BIOD59 / EEB1420 – Research paper topics

Fall 2019

Theoretical Ecology:

1. **The revenge of the mesopredator.**
   Through their ability of unravelling complex dynamics, models have contributed tremendously to our general understanding of ecological processes. Lotka and Volterra's work, for example, shed light on the reasons why predator populations cycle asynchronously with their prey, or how species may competitively exclude other species. The power of models in this context lies in their ability to formalize and formally evaluate the consequences of novel hypotheses. One intriguing hypothesis, that has not yet been formally evaluated, concerns the interactions between apex predators and mesopredators. Often, it is assumed that apex predators suppress mesopredator populations due to some dietary overlap and by being generally better competitors (imagine, for example, a jaguar and an ocelot fighting for the same kill). However, Roemer *et al.* (2009) also suggested that mesocarnivores may be released from this competition by a mechanism they termed the 'revenge of the mesopredator': smaller, more abundant, mesopredators are more likely to come into contact with domestic animals and their diseases than larger predators, and may act as a reservoir for such diseases; spillover of disease from mesopredators to apex predators during interactions in the forest may subsequently decimate apex predator populations and release mesopredators from competition. Develop a model to describe the dynamics suggested by the 'Revenge of the mesopredator hypothesis', and explore the dynamics of your model to outline conditions under which the hypothesis may or may not hold true.
   https://academic.oup.com/bioscience/article/59/2/165/228398

Applied Ecology:

2. **Our friendly neighbors: raccoons in the GTA**
   Toronto is home to the largest urban raccoon population in the world. This population thrives in part because the raccoons have access to our garbage and thus an overabundance of food. In other words, how effectively we secure our garbage likely has an effect on the population dynamics and abundance of raccoons. Use population models to explore how our garbage might affect the population dynamics of raccoons, and how changes in our behavior (e.g. securing our garbage better) might affect raccoon populations.

3. **Observe & model your own backyard.**
   Autumn is upon us. The leaves will soon be turning their colors and then start falling. Use photographs to document the changes in an area of your choice. Use models to evaluate these data and estimate the rates at which the color changes progress until ultimately the leaves are shed.

Conservation Biology:

4. **Population viability of Northern right whales – recent losses and ways forward**
The Northern right whale is critically endangered with only about 500 individuals remaining globally. Recent spikes in the number of deaths (at least ten in June/July 2017) and drops in the birth rate (minus 40% from 2010 to 2016) have caused alarm, with conservationists scrambling to find the underlying causes and possible solutions. In 2001, Fujiwara and Caswell used matrix models to analyze the viability of the Northern right whale population, and concluded that preventing the deaths of only two females a year could switch an ongoing population decline to population growth. However, with the recent developments, it is unclear how the outlook for Northern right whales may have changed and what conservation measures may prove the most effective. Using matrix models for a stage-structured population viability analysis, help conservationists shed light on these questions.
http://news.nationalgeographic.com/2017/06/north-atlantic-right-whale-deaths-st-lawrence-spd/
http://www.cbc.ca/beta/news/canada/nova-scotia/right-whales-disappearing-from-u-s-breeding-grounds-1.4289159
https://www.ncbi.nlm.nih.gov/pubmed/11734852

5. **Fish farms, climate change, and the sex ratio of American crocodiles.**
Climate change is thought to affect American crocodiles because the sex of their offspring depends on air temperatures during incubation. Warmer temperatures normally lead to a higher proportion of females in the clutch, but in Costa Rica the opposite is found: highly male-biased sex ratios, possibly due to a growth hormone originating from fish farms. Although there are many unknowns in this system, the risk is evident: reproduction will decline with too many males (and too few females) or with too many females (and too few males). Use a modelling approach to explore how changes in the sex ratio may affect the viability of Costa Rican populations of American crocodiles, and discuss your results in the context of the above-mentioned threats.
http://www.sciencemag.org/news/2017/08/something-changing-sex-costa-rican-crocodiles?platform=hootsuite

Disease Ecology / Human Epidemiology:

6. **A population dynamics experiment for disease transmission**
On Tuesday, October 22, 4-6pm, I will be teaching about basic disease dynamics, SIR-models, and herd immunity in my *Introductory Ecology* course, BIOB50. As part of this lecture, we will simulate disease progression in a population where (a) a small portion of people is vaccinated, and (b) a large portion is vaccinated. To do this, we will randomly choose a BIOB50 student to be patient zero and start infecting other students in the class. Infected people can then infect other people who haven't had the disease yet. After a set number of time steps, students will "recover" or "die". At each time step you will collect data on how many students are currently in the S, I, and R-stages, respectively. Use these data to estimate key transmission parameters and develop a model that describes the disease progression in our exercise. What kind of conclusions can you draw from your model about our hypothetical disease and potential mitigation measures?
Note: This project requires your group's presence during the data collection on October 22.

7. **Host-parasite cycles in a warming climate**
   The influence of parasites can lead to population cycles in their hosts. Perhaps the most famous example comes from red grouse and the parasitic nematode *Trichostrongylus tenuis* (Dobson & Hudson 1992, Journal of Animal Ecology 61, 487-498). Several parameters of this system are temperature-dependent. Explore how warmer temperatures might affect the host-parasite dynamics of this system.

8. **Controlling a mysterious killer: white-nose syndrome in bats.**
   White-nose syndrome (WNS) has killed millions of bats since it was first detected in the state of New York in 2006. Although there is still some debate about the cause of WNS, most evidence points towards the fungus *Geomyces destructans* that seems to interfere with the bats' physiology, leading to increased energy use during hibernation and starvation. Not only is the loss of bats a conservation concern, it may also lead to increased disease in humans as a decline in bat numbers leads to increased mosquito populations. A cure remains to be found but some promising approaches exist, such as the discovery of a bacterium that seems to slow or kill the fungus (see articles below for more details). In preparation for the time when a cure becomes available, develop a model for the dynamics of WNS. For the purpose of this project, you can assume that WNS is indeed caused by *G. destructans*, and that transmission occurs by contact between infected and uninfected bats. Make sure that your model accounts for the 'metapopulation structure' of bats: that is, transmission will occur at much higher rates between bats roosting in the same cave than between different colonies in different caves. Based on your model(s), explore possible control strategies.
   https://www.scientificamerican.com/article/night-stalker-white-nose/
   http://news.nationalgeographic.com/2015/05/150527-bats-white-nose-syndrome-treatment-conservation-animals-science/

9. **Google's mosquitoes**
   The Zika virus is transmitted by *Aedes aegypti* mosquitoes to humans. Both the virus and its mosquito vector are present in and around Fresno, CA. To control the mosquito population, and hence prevent epidemic outbreaks, Google's life sciences unit released 20 million male mosquitoes that are infected with *Wolbachia* bacteria in the area this summer. When these males mate with a female, her eggs will become infertile, so the hope is that enough bacteria-infected males will mate with naturally occurring females to curtail reproduction and drive the population to extirpation. There are many unknowns in this system, but a modelling approach can help optimize the control strategy and inform on the chances of success. For example, it will depend on the rate at which infected and uninfected mosquitoes mate, as well as on the total number of mosquitoes in the population whether releasing 20 million mosquitoes is sufficient or not.
   https://techcrunch.com/2017/07/14/googles-life-sciences-unit-is-releasing-20-million-bacteria-infected-mosquitoes-in-fresno/
   https://blog.verily.com/2017/07/debug-fresno-our-first-us-field-study.html

10. **Measles at UTSC**
    Measles is a highly infectious disease that can be very dangerous if contracted by adults. Vaccinations have been highly effective in controlling measles in developed nations, but a recent

rise in anti-vaccine campaigns have led to lower rate of vaccinations and a resurgence of measles. Develop a model to explore what might happen if measles appears at UTSC. Depending on how many cases are introduced, when they are introduced and on how many people are vaccinated, such an epidemic could take very different courses. Use your model(s) to discuss prevention and mitigation strategies.

Design your own project

11. **Design your own project**
    Projects other than those outlined above may be considered if the suggested questions can be approached with the tools covered in this course, if the project is doable within the timeframe of the course, and if all group members agree on the suggested topic. If this is the case, please contact the instructor to discuss your suggestions.