors. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. p. 1499–1566.

Mahato S, Dasgupta S, Todaria NP. 2016. Tree and soil carbon stock by community managed forests in Garhwal Himalaya. *Plant Archives* 16(2):805–811.

Maikhuri RK, Phondani PC, Dhyani D, Rawat LS, Jha NK, Kandari LS. 2018. Assessment of climate change impacts and its implications on medicinal plants-based traditional healthcare system in central Himalaya, India. *Iranian Journal of Science and Technology, Transactions A: Science* 42(4):1827–1835. doi:10.1007/s40995-017-0354-2.

Mairal M, Sanmartín I, Herrero A, Pokorny L, Vargas P, Aldasoro JJ, Alarcón M. 2017. Geographic barriers and Pleistocene climate change shaped patterns of genetic variation in the Eastern Afromontane biodiversity hotspot. *Scientific Reports* 7(1):45749. doi:10.1038/srep45749.

Malonza PK. 2015. Patterns of reptile and amphibian species richness along elevational gradients in Mt. Kenya. *Zoological Research* 36(6):342–347. doi:10.13918/j.issn.2095-8137.2015.6.342.

Mandal G, Joshi SP. 2015. Plant invasion: dynamics and habitat invasion capacity of invasive species in western Indian Himalaya. *Annali di Botanica* 5:1–16. doi:http://doi.org/10.4462/annbotrm-12469.

Marinaro S, Grau HR, Macchi L, Zelaya PV. 2015. Land tenure and biological communities in dry Chaco forests of northern Argentina. *Journal of Arid Environments* 123:60–67. doi:10.1016/j.jaridenv.2014.06.005.

Maroschek M, Rammer W, Lexer MJ. 2015. Using a novel assessment framework to evaluate protective functions and timber production in Austrian mountain forests under climate change. *Regional Environmental Change* 15(8):1543–1555. doi:10.1007/s10113-014-0691-z.

Marshall AR, Platts PJ, Gereau RE, Kindeketa W, Kang'ethe S, Marchant R. 2012. The genus Acacia (Fabaceae) in East Africa: distribution, diversity and the protected area network. *Plant Ecology and Evolution* 145(3):289–301. doi:10.5091/plecevo.2012.597.

Marsoner T, Egarter Vigl L, Manck F, Jaritz G, Tappeiner U, Tasser E. 2018. Indigenous livestock breeds as indicators for cultural ecosystem services: A spatial analysis within the Alpine Space. *Ecological Indicators* 94:55–63. doi:10.1016/j.ecolind.2017.06.046.

Marti C. 2018. Conservation of black grouse in times of tourism development and climate change [Schutz des Birkhuhns in den Alpen: Einflüsse von touristischen Erschließungen und Klimawandel. *Naturschutz und Landschaftsplanung* 50(7):242–249.

Mathew MM, Majule AE, Sinclair F, Marchant R. 2016. Relationships between on-farm tree stocks and soil organic carbon along an altitudinal gradient, Mount Kilimanjaro, Tanzania. *Forests, Trees and Livelihoods* 25(4):255–266. doi:10.1080/14728028.2016.1202790.

Matthews-Bird F, Brooks SJ, Gosling WD, Gulliver P, Mothes P, Montoya E. 2017. Aquatic community response to volcanic eruptions on the Ecuadorian Andean flank: evidence from the palaeoecological record. *Journal of Paleolimnology* 58(4):437–453. doi:10.1007/s10933-017-0001-0.

Mazzorana B, Nardini A, Comiti F, Vignoli G, Cook E, Ulloa H, Iroumé A. 2018. Toward participatory decision-making in river corridor management: two case studies from the European Alps. *Journal of Environmental Planning and Management* 61(7):1250–1270. doi:10.1080/09640568.2017.1339593.

Mbane JO, Chira RM, Mwangi EM. 2019. Impact of land use and tenure changes on the Kitenden wildlife corridor, Amboseli Ecosystem, Kenya. *African Journal of Ecology* 57(3):335–343. doi:10.1111/aje.12611.

McGinley M. 2009. Biological diversity in the Eastern Afromontane.

Meena VS, Mondal T, Pandey BM, Mukherjee A, Yadav RP, Choudhary M, Singh S, Bisht JK, Pattanayak A. 2018. Land use changes: strategies to improve soil carbon and nitrogen storage pattern in the mid-Himalaya ecosystem, India. *Geoderma* 321:69–78. doi:10.1016/j.geoderma.2018.02.002.

Mehraj G, Khuroo AA, Qureshi S, Muzafar I, Friedman CR, Rashid I. 2018. Patterns of alien plant diversity in the urban landscapes of global biodiversity hotspots: a case study from the Himalayas. *Biodiversity and Conservation* 27(5):1055–1072. doi:10.1007/s10531-017-1478-6.

Meng H, Carr J, Beraducci J, Bowles P, Branch WR, Capitani C, Chenga J, Cox N, Howell K, Malonza P, et al. 2016. Tanzania's reptile biodiversity: Distribution, threats and climate change vulnerability. *Biological Conservation* 204:72–82. doi:10.1016/j.biocon.2016.04.008.

Meusburger K, Porto P, Mabit L, La Spada C, Arata L, Alewell C. 2018. Excess Lead-210 and Plutonium-239+240: two suitable radiogenic soil erosion tracers for mountain grassland sites. *Environmental Research* 160:195–202. doi:10.1016/j.envres.2017.09.020.

Mganga KZ, Razavi BS, Kuzyakov Y. 2016. Land use affects soil biochemical properties in Mt. Kilimanjaro region. *CATENA* 141:22–29. doi:10.1016/j.catena.2016.02.013.

Mills-Novoa M, Borgias SL, Crootof A, Thapa B, de Grenade R, Scott CA. 2017. Bringing the hydrosocial cycle into climate change adaptation planning: lessons from two Andean mountain water towers. *Annals of the American Association of Geographers* 107(2):393–402. doi:10.1080/24694452.2016.1232618.

Mina M, Bugmann H, Klopcic M, Cailleret M. 2017. Accurate modeling of harvesting is key for projecting future forest dynamics: a case study in the Slovenian mountains. *Regional Environmental Change* 17(1):49–64. doi:10.1007/s10113-015-0902-2.

Miner KR, Bogdal C, Pavlova P, Steinlin C, Kreutz KJ. 2018. Quantitative screening level assessment of human risk from PCBs released in glacial meltwater: Silvretta Glacier, Swiss Alps. *Ecotoxicology and Environmental Safety* 166:251–258. doi:10.1016/j.ecoenv.2018.09.066.

Ministerio de Ambiente y Desarrollo Sostenible P de las NU para el D. 2014. Quinto Informe Nacional de Biodiversidad de Colombia ante el Convenio de Diversidad Biológica. Bogotá, D.C., Colombia.

Ministerio del Ambiente. 2015. Quinto Informe Nacional ante el Convenio sobre la Diversidad Biológica: Perú (2010-2013). Lima – Perú.

Ministerio del Ambiente del Ecuador. 2015. Quinto Informe Nacional para el Convenio sobre la Diversidad Biológica. Quito, Ecuador.

Ministerio del Medio Ambiente. 2014. Quinto Informe Nacional de Biodiversidad de Chile ante el Convenio sobre la Diversidad Biológica (CBD). Santiago, Chile.

Ministry of Environment and Forests. 2014. India’s Fifth National Report to the Convention on Biological Diversity. New Delhi, India.

Mishra NB, Chaudhuri G. 2015. Spatio-temporal analysis of trends in seasonal vegetation productivity across Uttarakhand, Indian Himalayas, 2000–2014. *Applied Geography* 56:29–41. doi:10.1016/j.apgeog.2014.10.007.

Mishra NB, Mainali KP. 2017. Greening and browning of the Himalaya: spatial patterns and the role of climatic change and human drivers. *Science of The Total Environment* 587–588:326–339. doi:10.1016/j.scitotenv.2017.02.156.

Mittermeier RA, Gil PR, Hoffman M, Pilgrim J, Brooks T, Mittermeier CG, Lamoreux J, Da Fonseca GAB. 2004. Hotspots revisited: earth’s biologically richest and most endangered terrestrial ecoregions. Chicago, USA.

Mmbaga NE, Munishi LK, Treydte AC. 2017. How dynamics and drivers of land use/land cover change impact elephant conservation and agricultural livelihood development in Rombo, Tanzania. *Journal of Land Use Science* 12(2–3):168–181. doi:10.1080/1747423X.2017.1313324.

Molina-Venegas R, Fischer M, Hemp A. 2019. Plant evolutionary assembly along elevational belts at Mt. Kilimanjaro: Using phylogenetics to assess biodiversity threats under climate change. *Environmental and Experimental Botany*:103853. doi:10.1016/j.envexpbot.2019.103853.

Mollel NP, Fischer M, Hemp A. 2017. Usable wild plant species in relation to elevation and land use at Mount Kilimanjaro, Tanzania. *Alpine Botany* 127(2):145–154. doi:10.1007/s00035-017-0187-9.

Mori E, Sforzi A, Bogliani G, Milanesi P. 2018. Range expansion and redefinition of a crop-raiding rodent associated with global warming and temperature increase. *Climatic Change* 150(3–4):319–331. doi:10.1007/s10584-018-2261-8.

Moser FN, van Rijssel JC, Ngatunga B, Mwaiko S, Seehausen O. 2019. The origin and future of an endangered crater lake endemic; phylogeography and ecology of Oreochromis hunteri and its invasive relatives. *Hydrobiologia* 832(1):283–296. doi:10.1007/s10750-018-3780-z.

Mukasa AD, Mutambatsere E, Arvanitis Y, Triki T. 2013. Development of wind energy in Africa. Tunis, Tunisia.

Munishi LK, Lema AA, Ndakidemi PA. 2015. Decline in maize and beans production in the face of climate change at Hai District in Kilimanjaro Region, Tanzania. *International Journal of Climate Change Strategies and Management* 7(1):17–26. doi:10.1108/IJCCSM-07-2013-0094.

Muñoz-Mendoza C, D’Elía G, Panzera A, Méndez T. MA, Villalobos-Leiva A, Sites JW, Victoriano PF. 2017. Geography and past climate changes have shaped the evolution of a widespread lizard from the Chilean hotspot. *Molecular Phylogenetics and Evolution* 116:157–171. doi:10.1016/j.ympev.2017.08.016.

Murali R, Redpath S, Mishra C. 2017. The value of ecosystem services in the high altitude Spiti Valley, Indian Trans-Himalaya. *Ecosystem Services* 28:115–123. doi:10.1016/j.ecoser.2017.10.018.

Murillo-Sandoval P, Hilker T, Krawchuk M, Van Den Hoek J. 2018. Detecting and attributing drivers of forest disturbance in the Colombian Andes using Landsat time-series. *Forests* 9(5):269. doi:10.3390/f9050269.

Musila S, Chen Z, Li Q, Yego R, Onditi K, Muthoni I, Omondi S, Mathenge J, N. Kioko E. 2019. Diversity and distribution patterns of non-volant small mammals along different elevation gradients on Mt. Kenya, Kenya. *Zoological Research* 40(1):53–60. doi:10.24272/j.issn.2095-8137.2019.004.

Musonge PSL, Boets P, Lock K, Damanik Ambarita NM, Forio MAE, Verschuren D, Goethals PLM. 2019. Baseline assessment of benthic macroinvertebrate community structure and ecological water quality in Rwenzori rivers (Albertine rift valley, Uganda) using biotic-index tools. *Limnologica* 75:1–10. doi:10.1016/j.limno.2018.12.001.

Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J. 2000. Biodiversity hotspots for conservation priorities. *Nature* 403(6772):853–858. doi:10.1038/35002501.

Nagler M, Fontana V, Lair GJ, Radtke A, Tasser E, Zerbe S, Tappeiner U. 2015. Different management of larch grasslands in the European Alps shows low impact on above- and belowground carbon stocks. *Agriculture, Ecosystems & Environment* 213:186–193. doi:10.1016/j.agee.2015.08.005.

Nandy S, Singh C, Das KK, Kingma NC, Kushwaha SPS. 2015. Environmental vulnerability assessment of eco-development zone of Great Himalayan National Park, Himachal Pradesh, India. *Ecological Indicators* 57:182–195. doi:10.1016/j.ecolind.2015.04.024.

Näschen K, Diekkrüger B, Leemhuis C, Steinbach S, Seregina L, Thonfeld F, van der Linden R. 2018. Hydrological modeling in data-scarce catchments: the Kilombero floodplain in Tanzania. *Water* 10(5):599. doi:10.3390/w10050599.

Naudiyal N, Schmerbeck J. 2017. The changing Himalayan landscape: pine-oak forest dynamics and the supply of ecosystem services. *Journal of Forestry Research* 28(3):431–443. doi:10.1007/s11676-016-0338-7.

Naudiyal N, Schmerbeck J. 2018. Linking forest successional dynamics to community dependence on provisioning ecosystem services from the Central Himalayan forests of Uttarakhand. *Environmental Management* 62(5):915–928. doi:10.1007/s00267-018-1087-5.

Negi CS, Joshi P, Bohra S. 2015. Rapid vulnerability assessment of Yartsa Gunbu (Ophiocordyceps sinensis [Berk.] G.H. Sung et al) in Pithoragarh district, Uttarakhand State, India. *Mountain Research and Development* 35(4):382–391. doi:10.1659/MRD-JOURNAL-D-14-00005.1.

Negi VS, Kewlani P, Pathak R, Bhatt D, Bhatt ID, Rawal RS, Sundriyal RC, Nandi SK. 2018. Criteria and indicators for promoting cultivation and conservation of Medicinal and Aromatic Plants in Western Himalaya, India. *Ecological Indicators* 93:434–446. doi:10.1016/j.ecolind.2018.03.032.

Negi VS, Maikhuri RK, Pharswan D, Thakur S, Dhyani PP. 2017. Climate change impact in the Western Himalaya: people's perception and adaptive strategies. *Journal of Mountain Science* 14(2):403–416. doi:10.1007/s11629-015-3814-1.

Nellier Y-M, Perga M-E, Cottin N, Fanget P, Malet E, Naffrechoux E. 2015. Mass budget in two high altitude lakes reveals their role as atmospheric PCB sinks. *Science of The Total Environment* 511:203–213. doi:10.1016/j.scitotenv.2014.12.052.

NEMA. 2014. Fifth National Report to the Convention on Biological Diversity. Kampala, Uganda.

Nepal M, Rai R, Das S, Bhatta L, Kotru R, Khadayat M, Rawal R, Negi G. 2018. Valuing cultural services of the Kailash Sacred landscape for sustainable management. *Sustainability* 10(10):3638. doi:10.3390/su10103638.

Newmark WD, Jenkins CN, Pimm SL, McNeally PB, Halley JM. 2017. Targeted habitat restoration can reduce extinction rates in fragmented forests. *Proceedings of the National Academy of Sciences* 114(36):9635–9640. doi:10.1073/pnas.1705834114.

Nicolet G, Eckert N, Morin S, Blanchet J. 2018. Assessing climate change impact on the spatial dependence of extreme snow depth maxima in the French Alps. *Water Resources Research* 54(10):7820–7840. doi:10.1029/2018WR022763.

Norfolk O, Jung M, Platts PJ, Malaki P, Odeny D, Marchant R. 2017. Birds in the matrix: the role of agriculture in avian conservation in the Taita Hills, Kenya. *African Journal of Ecology* 55(4):530–540. doi:10.1111/aje.12383.

Novoa C, Astruc G, Desmet J-F, Besnard A. 2016. No short-term effects of climate change on the breeding of Rock Ptarmigan in the French Alps and Pyrenees. *Journal of Ornithology* 157(3):797–810. doi:10.1007/s10336-016-1335-5.

Nyongesa JM, Bett HK, Lagat JK, Ayuya OI. 2016. Estimating farmers' stated willingness to accept pay for ecosystem services: case of Lake Naivasha watershed Payment for Ecosystem Services scheme-Kenya. *Ecological Processes* 5(1):15. doi:10.1186/s13717-016-0059-z.

Obojes N, Meurer A, Newesely C, Tasser E, Oberhuber W, Mayr S, Tappeiner U. 2018. Water stress limits transpiration and growth of European larch up to the lower subalpine belt in an inner-alpine dry valley. *New Phytologist* 220(2):460–475. doi:10.1111/nph.15348.

Ocampo-Peñuela N, Garcia-Ulloa J, Ghazoul J, Etter A. 2018. Quantifying impacts of oil palm expansion on Colombia's threatened biodiversity. *Biological Conservation* 224:117–121. doi:10.1016/j.biocon.2018.05.024.

Ojoyi MM, Odindi J, Mutanga O, Abdel-Rahman EM. 2016. Analysing fragmentation in vulnerable biodiversity hotspots in Tanzania from 1975 to 2012 using remote sensing and fragstats. *Nature Conservation* 16:19–37. doi:10.3897/natureconservation.16.9312.

Olaya Rodríguez MH, Escobar Lizarazo MD, Cusva A, Lasso Alcalá CA, Londoño Murcia MC. 2017. Mapeo del servicio ecosistémico de alimento asociado a la pesca en los humedales interiores de Colombia. *Ecología Austral* 27(1bis):123–133. doi:10.25260/EA.17.27.1.1.261.

Omambia AN, Shemsanga C, Hernandez IAS. 2017. Climate change impacts, vulnerability, and adaptation in East Africa (EA) and South America (SA). In: Handbook of Climate Change Mitigation and Adaptation. Cham: Springer International Publishing. p. 749–799.

Orlandi S, Probo M, Sitzia T, Trentanovi G, Garbarino M, Lombardi G, Lonati M. 2016. Environmental and land use determinants of grassland patch diversity in the western and eastern Alps under agro-pastoral abandonment. *Biodiversity and Conservation* 25(2):275–293. doi:10.1007/s10531-016-1046-5.

Otto M, Gibbons RE. 2017. Potential effects of projected decrease in annual rainfall on spatial distribution of high Andean wetlands in southern Peru. *Wetlands* 37(4):647–659. doi:10.1007/s13157-017-0896-2.

Pabst H, Gerschlauer F, Kiese R, Kuzyakov Y. 2016. Land use and precipitation affect organic and microbial carbon stocks and the specific metabolic quotient in soils of eleven ecosystems of Mt. Kilimanjaro, Tanzania. *Land Degradation & Development* 27(3):592–602. doi:10.1002/ldr.2406.

Padilla-González GF, Diazgranados M, Da Costa FB. 2017. Biogeography shaped the metabolome of the genus Espeletia: a phytochemical perspective on an Andean adaptive radiation. *Scientific Reports* 7(1):8835. doi:10.1038/s41598-017-09431-7.

Pagiola S, Bishop J, Landel-Mills N. 2002. Selling forest environmental services: market-based mechanisms for conservation and development. London and Washington: Earthscan Publications Limited.

Palomino-Ángel S, Anaya-Acevedo JA, Botero BA. 2019. Evaluation of 3B42V7 and IMERG daily-precipitation products for a very high-precipitation region in northwestern South America. *Atmospheric Research* 217:37–48. doi:10.1016/j.atmosres.2018.10.012.

Pandey NC, Bhatt D, Arya D, Upreti BM, Chopra N, Joshi GC, Tewari LM. 2017. Patterns of agro-diversity with its socio-economic uses at Gagas Valley, Almora, Kumaun Himalaya. *International Journal of Conservation Science* 8(2):317–324.

Pandey P, Shaner P-JL, Sharma HP. 2016. The wild boar as a driver of human-wildlife conflict in the protected park lands of Nepal. *European Journal of Wildlife Research* 62(1):103–108. doi:10.1007/s10344-015-0978-5.

Pandey R, Kumar P, Archie KM, Gupta AK, Joshi PK, Valente D, Petrosillo I. 2018. Climate change adaptation in the western-Himalayas: household level perspectives on impacts and barriers. *Ecological Indicators* 84:27–37. doi:10.1016/j.ecolind.2017.08.021.

Pandit AK, Shah JA, Mustafa Shah G. 2016. Research trends in cladoceran diversity from Kashmir Himalaya. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences* 86(2):239–246. doi:10.1007/s40011-014-0480-y.

Pansu J, Giguet-Covex C, Ficetola GF, Gielly L, Boyer F, Zinger L, Arnaud F, Poulenard J, Taberlet P, Choler P. 2015. Reconstructing long-term human impacts on plant communities: an ecological approach based on lake sediment DNA. *Molecular Ecology* 24(7):1485–1498. doi:10.1111/mec.13136.

Paudel PK, Heinen JT. 2015. Conservation planning in the Nepal Himalayas: effectively (re)designing reserves for heterogeneous landscapes. *Applied Geography* 56:127–134. doi:10.1016/j.apgeog.2014.11.018.

Pellissier L, Anzini M, Maiorano L, Dubuis A, Pottier J, Vittoz P, Guisan A. 2013. Spatial predictions of land-use transitions and associated threats to biodiversity: the case of forest regrowth in mountain grasslands. Cousins S, editor. *Applied Vegetation Science* 16(2):227–236. doi:10.1111/j.1654-109X.2012.01215.x.

Perger R, Guerra F. 2016. The description of a new calyptrate fly mimicking species of the fungus weevil genus Gymnognathus Schönherr 1826 from the southern Bolivian Andes (Coleoptera: Anthribidae: Anthribinae). *Zootaxa* 4084(2):277. doi:10.11646/zootaxa.4084.2.7.

Petitpierre B, McDougall K, Seipel T, Broennimann O, Guisan A, Kueffer C. 2016. Will climate change increase the risk of plant invasions into mountains? *Ecological Applications* 26(2):530–544. doi:10.1890/14-1871.

Peyre G, Balslev H, Martí D, Sklenář P, Ramsay P, Lozano P, Cuello N, Bussmann R, Cabrera O, Font X. 2015. VegPáramo, a flora and vegetation database for the Andean páramo. *Phytocoenologia* 45(1):195–201. doi:10.1127/phyto/2015/0045.

Phondani PC, Bhatt ID, Negi VS, Kothyari BP, Bhatt A, Maikhuri RK. 2016. Promoting medicinal plants cultivation as a tool for biodiversity conservation and livelihood enhancement in Indian Himalaya. *Journal of Asia-Pacific Biodiversity* 9(1):39–46. doi:10.1016/j.japb.2015.12.001.

Piiroinen R, Fassnacht FE, Heiskanen J, Maeda E, Mack B, Pellikka P. 2018. Invasive tree species detection in the Eastern Arc Mountains biodiversity hotspot using one class classification. *Remote Sensing of Environment* 218:119–131. doi:10.1016/j.rse.2018.09.018.

Pitman N, Joergensen P, Williams, R.León-Yánez S, Valencia R. 2002. Extinction rates estimates for a modern neotropical flora. *Conservation Biology* 16(5):1427–1431.

Prakash Singh C, Mohapatra J, Pandya HA, Gajmer B, Sharma N, Shrestha DG. 2018. Evaluating changes in treeline position and land surface phenology in Sikkim Himalaya. *Geocarto International*:1–17. doi:10.1080/10106049.2018.1524513.

Price B, Kaim D, Szwagrzyk M, Ostapowicz K, Kolecka N, Schmatz DR, Wypych A, Kozak J. 2017. Legacies, socio-economic and biophysical processes and drivers: the case of future forest cover expansion in the Polish Carpathians and Swiss Alps. *Regional Environmental Change* 17(8):2279–2291. doi:10.1007/s10113-016-1079-z.

Qamer F, Xi C, Abbas S, Murthy M, Ning W, Anming B. 2016. An Assessment of productivity patterns of grass-dominated rangelands in the Hindu Kush Karakoram region, Pakistan. *Sustainability* 8(9):961. doi:10.3390/su8090961.

Qin S, Golden Kroner RE, Cook C, Tesfaw AT, Braybrook R, Rodriguez CM, Poelking C, Mascia MB. 2019. Protected area downgrading, downsizing, and degazettement as a threat to iconic protected areas. *Conservation Biology* 33(6):1275–1285. doi:10.1111/cobi.13365.

Quenta E, Molina-Rodriguez J, Gonzales K, Rebaudo F, Casas J, Jacobsen D, Dangles O. 2016. Direct and indirect effects of glaciers on aquatic biodiversity in high Andean peatlands. *Global Change Biology* 22(9):3196–3205. doi:10.1111/gcb.13310.

Quintero-Gallego ME, Quintero-Angel M, Vila-Ortega JJ. 2018. Exploring land use/land cover change and drivers in Andean mountains in Colombia: A case in rural Quindío. *Science of The Total Environment* 634:1288–1299. doi:10.1016/j.scitotenv.2018.03.359.

Quiroz Dahik C, Crespo P, Stimm B, Murtinho F, Weber M, Hildebrandt P. 2018. Contrasting stakeholders' perceptions of pine plantations in the Páramo ecosystem of Ecuador. *Sustainability* 10(6):1707. doi:10.3390/su10061707.

Rahman IU, Ijaz F, Iqbal Z, Afzal A, Ali N, Afzal M, Khan MA, Muhammad S, Qadir G, Asif M. 2016. A novel survey of the ethno medicinal knowledge of dental problems in Manoor Valley (Northern Himalaya), Pakistan. *Journal of Ethnopharmacology* 194:877–894. doi:10.1016/j.jep.2016.10.068.

Rahn E, Liebig T, Ghazoul J, van Asten P, Läderach P, Vaast P, Sarmiento A, Garcia C, Jassogne L. 2018. Opportunities for sustainable intensification of coffee agro-ecosystems along an altitudinal gradient on Mt. Elgon, Uganda. *Agriculture, Ecosystems & Environment* 263:31–40. doi:10.1016/j.agee.2018.04.019.

Rashid I, Romshoo SA, Amin M, Khanday SA, Chauhan P. 2017. Linking human-biophysical interactions with the trophic status of Dal Lake, Kashmir Himalaya, India. *Limnologica* 62:84–96. doi:10.1016/j.limno.2016.11.008.

Rather MI, Rashid I, Shahi N, Murtaza KO, Hassan K, Yousuf AR, Romshoo SA, Shah IY. 2016. Massive land system changes impact water quality of the Jhelum River in Kashmir Himalaya. *Environmental Monitoring and Assessment* 188(3):185. doi:10.1007/s10661-016-5190-x.

Ravnikar T, Bohanec M, Muri G. 2016. Monitoring and assessment of anthropogenic activities in mountain lakes: a case of the Fifth Triglav Lake in the Julian Alps. *Environmental Monitoring and Assessment* 188(4):253. doi:10.1007/s10661-016-5234-2.

Rawat S, Nagar B. 2017. Wild edible plants: a viable option for sustaining rural livelihood in Western Himalaya. *Indian Journal of Ecology* 44(2):289–294.

Rawat S, Nagar B, R. D. 2018. Rural households' perception on forest resource utilization during climatic adversities in Garhwal Himalaya. *Indian Journal of Ecology* 45(1):84–87.

Rehnus M, Bollmann K, Schmatz DR, Hackländer K, Braunisch V. 2018. Alpine glacial relict species losing out to climate change: The case of the fragmented mountain hare population (Lepus timidus) in the Alps. *Global Change Biology* 24(7):3236–3253. doi:10.1111/gcb.14087.

Republic of Kenya. 2015. Fifth National Report to the Conference of Parties to the Convention on Biological Diversity. Nairobi, Kenya.

Restrepo JD, Park E, Aquino S, Latrubesse EM. 2016. Coral reefs chronically exposed to river sediment plumes in the southwestern Caribbean: Rosario Islands, Colombia. *Science of The Total Environment* 553:316–329. doi:10.1016/j.scitotenv.2016.02.140.

Rewicz T, Wattier R, Rigaud T, Grabowski M, Mamos T, Bącela-Spychalska K. 2017. The killer shrimp, Dikerogammarus villosus , invading European Alpine Lakes: A single main source but independent founder events with an overall loss of genetic diversity. *Freshwater Biology* 62(6):1036–1051. doi:10.1111/fwb.12923.

Ricketts TH, Soares-Filho B, da Fonseca GAB, Nepstad D, Pfaff A, Petsonk A, Anderson A, Boucher D, Cattaneo A, Conte M, et al. 2010. Indigenous lands, protected areas, and slowing climate change. *PLoS Biology* 8(3):e1000331. doi:10.1371/journal.pbio.1000331.

Ringler A, Grabherr G. 2017. Trends in the grassland of the Alps. *Natur und Landschaft* 92(43747):424–431.

Rios M, Tinitana F, Jarrín-V P, Donoso N, Romero-Benavides JC. 2017. "Horchata" drink in Southern Ecuador: medicinal plants and people's wellbeing. *Journal of Ethnobiology and Ethnomedicine* 13(1):18. doi:10.1186/s13002-017-0145-z.

Rodríguez MA, Angueyra A, Cleef AM, Van Andel T. 2018. Ethnobotany of the Sierra Nevada del Cocuy-Güicán: climate change and conservation strategies in the Colombian Andes. *Journal of Ethnobiology and Ethnomedicine* 14(1):34. doi:10.1186/s13002-018-0227-6.

Rogora M, Frate L, Carranza ML, Freppaz M, Stanisci A, Bertani I, Bottarin R, Brambilla A, Canullo R, Carbognani M, et al. 2018. Assessment of climate change effects on mountain ecosystems through a cross-site analysis in the Alps and Apennines. *Science of The Total Environment* 624:1429–1442. doi:10.1016/j.scitotenv.2017.12.155.

Rolando JL, Dubeux JCB, Ramirez DA, Ruiz-Moreno M, Victor Mares CT, Sollenberger LE, Quiroz R. 2018. Land use effects on soil fertility and nutrient cycling in the Peruvian High-Andean Puna grasslands. *Soil Science Society of America Journal* 82(2):463. doi:10.2136/sssaj2017.09.0309.

Rosbakh S, Leingärtner A, Hoiss B, Krauss J, Steffan-Dewenter I, Poschlod P. 2017. Contrasting effects of extreme drought and snowmelt patterns on mountain plants along an elevation gradient. *Frontiers in Plant Science* 8. doi:10.3389/fpls.2017.01478.

Rotta F, Cerasino L, Occhipinti-Ambrogi A, Rogora M, Seppi R, Tolotti M. 2018. Diatom diversity in headwaters influenced by permafrost thawing: First evidence from the Central Italian Alps. *Advances in Oceanography and Limnology*. doi:10.4081/aiol.2018.7929.

Rovero F, Owen N, Jones T, Canteri E, Iemma A, Tattoni C. 2017. Camera trapping surveys of forest mammal communities in the Eastern Arc Mountains reveal generalized habitat and human disturbance responses. *Biodiversity and Conservation* 26(5):1103–1119. doi:10.1007/s10531-016-1288-2.

Royal Government of Bhutan. 2014. The Fifth National Report National Environment Commission Secretariat. Thimphu, Bhutan.

Rubio MC, Rubio C, Salomón M, Abraham E. 2017. Conservation of ecosystem services in high-altitude Andean wetlands: social participation in the creation of a natural protected area. *Ecología Austral* 27(1).

Ruiz DM, Martínez Idrobo JP, Otero Sarmiento JD, Figueroa Casas A. 2017. Effects of productive activities on the water quality for human consumption in an Andean basin, a case study. *Revista Internacional de Contaminación Ambiental* 33(3):361–375. doi:10.20937/RICA.2017.33.03.01.

Rumpf SB, Hülber K, Klonner G, Moser D, Schütz M, Wessely J, Willner W, Zimmermann NE, Dullinger S. 2018. Range dynamics of mountain plants decrease with elevation. *Proceedings of the National Academy of Sciences* 115(8):1848–1853. doi:10.1073/pnas.1713936115.

Saavedra-Ramírez KA, Etter A, Ramírez A. 2018. Tropical ash (Fraxinus udhei) invading Andean forest remnants in Northern South America. *Ecological Processes* 7(1):16. doi:10.1186/s13717-018-0131-y.

Saikia P, Deka J, Bharali S, Kumar A, Tripathi OP, Singha LB, Dayanandan S, Khan ML. 2017. Plant diversity patterns and conservation status of eastern Himalayan forests in Arunachal Pradesh, Northeast India. *Forest Ecosystems* 4(1):28. doi:10.1186/s40663-017-0117-8.

Sales LP, Neves OV, De Marco P, Loyola R. 2017. Model uncertainties do not affect observed patterns of species richness in the Amazon. *PLOS ONE* 12(10):e0183785. doi:10.1371/journal.pone.0183785.

Salgado Salomón ME, Barroetaveña C, Pildain MB, Williams EA, Rajchenberg M. 2018. What happens to the mycorrhizal communities of native and exotic seedlings when Pseudotsuga menziesii invades Nothofagaceae forests in Patagonia, Argentina? *Acta Oecologica* 91:108–119. doi:10.1016/j.actao.2018.07.003.

Salvador, F., Monerris J, Rochefort L. 2014. Peatlands of the Peruvian Puna ecoregion: types, characteristics and disturbance. *Mires and Peat* 15(4):1–17.

Sandhu H, Sandhu S. 2015. Poverty, development, and Himalayan ecosystems. *AMBIO* 44(4):297–307. doi:10.1007/s13280-014-0569-9.

Sanín MJ, Kissling WD, Bacon CD, Borchsenius F, Galeano G, Svenning J-C, Olivera J, Ramírez R, Trénel P, Pintaud J-C. 2016. The Neogene rise of the tropical Andes facilitated diversification of wax palms (Ceroxylon : Arecaceae) through geographical colonization and climatic niche separation. *Botanical Journal of the Linnean Society* 182(2):303–317. doi:10.1111/boj.12419.

Schaafsma M, Burgess ND, Swetnam RD, Ngaga YM, Kerry Turner R, Treue T. 2014. Market signals of unsustainable and inequitable forest extraction: assessing the value of illegal timber trade in the Eastern Arc mountains of Tanzania. *World Development* 62:155–168. doi:10.1016/j.worlddev.2014.05.011.

Schirpke U, Kohler M, Leitinger G, Fontana V, Tasser E, Tappeiner U. 2017. Future impacts of changing land-use and climate on ecosystem services of mountain grassland and their resilience. *Ecosystem Services* 26:79–94. doi:10.1016/j.ecoser.2017.06.008.

Schirpke U, Meisch C, Marsoner T, Tappeiner U. 2018. Revealing spatial and temporal patterns of outdoor recreation in the European Alps and their surroundings. *Ecosystem Services* 31:336–350. doi:10.1016/j.ecoser.2017.11.017.

Schirpke U, Meisch C, Tappeiner U. 2018. Symbolic species as a cultural ecosystem service in the European Alps: insights and open issues. *Landscape Ecology* 33(5):711–730. doi:10.1007/s10980-018-0628-x.

Schirpke U, Timmermann F, Tappeiner U, Tasser E. 2016. Cultural ecosystem services of mountain regions: modelling the aesthetic value. *Ecological Indicators* 69:78–90. doi:10.1016/j.ecolind.2016.04.001.

Schulze-Sylvester M, Corronca J, Paris C. 2018. Growing industries, growing invasions? The case of the Argentine ant in vineyards of northern Argentina. *Insects* 9(1):11. doi:10.3390/insects9010011.

Schwörer C, Colombaroli D, Kaltenrieder P, Rey F, Tinner W. 2015. Early human impact (5000-3000 BC) affects mountain forest dynamics in the Alps. *Journal of Ecology* 103(2):281–295. doi:10.1111/1365-2745.12354.

Sears R, Choden K, Dorji T, Dukpa D, Phuntsho S, Rai P, Wangchuk J, Baral H. 2018. Bhutan’s forests through the framework of ecosystem services: rapid assessment in three forest types. *Forests* 9(11):675. doi:10.3390/f9110675.

Seimon TA, Seimon A, Yager K, Reider K, Delgado A, Sowell P, Tupayachi A, Konecky B, McAloose D, Halloy S. 2017. Long-term monitoring of tropical alpine habitat change, Andean anurans, and chytrid fungus in the Cordillera Vilcanota, Peru: Results from a decade of study. *Ecology and Evolution* 7(5):1527–1540. doi:10.1002/ece3.2779.

Seipel T, Alexander JM, Edwards PJ, Kueffer C. 2016. Range limits and population dynamics of non-native plants spreading along elevation gradients. *Perspectives in Plant Ecology, Evolution and Systematics* 20:46–55. doi:10.1016/j.ppees.2016.04.001.

Semple JL, Moore GWK, Koutrakis P, Wolfson JM, Cristofanelli P, Bonasoni P. 2016. High concentrations of ozone air pollution on Mount Everest: health implications for sherpa communities and mountaineers. *High Altitude Medicine & Biology* 17(4):365–369. doi:10.1089/ham.2016.0042.

SENPLADES. 2013. Plan Nacional para el Buen Vivir 2013-2017. Quito, Ecuador.

Shaban KS, Okumu JO, Paul O, Joseph O. 2016. Assessing community-based organizations' influence on trees and grass planting for forest, soil and water management around Mt. Elgon National Park in Uganda. *Forests, Trees and Livelihoods* 25(3):161–172. doi:10.1080/14728028.2015.1102094.

Sharma G, Hunsdorfer B, Singh KK. 2016. Comparative analysis on the socio-ecological and economic potentials of traditional agroforestry systems in the Sikkim Himalaya. *Tropical Ecology 57 4* 57(4):751–764.

Sharma LN, Vetaas OR. 2015. Does agroforestry conserve trees? A comparison of tree species diversity between farmland and forest in mid-hills of central Himalaya. *Biodiversity and Conservation* 24(8):2047–2061. doi:10.1007/s10531-015-0927-3.

Sharma M, Areendran G, Raj K, Sharma A, Joshi PK. 2016. Multitemporal analysis of forest fragmentation in Hindu Kush Himalaya—a case study from Khangchendzonga Biosphere Reserve, Sikkim, India. *Environmental Monitoring and Assessment* 188(10):596. doi:10.1007/s10661-016-5577-8.

Sharma M, Chakraborty A, Garg JK, Joshi PK. 2017. Assessing forest fragmentation in north-western Himalaya: a case study from Ranikhet forest range, Uttarakhand, India. *Journal of Forestry Research* 28(2):319–327. doi:10.1007/s11676-016-0311-5.

Sher H, Bussmann RW, Hart R. 2017. Promoting sustainable use of medicinal and aromatic plants for livelihood improvement and biodiversity conservation under global climate change, through capacity building in the Himalaya mountains, Swat District, Pakistan. *Annals of the Missouri Botanical Garden* 102(2):309–315. doi:10.3417/D-16-00001A.

Shrestha UB, Bawa KS. 2015. Harvesters' perceptions of population status and conservation of Chinese caterpillar fungus in the Dolpa region of Nepal. *Regional Environmental Change* 15(8):1731–1741. doi:10.1007/s10113-014-0732-7.

Shrestha UB, Dhital KR, Gautam AP. 2019. Economic dependence of mountain communities on Chinese caterpillar fungus Ophiocordyceps sinensis (yarsagumba): a case from western Nepal. *Oryx* 53(2):256–264. doi:10.1017/S0030605317000461.

Simoni S, Vignoli G, Mazzorana B. 2017. Enhancing sediment flux control and natural hazard risk mitigation through a structured conceptual planning approach. *Geomorphology* 291:159–173. doi:10.1016/j.geomorph.2017.01.026.

Singh G, Sarkar MS, Pandey A, Lingwal S, Rai ID, Adhikari BS, Rawat GS, Rawal RS. 2018. Quantifying four decades of changes in land use and land cover in India's Kailash Sacred Landscape: suggested option for priority based patch level future forest conservation. *Journal of the Indian Society of Remote Sensing* 46(10):1625–1635. doi:10.1007/s12524-018-0817-8.

Singh R, Bhardwaj DR, Pala NA, Rajput BS. 2017. Variation in floral diversity of eight agro-ecosystems along elevational gradient in Northwestern Himalaya. *Range Management and Agroforestry* 38(2):181–190.

Singh RK, Srivastava RC, Pandey CB, Singh A. 2015. Tribal institutions and conservation of the bioculturally valuable 'tasat' (Arenga obtusifolia) tree in the eastern Himalaya. *Journal of Environmental Planning and Management* 58(1):69–90. doi:10.1080/09640568.2013.847821.

Singh V, Sharma MP, Sharma S, Mishra S. 2019. Bio-assessment of River Ujh using benthic macro-invertebrates as bioindicators, India. *International Journal of River Basin Management* 17(1):79–87. doi:10.1080/15715124.2017.1394318.

Sklenář P, Hedberg I, Cleef AM. 2014. Island biogeography of tropical alpine floras. *Journal of Biogeography* 41(2):287–297. doi:10.1111/jbi.12212.

Spehn EM, Körner C. 2017. Climate change impacts on Alpine nature. *Natur und Landschaft* 92(43747):407–411. doi:10.17433/9.2017.50153499.407-411.

Spira C, Kirkby A, Kujirakwinja D, Plumptre AJ. 2019. The socio-economics of artisanal mining and bushmeat hunting around protected areas: Kahuzi–Biega National Park and Itombwe Nature Reserve, eastern Democratic Republic of Congo. *Oryx* 53(1):136–144. doi:10.1017/S003060531600171X.

Srinivasan U, Hines JE, Quader S. 2015. Demographic superiority with increased logging in tropical understorey insectivorous birds. *Journal of Applied Ecology* 52(5):1374–1380. doi:10.1111/1365-2664.12475.

Stanchi S, Falsone G, Bonifacio E, Stanchi S, Falsone G, Bonifacio E. 2015. Soil aggregation, erodibility, and erosion rates in mountain soils (NW Alps, Italy). *Solid Earth* 6(2):403–414. doi:10.5194/se-6-403-2015.

Stanisci A, Frate L, Morra Di Cella U, Pelino G, Petey M, Siniscalco C, Carranza ML. 2016. Short-term signals of climate change in Italian summit vegetation: observations at two GLORIA sites. *Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology* 150(2):227–235. doi:10.1080/11263504.2014.968232.

Subba SA, Shrestha AK, Thapa K, Malla S, Thapa GJ, Shrestha Sujeet, Shrestha Shrota, Subedi N, Bhattarai GP, Ottvall R. 2017. Distribution of grey wolves Canis lupus lupus in the Nepalese Himalaya: implications for conservation management. *Oryx* 51(03):403–406. doi:10.1017/S0030605316000296.

Swetnam RD, Fisher B, Mbilinyi BP, Munishi PKT, Willcock S, Ricketts T, Mwakalila S, Balmford A, Burgess ND, Marshall AR, et al. 2011. Mapping socio-economic scenarios of land cover change: A GIS method to enable ecosystem service modelling. *Journal of Environmental Management* 92(3):563–574. doi:10.1016/j.jenvman.2010.09.007.

Syed Z, Khan MS. 2017. Livestock and wild herbivores in the western Himalaya: competition or co-existence? *Journal of Threatened Taxa* 9(4):10084. doi:10.11609/jott.2593.9.4.10084-10088.

Tampucci D, Citterio C, Gobbi M, Caccianiga M. 2016. Vegetation outlines of a debris-covered glacier descending below the treeline. *Plant Sociology* 53(1):45–54. doi:10.7338/pls2016531/03.

Tampucci D, Gobbi M, Boracchi P, Cabrini E, Compostella C, Mangili F, Marano G, Pantini P, Caccianiga M. 2015. Plant and arthropod colonisation of a glacier foreland in a peripheral mountain range. *Biodiversity* 16(4):213–223. doi:10.1080/14888386.2015.1117990.

Tellería JL, Venero JL, Santos T. 2006. Conserving birdlife of Peruvian highland bogs: effects of patch-size and habitat quality on species richness and bird numbers. *Ardeola* 53(2):271–283.

Thakur SD, Kapoor KS, Samant SS. 2017. Exploration of economically important fodder plants and its extraction trend by the villagers residing in the surrounding of Tirthan wildlife sanctuary, District Kullu, Himachal Pradesh, India. *Ecology, Environment and Conservation* 23:345–348.

Thapa S, All J, Yadav RKP. 2016. Effects of livestock grazing in pastures in the Manaslu conservation area, Nepalese Himalaya. *Mountain Research and Development* 36(3):311. doi:10.1659/MRD-JOURNAL-D-13-00066.1.

Thapa S, Chitale V, Rijal SJ, Bisht N, Shrestha BB. 2018. Understanding the dynamics in distribution of invasive alien plant species under predicted climate change in Western Himalaya. *PLOS ONE* 13(4):e0195752. doi:10.1371/journal.pone.0195752.

Thöle L, Schwörer C, Colombaroli D, Gobet E, Kaltenrieder P, van Leeuwen J, Tinner W. 2016. Reconstruction of Holocene vegetation dynamics at Lac de Bretaye, a high-mountain lake in the Swiss Alps. *The Holocene* 26(3):380–396. doi:10.1177/0959683615609746.

Thuiller W, Guéguen M, Georges D, Bonet R, Chalmandrier L, Garraud L, Renaud J, Roquet C, Van Es J, Zimmermann NE, et al. 2014. Are different facets of plant diversity well protected against climate and land cover changes? A test study in the French Alps. *Ecography* 37(12):1254–1266. doi:10.1111/ecog.00670.

Tinitana F, Rios M, Romero-Benavides JC, de la Cruz Rot M, Pardo-de-Santayana M. 2016. Medicinal plants sold at traditional markets in southern Ecuador. *Journal of Ethnobiology and Ethnomedicine* 12(1):29. doi:10.1186/s13002-016-0100-4.

Tinoco BA, Santillán VE, Graham CH. 2018. Land use change has stronger effects on functional diversity than taxonomic diversity in tropical Andean hummingbirds. *Ecology and Evolution* 8(6):3478–3490. doi:10.1002/ece3.3813.

Uddin K, Chaudhary S, Chettri N, Kotru R, Murthy M, Chaudhary RP, Ning W, Shrestha SM, Gautam SK. 2015. The changing land cover and fragmenting forest on the Roof of the World: A case study in Nepal's Kailash Sacred Landscape. *Landscape and Urban Planning* 141:1–10. doi:10.1016/j.landurbplan.2015.04.003.

Umweltbundesamt. 2014. Fifth National Report of Austria to the Convention on Biological Diversity. Vienna, Austria.

Uprety Y, Poudel RC, Gurung J, Chettri N, Chaudhary RP. 2016. Traditional use and management of NTFPs in Kangchenjunga Landscape: implications for conservation and livelihoods. *Journal of Ethnobiology and Ethnomedicine* 12(1):19. doi:10.1186/s13002-016-0089-8.

Vacchiano G, Maggioni M, Perseghin G, Motta R. 2015. Effect of avalanche frequency on forest ecosystem services in a spruce–fir mountain forest. *Cold Regions Science and Technology* 115:9–21. doi:10.1016/j.coldregions.2015.03.004.

Valderrama MM, Buitrago D, Bedoya MM, Benavides JC. 2017. Variación en los restos de macrofósiles y dinámica reciente en turberas de Cojines de Distichia Muscoides de la Sierra Nevada del Cocuy, Colombia. *Caldasia* 39(1):79. doi:10.15446/caldasia.v39n1.64327.

Vanacker V, Vanderschaeghe M, Govers G, Willems E, Poesen J, Deckers J, De Bievre B. 2003. Linking hydrological, infinite slope stability and land-use change models through GIS for assessing the impact of deforestation on slope stability in high Andean watersheds. *Geomorphology* 52(3–4):299–315. doi:10.1016/S0169-555X(02)00263-5.

Vice President's office. 2014. Fifth National report on the implementation of the convention on biological diversity.

Viganò G, Confortola G, Fornaroli R, Cabrini R, Canobbio S, Mezzanotte V, Bocchiola D. 2016. Effects of future climate change on a river habitat in an Italian alpine catchment. *Journal of Hydrologic Engineering* 21(2):04015063. doi:10.1061/(ASCE)HE.1943-5584.0001293.

Vihemäki H, Hall JM, Leonard C, Mwangoka M, Mkongewa V. 2013. Bird and plant diversity in tropical landscape mosaics in East Usambaras, Tanzania. *Small-scale Forestry* 12(1):125–143. doi:10.1007/s11842-012-9202-6.

Vila I, Pardo R, Scott S. 2007. Freshwater fishes of the Altiplano. *Aquatic Ecosystem Health & Management* 10(2):201–211. doi:10.1080/14634980701351395.

Viterbi R, Imperio S, Alpe D, Bosser-peverelli V, Provenzale A. 2015. Climatic control and population dynamics of black grouse (Tetrao tetrix) in the Western Italian Alps. *The Journal of Wildlife Management* 79(1):156–166. doi:10.1002/jwmg.810.

Vuille M, Carey M, Huggel C, Buytaert W, Rabatel A, Jacobsen D, Soruco A, Villacis M, Yarleque C, Elison Timm O, et al. 2018. Rapid decline of snow and ice in the tropical Andes – impacts, uncertainties and challenges ahead. *Earth-Science Reviews* 176:195–213. doi:10.1016/j.earscirev.2017.09.019.

Vuille M, Franquist E, Garreaud R, Lavado Casimiro WS, Cáceres B. 2015. Impact of the global warming hiatus on Andean temperature. *Journal of Geophysical Research: Atmospheres* 120(9):3745–3757. doi:10.1002/2015JD023126.

Willcock S, Phillips OL, Platts PJ, Swetnam RD, Balmford A, Burgess ND, Ahrends A, Bayliss J, Doggart N, Doody K, et al. 2016. Land cover change and carbon emissions over 100 years in an African biodiversity hotspot. *Global Change Biology* 22(8):2787–2800. doi:10.1111/gcb.13218.

Williams PH, Bystriakova N, Huang J, Miao Z, An J. 2015. Bumblebees, climate and glaciers across the Tibetan plateau (Apidae: Bombus Latreille). *Systematics and Biodiversity* 13(2):164–181. doi:10.1080/14772000.2014.982228.

Winkler M, Illmer P, Querner P, Fischer BM, Hofmann K, Lamprecht A, Praeg N, Schied J, Steinbauer K, Pauli H. 2018. Side by side? Vascular plant, invertebrate, and microorganism distribution patterns along an alpine to nival elevation gradient. *Arctic, Antarctic, and Alpine Research* 50(1):e1475951. doi:10.1080/15230430.2018.1475951.

Winowiecki L, Vågen T-G, Massawe B, Jelinski NA, Lyamchai C, Sayula G, Msoka E. 2016. Landscape-scale variability of soil health indicators: effects of cultivation on soil organic carbon in the Usambara Mountains of Tanzania. *Nutrient Cycling in Agroecosystems* 105(3):263–274. doi:10.1007/s10705-015-9750-1.

Winter M-B, Baier R, Ammer C. 2015. Regeneration dynamics and resilience of unmanaged mountain forests in the Northern Limestone Alps following bark beetle-induced spruce dieback. *European Journal of Forest Research* 134(6):949–968. doi:10.1007/s10342-015-0901-3.

Yadav RP, Bisht JK, Bhatt J. 2017. Biomass, carbon stock under different production systems in the mid hills of Indian Himalaya. *Tropical Ecology* 58(1):15–21.

Yadav RP, Gupta B, Bhutia PL, Bisht JK, Pattanayak A. 2019. Sustainable agroforestry systems and their structural components as livelihood options along elevation gradient in central Himalaya. *Biological Agriculture & Horticulture* 35(2):73–95. doi:10.1080/01448765.2018.1457982.

Young KR. 2015. Ecosystem change in high tropical mountains. In: Huggel C, Carey M, Clague JJ, Kaab A, editors. THE HIGH-MOUNTAIN CRYOSPHERE. Cambridge: Cambridge University Press. p. 227–246.

Young KR, Ponette-González AG, Polk MH, Lipton JK. 2017. Snowlines and Treelines in the Tropical Andes. *Annals of the American Association of Geographers* 107(2):429–440. doi:10.1080/24694452.2016.1235479.

Yusseppone MS, Rocchetta I, Sabatini SE, Luquet CM, Ríos de Molina M del C, Held C, Abele D. 2018. Inducing the alternative oxidase forms part of the molecular strategy of anoxic survival in freshwater bivalves. *Frontiers in Physiology* 9. doi:10.3389/fphys.2018.00100.

Zampieri M, Russo S, di Sabatino S, Michetti M, Scoccimarro E, Gualdi S. 2016. Global assessment of heat wave magnitudes from 1901 to 2010 and implications for the river discharge of the Alps. *Science of The Total Environment* 571:1330–1339. doi:10.1016/j.scitotenv.2016.07.008.

Zampieri M, Scoccimarro E, Gualdi S, Navarra A. 2015. Observed shift towards earlier spring discharge in the main Alpine rivers. *Science of The Total Environment* 503–504:222–232. doi:10.1016/j.scitotenv.2014.06.036.

Zemp M, Haeberli W, Hoelzle M, Paul F. 2006. Alpine glaciers to disappear within decades? *Geophysical Research Letters* 33(13):L13504. doi:10.1029/2006GL026319.

Zhou Y, Chen S, Hu G, Mwachala G, Yan X, Wang Q. 2018. Species richness and phylogenetic diversity of seed plants across vegetation zones of Mount Kenya, East Africa. *Ecology and Evolution* 8(17):8930–8939. doi:10.1002/ece3.4428.

Zoderer BM, Tasser E, Erb K-H, Lupo Stanghellini PS, Tappeiner U. 2016. Identifying and mapping the tourists perception of cultural ecosystem services: a case study from an Alpine region. *Land Use Policy* 56:251–261. doi:10.1016/j.landusepol.2016.05.004.

Zomer RJ, Xu J, Wang M, Trabucco A, Li Z. 2015. Projected impact of climate change on the effectiveness of the existing protected area network for biodiversity conservation within Yunnan Province, China. *Biological Conservation* 184:335–345. doi:10.1016/j.biocon.2015.01.031.