Ecology of Managed Systems – ESPM 3108/5108 - DRAFT

Fall 2016

Course Meeting Location:	Green Hall 110
Days and Meeting Time:	Lecture: Tuesday, Thursday 8:45 AM – 10:00 AM Field Trip: Tuesday, Thursday 7:30-10:00 AM (3 times during semester)
Credit Hours:	3 credits
Course Prerequisites:	BIOL 1001, 1009, HORT 1001, or equivalent or permission of instructor
Course Instructors:	Mary Rogers Office: 438 Alderman Hall Telephone: 612-624-8871 Email: roge0168@umn.edu Office hours: 10:45 – 11:45 a.m. Tues. & Thurs. or by appointment Marcella Windmuller-Campione Office: 330 G Green Hall Telephone: 612-624-3699 Email: mwind@umn.edu Office hours: 2 – 4 p.m. Tues. or by appointment
Teaching Assistant:	Heidi Anderson Email: ande9063@umn.edu Office hours: TBA Brian Anderson Email: and03662@umn.edu Office hours: TBA

Course Description

This course examines the ecology of ecosystems that are primarily composed of managed plant communities, such as managed forests, field-crop agroecosystems, rangelands, and some nature reserves and parks. It is designed to serve as an introductory ecology course that focuses on scientific principles, while addressing interrelationships between the environment and human society, and the roles of science, technology, and policy in shaping societal responses to environmental challenges within managed ecosystems.

The basic premise of the course is that managed ecosystems must provide for a range of human needs on an ongoing (sustainable) basis, including production of food, forest products and other materials; conservation of essential resources for production (such as soil, water and biodiversity); and cultural, spiritual, and ethical sustenance. Management and stewardship of ecosystems to meet these multiple human needs is called multi-objective management. To succeed in multi-objective management, many different aspects of ecosystems need to be considered together.

Therefore, we aim to build your understanding of key concepts of ecology, and to provide tools for applying these concepts to multi-objective management of sustainable managed ecosystems. We aim to provide a foundation for future work with a wide variety of human-managed ecosystems. This course will explore how the structure and function of managed ecosystems (for example, the spatial pattern of different plant species across a landscape) affect their properties, with focus on key ecosystem properties such as productivity, resource-use efficiency, nutrient cycling, and resilience. Emerging principles for design of sustainable managed ecosystems that meet multiple human needs will be examined. In addition, the societal implications of these management decisions and processes will be explored. Importantly, this course focuses on several environmental issues of current major significance, including invasive species, air and water pollution, and global climate change.

An important goal of the course is to help you build an ability to collect, integrate, and interpret information and knowledge that is relevant to multiple-objective ecosystem management. To this end, we have designed this as a course for persons who will be actively involved in ecosystem management in their future work. To support these learning goals, the course is designed around a series of case studies, in which important ecological principles are introduced and applied in cases that exemplify management challenges that arise in forestry, agriculture, wetlands, and urban ecosystems. In each case study, you will be introduced to scientific principles relevant to the management challenges that arise in the case. Then, we will work together to apply those principles, identify and evaluate credible information and knowledge, and consider options for addressing the management challenges in the case. In addition, because each case involves human-managed ecosystems, you will be asked to evaluate these options from ethical and values-based points of view.

Course Learning Goals

Learning is not a passive activity in which you simply absorb and repeat back facts given by an instructor. Rather, learning requires you to take an active role. As instructors, we are committed to facilitate your learning in an active way, but ultimately you bear the responsibility for understanding the material and making it your own.

As a result of your participation in this course, you should be able to

- Understand societal expectations regarding performance of managed ecosystems, presently and in the foreseeable future
- Understand scientific principles within the field of ecology, and their application to conservation and management in managed ecosystems
- Understand conceptual and practical frameworks for analysis, management and improvement of ecosystem performance
- Apply these conceptual frameworks to several important classes of managed ecosystems
- Use the process of scientific inquiry to identify important gaps in knowledge about multi-objective management of particular managed ecosystems
- Evaluate and integrate a variety of information and knowledge to develop potential solutions to challenges facing multi-objective ecosystem management, considering current scientific understanding, ethics, and values of society
- Communicate your understanding to peers and others
- Work as a member of a productive, collaborative team

Course Management

This course uses Moodle as a course management tool. To access our course visit the main U of M Moodle site. From this page you will see courses you are enrolled in as well as learning sites for getting to know Moodle. Lecture slides, outside readings, answers to quizzes and exams, and homework activities will be presented at this course site. Regular use of Moodle to post your class exercises and papers will contribute to your participation grade.

Readings

Each learning unit will have several assigned readings that will supplement lecture and lab materials. All of these materials can be found on the course Moodle site.

Field Trips

During the first part of the course, half of the class will be participating each week in field trips to managed ecosystems within the Twin Cities metro area. During this period, there will be one lecture meeting per week. On Thursday, one half of the class will be involved in a field trip; while the other half of the class meets during normal lecture hours. The following Tuesday, these roles will reverse. **YOUR PARTICIPATION IN THESE FIELD TRIPS AND IN-CLASS EXERCISES IS MANDATORY**, so please make sure you are ready to leave promptly at 7:30 AM. We will meet for all field trips in the St. Paul Gym Parking lot and will take attendance at both the in-class activity and on the field trip.

Field Trip #1: Sucker & Vadnais Lakes: September 15 and 20
Field Trip #2: Como Lake Watershed: October 13 and 18
Field Trip #3: Stone's Throw Urban Farm: October 27 and November 1

Credits and Assignments

Class handouts will be provided describing the specific requirements and expectations for all papers, presentations, and participation assignments. These will be posted on the course Moodle site for reference prior to and after assignments are due.

Assignment	Due Date	% of Grade
Exam #1	October 20th (in class)	16%
Exam #2	Nov 17th (in class)	16%
Exam #3	December 13th (in class)	18%
Report #1	November 8th (Moodle submission by 10:30 am)	10%
Report #2	December 16th (Moodle submission by 4:00PM)	10%
Lab Exercises	Submission after lab sessions, unless noted otherwise	15%
Class Participation	In-class exercises	15%

Policy on Late Assignments

We provide due dates as guidelines to keep each of you on task. Deadlines are guidelines to ensure that you make good progress completing tasks and getting feedback that will help you improve, correct mistakes, and learn the material. Ultimately, it is your responsibility to get the work done. Assignments will be due on the date stated unless prior arrangements are made. Under extreme circumstances, unexcused late assignments may be accepted at the discretion of the instructor. Otherwise, **late assignments will be deducted 10% per day until they are received.**

Grading

The course will be graded from A through F (with pluses and minuses). All exams, written assignments, participation, and presentations will be given a numerical grade and multiplied by their respective contribution as a percent of the calculated final grade.

A	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D+**	**D**	**F**
≥ 93	90	87	83	80	77	73	70	67	60	<60

A= **Outstanding achievement that demonstrates superior mastery** of the material and exemplary performance on both tests and written exercises. The distinction between A and B will depend on the student's ability to understand and articulate explicit and implicit concepts.
B = Achievement that **significantly exceeds the level necessary** to meet the course requirements.
C = Achievement that **meets all course requirements** at an average level.
D = Achievement **worthy of credit**, but which does not fully meet the course requirements.
F = Failure to complete the course requirements, **not worthy of credit** without pre-arranged agreement between the student and the instructor regarding a grade of incomplete.

Graduate Students

Students taking this course for graduate credit will be required to complete a research paper that integrates the conceptual frameworks outlined in this course with a managed ecosystem of their choosing. You are highly encouraged to focus this paper on your thesis work or a particular managed ecosystem you are interested in. Specific details for this assignment will be provided during the semester.

Weekly Class Schedule

GETTING STARTED: (September 6, 8)
Introduction to Managed Ecosystems

An introduction to the course and the global context of managed systems, including major environmental issues facing these systems, as well as key concepts and models that will frame the course, including socio-ecological systems, ecological services, multifunctionality, ecosystem conceptual models and adaptive management. In addition, this section introduces the historic interrelationships between human society and managed ecosystems.

Key Concepts:
- Looking at an ecosystem as a whole
- Looking 'up & out' at landscape(s) that surround and contain ecosystems
- Looking within an ecosystem
- Looking through many eyes: adaptive co-management

UNIT 1: (September 13, 15, 20, 22)
Ecosystem Services
Many ecosystem processes and resources are critical for sustaining human populations. In this unit, key ecosystem processes, including carbon and hydrologic cycles, as well as the relationships between biodiversity and resilience will be discussed. A conceptual ecosystem model (driver/stressor/effect/attribute) will also be introduced and used in lab exercises to highlight the interrelationships between environmental resources and human society. The forests surrounding Vadnais and Sucker Lakes will serve as a case study for this section of the class, highlighting potential sources of stress and their impacts on ecosystem services. This section addresses important environmental issues related to land-use effects on water quality and introduces underlying scientific principles related to water quality. In addition, the interrelationships between the ethics and values of local residents and various approaches to maintaining water quality will be explored.

Field Trip: Vadnais and Sucker Lakes, Vadnais Heights, MN (**September 15 or 20**)

Lab Session: Driver/stressor/effect/attribute ecosystem models. Due **September 27th** posted on Moodle by 12:00 PM. Submission as attachment.

Readings:
#1 Kremen, C., and R.S. Ostfeld. 2005. A call to ecologists: measuring, analyzing, and managing ecosystem services. Frontiers in Ecology and the Environment 3: 540-548.
#2 Galatowitsch, S.G. In press. Diagnosis and Assessment. In: Ecological Restoration. Sinauer Associates, Inc. Sunderland, MA.

Key Concepts:
- Major types of ecosystem services
- Effect of management on the delivery and maintenance of an ecosystem service
- General approaches used for protecting and enhancing ecosystem services
- Biodiversity-stability relationships
- Major factors affecting quality and quantity of water
- The carbon cycle, including pools, fluxes, and sequestration, and effects of management
- Construction of driver/stressor/effect/attribute models (ecosystem conceptual models)
- Application of ecosystem conceptual models to address an environmental issue

UNIT 2: (September 27, 29 October 4)
Plant community structure and function
Our management of land and water affects which species occur in an ecosystem either because we modify their abundances directly, through introductions or harvesting, or indirectly, by altering resource levels or other actions. Our actions also affect species interactions, often with surprising results. When those surprises are undesirable, managers are faced with the challenge of not only managing resources, but also of reassembling or modifying networks of interacting species so these resources can be sustained. In this unit, we'll explore how species composition and diversity affects ecosystem function and how species interact in ecosystems. We'll look at examples from a variety of ecosystems to learn why managing community structure and function are crucial for sustaining ecosystems that effectively provide ecosystem services to society. An

in-class activity involving designing a native seed mix for a Minnesota roadside will introduce you to a seemingly straightforward decision process that can have large, cumulative effects on landscape species diversity and ecosystem function.

Lab Session: Designing a native seed mix. Lab write-up due **October 11** by 12:00 PM. Submission via Moodle, as attachment.

Readings:
#3 Diaz, S., J. Fargione, et al. 2006. Biodiversity loss threatens human well-being. PLoS Biology 4: 1300-1305.
#4 Glover, J. D., J. P. Reganold, J. P., & C. M. Cox. 2012. Agriculture: Plant perennials to save Africa's soils. *Nature*, *489*(7416), 359-361.

Supplemental resources: Wikipedia site on **biological interactions** (http://en.wikipedia.org/wiki/Biological_interaction) and book chapter:

Diboll, N. 1997. Designing seed mixes. P. 135-150. In Packard, S. and C.F. Mutel (Eds). The Tallgrass Restoration Handbook. Island Press. 432 p. Covelo, California.

Key Concepts:
- Chain of cause and effect from structure & function of ecological communities and ecosystem processes to ecosystem services to human well-being.
- Measures of plant community structure and explanations for the benefits of diversity
- How local species diversity is determined by multiple species pools
- Major types of species interactions and how management may influence species interactions
- 'Evergreen' agriculture

UNIT 3: (October 6, 11, 13, 18)

Linkages between terrestrial and aquatic ecosystems
The nature and condition of aquatic ecosystems are a reflection of the watershed in which they are situated. In this unit, we will introduce what a watershed is and how to delineate them, how nutrients move through landscapes, and how nutrient and sediment inputs regulate aquatic ecosystems and best management practices. This unit also introduces the concept of resiliency, alternate stable states and trophic cascades. The Como Lake Watershed will be used as a case study for this section of the class, highlighting adaptive management decision-making. This section addresses important environmental issues related to the impact of land-use practices on water quality and aquatic habitats and introduces underlying scientific principles related to trophic interactions, phosphorous cycles, and hydrology. In addition, the roles of policy in shaping the types of land-use occurring within the Como Lake Watershed, as well as the resulting ecosystem impacts are discussed.

Field Trip: Como Lake Watershed (**October 13 or 18)**

Lab Session: Watershed delineation and nutrient budgets. **Due in lab.**

Readings:

#8 Carpenter, S.R. and K.L. Cottingham. 1997. Resilience and restoration of lakes. Conservation Ecology. Ecologyandsociety.org.
#9 Pace, M.L., J.J. Cole, S.R. Carpenter, J.F. Kitchell. 1999. Trophic cascades revealed in diverse ecosystems. Trends in Ecology and Evolution 14: 483-488.

Supplemental resources: Wikipedia sites on **eutrophication** and **lentic ecosystems**

Report #1: Due November 8, submission to Moodle by 10:30 AM, as attachment.

Key Concepts:

- Phosphorous movement through a landscape and impacts of P addition on lakes.
- Shallow eutrophic lake states and attributes that maintain these alternate steady states
- Trophic cascades: what are they and their implications for ecosystem resilience and restoration
- Best management practices for minimizing eutrophication and phosphorous run-off

EXAM #1: October 20nd in class (1 hour)

UNIT 4: (Oct 25, 27, Nov. 1, 3)

Sustaining Productivity

Producing food is the most demanding way we (i.e., humans) use land and water. Not surprisingly, agricultural production drives some of the most widespread and serious environmental problems we face, including pollution of water bodies and groundwater, declining sources of energy and water, soil erosion, and even "dead zones" in oceans. While intensification of agriculture has greatly contributed to these environmental problems, we still must commit a certain portion of the earth's surface to producing food. Most food crops are annual plants that are grown from seed each year and produce a crop that is harvested; the soil then lays bare until the next growing season. For a plant to go from a seed to producing a heap of tomatoes or peppers requires a lot of nutrients and water. Even perennial crop plants make high demands on the soil. And exposed soils common in agricultural fields are prone to wind and water erosion. Are there ways to produce food without damaging the environment? People (consumers, farmers, scientists) have been asking this question for several decades and have developed some strategies for managing agricultural ecosystems to reduce impacts. Some of these strategies focus on improving practices at the site scale, managing soil so crops can be produced with little or no use of synthetic fertilizers and pesticides. Others consider how we can manage agricultural landscapes so they provide many ecological services, not only food production. In this unit, we'll explore both site and landscape management strategies for sustainable agricultural production, and consider strategies for making agriculture less vulnerable to climate change.

Field Trip: Urban organic farms: Stone's Throw Urban Farm **(October 27 or November 1)**

Lab Session: Soil management in organic farming. **Due in lab.**

Readings:

#5 Schulte, Lisa A., H. Asbjornsen, M. Liebman, and T. R. Crow. Agroecosystem restoration through strategic integration of perennials. *Journal of Soil and Water Conservation* 61, no. 6

(2006): 164A-169A.
#6 Robertson, G.P. and S.M Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment 3: 38-46.
#7 Magdoff, F. and H. van Es. 2009. Building Soils for Better Crops: Sustainable Soil Management. Chapter 9: Managing for high-quality soils: organic matter, soil physical condition, nutrient availability, p. 87-98. Sustainable Agriculture Research Education Program Handbook Series. Waldorf, Maryland.

Supplemental resources: Wikipedia sites on carbon and nitrogen cycles: (http://en.wikipedia.org/wiki/Carbon_cycle; http://en.wikipedia.org/wiki/Nitrogen_cycle)

Key Concepts:

- Why we need to increase production of agricultural commodities and ecosystem services
- How to adapt agriculture to climate variability and change
- Human management of soils for ecological services provided by carbon and nitrogen cycling
- How management of agricultural landscapes can affect production of commodities and ecosystem services
- Critical landscape areas and functional ecological profiles

UNIT 5: (November 8, 10, 15)
Forest management in a changing climate

The structure and composition of plant communities is strongly influenced by successional patterns, disturbance and their interactions with regional climate. Often, forest management decisions are aimed at emulating or limiting natural disturbance or successional processes in attempts to maintain certain forest conditions. Such management decisions are based on knowledge of species tolerances, growth rates and species interactions in a particular region with a particular climate. What happens when the climate changes? This unit uses a case study centered on boreal forest tree species currently common in northern Minnesota, USA to introduce succession, fire ecology, silvics of tree species, vulnerability to climate change and adaptive forest management in a changing climate.

This section explores important environmental issues related to changing disturbance regimes and species interactions associated with climate change. Underlying scientific principles introduced in this section include plant succession, species range limits, species ecological tolerances, competition and disturbance ecology. The ethical issues raised by various proposed solutions to managing ecosystems in a changing climate are discussed within the context of current societal and policy expectations for these areas. An in-class activity involving the "redesign" of a managed landscape is used to illustrate the limitation of technology in addressing landscape-scale environmental issues without raising important ethical issues.

Lab Session: Priorities for landscape-level conservation and management in MN

Reading:
#10 Excerpts from Handler et al. 2014. Minnesota forest ecosystem vulnerability assessment and

synthesis: a report from the Northwoods Climate Change Response Framework project. Gen. Tech. Rep. NRS-133. Newtown Square, PA; U.S. Department of Agriculture, Forest Service, Northern Research Station. 228 p.
#11 D'Amato, A.W., J.B. Bradford, S.Fraver, and B.J. Palk. 2013. Effects of thinning on drought vulnerability and climate response in north temperate forest ecosystems. Ecological Applications 23(8):1735-1742.

Supplemental resources: Wiki sites on **ecological succession** and **landscape ecology**

Key Concepts:

- Modes of succession and how disturbance severity influences post-disturbance processes
- Silvics of selected Great Lakes species
- Management based on natural disturbances and historic range of variation
- Scenarios for climate change in the Great Lakes
- Managing for climate change
- Grain and extent as it relates to managing ecosystems for a particular organism or process
- Patch-corridor-matrix model and and it's application

EXAM #2: Nov 17th in class (1 hour)

UNIT 6: (November 22 & 29)
Invasive species management and restoration
Even though only a small fraction of species introduced to new locales aggressively spread, those that do can have adverse ecological and economic impacts. Developing strategies for invasive species control need to consider the effectiveness and limitations of various methods. As importantly, vegetation management strategies also need to address reducing the risks of reinvasion. This unit will introduce invasiveness, predicting spread of invasive species, invasive plant management techniques, and post-eradication revegetation. Attempts to control reed canary grass in salmon habitat on the Kenai Peninsula (Alaska) will be used as the case for this unit of the course. Because invasive species represent one of the most important, current environmental issues facing managed systems, this unit provides critical information on the ways in which invasive species affect landscapes and societies through the impacts on ecosystem services. In addition, the limitations of current technologies in addressing these issues are explored.

Lab Session: Kenai Peninsula decision case.

Readings:
#12 Mack, R. N., D. Simberloff, M. Lonsdale, H. Evans, M. Clout, M., & F. Bazzaz, F. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological applications*, *10*(3), 689-710.
#13 Zavaleta, E.S., R.J. Hobbs, and H.A. Mooney. 2001. Viewing invasive species removal in a whole ecosystem context. Trends in Ecology and Evolution 16: 454-459.

Wikipedia site on **invasive species**: http://en.wikipedia.org/wiki/Invasive_species

Key Concepts:

- Common ecological effects invasive species have on managed systems

- The four stages of the invasion process
- Traits commonly associated with invasive plant species and habitats commonly invaded
- General approaches to controlling and managing invasive species and associated pros and cons

UNIT 7: (December 1, 6, 8)
Multiple Stressor Effects on Ecosystems
Conservation of rare and endangered species and their habitats has long history of conflict with other human land uses. Developing strategies for conservation and management of native species must recognize human dimensions of natural resource use as well as cultural significance of certain land uses (e.g., hunting and fishing). This unit introduces students to social-ecological tensions in conservation decision-making, multiple stressor effects on ecosystems (invasives, herbivory, disease), and ethical consideration related to invasive animal control. Feral pig impacts on native Hawaiian flora and fauna and contentious cultural issues surrounding feral pig control will be used as the case for this unit of the course.

This unit explores how the ethics and values of a society influence the acceptability of solutions to environmental problems. In addition, we explore how the natural and managed landscapes of Hawaii currently influence the livelihood and values of its native people.

Readings:
#14 Van Driesche, J. and R. Van Driesche. 2004. From Endemic to Generic: Feral Pigs and the Destruction of Hawaii's Native Forests. Pp 7-31 in Nature out of place: biological invasions in the global age. Island Press, Washington, D.C.
#15 Ewel, J.J., and F.E. Putz. 2004. A place for alien species in ecosystem restoration. Frontiers in Ecology and the Environment 2: 354-360.

Report #2: Due **December 16th** Submission to moodle site by 4:00 PM.

Key Concepts:
- Multiple stressors that currently influence native species in Hawaii
- How human dimensions of natural resource use can influence decision-making regarding management of natural areas
- Processes for achieving consensus surrounding multi-use management of natural resources

EXAM #3: December 13th (in class)

Course Policies
1. The two major grading systems used are the A-F and S-N. ESPM majors must take this course on the A-F system; non-majors may use either system. The instructors will specify criteria and achievement levels required for each grade. All students, regardless of the system used, will be expected to do all work assigned in the course. Any changes you wish to make in the grading base must be done in the first two weeks of the semester.
2. Incompletes are given only through prior arrangement with instructors. Incompletes are assigned at the discretion of the instructor and are only given when extraordinary circumstances prevent completion of course work on time. The instructors will set dates and conditions for makeup work. "I" grades will automatically lapse to "F"s at the end of the next

semester of a student's registration.

3. Inquiries regarding any changes of a final grade should be directed to the instructors of the course; you may wish to contact the Student Conflict Resolution Center (SCRC) in 211 Eddy Hall (624-7272) for assistance.
4. A student is not permitted to submit extra work in an attempt to raise his or her grade.
5. Scholastic misconduct is broadly defined as "any act that violates the right of another student in academic work or that involves misrepresentation of your own work. Scholastic dishonesty includes, (but is not necessarily limited to): cheating on assignments or examinations; plagiarizing, which means misrepresenting as your own work any part of work done by another; submitting the same paper, or substantially similar papers, to meet the requirements of more than one course without the approval and consent of all instructors concerned; depriving another student of necessary course materials; or interfering with another student's work." Within this course, a student responsible for scholastic dishonesty can be assigned a penalty up to and including an "F" or "N" for the course. If you have any questions regarding the expectations for a specific assignment or exam, ask. Cooperating on the content of examinations, homework, projects, or reports is prohibited unless explicitly required or permitted as part of the assignment. Cooperation and assistance among students in preparing team reports is required.
6. Students with disabilities that affect their ability to participate fully in class or to meet all course requirements are encouraged to bring this to the attention of the instructors so that appropriate accommodations can be arranged. Further information is available from Disabilities Services (230 McNamara).
7. University policy prohibits sexual harassment as defined in the December 1998 policy statement, available at the Office of Equal Opportunity and Affirmative Action. Questions or concerns about sexual harassment should be directed to this office, located in 419 Morrill Hall.

An Honor System

The honor system is most accurately defined as a student self-government system for conducting examinations. Under the honor system, students accept responsibility for the supervision of student conduct during examinations. It operates on the assumption that students are honest and enjoy working in a situation where their honesty and the honesty of others are not in question. It operates to respect honesty and to prevent cheating, as well as to punish those who cheat. The honor system contributes to the development and expression of ethical standards desirable for all professionals in whom the public places confidence.