Tropical Ecology of the Amazon
SFS 3830

Syllabus

The School for Field Studies (SFS)
Center for Amazon Studies (CAS)
Loreto, Peru

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 may be present. In other words, the elephants are not always where we want them to be, so be flexible!

Course Overview

Tropical regions are highly biodiverse and the Western Amazon region is one of *the most* biodiverse places in the tropics. Ecology, the study of interactions of organisms with their environment, both its living and non-living components, can help us understand why and how this region harbors such a variety of life. In Tropical Ecology of the Amazon, we will be looking at the natural history and processes that created and sustain the region's biodiversity at multiple scales: species, community, ecosystem, and landscape.

The main goal of this course is for students to understand the processes that contribute to the diversity of life in the Western Amazon and gain insight into similar processes operating in tropical areas around the world. We will explore fundamental principles of ecology by studying a diverse set of ecosystems, habitats and species found here, including a variety of lowland tropical forest types and high-elevation forests at the headwaters of the Amazon River in the Andes Mountains.

Our exploration is grounded by three themes:

1. What is biodiversity? evolutionary origins, scales, and measurement
2. Why are the tropics so diverse? Interactions, ecosystem dynamics, succession
3. How does biodiversity respond to global change? Climate and land-use (past, present, future)

Using field methodology and guided by the scientific method, we will focus on learning tools that allow students to measure, describe, and explain biodiversity and its dynamics. This course is closely linked to the *Conservation Science* course, where the focus will be more on threats to, monitoring of, and strategies for the conservation of biodiversity. It also will provide background information on the natural arena in which human use and extraction of Amazonian natural resources by global, national and local actors takes place (discussed in *Political Ecology of Developing Landscapes*).

The focus is on field-based and hands-on learning, so come prepared to get your feet wet and hands dirty.

Learning Objectives

In this course students should develop conceptual understandings and practical skills that afford them an appreciation of the diversity and complexity of the natural systems of the Amazon region. Specific learning objectives are the following:

1. Gain an understanding of ecological complexity of tropical ecosystems, evolutionary processes, and landscape patterns that underlie species diversity and co-existence.
2. Understand the richness of life forms and their interactions (herbivory, predation, parasitism, seed dispersal, pollination, co-evolution).
3. Describe the structure and composition of the major ecosystems in the Northwestern Amazon region.
4. Understand how a tropical forest functions: the processes of nutrient cycling, regeneration and response to disturbances, and the anatomical and physiological characteristics of tropical plants.
5. Employ field research methods and analytical tools—both qualitative and quantitative— used in the study of ecology and biogeography.

Assessment

Assessment Item	Value (%)
Quizzes (3)	15
Communication & Collaboration in Science	
(1) Readings summary & oral presentation	5
(2) Peer-Review	5
FEX 1: Understory Diversity	15
FEX 2: Forest Structure	20
Final Exam	30
Participation	10
TOTAL	**100**

Assessment Descriptions

Quiz

Short quizzes will be administered throughout the semester to assess periodic comprehension of the course's material. Quiz questions will be synthetic and answers will be expected in short essay form.

Field Lab: Vertical Zonation in the Forest Canopy

On a self-guided walk along the Amazon Canopy Walkway, students will make observations of canopy closure, light, and general vegetation structure. We will come together as a class to discuss any patterns observed, hypotheses regarding any natural patterns and how we might test them. Then small groups will brainstorm how we might use carefully planned observational surveys or manipulative experiments test one of the hypotheses discussed, producing a short presentation on their ideas.

FEX 1: Measuring and Quantifying Biodiversity- Understory Plants

Students will systematically survey and collect understory plants along the trails of the CAS forest, and try to identify them to the lowest taxonomic unit. We will use this data to explore the different metrics used to quantify and compare biodiversity between different samples (species accumulation curves, diversity indices). Students will work in groups to generate this information for their samples and we will come together to compare the results of different groups. A short written assignment explaining the methods and results will be handed in by each group for feedback.

FEX 2: Measuring and Quantifying Biodiversity- Forest Trees & Forest Structure

We will survey forest structure in two different forest types (white-sand forest and secondary *terra firme* forest OR primary *terra firme* forest) in order to compare them. Using several plots or transects at each site, we will collect standard forest structure metrics (tree height, DBH, canopy cover). We will use standard statistical analyses (t-tests, ANOVA and Chi-Square Tests) to compare and contrast the sites. Analyses can be done in groups, but students will turn in individual reports using scientific article structure. A grading rubric will be provided separately.

Science Communication and Collaboration Assignments

Effective communication of findings and ideas and collaboration among individual scientists are important for the advancement of science. Research and review articles are an important tool for communication among scientists and learning to read them effectively is an important skill for understanding and eventually writing scientific papers. In addition to collaboration on research projects, scientific peers also frequently collaborate on writing by serving as peer-reviewers of manuscripts in progress or submitted to journals. You will practice how to effectively and efficiently read and convey information in research/review articles and provide constructive criticism.

(1) Readings summary & Oral Presentation

Students will present a brief (1-2 paragraphs) written summary of one of the course readings and deliver an oral summary to the class before or during the class period corresponding with the reading. Detailed instructions will be given at the start of the course.

(2) FEx Report Peer-review

Students will read and review a classmate's field exercise report and provide feedback in the form of a "Letter to the Editor." Detailed instructions will be given at the time of the assignment.

Exam

The final exam is closed-book. You will be given time to study for the exam; a class period will be designated as review. You will be examined on what you have been exposed to in class (lectures, discussions, etc.) and in the field, and what you have been asked to read. The exam will ask you to draw on multiple concepts and experiences and synthesize information in response to ecological scenarios.

Grading Scheme

A	95.00 – 100.00%	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	0.00 – 59.99%
		B-	80.00 – 82.99%	C-	70.00 – 72.99%		

General Reminders

Readings – Some readings are required and most readings are optional, but reviewing them is strongly encouraged as they will enhance your understanding of the lecture and field lecture material and serve as examples of how scientific papers are written. Readings are available as PDFs on the student computer. The reading list might be updated or changed during the course of the semester.

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). Unless specifically stated, all assignments should be individual pieces of work.

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 three days.

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 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 land- and water-based activities, bring the necessary equipment for field exercises and directed research, and simply get involved.

Course Content

Type: L-Lecture, **FL-** Field Lecture, **FEX-** Field Exercise, **FLAB-** Field Lab Exercise, **LAB-** Lab Exercise

(*)= Readings assigned for student summaries.

Type	*Hrs*	*Lecture Title and Description*	*Reading*
TE1 (L)	**1.0**	**Introduction to Tropical Ecology: Course Overview** This lecture will introduce tropical ecology as an interdisciplinary field and set course expectations.	Week 1
TE2 (L)	**1.0**	**The Torrid Zone: Climate & Soils of the Tropics** What does "tropical" mean? This lecture will explore how terrestrial astronomy and the interactions between air, water, and landmasses generates tropical ecosystems. It will also explore characteristics and distributions of soils in the tropics and how they create variability in the landscape.	Week 1 Optional: *Quesada et al. (2011)*
TE3 (L)	**2.0**	**What is biodiversity?** This lecture will review the different definitions of biological diversity ranging from genetic to landscape scales. We will introduce classic methods and indices used to quantify biodiversity in preparation for our Understory Plant Diversity Lab.	Week 1 & 2
TE4 (FL/D)	**2.0**	**The Western Amazon: Biodiversity Treasure** We will briefly introduce the high biodiversity of tropical regions and the Western Amazon in a global context (e.g., latitudinal diversity gradient). A guided walk and trail orientation in the forest around our center will introduce students to some of this diversity and let them start honing their observation skills.	Week 1 *Gentry (1988)* Optional: *Hillebrand (2004)*
TE5 (L/FL)	**1.0**	**Tropical Forests: Types & Structure** We will discuss forest classification and the four major forest types of the lowland Amazon we will see during the course. We will also introduce ways of measuring and quantifying forest structure, with field practicums at upland broadleaf forest (CAS Forest) and white-sand forest (Field Trip to Allpahuayo-Mishana).	Week 1 **Stropp et al. (2011)* **Myster et al. (2017)* Optional: *Myster (2016)* *Adeney et al. (2016)*
TE6 (GL/FL/LAB)	**3.0**	**Tropical Plant Families** We will be introduced to some of the most important tropical families and how to identify them using a tropical botanist's best tool-kit: sight, sound, smell and taste. We will also discuss how to collect specimens and information from the field to allow for later	Week 2 **Cardoso et al. (2017)*

Type	*Hrs*	*Lecture Title and Description*	*Reading*
		species ID. (Guest Co-Instructor: Fredy Ramirez Arevalo, M.Sc.)	
TE7 (FEX1/LAB)	**4.0**	**FEX I: Understory Plant Diversity** How can we measure biodiversity? We will put methods and indices used to quantify biodiversity to practice with a field lab exploring the floristic diversity along the trails in our center. (Field: 2.5 hrs, Lab: 1.5 hrs) (Guest Co-Instructor: Fredy Ramirez Arevalo, M.Sc.)	Week 2 Optional: Gotelli & Colwell (2001) *Longino et al. (2002)*
TE8 (L)	**1.0**	**A Fishy Tale: Fish Diversity in the Amazon Basin** South America has an incredible diversity of fish. We will examine how geologic history has shaped fish diversity in the Amazon basin and learn about some of the most common Amazonian fish orders, a few of which we'll see during our fish surveys in Tamshiyacu-Tahuayo monitoring excursions. **(Quiz 1)**	Week 3 **Freitas et al. (2014)* Optional: *Lundberg et al. (2010)* *Albert et al. (2011)*
TE9 (L/D/FLAB)	**1.0**	**"The Fish and the Forests": The Ecology of Fish and Trees in the Amazon Floodplain** The floodplain forests of the Amazon are the setting of an incredible story of interdependence between fish and trees. This lecture will explain how the trees and the forest are an important seasonal resource that can affect river fish populations and diversity.	Week 3 **Lucas (2008)*
TE10 (GL/D)	**3.0**	**Amazon Geology & Flooded Forest Ecology** How has geological history and variable river system influenced the high biodiversity of the Western Amazon? What is left of what was once a Mega-Wetland? How does flooding seasonality shape the ecology of flooded forest communities? What might future climate scenarios mean for the future of flooded forests? Guest Lecturer: Dr. Richard Bodmer (Lecture 2.5 hrs, Discussion: 0.5 hrs.)	Week 3 *Bodmer et al. (2014)* Optional: *Bodmer et al. (2017)*
TE11 (FEX)	**3.0**	**FEX II: Broadleaf *Terra Firme* Forest** Data collection of forest structure at CAS forest.	Week 4
TE12 (FL/D)	**2.0**	**Of Chemical & Other Warfare: Plant Defenses & Secondary Compounds** What do human plant uses have to do with insects? We will explore the diverse adaptations plants use to protect themselves against natural enemies and how these defenses have been exploited by humans and animals. This will include a visit to a traditional medicinal garden and a discussion of a local healer's explanation of medicinal uses.	Week 4 *Optional: Agrawal and Konno (2009)*

Type	*Hrs*	*Lecture Title and Description*	*Reading*
TE13 (L/FL/D)	**1.5**	**Into the "Jungle": Tropical Forest Succession** During this field lecture, we will examine the role of disturbance (human and natural) in tropical forests and the subsequent process of recovery and vegetation change, discussing the differences between the forests around ExploNapo, our home center, and fallow fields observed in the community of Sucusari.	Week 4 *Optional:* *Norden et al. (2017)* *Capers et al. (2005)*
TE14 (FLAB/D)	**2.0**	**Into the Treetops** How does the forest environment change vertically and how to organisms use this structure? We will use a canopy walkway to explore the vertical structure of a mature rainforest and observe how light and temperature varies with height, and how organisms such as epiphytes and birds change along this gradient.	Week 4 **Madigosky & Vatnick (2000)* **Hietz & Briones (1998)*
TE15 (FEX)	**3.0**	**FEX II: White Sand Forest** Data collection of forest structure at Reserva Nacional Allpahuayo-Mishana (RNAM)	Week 5
TE16 (LAB)	**2.0**	**FEX Data Analysis Workshop**	Week 5
TE17 (L/D)	**2.0**	**Why are the tropics so biodiverse?** Why is there a latitudinal diversity gradient? We'll examine the different ideas for why the tropics house so many different species and the evidence for and against each hypothesis.	Week 5 *Optional: Mittelbach et al. 2007*
TE18 (FL)	**2.0**	**"Summer Every Day, Winter Every Night": Tropical Alpine & Montane Ecosystems** We will examine how vegetation communities respond to montane climate and vegetation. Students will be introduced to the highland tropics and variety of ecosystems found in the Eastern Andes-Amazon interface as we cross across a west-east moisture gradient from Cuzco to Wayqecha Biological Station (high elevation wetlands, puna grassland, tussock grassland, and elfin/cloud forest). We will discuss adaptations tropical alpine plants have to deal with the unique climatic challenges of living high in the tropics.	Week 6 **Sklenár et al. (2016)*
TE19 (FL)	**2.0**	**Montane Forests & Climate Change** How will the tropical treeline and montane forest respond to climate change? Cloud forests occur where a condensation belt around mountains creates high-humidity conditions, but climate change may change this humid belt. We will visit a new and ambitious manipulative "fog exclusion" experiment at Wayqecha Biological Station that seeks to answer how plants and nutrient cycling might respond to climate change. **(Quiz 2)**	Week 6 **Nadkarni & Solano (2002)*
TE20 (FL)	**2.0**	**Forest Islands in a Grassy Sea: The *Polylepis* Dilemma** We will visit high-elevation forests dominated by unique *Polylepis* trees found at Abra Malaga. These are some of the forests growing at the highest elevations in the world and of high	Week 6 **Lloyd & Marsden (2011)*

Type	Hrs	Lecture Title and Description	Reading
		conservation concern. We will discuss the causes and consequences of their patchy spatial distribution, their role as bird habitat, and their regeneration ecology. Back in the classroom we will discuss the open questions regarding the history and future of the biological community they host and the challenges to their conservation.	
		BREAK	
TE21	**2.5**	**FEX Writing Workshop** **(FEX Draft Due for Peer-Review; Peer-Reviews Due)**	Week 8
TE22 (L/FL)	**2.0**	**A Tangled Web I: Tropical Trophic Dynamics** Tropical food and interaction webs can be particularly complex. We will review the major organismal interactions and may take a walk into the center forest to examine of the most iconic of tropical interactions (ant-plant mutualisms).	Week 8 **Frederickson & Gordon (2007)*
TE23 (FL/D)	**2.0**	**A Tangled Web II: Butterfly Microcosm** We will visit a butterfly farm and learn about how butterflies are raised by the community of San Rafael. Students will observe the incredible variety of interactions occurring in this one small system and how one species can have different interactions with different organisms throughout its life.	Week 8
TE24 (L/FL)	**3.0**	**Top-down Forces: Animal-Plant Interactions** Animals play a key role in shaping tropical forests as herbivores, pollinators, seed predators and seed dispersers. We will focus on the role that frugivorous mammals and large birds play in maintaining plant diversity and examine the consequences of defaunation for forest composition and biomass.	Week 8 & 9 **Terborgh et al. (2001)* **Paine & Beck (2007)*
TE25 (FL/ D)	**2.0**	**Climate Change Effects on Amazonian Forests** There is great interest but great uncertainty on how Amazonian ecosystems will respond to climate change. The responses of trees and microbial communities could have important consequences for biogeochemical cycles. Long-term monitoring and observations of responses to extreme climate events (drought/flood) can offer a window into potential responses. We will visit a *Mauritia flexuosa* palm swamp at Quistococha to see an Eddy Covariance Flux tower monitoring carbon and water fluxes from this Neotropical peatland and discuss what we already know about upland tree response to drought events.	Week 8 **Feldpausch et al. (2016)*
TE26 (LAB)	**1.0**	**Field Techniques: Mist-Netting** Students will learn and practice how to set up and break down mist-nets properly to capture flying birds and mammals in preparation for our field visit to the UCP CCARI reserve. **(Quiz 3)**	Week 9

Type	*Hrs*	*Lecture Title and Description*	*Reading*
TE27 (GL/FLAB)	**3.0**	**Bats: Keystone Species** Tropical bats are a highly diverse community with important ecological roles. We will learn about the 45 species of bats in the UCP CCARI reserve and their roosting ecology, observing different techniques for studying bats (mist-netting and bat detectors). (Guest Co-Instructor: Harold Portocarrero, Universidad Científica del Perú)	Week 9 **Sampaio et al. (2002)*
TE28	**2.0**	**Exam Review**	Week 10
TE29	**2.0**	**Final Exam**	Week 10
	60.0	**TOTAL CONTACT HOURS**	

Reading List

Adeney, J.M, Christensen, N.L., Vincentini, A., and M. Cohn-Haft (2016) White-sand Ecosystems in Amazonia. Biotropica 48: 7-23.

Agrawal, A. and K. Konno (2009) Latex: A Model for Understanding Mechanisms, Ecology, and Evolution of Plant Defense Against Herbivory. Annual Review of Ecology, Evolution, and Systematics 40: 311-331.

Albert, J. S., Carvalho, T. P., Petry, P., Holder, M. A., Maxime, E. L., et al. (2011) Aquatic Biodiversity in the Amazon: Habitat Specialization and Geographic Isolation Promote Species Richness. Animals : An Open Access Journal from MDPI 1: 205–241.

Bodmer, R., Fang. T., Puertas, P.E., Antunez, M., Chota, K. and W.E. Bodmer (2014). Abstract *in:* Cambio climático y fauna silvestre en la Amazonía Peruana. Pp. 25-26.

Bodmer R., Fang, T., Antunez, M., Puertas, P., Chota, K., *et al.* (2017) Impact of recent climate fluctuations on biodiversity and people in flooded forests of the Peruvian Amazon *in:* The Lima Declaration on Biodiversity and Climate Change: Contributions from Science to Policy for Sustainable Development. CBD Technical Series No. 89. (eds. Rodriguez, L. and I. Anderson). Secretariat of the Convention on Biological Diversity, Montreal. pp. 81-90.

Cardoso, D., Sarkinen, T., Alexander, S., Amorim, A., Bittrich, V., *et al.* (2017) Amazon plant diversity revealed by a taxonomically verified species list. Proceedings of the National Academy of Sciences 40: 10695-10700.

Dudley, R., Kaspari, M., S. Yanoviak (2012). Lust for Salt in the Western Amazon. Biotropica 44: 6-9.

Espirito-Santo, F.D.B., Gloor, M., Keller, M., Mahli, Y. *et al.* (2014) Size and frequency of natural forest disturbances and the Amazon forest carbon balance. Nature Communications 5:3434.

Feldpausch TR, Phillips OL, Brienen RJW, Gloor E, Lloyd J, *et al.*(2016) Amazon forest response to repeated droughts. Global Biogeochemical Cycles.

Frederickson, M.E. and D.M. Gordon (2007) The devil to pay: a cost of mutualism with *Myrmelachista schumanni* ants in 'devil's gardens' is increased herbivory on *Duroia hirsuta* trees. Proceedings of the Royal Society B 274: 1117-1123.

Freitas, C.E.C., Siqueira-Souza, F.K., Florentino, A.C. and L.E. Hurd (2014) The importance of spatial scales to analysis of fish diversity in Amazonian floodplain lakes and implications for conservation. Ecology of Freshwater Fish 23:470-477.

Gentry, A. (1988) Tree species richness of upper Amazonian forests. Proceedings of the National Academy of Sciences 85: 156-159.

Gotelli, N.J. and R.K. Colwell (2001) Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. Ecology Letters 4: 379-391.

Hietz, P. and O. Briones (1998) Correlation between water relations and within-canopy distribution of epiphytic ferns in a Mexican cloud forest. Oecologia 114:305-316.

Hillebrand, H. (2004) On the generality of the latitudinal diversity gradient. The American Naturalist 163:192-211.

Lloyd, H. and S.J. Marsden (2011) Between-patch bird movements within a High-Andean *Polylepis* woodland/matrix landscape: Implications for habitat restoration. Restoration Ecology 19:74-82.

Lucas, C.M. (2008) Within flood season variation in fruit consumption and seed dispersal by two characin fishes of the Amazon. Biotropica 40:581- 589.

Lundberg, J.G., Sabaj Perez, M.H., Dahdul, W.H. and O.A. Aguilera (2010) The Amazonian Neogene fish faunas *in*: Amazonia: Landscape and Species Evolution (eds. Hoorn C. and F. Wesselingh). Pp. 281-301.

Madigosky, S.R. and I. Vatnick (2000) Microclimatic characteristics of a primary tropical Amazonian rain forest, ACEER, Iquitos, Peru. Selbyana 21: 165-172.

Mittelbach, G.G., Schemske, D.W., Cornell, H.V., Allen, A.P., Brown, J.M., *et al.*(2007) Evolution and the latitudinal diversity gradient: speciation, extinction and biogeography. Ecology Letters 10: 315–331.

Myster, R.W. (2016) The Physical Structure of Forests in the Amazon Basin: a Review. Botanical Review 82: 407-427.

Myster, R.W. (2017) A comparison of the forest soils in the Peruvian Amazon: *Terra firme*, palm, white sand and igapó. Journal of Soil Science and Environmental Management 8: 130-134.

Nadkarni, N.M. and R. Solano (2002) Potential effects of climate change on canopy community in a tropical cloud forest: an experimental approach. Oecologia 131:580-586.

Norden, N., Boukili, V., Chao, A., Ma, K.H., *et al.* (2017) Opposing mechanisms affect taxonomic convergence between tree assemblages during tropical succession. Ecology Letters 20:1448-1458.

Paine, C.E.T. and H. Beck (2007) Seed predation by neotropical rain forest mammals increases diversity in seedling recruitment. Ecology 88: 3076-3078.

Sampaio, E.E., Kalko, E.K., Bernard, E. et al. (2003) A biodiversity assessment of bats (Chiroptera) in a Tropical Lowland Rainforest of Central Amazonia, Including Methodological and Conservation Considerations. Studies on Neotropical Fauna and Environment 38: 17-31.

Sklenár, P., Kucevora, A., Macková, J. and K. Romoleroux (2016) Temperature microclimates of plants in a tropical alpine environment: How much does growth form matter? Arctic, Antarctic, and Alpine Research 48:61-78.

Stropp, J., Van der Sleen, P., Assuncao, P.A. , da Silva, A.L. and H. Ter Steege (2011) Tree communities of white-sand and terra-firme forests of the upper Rio Negro. Acta Amazonica 41: 521-544.

Terborgh, J., Lopez, L., Nuñez P., Rhao, M., Shahabuddin, G., *et al.* (2001) Ecological Meltdown in Predator-Free Forest Fragments. Science 294: 1923- 1925.