Climate change is rapidly changing ecosystems across the world, especially alpine ecosystems. This lecture is designed to provide background on climate change and biotic responses. One of the challenging aspects of climate change is that small changes in climate can have abrupt biotic responses, mediated by state changes (snow -> rain; ice->water) and species interactions.

CLIMATE CHANGE—WHAT IS HAPPENING? (data from IPCC 2007)

Temperature

- Last 50 years, global surface temperatures have increased average of ~ 0.13 degrees C/decade
- Sea level is rising (2 cm per decade)
    - Thermal expansion (~57% of rise)
    - Melting glaciers and ice caps (~28% of rise)
    - Melting polar ice (~15%)
- Snow cover is decreasing (7% decrease in frozen ground in N. Hemisphere since 1900)
- Higher latitudes have increased in temperature more rapidly (approximately 2X as fast)

Precipitation

- Changing dramatically, but spatially dependent.
- Form of precipitation also changing, with more rain, less snow.
- BC is predicted to get more precipitation (and more of it as rain)
- Streams and rivers are now peaking ~2 weeks earlier

Extreme weather seems to be increasing in frequency and severity

- Increasing hotter days and nights, cyclones, heavy storms

WHY IS CLIMATE CHANGE HAPPENING?

Natural: fluctuations naturally occur in the climate system over long and short time scales. However, models predict that the natural cycle would be towards cooling.

Anthropogenic: There is extremely high scientific certainty that greenhouse gas emissions are the primary cause of climate change.

- Greenhouse gases—current concentrations of greenhouse gases are greater than they have been in 650,000 years.
- Examples: CH_4 (Methane), CO_2 (Carbon Dioxide), N_2O (Nitrous oxide)
- Land use

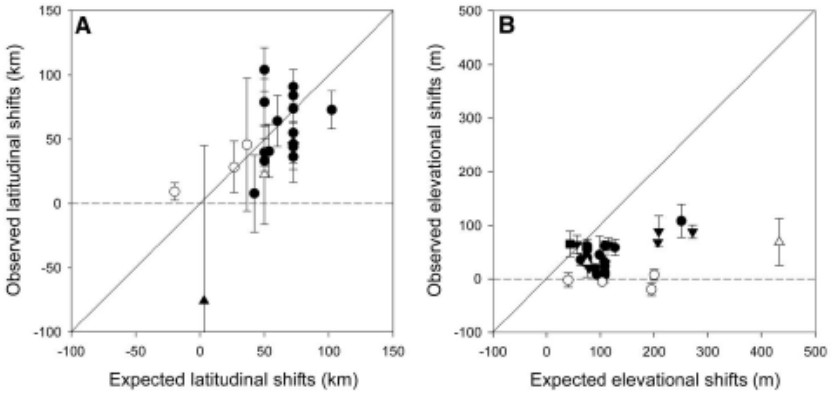
WHAT ARE BIOTIC RESPONSES TO CLIMATE CHANGE?

Go extinct—

- No species extinctions can be unambiguously blamed on climate change. But . . . several possibilities (e.g. golden toad).
- Model predictions based on species niches predict high species loss rates given climate change.

Change Location—Organisms can just move to colder places, right?

- Higher in elevation—Species have moved 11 meters/decade up mountains
- Higher in latitude—Species have moved 16.9 km/decade to higher latitudes.



(from Chen et al. 2011)

Key questions:

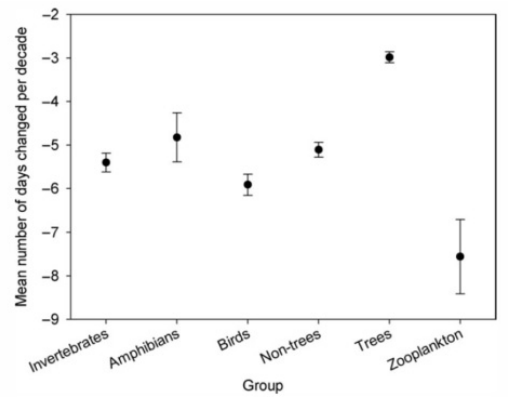
- Can species move fast enough? (birds vs. plants vs. slugs)
- What if they run out of mountain?
- Assisted migration?

Change timing

- **Phenology**--Timing of life-history events. For example, the timing of plant flowering or bird migration.
- Climate change is driving earlier springs/Later falls
- On average, spring phenology is becoming earlier at 5 days/decade
    - Many of these data are from citizen science—people collecting data and then sharing it

Example: cherry blossoms.

There is variation across taxonomic groups and species in terms of their response to climate change.

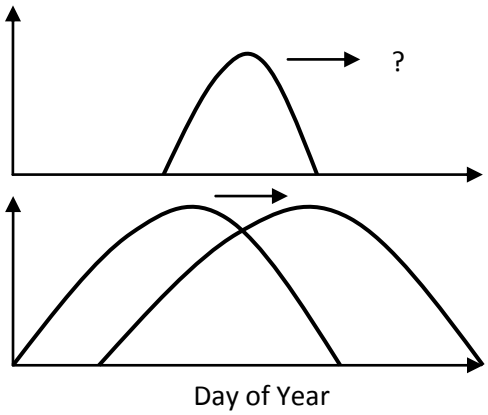


(Graph from Root et al. 2003)

Potential for disruption of coordination in timing between interacting species

- Predators and prey
- Pollinators and plants
- Parasitoids and hosts

Match-Mismatch



Example: Lake Washington food web.