Tropical Ecology and Conservation (WFC 125)

Lecture Location & Time: REMOTE; 12:10-1:30p, Monday/Wednesday
Section Locations & Times: A01- REMOTE, Thursday 2:10-3:00pm;
A02- REMOTE, Thursday 3:10-4:00pm; A03- REMOTE, Friday 3:10-4:00pm

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Include WFC 125 in subject line

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Reading Materials:

1. **Academic articles**, Available through the course website
2. **Optional text,** Tropical Ecology, John Kricher

Purpose:

The tropics house the vast majority of Earth's species and its cultural diversity, but the region also suffers from increasing environmental degradation and rampant poverty. Indeed, the tropics are the only zone to exhibit a trend of accelerating deforestation, driven by rapid rates of agricultural expansion and intensification. Similarly, warming and acidifying oceans are causing vast swaths of coral reefs to bleach, dissolve, and die. Beyond the dire implications for global biodiversity, these environmental changes are also eroding Earth's life-support systems, compromising the health and wellbeing of local people. And yet, there is still reason for hope. The world's governments have committed to major forest and reef conservation and restoration initiatives. And scientists are developing strategies to inform these efforts, seeking interventions that would enhance conservation and human wellbeing simultaneously.

WFC 125 is intended to (1) introduce students to the ecology and natural history of the tropics, including the similarities and differences with biomes in temperate latitudes; (2) explore the challenges and opportunities associated with pursuing tropical conservation; and (3) empower students to design, implement, and communicate their own individually-driven research projects. In doing so, WFC 125 will help students understand and develop useful skills for the modern tropical conservation scientist. Specifically, students will learn basic science literacy (*e.g.,* by reading, discussing, and critiquing scientific articles), how to develop and answer novel scientific questions, how to collaborate in groups, and how to clearly communicate their findings.

Learning Objectives:

1. Be able to compare and contrast the ecology of tropical versus temperate regions.
2. Express the challenges and opportunities associated with tropical conservation.
3. Effectively critique cutting-edge studies in tropical ecology and conservation.
4. Apply the scientific method to answer an original question by developing and implementing a student-driven research project.
5. Work effectively in groups, leveraging your fellow students' skills and interests to produce novel scientific findings.
6. Demonstrate effective science communication through oral presentations and a research report, modeled after academic papers.

Assessment (Overview)

WFC 125 is organized into a twice weekly lecture and a once-a-week section. Lectures will focus on the theoretical basis of tropical ecology and conservation; sections will concentrate on applying knowledge in debates, activities, and through the student-led research project. Before each lecture, Prof. Karp will assign 1-2 scientific articles to be discussed in class. Lectures will roughly follow the textbook, Tropical Ecology by John Kricher. Reading this textbook may improve understanding but is **optional**— students will only be required to learn material covered in lectures, sections, or assigned scientific articles. Grades will be assigned as follows:

Assessment	**Value**	**Due date**
Questions and hypotheses	5%	10/16/2020
Database creation AND reflection	10%	10/30/2020
Midterm exam	20%	11/2/2020
Annotated bibliography	10%	11/18/2020
Research presentation	15%	12/7/2020 or 12/9/2020
Research report AND reflection	15%	12/11/2020
Final exam	25%	12/15/2020, 6:00-8:00pm

Late Policy: Students will lose 10% each day that an assignment is late. Canvas will lock out submissions immediately at 11:59pm the day an assignment is due. If an assignment is late, email it as soon as it is finished to both Prof. Karp and TA Lauck. Any assignment that is not submitted by 11:59pm the day an assignment is due will be considered late. If canvas malfunctions, assignments can be emailed to Prof. Karp and TA Lauck and still receive full credit (provided that the email is time stamped before the due date).

Tentative Schedule (Readings, topics, and timings subject to change)

WEEK 1

Lecture 1 (9/30/2020): Introduction to the tropics

- Readings: Barlow *et al.* (2018) *Nature*.
- In class activities: None- introductory class and lecture.
- Learning Objectives: (I) Understand the course structure and assignments; (II) articulate how climate structures tropical biomes

Section 1: Reading and critiquing scientific literature

- Learning Objectives: (I) understand how academic articles are structured; (II) learn to search for pertinent articles; (III) actively critique published literature

WEEK 2

Lecture 2 (10/5/2020): Biogeography and evolution of the tropics

- Readings*:* (I) Haffer (1969) *Science.* (II) Knapp and Mallet (2003) *Science*. (III) Garzón-Orduña *et al.* (2014) *Journal of Biogeography*.
- In class activities: Discussion and debate of the "refugium hypothesis"
- Learning Objectives: (I) Articulate different modes of dispersal for explaining tropical species distributions and how plate tectonics fits in; (II) Explain how to tell when traits are or were adaptive; (III) Spell out the different modes of tropical speciation

Lecture 3 (10/7/2020): Tropical biodiversity 1: the latitudinal diversity gradient

- Readings: (I) Schemski et al (2009) *Annual Review in Ecology, Evolution, and Systematics*. (II) Weins and Donoghue (2004) *Trends in Ecology and Evolution.* Feel free to skim the beginning and dig in to pages 642-643.
- In class activities: (I) Calculating diversity at multiple scales, (II) Designing an experiment to

understand the drivers of the latitudinal diversity gradient
- Learning Objectives: (I) Characterize the latitudinal diversity gradient, (II) Compare and contrast different explanations for the gradients, arguing for their merits based on the underlying evidence

Section 2: Formulating questions and hypotheses
- Learning Objectives: (I) learn to pose a testable hypothesis and compare against null expectations; (II) collaboratively develop novel questions for group-based research topics

WEEK 3

Lecture 4 (10/12/2020): Guest Lecture: Alejandra Echeverri
- Readings*:* (I) Echeverri *et al*. (2019) *People and Nature.*
- In class activity: Following the guest lecture and discussion, students will assemble into their research groups and be given dedicated time to make progress on their research projects. Dr. Karp and TA Lauck will spend time with each group to help refine hypotheses and discuss ideas for data analysis.
- Learning Objectives: (I) Differentiate between cultural services; (II) Articulate strategies for measuring cultural services in Neotropical birds; (III) Make concrete hypotheses about how avian traits should relate to bird-mediated cultural services; (IV) As a research group, come up with a rough plan for future data collection and analysis

Lecture 5 (10/14/2020): Tropical biodiversity 2: maintaining biodiversity
- Readings*:* (I) Wright (2002) *Oecologia*. (II) Mangan *et al.* (2010) *Nature*.
- In class activity: (I) Unpacking and critiquing a scientific article focused on diversity maintenance in the tropics
- Learning Objectives: (I) Articulate the different hypotheses for how such high tropical diversity can be maintained, (II) Discuss the evidence for and against Neutral Theory, (III) Apply Island Biogeography to tropical systems, (IV) Learn how to design experiments to test theories of diversity maintenance

Section 3: Finding and collecting data
- Learning Objectives: (I) learn to collect data from trip itineraries; (II) understand quality control and how to collaboratively build a large database; (III) learn how to document metadata

WEEK 4

Lecture 6 (10/19/2020): Tropical rainforests
- Readings: (I) Hooper *et al.* (2005) *Journal of Applied Ecology.* (II) Watch Planet Earth II-Rainforests episode (either on Netflix or $2 on Amazon Video).
- In class activity: (I) Strategizing forest restoration in the context of tropical forest succession; (II) Discussion about Planet Earth II video.
- Learning Objectives: (I) Learn about basic natural history of tropical flora, (II) Explore the structure of a tropical forest, (III) Articulate alternate theories for tropical forest succession

Lecture 7 (10/21/2020): Tropical dry forests and savannahs
- Readings*:* (I) DRYFLOR (2016) *Science*, (II) Kartinzel *et al*. (2015) *PNAS*, (III) Watch this video: https://www.youtube.com/watch?time_continue=476&v=8eH6X2rAQEs
- In class activity: (I) Niche partitioning and species coexistence on the African savanna
- Learning Objectives: (I) Articulate the key forces that determine the existence of savannas vs. dry forests, (II) Learn to collect data that explains how African herbivores are able to coexist, (III) Appreciate the cascading effects of African megafauna on savanna ecosystems

Section 4: Forest conservation in the Congo— role play activity

- Learning Objectives: (I) gain awareness of cultural and personal motivations; (II) engage in thoughtful debate; (III) appreciate the complexities of navigating conservation decisions

WEEK 5

Lecture 8 (10/26/2020): From rivers to reefs

- Readings: (I) Castello *et al.* (2013) *Conservation Letters*; (II) Hughes *et al.* (2017) *Nature*; (III) Mumby *et al.* (2004) *Nature*
- In class activities: (I) Dissecting Mumby *et al.* (2004) and proposing follow-up experiments; (II) Managing coral reefs in the Anthropocene
- Learning Objectives: (I) Understand the patterns and drivers of diversity in tropical aquatic systems; (II) Articulate the major threats to freshwater and coral ecosystems; (III) Learn about the unique adaptions that fish, mangroves, and corals exhibit

Lecture 9 (10/28/2020): Soils and nutrient cycling

- Readings*:* (I) Cleveland *et al.* (2011) *Ecology Letters*; (II) Turner *et al.* (2018) *Nature*; (III) Dance (2008) *Nature.*
- In class activity: Comparing approaches for studying Phosphorous limitation in rainforests
- Learning Objectives: (I) Understand how nutrients cycle through the tropics and limit productivity; (II) Articulate why tropical soils are nutrient poor; (III) Learn about the key players in soil formation, decomposition, and nutrient cycling

Section 5: Midterm review session

- Learning Objectives: (I) solidify understanding of tropical ecology; (II) compare the ecology of different tropical biomes; (III) explain the evolution and maintenance of tropical diversity

WEEK 6

MIDTERM 1 (11/2/2020)

Lecture 10 (11/4/2020): Mutualism

- Readings: (I) Palmer *et al.* (2008) *Science*; (II) Wandrag *et al.* (2017) *PNAS*
- In class activity: Defining species interactions
- Learning Objectives: (I) Relate coevolution to mutualism; (II) Articulate how mutualisms break down and the ensuing consequences; (III) Appreciate the rich natural history of tropical mutualism

Section 6: Basic data analysis

- Learning Objectives: (I) differentiate between dependent and independent variables; (II) Implement basic linear regression and ANOVA; (III) explain how pseudoreplication and normality could influence statistical results

WEEK 7

Lecture 11 (11/9/2020): Predation and trophic cascades

- Reading*:* Hughes (1994) *Science*
- In class activity: Trophic cascades interactive exercise
- Learning Objectives: (I) Understand how color is used as a defense in the tropics; (II) Differentiate between plant defenses; (III) Create diagrams depicting how species losses can reverberate through ecosystems

Veteran's Day Holiday (11/11/2020): No class

Section 7: Making figures

- Learning Objectives: (I) learn how to interpret various types of graphs; (II) create a figure using real data to clearly depict a statistical analysis

WEEK 8

Lecture 12 (11/16/2020): Indigenous people in the tropics

- Readings: Drew *et al.* (2005) *Conservation Biology*; Roberts *et al.* (2017) *Nature Plants*
- Activities: Discussion about (1) whether tropical forests are 'pristine' and why it matters and (2) the role of traditional ecological knowledge in conservation
- Learning Objectives: (I) Understand historical and current impacts of local peoples on tropical ecosystems, (II) Discuss how local ecological knowledge can be harnessed

Lecture 12 (11/18/2020): Deforestation and fragmentation

- Readings*:* Haddad *et al.* (2015) *Science Advances*; Vellend *et al.* (2013) *PNAS*; Newbold *et al.* (2015) *Nature.*
- Activities: (1) Debate about local diversity loss; (2) Video discussion on seed dispersal; (3) Conserving forest in fragmented landscapes.
- Learning Objectives: (I) Understand how habitat loss affects species diversity and community composition at multiple scales; (II) Critically evaluate the relative importance of forest loss versus fragmentation.

Section 8: How to communicate science to scientists

- Learning Objectives: (I) clearly articulate the building blocks of scientific papers and posters; (II) understand how to use visuals to attract and maintain attention

WEEK 9

Lecture 14 (11/23/2020): Managing tropical forests

- Readings*:* Karp *et al.* (In Review) *JAE*; Betts *et al.* (2017) *Nature;* Watson *et al.* (2014) *Nature.*
- Activities: (I) Restoration and forest monitoring videos; (II) Protected area prioritization discussion; (III) Restoration priorities
- Learning Objectives: (I) Understand opportunities and pitfalls associated with tropical protected areas; (II) Articulate tradeoffs involved in pursuing conservation on private lands; (III) Debate the merits of active versus passive restoration

Lecture 15 (11/25/2020): Climate change in the tropics

- Readings: Deutsch *et al.* (2008) *PNAS*; Feeley *et al.* (2017) *Diversity and Distribution*; Jones *et al.* (2012) *Nature Climate Change.*
- Activities: (I) Comparing climate sensitivity of tropical versus temperate species; (II) Brainstorm on ecosystem-based climate adaptation
- Learning Objectives: (I) Appreciate the unique impacts and threats that climate change poses to tropical ecosystems; (II) Understand the theory underlying why tropical species may be more or less sensitive to climate change; (III) Differentiate between when forests act as carbon sources versus sinks

Thanksgiving break: no section

WEEK 10

Lecture 16 (11/30/2020): Overhunting and overharvest

- Readings: Redford (1992) *BioScience*; Benítez-López *et al.* (2017) *Science.*
- Activities: (I) How to estimate hunting pressure; (II) Discussion of defaunation science, then and now; (III) Debate about whether trophy hunting and conservation are compatible
- Learning Objectives: (I) Articulate the key drivers of overhunting and overfishing; (II) Learn about the direct and cascading impacts; (III) Critically evaluate different defaunation mitigation strategies

Lecture 17 (12/2/2020): International conservation policy.

- Readings: Prathapan *et al*. (2018) *Science;* IPBES (2018) Americas Regional Assessment.
- Activities: (I) Discussion about the merits of the Nagoya protocol; (II) Essential Biodiversity Variable exercise; (III) Utility of regional IPBES assessments
- Learning Objectives: (I) articulate strategies for solving cross-border conservation problems; (II) learn about key players in the international conservation science/policy landscape

Section 9: The Matrix Matters- in class activity

- Learning Objectives: (I) learn how to evaluate, test, and differentiate among multiple hypotheses; (II) interpret scientific results and graphs

WEEK 11

Lecture 18 (12/7/2020): Research symposium, Day 1

Lecture 19 (12/9/2020): Research symposium, Day 2

Section 10: Final review session

- Learning Objectives: (I) solidify understanding of tropical ecology and conservation; (II) appreciate the conservation challenges facing tropical biomes; (III) clearly articulate win-win solutions for enhancing tropical diversity and rural livelihoods

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Course-based Research Project:
What traits do bird-watching tourists value in Neotropical birds?

Beyond the essential goods and services that directly support human livelihoods, nature also provides us with many intangible benefits that enrich our lives. People around the world spend vast sums of money every year to interact with nature and biodiversity in zoos, in protected areas, and in their backyards. For example, nearly 15 years ago, researchers estimated that 50 million people spent >$30 billion per year in the United States alone on birdwatching related activities. Indeed, nature-based tourism industries have grown to encompass substantial fractions of some countries' economies, especially in tropical countries like Costa Rica. Beyond providing joy and inspiration to millions of people worldwide, responsible nature-based tourism can also result in remarkable conservation gains. In Peru, for example, researchers showed nature-based tourism was far-and-away the most profitable use of tropical rainforest land, much more so than replacing forests with mining, timber, or industrial agricultural operations. Thus, when designed responsibly, incentivizing nature-based tourism can represent a win-win for rural communities and local wildlife.

Unfortunately, however, climate change, deforestation, and other global environmental changes now threaten many of the species that drive nature-based tourism industries. Protecting these species is critical for ensuring that nature-based tourism lodges and nature reserves are not replaced with mines, farms, or other land uses. But what makes one species more desired by tourists over another? Are there key traits (*i.e.,* species characteristics) that most tourists value in wildlife over others? For example, do they tend to prefer more colorful, larger, or endemic wildlife? Do they prefer at-risk species, meaning that biodiversity loss may rapidly degrade nature-based tourism industries? Or are preferred species resilient, meaning nature-based tourism industries may be as well?

By determining which species tourists value most, and which characteristics they tend to share, biologists could help prioritize conservation efforts to ensure nature-based tourism continues to bring joy to tourists, which simultaneously incentivizing conservation and sustaining local livelihoods. One approach is to look to the experts— the nature-based tourism guides and tour companies— to determine which species elicit the most joy in their customers. To capture prospective customer's imaginations and spur them to travel, tour companies often post detailed

trip itineraries, complete with descriptions of the locations that their customers would visit and the wildlife that they may encounter. For the advertising to be effective, it would be expected that the most desired species would be highlighted, and the disliked species would be ignored.

In WFC 125, students will be charged with building a new database of the tourism value associated with different Costa Rican bird species by visiting birdwatching tour company websites and noting how many times each Costa Rican bird species appears in advertised travel itineraries. By quantifying the fraction of trip itineraries in which each species is mentioned, students will be able to develop an index of the value of each species to birdwatching tourists. With this database in tow, students will divided be into groups of ~5 and asked to develop original research questions surrounding what traits birdwatching tourists value in Costa Rican birds. Groups will generate a multitude of hypotheses. Two examples are:

1. Birdwatching tourists tend to prefer species that are more colorful and larger.
2. 9)

Each group will work with Prof. Karp and the TA to narrow down their study to 1-2 research questions and associated hypotheses. Then, students will be provided with an extensive database of traits related to the appearance, vocalizations, behaviors, diet, conservation, and life-history of species in the Guanacaste region of Northwest Costa Rica (where Prof. Karp works) as well as a more limited dataset for all the species that occur throughout the country. It is possible that testing a group's hypothesis may require collecting more data. If this is the case, Prof. Karp and the TA will help groups find data sources to answer their question. Once the datasets are assembled, students will be trained in basic statistical techniques and asked to analyze their data and produce figures depicting their results. Each student will also be asked to produce a short, annotated bibliography summarizing at least 5 scientific papers that are relevant to their research question. Then, each group will write a research report and design a 12-minute Powerpoint presentation to communicate their work and findings. The last two class lectures will be dedicated to the presentations.

Working as a team is essential in science but can be difficult if some team members monopolize the work and/or others do not contribute adequately. Importantly, people vary in work strategies which can also lead to conflict. Students will be asked to write a 2-paragraph reflection midway through the project to identify any sources of conflict within the group and discuss how they have/plan to contribute looking forward. These reflections will be graded and can influence others' grades. They will also be used so that Prof. Karp and the TA can facilitate constructive conversations about group dynamics and conflict resolution looking forward. Along with the group research report, students will also turn in a final 2 paragraph reflection that both outlines their contributions to the project and discusses group dynamics. This reflection will also influence grading. See detailed instructions for each step of this assignment on the separate assignment document.

Assessment Description

Questions and hypotheses: In section 2, students will learn how to develop research questions and hypothesis. Students will be divided into groups of ~5, and asked to outline at least **THREE** novel research questions (and associated hypotheses) that could potentially guide their student driven-research projects.

Database creation: In section three, students will learn how to collect data from birdwatching trip itineraries and enter it into a course database. Then, each student will be assigned different birdwatching tour websites, tasked with collecting associated data, and asked to turn in a standardized Excel form with their data entered. Along with a completed dataset, each individual will write a TWO PARAGRAPH reflection about how their research group has functioned to

date. The first paragraphs will constitute a self-reflection, discussing what the student has contributed to the team and how he/she plans to participate looking forward. The second paragraph will be a candid discussion of team dynamics. This will be confidential and represents a space for students to discuss whether or not any project members have been failing to pull their weight or are monopolizing the research process.

Grades for database creation will be assigned based on individual work related to creating the class database (2/3 of the grade) and the reflection (1/3 of the grade). Note: Dr. Karp and the TA reserve the right to change a student's group work grade if reflections from other group-members indicate that the student has not meaningfully contributed to the group.

Midterm exam: An exam will be administered midway through the course. The midterm will cover all lectures and readings up to and including lecture 9 (soils and nutrient cycling).

Annotated bibliography: Each student will be asked to search the literature and identify **FIVE** scientific papers that are relevant to their group's research project. Students will need to coordinate with their group members such that no two students review the same article. The papers are allowed to contribute to background information and be broadly related to the topic. Each student will then compose a short, annotated bibliography that contains: (i) the full citation for each journal article, (ii) a 3 sentence summary of each article detailing the research question, the main method of analysis, and the core finding, and (iii) a short, ~3 sentence description of how the article is relevant to their research project.

Research report: Each group will be asked to turn in a research report (maximum 6 pages, single spaced, 12pt font, 1 inch margins). Reports will include the following sections:

- Abstract: A one paragraph overview of the study, methods, core findings, and implications.
- Introduction: This section will set the work in context and provide relevant background. Students will draw heavily on their annotated bibliographies, including at least **15** citations of peer-reviewed manuscripts. The section will end with a few sentences outlining the core research question and predictions that guided each group's work
- Methods: Students will thoroughly outline their approach for compiling and analyzing their data. The methods should be written with sufficient detail such that another scientist could easily replicate their work.
- Results: This section will contain declarative statements about the core findings, with relevant statistics to back up their claims. At least two graphs will be included in this section, alongside descriptive captions.
- Discussion: The report will end with a short discussion of the implications of the students' work. The students will set their work in the context of the broader literature, citing at least **10** peer-reviewed publications.

Each individual will also submit another TWO PARAGRAPH reflection. As before, the first paragraph will constitute a self-reflection, discussing what the student has contributed to the team and to the project. The second paragraph will again focus on group dynamics and provide space for students to discuss whether any team member did not sufficiently contribute to the team. Grades will be assigned based on the research report (3/4 of the grade) and the reflection (1/4 of the grade). If it is apparent that a student did not sufficiently contribute to the team, his or her grade may be adjusted.

Oral presentation: In addition to the research report, each group will prepare a 12 minute oral presentation to be delivered during the in-class research symposium. The same sections will be included as in the research report (abstract, introduction, methods, results, and discussion);

Final exam: The final exam will cover all course lectures and readings but emphasize the lectures and readings not covered in the first midterm.