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Spring 2-1-2019

BIOS 534.01: Integrated Systems Ecology

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Kimball, John S., "BIOS 534.01: Integrated Systems Ecology" (2019). *Syllabi*. 9326.
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INTEGRATED SYSTEMS ECOLOGY (BIOS 534)

Spring 2019

Professor: John Kimball

ISB 416, Phone: 243-4922

Office Hours: Fridays 3-5PM or by appointment

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

Class Schedule: Bldg/Rm: CHCB 426; Cr: 3; Days: MW; Time: 11AM-12:50PM

SCHEDULE:

DATE	SESSION	CH	TOPIC
1/14	1	---	Class Introduction and Summary
1/16	2	1	Ecosystem Modeling Principles 1
1/21	---	---	NO CLASS (Martin Luther King Jr Day)
1/23	3	1	Ecosystem Modeling Principles 2
1/28	4	1	Space/Time Scaling
1/30	5	2	Energy Budgets
2/4	6	2	Water Cycle
2/6	7	3	Carbon Cycle 1 - Photosynthesis
2/11	8	3	Carbon Cycle 2 - Respiration
2/13	9	---	CLASS MODEL SUMMARIES
2/18	---	---	NO CLASS (Presidents Day)
2/20	10	3	Carbon Cycle 3 – Plant Carbon Allocation
2/25	11	4	Nutrient Cycles
2/27	12	5	Succession – Stand Development
3/4	13	6	Disturbance
3/6	14	6	Cold/Heat Stress, Dormancy, Phenology
3/11	15	7	Remote Sensing Principles
3/13	16	---	CLASS MODEL ANALYSES
3/18	17	---	CLASS MODEL ANALYSES
3/20	18	---	CLASS MODEL ANALYSES
3/25	---	---	NO CLASS (Spring Break)
3/27	---	---	NO CLASS (Spring Break)
4/1	19	7	Landcover Change
4/3	20	8	Ecosystem & Biogeochemistry Models (RESSys)
4/8	21	8	Vegetation – Atmosphere Models (GCM, ESM, DGVM)
4/10	22	9	Global Carbon Cycle
4/15	23	10	Model Uncertainty and Validation
4/17	24	10	Climate Change Evidence and Impacts
4/22	25	---	FINAL PROJECTS
4/24	26	---	FINAL PROJECTS
4/29	27	---	FINAL PROJECTS (FINALS WEEK)

CLASS OVERVIEW

Computer modeling is an effective tool for studying ecological systems because one can never measure all relevant functions of a complex system. Computational modeling also provides an efficient mechanism for hypothesis testing and extrapolation of ecological predictions that extend well beyond the limits of sparse observations. Satellite remote sensing is an important component of the ecosystem modeling framework because it provides spatially continuous observations of landscape conditions that can be used as both model drivers and validation.

Students in this course will learn the principles of integrated systems ecology through an ecosystem modeling framework. We will explore the major model types and their components, while evaluating underlying model assumptions, strengths and limitations. Systems modeling 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. Students will also investigate major steps in model development, including: identifying a science question; developing modeling objectives to address the question; developing a conceptual model; determining mathematical equations representing key processes; computer implementation; model calibration and validation; and drawing conclusions from model results.

This course includes lectures and topical 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 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 modeling. 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 DISCUSSION during class [15% of total grade]

2] First Model Summary Exercise [Deliverable: Oral powerpoint 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 Powerpoint 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 Powerpoint 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 ~10 pages long, with appropriate graphics showing the model, validation, references, science done with the model, etc.

4] Final project [Deliverables: Oral Powerpoint 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 Powerpoint presentation, and as a written report (~20p). 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	Jan 31st = 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'.	February 1 through March 15
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 45 th instructional day of the semester.	March 18-April 26

DISABILITY MODIFICATIONS

The University of Montana assures equal access to instruction through collaboration between students with disabilities, instructors, and [Disability Services for Students](#). If you think you may have a disability adversely affecting your academic performance, and you have not already registered with Disability Services, please contact Disability Services in Lommasson Center 154 or call 406.243.2243. I will work with you and Disability Services to provide an appropriate modification.

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.ntsug.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.ntsug.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/>