EVPP 650 **FALL SEMESTER 2020**

ECOSYSTEM ANALYSIS AND MODELING

Call #: 81247-001 for lecture
Call # 81272-201 for lab

INSTRUCTOR:	**DR. CHANGWOO AHN**
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CLASS TIME:	**Mondays** 4:30 – 7:10 P.M
CLASS LOCATION:	Innovation Hall 205
LAB TIME:	**Fridays** 10:30 am –1:10 PM
LAB LOCATION:	Blueridge Hall 127

CREDIT HOURS: 4

PREREQUISITE: Math 113 (calculus) or equivalent and Ecology course or equivalent. Additional courses in calculus, statistics, linear algebra, and computer programming are not necessary, but could be helpful

COURSE DESCRIPTION: Introduction to the principles, history, and methodologies of systems ecology, emphasizing the development and simulation of ecological models for natural resource/ecosystem management, conceptual and symbolic models, simulation techniques on microcomputers. Students learn to conceptualize ecological systems, represent these conceptualizations through system language, and develop and test models against literature/field/mesocosm data.

TEXT: Odum H. T. and E. C. Odum 2000. *Modeling for All Scales: An Introduction to System Simulation*, Academic Press (some chapters made into a packet for purchase since the book is out of print).

ISEE systems. An Introduction to Systems Thinking with STELLA by Barry Richmond (http://www.iseesystems.com/store/IntroToSystemsThinking/IST_STELLA.aspx)

Additional handouts throughout the course will be provided.

ADDITIONAL REFERENCES:

1. *Ecological Engineering and Ecosystem Restoration* (2003), W.J. Mitsch and S.E. Jorgensen, John Wiley and Sons, 396 pp. (Chap 14)
2. Jorgensen, S. E. 1994. *Fundamentals of Ecological Modeling*, 2nd edition, Elsevier
3. Jorgensen, S. E.2011. Handbook of Ecological Models Used in Ecosystems and Environmental Management. CRC Press.
4. John Todd. 2019. Healing Earth. North Atlantic Books, Berkeley, CA.

OTHER REQUIRED MATERIALS

- Supply of a USB drive (memory stick)
- Calculator and/or EXCEL (laptop, personal computer)

SOFTWARE (RECOMMENDED): STELLA™ 8.0 simulation (version may vary) software (Ten computers in lab classroom will be loaded with STELLA program). Personal copy of the program can be purchased (available for IBM and MAC with proof of student status). Contact for purchase:
Orders: www.iseesystems.com <http://www.iseesystems.com>

THIS IS NOT A REQUIRED PURCHASE AS SOFTWARE will be AVAILABLE IN LAB. BUT LAB HOURS MAY NOT BE CONVENIENT FOR USE DUE TO OTHER CLASSES.

COURSE OBJECTIVES:
The course introduces students to a systems approach to the understanding and management of ecosystems such as wetlands, lakes, reservoirs, forests, and human-dominated systems. This semester, the class is specifically dedicated **to modeling application for a green infrastructure theme, including created wetlands and floating island wetlands for stormwater quality improvement**. Our own Mason Pond or other local shallow pond (e.g., Ashby pond) will be used as a model for a water quality model to be developed. Within the aid of energy system language (energese) and computers, the course introduces concepts of model development, modeling mathematics, parameters estimations, hierarchy of systems, computer simulations, model calibration and verification, and ecosystem management along with actual collection of the data that will be used for a water quality model. Students will also work through example exercises in the first few lab sessions, either alone or in a small group. Students will be expected to produce a dynamic water quality model *on a green infrastructure design or processes* by the end of the course.

COURSE POLICY AND EXPECTATIONS: Attendance to class is highly recommended due to the volume of material covered each week. I expect each of you to be present and prepared for each class. *Academic dishonesty* will not be tolerated. *Some changes in course organization and content* may be necessary. Students will be made aware and asked for input if such actions are needed.

Counseling: If you feel that you may have a learning disability, you should contact the Counseling Center on campus (located in Student Union Building I, Room 222; Tel: 703- 993-2474; ttp://www.gmu.edu/student/drc/services.html).

GRADING:

	% of Grade
Reading Assignment (I)	10
Labs (I or G)	20
Midterm (I)	20
Literature review (summary and presentation) (I or G)	15
Modeling project (Paper and presentation) (I)	35 (30/5)
I: individual, G: Group	
TOTAL POINTS	100

Reading assignment will require two-page summary of the key content of paper assigned (12 fonts, single pace, 1" margin, 1000 words). The midterm exam covers lecture material from the previous group of lectures only. Literature review can be an individual or group presentation of a selected publication on ecological modeling. Modeling project can be either an individual or a group effort depending on the number of students in class (2 people top), but it requires an individual submission as a product of the project for grade. Individual presentation of the product at the end of the semester will be conducted. In that case, all members of a group will be assigned the same grade for presentation, but not for final paper.

CLASS E-MAIL:
I will frequently e-mail to remind you of deadlines or to clarify points from a lecture. Please use GMU e-mail (**@gmu.edu) to facilitate any communication or discussion. Please check your e-mail **daily at least**.

MODELING LABS:
Students are required to participate in formal lab practices and water quality data collection during the class period. The water quality measurements can be arranged individually or as a group once a week. The rest of the lab sessions can be used to work on individual class projects. Laboratories are scheduled for Thursdays 4:30 –7:10 P.M. Additional work may be necessary for students to finish laboratory exercises. The laboratory used in the class may be available for student use if it does not have a formal lab or lecture scheduled. Student will demonstrate to the instructor that they have completed the assignments in the laboratory. This can be accomplished by showing the instructor or TA during the laboratory that you have completed the exercises; you can use the computer screen or a saved file. One of the STELLA models developed (Ahn and Mitsch 2002) will be intensely studied to teach how to build a model for hydrology, vegetation and nutrient dynamics.

LITERATURE REVIEW AND PAPER PRESENTATION:
One of the most important experiences in a graduate course is to explore the published literature. Each student (or group) will be required to give a short (15minute) synopsis of a modeling paper related to their modeling projects. Incorporate up-to-date literature on the subject matter. Use a maximum of 10-13 PowerPoint slides (~ max. 15-20 min.) to show the model being presented and its general findings. Handouts will be provided earlier in the class to guide the selection of paper to review. Additional good sources for information are:

- the journal *Ecological Modeling* (Elsevier)
- other ecological literature, e.g. *Ecological Applications, Water Research, Ecological Engineering, River Research and Applications, Environmental Modeling and Software, Wetlands, Ecosystems, Biogeochemistry* etc.

MODELING PROJECT:
Students will develop from scratch an ecological model of a chosen topic with a few suggested ideas for environmental sustainability and topic associated with it. You will quantify and simulate the model with techniques learned in class. The simulations will be dynamic, that is, they will include time as an independent variable. The model will be tested with the data you will participate in collecting. The final project for each student can be to develop a **research paper** for a modeling project. Students will be required to complete the following on their project:

1. an oral presentation of their models to class on **December 3.**
2. An electronic copy (via emails) of written manuscript (either for a paper or a proposal) due **by December 10 (by noon)** (follow *Ecological Modeling or Ecological Engineering* publication format).
   *There will be a lecture on the styles and formats to strictly follow on the final project material for both proposals and research papers.

The research paper is required to include a conceptual model in energese or STELLA. Do not put this modeling project off until the last moment as it is a very time consuming and grade-important part of this class.

METHODOLOGY IN MODELING PROJECT

Students are able to use the following to conduct their modeling projects in this class.
- The experimental way with data and information collection through lab and field works, and intensive literature review.

LECTURE COURSE SCHEDULE (subject to minor modification**):**

Date	**Topic**	**Text Reading**
AUG 24	Introduction of the course, Syllabus, Lab/study group assignment	
AUG 28	No lab	
AUG 31	Paper review, library resources, how to design a modeling project.	
SEP 4	Lab orientation, orientation for class project topics	
SEP 7	No class (Labor Day)	
SEP 11	Introduction to modeling and methodology, ecological microcosms –wetland compound	
SEP 14	System Ecology and the History, systems (Mitsch and Day, 2004) & STELLA introduction , Odum diagram	
SEP 18	Individual modeling practice –conceptual diagram exercise	
SEP 21	Modeling Methodology, Basic Models, Integration methods -paper review 1	
SEP 25	Water quality measurement and DRAIN/EXPONONETIAL INCREASE or DECAY LOISTIC GROWTH and WHAT IF exercises	
SEP 28	Paper presentation and analysis- paper review 2	
OCT 2	Water Quality measurements and DRAIN/EXPONONETIAL INCREASE or DECAY LOISTIC GROWTH and WHAT IF exercises	
OCT 5	Model equation and coefficient determination, paper review 3	
OCT 9	No lab	
OCT 12	Fall Break: No class	
OCT 16	**Mid-term**	
OCT 19	Ahn model breakdown –Hydrology, Plant growth, Nutrient dynamic (N, and P), paper review 4	
OCT 23	STELLA individual exercise	
OCT 26	Data collection and analysis	

OCT 30	Emergy concept and other ecological models
NOV 2	Other Ecosystem models with STELLA, guest speaker (TBA)
NOV 6	**No lab** - work on individual projects
NOV 9	Modeling nitrogen removal in constructed wetlands -paper review 5
NOV 13	Final project conceptual model presentation & discussion
NOV 16	Modeling phosphorus removal in constructed wetlands
NOV 20	**No lab** –work on individual projects, Water quality measurements
NOV 23	Data analysis for models, paper review
NOV 27	*Thanksgiving-No class*
NOV 30	Modeling writing workshop/ STUDENT PRESENTATION
DEC 4	STUDENT PRESENTATION

FINAL SUBMISSION DUE BY DECEMBER 10 (BY NOON)

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*Ahn Wetland Mesocosm Compound:

Direction to Wetland Mesocosm Compound

You come on University Drive, and drive across Ox Rd and stay on University Drive, then you will see on your left the sign for "Intramural Fields". Turn left to enter the Fields. You will see the first softball playground on your left. Immediately after the playground there is a gravel road on your left. Turn left onto the newly paved road and drive a few yards down the road, then you will see the fenced area with a sign for "Wetland Mesocosm Compound".

The list of reading and paper presentation materials for class:

- Ahn, C. and W. J. Mitsch. 2002. Scaling considerations of mesocosm wetlands in simulating a large marsh. *Ecological Engineering* 18:327-342.(paper 1).
- Chang Ni-Bin et al., 2013. Exploring hydrobiogechemical processes of floating treatment in a subtropical stormwater wet detention pond. Ecological Engineering 54: 66-76 (Paper 2).
- Marimon , Z. A. et al. 2013. System dynamics modeling with sensitivity analysis for floating treatment wetlands in a stormwater wet pond. Ecological Modeling 267: 66-79. (paper 3)
- Spieles DJ, Mitsch WJ . 2000. The effects of season and hydrologic and chemical loading on nitrate retention in constructed wetlands: a comparison of low- and high-nutrient riverine systems. Ecological Engineering14: 77-91. (paper 4)
- Wang, N. Mitsch WJ. 2000. A detailed ecosystem model of phosphorus dynamics in created riparian wetlands. Ecological Modeling 126: 101-130. (paper 5)

PRIMARY REFERENCES – ECOLOGICAL MODELING AND SYSTEM ECOLOGY

Beyers, R. J. and H. T. Odum. 1993. Ecological Microcosm. Springer-Verlag, New York, 572 pp. reviews the expending field of ecosystem research and relates the results and models of microcosm studies to general concepts in ecology

Grant, W. E., and Todd M. Swannack. 2008. Ecological Modeling, A common-sense approach to Theory and Practice. Blackwell Publishing.

Halfon, E. 1979. Theoretical Systems Ecology. Academic Press, New York, 516 pp.

Hall, CAS ed. 1995. Maximum Power: The ideas and Applications of H. T.Odum. University Press of Colorado, Niwot, Colorado. 393 p. ~ a tribute to H. T. Odum by his former students and collegues.

Hannon B, Ruth M. 1997.Modeling dynamic biological systems. Springer-Verlag, New York, 399 pp.

Jørgensen SE ed. 1994. Fundamentals of Ecological Modelling., 2nd ed. Elsevier Sci. Pub. Co. Amsterdam, 628 pp.

Jørgensen SE ed. 2011. Handbook of Ecological Models used in Ecosystems and Environmental Managementr. CRC Press.

Jørgensen SE and Mitsch WJ. 1983. Application of Ecological Modeling in Environmental Management, Part B. Elsevier, Amsterdam.

Jørgensen SE, Nielsen SR, Jørgensen LA. 1991. Handbook of Ecological Parameters and Ecotoxicology. Elsevier, Amsterdam, 1263 pp.

Jørgensen SE, Halling-Sørgensen B, Nielsen, SN. 1995. Handbook of Environmental and Ecological Modelling. Lewis Publishers (CRC Press), Boca Raton, FL.

Mitsch WJ, Ragade RK, Bosserman RW, Dillon JA. Eds. 1982. Energetics and Systems. Ann Arbor Press, Ann Arbor, Michigan.

Mitsch WJ, Straskraba M, Jørgensen SE. 1988. Wetland Modelling. Elsevier, Amsterdam, 227 pp

Odum HT. 1971. Environment, Power, and Society. J. Wiley, 331 pp.

Odum HT. 2007. Environment, Power, and Society (updated). Columbia University Press.

Odum HT. 1983. Systems Ecology: An Introduction. J. Wiley. 644 pp.

Odum HT. 1994. Ecological and General Systems: An Introduction to Systems Ecology. University Press of Colorado, a reprint of Odum 1983.

Odum HT, Odum EC. 1981. Energy Basis for Man and Nature. McGraw-Hill, New York, 337 pp.

Odum HT, Odum EC. Modeling for all Scales. 2000. Academic Press.

Most recent HT Odum's system modeling book

Orlob GT. 1983. Mathematical Modeling of Water Quality: Streams, Lakes, and Reservoirs. John Wiley & Sons, New York, 518 pp.

Patten BC., ed. 1971-1975. Systems Analysis and Simulation in Ecology. Volume 1 through 4, Academic Press, New York.

Patten BC, Jørgensen SE, eds. 1995. Complex Ecology: The Part-Whole Relation in Ecosystems. Prentice Hall, Englewood Cliffs, NJ, 705 pp.

Ulanowicz RE. 1986. Growth and Development: Ecosystems Phenomenology. Springer-Verlag, New York, 203 pp.