How Many Moose Can An Island Hold?
Climate Change and Isle Royale

Audience

High school science (possibly environmental science).

Goal

Students will understand how climate change could affect Isle Royale, specifically with respect to the moose-wolf relationship.

Objectives

At the completion of this lesson students will be able to:

1. Define biome shift. Describe how forest and soil types are related to regional climate and how, if global climate change occurs, a change in the forest and soil types follows.
2. Describe some of the resulting effects of biome shift on moose.
3. Describe how changes to moose population feed back to changes in plant community and affects fire regime.

Procedure

I. DISCUSSION

Begin the lesson with a brief discussion of climate change, some possible factors leading to accelerate climate change, and some possible results of climate change. This will serve as an introduction to the effects of climate change on Isle Royale.

A. Climate Change:

1. Define climate change
2 Discuss factors that possibly lead to accelerate climate change, such as:
    a. Emission of greenhouse gases (water, CO_2, CFCs, methane), development of ozone, and how the ozone layer prevents the escape of heat
    b. Decreased albedo effect (not enough ice to reflect radiant heat)
3. Describe magnitude and direction of change and give examples.
    a. Changes in precipitation patterns (snow accumulation and duration)
    c. More severe storms, less frequent in occurrence
    c. Changes in air temperature
    d. Changes in water temperature (Lake Superior)

After the introductory discussion about climate change discuss how climate change could specifically affect Isle Royale. The idea is to follow the general chain of Water Level - Air

Temperature/Water Temperature - Plant Community - Moose/Wolves (feedback loops) *to simplify discussion of the broad topics below.*

B. How might climate change affect Isle Royale.

1. Describe the changes that occur because of a rise in water temperature of Lake Superior.
    a. plant communities - decline/loss of arctic disjuncts such as devil's club, Saxifrage
    b. fish species - loss of coaster brook trout
2. Define biome shift. Describe how forest and soil types are related to regional climate and how, if global climate change occurs, a change in the forest and soil types follows.
    a. This is a long-term change.
    b. Decrease in area and extent of boreal forest type, soils become less acidic.
    c. Increase of sugar maple and yellow birch because northern hardwoods are favored by warmer temperatures
    d. Decrease of balsam fir, spruce, Lycopodia, mosses
3. Describe some of the resulting effects on moose
    a. Warmer temperature favor winter ticks
    b. Change in plant community changes moose diet (and vice versa – forest community changes as moose population declines)
    c. Rising air temperature changes moose activity patterns (thermoregulation)
    d. Potential decline of moose will affect wolf population (change in diet and potential decline)

II. PRESENTATIONS

1. Biome shift – Show photos (differences in seasonal gestalt), vegetation maps (current).
2. Computer modeling that shows differences in moose, ticks, and plants based on a series of environmental conditions that are entered. Or use a felt board with images (moose, wolves, ticks) that are moved based on the changing conditions (T increases by 1 step, moose decrease by 2 steps). How can we predict the conditions that will cause the disappearance of moose or wolves or balsam fir through modeling, using the simplified numbers above?

III. ACTIVITIES

1. Use a current description of Isle Royale habitats as a starting point and draw on a blank map what you think the habitat would look like based on a given set of conditions.
2. "How Many Moose Can An Island Hold?" (adapted from Project Wild's "Carrying Capacity" activity). This activity will help students understand habitat, limiting factors, and how changes in habitat affect carrying capacity. This activity is attached.

Assessment

Have students work in small groups to create a poster describing at least one aspect of how climate change might affect Isle Royale National Park.

Wisconsin Model Academic Standards addressed in this activity:

A. *Science Connections* 12.1, 12.3, 12.5, 12.6, 12.7
Students in Wisconsin will understand that there are unifying themes: systems, order, organization, and interactions; evidence, models, and explanations; constancy, change, and measurement; evolution, equilibrium, and energy; form and function among scientific disciplines.

B. *Nature of Science* 12.4, 12.5
Students in Wisconsin will understand that science is ongoing and inventive, and that scientific understandings have changed over time as new evidence is found.

C. *Science Inquiry* 12.1, 12.5
Students in Wisconsin will investigate questions using scientific methods and tools, revise their personal understanding to accommodate knowledge, and communicate these understandings to others.

F. *Life and Environmental Science* 12.6, 12.7, 12.8, 12.9
Students in Wisconsin will demonstrate an understanding of the characteristics and structures of living things, the processes of life, and how living things interact with one another and their environment.

G. *Science Applications* 12.2, 12.3, 12.4
Students in Wisconsin will demonstrate an understanding of the relationship between science and technology and the ways in which that relationship influences human activities.

H. *Science in Social and Personal Perspectives* 12.1, 12.5
Students in Wisconsin will use scientific information and skills to make decisions about themselves, Wisconsin, and the world in which they live.

Reference Index

Teachers may find the following papers and websites useful in supplying graphics for classroom discussion. Some may be suitable for student reading assignments.

Research Papers

Austin, J.A., and S.M. Colman. 2007. Lake Superior summer water temperatures are increasing more rapidly than regional air temperatures: A positive ice-albedo feedback. Geophysical Research Letters 34, L06604. Online:
Gives a good account of what is actually happening to Superior lately, with reasons for the importance of winter ice cover and the effects on air and water temperatures.

Davis, M., C. Douglas, R. Calcote, K.L. Cole, M.G. Winkler, and R. Flakne. 2000. Holocene climate in the western Great Lakes national parks and lakeshores: Implications for future climate change. Conservation Biology 14: 968-983.

Talks about prehistoric climate changes in the region, which might help inform us regarding future changes and what factors are important.

Egan, A. 2008. Gypsy moth trapping survey, Isle Royale National Park, Michigan. Resource Management Report 08-3. National Park Service files, Houghton, MI.
Includes some information that could help illustrate why climate change will increase invasive species, which often drive negative trends in native species. In this case, a large part of this is due to extreme vegetation impacts and habitat changes as a result.

Magnuson, J.J., K.E. Webster, R.A. Assel, C.J. Bowser, P.J. Dillon, J.G. Eaton, H.E. Evans, E.J. Fee, R.I. Hall, L.R. Mortsch, D.W. Schindler, and F.H. Quinn. 1997. Potential effects of climate changes on aquatic systems: Laurentian Great Lakes and Precambrian shield region. Hydrological Processes 11: 825-871.
Gives great information on how climate change could affect large and small lakes in our region. The text is a bit much, but the abstract alone is a treasure of information.

Post, E., R.O. Peterson, N.C. Stenseth, and B.E. McLaren. 1999. Ecosystem consequences of wolf behavioural response to climate. Nature 401: 905-907.

Sell, S.M. 2007. Interactions between moose and their primary forage at Isle Royale National Park, Lake Superior. Ph.D. Dissertation, University of Minnesota, St. Paul.
Discusses Isle Royale moose, their browsing habits, and how climate change might be important.

Vucetich, J.A., and R.O. Peterson. 2004. The influence of top-down, bottom-up and abiotic factors on the moose (*Alces alces*) population of Isle Royale. Proceedings of the Royal Society of London **B** 271: 183-189.
Discusses the ecological relationships with moose, wolves, and climatic variables.

Websites

http://www.ndbc.noaa.gov/maps/WestGL_hist.shtml Historical weather data from Lake Superior buoys and light stations

http://www.ndbc.noaa.gov/station_history.php?station=roam4 Historical weather data for Station ROAM4 (Rock of Ages Lighthouse)

http://www.ndbc.noaa.gov/station_history.php?station=pilm4 Historical weather data for Station PILM4 (Passage Island Lighthouse)

http://www.ndbc.noaa.gov/station_history.php?station=45001 Historical weather data for Station 45001 - MID SUPERIOR (water surface buoy)

www.isleroyalewolf.org Isle Royale Wolf-Moose Study (wolf and moose population data)

http://web4.msue.msu.edu/mnfi/pub/abstracts.cfm#Communities Michigan Natural Features Inventory (plant community profiles)
A number of communities are found on Isle Royale, though only the Boreal Forest abstract mentions the island specifically. May want to select communities of interest based on island

vegetation map. Can use photos in abstracts to get an idea of what Isle Royale forests look like and how they could change based on climatic variables (i.e., shift from boreal to northern hardwoods).

http://biology.usgs.gov/npsveg/isro/images/isroveg_large.pdf Isle Royale Vegetation Map (large)

http://biology.usgs.gov/npsveg/isro/images/isroveg.pdf Isle Royale Vegetation Map (small)

Books

Linn, R.M. 1966. *Forests and Trees of Isle Royale National Park*.
Gives a good, very basic overview of island forests.

Murie, A. 1934. *The Moose of Isle Royale*.
Online at http://deepblue.lib.umich.edu/bitstream/2027.42/56270/1/MP025.pdf
See "Annotated List of Food Plants" on p. 32.

Peterson, Rolf O. *The Wolves of Isle Royale, A Broken Balance*

Shelton, Napier. *Superior Wilderness: Isle Royale National Park* (an updated version of *The Life of Isle Royale*)

Shelton, Napier. *The Life of Isle Royale*

Activity 2: *How Many Moose Can An Island Hold?*
(Adapted from "Carrying Capacity," by *Project Wild*)

This activity is based on Project Wild's activity titled "Carrying Capacity," but with a few small differences to account for conditions on Isle Royale. For example, Project Wild instructions involve dividing students into small groups, or "herds." Since in this case students will be acting as moose, which are not herd animals, skip this step.

The following are basic assumptions you can start with for moose and wolf food requirements:

1. An adult moose requires about 25 lbs of browse every day to survive; and
2. A pack of 5-6 wolves would have to make a kill about once a week.

Use poker chips to represent vegetative food resources that the moose (students) need to collect. Say that each poker chip represents 15 lbs of browse. In addition, have a smaller quantity of higher-quality resources (represented by different colored poker chips) which equal 25 lbs of browse. The ratio should be about 1 high-quality to 4 regular. Count out enough poker chips so that there are more than enough for everyone.

We will set one round of foraging to equal 3 days. Each student is acting as a moose who has to collect 75 lbs of food in each round. If a moose does not have sufficient food after a round, it will not survive.

Set the timing of each round so that not everyone can succeed (probably less than 1 minute, depending on number of students and size of foraging area). If possible, conduct the activity in a large open area (gymnasium or playing field), so you can spread the "food" out and students have to move around to get it. About a 40x40 foot area for 15-30 students is appropriate. Also make sure you require that students are walking, not running around, to collect food.

After every round, determine how many moose are still alive based on their foraging success. Have students keep track of how many moose survive each round, and how the population is changing. After each round re-scatter all the poker chips in the foraging area.

Add in some or all of these additional variables after playing the basic version in order to simulate the true complexity of the system. Also, discuss with students the pros and cons of this "model." How accurate/complete is it? What variables are missing and what effects would they have? For example: harsh winter weather, beaver as an alternate food source for wolves, winter ticks on moose, etc.

1) Introduce a pack of wolves (or two, depending on class size). Each wolf pack needs to kill one moose every three rounds. So, an additional one moose per pack dies after every three rounds, even though the student had collected the required amount of food. However, if the moose density is too low, the wolves have a harder time catching them.

So if there are fewer than five moose remaining at the end of the third round, the wolves go hungry. If the wolves are hungry for two weeks in a row, the pack dies.

2) Overbrowsing can reduce the amount of food available to the moose. After each round, determine how many of the high-quality poker chips were collected (i.e. "consumed"). When replacing the chips for the next round, put in only half the number of high-quality chips that were collected.

3) After a few rounds, add in the next generation of moose. In order for a moose to have enough energy to reproduce, they must consume even more than 75 lbs of food per round. If a student is able to collect 125 lbs of food or more in a round, they are able to reproduce. However, every moose needs a mate! So they can only reproduce if at least one other student has also collected 125 lbs of food. If the moose reproduce, a calf is born. Have a student who was eliminated earlier (for not collecting enough food) rejoin the game as the new calf, thus increasing the moose population. Since moose only mate once per year, the same students can't keep "reproducing" in consecutive rounds.

4) Climate change has caused the temperature to increase by a few degrees. How does this change things? Moose become heat-stressed and thus forage for fewer hours per day. The temperature increase has also changed the array of vegetation, so high-quality browse is less available. Remove the "high-quality" poker chips representing 25 lbs of food from the game. In addition, shorten the time allowed for foraging in each round. Does this eventually effect the wolf population?