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BIOE 342.30: Field Ecology

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Field Ecology – BIOL 342
Syllabus
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INTRODUCTION

Ecology is the study of biophysical controls on the distribution and abundance of biota, including human influences. The course provides detailed study and discussion of ecological phenomena including: behavior and life cycles of organisms; population, community and landscape dynamics; biodiversity and productivity; biophysical processes (e.g., climate change, nutrient cycles, herbivory, predator–prey interactions) and organization (e.g., genomes, ecosystems, biomes, ecoregions) across space (local to global) and time scales; and ecological economics and human ecology. Natural history observations and ecological principles are used to explain biological patterns, processes, responses and complex interactions as influenced by changing environmental conditions. Lectures build upon the laws of thermodynamics, evolution, trophic dynamics and other unifying principles to present ecology as a key discipline of the natural world and essential to human well being. This course is conducted outdoors regardless of weather, including all lectures and lab exercises, so those ecological phenomena can be examined in real time and real life. All day and over-night trips, mainly by foot, will be conducted throughout the course, taking students into the full range of aquatic and terrestrial environments near the Biological Station and the adjacent mountain areas, including Glacier National Park. Students are expected to take detailed notes and conduct directed measurements that will require analysis and interpretation through written and oral presentations and written reports edited by the instructors.

Learning outcomes: After taking this course students will be able to: 1) identify and describe the ecological processes that that determine the distribution and abundance of organisms and their ecosystems within the landscapes of the Northern Rockies; 2) to identify common plant and animal species of the Northern Rockies, 3) understand basic tenets of ecology, such as trophic dynamics, evolution, life history energy balance, competition and habitat-niche relationships; 4) apply experimental designs and systems thinking to test hypotheses and build conceptual modes of biophysical processes that define ecology as a discipline; and, 5) understand the vitally important role of ecology in sustaining ecosystem services that influence human well-being.

Prerequisites: College level biology and mathematics.

TEXTS

Molles Jr., M. C. 2008. Ecology: Concepts and Applications (4th Edition). WCB/McGraw-Hill Publishers, New York, NY. ISBN 0072439696 Paper Back; ISBN 0072439696 Hardback

Kershaw, L., A. MacKinnon and J. Pojar. 1998 or newest. Plants of the Rocky Mountains. Lone Pine Field Guide. Lone Pine Publishing, Renton, WA. ISBN 155105088-9

Wilson, E. O. 2003. The Future of Life. Vintage Books, Division of Random House, Inc., New York, NY.

Electronic copies of supplementary reference materials will be provided by the professor and FLBS.

EXAMS AND GRADING

- Participation in class work and discussion – 10%
- Quality of 4 data analysis assignments, each with written reports – 30%
- Research project. This is a 5–10 page written report and oral presentation about some ecological interaction or phenomenon quantified independently by the student during the course – 30% (note that 50% of the final grade is determined by written reports that students complete independently using data collected in class or independently in accordance with instructions in handouts or by interaction with Dr. J).
- Final exam (essay-type, take home) – 30%

BRING YOUR LAPTOP COMPUTER – all materials are digital.

APPROACH AND PHILOSOPHY

The goal in this class is for students to thoroughly understand ecology in a functional process context through observation and directed analyses in the Crown of the Continent Ecosystem. We will learn common plants and animals of this region, how they interact along complex biophysical gradients and how ecosystems like this one provide goods and services that are essential to human well being.

Please note – the course is taught entirely outside, regardless of weather, Monday through Thursday, often using 10 hours or more per day. We will hike some every day and on some days we will hike all day, studying ecology as we go. Students must be prepared. If you are absolutely certain that you can hike at least 10 miles in the mountains with a light pack in a day, you will really enjoy this course. If you are not sure of your hiking skills in the rough terrain of mountain landscapes, but you like to exercise and are really committed to learning Ecology in this marvelous field setting, Dr. J will teach you how to enjoy hiking as a part of the ecological experience. Dr. J has done so with many students over the years. But, you must be willing to try to keep up with the old professor and the rest of the class as we foray into the woods, grasslands, streams and mountains.

Analysis and writing assignments based on in-class data collection:
Each student is required to complete directed analysis of data collected by the class and produce written reports. The instructors will evaluate and discuss reports with each student to improve writing skills. So, special attention is paid to how reports are prepared. All reports should generally follow formatting for the journal *Ecology*. See Moodle Day 1 for a link to the *Ecology* webpage with instructions for authors. In short, include a title, a short abstract less than 150 words, Introduction, Methods, Results, Discussion, Literature Cited, Tables and Figures. The results section will include graphical presentation of the analyses and statistical interpretation of the data. Handouts are provided in electronic format on Moodle with information on how to conduct the work and with questions that should be addressed in the write up. The objective of these reports is to introduce the student to scientific method in ecology, proper approaches to data collection and analysis and conduct of scientific writing. Reports typically are 3–5 pages in length, including graphics.

Report 1. Analysis of small mammal plot trapping (mark-recapture)
Report 2. Analysis of thermal stratification in Flathead Lake.
Report 3. Analysis of lodgepole pine regeneration following wildfires.
Report 4. Analysis of physical data and macroinvertebrates sampled in different streams

Projects:
Each student is required to conduct an independent research project on an ecological phenomenon. The project may be observational or experimental, but must be empirical. A written proposal or study plan approved by the instructors is required prior to conduct of the study, by the end of week one (prior to start of Field Day 5). Draft project reports are due prior to the start of the first day of the 4th week of the

course. Example reports from previous classes are available for perusal on the Moodle course interface under Day 1. Dr. J will edit the reports and return them to the student for revision. Final reports are due on the last day of the course when each student also will make a PowerPoint presentation to the class describing his/her project in scientific terms. The purpose of independent projects is to provide hands-on experience in planning, conducting and conveying ecological research.

Outside of Class:

Use Friday–Sunday periods to read, review and work on assignments and projects. You cannot do well in this course without reading the text cover to cover as fast as possible. We will cover all the major topics in the book during the first two weeks and then reinforce them by repeatedly revisiting concepts and processes as we encounter them during our field day jaunts. Students are expected to take notes in the field, make directed measures (focused field studies) and in the evenings work in groups to analyze and present the data (group work products). Some of the focused field data will be analyzed individually and presented to the professor as written reports.

Hiking on the off days is encouraged because there is so much to see around FLBS, but conduct your trips in the context of the course content.

Use of Wireless Internet at FLBS:

The Ecology Lab and Cabins B–E are equipped with a secure wireless connection to the Internet. The FLBS cybertech will provide instructions for connecting your laptop computer to the wireless network. An online learning interface (Moodle) is used to provide electronic versions of many of the course assignments and supplementary readings for the Field Ecology course. This site will allow you to correspond with the professors on reports and tests, and will provide for the electronic sharing of data, photos and other information with the entire class. Class assignments are also posted on the Moodle site and all assignments are to be submitted to Moodle. Links are provided with assignment instructions and for assignment submission. Additionally, each student has a UM email address that will be used to communicate with the professors during the course. Your login name is your first name and last name followed by umontana.edu. For example, John Smith is john.smith@umontana.edu. To login to Moodle you will need a net login ID. See Jeremy for your login ID and initial password (we will meet with him at 8:15am the first day of class). Use the internet, especially Google Scholar for report resources.

COURSE SCHEDULE AND PRIMARY TOPICS

We follow this schedule rain or shine; topics may vary depending on what we encounter in the field. It is up to the student to elaborate understanding by reading the text book.

Week One:

Field Day 1 – Introduction to processes controlling biodiversity: the Bio Station forest and Flathead Lake from the shoreline.

Today we will learn the difference between natural history and ecology with emphasis on what is meant by biodiversity and how to measure it along biophysical gradients. Context with evolution and life history energy balances is also fundamentally important. We will also learn about using capture-mark-recapture methods to estimate population sizes.

- Defining ecology in a natural-cultural context.
- Natural history: life on land and water, biodiversity and its attributes.
- Unifying principles in ecology: thermodynamics, evolution, trophic dynamics, others.

Focused field studies:

a. Introduction to plant communities – characterizing the lakeside forest and discussion of disturbance (blowdown) and management options.
b. Recognizing and documenting ecological gradients (e.g., microclimates).c. ecology and reproduction of bald eagles and ospreys.
c. Field exercise in capture-mark-recapture – small mammal trapping on the biostation grounds. This work has to be carefully supervised because some of the rodents carry a virus that can infect humans, although the risk is very low. See documents on Moodle for additional details.
d. Extra reading assignment 1. Hall, C. A. S., J. A. Stanford, and F. R. Hauer. 1992. The distribution and abundance of organisms as a consequence of energy balances along multiple environmental gradients. Oikos **65**:377–390.

Independent work products:
1. Distribution of trees and shrubs (point/quarter method, see handout) in the FLBS forest in relation to localized moisture and temperature gradients (see weather station data).
2. Independent study of tree and shrub identification – Dr. J will quiz each student in the 2nd week of the class on woody plant identification; you must learn the local flora.

Field Day 2 –Intermountain hill slope forests and stream ecology: Bear Trap Mountain Trek
Today we will study the distribution of trees and shrubs along the moisture and temperature gradient from lake shore to top of Bear Trap Mountain. As we hike from FLBS up the mountain we will periodically stop and use the point-quarter method to determine density by species of the vegetation along the gradient. Weather stations are maintained at various points along the way. These stations provide data that allow each student to plot distribution and abundance vegetation in relation to precipitation and temperature. Archival data from the weather stations will be available on the Moodle class site.

- Biophysical influences on life cycles: temperature - the master variable- dynamics of water and nutrients; aquatic-terrestrial linkages.
- Drivers of plant and animal dispersal
- Human influences: effects of clear cut logging.
- Wildlife management in forest settings.

Focused Field Studies:
a. Mark-recapture trapping on the FLBS mammal plot
b. Controls on altitudinal distribution of woody vegetation.
c. Efficacy of logging practices and influences on forest succession, runoff patterns and stream biogeochemistry.

Field Day 3- Biostation grounds – Stream ecology I and BioStation birds and mammals
Today we will begin learning about populations of animals and plants, how they move around, their interactions and how they play into food webs. We will continue to set traps on a sampling grid as an example of how to census animals using mark and recapture techniques in addition to observation. We will contrast populations in streams and in forest settings. We will learn the fundamentals of stream ecology, sample macroinvertebrates in two streams with different characteristics, and measure physical characteristics of Roy's Creek along a gradient from where it originates to its outlet at the lakeshore.

- The physical basis of stream networks, role of flow and temperature
- Biophysical organization and trophic interactions
- Wildlife of the Crown of the Continent Ecosystem
- Animal adaptations to environmental variation, relationship to life histories
- Why do animals migrate? How do they navigate?
- Distribution and abundance of small mammals – the FLBS mammal plot (mark recapture sampling)

Focused field studies:
a. Mark recapture study of the Bio Station mammal plot
b. Major insect (trophic) groups of Roy's and Yellow Bay Creeks determined by benthos sampling comparative food webs (how does presence of fish influence food web structure?).
c. Patterns in temperature, conductivity, and upwelling/downwelling in Roy's Creek
d. Animal skulls and skins – understanding adaptations to environmental variation – skin and skull preparation techniques.
e. Summer birds of the Bio Station – identification from calls; breeding behaviors; migration

Individual work Products
Report 1. Abundance of small mammals. Today we finished trapping small mammals on the biostation small mammal plot. Historical data and instructions have been provided on the Moodle class site. Use the new 2013 class data to estimate population sizes of all small mammals captured on the small mammal plot. Also, compare populations to last year and examine long term data from this site. Determine the influence of the stand change caused by blow down in 2008. How has the mammal population changed? This report is due at the end of week one (before the start of Field Day 5).

Field Day 4- Agroecosystems: Lake Farm
Today we will learn how a family farm is operated using state-of-the-art practices in growing seed potatoes. The lesson is about how food is produced in mass quantities to feed the burgeoning human population of the world.

- Potato production: maximum sustained yield farming and feeding the masses
- Plant cloning and genetic engineering
- Pest control: biocontrol and other alternatives to pesticides and herbicides
- "Organic" farming alternatives
- Food production and distribution and energy consumption: how are we going to feed all those people?

Focused field study:
a. Determine incidence of wasp parasites in cereal leaf beetles in the insectivory.
b. Document the sequence of events in the production of potatoes from initial virus-free clone to fries and chips on the market.
c. Your thoughts on farming, could we do it differently?

Evening: Anima mundi DVD presentation; discussion of biodiversity – Dr. J's house
*Friday-Sunday: Reading, updating notebooks, finish Report #1 Due Monday Field Day 5 by 8am, Plan independent project (*including a written proposal due Monday Field Day 5, by 8am).*

Week Two:

Field Day 5 - Limnology of glacial lakes: Flathead Lake on the Jessie B
Today we will learn the biophysical dynamics of lakes with emphasis on how lake biota respond to increased nutrient loading and cascading interactions caused by invasions of non-native biota.

- Formation of lake basins and the physical properties of water and lakes
- Primary production and energy flow
- Lake trophic structure
- Invasion ecology
- Importance of long-term data in ecology: clean water and watershed landscape change

- CO_2 flux in lakes and global climate change
- Living by the lake: environmental laws and protecting, sustaining and conserving water quality

Focused field study:
a. Limnological methods – gathering long term data that describe biophysical dynamics in the lake.
b. Measure secchi depth and obtain depth profiles of temperature, dissolved oxygen, specific conductance and pH, collect net hauls for on-boat examination of phyto- and zooplankton.
c. Extra reading assignment 3: Ellis et al., 2011. Cascading trophic interactions in a large oligotrophic lake. Paper published in the Proceedings of the National Academy of Science.

Individual work products:
Report 2. Limnology of Flathead Lake. Obtain the data from water column profiles collected today along with historical data. Plot today's data to show the vertical profiles using the graphics program. Produce an isopleth plot of annual temperatures in relation to depth using the Surfer program. The Surfer program is loaded on the laptop located in the Ecology classroom. Include your plots in a report that discusses the thermal properties of Flathead Lake. Included in your report a short description of how you would determine the thermal and nutrient budgets for the lake and describe the generalized trophic structure of the lake based on class lectures. This report is due before the start of class tomorrow (Field day 6).

Field Day 6 - Forest Fire Ecology – Red Bench, Moose Fire areas –
Today we will learn how forest fires create landscape patches that increase biodiversity through initiation of succession and release of plant available nutrients that increases productivity in relation to old growth systems. Climate of course is a driver of wet and dry cycles wherein plant biomass is produced and subsequently burned. Many of the forest plants and animals are uniquely adapted to fire.

- Disturbance ecology – beetle epidemics and stand replacing fires
- Nutrient cycling and retention
- Adaptation to fire: life cycle of lodge pole pine
- Succession and stability in fire ecosystems: shifting patch mosaics in landscape ecology
- Climate variability and plant distributions: greenhouse gasses and global warming

Focused field study:
a. Plant succession after fire - the Hidden Meadow plots – measuring tree growth and density using point-quarter transects and plots. Students will set up transects and plots and measure diameter of trees at breast height, recording all data for inclusion in an electronic data base. At least 10 trees will be aged by coring to establish a dbh-age relationship for the stand.
b. Hidden Meadow – how is the meadow environment sustained as a patch in the lodgepole fire forest? How did the lake form? Make a sketch of the patch mosaic of the meadow-forest landscape. Note the ground squirrel colony, their behavior in foraging and communication.
c. The ancient Douglas fir – a sentinel tree.
d. Role of mountain pine beetle in the fire cycle – related or not?
Camp at the FLBS Nyack Research Natural Area – campfire review

Field Day 7 - Mountain-side forests and the subalpine: Rescue Creek Basin trek
Today we learn about how plants and animals take advantage of temperature and moisture gradients from river bottoms through the subalpine zones. Disturbances to the landscape by wind, fire, and avalanches will be quite evident**.**

- Species interactions and community structure
- Altitudinal zonation of forest community types
- Spatial ecology of grizzly bears and ground squirrels – ecological engineers

- Mutualism and role of mycorrizal fungi

Focused field study:
a. Causes and consequences of disturbance at different scales and in different settings from valley bottom to the subalpine
b. Structure of subalpine forests

Independent work products:
Report 3. Plot the age-dbh data for Hidden Meadow (day 6) and determine if the relationship is statistically significant. What can you say about year to year variation in growth of the trees from the cores? From the electronic spread sheet from Moodle, plot the density by species relationship for transects versus plots. Is there any statistical difference between the two measurement methods? Plot historical data for the Hidden Meadow site in relation to data obtained this year. Does the dbh data over time accurately measure growth of the trees since the fire? Is the stand gradually thinning? Discuss the data in relation to the life cycle of lodgepole and larch. This report is due on Monday before the start of class (Field Day 9).

Field Day 8 – Intermountain prairie grasslands I – Native Grassland Plot; National Bison Range and Duckhaven Research Natural Area.
Today we visit the intermountain prairie landscapes of the Mission Valley to contrast the biota of grasslands with the forest and stream systems studied so far. Most of the native grassland has been plowed into agriculture but the National Bison Range remains in a native state. The Duckhaven Research Natural Area was plowed and farmed for 50 years but for the last 20 years it has been fallowed is referred to as an old field system. Of main interest today is the way in which non-native plants been able to out compete the natives.

- Competition, herbivory and predation in the native grasslands and influence of invading weeds – facilitation in plant ecology
- Population ecology: dynamics, energy budgets, genetic variation, isolating mechanisms. On-the-spot examples: bitterroots, pronghorn and bison.
- Life Histories – energy balance and behavior (more on competition, herbivory, predation)
- Problem of scale in ecology

Focused field study:
a. Black bird ecology in pothole ponds - life history, population dynamics, foraging behavior, inter- and intra-specific competition for nest sites and outcomes, predators and behavioral adaptations that reduce predation, migration.
b. Elements of prairie ecosystems – geology, soils, grasses, forbs, pothole ponds, groundwater.
c. Functional processes in prairie ecosystems – herbivory (voles, bison), nutrient cycling, predation, soil formation, habitat mosaics, role of disturbances such as fire, drought, invasive plants and grasshopper outbreaks.
d. Trumpeter swan behavior, reproduction, signet care, habitat, historical migrations
e. Bison behavior and life cycle – why the big head and shoulders?
f. Riparian corridors of Post and Mission Creeks as seen from Bison Range;
g. Invasive weeds – why are the so successful; efficacy of biological controls and herbicides.
h. Extra reading assignment 2: Callaway, R. M., and E. T. Aschehoug. 2000. Invasive plants versus their new and old neighbors: a mechanism for exotic invasion. Science **290**:521–523.
i. *Evening review and discussion of the Wilson book at Dr. J's house.*

Week Three: **–** We have covered the basics, now to elaborate and reinforce them!!!

Field Day 9 – Stream ecology and old field succession

Today we return to Duckhaven to work on native plant restoration plots and to continue our discussion of how populations are sustained through time. If the water levels are not too high we will contrast the ecology of Crow Creek: where it emerges from the mountain front versus its course through the old field and ag landscapes of the valley bottom - to get a sense of how the biophysical conditions and benthic macroinvertebrates change spatially in relation to landscape type. We will also sample the fish community in Crow Creek within the valley bottom.

- More on Population dynamics – growth and reproduction – use of life tables, stock-recruitment models
- Old field succession at Duckhaven: native versus nonnative plants, influences on grassland structure
- Stream trophic structure: comparing mountain and prairie reaches of Crow Creek; factors that influence trophic structure, theories of temporal and spatial change in river ecology
- Biofuel from old field ecosystems – does it work? Is it cost effective? Role in climate change
- Use of population data in wildlife and fisheries management

Focused field study

a. Conduct stream surveys in mountain and prairie reaches of Crow Creek: biomass per unit area; index of biotic integrity and electro-fishing to determine fish density.

Independent work products:

Report 4. List species collected from Roy's Creek and the two different sections of Crow Creek (mountain vs. prairie) and prepare comparison plots per the handout that describes how to calculate the various metrics and conduct statistical tests. Were there significant differences between the three sites in species composition and density? What do differences in the EPT taxa tell us about water quality at the different sites? What are the main differences in taxa between the two Crow Creek reaches? Are there some taxa found only in the mountainous reach and what adaptations do they have to live in that type of habitat (check out Merrit and Cummins). This report is due tomorrow before class (Field Day 10).

***Field Day 10 – Front Range landscape ecology – Firebrand Pass trek* – camp at Nyack**

Today we learn how plants and animals adapt to the extreme conditions of the subalpine and alpine zones, where wind and cold are prime controlling variables.

- Climate variability: drivers of rain shadows and glacier advance/retreat
- Succession and stability in relation to landscape forming processes: plate tectonics, climate variability, wind, water, glaciation, soil formation, fire, herbivory, nutrient cycling and retention
- C, N and P generation and transformation in relation to hydrologic cycle
- Herbivory in a landscape and life history energy balance context: grasshoppers, beavers, elk, bighorn sheep, mountain goats
- Altitude and latitude – influences on adaptation

Focused field study:

a. Measure body size and shape changes along the altitudinal gradient - grasshoppers and willows
b. Note distribution of rock types through the Lewis Overthrust unconformity: fossils and bedrock chemistry.
c. Animal behavior – observe habits of wildlife encountered

***Field Day 11 – Alpine ecology – Siyeh Pass Trek* – 6:00 AM departure from Nyack**

Today we continue with lessons in alpine ecology but also learn about predator-prey relationships. With luck we will see mountain sheep and goats and learn about their adaptations to life in the high mountains and how they avoid predation by lions and bears. We will also learn about the life history of a quintessential alpine resident, the wolverine and its primary prey, the hoary marmot.

- Adaptation for life in extreme environments: life history strategies of alpine biota
- Ecology of an alpine fen: nutrient cycling and retention at the top of the geohydrologic continuum, the N loss conundrum.
- Grizzly bear farming (large animal disturbance ecology) of glacier lilies: influence on nutrient cycling and retention.
- Pika and other rodents of the alpine: prey for wolverine, golden eagle and grizzly bears; examples of predator-prey cycles and associated ecosystem feedbacks.

Focused field study –

a. Note structural features and fire paths in the McDonald Creek Valley from Sun Road overlook b. Note plant colonization patterns in the alpine, especially rills of *Dryas*.
b. Extra reading assignment 4 – Tardiff, S. E., and J. A. Stanford. 1998. Grizzly bear digging: effects on subalpine meadow plants in relation to mineral nitrogen availability. Ecology **79**:2219–2228.

Camp again at Nyack – with campfire stories and lessons

Field Day 12 - Ecology of an alluvial flood plain – Nyack Research Natural Area –

Today we learn the form and function of rivers and their floodplains, the most biodiverse and also the most endangered landscapes on earth.

- Riverscapes: the shifting habitat mosaic of river ecosystems
- Groundwater ecology
- Nutrient cycles and retention in the floodplain ecosystem
- Adaptation and natural selection: cottonwood trees, boreal toads, brook trout and knapweed (flood plain invaders – how do they do it?); flood plain *Dryas* – competition with knapweed
- Multidisciplinary approaches for understanding biocomplexity in natural-cultural systems
- Conservation biology of the river corridor: cottonwoods as keystone species – flood plains as hotspots of biodiversity

Focused field study:

a. Use piezometers and specific conductance-temperature meters to demonstrate gw-sw interactions; sketch layout of flood plain habitats in context of surface and groundwater control.
b. Sketch primary succession of woody plants with focus on cottonwood recruitment and stand age in relation to river geomorphology and hydrology
c. Diagram boreal toad life history - spawning and rearing habitats and conditions - consider gene flow among populations of toads in alpine versus flood plains.

Extra reading assignment 5: Stanford, J. A., M. S. Lorang, and F. R. Hauer. 2005. The shifting habitat mosaic of river ecosystems. Verh. Internat. Verein. Limnol. **29**:123–136.

Independent work products: The 4 individual assignment reports must be completed by Tuesday, Field Day 10. **A rough draft of your project report is due before class starts on Field Day 13.

Week Four: - Project reports due!!

Today and tomorrow we will walk through all the landscapes and ecosystems studied in this course allowing all the aspects of ecology learned so far to be reviewed and synthesized.

Field Day 13 - Alpine ecology– Scenic Point, Two Medicine area GNP

- Alpine plant – animal interactions
- Viewing multiple biomes – biogeography and human history in the Crown of the Continent.
- Legacy of Native Americans: quality of life in an ecological context (how important is material wealth?)

Focused field studies
a. Drivers and interactive effects of white bark pine senescence, glacier retreat and timberline advance in GNP
b. Sub-alpine meadow ecology – why is plant diversity so high here?
Camp at Two Medicine – campfire review.

Independent work products: Rough draft of project reports due today before start of class (Field Day 13).

Field Day 14 - Prairie to the Sky – Dawson-Pitamakin Loop Trek
- Cells to ecosystems – the nature of ecology
- Landscape change at different scales of resolution
- Where to from here: applying ecology in everyday life

Focused field studies
a. Compare plant community types as we walk through the altitudinal gradient of the loop trail
b. Observe mountain sheep behavior
c. Ecology of alpine marmots – water conservation, family groups, hibernation, predators.
d. The glacial landscape, rain shadows and climate change.
Camp at Two Medicine – campfire review.

Field Day 15 - Ambrose Fen
This will be a brief visit to a unique environment for this part of the world but actually is quite like the boreal forests of the far north. The lesson will be about how the fen formed and its unique biota. The point is that all landscapes have unique ecosystems that have characteristics of other biomes, which adds complexity to landscapes and increases regional biodiversity.
- The ecological legacy of a sphagnum mat: sequestering primary production
- Sphagnum ecology and global carbon dynamics
- Adaptation to fen environment: bog birch, sundew, water shrews, fire flies
- Island biogeography: the fen in an island context
- Paleoecology: patterns, processes, legacies

Focused field studies
a. Whatever we encounter in the fen.
Afternoon available for completing project reports. Dr. J. will edit them and return for revisions.

Day 16 – last day –
1. Project presentations.
2. Project report revisions.
3. Final Exam.
7 PM – Goodbye Party at Dr. J's