RMBL

Mission

The Rocky Mountain Biological Laboratory's mission is to advance the deep scientific understanding of nature that promotes informed stewardship of the Earth. The Lab accomplishes this by providing scientists and students access to diverse natural habitats, infrastructure for high-quality research and education, and a dynamic, collaborative, internationally recognized scientific community. Scientists build on an unusually broad base of knowledge about the ecology of high-altitude habitats, accumulated over decades of research. The combination of a deeply understood place, tools for further investigation, and outstanding people makes the RMBL an ideal training ground for the next generation of leaders in education and research in the field sciences.

Ecology of Place (Billick and Price, In Press)

Sustained investigation of ecosystems in Gunnison Basin

Long-term projects

- Stream Insects
- Avalanches
- Phenology
- Marmots
- Plant-pollinators
- Butterflies
- Burying beetles and small mammals
- Climate warming experiment

Climate Change

Warming Experiment

Experimental design

- 10 3 m x 3 m plots
- Heated through overhead radiators

"Climate manipulation"

- Accelerates snowmelt date 4-15 days
- Raises soil temperature up to 3 degrees C
- Drops soil moisture up to 25% of existing levels
- Existing vegetation has big effect on soil response (Harte and Torn 1995)

Effects on plants

- Decrease in showy wildflowers, increase in shrubs, mechanism is soil moisture (Harte and Shaw 1995)
- Flowering time will advance up to 11 days for every two weeks of earlier snowmelt or for every increase in average spring temperature/growing season temp (Dunne et al 2003)
- Flowering time of some species not effected and late-flowering species less sensitive (Dunne et al. 2003)
- Impact on flowering time not mediated by soil moisture (Dunne et al. 2003)

- Investment in reproductive effort depends upon species (Lambrecht et al. 2007)

Effects on herbivores

- Plants in warmed plots had more damage and were attacked by more species (Roy et al. 2004)
- Some herbivores performed better in cooler plots (Roy et al. 2004)
- Warming had no effect on aphids (Adler et al. 2007)

Impacts on Carbon Stocks

- Contrary to expectations associated with increased soil respiration, over 10 years carbon stocks decreased 8.5%, mechanism is increase in low-productivity species and decrease in highly productive species (Saleska et al. 2002)
- Long-term loss should be reversed because less productive species break down more slowly in soil and lead to longer carbon storage (Saleska et al. 2002)

<u>Other Climate-Change Related Studies</u>

Climate Responses

- Climate reconstruction over the last 5,000 years indicates that Gunnison Basin will seem some changes that are idiosyncratic to the Basin (Refsnider and Brugger 2007)

Plant Responses

- Lodgepole pine increases productivity in response to warmer temperatures and earlier snowmelt (Kueppers and Harte 2005, Perkins 2005*)
- Engleman spruce insensitive to changes in temperature and snowmelt (Kueppers and Harte 2005)
- Subalpine fir responds to drought in different ways at different sites (Valentovich 2006*)

Insect Responses

- Long-term data indicate mayfly emergence driven by peak flow and water temperature, experiments indicate temperature is driving factor. If relationship between flow and temperature changes, there will be impacts on population densities and distributions (Harper and Peckarsky 2006)
- Over 30+ years at a given site, there is an increase in some low-elevation bee (*Bombus*) species and decrease in high elevation bee species. Other *Bombus* and *Psithyrus* spp. show no changes (Miller 2007*)
- Mosquito species moving up in elevation which will affect disease distribution (anecdotal obs.)

Carbon Stocks

- Drought leads to decline in soil carbon stocks mediated by reduction in productivity (potential long-term increase) (Harte et al. 2005)
- Subalpine forests will put more carbon into atmosphere with warming (Kueppers and Harte 2005)

General Conclusions

Making species- and site-specific predictions will be tough

- Not surprisingly there will be strong context dependency in abiotic responses to warming, from microclimatic to regional scales
- There will be multiple pathways by which changes in abiotic environment will affect species (e.g., temperature, soil moisture)
- There will be many species specific effects, and some species may respond in different ways in different locations

Increasing variability in correlations of abiotic factors will be a problem

- Insects and plants use different cues in emergence and that can cause problems for pollinations systems as well as changes in distributions of butterflies (e.g., Carey 1994)
- There can be non-intuitive responses to increasing temperatures such as mayflies
- May affect marmots (e.g., snowpack and temperature)

Long-term responses may be quite different than short-term responses

- High elevation species tend to be long-lived, establishment is often critical life history phase

For the Future

We need to maintain investment in sustained, place-based investigations

- Without an understanding of the fundamentals of ecosystems, we'll be limited in our ability to address applied questions
- Maintain long-term studies, particularly repeated sampling
- Integrate remote and distributed sensors with field work
- NSF spends about $130 million on fundamental research in ecology and evolutionary biology

We need to bring management of field data into modern age of communication

- We need to aggressively find, document, and archive historical data
- Given explosion in technology, we need to comprehensively manage environmental sensing data
- We need to develop user interfaces that facilitate connecting disparate pieces of information
- We need to use technology to change the incentive structure that determines whether information is archived

Predicting the future

- As we downscale climate models, it is becoming possible to understand in amazing detail how species will respond (e.g., Colias butterflies)
- Amazing tools are being developed (e.g., ability to reconstruct changes in snow/water budgets from isotopes)
- We need better Digital Elevation Models (Lidar) for Gunnison Basin
- We need good, long-term data on basic abiotic parameters (RMBLnet)

References (*denotes unpublished works)

Additional references and PDF's can be found at http://www.rmbl.org/publications/search.php

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