



S F S THE SCHOOL
FOR FIELD STUDIES

Principles of Resource Management SFS 3740

Syllabus

The School for Field Studies (SFS)
Tropical Island Biodiversity Studies (TIBS)
Bocas del Toro
Republic of Panama

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

The Principles of Resource Management (PRM) course in the Tropical Island Biodiversity Studies (TIBS) program is intended to introduce students to the various definitions and concepts that provide the tools required to understand and manage forest resources. This component of the academic program links some principles of tropical rainforest ecology with the Tropical Coastal Ecology (TCE) course as well. The PRM course covers basic principles in forest dynamics and ecology, which will set the fundamentals to understanding the ecological processes in soil productivity, nutrient recycling, cleansing of air and water, and climatic cycles. Conceptual material focuses on biodiversity, valuation of ecosystem services, water resources and management, pollution and pollution management, habitat modification, forest management for timber and non-timber forest products, terrestrial protected areas, and global climate change. Throughout the course, lecture materials and extensive field activities will present local issues in resource use, resource exploitation, and resource management, which are important to the environmental and social well-being of the Bocas del Toro region.

Learning Objectives

Following this course, students should:

1. Comprehend the basic ecological principles that are important for understanding natural resources and their management.
2. Have a working knowledge of the tools available for assessing the status of forest resources.
3. Understand how resources within the Bocas del Toro region have historically been utilized and determine which extractive processes should be monitored more closely.
4. Gain an appreciation of the importance of balancing biodiversity conservation and natural resource use for human development.

Thematic Components and Research Direction

During the semester, discussions and analyses will be framed by two major themes, each of which we will address using specific local examples.

1. **The status of natural resources important to the ecological and socioeconomic well-being of Bocas del Toro.** The Bocas del Toro Archipelago is a complex mosaic of marine and terrestrial ecosystems, hosting diverse and unique natural resources. These resources are under increasing pressure from highly varied groups of stakeholders ranging from indigenous Ngöbe villagers, to Hispanic and Afro-Antillean island residents, to wealthy expatriate immigrants from the US and Europe – each with distinct patterns of resource use and impacts on terrestrial and marine ecosystems. Students will learn resource use patterns of these different groups, and focus on what steps can be taken by each group to advance towards more sustainable patterns in resource management.
2. **Management strategies that assist in maintaining or improving sustainability of natural resources in Bocas del Toro and contribute to future economic development and diversification.** Island ecosystems are characterized by delicate and unique ecological characteristics and are often highly susceptible to anthropogenic exploitation. In the Bocas del Toro region, a long history of human pressure has resulted in major ecological changes over the past centuries that significantly impacting the socioeconomic strategies of the inhabitants. Students will explore management strategies that assist in maintaining or improving



the sustainability of natural resources in Bocas del Toro, and contribute to future economic development and diversification. Gaining an appreciation for the ecology, resource management, and socio-economics of the Bocas del Toro region should provide students with a working knowledge of the principles of biodiversity protection and familiarity with a broad range of approaches to conservation on tropical islands.

Course Assessments

Assessment Items	Value (%)
Field Journal	20
Species Inventories	15
Field Exercise	25
Mini essay	10
Mid-term Exam	15
Final Exam	15
TOTAL	100

Field Journal (20%): Throughout the semester, students will keep a field notebook, which will translate into a field journal with relevant information gathered during field lectures and field trips; important components of the field journal include characteristics of the location visited and the carried out activity. In it, students will record everything that has been found, observed, and/or collected in the field. Students will complete a journal entry for the 4 field trips assigned, **only one entry will be graded at random**; however, completion of each entry will be assigned a percentage of the final grade for the field journal. Each journal entry will address a question from the course that has relevance to the topics discussed in class. Each journal entry should be a descriptive analysis of conservation actions, illustrations, and habitat and species inventories. Specific instructions on how to keep journal will be provided at the beginning of the semester. Journal entries will be evaluated based on clarity, content, quality of writing, depth of analysis, and effectiveness of illustrations and sketches. At the beginning of the semester, feedback will be given in order to improve future entries.

Species inventories (15%): Through the semester field trips, with their respective ID workshops, will be conducted, including sampling techniques, with their specific description of the flora and fauna of two different sites in the Archipelago (Isla Solarte and Isla Colon):

1. *Plant Diversity in Neotropical Forests:* students will practice plant sampling techniques through transects and quadrats. Plants samples will be collected and transported to the Center for further identification. A Plant ID Workshop, including mounting, labeling and cataloging each new specimen will be conducted. A week after the workshop, students will hand in all plant specimens collected, mounted in a formal manner, with scientific names and a brief description of each plant. All identified specimens will be placed in a grouped plant press as future reference will become part of the Center Herbarium started since Fall 2015.
2. *Insect Sampling in Forest Systems:* students will conduct an insect sampling activity to test different insect and arthropod sampling techniques. Organisms will be sampled using passive and active methods, such as nets, traps and handmade aspirators. Following a two-hour Insect ID Workshop, students will hand in a



dichotomy key, consisting of a series of choices that will lead to the correct identification (at least to the level of Order or Family) of each insect and/or arthropod collected.

Field Exercise (25%): The field exercise will be based in a particular topic relevant to the archipelago. Poison-dart frogs are well known to possess a dramatic variation in their body coloration. A group project on the “Population Ecology of *Oophaga pumilio*” will be conducted throughout the field trips of the first five weeks of the semester. After collecting data on the frogs’ morphometric, coloration, and sex, at different sites within the Bocas del Toro Archipelago, students will hand in a written report on the population of these particular species of poison-dart frog. The written report will follow the format of a “short communication”; short communications are short papers that present original and significant material for rapid dissemination. Short Communications are limited to 2500 words and are not subdivided. Students will be provided with lectures and guidelines to provide a written report in a form of a short communication, which should consist on a comprehensive, well-written, and well- organized document. During these Field Exercise students will gain experience for field observation, data collection, and report writing.

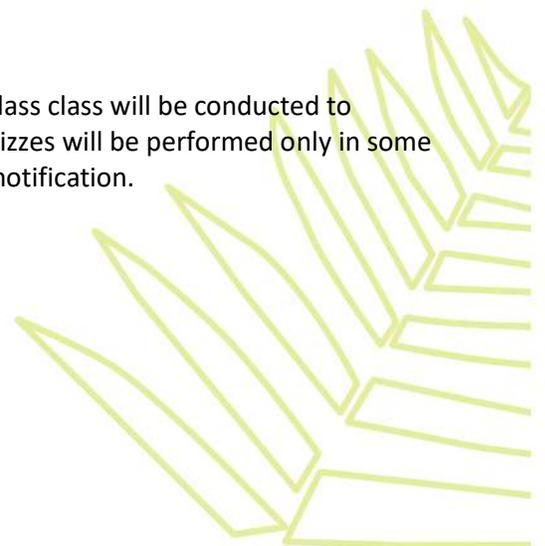
Mini essay (10%) : The purpose of this writing assignment is to practice a critical exploration of questions and issues relevant to the Bocas del Toro region. Throughout the semester, students are required to write a mini essay of up to 1000 words on a chosen topic developed to answer a specific question. Field trips will be conducted in order for the students to gather material for the mini essay. Students are required to read the materials previous to each field trip with enough detail, so that they can ask appropriate questions and participate in analytical discussions about the key issues relevant to each field trip. Topics to choose to write about:

- *Option 1: Tourism and Protected Areas:* large scale tourism vs local ecotourism. Visits to “Red Frog Island Resort & Spa”, “La Loma Jungle Lodge & Chocolate Farm” and “Tranquilo Bay Eco Adventure Lodge” on Bastimentos, should provide an insight to the type of accommodations in Bocas and how each of this lodges label themselves and behave towards the environment, and how they impact the Marine Protected Area adjacent to their facilities.
- *Option 2: Forest modification and degradation:* forest use; conventional vs. agro ecological plantations. Field trip to the District of Changuinola on the mainland to visit two different types of farms: a banana plantation in “Finca 80”, and a cacao (chocolate/multicrop) farm in Finca “La Magnita”.

Exams (30%): Two exams, a mid-term and a final, will be given based on material covered in lectures, readings, and field exercises and experiences. Each exam is worth 15% of the final grade.

Additional Items:

Quizzes: an undefined number of quizzes related to topics discussed in class will be conducted to evaluate the understanding of classroom and the field lectures. These quizzes will be performed only in some cases and at the beginning of the corresponding class, without previous notification.





Grading Scheme

A	95.00-100%	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	59.99% - 0.00%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

General Reminders

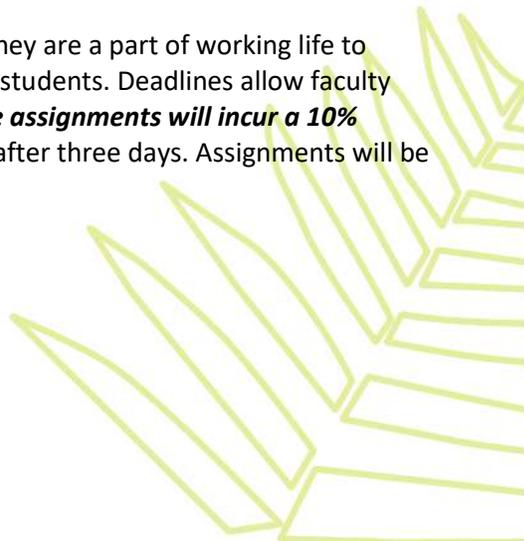
Participation and topic discussions – Active participation during classes, discussions and hikes is expected. Every student should be prepared for each academic session; these include not only lectures but field trips and field exercises. This implies reading the materials for each session with enough detail to be able to ask relevant questions; and to participate in analytical discussions about the key issues. Active participation during classes, discussions and hikes is expected.

Since SFS program is an intensive course in depth, missing even one lecture can have a proportionally greater effect on the final grade simply because there is little room to make up for lost time. Participation in all components of the program is mandatory because actions can significantly affect the learning experience. Therefore, it is important to be prompt for all activities, bring the necessary equipment for field exercises, field trips, workshops, and lab work, and simply get involved.

Readings – students are expected to have read all the assigned material prior to each class. Optional readings are to provide students with a background of each topic in class. All readings are available on PDF format. The purpose of using PDFs is to avoid printing and reduce impact on the environment and more particularly on the center's resources. ***Readings might be updated or changed during the course of the semester.*** Please, review the course outline on a regular basis.

Plagiarism – Using the ideas and material of others without giving due credit is consider cheating and will not be tolerated. A grade of zero will be assigned if students are caught cheating or aiding another person to cheat actively or passively (e.g. allowing someone to look at your exam). All assignments—unless stated by the instructor—should be original pieces of work.

Deadlines – Deadlines for 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. Deadlines allow faculty ample time to review and return assignments before others are due. ***Late assignments will incur a 10% penalty for each day that they are late.*** No assignment will be accepted after three days. Assignments will be handed back to students after a one-week grading period.



Course Content

D=Discussion, E=Exam, **FEX**=Field Exercise, **FL**=Field Lecture, **FT**=Field Trip, **FW**=Field Work, **L**=Lecture, **LW**=Laboratory Work, **W**=workshop.

No	Lecture Title and Description	Type	Time (hrs.)	Readings
PRM01	Course Intro Course structure, objectives, assignments, deadlines and evaluation.	L	0:30	
MODULE 1 – Principles of Tropical Ecology				
PRM02	Rainforest Dynamics Introduction to fundamental definitions and concepts relevant to tropical terrestrial ecology, including distribution of tropical ecosystems, drivers of biodiversity, and underlying forces at a tropical rainforest.	L	1:00	Denslow, J. S. (1987). 431-451.
PRM03	How to Keep a Field Journal Brief introduction to the relevance of keeping a field journal and some guidelines on how to keep one.	L	0:30	
PRM04	First Rainforest Walk Students will be immersed in the wonders of the rainforest for the first time and will have the opportunity to start getting familiar with keeping a field journal.	FL	1:00	
PRM05	Tropical Realm and the Rainforest Introduction to understanding that tropical rainforests are the result of how our planet hurtles through the universe.	L	1:00	Forsyth, A., & Miyata, K. (1984). <i>Chapter 1: In the Realm of the Tropics.</i>
PRM06	Rainforest walk Walk through the rainforest of Isla Solarte to observe first-hand the characteristics of this particular type of forest.	FL	1:30	
PRM07	Plant Diversity (<i>Janzen-Connell Biodiversity Hypothesis</i>) Field lecture on plant characteristics, relevance, and evolution.	L	1:00	Schupp, E. W. (1992). 526-530.
PRM08	Plant Sampling techniques Walk through the rainforest at Isla Solarte to collect plant specimens (leaves, flowers, and seeds) and taking notes in	FW	2:00	

	field journals; number and label specimens collected for further identification at the Center.			
PRM09	Mangrove Ecology Introduction to principles and fundamental definitions relevant to mangrove ecology, including local and global distribution, types and diversity of mangroves, and their ecological importance.	L	1:00	Kathiresan, K. & Bingham, B.L. (2001). 81-251.
PRM10	Mangrove exploration A walk through a mangrove island in the Bocas del Toro Archipelago to observe first-hand the characteristics of this particular type of forest and to collect data on mangrove bio-indicators.	FL	1:00	
PRM11	Plant ID Workshop Plant ID of the samples collected in Isla Solarte using resources such as books, internet and other type of means available.	W	3:00	Wright, J.S. (2002). 1-14.
PRM12	Soils and Nutrient Cycling Soil characteristics and nutrient cycling in wet tropical systems.	L	1:00	Attiwill, P.M. & Adams, M.A. (1993). 561-582.
PRM13	Soil Sampling Techniques Collect soil samples in the rainforest around the SFS Center.	FW	0:30	
PRM14	Soil Lab We will go through the soils samples previously collected and review them under the microscope to sort out some of the organisms found; as well as physicochemical characteristics of the samples.	LW	1:30	Usman, S., Muhammad, Y., & Chiroman, A. (2016).255-265.
PRM15	Epiphyte Life Introduction to fundamental concepts and definitions of epiphytes and their relevance to the rainforest, and the ecological niche.	L	1:00	Forsyth, A., & Miyata, K. (1984). <i>Chapter 4: Hangers-on.</i>
PRM16	Epiphyte Walk Walk through the rainforest at Hospital Point to identify and understand the importance of epiphytes in the rainforest. *Frog project sampling site 1 - data will be recorded on morphometries and	FL	2:00	

	coloration of the frogs present in Isla Solarte.			
PRM17	Animal Diversity 1: Insects and their kin Introduction to fundamentals regarding the insect and arthropod world in general; with special attention to the ecological role of this group and collecting techniques.	L	1:30	
PRM18	Bromeliad trail and sampling Collect bromeliad plants and measure their circumference for the Bromeliad lab exercise.	FW	2:00	
PRM19	Bromeliads as islands An exercise on the biodiversity found inside bromeliad leaves and its relation with the size-diversity theory.	L	0:30	
PRM20	Bromeliad Lab An intensive review of the items found inside the bromeliads and a discussion on the species-area relationship theory.	LW	1:30	Mogi, M. (2004). 13-22.
PRM21	ITEC Field Trip Prep Expectations and explanation of the assignments for the two-night overnight at the Institute for Tropical Ecology and Conservation (ITEC) in North Isla Colon.	L	0:30	
PRM22	Insect diversity and ID Develop Insects ID skills using different resources such as dichotomy keys. Discussion on the sampling and ID techniques, limitations and implications.	W	3:00	Gibb, T.J., & Oseto, C.Y. (2006).
PRM23	Night walk Optional night walk through the forest to observe nocturnal animals.	FL	2:00	Forsyth, A., & Miyata, K. (1984).
PRM24	Vertebrate diversity and ID: amphibians, reptiles and mammals An introduction to the ecology, behavior, and biogeography of Neotropical amphibians, reptiles, and mammals as well as the field techniques employed in their study. Vertebrates in the rainforest will be observed and identified through different observation and identification techniques. *Frog project sampling site 3 in Isla Colon.	L	2:00	Gardner, T.A., Ribeiro-Júnior, M.A., Barlow, J.O. S., Ávila-Pires, T.C.S., Hoogmoed, M.S., & Peres, C.A. (2007). 775-787.

PRM25	Island Biogeography, Diversity and Endemism Intro to key concepts in island biogeography, and illustrate major global trends in terrestrial and marine biodiversity.	GL	1:30	Brown, J.L., Maan, M.E., Cummings, M.E., & Summers, K. (2010). 891-901. Whittaker, R.J., Triantis, K.A., & Ladle, R.J. (2008). 977-994.
PRM26	Animal Diversity 2: Birds An introduction to the ecology, behavior, and biogeography of the birds of Bocas, and the field techniques employed in their study. An emphasis will be given to ecological role of this group of animals in the rainforest.	L	1:00	Bael, S.A.V., Zambrano, R., & Hall, J.S. (2013). 281-289.
PRM27	Bird Observation Bird observation and identification techniques will be put into practice.	FW	2:00	
PRM28	Review for Midterm Exam and Frog report "how and what to report"	L	1:00	
PRM29	Midterm Exam	E		
MODULE 2 – Principles of Resource Management				
PRM30	Climate Change Review of CC concepts, assessment of where the science is today, and a discussion of the implications for BLT	L	1:00	Moritz, C., & Agudo, R. (2013). 504-508. Wright, S. J., Muller-Landau, H. C., & Schipper, J. A. N. (2009). 1418-1426.
PRM31	Intro to Natural Resource Management Key concepts in natural resource management, including categories of resources, approaches to resource management, and discussion of goals for management of natural resources.	L	1:00	Rockström, J., et al (2009). 472-475.
PRM32	Protected Areas Design & Management Introduction to key concepts, types of PAs and a look at the role and effectiveness in the face of human population growth & climate change.	L	1:00	Laurance, W.F., et al. (2011). 56-67.
PRM33	Tourism and Protected Areas Prep A discussion on the implications of the forest modification and its implications of tourism surrounding a protected area.	L	0:30	
PRM34	Tourism and Protected Areas 1: "Tranquilo Bay" and "La Loma" Trip to Bastimentos Island to Red Frog Beach Resort and La Loma Eco lodge to observe and discuss the direct and indirect impacts of different kinds of tourism, and an exploration of "eco-friendly" approaches.	FL	2:00	Porter-Bolland, L., Ellis, E.A., Guariguata, M.R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). 268, 6-17.

PRM35	<p>Tourism and Protected Areas 2: “Red Frog” Trip to Bastimentos Island to visit "Tranquilo Bay" Eco Adventure Lodge facilities to observe and discuss the direct and indirect impacts of different kinds of tourism, and an exploration of “eco-friendly” approaches. Additionally, a great opportunity to do bird watch from an observation tower.</p>	FT	2:00	
PRM36	<p>Tourism and Protected Areas debrief</p>	D	0:30	
PRM37	<p>Habitat Modification, Degradation, and Fragmentation - We will discuss key concepts and major broad-scale trends in habitat modification and degradation.</p>	L	1:00	Lawton, J.H., et al. (1998). 72-76.
PRM38	<p>Introduction to Ecosystem Services Introduction to ecosystem services with a focus on habitats of Bocas del Toro to advance a working knowledge of importance and economic value of local ecosystems.</p>	L	1:00	Costanza, R., et al (1997). 253-260. Costanza, R., et al (2014). 152-158.
PRM39	<p>Changuinola Field Trip Prep Expectations and explanation of the assignments day at Finca "La Magnita" and Banana Plantation in Changuinola.</p>	L	0:30	
PRM40	<p>Changuinola Field Trip – Forest Modification and Management Trip to Changuinola District to visit a banana plantation facilities and a cacao farm.</p>	FT	3:00	Andersson, M.S., & Gradstein, S.R. (2005). 1101-1120.
PRM41	<p>Pollution and Waste Management Key concepts in pollution, linkages between terrestrial and marine environments, and management approaches in Bocas del Toro.</p>	L	1:00	Henriques, W., Jeffers, R. D., Lacher, T. E., & Kendall, R. J. (1997). 91-99.
PRM42	<p>Trip to the Dump, trash pick/ monitoring at Paki Students will have the opportunity to observe first-hand the waste management system in the island and how it has influence some environmental actions.</p>	FT	1:00	
PRM43	<p>Soil Resources and Management Explore the disconnection between soil health, nutrient cycling and human</p>	L	1:00	Barrios, E. (2007). 269-285.



	activity with particular attention to agricultural practices.			
PRM44	Water Resources and Water Management An introduction to key ecological principles of water cycling, and discussion of challenges for water management in developing nations and in tropical and island habitats.	L	1:00	Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P.,... & Davies, P.M. (2010). 555-561.
PRM45	Food Security, Agriculture & the Future of Forests – An examination of projected land-use requirements to feed the growing human population and role of agro ecological principles.	L	1:00	Foley, J.A., et al. (2011). 337-342. Godfray, H.C. J., et al. (2010). 812-818.
PRM46	Ecological and Carbon Footprint: Estimating Personal Carbon Budgets Students will estimate their own personal carbon emissions, and discuss lifestyle changes to reduce personal emissions.	W	1:00	Paterson, M., & Stripple, J. (2010). 341.
PRM47	Review for Final Exam	L	0:30	
PRM48	Final Exam	E		
PRM49	Cloud Forest – Pacific Trip (Boquete) A walk through the pipeline trail in the area of Boquete, Chiriqui offers the opportunity to observe and compare the flora and fauna of a Cloud Forest, as opposed to the rainforests already studied in a lowland evergreen rainforest in Bocas del Toro.	FL	1:00	
PRM50	Deciduous Forest – Pacific Trip (Boca Brava) The Pacific side of Panama is an occasion to compare a different type of tropical ecosystem in Panama, the deciduous forest.	FL	1:00	
	Total contact hours		60	



Reading List

- Denslow, J. S. (1987). Tropical rainforest gaps and tree species diversity. *Annual review of ecology and systematics*, 18(1), 431-451.
- Forsyth, A., & Miyata, K. (1984). Tropical Nature: Life and Death in the Rain Forests of Central and South America. Simon and Schuster - *Chapter 1: In the Realm of the Tropics*.
- Schupp, E. W. (1992). The Janzen-Connell model for tropical tree diversity: population implications and the importance of spatial scale. *The American Naturalist*, 140(3), 526-530.
- Kathiresan, K. & Bingham, B.L. (2001). Biology of Mangroves and Mangrove Ecosystems. *Advances in Marine Biology*, 40: 81-251.
- Wright, J.S. (2002). Plant diversity in tropical forests: a review of mechanisms of species coexistence. *Oecologia*, 130(1), 1-14.
- Attiwill, P.M. & Adams, M.A. (1993). Tansley Review No. 50. Nutrient cycling in forests. *New Phytologist*, 124 (4): 561-582.
- Usman, S., Muhammad, Y., & Chiroman, A. (2016). Roles of soil biota and biodiversity in soil environment—A concise communication. *Eurasian Journal of Soil Science*, 5(4), 255-265.
- Forsyth, A., & Miyata, K. (1984). Tropical Nature: Life and Death in the Rain Forests of Central and South America. Simon and Schuster – *Chapter 4: Hangers-on*.
- Mogi, M. (2004). Phytotelmata: hidden freshwater habitats supporting unique faunas. *Freshwater invertebrates of the Malaysian region. Kuala Lumpur, Malaysia: Academy of Sciences Malaysia*, 13-22.
- Gibb, T.J., & Oseto, C.Y. (2006). *Arthropod collection and identification: field and laboratory techniques*. Academic Press.
- Forsyth, A., & Miyata, K. (1984). Tropical Nature: Life and Death in the Rain Forests of Central and South America. Simon and Schuster – *Chapter 15: Night walks*.
- Gardner, T.A., Ribeiro-Júnior, M.A., Barlow, J.O. S., Ávila-Pires, T.C.S., Hoogmoed, M.S., & Peres, C.A. (2007). The value of primary, secondary, and plantation forests for a Neotropical herpetofauna. *Conservation biology*, 21(3), 775-787.
- Brown, J.L., Maan, M.E., Cummings, M.E., & Summers, K. (2010). Evidence for selection on coloration in a Panamanian poison frog: a coalescent-based approach. *Journal of Biogeography*, 37(5), 891-901.
- Whittaker, R.J., Triantis, K.A., & Ladle, R.J. (2008). A general dynamic theory of oceanic island biogeography. *Journal of Biogeography*, 35(6), 977-994.
- Bael, S.A.V., Zambrano, R., & Hall, J.S. (2013). Bird communities in forested and human-modified landscapes of Central Panama: a baseline survey for a native species reforestation treatment. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 9(4), 281-289.
- Moritz, C., & Agudo, R. (2013). The future of species under climate change: resilience or decline? *Science*, 341(6145), 504-508.

- Wright, S. J., Muller-Landau, H. C., & Schipper, J. A. N. (2009). The future of tropical species on a warmer planet. *Conservation biology*, 23(6), 1418-1426.
- Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., ... & Foley, J.A. (2009). A safe operating space for humanity. *Nature*, 461(7263), 472-475.
- Laurance, W.F., Camargo, J.L., Luizão, R.C., Laurance, S.G., Pimm, S.L., Bruna, E.M., ... & Van Houtan, K.S. (2011). The fate of Amazonian forest fragments: a 32-year investigation. *Biological Conservation*, 144(1), 56-67.
- Porter-Bolland, L., Ellis, E.A., Guariguata, M.R., Ruiz-Mallén, I., Negrete-Yankelevich, S., & Reyes-García, V. (2012). Community managed forests and forest protected areas: An assessment of their conservation effectiveness across the tropics. *Forest Ecology and Management*, 268, 6-17.
- Lawton, J.H., Bignell, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., & Watt, A.D. (1998). Biodiversity inventories, indicator taxa and effects of habitat modification in tropical forest. *Nature*, 391(6662), 72-76.
- Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., ... & Raskin, R.G. (1997). The value of the world's ecosystem services and natural capital. *Nature*, 387(6630), 253-260.
- Costanza, R., de Groot, R., Sutton, P., van der Ploeg, S., Anderson, S.J., Kubiszewski, I., ... & Turner, R.K. (2014). Changes in the global value of ecosystem services. *Global environmental change*, 26, 152-158.
- Andersson, M.S., & Gradstein, S.R. (2005). Impact of management intensity on non-vascular epiphyte diversity in cacao plantations in western Ecuador. *Biodiversity and Conservation*, 14, 1101-1120.
- Henriques, W., Jeffers, R. D., Lacher, T. E., & Kendall, R. J. (1997). Agrochemical use on banana plantations in Latin America: perspectives on ecological risk. *Environmental toxicology and chemistry*, 16(1), 91-99
- Barrios, E. (2007). Soil biota, ecosystem services and land productivity. *Ecological economics*, 64(2), 269-285.
- Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P.,... & Davies, P.M. (2010). Global threats to human water security and river biodiversity. *Nature*, 467(7315), 555-561.
- Foley, J.A., Ramankutty, N., Brauman, K.A., Cassidy, E.S., Gerber, J.S., Johnston, M., ... & Zaks, D.P. (2011). Solutions for a cultivated planet. *Nature*, 478(7369), 337-342.
- Godfray, H.C. J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F.,... & Toulmin, C. (2010). Food security: the challenge of feeding 9 billion people
- Paterson, M., & Stripple, J. (2010). My space: governing individuals' carbon emissions. *Environment and planning. D, Society and space*, 28(2), 341.