Ecological Diversity and Climate Change

Environ 323/623; spring 2024

James S Clark, Nicholas School of the Environment

Student blog from 2023

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 woodland diebacks, intensifying drought, increased wildfire, insect and pathogen outbreaks, and poleward migrations of populations. 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 include 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.

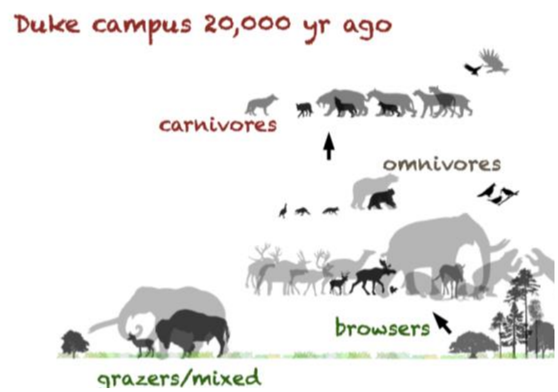
We use three case studies to focus on the threats of climate change and the challenges in understanding them:

Kruger National Park (KNP), S Africa: The nearly intact Pleistocene megafauna supports the high 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 (elephant, impala). Decades long 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.

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
- **Basis for our understanding**: How biodiversity is quantified, through field survey methods to data analysis and interpretation
- **Communication**: articulate how climate is changing now and, 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 would participate in all other aspects of the course, except for the research project. Graduate students will work in small groups on a research question selected from a short list that focus on the climate impacts on food webs. The questions would 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 three ecosystems. Following the field trip (4 wk), they will complete data analysis begun at KNP and prepare the final report and presentation. On alternate weeks, groups provide updates on progress relative to benchmarks to be distributed at the beginning of class. 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 $1020 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 in the field and guards. In addition, students will arrange their own travel to Johannesburg to arrive by the afternoon of 10 March and depart on 17 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 will have learned skills to

- Recognize basic types of data and methods used to analyze them
- Gain a first exposure to 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
    - Debate current issues, bringing in the science
- Vignettes:
    - 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

Cross-cutting themes

The setting: Pleistocene and contemporary climate change to global trends in biodiversity

Food web function: Principles of regulation

Data collection and analysis

- Structured and quasi-structured inventories (NEON, FIA, BBS, camera trap network)
- Citizen science and opportunistic data (ebird, MASTIF)
- Remotely sensed resources

Trophic interactions to community patterns

- Bottom-up controls: regulation of food
- Grazer, browser, mixed feeders
- Predation, disease

Dynamic food webs: Sustaining diversity through bottom-up/top-down controls

Model ecosystems

- intact Pleistocene megafauna: KNP
- Holocene megafauna: YNP
- minimal megafauna: DF

Prospects for the future

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 discussions
- 45% Group and individual assignments: mostly short answer
- 25% Final presentation and report

Draft Schedule

		Topic	Chapter	Concepts	Resources	Due
jan	11	**Planetary biodiversity**, past and future, on a dynamic template	*1*	Biodiversity and climate change	Intro2R, CO2 vignette	
	16			Three landscapes, roadmap for global trends		
	18		*2*	Global change as a discipline		1
	23			Biodiversity in the field: forest inventory/camera traps	Duke Forest trip	
	25		*3*	Climate and biodiversity now		2
	30			The biomes		
feb	1		*4*	The formative events in earth history	Climate change vignette	
	6					
	8		*5*	Global biodiversity in space and time		
	13		*6*	Evolution, organismal basis for biodiversity		
	15			Defining events for modern biodiversity		
	20	**Individuals to communities**	7	Demography to population growth		
	22			Species interaction	Discussion	
	27			Food webs: bottom-up/top-down		
	29	**Information & uncertainty**		Climate, soil grids, MODIS NPP	JSDM vignette	
mar	5			No meeting (make up for field trips)		
	7	**Analysis:** combining data with models to understand, predict		No meeting		
	9-16			Kruger trip: savanna ecology, grass, woody plants, birds, butterflies, small and large mammals		
	19			Kruger National Park: field data, megaherbivores		
	21			Kruger National Park: continued		
	26			Yellowstone National Park (YNP): wolf reintroduction	Dynamic food web vignette	
	28			Yellowstone National Park (YNP): continued		
apr	2			Comparative food web analysis	Wolf, elk vignette	
	4			Change happening now: drought, fire, biodiversity loss		
	9			**MP Symposium, no class**	Data analysis	Paper outlines
	11	**Anticipating change**: attribution, interpreting change		Interpreting benchmarks with continuing change	Data analysis	Presentation outlines
	16			**Biodiversity and global change**	Discussion	
	18	**Presentations**				
	23	**Presentations**		Final paper due		

Grads last day 18 April