THE SCHOOL FOR FIELD STUDIES

Mountain Ecology

SFS 3060

Purna B.Chhetri, Ph.D.
Resident Lecturer

The School for Field Studies (SFS)
Ugyen Wangchuck Institute for Conservation and Environment Research (UWICER)
Bumthang and Bhutan Ecological Society, Thimphu Bhutan
Centre for Himalayan Environment and Development Studies
Tsendona, Paro Bhutan

This syllabus may develop or change over time based on local conditions, learning opportunities, and faculty expertise. Course content may vary from semester to semester.

www.fieldstudies.org

Course Overview

The kingdom of Bhutan lies in the eastern Himalayan typically characterized by extensive and numerous mountains and valleys, world's highest peaks and a diversity of vegetation and wildlife. Mountain environments dominate Bhutan and shape both the culture and ecology of the land. Within this compact and mountainous country, are an extraordinary diversity of ecosystems and habitats, and Bhutan and the Eastern Himalayan region are globally recognized hotpots for biodiversity.

In this course, we focus on mountains. What are the processes that form mountains and shape their ecological communities? We will begin by studying the physical environment of mountains — the geology and climate. Upon gaining an understanding of the physical environment, we will investigate the effect of elevation gradients on vegetation, and highlight special features of mountain animals and the interaction between habitat and animal communities. How do mountains influence the distribution of biodiversity and how do scientists study ecology in mountainous environments? Finally, what are the threats to mountain regions in a rapidly changing world and what conservation tools are scientists and conservation biologists implementing to protect sensitive mountain environments and species?

Learning Objectives

The objective of this course is to provide students the background and tools necessary to understand and study the mountain environments of Bhutan and to learn its fauna and flora. Through classroom lectures, discussions, seminars, field lectures, and field exercises, we will examine what makes the Eastern Himalayan region unique. Classroom and field lectures will provide core concepts and tools for inquiry, whereas field exercises will reinforce these concepts and allow students to practice scientific inquiry skills and data collection. In this course students will develop a conceptual and practical understanding of the ecological complexity the Eastern Himalaya region. Specific learning objectives are the following:

1. Understand the geological history and biogeography of mountain regions in general and the Eastern Himalayan region specifically, while distinguishing characteristics of mountain environments that explain species distributions and speciation
2. Learn the natural history, biology and ecology of organisms in Bhutan
3. Employ field research methods and analytical tools, including qualitative and quantitative methods scientists and managers use to study and conserve biodiversity
4. Gain an understanding of the challenges mountain communities face and the unique and progressive conservation efforts being made in Bhutan
5. Practice the scientific method, gain experience conducting collaborative research in a multidisciplinary learning environment and advance science communication skills.

Assessment

Our goal is to conduct ongoing assessment of student learning throughout the course, and provide timely and constructive feedback. Some assignments encourage students to work together, to share ideas and knowledge. This allows students to take advantage of the range of backgrounds within the group. Assessment will be conducted on an individual basis, unless otherwise stated. The final course grade will be based on the following:

Assessment Item	Value (%)
Active participation	10
Plant Identification Quiz and Group Presentation	12
Survey Methods of Biodiversity and Life Zone Productivity	12
River and Terrestrial Invertebrate Community Sampling	12

Midterm Exam	10
Field Methods in Sampling Small Mammals	12
Field methods VIII: Forest Succession after Fire	12
Final examination	20
TOTAL	**100**

Assessment Descriptions

Active participation: During this program we will travel through many eco-regions and rural communities. We expect that you will be an active observer, constantly observing the landscape, livelihoods, and culture and participating in discussions regarding these observations. Active participation includes constructive engagement with the full range of course activities, respectful awareness of our cultural context, and responsible behavior as a group member who is involved in others' learning. There will be opportunities throughout the semester for constructive feedback.

Because we offer a program that is likely more intensive than you might be used to at your home institution, missing even one lecture can have a proportionally greater effect on your final grade simply because there is little room to make up for lost time. Participation in all components of the program is mandatory because your actions can significantly affect the experience you and your classmates have while at SFS. Therefore, it is important that you are prompt for all activities, be prepared by reading your assignments, bring the necessary equipment for the field, and simply get involved and stay engaged.

Field notebook: You will develop a comprehensive program field notebook that documents and captures your on-the-ground learning experiences and serves as your primary record of content and reflections during the course. This notebook should accompany you at all times: in the classroom, guest lectures, and the field. All class notes, field notes, data from field exercises, reflective comments and questions on course material, notes from discussions, and short written assignments should be contained in this notebook, which will serve as your main study tool. You may want to develop sections for observations during travel, translations or words in local languages, notes to remember for your directed research, cultural notes, and reflective writing on how this experience is reshaping your understanding of people and the environment. Keep this separate from personal journaling you may do. Additional course handouts should be kept in the folder provided.

When using citable material from your field notebook in written assignments, use the following format to acknowledge the source: (Sonam Phuntsho, Field notes, Pillcopata, 12 October 2014). Whenever possible, use the name of the person providing the information; if not possible, cite descriptively, for example: "Firewood gatherer in Manu forest."

Floral and faunal identification: A fundamental skill in ecology is the ability to identify organisms. In Mountain Ecology, we will focus on forest and common understory plant community identification, mammal, bird, terrestrial and river macro-invertebrate identification, because these are the most recognizable and best known taxonomic groups in the area. Field and laboratory practicums will be used for identification purposes.

Field Exercises (FEX): Field exercises are designed for students to learn and practice a series of different field techniques to collect data on biodiversity. You will learn how to use these techniques, collect data, and perform statistical tests and interpretation of the results. Handouts will accompany each FEX, which will ask students to interpret their findings and reflect on study design and improvement.

Exploration of Organisms and their Micro-Environments (ungraded): This exercise will be first one for this course, wherein the students are expected to get familiarize data gathering and recording methodology and processes in different micro-environments (streams, agricultural fields, forests etc) and we will also introduce some instrument use to measure biophysical attributes.

Field Methods I: Plant Identification Quiz: This exercise will enable students to know the main plant species major life zones in of Bhutan. The students will be given field lectures on identification of different plant species around Centre's campus, along the elevational gradient covering temperate to sub-tropical region. There will be plant identification quiz in the class using sample specimens. Individual student will pick a favorite plant species and a write short description illustrating its phylogeny, eco-region, its uses and management practices. A detail handout will be provided for this FEX.

Field Methods II: Survey Methods of Floral Biodiversity and Life Zone Productivity: Elevation transects provide important natural experiments for ecologists to understand plant and animal responses to environmental gradients. We will observe plant and animal distributions and document changes in species occurrence and richness along a gradient spanning the mountain top and valleys and consider how climate change may affect these communities in unpredictable ways.
We will document biodiversity along elevational gradient by dividing the class into groups of four/ five: each group will conduct detail survey of life forms in series of plots and woody trees, you will collect DBH, height and other attributes of the trees within the plot. Additionally the group will collect and record ecologically important morphological characteristics of those trees and then use the collected data to produce an estimate of total biomass, calculate biodiversity index and other ecologically important bio-indicators and plasticity. Additionally student will be taught to collect tree cores for growth pattern/trend analysis. The surveys will cover altitudinal gradient from valley bottom to mountain top. A detailed handout will be provided to conduct the field exercise and the group should produce comprehensive written report covering different aspects of the exercise.

Field methods III: River and Terrestrial Invertebrate Community Sampling : Aquatic invertebrate communities are determined by resources available in streams, rivers, and lakes– and are often influenced heavily by pollution. We will survey sites near the SFS Campus and Paro town, looking at how flow rates influence invertebrate communities. We will also survey some key terrestrial invertebrates such as dragonflies and ants using appropriate methodologies. Students will learn standardized surveys and aquatic invertebrate identification. Students will interpret their data in a short written report.

Field methods IV: Forest and Avian Community Changes along an Elevation Gradient (ungraded): We admire birds not only for their beauty, songs, and their miraculous ability to fly but they are also ecologically component of the ecosystems; pollinations, seed dispersal agent, maintain ecological balance through prey-predators relationships. In this course, we will travel to different parts of Bhutan, from the high temperate-Himalayan valleys to the sub-tropical valleys. Along the way we'll stop en route to observe and collect natural history data on plants and birds, while practicing field censusing techniques between different elevational transition zones and habitats.

Field methods V: Study of Small Mammals: Small mammals have significant influences on vegetation and soils, exert predatory pressure on other animals, and provide food for predators. Future management efforts should include consideration of these diverse influences
Traps are the most efficient method of surveying such animals such as rodents. We will strategic sampling methods and set of traps to capture small mammals at least in two systems (agricultural fields and a pine forest). Using the data from such traps, we will identify the species and estimate

species diversity, estimate biomass and establish their significance in two ecosystems. Students will assist in set up and checking of traps and the findings will be interpreted in a written report.

Field methods VII: Bioblitz! in High Altitude Environments (ungraded): Use of data gathered by non-professional 'citizen' scientists is growing tremendously in ecology. One popular event to gather biodiversity data in a set area is to organize a Bioblitz: a time- constrained exercise to document as many species as possible in a set area and time. Common locations for these events include urban parks or areas slated for development in order to raise awareness of the biodiversity living in close proximity.

Field methods VIII: Avian Mist-netting and Field Census Techniques (ungraded): Birds have become the model vertebrate group in ecology because of their ubiquity, diversity, and ease of observation. Yet, catching them, which is often needed for population studies, can be tough. We will spend at least one morning capturing and marking birds by banding [ringing] them, as well as learning how to age, sex, and score molt on certain species – part of a long-term study at UWICER. Between net checks, we will observe and identify bird species on UWICER campus, as well as learn how to conduct standardized observational transect and point count surveys.

Field methods VIII: Forest succession after Fire: Disturbance plays a vital role in ecosystem dynamics. Fire is one of the most important disturbances in Bhutan. Understanding its impact and make practical application of forest fire is fundamental to forest management especially in dry region of the country. Here the students will learn basic about forest fire and conduct a field survey and understand how forest successional takes place after fire. The students will work in group; conduct survey and produce write a written report.

Exams: One mid-term exam will be administered, followed by a comprehensive exam at the end of the course. You will be examined on what you have been exposed to in class (lectures, discussions, etc.), the field, and readings. The exams will challenge students to draw on multiple concepts and experiences, and to synthesize information.

Grading Scheme

The following grading scheme will be employed to award the final grade to the students.

A	95.00+	B+	86.00 – 89.99%	C+	76.00 – 79.99%	D	60.00-69.00%
A-	90.00 – 94.99%	B	83.00 – 85.99%	C	73.00 – 75.99%	F	59.99 to 0.00
		B-	80.00 – 82.99%	C-	70.00 – 72.99%		

General Reminders

Readings: Students are expected to have read all the required readings prior to each class. Information from required readings will be part of the course assessments. It is encouraged that 'optional readings' be reviewed by students.

Plagiarism: Using the ideas and material of others without giving due credit is cheating and will not be tolerated. A grade of zero will be assigned if anyone is caught cheating or aiding another person to cheat actively or passively (e.g., allowing someone to look at your exam). All assignments unless specifically stated should be individual pieces of work. Plagiarism cases may be reported to the student's home institution and may be grounds for further academic disciplinary action.

Deadlines: Deadlines for written and oral assignments are instated for several reasons: They are a part of working life to which students need to become accustomed and promote equity among students, and deadlines allow faculty time to review and return assignments before others are due. Assignments will be handed back to students after a one-week grading period. Late assignments will incur a 10% penalty for each day that they are late. No assignment will be accepted after third day from the agreed date.

Participation: Since we offer a program that is likely more intensive than student might be used to at home institution, missing even one lecture can have a proportionally greater effect on final grade as there is little room to make up for lost time. Participation in all components of the program is mandatory because student actions can significantly affect the experience a student and his/her classmates have while at SFS. Therefore, it is important that students are prompt for all activities, bring the necessary equipment for the field, and simply get involved.

Course Content

L lecture and discussion, **GL** guest lecture, **GFG** guest field guide, **FL** field lecture, **FEX** field exercise, **D** discussion, **DR** directed research.

***Readings in **Bold** fonts are compulsory reading materials for students to read and not bolded readings are meant for preparing lectures and students are also encouraged to read them.

No	*Title*	*Type*	*Time (hrs.)*	*Readings*
1	**Course Overview** Cover Course Objectives, Syllabus, Field Exercises, Questions and Expectations for semester.	L and D	1:15	
Mountain Physical Environments (MPE)				
2	**Introduction to Mountain Ecology** We discuss why mountains are located where they are. How did they get there? We'll explore the physical origins of mountains, theories of mountain building, and how our changing ideas about mountains and their genesis have shaped our engagement with them.	L and D	1:15	**Sayre et al, 2018** **Price et al. 2013 Ch 1** **Smethurst, 2010**
3	**Mountain Climate and Geology** How do mountains affect climate? How are mountains shaped by climate? What are the geological processes in the mountainous ecosystem? We will examine how elevation affects atmospheric processes, and discuss an ecological manifestation of mountain climate.	L and D	1:15	**Barry, 2008 (Ch.1 and 5)** **Price et al. Chapter 2** **Lugo,1999** Manish and Pandit, 2018 Harrison, 1992
4	**Adaptations of Organisms in the Mountains** What are the basic requirements for plants and animals for their growth and development? How do they develop mechanism to adapt to different environment? What are the mechanisms of adaptation plants and animals in a mountainous environment?	L and D	1:15 + 10:45 =12	**Halbritter et al,2018** **Srinivasan, 2013** **Badgley, 2008**
5	**Exploration and Discovering Organisms and their**	FL and	2:30	**Larcher, 2010**

	Micro-environments Here will explore different microsites and identify organisms their morphological traits. We will also learn how to handle basic equipment for measurement of various environmental variables. Here we will also learn to develop data recording methods.	FEX	9-11:30	**Körner,2011**
6	**Terrestrial Life Zone Ecology of Bhutan Himalaya** Here, we will learn and discuss different life forms (biomes) their special characteristics and implications for biodiversity conservation.	L and D	1:15	**Singh, 1987 (89-95)** **Ohsawa ,1987,** **Wangda, 2006** Banerjee,2016
7	**Fundamentals of Plant Identification Skills** Understand the basic morphological characteristics of leaves, fruits, flower and other parts of the of plant species to use in plant species classification system.	L and D	1:15	**BinderPlantID**
8	**Field Methods I: Plant Identification** Here we will explore and identify major life forms, identify plant species and their floral characteristics on different along the elevational gradient.	FEX	4:00	**Web based (3, 4, 6 and 7)**
9	**Alpine Life Zone** We will discuss the alpine environment with reference to ecology of *Ophiocordyceps sinensis*	L and D	1:15	**Cannon, 2009** **Winkler, 2008** **Müller,2016**
10	**Quantifying Ecology** We will learn the fundamental of Ecological Statistics including basic data manipulation	Land D	2:30	
11	**Field Methods II: Survey Methods of Biodiversity and Life Zone Productivity** Different types of sampling methods and basic calculations of forest statistics will be taught in this class. The output from this class will be applied in practice for descriptive statistics of forest structure and composition, estimates of forest volumes, biomass, forest stock increment, and other biodiversity indexes in life zone inventory field exercise.	FEX	4:00	**Asrat,2013** **CIFOR,2016**
12	**Mountain Aquatic Environments** What organisms are found in different wetland habitats? What are their adaptation mechanisms? We will discuss wetland ecosystems including rivers and understand basic requirement for macroinvertebrate survival in those ecosystems.	L and D	1:15	**Sherub et al. 2013** **Von Oheimb,2013** **Verhoeven,2006**
13	**Field Methods III: Sampling Techniques for Surveying Fresh Water Macroinvertebrates** Here we will also learn to conduct baseline survey methods of aquatic environment (water velocity, water pH and total dissolved substance.	FEX	4:00	**Scientists at Work'** **Mary Powers Mackey,1984**
14	**Fundamentals of Terrestrial Invertebrates**	L and D	1:15	**Acharya, 2015**

	Here we will learn about the role of terrestrial invertebrates and in functioning of the ecosystems in different microsites.			**Rosumek, 2009 Kalkman and Gyeltshen, 2015**
16	**Measuring Diversity of Terrestrial Invertebrates** The minute organisms such as ants are often left out during standard biodiversity inventories due to logical constraints. These organisms constitute a diverse group, making up a large proportion of the biomass in the area, and perform important or diverse ecological functions in the ecosystem**.** Here we will practice inventory of ants and dragon flies using different methods and tolls.	FL and FEX	2:45	
17	**Population Ecology of High Mountains** We will learn about dynamics of population structure which relates to density, foraging, habitat requirement especially of wild animals.	Land D	1:15	**Tamma, 2016 Amrhein,2012**
18	**Carnivore Ecology of Bhutan** Discussion of Large Carnivore Conservation and keystone species conservation such as tiger and its implications conservation of forest ecosystems.	GL- Dr. Tsherin g Tempa	1:15	**Tempa et al, 2013 Carter & Lindell 2016; Wolf & Ripple 2017**
19	Mid Term Exam		1:00	
20	**Herbivore Ecology** Here we will learn about the national animal (Takin) of Bhutan with lecture and field observations at Takin Reserve at Thimphu	L and D and FL	2:00	**Wangchuk,2015 Badgley, 2008**
21	**Avian Ecology and Migration** Here we will learn about high elevation bird species, adaptations and migration of some key bird species of Bhutan Himalaya.	L and D	1:15	**Zhang et al. 2017 Hawkes et al. 2011 Norbu, 2013 Hu et al,2018**
22	**Field Methods IV: Mist Netting and Birds' Community Changes Along Elevational Gradients** Here we will learn the fundamental on avian research through mist netting and also field survey of birds along an elevational gradient	FEX	4:00	**Pan et al, 2016 Amrhein,2012 Acharya and Vijayan 2017**
23	**Field Methods V: Ecology of Black-Necked Cranes at Phobjikha** Here we will explore the black-necked crane habitat, count the cranes and observed basic behavior such as preening, sequential vigilance, estimate walking distance during feeding etc.	FL and FEX	3:00	**Lind,2010 Zhongqiu,2014 ICIMOD and RSPN, 2014**
24	**Ecology of Small Himalayan Mammals I** Here we will learn the basic and fundamental of small mammals species of Bhutan	L and D	1:15	**Hoffmann, 2010**
25	**Ecology of Small Himalayan Mammals II** Here we will learn the methods to study small mammals (e.g. rodent on different micro-sites in the mountainous region)	FEX	3:00	**Flowerdew, 1976 Hoffmann, 2010**
26	**Species Interactions in Mountainous Environment**	SLD	1:15	**Zamora-Vilchis et**

	We will examine the diversity of species interactions, their influence on demographic processes, and their role as agents of natural selection. Interspecific competition, process of predation (prey and predator) and population regulation. Parasite and their host (Are montane communities more disease resistant than lowland communities, or have montane organisms escaped lowland disease vectors?			**al. 2012; Rockwood 2006, Ch 9**
27	**Field Methods VII: Bioblitz** Here we will explore the organism existing around UWICER campus as Bioblitz exercise. The students are expected to observe measure and calculate morphological traits of at least three organisms.	FEX	2:00	**inaturalist**
28	**Mountain Forest and Disturbance Ecology** We will identify the major disturbances in the mountainous terrain including human use of mountain forests in Bhutan and their implications on sustainable management of mountainous ecosystems.	L and D	1:15	**Dortch,2009 Xu et al. 2009 Bajracharya. 2014 Hobbs, 2006 Ellis, 2011**
29	**Forest Ecosystem and Water** We will closely examine the ecological processes relating to forest and water and discuss the implication on mountain forest and conservations.	L and D	1:15	**O'Conner et al. 2015; Price et al. 2011**
30	**Field Methods VIII: Forest Succession Ecology after Fire** Here we will learn about the forest succession after forest fire and discuss the pros and cons of forest fire and implications for conservations in relation to global climate change.	FEX	2:30	**Dobson, 1997**
31	**Students Led Discussion: Mountain Biodiversity in Anthropocene** Here students can pick up certain topic of their interests and deliver a discussion. I would suggest carbon foot print as one of the topic	GL	1:15	
32	Final Exam Review	TBA	1:00	
33	Final Exam	TBA	2:00	
		TOTAL	**60**	

Readings

Acharya, B. K., & Vijayan, L. (2015). Butterfly diversity along the elevation gradient of Eastern Himalaya, India. Ecological Research, 30(5), 909–919.

Acharya, B.K. and L. Vijayan. 2017. Vertical stratification of birds in different vegetation types along an elevation gradient in the Eastern Himalaya, India. Ornithological Science 16: 131-140.

Amrhein, V., et al. (2012). Estimating adult sex ratios from bird mist netting data. Methods in Ecology and Evolution, 3(4), 713–720.

Asrat, Z., and Tesfaye, Y. (2013), Training manual on forest inventory and management in the context of SFM and REDD +, Ethopia.

Badgley, C. et al. (2008). Ecological changes in Miocene mammalian record show impact of prolonged climatic forcing.PNAS , 105 (34) 12145-12149

Banerjee, A., & Bandopadhyay, R. (2016). Biodiversity hotspot of Bhutan and its sustainability.Current Science,110(4), 521-527.

Barry, R.G. (2008). Mountain Weather and Climate, Cambridge

Barve, S., A.A. Dhondt, V.B. Mathur, Z.A. Cheviron. (2016). Life-history characteristics influence physiological strategies to cope with hypoxia in Himalayan birds. Proc Royal Society B 283: 1-8

Beall, C. M. (2007). Two routes to functional adaptation: Tibetan and Andean high-altitude natives. Proc. Natl. Acad. Sci. U.S.A. 104:8655–8660.

Brooks, T.M., et al. (2006). Global Biodiversity Conservation Priorities. Science. 313: 58-61.

Burton, A. C. et al. (2015). REVIEW: Wildlife camera trapping: a review and recommendations for linking surveys to ecological processes. Journal of Applied Ecology, 52(3), 675–685.

Chaudhary, A., Pourfaraj, V., & Mooers, A. O. (2018). Projecting global land use-driven evolutionary history loss. Diversity and Distributions, 24(2), 158-167.

CIFPOR (2006). A Field Manual for Rapid Vegetation Classification and Survey for general purposes. Indoensia.

Callaway, R. M. et al. (2002). Positive interactions among alpine plants increase with stress. Nature, 417(6891), 844-848.

Cannon, P.F., et al. (2009). Steps towards sustainable harvest of Ophiocordyceps sinensis in Bhutan. Biodivers Conserv (2009) 18:2263–2281

Carter, N.H. and J.D.C. Lindell. (2016). Co-adaptation is key to coexisting with large carnivores. Trends in Ecology and Evolution 31: 575-578.

Dirzo, R., H. et al. (2014). Defaunation in the Antropocene. Science 345: 401-406. 7

Dobson, A. P., Bradshaw, A .D & Baker, A.J.M. (1997). Hopes for the Future: Restoration Ecology and Conservation Biology. Science. 277. 515-522.

DoFPS (2017). National Forest Inventory Report Stocktaking Nation's Forest Resources, MoAF, Thimphu Bhutan.

Dortch, J. M., et al. (2009). Nature and timing of large landslides in the Himalaya and Transhimalaya of northern India. Quaternary Science Reviews, 28(11-12), 1037–1054.

Fjeldsa, J., et al. (2012). The role of mountain range in the diversification of birds. Annual Review of Ecology, Evolution and Systematics:

Fujita, K., et al. Potential flood volume of Himalayan glacial lakes, Nat. Hazards Earth Syst. Sci., 13, 1827-1839,

Ellis, E. C. et al. (2010). Anthropogenic transformation of the biomes, 1700 to 2000.Global Ecology and Biogeography,19(5), 589-606.

Flowerdew, J. R. (1976). Chapter 4: Ecological methods. Mammal Review, 6(4), 123–159.

Gilani, H., et al. (2015). Decadal land cover change dynamics in Bhutan. Journal of Environmental Management, 148, 91-100.

Hoffmann, Anke et al. (2010). Field Methods and Techniques for Monitoring Mammals.

Halbritter, A. H., et al. (2018). Trait differentiation and adaptation of plants along elevation gradients. Journal of Evolutionary Biology, 31(6), 784–800.

Harrison,T.M., Copeland, P.Kidd, W.S.F. and Yin, A. (1992). Raising Tibet. Science, 255(5052), 1663–1670.

Hawkes, L., S. Balachandran, N, Batbayar et al. (2011). The trans-Himalayan flights of bar-headed geese (Anser indicus). Proc. Natl. Acad. Sci. U.S.A. 108: 9516-9519.

Hobbs, R. J., et al. (2006). Novel ecosystems: Theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography, 15(1), 1-7.

Hughes, C. E., & Atchison, G. W. (2015). The ubiquity of alpine plant radiations: from the Andes to the Hengduan Mountains. New Phytologist, 207(2), 275–282.

ICIMOD and RSPN (2014). An integrated assessment of the effects of natural and human disturbances

on a wetland ecosystem: A retrospective from Phobjikha Conservation Area, Bhutan. Kathmandu: ICIMOD.
Jenkins, C. N., S. L. Pimm, and L.N. Joppa. (2013). Global patterns of terrestrial vertebrate diversity and conservation. Proc. Natl. Acad. Sci. U.S.A. 110:2602–2610.
Kalkman, V.J. & Gyeltshen, T. (2015). Records of dragonflies from western Bhutan collected in October 2015. Journal of the International Dragonfly Fund. 1-15.
Karmapa, H. H., & Dorje, O. T. (2011). Walking the path of environmental Buddhism through compassion and emptiness. Conservation Biology, 25(6), 1094-1097.
Koner, C.,Paulsen, J.,Spehn, E.M. (2011). Alp A definition of mountains and their bioclimatic belts for global comparisons of biodiversity data. Botany (2011) 121:73–78
Krausmanna, F. et al. (2013). Global human appropriation of net primary production doubled in the 20th century. PNAS, (110) 25, 10324–10329.
Kubiszewski, I., et al. (2013). An initial value of ecosystem services in Bhutan. Ecosystem Services 3: e11-e21.
Larcher, W., Kainmüller, C., & Wagner, J. (2010). Survival types of high mountain plants under extreme temperatures. Flora - Morphology, Distribution, Functional Ecology of Plants, 205(1), 3–18.
Lindsey et. al (2017). Relative efforts of countries to conserve the world's megafauna. Global Ecology and Conservation 10:243-252.
Lugo, A. E., et al. (1999). The Holdridge life zones of the conterminous United States in relation to ecosystem mapping. Journal of Biogeography, 26(5), 1025–1038.
Manish, K. and Pandit, M.K. (2018). Geophysical upheavals and evolutionary diversification of plant species in the Himalaya.
Mackey, A. P., Cooling, D. A., & Berrie, A. D. (1984). An Evaluation of Sampling Strategies for Qualitative Surveys of Macro- Invertebrates in Rivers, Using Pond Nets. The Journal of Applied Ecology, 21(2), 515.
Myers, N., et al. (2000). Biodiversity hotspots for conservation priorities. Nature, 403(6772), 853-858.
Namgay, R., & Wangchuk, S. (2016). Habitat preferences and conservation threats to black-necked cranes wintering in Bhutan. Springer Plus, 5(1), 1-6.
Norbu, N., et al. (2013). Partial altitudinal migration of a Himalayan forest pheasant. Plos One 8: 1-9.
Norbu, N. et al. (2017). Parital altitudinal migration of the near threatened Satyr Tragopan Tragopan satyr in the Bhtuan Himalayas: implications for conservation in mountainous environments. Oryx 51: 166-173.
Nowrouzi, S. et al. (2016) Ant Diversity and Distribution along Elevation Gradients in the Australian Wet Tropics: The Importance of Seasonal Moisture Stability. PLoS ONE 11(4).
NSSC (2017). Digital Soil Mapping of Soil Organic Carbon Stock in Bhutan. National Soil Services Centre. Department of Agriculture, Ministry of Agriculture and Forests, Royal Government of Bhutan, Thimphu.
O'Connor, J.E., et al. (2015). Dam removals are reconnecting rivers in the U.S. Science 348:496-497.
Ohsawa, M. 1987. Life zone ecology of the Bhutan Himalaya. Laboratory of Ecology, Chiba University, Chiba, Japan.
Ohsawa, M. (1993). Latitudinal pattern of Asian mountain vegetation -13,Journal of Vegetation Science 4: 13-18.
Pan et al. (2016). Elevational pattern of bird species richness and its causes along a central Himalaya gradient, China.
Pandit, M.K., K. Manish, and L.P. Koh. (2014). Dancing on the roof of the world: ecological transformation of the Himalayan landscape. BioScience 64: 980-992.
Poorter, H. et al. (2009). Causes and consequences of variation in leaf mass per area (LMA): a meta-analysis. New Phytologist, 182(3), 565–588.
Prakash Kumar Paudel, P.K., and Šipoš, J. (2014). Conservation status affects elevational gradient in bird diversity in the Himalaya:A new perspective . Global Ecology and Conservation, (2014), 2, 338-348.

Phuntsho, T. and J. Tshering. (2014). Black-necked Crane (Grus nigricollis) in Bhutan: Current population status and conservation initiatives. Zoological Research 35:10-19.
Price, M.F., G. Gratzer, L.A. Duguma, T. Kohler, D. Maselli, and R. Romeo (Editors). 2011. Mountain Forests in a Changing World - Realizing Values, Addressing Challenges. FAO/MPS and SDC, Rome.
Price, M.F., et al. (2013). Mountain geography. University of California Press, Berkeley, USA.
Roder, W., Calvert, and Dorji, Y. (1992). Shifting cultivation systems practised in Bhutan Agroforestry Systems 19: 149--158, 1992.
Rosumek, F. B., et al. (2009). Ants on plants: a meta-analysis of the role of ants as plant biotic defenses. Oecologia, 160(3), 537–549.
Sangay, T., and Vernes, K. (2008). Human-wildlife conflict in the Kingdom of Bhutan: Patterns of livestock predation by large mammalian carnivores. Biological Conservation, 141(5), 1272-1282.
Sayre,R., et al. (2018). A New High-Resolution Map of World Mountains and an Online Tool for Visualizing and Comparing Characterizations of Global Mountain Distributions. Mountain Research and Development, 38(3):240-250 (2018).
Sherub, S., N. Wangdi, and N. Norbu. (2012). Saving wetland sky high: inventory of high altitude wetlands in Bhutan. UWICE Publication. Bumthang, Bhutan.
Singh, J.S. and Singh, S.P. (1987). Forest Vegetation of the Himalaya. The Botanical Review, (53)1,80-192.
Smethurst, D. (2010). Mountain Geography.The Geographical Review 90 (I): 35-56.
Srinivasan, U., Tamma, K., & Ramakrishnan, U. (2013). Past climate and species ecology drive nested species richness patterns along an east-west axis in the Himalaya. Global Ecology and Biogeography, 23(1), 52–60.
Tempa, T. et al. (2013). Royal manas national park, Bhutan: A hot spot for wild felids. Oryx, 47(2), 207-210.
Wangchuk, T. R., Wegge, P., & Sangay, T. (2015). Habitat and diet of Bhutan takin Budorcas taxicolor whitei during summer in Jigme Dorji National Park, Bhutan. Journal of Natural History, 50(11-12), 759–770.
Wang, S.W., and D.W. Macdonald. (2009). The use of camera traps for estimating tiger and leopard populations in the high altitude mountains of Bhutan. Biological Conservation 142:606–613.
Wangchuk, K., & Wangdi, J. (2015). Mountain pastoralism in transition: Consequences of legalizing Cordyceps collection on yak farming practices in Bhutan. Pastoralism, 5(1)
Wangchuk, K., et al. (2013). Shrubland or pasture? restoration of degraded meadows in the mountains of Bhutan. Mountain Research and Development, 33(2), 161-169.
Wangda, P., & Ohsawa, M. (2006). Structure and regeneration dynamics of dominant tree species along altitudinal gradient in a dry valley slopes of the Bhutan Himalaya. Forest Ecology and Management, 230(1-3), 136-150.
Tamma, K., Marathe, A., and Ramakrishnan, U. (2016). Past influences present: Mammalian species from different biogeographic pools sort environmentally in the Indian subcontinent. Frontiers of Biogeography, 8(1).
Verhoeven, J. et al. (2006). Regional and global concerns over wetlands and water quality. Trends in Ecology & Evolution, 21(2), 96–103.
Von Oheimb, et al. (2013). Testing the role of the Himalaya Mountains as a dispersal barrier in freshwater gastropods (Gyraulusspp.). Biological Journal of the Linnean Society, 109(3), 526–534.
Wangchuk, T.R., P. Wegge and T. Sangay. (2016). Habitat and diet of Bhtuan takin (Budorcas taxicolor whitei) during summer in Jigme Dorji National Park, Bhutan. Journal of Natural History 50: 756-770. 8
Wangchuk, S. et al. (2017). Half-Bhutan: The evolution and effectiveness of protected areas in a country that recognizes nature needs half. International Journal of Wilderness 23: 44-46.

Walston, J., et al. (2010). Bringing the tiger back from the brink - the 6 percent solution. PLOS Biology 8: 1-4.
White, A. Geographical barriers and dispersal propensity interact to limit range expansions of Himalayan birds. The American Naturalist 188: 99-112.
Wikramanayake, E., et al. (2011). A landscape-based conservation strategy to double the wild tiger population. Conservation Letters 4:219-227.
Winkler, D. (2008). "Yartsa Gunbu (Cordyceps Sinensis) and the fungal commodification of Tibet's rural economy." Economic Botany, (62)3: 291–305.
Wilson, K.A., Carwardine,J., and Possingham H.P. (2009). Setting Conservation Priorities. The Year in Ecology and Conservation Biology, 2009: Ann. N.Y. Acad. Sci. 1162: 237–264 (2009).
Wolf, C. and W. Ripple. Range contractions of the world's large carnivores. Royal Society open sci. 4: 170052.
Xu, J., et al. (2009). The melting Himalayas: cascading effects of climate change on water, biodiversity and livelihoods. Conservation Biology 23: 520-530.
Zhang et al. (2017). Topographic heterogeneity and temperature amplitude explain species richness patterns of birds in the Qinghai-Tibetan Plateau. Current Zoology 63: 131-137.

Useful links

1.http://www.mountainbiodiversity.org/datasets
2.http://www.birdlife.org
3. https://www.inaturalist.org/
4. https://biodiversity.bt/
5.birdinternational

Apps
6. PictureThis
7. https://www.ipni.org/