THE SCHOOL FOR FIELD STUDIES

Tropical Ecology and Sustainable Development
SFS 3770

Syllabus

The School for Field Studies (SFS)
Center for Sustainable Development Studies (CSDS)
Atenas, Costa Rica

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.

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

The clearing of the world's forests has created habitat fragmentation and caused a considerable number of species extinctions. Increasingly fragmented populations succumb to the demographic and genetic consequences associated with small population sizes. It is estimated that between 3,000 and 30,000 species are going extinct every year based on rates of forest habitat loss and estimates of global biodiversity. This is particularly true for tropical regions where biodiversity is highest. The drivers of forest loss are complex and operate across a variety of geographic and socio-political scales. In addition, the ongoing global climate change is altering the phenology of many species and inducing shifts in species geographic range. These ecological alterations act synergistically with other anthropogenic factors (e.g. hunting, urban development, pollution, etc.) thus accelerating the rate of species extinction.

Developing countries have different development models that directly or indirectly affect the environment. Costa Rica took a major shift from an agriculture-based economy to a service-based, environmentally friendly economy. For instance, the ecotourism industry is supported by a network of protected areas that form the national system of conservation areas. However, the down side of ecotourism development brings an increase in infrastructure, such roads and resorts that cause environmental alteration. It is known that the construction and the use of roads create habitat loss, interrupt continuity of habitats and generate chemical and noise pollution. In addition, roads pose direct and indirect threats to wildlife as roads may limit or preclude animal dispersal movements or induce mortality through vehicle-animal collisions. Many of these negative impacts can be avoided or mitigated if the necessary knowledge of the interacting ecological processes and human activities is acquired.

Modern science is a multidisciplinary effort with a significant social impact. The construction of a sustainable future will depend on a multidisciplinary approach to understand and solve conservation problems. This understanding ought to be based on solid ecological information, especially in tropical ecosystems where the diversity of life forms and biological interactions are complex, and where social and economic challenges are daunting. Thus, in order to have an understanding of the current ecological problems and to look for potential solutions to those problems, we will study the main following themes: a) tropical forest dynamics, b) the origin of tropical diversity, c) mechanism of species extinction, d) assessment and use of biodiversity, e) ecosystem dynamics and human-initiated disturbances (ecological consequences of roads and forest fragmentation), f) climate change and tropical forest dynamics, and g) the ecology of emerging diseases and invasive species. We will do this through lectures, group discussions, field trips, and field research. In this integrated multidisciplinary program, the students will examine the negative impacts of development on the ecosystems in various parts of Costa Rica and Panama and evaluate cases of effective conservation and management practices.

Learning Objectives

The Tropical Ecology course seeks to provide students with:

1) An introduction of the natural history of the major ecosystems in Costa Rica and Panama.
2) An introduction to the ecological complexity of tropical forests and evolutionary processes of species co-existence.
3) An understanding of the causes of the origin of tropical species diversity.
4) An understanding of present-day ecological factors affecting the distribution of tropical organisms (climatic and topographic heterogeneity).
5) An understanding of the richness of life forms and biological interactions (herbivory, seed dispersal, pollination, coevolution).

6) An understanding of monitoring plans to assess potential ecological impacts (the use of bio-indicators).
7) An understanding of how a tropical forest functions, such as nutrient cycling, regeneration and response to disturbances, and the physiological characteristics of tropical organisms.
8) Definitions and quantifications of the biodiversity concept.
9) An understanding of current threats to tropical biodiversity. This includes habitat fragmentation, ecological impacts derived from agricultural and urban sprawling.
10) An understanding of how climate change affects species distribution, phenology and the likelihood of species extinction.
11) The ability to integrate the above topics to generate alternatives to minimize negative impacts on tropical ecosystems.
12) The necessary creativity to develop ecologically sound alternatives of land use practices and conservation mechanisms. This includes sustainable agriculture that enhances habitat connectivity, climate change mitigation (e.g. carbon offset mechanisms), environmentally friendly certification programs (e.g. RFA) and strategic alliances with stakeholders.

Thematic Components and Research Direction

The overarching question we address in the CSDS curriculum is:

How can Costa Rica respond to local and global challenges while securing the functionality of its natural and human systems?

In order to address this rather broad question we will examine two specific components:

1. Relationships between conservation and economic development

Balancing economic development with environmental conservation is imperative. The paradigm is shifting towards the integration of human communities in the management and conservation of protected areas, and the valuation of ecosystem services. Innovative ways are needed to integrate human communities with conservation efforts, while adding value to ecosystem services. Through this component we will assess the human capital around protected areas and identify alternatives to manage increased visitation to national parks while investigating the potential impacts of tourism on park infrastructure and biodiversity. Delivering this information for managers and communities alike is a necessary step to balance economic development with the maintenance of healthy ecosystems.

2. Ecosystem function and connectivity

Human activities in Costa Rica are major drivers of alteration and destruction of natural habitats and the associated loss of biodiversity. Forest clearing reduces the size of suitable habitats for many species and often creates subdivisions of the original continuous forest, leading to habitat fragmentation. A key aspect for a healthy functioning of ecosystems is the natural dispersal of both animals and plants; this depends on the continuity of habitats.

Thus, the functionality of ecosystems can be understood and measured by the environmental services provided. The sustainable use of the landscapes may regulate the provision of fresh water, sequester carbon in soils and vegetation, maintain soil fertility, and protect biological diversity. This component examines the sustainable use of landscapes and the environmental services they provide, the responses of ecosystems to climate change, the monitoring and assessments of the biodiversity in protected areas, and the impacts of infrastructure and human disturbances on wildlife.

Assessment

The evaluation breakdown for the course is as follows:

Assessment Item	Value (%)
Participation	5
Quizzes	10
Animal workshop	10
Field Exercise 1	15
Field Exercise 2	20
Mid-term Exam	20
Final Exam	20
TOTAL	**100**

Participation and topic discussions (5%): Everybody should be prepared for each academic session. This implies reading the materials for each session with enough detail to be able to ask relevant questions, and to participate in analytical discussions about the key issues. Active participation during classes, discussions, assignments and hikes is expected.

Quizzes (10%): Two short quizzes will be used to evaluate the field lectures.

Animal workshop (10%): This field activity will be carried out in Manu Center, during the first field trip. The students will learn about the mist-netting technique in ecology and animal identification skills.

Field Exercises (FEX) (35%): Two field exercises will be conducted. With these FEXs students will gain experience for the Directed Research component at the end of the semester. The FEXs require field observation, data collection and report writing.

Context: Science is based on intuition, logic and reason. The scientific method begins with an *observation*; we seek *patterns* and then formulate *hypotheses* that could explain those patterns. We can also use experiments to test hypotheses. Finally, we conclude on the results thus contributing to a broader theory.

Objective: Our objective is to develop observation skills in the field and to learn the process of the scientific method.

FEX 1 (15%)
Subject: Observational skills and hypothesis testing
Methods: We will use the forest of Monteverde as a natural laboratory. Students will be provided with theory during the orientation hikes and guidance in the process of observation, hypothesis formulation, analysis and writing.

FEX 2 (20%)
Subject: Experimental design in ecology
Methods: We will use the SFS campus in Atenas for the experiment setting and execution. Students will receive a handout on the subject along with a list of potential topics for the project. In addition,

students need to discuss the project with the professor to receive feedback about the theory, logistics and equipment involved during the field data collection.

Assessment: Students will be assessed based on their ability to develop a sound hypothesis, data collection effort, and the written report.

Midterm Exam and Final Exam (40%): Two written exams will be given based on material covered in lectures, readings, and field experiences. Each exam is worth 20%.

Grade corrections in any of the above items should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

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

The assigned readings will be available in a printed anthology. Please take good care of this anthology and do not loose it. The goal of this compilation of articles is to eliminate the need for printing more copies using laser printers (reducing our impact on paper and other center resources). It is important to read the assigned readings prior to class or discussions. We will often use these as starting points or examples for class discussion or as background information for field trips. Reference and resource materials are useful starting points for your directed research. Additional references can be provided upon request.

Plagiarism: Using the ideas or material of others without giving credit is cheating and will not be tolerated. A grade of zero will be assigned for anyone caught cheating or aiding another person to cheat, either actively or passively (e.g. allowing someone to look at your exam). In addition, we will use Turnitin to evaluate the originality of the written material produced by you.

Deadlines for assignments are established to promote equity among students, to allow faculty enough time to review and return comments and grade before other assignments are due, and to avoid clashes with other activities and courses. Therefore, deadlines are firm and extensions will only be considered under extreme circumstances. When appropriate, the files should be placed in the assigned folder within the students drive on the server. Late assignments will incur a 10% penalty for each day that they are late. Papers submitted after 3 days of the dateline will not be accepted. Please plan ahead to avoid such situations. Assignments will be handed back to students within one-week grading period.

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 Costa Rica. Therefore, it is important that you are prompt for all land and water based activities, and to bring the necessary equipment for field exercises and directed research, and simply get involved.

Course Content

Type: D: Discussion, **FL:** Field Lecture, **GL:** Guest Lecture, **L**: Lecture, **O**: Orientation

No.	*Title and outline*	*Required Readings*	*Type*	*Hours*
TE1	Field trip briefing: Agricultural practices and the environment (Braulio Carrillo National Park, Manu Center, sustainable farm and monocrop plantation)		O	0.5
TE2	HIKE: Rainforest ecology (Braulio Carrillo National Park). Introduction to the general ecology of tropical rainforest and natural history of various representative species of this ecosystem.		O	1.5
TE3	Animal Workshops Bird and bat ecology: natural history, morphology and adaptations, species identification, and mist-netting techniques.		FL	3.0
TE4	Agricultural practices and the environment: Small-scale multi-crop system (El Progreso farm): a) Diversification of agricultural systems. b) Organic agriculture. c) Sustainable issues in agricultural processes.		GL	1.0
TE5	Agricultural practices and the environment: large-scale monocrop system: a) Monocrop plantation management. b) Processing of agricultural products. c) Sustainable issues in agricultural processes		GL	2.0
TE6	General Introduction to the Tropical Ecology course. a) Objectives of the Tropical Ecology course in relation to the general goals of the SFS program. b) Review of the main themes in tropical	Syllabus www.fieldstudies.org	O	1.0

No.	Title and outline	Required Readings	Type	Hours
	ecology, theory and the application of ecological concepts in conservation and sustainability.			
TE7	Natural History of Costa Rica a) Geologic formation of the Central American land bridge. b) Biogeographic consequences of the land bridge formation for terrestrial and marine biota. c) Climate and topography of Costa Rica. d) Life Zones, habitats and species richness. e) Humans and the environment.	Optional reading: Costa Rican Natural History. 1983. Ed. Daniel H. Janzen, Univ. of Chicago Press (Available in SFS Library)	L	1.0
TE8	Diversity of tropical rainforests a) The Latitudinal Diversity Gradient (LDG) b) Habitat heterogeneity and species richness c) Alpha and Beta diversity	Brown, J.H. 2014. Why are there so many species in the tropics? J. Biogeogr 41, 8-22. **Anthology pp: 1-15**	L	1.5
TE9	TE Field Exercise (FEX) 1 explanation Observational skills and hypothesis testing		O	1.0
TE10	HIKE: Natural history of tropical premontane forests. Introduction to the general ecology of the premontane forest and natural history of various representative species of this life zone.		O	1.5
TE11	Discussion and direction of the FEX 1 project ideas		D	1.5
TE12	FEX 1data collection (field assistance)		FEX	2.0
TE13	Tropical Cloud Forest Ecology a) Physical environment of premontane forests b) Forest structure, dynamics and species diversity c) Animal-plant interaction	Optional reading: Nadkarni, N and N.T. Wheelwright. 2000. Monteverde Ecology and conservation of a tropical cloud forest. Oxford University Press (SFS Library)	FL	1.0
TE14	HIKE: Natural history of tropical cloud forest species (Monteverde Reserve).		O	1.5

No.	Title and outline	Required Readings	Type	Hours
	Introduction to the general ecology of tropical cloud forests and natural history of various representative species of this ecosystem.			
TE15	FEX data analysis		O	1.5
TE16	Field trip briefing: Tarcoles River and Carara National Park		O	0.5
TE17	Mangrove ecology a) Tarcoles river, pollution and wildlife b) Mangrove forest physiognomy and function c) Ecological importance of Mangrove ecosystems		FL	1.0
TE18	Road ecology: negative effects of roads on protected areas	Arévalo, J.E. & E. Blau. 2108. Road Encroachment Near Protected Areas Alters the Natural Soundscape Through Traffic Noise Pollution in Costa Rica. Revista de Ciencias Ambientales (Tropical Journal of Environmental Science), 52(1): 2215-3896. **Anthology pp: 16-37**	FL	1.0
TE19	HIKE: Ecology of wet-to-dry transitional forests (Carara National Park) Introduction to the general ecology of transitional forests and natural history of various representative species of this ecosystem.		O	1.5
TE20	Mechanisms of species diversity a) Mechanism of speciation b) The competitive exclusion principle c) The Negative Density Dependence effect d) Mechanism of species coexistence	Coley, P.D & T.A. Kursar. 2014. On tropical forest and their pests. Science 343, 35-36. **Anthology pp: 38-39**	L	1.5
TE21	Neotropical Forest Dynamics a) Forest gap dynamics and species diversity			1.5

No.	Title and outline	Required Readings	Type	Hours
	b) Spatio-temporal variation and niche regeneration c) Intermediate Disturbance Hypothesis			
TE22	Climate Change and Tropical Forests a) Tropical forest changes and Climate Change (CC) b) Implications of CC on tropical biodiversity c) Predicting future negative impacts through understanding and monitoring biodiversity d) Monteverde: A case study on climate change and global amphibian decline	Yang, L. H. and V. H. W. Rudolf. 2010. Phenology, ontogeny and the effects of climate change on the timing of species interactions. Ecology Letters, 13: 1-10. **Anthology pp:** 40-**49**	L	1.5
TE23	FEX2 Experimental design – Objectives and theory		FEX	1.0
TE24	Urban management for habitat connectivity (UCR)		L	1.0
TE25	Transgenic organisms and ecological impacts a) Risks of tropical ecosystem alterations due to GMOs use b) Potential evolutionary implication of GMOs on wildlife.		L	1.0
TE26	Discussion on UCR trip		D	1.0
TE27	FEX2 Experimental design – Observation and standardization of the methods, field design.		FEX	2.0
TE28	FEX2 Data collection		FEX	1.5
TE29	TE topic discussion I	Bradshaw, C.J.A., N.S. Sodhi, and B.W. Brook. 2009.Tropical turmoil: a biodiversity tragedy in Progress. Front Ecol Environ, 7(2): 79–87. **Anthology pp: 50-58**	D	1.5

No.	Title and outline	Required Readings	Type	Hours
TE30	FEX2 Data collection		FEX	1.5
TE31	Review and preparation for the first exam	Readings, lecture notes, class notes	O	1.0
TE32	a) Exam 1		Exam	1.0
TE33	Landscape Ecology a) Ecological consequences of habitat fragmentation. b) Conservation of the soundscape c) Conservation of biodiversity in a human-dominated landscape	Lewis, L.S., D.P. Edwards & D. Galbraith. 2015. Increasing human dominance of tropical forests. Science, 349: 827-832. **Anthology pp: 59-64**	FL	1.5
TE34	The globalization of species extinction. a) Revision of major extinction events: are we facing another mass extinction? b) Major causes of extinction (habitat loss and fragmentation, defaunation, climate change, overhunting). c) Species co-extinction and ecological cascade effects. d) Climate change and extinction risks.	Pimm, S. L., C. N. Jenkins, R. Abell, T. M. Brooks, J. L. Gittleman, L. N. Joppa, P. H. Raven, C. M. Roberts, J. O. Sexton. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science, (344): 6187. **Anthology pp:65-75**	L	1.5
TE35	Ecology of emerging diseases – Wildlife and human interactions	Bradley, C.A and S. Altizer. 2006. Urbanization and the ecology of wildlife diseases. TRENDS in Ecology and Evolution. 22(2): 95-102. **Anthology pp: 76-83**	D	1.5
TE36	The Ecology of Panamanian Ecosystems. a) Natural history and current status of biodiversity in Panama. b) Introduction to the main types of habitats. c) Academic program of the trip		L	1.0
TE37	FEX 2 Data Management and Statistical Analyses			2.0
TE38	Natural history of the Talamanca Mountain Range		O/L	1.0

No.	Title and outline	Required Readings	Type	Hours
	a) Natural History of Baru Volcano b) Biodiversity hotspots and endemism			
TE39	Topic discussion II Ecosystem change, invasiveness and ecosystem resilience	Chaffin, B. C. 2016. Biological invasions, ecological resilience and adaptive governance. Journal of Environmental Management, 1-9. **Anthology pp: 84-92**	D	1.5
TE40	Panama: strategies for sustainable development		D	1.0
TE41	DISCUSSION: Panamanian International Trip		D	1.0
TE42	Biodiversity assessment and measurement. a) Species-area relationship. b) Species richness and Evenness. c) Species accumulation curves. d) Methods and metrics to quantify biological diversity.	Chiarucci, A., G. Bacaro and S. M. Scheiner. 2011. Old and new challenges in using species diversity for assessing biodiversity. Phil. Trans. R. Soc. B, 2426-2437. **Anthology pp: 93-104**	L	2.0
TE43	The use of bioindicators and ecological trends. a) Using organisms as ecological indicators b) Attributes for a good bioindicator c) Using bioindicators for conservation d) Pros and con of bioindicators	Siddig, A. A.H. et al. 2016. How do ecologists select and use indicator species to monitor ecological change? Ecological Indicators, 60: 223-230. **Anthology pp: 105-112**	L	1.5
TE44	Final exam review	Readings, lecture notes, class notes	O	1.0
TE45	Final Exam		Exam	1.0
		Total hours		60

Reading List

*Readings are listed in the order in which they appear in the above table.

Costa Rican Natural History. 1983. Ed. Daniel H. Janzen, Univ. of Chicago Press (Available in SFS Library)

Brown, J.H. 2014. Why are there so many species in the tropics? J. Biogeography 41, 8-22.

Nadkarni, N and N.T. Wheelwright. 2000. Monteverde Ecology and conservation of a tropical cloud forest. Oxford University Press (SFS Library)

Coley, P.D & T.A. Kursar. 2014. On tropical forest and their pests. Science 343, 35-36.

Yang, L. H. and V. H. W. Rudolf. 2010. Phenology, ontogeny and the effects of climate change on the timing of species interactions. Ecology Letters, 13: 1-10.

Arévalo, J.E. & E. Blau. 2108. Road Encroachment Near Protected Areas Alters the Natural Soundscape Through Traffic Noise Pollution in Costa Rica. Revista de Ciencias Ambientales (Tropical Journal of Environmental Science), 52(1): 2215-3896.

Bradshaw, C.J.A., N.S. Sodhi, and B.W. Brook. 2009.Tropical turmoil: a biodiversity tragedy in Progress. Front Ecol Environ, 7(2): 79–87.

Bradshaw, C.J.A., N.S. Sodhi, and B.W. Brook. 2009. 79–87.

Lewis, L.S., D.P. Edwards & D. Galbraith. 2015. Increasing human dominance of tropical forests. Science, 349: 827-832.

Bradley, C.A and S. Altizer. 2006. Urbanization and the ecology of wildlife diseases. TRENDS in Ecology and Evolution. 22(2): 95-102.

Pimm, S. L., C. N. Jenkins, R. Abell, T. M. Brooks, J. L. Gittleman, L. N. Joppa, P. H. Raven, C. M. Roberts, J. O. Sexton. 2014. The biodiversity of species and their rates of extinction, distribution, and protection. Science, (344): 6187.

Chiarucci, A., G. Bacaro and S. M. Scheiner. 2011. Old and new challenges in using species diversity for assessing biodiversity. Phil. Trans. R. Soc. B, 2426-2437.

Siddig, A. A.H. et al. 2016. How do ecologists select and use indicator species to monitor ecological change? Ecological Indicators, 60: 223-230.

Chaffin, B. C. 2016. Biological invasions, ecological resilience and adaptive governance. Journal of Environmental Management, 1-9.