Ecological Diversity and Climate Change[1]

1:25 – 2:40 TTh, 156 LSRC

James S Clark, Professor, Nicholas School of the Environment (jimclark@duke.edu)

Kira Meyer, PhD student, Nicholas School of the Environment (kira.meyer@duke.edu) ; office hours: Friday 2 – 4 pm, A312 LSRC

Disabilities: If you are registered with Duke's Student Disability Access Office and require accommodation in this class, contact me by email.

Student blog from 2023

Student video, 2024

In this course, we evaluate the science of biodiversity and climate change, including changes happening now, in the past, and what we can expect in the future. The issues are focused by three contrasting case studies, including the field trip to Kruger National Park (KNP), S Africa during spring break. Topics include the origins of biodiversity, what maintains it, what's ahead. Current threats challenges include forest diebacks, intensifying drought, increased wildfire, insect and pathogen outbreaks, migrations of populations, and rewilding. We take a food-web approach, considering how species interactions respond dynamically to global change. Class activities include lectures, working group collaborations, class discussions, and the field trip. Analytical tools used to quantify change involve data manipulation in R, including data sets collected during the course. Examples include population size and growth, regression, GLMs, and species distribution modeling. Prerequisites: statistics.

We use four case studies to focus on the threats of climate change and the challenges in understanding them:

Kruger National Park (KNP), S Africa: The nearly intact Pleistocene megafauna supports the grazing and browse pressure that shapes this savanna community. In fact, KNP supports a diversity of grazers (buffalo, zebra, wildebeest), browsers (giraffe, kudu, duiker, klipspringer, bushbuck, nyala, black rhino), and mixed feeders

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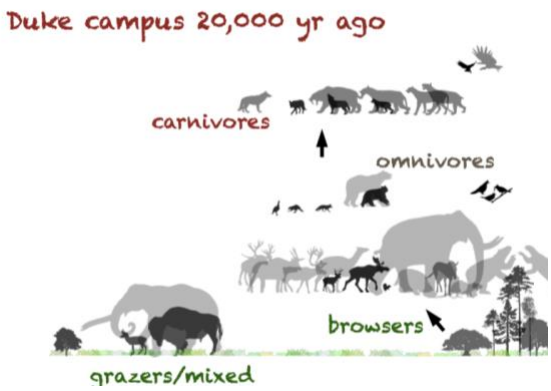
(elephant, impala). Recent drought combined with shifting management have affected large mammal populations as documented in long-term survey data. Existing data, combined with field data to be collected by students in the 9-day field trip will be used to evaluate the relative importance of bottom-up (grass and browse production) and top-down (predation) forces that change with shifting drought stress.

Yellowstone National Park (YNP), Wyoming: This grassland/woodland mosaic supports large grazers (bison, pronghorn) and browsers (elk, brown and black bear, several deer species). In a region that is experiencing rapid warming, the recent reintroduction of wolves has shifted the balance in herbivore pressures to impact all aspects of food webs. Field data collected during the period of wolf reintroduction, together with browse productivity from ours and other labs will be used to evaluate climate impacts in this cold-dry setting.

Parque natural Sierra de Grazalema: A Mediterranean (winter rain) climate from low elevation scrub to wet high elevations that harbor endemic Spanish fir. Geology and topographic relief result in a diversity of habitats, including acidic soils dominated by cork oak in Alcornocales and limestone karst extended up to high elevations. Sapiens has been integral from Pleistocene hunter-gatherers. The agricultural setting supports grazing livestock and olive production.

Duke Forest (DF), an eastern deciduous forest: The abundant moisture supply to this temperate climate supports continuous forest where Pleistocene megafauna disappeared by 14K BP. Gone are the megaherbivores that could browse the canopy and disperse fruits and seeds. The high and temperature limited NPP in the eastern deciduous forest, limited to small megafauna, provides a contrast with browser (KNP) and grazer (YNP) dominated systems. The course could include one field trip to a site in Duke Forest.



Course objectives

Students gain an understanding of changes in climate that affect biodiversity and how:

- Biodiversity dynamics: The components of ecological food webs, including species interactions that are governed by climate and habitat; humans are an integral part of food webs.
- **The basis for our understanding**: How biodiversity is quantified, through field survey methods to data analysis and interpretation

- **Communicate** how climate is changing now, how communities of species are responding, and where these changes are taking us

General Course requirements

Class and field trip participation, including spring break in Kruger National Park, South Africa. Students registered for the undergraduate number participate in all aspects of the course except for the research project. Graduate students work in small groups on a research question selected from a short list that focus on the climate impacts on food webs. The questions center on the contrasting bottom-up supply of resources. Prior to the field trip (approx. 9 weeks), grad students will conduct background research on the four ecosystems. Following the field trip (4 wk), they will complete data analysis begun at KNP and prepare the final report and presentation. The research project will include a final report, formatted as a journal article, and progress reports and a final presentation by each group.

A course fee of approximately $900 per student will be added to your bursar account. The course fee covers meals and lodging at the Skukuza field station, and it further pays for assistants and guards in the field. Students arrange their own travel to Johannesburg to arrive by the afternoon of 8 March and depart on 16 March. Students are responsible for their travel costs to Johannesburg, which is not covered by the course fee. Ground transport from Johannesburg to KNP is covered by the course fee. If you need to adjust your financial aid to cover the additional costs, please consult with your financial aid counselor. For MEM and MF students, Cindy Peters is your financial aid counselor. If you wish to discuss additional loans to cover your travel expenses, please contact her for an appointment.

Christy Parrish at Duke's Office of Global Affairs can assist with Visa questions for the South Africa trip. A Graduate/Professional student has support from Duke to travel to a 3rd party nation (i.e., not their home country and not the country of their citizenship) as long as: 1) both their legal status here in the U.S. as well as their travel documentation from their home country are valid for at least 6-months beyond the proposed return date of 18 March 2023; and 2) the host nation does not ban citizens from their country. Depending on citizenship, a student may need a visa for South Africa and a valid F-1 visa in their passport in order to return to the US. A travel signature from Duke's Office of Global Affairs on the I-20 is needed for return to the US, which can be obtained at any time by coming to Visa Services with their visa documents (passport, I-20, I-94). No appointment is necessary, this is a walk-in service.

Students learn skills to:

- Recognize basic types of data and methods used to analyze them
- Gain concepts in modeling and computation
- Incorporate analyses into discussion and debate

Format

- Class activities:
    - Overview lecture material from vignettes
    - Discussion of readings from science and the media
    - Data analysis in R
    - Short quizzes, final report (see below)
- Field trip: sampling biodiversity, with analysis at Kruger National Park: 8 – 16 March

- Modules:
    - Food web dynamics and climate change
    - Drought emergence and megaherbivore dynamics: decade-scale transition at Kruger National Park
    - Introduced predators with warming, drying, and floods: a century of change at Yellowstone National Park
    - Food web dynamics in the absence of megafauna: Duke Forest dynamics since the 20th century

Assignments

- Questions based on readings and data applications will be posted by each student prior to meetings.
- Final presentation and report

Grading

- 30% Participation in class, including discussions
- 45% Group and individual assignments: mostly short answer; approximately nine quizzes, five points each
- 25% Final presentation and report

Schedule

Date		Chapter/topic	Additional readings	Concepts/tools
jan	9	**Chap 1**, Biodiversity science and global change	Armstrong Mackay, Kauffman	Six big ideas for a changing planet; Kruger trip summary
	14		Intro2R; Module 1 Mauna Loa CO2 vignette Discussion: tipping points, Yellowstone elk-wolves	
	16	**Chap 2**; Evidence and data	Ecol data types, design, uncertainty, interpretation Counting animals: Ferreira, Kays	Global change as a discipline environmental data from global to habitat
	21		Global change data and interpretation	
	23	**Chap 3;** Drifting continents	Since Pangea: McIntyre, Lyson	Geologic time, paleogeography, biotic interchanges
	28		Quaternary CO2 data in R; Cenozoic trends: Chevalier, Woodburne, Osborne, Johnson, Mumma	
	30	**Chap 4;** Climate/ biodiversity connections	Climate foundations; Laurence Kruger on field trip; savanna readings: Staver, Kartzinel, Donaldson	Radiation balance, atmospheric circulation, seasonality, norms/anomalies/extremes Biome-climate connections
feb	4		Camera traps; Kruger megaherbivore discussion	
	6		Savanna climate and biomes; for next time: climate connections, Bonan, Clark (extremes), Dobrowski	
	11	**Chap 5;** Evolution to diversity	Climate in R; Evol mechanisms, adaptation & diversification, phylogenies; Benton, Condamine, Brown	Evol mechanisms, diversification, traits, including temp/H2O regulation, diet/trophic relationships
	13		Adaptation & diversification of animals; Murchie, Smith, Milton,	
	18		Frugivory and diversity Janzen, Miller, Bunney, Midgley	
	20		Seed dispersal/masting; Journe, Qui	
	25		Island biogeography	
	27	Kruger field trip	Bird point counts, mammal citizen science, tree fecundity; Beresford, Scher	Grass, woody plants, Invertebrates, vertebrates
mar	4		Do not meet	Make up field trip
	6			
	8 - 16		Skukuza	Field data collection
	18	Kruger data analysis	Group projects in R	Bird point counts, mammal citizen science, tree fecundity
	20			
	25	**Chap 6:** Sapiens	Fibiger, Pendergast, Librado, Wright, Weitzel	Landscapes of cooperation and conflict Environmental context redefined
	27		Discussion	
apr	1	**Chap 7:** Food webs		Populations to communities
	3			
	8		Discussion on Food webs	
	10	OVERVIEW	Presentations	
	15	Final reports	Presentations	

*Ecology seminars are Tuesdays at 11:45

Readings

Armstrong Mackay, Exceeding 1.5°C global warming could trigger multiple climate tipping points

Beresford, Phenology and climate change in Africa and the decline of Afro-Palearctic migratory bird populations

Benton, The Angiosperm Terrestrial Revolution and the origins of modern biodiversity

Bonan, Climate, ecosystems, and planetary futures: The challenge to predict life in Earth system models

Brown, Why are there so many species in the tropics?

Bunney, Seed dispersal kernel of the largest surviving megaherbivore—the African savanna elephant

Condamine, The rise of angiosperms pushed conifers to decline during global cooling

Chevalier, Pollen-based climate reconstruction techniques for late Quaternary studies

Clark, Continental contrasts in climate extremes that control forest recovery (in review, on Canvas)

Clark, The emergent interactions that govern biodiversity change.

Clark, Generalized joint attribute modeling for biodiversity analysis: median-zero, multivariate, multifarious data

Clark, Foodwebs based on unreliable foundations: spatiotemporal masting merged with consumer movement, storage, and diet

Dobrowski, Protected-area targets could be undermined by climate change-driven shifts in ecoregions and biomes

Donaldson, Fire, grazers, and browsers interact with grass competition to determine tree establishment in an African savanna

Ferreira, Estimating lion population variables: prey and disease effects in Kruger National Park, South Africa

Fibiger, Conflict, violence, and warfare among early farmers in Northwestern Europe

Janzen, Herbivores and the Number of Tree Species in Tropical Forests

Johnson, A progressively wetter climate in southern East Africa over the past 1.3 million years

Journe, Globally, tree fecundity exceeds productivity gradients

Kartzinel, *DNA metabarcoding illuminates dietary niche partitioning by African large herbivores*

Kauffman, *Are wolves saving Yellowstone's aspen? A landscape-level test of a behaviorally mediated trophic cascade.*

Kays, *An empirical evaluation of camera trap study design: How many, how long and when?*

Lyson, Exceptional continental record of biotic recovery after the Cretaceous–Paleogene mass extinction

Librado, The origins and spread of domestic horses from the Western Eurasian steppes

Magri, *Quaternary disappearance of tree taxa from Southern Europe: Timing and trends*

McIntyre, *Global biogeography since Pangaea*

Midgley, *The role of the elephant (Loxodonta africana) and the tree squirrel (Paraxerus cepapi) in marula (Sclerocarya birrea) seed predation, dispersal and germination*

Miller, *Dispersal of Acacia Seeds by Ungulates and Ostriches in an African Savanna*

Milton, *Diet and primate evolution*

Mumma, *A 28,000 year history of vegetation and climate from Lower Red Rock Lake, Centennial Valley, Southwestern Montana*

Murchie, *Collapse of the mammoth-steppe in central Yukon as revealed by ancient environmental DNA*

Osborne, *Atmosphere, ecology and evolution: what drove the Miocene expansion of C4 grasslands?*

Prendergast, *Ancient DNA reveals a multistep spread of the first herders into sub-Saharan Africa*

Qiu, *Masting is uncommon in trees that depend on mutualist dispersers in the context of global climate and fertility gradients*

Qiu, *Habitat–trait interactions that control response to climate change: North American ground beetles (Carabidae)*

Scher, *Species traits and observer behaviors that bias data assimilation and how to accommodate them*

Smith, *Body Size Evolution Across the Geozoic*

Smith, *Initial formation of an indigenous crop complex in eastern North America at 3800 B.P*

Staver, *The past, present, and future of herbivore impacts on savanna vegetation*.

Staver, *Grazer movements exacerbate grass declines during drought in an African savanna*.

Weitzel, *Food Production and Domestication Produced Both Cooperative and Competitive Social Dynamics in Eastern North America*

Woodburne, *The Great American Biotic Interchange: Dispersals, Tectonics, Climate, Sea Level and Holding Pens*

Wright, *Impact of farming on African landscapes*