Spring 2-1-2022

NRSM 532.01: Integrated Systems Ecology

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INTEGRATED SYSTEMS ECOLOGY (BIOS 534; NRSM 532) **Spring 2022**

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Office Hours: By appointment

Text (recommended): Forest Ecosystems: Analysis at Multiple Scales (2010), by R.H. Waring and S.W. Running.

Class Info: Location: 416 Interdisciplinary Science Building (ISB)**; Cr:** 3**; Days:** MW**; Time:** 11AM-12:20PM

Class Zoom Link: https://umontana.zoom.us/j/94379585400

SCHEDULE:

DATE	SESSION	CH	TOPIC
1/19	1	--	Class Introduction and Summary
1/24	2	1	Ecosystem Modeling Principles 1
1/26	3	1	Ecosystem Modeling Principles 2
1/31	4	1	Space/Time Scaling
2/2	5	2	Energy Budgets
2/7	6	2	Water Cycle
2/9	7	3	Carbon Cycle I: Photosynthesis
2/14	8	--	**MODEL SUMMARY PRESENTATIONS**
2/16	9	--	**MODEL SUMMARY PRESENTATIONS**
2/21	--	--	**NO CLASS** (Presidents Day)
2/23	10	3	Carbon Cycle 2 – Respiration
2/28	11	3	Carbon Cycle 3 – Plant Carbon Allocation
3/2	12	4	Nutrient Cycles
3/7	13	5	Succession – Stand Development
3/9	14	6	Disturbance
3/14	15	--	**MODEL ANALYSIS PRESENTATIONS**
3/16	16	--	**MODEL ANALYSIS PRESENTATIONS**
3/21	--	--	**NO CLASS (Spring Break)**
3/23	--	--	**NO CLASS (Spring Break)**
3/28	17	6	Stress, Cold Hardiness, Phenology
3/30	18	7	Remote Sensing Principles
4/4	19	7	Weather & Climate Data
4/6	20	7	Vegetation Indices **(Guest Lecture)**
4/11	21	7	Land Cover Change
4/13	22	8	Ecosystem & Biogeochemistry Models
4/18	23	9	Earth System Models (GCM, ESM, DGVM)
4/20	24	9	Coupled Human-Natural Systems
4/25	25	9	Global Carbon Cycle
4/27	26	10	Climate Change Evidence and Impacts
5/2	27	--	**FINAL PROJECT PRESENTATIONS**
5/4	28	--	**FINAL PROJECT PRESENTATIONS**
5/9	29	--	**FINALS WEEK**

CLASS OVERVIEW

Integrated systems ecology represents a holistic systems analysis approach to the study of ecosystems, including biotic and abiotic components, and their interactions. Systems ecology also addresses human-ecosystem interactions, and their impact on ecosystem functioning. Students in this course will learn general principles and applications of systems ecology through an ecosystem modeling framework. This framework provides an effective tool for studying system boundaries, key components and internal linkages of complex systems, including flows, storage and transformations of energy, water, carbon and nutrients, and other materials. The modeling framework also provides an efficient mechanism for hypothesis testing and extrapolation of ecological predictions that extend beyond the limits of sparse observations.

We will review foundational ecological principles and components, and their representation within a modeling structure. We will learn about different model types and applications, and their underlying assumptions, key simplifications, strengths and limitations. Systems elements investigated will include: analyzing the entire system holistically; identifying connections and causality; organizing and prioritizing data collections; generalizing beyond an individual study site; investigating perturbations, and predicting system behavior in context with underlying model uncertainty. We will learn about remote sensing as a key aspect of systems ecology, providing spatially continuous observations of landscape conditions and environmental behavior. Students will also investigate the major steps in systems analysis and model design, including: identifying a science question; developing objectives to address the question; developing a conceptual model; identifying mathematical formulations representing key processes; model implementation, calibration and validation; and drawing conclusions from model results.

This course includes lectures, topical presentations and discussions on ecological modeling principles and major elements of vegetation ecophysiology; water, carbon, nutrient and energy cycles; remote sensing principles, and model applications. Students will engage in giving oral and written presentations, and participating in class discussions involving different ecosystem models relevant to their own research. Different models will be evaluated and compared in relation to their conceptual basis, appropriate uses, key assumptions, input requirements, strengths and limitations. Student classwork responsibilities and grading are based on active student participation in class discussions, oral presentations and written reports. Students will give an initial oral presentation summarizing a model of their choice, including conceptual basis, appropriate uses, key assumptions, strengths and limitations. Students will then give a more detailed oral presentation and written report on another model of their choosing, including detailed discussion of model scope and objectives, key assumptions, domain of interest, necessary inputs, model structure and key linkages, and published applications. As a final project, each student will develop a conceptual layout of an ecosystem analysis problem of their choice, with objectives, assumptions, domain, logical flowchart, key cause-effect linkages and references, culminating in a final oral presentation and written report.

LEARNING OUTCOME

A desired learning outcome from this course is for each student to have the ability to analyze any new ecosystem model they might encounter for stated purpose, key assumptions, structural organization, and range of applicability. Students will also explore and evaluate different remote sensing products and applications related to ecosystem analysis. By the end of the course each student should be able to critically evaluate and identify appropriate models, applications, and data sources relevant to their individual research areas.

CLASS PROJECTS and RESPONSIBILITIES (this is what your grade is based on):

1] ATTENDANCE and PARTICIPATION in class [15% of total grade]

This includes leading one class discussion of the assigned reading(s): developing the questions for discussion, presenting them to the class, and guiding the discussion during class.

2] First Model Summary Exercise [Deliverable: Oral presentation; 15% of total grade].

I will help each of you choose an ecosystem model relevant to your own studies, and guide you to where the model is published. You will prepare a brief summary of the model, using the presentation template provided, to give oral presentation to the class. We will then, as a class, evaluate each of these models for their conceptual basis, appropriate uses, key assumptions, input requirements and limitations.

3] Detailed model analysis. [Deliverables: Oral presentation, Written report; 30% of total grade]

Next, I want each of you to choose a *different* model from your first, and do a more detailed analysis. I want you to choose a well-documented and widely-used ecosystem model and evaluate it carefully. Your analysis and presentation should include the following elements: Stated objective and purpose of the model; key model assumptions; the effective modeling domain in time and space; necessary model inputs and drivers; general model structure and key internal linkages; a model processing flowchart; the most important model outputs; methods for testing and validation; example applications of the model from the literature. I expect the written report to be ~5-10 pages long (12pt font, ≤1.5 spacing, 1" margins), with appropriate graphics showing the model, validation, references, science done with the model, etc.

4] Final project [Deliverables: Oral presentation, Written report; 40% of total grade].

To develop your own skills in systems analysis, I want each student to develop a conceptual layout of an ecosystem analysis problem of your choice, with objectives, assumptions, domain, logical flowchart, key cause-effect linkages and references. Each student will present their project to the class as an oral presentation, and as a written report (~10-20p, 12pt font, ≤1.5 spacing, 1" margins). The following elements should be considered in assembling the final project.

Recall from lecture and reading materials the general purposes of systems modeling:

- to analyze the entire system holistically
- to understand connections and causality
- to organize field data
- to prioritize future data collection
- to generalize beyond the study site
- investigate manipulations and perturbations
- predict future system behavior

Recall the seven steps to model development:

1. Define the question
2. Bound the question – model objective
3. Develop a conceptual model
4. Determine the equations that define the process
5. Computer implementation and parameterization

6. Model testing and implementation
7. Make conclusions

STUDENT CONDUCT CODE

Students are expected to adhere to the University of Montana *Student Conduct Code*.

COURSE WITHDRAWAL

Deadline	Description	Date
To 15th instructional day	Students can drop classes on cyberbear	Feb 1st @5pm = last day
16th to 45th instructional day	Drop requires form with instructor and advisor signature, a $10 fee from registrar's office, student will receive a 'W'.	Feb 2 - Mar 12 @5pm
Beginning 46th instructional day	Students are only allowed to drop a class under very limited and unusual circumstances. Not doing well in the class, deciding you are concerned about how the class grade might affect your GPA, deciding you did not want to take the class after all, and similar reasons are not among those limited and unusual circumstances. If you want to drop the class for these sorts of reasons, make sure you do so by the end of the 45th instructional day of the semester.	Mar 13 - Apr 30 @5pm

DISABILITY MODIFICATIONS

Accessibility, disabilities, and special accommodations:
The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and the Office for Disability Equity (ODE). If you anticipate or experience barriers based on disability, please contact the ODE at: (406) 243-2243, ode@umontana.edu , or visit www.umt.edu/disability for more information. Retroactive accommodation requests will not be honored, so please, do not delay. As your instructor, I will work with you and the ODE to implement an effective accommodation, and you are welcome to contact me privately if you wish. Any questions please contact me.

Some Example Systems Ecology Models

Each of the following models has a history of journal publications, validation, testing, open source code and documentation. However, this list is only a small selection of available models; the number of available models, model types, and applications keeps growing! Feel free to suggest one that you are interested in.

Stand Level models

Biome-BGC – multi scale ecosystem biogeochemical cycles model
http://www.ntsg.umt.edu/project/biome-bgc.php

FIRE BGC – a version of Biome-BGC that incorporates fire disturbance and successional processes

FVS-BGC and TREE-BGC – forest inventory driven hybrid models

Century and DAYCENT – a grassland biogeochemical cycling model
http://www.nrel.colostate.edu/projects/century/

Ecosystem Demography Model (ED2) – a forest model of stand demographics
https://github.com/EDmodel/ED2

Terrestrial Ecosystem Model (TEM) – a terrestrial ecosystem model of biogeochemical dynamics http://ecosystems.mbl.edu/TEM/

DLEM – dynamic land ecosystem model
http://wp.auburn.edu/cgc/models/

StandCarb – forest stand carbon budget
https://andrewsforest.oregonstate.edu/publications/2817

Watershed - Regional level models

RHESSYS – a regional scale hydro-ecological simulation that routes streamflow
http://fiesta.bren.ucsb.edu/~rhessys/

VIC – a hydrologic and water management model
http://www.hydro.washington.edu/Lettenmaier/Models/VIC/

HEC-RAS – watershed management model
http://www.hec.usace.army.mil/software/hec-ras/

WASP – EPA Watershed and Water Quality model
http://epawasp.twool.com

MOD17 – satellite data driven calculation of terrestrial plant production
http://www.ntsg.umt.edu/project/modis/mod17.php

SWAT – Watershed Soil & Water Assessment Tool
http://swat.tamu.edu

TCF / L4C – satellite data driven terrestrial carbon flux model https://nsidc.org/data/spl4cmdl

3PG – a simple satellite driven physiologically based model of forest growth
http://3pg.forestry.ubc.ca/

Ecopath and Ecosim – aquatic ecosystem and fish management model
http://ecopath.org/

DSSAT - Dynamic crop growth simulation models
https://dssat.net/

AQUATOX – EPA model for water quality
https://www.epa.gov/exposure-assessment-models

Global land models

NCAR CLM – a land biophysical process model that works in a GCM
http://www.cesm.ucar.edu/models/clm/

IBIS – Integrated Biosphere Simulator in a GCM
https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=808

Orchidee – Dynamic Global Vegetation Model (DGVM)
http://orchidee.ipsl.fr/

LPJ – GUESS (DGVM)
http://iis4.nateko.lu.se/lpj-guess/

MC1(2) and MAPSS - Biogeography Model and DGVM
http://www.fsl.orst.edu/dgvm/

Ecosystem service – socioeconomic models

Invest – an ecosystem services model for water, carbon, and biodiversity
http://www.naturalcapitalproject.org/models/models.html

2052 – a global socio-economic model
http://www.2052.info/

MAGICC – a global integrated assessment model
http://www.cgd.ucar.edu/cas/wigley/magicc/

IGSM - MIT IGSM Integrated Global Assessment Model
http://globalchange.mit.edu/research/IGSM

DICE – Dynamic Integrated Assessment Model (IAM) of Climate and Economics
https://sites.google.com/site/williamdnordhaus/dice-rice

IMAGE - Global integrated assessment model
http://themasites.pbl.nl/tridion/en/themasites/image/

FUND - Climate Framework for Uncertainty, Negotiation and Distribution (FUND) is a so-called integrated assessment model of climate change.
http://www.fund-model.org/

EPIC – agricultural crop management model
http://epicapex.tamu.edu/epic/