Introductory material

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Introduction

Course overview

- Course information on AtL and at http://lalashan.mcmaster.ca/theobio/3SS/
- Lecture notes for each section will be available on AtL the evening before you need them
- Check AtL frequently for announcements and new information
- Contacts:
  - **Marvin Gunderman**, course coordinator:
    first contact for any administrative issues
    `gundermn@mcmaster.ca`; LSB 116; x23556
  - **Ben Bolker**, professor:
    http://www.math.mcmaster.ca/bolker;
    Hamilton Hall 314 *or* LSB 336

Expectations of professor

- Start and end on time
- Focus on conceptual understanding
- Make clear what terminology and facts must be learned
- Open to questions
  - in class (within reason)
  - office hours (Thurs 1:30-2:30, or by appointment)
  - AtL forums (for general questions)
  - e-mail, `bbolker@mcmaster.ca`:
    please include BIO 3SS3 and MacID in title of e-mail

Expectations of students

- Courtesy/rules

  - Don't talk while other students are talking, or while I am responding to student questions
  - If you must talk at other times, be unobtrusive
  - Don't connect to the internet in class
  - Give the professor his 50 min
  - Lectures are required
  - Tutorials are required, unless otherwise specified
  - Don't cheat (see the official course outline; your first assignment is to read it thoroughly)

- Intellectual
  - Wrestle with the material
  - Please **do** ask questions

Texts

- The primary text for this course is the lecture notes
- Readings will be posted to AtL
- You are required to have an Ecology textbook
- Any 2F03 textbook is OK (Molles; Molles and Cahill; Cain, Bowman and Hacker)

Structure of presentation

- Required material will be clearly outlined in the notes
- Required terminology will be presented in **bold**
- Class material may also be required; take notes on these in your own words
- I will be using PollEverywhere for class responses
  - Polls will count for **extra credit**
  - You will need a cell phone with a texting plan; if don't have one but want the extra credit, e-mail me with an interesting fact or idea related to the missed question(s)
    (e.g. from a scientific paper, from an ecology textbook, or from a *reputable* scientific web site or blog)
  - before the next class, register at http://www.polleverywhere.com/register?p=2n6a5-1f6n&pg=UEcduf4; enter your Mac ID and your phone number
  - Why are you taking this class?
  - What is ecology good for?

Meta- stuff

Ecology vs. environmentalism, science vs. policy

- tree huggers vs. Hummer drivers
- ecology ≠ environmental science ≠ environmentalism
- ecologists (in their professional capacity) should say *what will happen*, not *what you should do* ...

Opinions about advocacy

"Scientists should ..." (Lach et al. 2003)

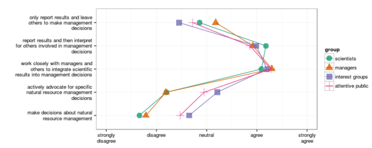

Figure 1: plot of chunk lachDat

Definitions

What is **population ecology**? What other kinds of ecology are there?

- Hierarchical scales:
  - Behavioural, physiological
  - Population
  - Community ("micro" vs "macro")
  - Ecosystem
- Taxon-specific:
  plant, animal, microbial, insect, human, ...

Goals of ecology

- Goals
  - Understanding (basic science)
  - Prediction
  - Control/management
- What population are you interested in?

humans, crops, trees, fish, game, pests, invasive species, endangered species, microbes, infected people, infected cells, ...

Population ecology: questions

- What processes affect organisms' population sizes?
- How do population sizes respond to these effects?
  - Why are some populations large, and others small?
  - Why are some cyclical and others stable?
  - When can similar species coexist in the same area?

Math and models

- Population ecology uses models, and math
- Math is a critical tool for linking processes to outcomes; it will play a central role in the course
- We will keep it *simple* (not necessarily easy)
- Logic is more important than math (Platt 1964), but math is still important

Examples

Malaria

- A nasty disease spread by mosquitoes
- In some places (e.g., the southeastern US), it has been eradicated almost by accident
- They still have mosquitoes there
- In other places it persists at high levels despite concerted efforts at elimination
- *What are the risk factors for malaria spread, and what determines when it can be controlled?*

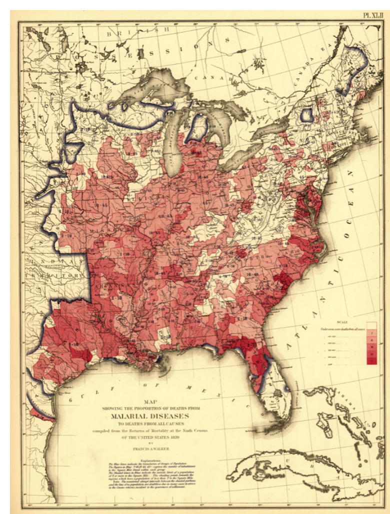

Figure 2: US Malaria, 1870

Red squirrels

- Red squirrels are rapidly disappearing from England
  - Loss of suitable habitat?
  - Competition (for food) from gray squirrels introduced from North America?
  - Diseases carried by gray squirrels?
  - More than one of the above? Synergy?

Gypsy moths

- Introduced to North America from Eurasia
- Dramatic population cycles: can devastate forests at peak population sizes
- What causes gypsy moth population cycles, and (how) can these cycles be better controlled? (Kendall et al. 1999)
  - weather
  - resource availability (food quality)
  - predators (mice, birds)
  - parasitoids
  - disease (virus, fungus)

Population dynamics

- Why are there no fish in my favourite mountain lake?

- What factors will determine what will happen if I introduce some fish?

Models

Example: dandelions

- Start with one dandelion; it produces 500 seeds, of which only 1% survive to reproduce.
- How many dandelions will there be after 3 years?
- Spreadsheet

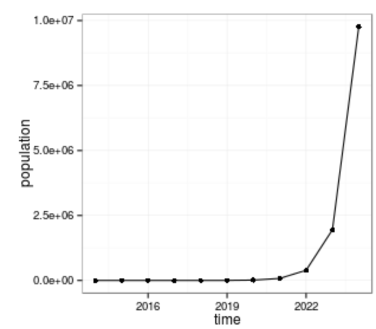

Figure 3: plot of chunk dandelion1

Example: dandelions

Rabbits

- Imagine we have a population of rabbits
- Baby rabbits become adults after one month
- Each pair of adult rabbits produces one pair of baby rabbits each month
- Rabbits never die
- *What happens to this population?*
- Spreadsheet
- These are the Fibonacci numbers

Exponential growth

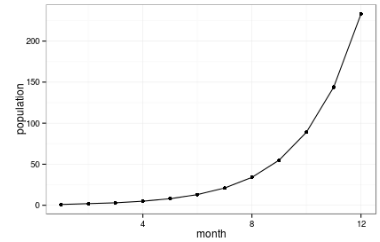

Figure 4: plot of chunk rabbits1

What is a model?

- A **model** is a set of **assumptions** that can be used to make *predictions*
- For example, we make assumptions about rabbit lifespan and reproduction, and then evaluate the *consequences* of these assumptions
- Ecological models always have many *unstated* assumptions
- What is an unstated assumption about the dandelion model?

Models are useful

- Models link
  - individual-level actions and population-level effects
  - what is happening at a given instant, and the result over a longer time period

Models are approximations

- The real world is much more complicated than any of our models: The map is not the territory (Korzybski, Bateson (1980), Borges, Carroll)
- "All models are wrong, but some are useful" (G. Box) ...
  - ... for making precise quantitative predictions
  - ... for combining information from different (physical or temporal) scales
  - When simple models fail, they can help us figure out where to look for what assumptions are wrong, or what additional assumptions are needed

Ways to be wrong

	assumptions OK	assumptions not OK
predictions OK	hooray! (but can we extrapolate?)	right answer for the wrong reason
predictions not OK	incorrect model	garbage in, garbage out

- **incorrect** model: math mistake, or a bug in the program
  (e.g. "the rabbit model leads to linear population growth")
- in ecology, model assumptions are (almost) **never** exactly right,
  but they may be close enough ("OK");
  figuring out if they are OK is hard
- ditto for predictions

A classic example: Hardy-Weinberg equilibrium

- In the early 1900s some geneticists thought that dominant alleles would take over a population: "if brachydactly is dominant 'in the course of time one would expect, in the absence of counteracting factors, to get three brachydactylous persons to one normal' "
- Hardy (1908) used *simple arithmetic* (i.e., a mathematical model) to show that (in the absence of everything interesting) they would not - in fact the allele frequencies remain equal
- Hardy-Weinberg equilibrium
- "In a word, there is not the slightest foundation for the idea that a dominant character should show a tendency to spread over a whole population, or that a recessive should tend to die out"

Our examples

- The rabbit and dandelion examples are models
- We didn't *assume* exponential growth, we *concluded* it from our simple assumptions
- If individuals survive and reproduce at a constant rate, we expect populations to grow exponentially
- What can we conclude if the population doesn't grow exponentially?

Exponential growth

Growth and decline

- What is exponential growth?
  - When something grows *proportionally* to its own size
  - Grows faster and faster as it gets bigger and bigger
- What is exponential decline?
  - When something declines *proportionally* to its own size

- Declines slower and slower as it gets smaller and smaller

- **Geometric** growth is a synonym for exponential growth
- What can we conclude if a population grows slowly?

The zeroth law of population dynamics

- change in population size = immigration - emigration + birth - death
- this is really the **only** immutable rule

The first law of population dynamics

- if **per capita** birth and death (and immigration/emigration) rates are constant
  - the population-level rate of growth (or decline) is proportional to the population size
  - the population grows (or declines) exponentially
- **density-independent** growth or decline

Scales of comparison

1 is to 10 as 10 is to . . . ?

Arithmetic and geometric differences

- If you are thinking additively, the differences between quantities are called **arithmetic** differences
- If you are thinking multiplicatively, the differences between quantities are called **geometric** differences
- Regular graphical plots display arithmetic (additive) differences ("linear scale")
- Plots that use log-scaled axes display geometric (multiplicative) differences

Provinces of Canada (linear scale)

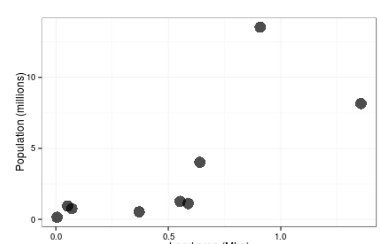

Figure 5: plot of chunk prov1

Provinces of Canada (log scale)

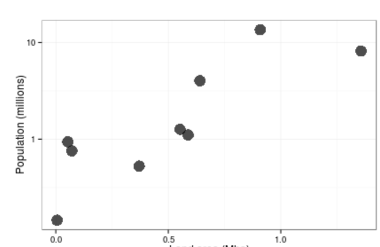

Figure 6: plot of chunk prov2

Examples

What would it look like if we added

- This classroom?
- The territories?
- The planet Earth?
- The planet Jupiter?

Dandelions revisited

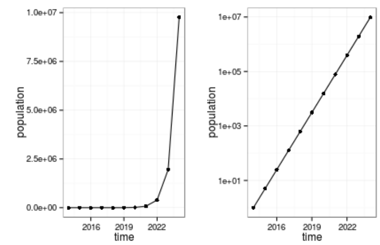

Figure 7: plot of chunk dand2

Rabbits revisited

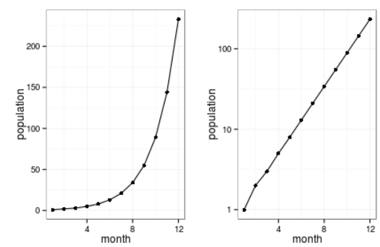

Figure 8: plot of chunk rabbits2

Gypsy moth time series

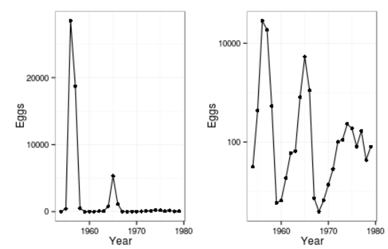

Figure 9: plot of chunk gypsy

Different scales

- The log scale and linear scale provide different ways of looking at the same data
- Equally valid
- What is an advantage of the geometric scale?

Unit summary

- ecology vs environmentalism vs advocacy
- definitions and goals of ecology
- examples: malaria, red squirrels, gypsy moths
- toy models of population growth
- exponential growth
- arithmetic and geometric scales

Extra links

- Maybe Fibonacci numbers are a bad model for biological quantities?

References

Bateson, Gregory. 1980. *Mind and Nature: a Necessary Unity.* Toronto: Bantam Books.

Hardy, G. H. 1908. "Mendelian Proportions in a Mixed Population." *Science* 28 (706) (July): 49–50. http://www.jstor.org/stable/1636004.

Kendall, B., C. Briggs, W. Murdoch, P. Turchin, S. Ellner, E. McCauley, R. Nisbet, and S. Wood. 1999. "Why Do Populations Cycle?

a Synthesis of Statistical and Mechanistic Modeling Approaches." *Ecology* 80: 1789–1805.

Lach, Denise, Peter List, Brent Steel, and Bruce Shindler. 2003. "Advocacy and Credibility of Ecological Scientists in Resource Decisionmaking: a Regional Study." *BioScience* 53 (2): 170–178. http://www.jstor.org/stable/10.1641/0006-3568(2003)053%5B0170:AACOES%5D2.0.CO;2.

Platt, John R. 1964. "Strong Inference." *Science,* Series 3 146 (October): 347–353. http://links.jstor.org/sici?sici=0036-8075/%2819641016/%293/%3A146/%3A3642/%3C347/%3ASI/%3E2.0.CO/%3B2-K.