Fall 2025

ESM 240 – Climate Change Biology

Tuesdays and Thursdays, 12:30-1:45 PM, Bren 1424

Instructors: Lee Hannah, Patrick Roehrdanz, Dr. Isaac Brito-Morales, Dylan Glave

Week 1 (Week of 9/29-10/3)

- Session 1 (Lee) Course Overview
    - Assignments, grading, reading
    - Grand Challenges: Species moving, Production system change, Renewable energy land needs, Geoengineering
    - Evolution of the Field: 1st WWF meeting to present
    - Core Concepts – 10 Things I Hate about Climate Change, 1-5
    - ***Recommended Reading: Chapters 2,6,12***

- Session 2 (Lee):
    - 10 Things I Hate about Climate Change 6-10
    - How do we measure species movement?
    - Extinction risk
    - Biogeography of species movement
    - Designing Conservation for species on the move
    - Next up: Land and Ocean Conservation Issues
    - ***Recommended Reading: Chapters 9, 10***

Week 2 (10/6-10/10)

- Session 3 (*Patrick)*: Terrestrial Concepts
    - Biodiversity data
    - Mapping biodiversity
    - Forecasting species responses
    - Spatial planning for species under climate change
    - Spatial planning for both species conservation and production
    - ***Chapters 14, 17***
- Session 4 (*Patrick)*: Applied Problems (graded assignment)

- Species distribution modeling with ‘Wallace’

Week 3 (10/13-10/17)

- Session 5 (*Isaac)*: **Climate-smart conservation in a warming ocean**

This session will explore a central question in marine ecology: how can climate change be included in conservation science, especially considering the three-dimensional nature of the ocean? We will be covering three main topics in climate-change conservation:

- How climate change can inform conservation actions
- How climate change varies across ocean depth layers, posing a challenge for marine conservation
- How can we build conservation plans that consider the 3D nature of the ocean and the impacts of climate change
- ***Recommended Reading: Chapters 8, 10***

- Session 6 (*Isaac):* **Hands-on session:** In the previous discussion, we explored different challenges in marine climate-change conservation. Now, it's time to roll up our sleeves and explore “some” potential solutions/approaches. During this session, we'll engage in interactive activities and exercises that bring to life the concepts we've discussed above. Recommended Reading: Chapters 8, 10
    - Understanding ocean climate models: learn to how to work with ocean models, and applications in conservation research
    - Data extraction: learn the art of processing ocean climate models to extract relevant information
    - Climate-Smart conservation: we'll cover the fundamental principles of climate-smart conservation science with real-world examples in marine conservation.

Week 4 (10/20-10/24)

- Session 7 (*Dylan)* Managing Climate Change
    - Social Ecological Systems
    - Natural Climate Solutions
    - Science and Implementation

- ***Recommended Reading: Chapter 18***

- Session 8 (*Dylan)* In-class analysis and presentation (graded assignment)

Week 5 (10/27-10/31)

- Session 9 (Lee): Global Policy
  - IPCC, Climate Policy, Emissions trajectories and controls, overshoot
  - ***Recommended Reading: Chapters 20, 21***
- Session 10 (Lee): Biodiversity adaptation, funding
  - Green Climate Fund, Tension between NCS and Biodiversity + adaptation and human adaptation.
  - What are students impressions of these 5 big challenges?
  - Where is this heading? Group discussion with faculty

Course Themes and Key Concepts

Grand Challenges of Climate Change Biology

- Species on the move
- Human production on the move
- Renewable energy land use
- Geoengineering land use

Core Concepts – '10 Things I Hate about Climate Change'

1. Species are happiest right next to where they are dead
2. Species movements to track climate are individualistic
3. Novel and Disappearing Climates
4. Velocity of climate change
5. Reid's Paradox - Dispersal limits to range shifts
6. Connectivity and Refugia - its not what you think!
7. Niche Filling in the ocean and on land
8. Emergence of extremes
9. Climate Policy
10. Biological consequences of Overshoot

Grading

2 hands-on skill assignments – 66%

1 in-class presentation – 33%

Random acts of kindness – 1%

Reading

Climate Change Biology (Hannah/Academic Press) 3rd edition (be **sure** it's 3rd edition!)

See notes in weekly class schedule above for chapter reading order

Weekly Detail and Supplemental Readings

Week 2

Climate Smart Spatial Planning for Terrestrial Systems

Patrick Roehrdanz – Director, Climate Change and Biodiversity, Conservation International

Session 3: Climate-smart spatial planning (terrestrial)

Theory & Practice: Demonstration of principles and lessons learned through the SPARC project (www.sparc-website.org)

- Principles of climate-smart spatial planning
    - Justification and theory of change
    - Taxonomy of approaches
        - Focus on refugia
        - Conserving the stage
        - Dynamic spatial prioritization
- Data inputs and modelling
    - Climate exposure metrics (abiotic)
    - Species exposure metrics/range projections
    - Ecosystem-level projections
- Tools and methods
    - Systematic conservation planning (e.g. Marxan/Zonation)
    - Network flow
    - Multi-objective optimization

Suggested Reading:

Hannah, L., Roehrdanz, P.R., Marquet, P.A., Enquist, B.J., Midgley, G., Foden, W., Lovett, J.C., Corlett, R.T., Corcoran, D., Butchart, S.H.M., Boyle, B., Feng, X., Maitner, B., Fajardo, J., McGill, B.J., Merow, C., Morueta-Holme, N., Newman, E.A., Park, D.S., Raes, N. and Svenning, J.-C. (2020), 30% land conservation and climate action reduces tropical extinction risk by more than 50%. Ecography, 43: 943-953. https://doi.org/10.1111/ecog.05166

Jung, M., Arnell, A., de Lamo, X. et al. Areas of global importance for conserving terrestrial biodiversity, carbon and water. Nat Ecol Evol 5, 1499–1509 (2021). https://doi.org/10.1038/s41559-021-01528-7

Session 4: Biodiversity Data and Species Modelling

Theory

- Introduction to sources of biodiversity spatial data
    - IUCN Red List Range Data
    - GBIF
    - eBird
    - BIEN
- Overview of Species Distribution Modelling Methods

Practice

- Hands on walkthrough of creating a species distribution model and projection under climate change using the Wallace open source platform: https://wallaceecomod.github.io/

Suggested Reading:

Kass, J.M., Vilela, B., Aiello-Lammens, M.E., Muscarella, R., Merow, C., Anderson, R.P. (2018). Wallace: A flexible platform for reproducible modeling of species niches and distributions built for community expansion. Methods in Ecology and Evolution, 9(4),1151-1156. https://doi.org/10.1111/2041-210X.12945

Maitner, BS, Boyle, B, Casler, N, et al. The bien r package: A tool to access the Botanical Information and Ecology Network (BIEN) Database. Methods Ecol Evol. 2018; 9: 373–379. https://doi.org/10.1111/2041-210X.12861

Week 3

Climate-smart conservation in a warming ocean

Dr Isaac Brito-Morales

Session 5: Climate-smart conservation in a warming ocean

Species are rapidly shifting poleward as the climate warms, which represents a key challenge in ocean conservation. In the ocean, the impacts of climate change on species' movement have generally been evaluated near the surface, which could be important for species that live in the epipelagic zone (<200 m), but they have been largely ignored in the mesopelagic and bathypelagic zones (below 200 m). Predicting the distribution shift of thousands of species is challenging, too. This session will explore a central question in marine ecology: how can climate change be included in conservation science, especially considering the three-dimensional nature of the ocean? We will be covering three main topics in climate-change conservation: 1) how climate change can inform conservation actions; 2) how climate change varies across ocean depths layers, posing a challenge for marine conservation; and 3) how can we build conservation plans that consider the 3D nature of the ocean and the impacts of climate change. Given that the "blue acceleration" – a race among diverse and competing interests for ocean food, material, and space – is threatening marine systems, this session will help to advance climate-smart conservation science.

Session 6: Hands-on session

In the previous discussion, we explored different challenges in marine climate-change conservation. Now, it's time to roll up our sleeves and explore "some" potential solutions/approaches. During this session, we'll engage in interactive activities and exercises that bring to life the concepts we've discussed above.

Throughout this session, we will focus on:

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- Data extraction: learn the art of processing ocean climate models to extract relevant information
- Climate-Smart conservation: we'll cover the fundamental principles of climate-smart conservation science with real-world examples in marine conservation.