Meadow Warming Experiment

Grading Key - Worth 15 pts

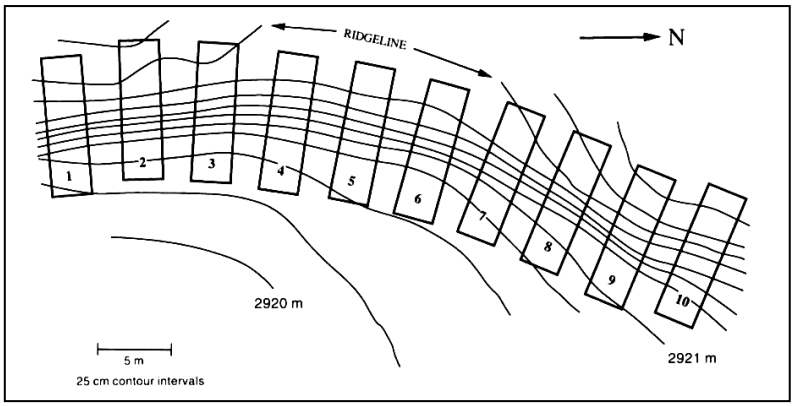
http://www.digitalrmbl.org/p120.php?pageID=127

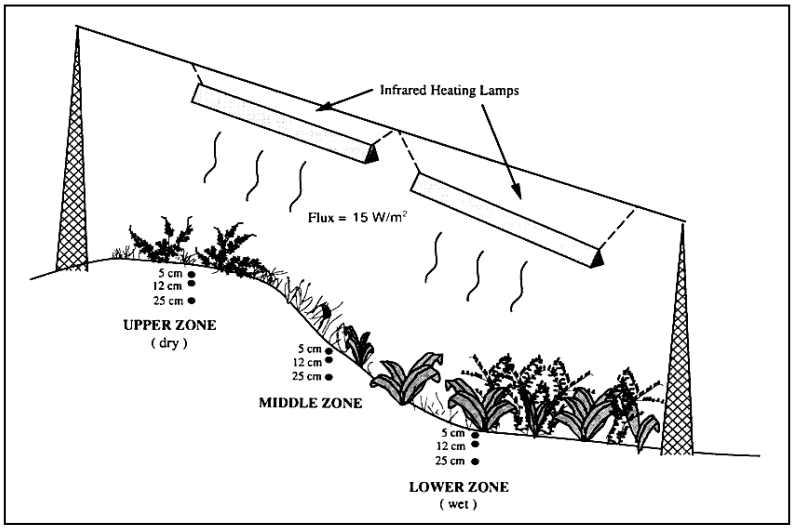
*When you click on the link above, you will be taken to a page called 'The Warming Meadow Experiment' on the **Design** tab of the Digital RMBL website. You will see essentially the same information as on this page.*

Since 1990, John Harte and his students and colleagues have been studying the effects of climate warming on a subalpine meadow in Gothic CO, called the "warming meadow". In the warming meadow, suspended heaters artificially warm subalpine meadow plots allowing direct observation of biotic and abiotic responses to additional energy inputs. This long-term experiment provides a means of discovering the actual mechanisms governing ecosystem responses to climate warming.

Warming Meadow Experimental Design

Ten 3x10 m plots are located on an east to southeast facing glacial moraine, with their long dimension parallel to the hill slope. Control and experimental plots alternate and are separated by a 3 m gap to ensure that control plots are not affected by the warming experiment. Electric heaters are suspended 2.5 m above experimental plots from steel cables attached to steel towers at the corners of the plots. The electric heaters provide uniform heating (22 watts per square meter) to simulate warming predicted due to doubled atmospheric carbon dioxide levels. Heaters have been turned on, day and night, year-round since 1990.





Based on slope, vegetative cover, and soil properties, each plot is divided into upper (U), middle (M), and lower (L) zones. Zones U and M are relatively dry and sparsely vegetated; zone U is much less steep than zone M, which has an average slope of 15 degrees. Zone L is relatively flat and lush; its soils tend to be moist because surface water collects in this part of the landscape.

To extend the findings in the warming meadow to natural systems, Dr. Harte and his colleagues also observe climate-ecosystem patterns across natural ecological and climate gradients, and model systems using mathematical relationships. Gradient studies and mathematical models allow researchers to scale up mechanisms and implications from plot to landscape scale.

Description of the Dataset

Because the warming meadow experiment is conducted outside in the open system of the natural world instead of in a closed laboratory setting, abiotic factors such as temperature and precipitation vary within each growing season and from year to year.

Aboveground Carbon (Vegetation and Litter)
Aboveground biomass is a combination of two measures. First, the amount of vegetation is measured by visually estimating how much of the plot is covered by shrubs, forbs, and grasses. This measure is combined with the amount of plant litter in the plot, measured by collecting and weighing (oven-dried) litter. Why do you think the litter is dried before weighing?

Soil Carbon
Four soil cores are taken from each plot, twice each growing season (June and August) in the same area as aboveground carbon measurements. Soil organic carbon is estimated by measuring soil mass before and after 'burning' the sample in an oven - the mass lost as a result of combustion is the soil carbon.

Snowmelt Date
The snowmelt date for each plot is estimated from soil temperature and soil moisture data. Direct observations of snow melt date are not necessary - snow-free conditions are usually marked by a sharp increase in soil temperature at 5 cm.

Hypothesis Testing

Now that you have read about the experimental design and the dataset, think of a question that you could test with the data. The question should be stated in the form of "IF (something is true), and we run the meadow warming experiment, THEN (what do you predict will happen?)"

1. What is your IF…THEN question? What is your hypothesis? What is your prediction?

Some trends that could be tested:

- The heated plots have earlier snow melt dates than the control plots.
- Soil carbon is lower in the heated plots than the control plots, except at the beginning of the experiment.
- In general, the heated plots have less forbs and more shrub biomass.
- The control plots show the opposite relationship, with more forbs and less shrub biomass.

Meadow Warming Experiment – Data

*To look at the raw data and visualize it as graphs, click the **Data** link: http://www.digitalrmbl.org/p121.php*

*To explore the data, click on the **Explore** link:* http://rmbl.info/rockymountainbiolab/rdc/rdc_warming_data.html

Peruse the dataset on this tab and look for trends and patterns to test the prediction of your hypothesis. Now open up the Excel file with all the raw data from the meadow warming experiment, then create graphs for each dataset to explore the data.

Test Your Prediction

2. **Explain how the dataset either supports or fails to support your prediction. Why do you think that is?**

Year-to-Year Variations

You may notice that in some years, there is a larger difference in melt date between control and heated plots. Or that soil carbon values are very similar in some years, even between the control and heated plots.

3. What could cause those differences or similarities? What varies from year to year?

Remember, this experiment is not conducted in a laboratory setting, but is a manipulation of natural conditions. For example, the summer of 2003 was much drier than average throughout the southwestern US, as seen in the maps from the Drought Monitor Archives (see website).

4. How might changing abiotic conditions, like temperature or amount and timing of precipitation, affect conditions in the control and heated plots?

5. Did the 2003 drought affect the area around RMBL? How might drought impact the warming meadow? What other environmental events, besides drought, might play a role?