



S F S THE SCHOOL
FOR FIELD STUDIES

Mountain Ecology

SFS 3060

Syllabus
4 credits

The School for Field Studies (SFS)
Center for Climate and Sustainable Futures (CCSF)
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.

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COURSE CONTENT SUBJECT TO CHANGE

Please note that this is a copy of a recent syllabus. A final syllabus will be provided to students on the first day of academic programming.

SFS programs are different from other travel or study abroad programs. Each iteration of a program is unique and often cannot be implemented exactly as planned for a variety of reasons. There are factors which, although monitored closely, are beyond our control. For example:

- Changes in access to or expiration or change in terms of permits to the highly regulated and sensitive environments in which we work;
- Changes in social/political conditions or tenuous weather situations/natural disasters may require changes to sites or plans, often with little notice;
- Some aspects of programs depend on the current faculty team as well as the goodwill and generosity of individuals, communities, and institutions which lend support.

Please be advised that these or other variables may require changes before or during the program. Part of the SFS experience is adapting to changing conditions and overcoming the obstacles that they may present. In other words, this is a field program, and the field can change.

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. The 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; Bhutan and the Eastern Himalayan region are globally recognized as one of the hotspots for the 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 of 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 challenge's mountain communities face and the unique and progressive conservation efforts being made in Bhutan and
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 (%)
Participation (including ungraded FEXes)	10
Graded FEX 1: Plant identification and quiz	15
Graded FEX 2: Measuring plant communities along elevation gradient	15
Graded FEX 3: Measuring aquatic macroinvertebrates	15
Graded FEX 4: Forest succession after fire	15
Final Exam	30
TOTAL	100

Participation (10%)

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 Bhutanese 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.

Graded Field Exercises (FEX) (60%, 15% each)

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.

Plant Identification and Quiz (15%)

This exercise will enable students to identify the main plant species and major life zones of Bhutan. The students will be given field lectures on plant identification around the 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 write a short description illustrating its phylogeny, habitat where it grows, its uses and how it is propagated. A detailed handout will be provided for this FEX.

Measuring Plant Communities Along an Elevation Gradient (15%)

Elevation transects are 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. We will document biodiversity along elevational gradient by dividing the class into groups. Each group will conduct a detailed survey of life forms in series of plots. Students will identify the plant species and measure woody trees for their DBH, height and other attributes of the trees within the plot. Additionally, the group will collect and record ecologically important morphological characteristics. Using these data, the students will estimate total biomass, calculate biodiversity index and other ecologically important bio-indicators. The surveys will cover altitudinal gradient from valley bottom to mountain top. Each group should produce a comprehensive written report covering different aspects of the exercise.

Measuring Freshwater Macroinvertebrates (15%)

Aquatic invertebrate communities are determined by resources available in streams, rivers, and lakes and are often influenced heavily by pollution. We will survey aquatic sites, observing how flow rates influence invertebrate communities. Students will use standardized survey techniques and keys to identify aquatic invertebrate species and summarize their findings in a short report.

Forest Succession After Fire (15%)

Disturbance plays a vital role in ecosystem dynamics. Fire is one of the most important disturbances in Bhutan. Understanding its impact and providing practical application of forest fire is fundamental to forest management especially in dry region of the country. Students will learn the ecological processes of forest succession after a forest fire. The students will conduct a field survey in groups and produce a written report for a scientific journal.

Ungraded Field Exercises (FEX)

Measuring Terrestrial Macroinvertebrates (Ungraded)

Terrestrial macro invertebrates are critical in decomposition, nutrient cycling, physical processes, and disturbance regimes. Soil invertebrates modulate the environment such as soil temperature, moisture, nutrients, plant species composition, soil compaction, mixing, trace gas production, aggregate formation and stability, soil crusting, aeration, runoff, carbon storage, organic matter stabilization, macropores, water transport, and microbial community structure to varying degrees. There are also sources of food within the complex food chain. Insects are also important ecosystem regulators via the action of many species as powerful herbivores. Therefore, understanding their ecological roles becomes critical for their conservation. We will learn a few basic methods to quantify terrestrial macro invertebrates. A detailed guideline will be provided to conduct this survey.

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 two mornings in capturing the birds in mist net and learn how to handle the captured birds, as well as how to determine age, sex, and score molt on certain species. Between net checks, we will observe and identify bird species on campus, as well as learn how to conduct standardized observational transect and point count surveys.

Surveying Large Mammals Using Camera Traps (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 two mornings in capturing the birds in mist net and learn how to handle the captured birds, as well as how to determine age, sex, and score molt on certain species. Between net checks, we will observe and identify bird species on campus, as well as learn how to conduct standardized observational transect and point count surveys.

Final Exam (30%)

One final comprehensive final exam will be administered, 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

A	95.00 - 100.00%	B+	86.00 - 89.99%	C+	76.00 - 79.99%	D	60.00 - 69.99%
A-	90.00 - 94.99%	B	83.00 - 85.99%	C	73.00 - 75.99%	F	0.00 - 59.99%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

General Reminders

Field notebook - You will develop a comprehensive 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 always accompany you: 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 any personal journaling you may write.

When using citable material from your field notebook in written assignments, use the following format to acknowledge the source: (*Sonam Phuntsho, Field notes, 12 October 2014*). Whenever possible, use the name of the person providing the information; if not possible, cite descriptively, for example: "A *Cordyceps* collector of Soe-Yaktsa."

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 freshwater 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.

Readings – You are expected to have read all the assigned research articles prior to each class. All readings are available as PDFs on the Student Drive. Readings might be updated or changed during the course of the semester. Readings from textbook chapters are for reference/supplemental learning. Not all material will be explicitly taught during lectures, material from textbook chapters not covered in lecture will NOT be on exams. Additional readings could be assigned.

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.

Deadlines – Deadlines for FEX assignments will be at midnight two days after the actual FEX unless otherwise stated in assignment. Late assignments will incur a 10% penalty for each day that they are late. Assignments will be handed back to students after a one-week grading period at the latest.

Participation – Since 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 course is mandatory, it is important that you are prompt for all activities, bring the necessary equipment for field exercises and class activities, and simply get involved.

Course Content

Type- L: Lecture, **FL:** Field Lecture, **GL:** Field Lecture, **FEX:** Field Exercise, **D:** Discussion

***Required readings are in bold**

No	Title and outline	Type	Time (hrs)	Readings
ME 1	Course Overview Course Objectives, Syllabus, Field Exercises, Deadlines, Questions and Expectations for semester.	L; D	1:00	
ME 2	Introduction to Mountain Ecology Why are mountains 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; D	1:15	Price et al. Chapter 2 Foggin, 2016 Sayre et al, 2018
ME 3	Mountain Geology and Soils I We will learn the basics of mountain building processes and their implication on mountain ecology.	L; D	1:15	Smethurst, 2010
ME 4	Mountain Geology and Soils II We will learn about basics of Himalayan geology and soils. Discuss various implications of geology and soil management.	L; D	1:15	Crowther et al, 2019 Harrison, 1992
ME 5	Mountain Climate How do mountains affect climate? How are mountains shaped by climate? What are the geological processes in mountainous ecosystems? We will examine how elevation affects atmospheric processes and discuss an ecological manifestation of climate change on mountain systems.	L; D	1:15	Spicer, 2017 Barry, 2008 (Ch.1 and 5) Srinivasan, 2013
ME 6	Adaptations of Organisms in the Mountains What are the basic requirements for plants and animals for their growth and development? How do they adapt to different environment? What is the adapting mechanism of plants and animals in the mountainous environment?	L; D	1:15	Halbritter et al, 2018 Fjeldsa et al, 2013 Badgley, 2008 Manish and Pandit, 2018
ME 7	Field Survey Method I We will learn different survey methods to study animal communities and learn how to handle basic equipment for measurement of various environmental variables. We will also learn to develop data recording methods.	L; D	1:15	Lohmus et al, 2018
ME 8	Field Survey Method II We will learn about different sampling methods for ecological studies of plant communities including dendrochronology and learn how to handle different equipment used for surveys.	L; D	1:15	Arenas-Castro et al, 2015

No	Title and outline	Type	Time (hrs)	Readings
ME 9	Terrestrial Life Zone Ecology of Bhutan Himalaya We will learn and discuss different life forms (biomes), their special characteristics and implications for biodiversity conservation including cloud forests.	L; D	1:15	Wangda and Ohsawa, 2011 Singh, 1987 Wangda and Ohsawa, 2006 Lugo, 1999 Banerjee, 2016
ME 10	Fundamentals of Plant Identification Skills We will 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; D	1:15	Wondafrash, 2008
ME 11	FEX I: Plant Identification We will explore and identify major life forms, identify plant species and their floral characteristics on different along the elevational gradient. This will be a continuous exercise.	FEX	4:00	
ME 12	Alpine Life Zone We will discuss the alpine environment with reference to ecology of <i>Ophiocordyceps sinensis</i>	L; D	1:15	Jamtsho and Sridith, 2015 Cannon, 2009 Winkler, 2008 Müller, 2016
ME 13	FEX II: Measuring Floral Biodiversity Different types of sampling methods and basic calculations of biodiversity 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 biomass, forest stock increment, and other biodiversity indexes in life zone inventory field exercise.	FEX	4:00	Poorter, 2009 CIFOR, 2016
ME 14	Mountain Aquatic Environments What organisms are found in different wetland habitats? What are their adaptation mechanisms? We will discuss wetland ecosystems and understand basic requirement for macroinvertebrate survival in those ecosystems.	L; D	1:15	Von Oheimb, 2013 Verhoeven, 2006 Sherub et al., 2013
ME 15	FEX III: Measuring 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	3:00	Mackey, 1984
ME 16	Fundamentals of Terrestrial Invertebrates Here we will learn about the role of terrestrial invertebrates and in functioning of the ecosystems in different microsites.	L; D	1:15	
ME 17	FEX IV: Measuring Terrestrial Macro 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.	FL; FEX	3:00	Kalkman and Gyeltshen, 2015 Joshi et al, 2008

No	Title and outline	Type	Time (hrs)	Readings
	Here we will practice inventory of ants and dragon flies using different methods and tolls.			
ME 18	Population Ecology of High Mountains We will learn about dynamics of population structure which relates to density, foraging, habitat requirement especially of wild animals.	L; D	1:15	Tamma, 2016 Amrhein, 2012
ME 19	Large Mammals Ecology of Bhutan Discussion of Large Carnivore Conservation and keystone species conservation such as tiger and its implications conservation of forest ecosystems.	GL	1:15	Tempa et al, 2013 Carter & Lindell, 2016 Lindsey et al, 2017
ME 20	Plant identification quiz		1:00	
ME 21	Takin Ecology Learn about the national animal (Takin) of Bhutan.	FL; GL; D	3:00	Sangay et al, 2016
ME 22	Avian Ecology and Migration Learn about high elevation bird species, adaptations, and migration of some key bird species of the Bhutan Himalayas.	GL; D	1:15	Zhang et al, 2017 Hawkes et al. 2011 Norbu, 2013 Hu et al, 2018
ME 23	FEX V: Avian Mist-netting and Field Census Techniques Learn a few fundamentals on avian research through mist netting and field survey of birds along an elevational gradient	FEX	3:00	Pandit et al, 2016 Amrhein, 2012
ME 24	FEX VI: Counting Black-Necked Cranes at Phobjikha/Bioblitz Explore black-necked crane habitat, count cranes, and observe basic behavior such as preening, sequential vigilance, and estimate walking distance during feeding.	FL; FEX	3:00	Namgay, 2016 Lind, 2010 Zhongqiu, 2014 ICIMOD and RSPN, 2014
ME 25	Ecology of Small Himalayan Mammals Here we will learn the basic and fundamental of small mammal species of Bhutan.	L; D	1:15	Flowerdew, 1976
ME 26	FEX VII: Surveying Large Mammals Using Camera Traps Here we will learn methods to study large mammals using camera trapping in different micro-sites of Paro Valley.	FEX	4:00	Wearn and Glover-Kapfer, 2019
ME 27	Species Interactions in Mountainous Environment We will examine multiple species interactions (interspecific competition, predation, and population regulation, parasitism) and their influence on demographic processes and as agents of natural selection. Are montane communities more disease resistant than lowland communities, or have montane organisms escaped lowland disease vectors?	L; D	1:15	Telwala et al, 2009 Hobbs, 2006
ME 28	Mountain Forest and Disturbance Ecology We will identify major disturbance regimes such as climate change in mountainous terrain including human use of mountain forests in Bhutan and their implications on sustainable management of these mountainous ecosystems.	L; D	1:15	Dortch, 2009 Bajracharya, 2014 Beran et al, 2018 Jekins et al, 2013 Manral, 2017

No	Title and outline	Type	Time (hrs)	Readings
ME 29	Forest Ecosystem Vulnerability Assessment We will closely examine ecological processes in relation to forest and water and other ecosystem services and identify different indicators of mountain risk and vulnerability in relation to climate change.	L; D	1:15	Ellison et al, 2017 Price et al, 2013
ME 30	FEX VII: Forest Succession Ecology after Fire Here we will learn about forest succession after surveying fire burnt area and assess the vulnerability to ecosystems	FEX	3:00	
ME 31	Protecting and Conserving Bhutan's Ecosystem Learn about different adaptation and mitigations of Bhutanese ecosystems including financial systems.	L; D	1:15	Seddon et al, 2016 Ellis, 2011 Xu, et al, 2009 Wilson, 2009 Dirzo, 2014
ME 32	Final Exam Review		1:00	
ME 33	Final Exam		2:00	
	Total contact hours		60	

Reading List

*Required readings are in bold

1. Abdin, M. Z., Kiran, U., Kamaluddin, A. A. (2017). Plant Biotechnology: Principles and Applications || Plant Adaptation in Mountain Ecosystem., 10.1007/978-981-10-2961-5(Chapter 10), 249–271. doi:10.1007/978-981-10-2961-5_10.
2. **Amrhein, V., Scaar, B., Baumann, M., Minéry, N., Binnert, J.-P., & Korner-Nievergelt, F. (2012).** Estimating adult sex ratios from bird mist netting data. *Methods in Ecology and Evolution*, 3(4), 713–720. doi:10.1111/j.2041-210x.2012.00207.x.
3. **Arenas-Castro, S., Fernández-Haeger, J., & Jordano-Barbudo, D. (2015).** A Method for Tree-Ring Analysis Using Diva-Gis Freeware on Scanned Core Images. *Tree-Ring Research*, 71(2), 118–129. doi:10.3959/1536-1098-71.2.118.
4. Banerjee, A., & Bandopadhyay, R. (2016). Biodiversity hotspot of Bhutan and its sustainability. *Current Science*, 110(4), 521-527. doi:10.18520/cs/v110/i4/521-527.
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6. Beran, L., & Dyckhoff, H. (2018). Global Biomass Supply and Sustainable Development. *Human and Environmental Security in the Era of Global Risks*, 291–316. doi:10.1007/978-3-319-92828-9_15.
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8. CIFPOR (2006). *A Field Manual for Rapid Vegetation Classification and Survey for general purposes*. Indonesia.
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13. Ellison, D., Morris, C. E., Locatelli, B., Sheil, D., Cohen, J., Murdiyarso, D., ... Sullivan, C. A. (2017). Trees, forests and water: Cool insights for a hot world. *Global Environmental Change*, 43, 51–61. doi:10.1016/j.gloenvcha.2017.01.002.
14. Ellis, E. C., Goldewijk, K. K., Siebert, S., Lightman, D., & Ramankutty, N. (2010). Anthropogenic transformation of the biomes, 1700 to 2000. *Global Ecology and Biogeography*, 19(5), 589–606. doi:10.1111/j.1466-8238.2010.00540.x.
15. **Fjeldsa, J., R.C.K. Bowie, and C. Rahbek. (2012).** The role of mountain range in the diversification of birds. *Annual Review of Ecology, Evolution and Systematics*.
16. Foggin, J. M. (2016). Conservation Issues: Mountain Ecosystems. Reference Module in Earth Systems and Environmental Sciences. doi:10.1016/b978-0-12-409548-9.09199-5.
17. **Flowerdew, J. R. (1976).** Chapter 4: Ecological methods. *Mammal Review*, 6(4), 123–159. doi:10.1111/j.1365-2907.1976.tb00208.x.
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24. **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.
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