ESSM 600

PRINCIPLES OF ECOSYSTEM SCIENCE AND MANAGEMENT

M-W-F 9:10-10:00 AM

HFSB 105

INSTRUCTOR: Dr. Thomas W. Boutton
Department of Ecosystem Science & Management

OFFICE: KLCT Room 213 (Office Hours M-W-F 10 AM -12 noon)

PHONE: 845-8027

E-MAIL: boutton@tamu.edu

HOME PAGE: http://agrilife.org/boutton/

COURSE DESCRIPTION:

This course reviews the principles of ecosystem science that are fundamental to the development of sustainable land use systems, and examines contemporary land use practices and their ecological significance in the major ecosystems of the world. First, the importance of ecosystems and the services they provide to human society will be identified and discussed. Then, basic principles of ecosystem science that are critical to man's sustainable use of ecosystems will be reviewed. Emphasis is placed on ecosystem processes that also have significance at landscape, regional, and global scales. Finally, current land use practices and issues in forests, rangelands, wetlands, croplands, and urban ecosystems will be examined.

LEARNING OUTCOMES AND OBJECTIVES:

1) Be able to define the ecosystem concept and understand where ecosystems fit into ecological hierarchy.

2) Develop an in-depth knowledge of some of the most fundamental aspects of ecosystem science (energy flow, biogeochemistry, succession, and the role of disturbance).

3) Be able to describe how ecosystem processes are linked to other portions of the ecological hierarchy and other spatial and temporal scales.

4) Be able to document how land cover/land use changes alter and interact with ecosystem structure and function in grassland, forest, wetland, agricultural, and urban ecosystems.

5) Develop an understanding of some of the key environmental problems associated with land uses in grassland, forest, wetland, agricultural, and urban ecosystems.

6) Develop an awareness of ecosystem management practices that can mitigate and restore systems that have been affected adversely by human activity.

EVALUATION PROCEDURES:

(1) 2 exams worth 100 points each
(2) participation in class discussions
(3) presentation of an independent research project, 150 points

---

COURSE MATERIALS:

Assigned readings and class notes are available on e-Campus: http://ecampus.tamu.edu/

AMERICANS WITH DISABILITIES ACT (ADA) POLICY STATEMENT:

The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please contact Disability Services, in Cain Hall, Room B118, or call 845-1637. For additional information visit http://disability.tamu.edu

---

ACADEMIC INTEGRITY STATEMENT:

"An Aggie does not lie, cheat, or steal or tolerate those who do."

For more information see the Honor Council Rules and Procedures on the web at: http://www.tamu.edu/aggiehonor

---

ESSM 600
Principles of Ecosystem Science and Management
Course Outline

I. ECOLOGY AND LAND USES

A) Introduction

1) what is ecology?
2) significance of space and time (scaling)
3) ecology in relation to land use
4) ecology and natural resources

II. THE SCIENCE OF ECOLOGY: KEY CONCEPTS FOR LAND USERS

A) The contemporary context

1) ecosystems and the services they provide
2) human appropriation of ecosystem services via land uses
3) consequences of human land use from ecosystem to global scales
4) the need for sustainability of land uses

B) The ecosystem concept

C) Ecological energetics

1) laws of thermodynamics
2) qualities of solar energy
3) energy budget of earth-atmosphere system
4) productivity/decomposition
5) food chains and food webs
6) human modification of biological and physical aspects of energy flow

D) Biogeochemistry and nutrient cycling

1) nutrients essential for life
2) general characteristics of nutrient cycles
3) hydrologic cycle
4) carbon cycle
5) nitrogen cycle
6) nutrient cycles, climate, and global change

E) Succession

1) development of succession concept
2) primary and secondary succession
3) changes in ecosystem function during succession

4) past and present thoughts on the climax concept
5) contemporary models of mechanisms of succession
6) significance of succession to land use systems

F) Disturbance as an Ecosystem Characteristic

1) what is disturbance?
2) properties of disturbances - frequency, intensity, scale
3) influence on ecosystem structure and function
4) impact on biodiversity
5) role of disturbance in land management

G) Soils and their properties

1) components of the soil
2) soil formation
3) soil texture
4) soil profiles
5) major soil types and their distribution
6) soil erosion and soil conservation

H) Landscape ecology

1) structure, function, and dynamics of landscapes
2) landscape elements and their interactions
3) role of geomorphology in landscape ecology
4) landscape ecology and land management

I) Principle biomes of the world

1) geographic distribution of biomes
2) characteristics – climate, soils, plants, animals
3) slide show illustrating major biomes

III) LAND USES IN DIFFERENT ECOSYSTEM TYPES

A) Land uses in forestlands

1) geographic distribution of forestlands
2) North American forest types and major species
3) types of land uses on forestland
4) forest management
    a) site quality and site indices
    b) rotation
    c) methods of tree harvest

d) effects of harvesting on nutrient cycling and hydrology

B) Land uses in rangelands

1) geographic distribution of rangelands
2) rangeland types
3) land uses on rangelands
4) management of rangelands
    a) range site concept
    b) range condition concepts – past and present
    c) assessing and describing range condition
    d) grazing systems

C) Land uses in agricultural ecosystems

1) concept of sustainable agriculture
2) significance of tillage systems and crop rotations
3) impacts on watersheds

D) Land use in wetlands

1) varieties of wetlands and their occurrence
2) ecological significance of wetlands
3) current land uses and management practices in wetlands

E) Land uses in urban ecosystems

1) comparison of natural vs. urban ecosystems
2) physical and biotic characteristics of the city
3) ecosystem processes in the city
4) urban ecology as a planning approach
5) social ecology

F) Restoration ecology

1) the degraded system as an alternative state
2) feedbacks that increase resilience in degraded systems
3) overcoming constraints to restoration
4) goals, trajectories, evaluation criteria

ESSM 600 – PRINCIPLES OF ECOSYSTEM SCIENCE AND MANAGEMENT

FALL 2019 - CLASS SCHEDULE

Mon	Aug 26	Introduction
Wed	Aug 28	What is ecology?
Fri	Aug 30	Contemporary context of ecology
Mon	Sept 2	Ecological energetics– physics and energy budget
Wed	Sept 4	Ecological energetics– climate system
Fri	Sept 6	Ecological energetics– primary production and decay
Mon	Sept 9	Ecological energetics– food chains and food webs
Wed	Sept 11	Biogeochemistry – hydrologic cycle
Fri	Sept 13	Biogeochemistry – carbon cycle
Mon	Sept 16	Biogeochemistry – nitrogen cycle
Wed	Sept 18	Biogeochemistry – global change
Fri	Sept 20	Succession – ecosystem dynamics
Mon	Sept 23	Succession – ecosystem dynamics
Wed	Sept 25	Succession – ecosystem dynamics
Fri	Sept 27	Role of disturbance in ecology – type, frequency, intensity
Mon	Sept 30	Role of disturbance in ecology – causes and consequences
Wed	Oct 2	Soil structure and function
Fri	Oct 4	Soil structure and function
Mon	Oct 7	Landscape ecology
Wed	Oct 9	Landscape ecology
Fri	Oct 11	**MIDTERM EXAM**
Mon	Oct 14	Biomes
Wed	Oct 16	Biomes
Fri	Oct 18	Biomes

Mon	Oct 21	Forest ecology and management
Wed	Oct 23	Forest ecology and management
Fri	Oct 25	Rangeland ecology and management
Mon	Oct 28	Rangeland ecology and management
Wed	Oct 30	Agroecosystems
Fri	Nov 1	Agroecosystems
Mon	Nov 4	Wetlands
Wed	Nov 6	Wetlands
Fri	Nov 8	Urban ecosystems
Mon	Nov 11	Urban ecosystems
Wed	Nov 13	Restoration ecology
Fri	Nov 15	Restoration ecology
Mon	Nov 18	Group I – Presentation
Wed	Nov 20	Group II – Presentation
Fri	Nov 22	Group III – Presentation
Mon	Nov 25	Group IV – Presentation
Wed	Nov 27	**Reading Day – No Class**
Fri	Nov 29	**Thanksgiving Holiday – No Class**
Mon	Dec 2	Group V – Presentation
Wed	Dec 4	Group VI – Presentation
Fri	Dec 6	**No Class**
Mon	Dec 9	**FINAL EXAM, 8-10 AM**

ESSM 600
PRINCIPLES OF ECOSYSTEM SCIENCE AND MANAGEMENT
REQUIRED READING LIST

---

(1) INTRODUCTION TO ECOSYSTEM SCIENCE

Weathers K, Strayer D, Likens GE. 2013. Introduction to ecosystem science. IN: *Fundamentals of Ecosystem Science* (KC Weathers, DL Strayer, GE Likens, eds.), pp. 3-23. Elsevier, New York.

(2) CONTEMPORARY CONTEXT OF ECOLOGY AND RESOURCE MANAGEMENT

Daily GC, Alexander S, Ehrlich PR, Goulder L, Lubchenco J, Matson PA, Mooney HA, Postel S, Schneider SH, Tilman D, Woodwell GM. 1997. Ecosystem services: Benefits supplied to human societies by natural ecosystems. ***Issues in Ecology*** 2: 1-16.

Barnosky AD, Hadly EA, Bascompte J, Berlow EL, Brown JH, Fortelius M, Getz WM, Harte J, Hastings A, Marquet PA, Martinez ND, Mooers A, Roopnarine P, Vermeij G, et al. 2012. Approaching a state shift in Earth's biosphere. ***Nature*** 486: 52-58.

Ruddiman WF, Ellis EC, Kaplan JO, Fuller DQ. 2015. Defining the epoch we live in. Is a formally designated "Anthropocene" a good idea? ***Science*** 348: 38-39.

Schlesinger WH. 2017. When science informed policy. ***Biogeochemistry*** 133: 127-128.

(3) ECOLOGICAL ENERGETICS

Pace ML, Lovett GM. 2013. Primary production: The foundation of ecosystems. IN: *Fundamentals of Ecosystem Science* (KC Weathers, DL Strayer, GE Likens, eds.), pp. 25-51. Elsevier, New York.

Strayer DL. 2013. Secondary production and consumer energetics. IN: *Fundamentals of Ecosystem Science* (KC Weathers, DL Strayer, GE Likens, eds.), pp. 53-74. Elsevier, New York.

Chapin FS, Randerson JT, McGuire AD, Foley JA, Field CB. 2008. Changing feedbacks in the climate-biosphere system. ***Frontiers in Ecology and the Environment*** 6: 313-320.

(4) BIOGEOCHEMISTRY AND GLOBAL CHANGE

Oki T, Kanae S. 2006. Global hydrologic cycles and world water resources. ***Science*** 313: 1068-1072.

Abbott BW, Bishop K, Zarnetske JP, Minaudo C, Chapin FS, Krause S, et al. 2019. Human domination of the global water cycle absent from depictions and perceptions. ***Nature Geoscience*** 12: 533-540.

Cole JJ. 2013. The carbon cycle, with a brief introduction to global biogeochemistry. IN: *Fundamentals of Ecosystem Science* (KC Weathers, DL Strayer, GE Likens, eds.), pp. 109-135. Elsevier, New York.

Groffman PM, Rosi-Marshall EJ. 2013. The nitrogen cycle. IN: *Fundamentals of Ecosystem Science* (KC Weathers, DL Strayer, GE Likens, eds.), pp. 137-158. Elsevier, New York.

National Academy of Sciences. 2005. *Understanding and responding to climate change*. The National Academy of Sciences, Washington, D.C.

(5) SUCCESSION AND ECOSYSTEM DYNAMICS

Krohne DT. 2018. Ecological succession. IN: *Ecology: Evolution, application, integration* (DT Krohne), pp. 331-357. Oxford University Press, New York, NY.

(6) DISTURBANCE AS A COMPONENT OF ECOSYSTEMS

Tilman D. 1996. The benefits of natural disasters. ***Science*** 273: 1518.

Leach MK, Givnish TJ. 1996. Ecological determinants of species loss in remnant prairies. ***Science*** 273: 1555-1558.

Wootton JT, Parker MS, Power ME. 1996. The effect of disturbance on river food webs. ***Science*** 273: 1558-1561.

Reice SR. 1994. Nonequilibrium determinants of biological community structure. ***American Scientist*** 82: 424-435.

Moreno-Mateos D, Barbier EB, Jones PC, Jones HP, Aronson J, Lopez-Lopez JA, McCrackin ML, Meli P, Montoya D, Rey Benayas JM. 2017. Anthropogenic ecosystem disturbance and the recovery debt. ***Nature Communications*** 8: 14163, doi: 10.1038/ncomms14163.

(7) THE SOIL RESOURCE

Wall DH, Six J. 2015. Give soils their due. ***Science*** 347: 695.

Smith RL, Smith TM. 2003. Soil. IN: *Elements of Ecology* (5th ed.) (by RL Smith and TM Smith), pp. 79-98. Benjamin Cummings, San Francisco.

Comerford NB, Franzluebbers AJ, Stromberger ME, Morris L, Markewitz D, Moore R. 2013. Assessment and evaluation of soil ecosystem services. ***Soil Horizons*** 2013: doi:10.2136/sh12-10-0028

(8) LANDSCAPE ECOLOGY

Molles MC. 2002. Landscape ecology. IN: *Ecology: Concepts and Applications* (by MC Molles), pp. 478-501. McGraw-Hill, New York.

Forman RTT. 1981. Interactions among landscape elements: A core of landscape ecology. IN: *Perspectives in Landscape Ecology: Contributions to Research, Planning, and Management of our Environment* (SP Tjallingii and AA deVeer, eds), pp. 35-48. Pudoc, Wageningen, Netherlands.

Stokstad E. 2005. Flying on the edge: Bluebirds make use of habitat corridors. ***Science*** 309: 35.

Levey DJ, Bolker B, Tewksbury J, Sargent S, Haddad N. 2005. Effects of landscape corridors on seed dispersal by birds. ***Science*** 309: 146-148.

Kremen C, Merenlender AM. 2018. Landscapes that work for biodiversity and people. ***Science*** 362, eaau6020.

(9) BIOMES

Gurevitch J, Scheiner SM, Fox GA. 2006. Biomes. IN: *The Ecology of Plants* (2nd ed). pp. 417-443. Sinauer Associates, Sunderland, MA.

(10) LAND USES: FORESTLANDS

Noble IR, Dirzo R. 1997. Forests as human-dominated ecosystems. ***Science*** 277: 522-525.

Aber J, Christensen N, Fernandez I, Franklin J, Hidinger L, Hunter M, MacMahon J, Mladenoff D, Pastor J, Perry D, Slangen R, van Miegroet H . 2000. Applying ecological principles to management of the U.S. National Forests. ***Issues in Ecology*** 6: 1-20.

Spurr SH. 1964. Site. IN: *Forest Ecology* (by SH Spurr), pp. 125-146. Ronald Press, New York.

Science 2008. The future of forests: special issue. ***Science*** 320: 1435-1517.

Bastin JF, Finegold Y, Garcia C, Mollicone D, Rezende M, Routh D, Zohner CM, Crowther TW. 2019. The global tree restoration potential. ***Science*** 365: 76–79.

Veldman JW, Aleman JC, Alvarado ST, Anderson TM, Archibald S, Bond WJ, Boutton TW, Buchmann N Buisson E, Canadell JG, et al. 2019. Comment on the global tree restoration potential. ***Science*** (submitted, in review).

(11) LAND USES: RANGELANDS

Bengtsson J, Bullock JM, Egoh B, Everson C, Everson T, O'Connor T, O'Farrell PJ, Smith HG, Lindborg R. 2019. Grasslands – more important for ecosystem services than you might think. ***Ecosphere*** 10(2): Article e02582, doi 10.1002/ecs2.2582.

Sandhage-Hofmann A. 2016. Rangeland management. *Reference Module in Earth Systems and Environmental Sciences*, Elsevier. doi: 10.1016/B978-0-12-409548-9.10455-5.

Holechek JL, Pieper RD, Herbel CH. 1998. Range inventory and monitoring. IN: *Range Management: Principles and Practices* (by JL Holechek, RD Pieper, and CH Herbel), pp. 163-189. Prentice Hall, Upper Saddle River, New Jersey.

Briske DD, Fuhlendorf SD, Smeins FE. 2005. State-and-transition models, thresholds, and rangeland health: A synthesis of ecological concepts and perspectives. ***Rangeland Ecology and Management*** 58: 1-10.

(12) LAND USES: AGRICULTURAL ECOSYSTEMS

Godfray HC, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C. 2010. Food security: The challenge of feeding 9 billion people. ***Science*** 327: 812-818.

Foley JA, Ramankutty N, Brauman KA, Cassidy ES, Gerber JS, Johnston M, Mueller ND, O'Connell C, Ray DK, West PC, Balzer C, Bennett EM, Carpenter SR, Hill J, Monfreda C, Polasky S, Rockstrom J, Sheehan J, Siebert S, Tilman D, Zaks DP. 2011. Solutions for a cultivated planet. ***Nature*** 478: 337-342.

Tilman D, Balzer C, Hill J, Befort BL. 2011. Global food demand and the sustainable intensification of agriculture. ***Proceedings of the National Academy of Sciences of the USA*** 108: 20260-20264.

Xie J, Hu L, Tang J, Wu X, Li N, Yuan Y, Yang H, Zhang H, Luo S, Chen X. 2011. Ecological mechanisms underlying the sustainability of the agricultural heritage fish-rice coculture system. ***Proceedings of the National Academy of Sciences USA*** 108: E1381-E1387.

(13) LAND USES: WETLANDS

Zedler JB, Kercher S. 2005. Wetland resources: Status, trends, ecosystem services, and restorability. ***Annual Review of Environment and Resources*** 30: 39-74.

Scholz M, Harrington R, Carroll P, Mustafa A. 2007. The integrated constructed wetland concept. ***Wetlands*** 27: 337-354.

Moreno-Mateos D, Power ME, Comin FA, Yockteng R. 2012. Structural and functional loss in restored wetland ecosystems. ***PLoS Biology*** 10(1): e1001247.doi:10.1371/journal.pbio.1001247.

Morgan JA, Martin JF, Bouchard V. 2008. Identifying plant species with root associated bacteria that promote nitrification and denitrification in ecological treatment systems. ***Wetlands*** 28: 220-231.

(14) LAND USES: URBAN ECOSYSTEMS

Grimm NB, Faeth S, Golubiewski N, Redman C, Wu J, Bai X, Briggs J. 2008. Global change and the ecology of cities. ***Science*** 319: 756-760.

Pickett STA, Cadenasso ML, Grove JM, Groffman PM, Band LE, Boone CG, Burch W, Grimmond S, Hom J, Jenkins J, Law N, Nilon C, Pouyat R, Szlavecz K, Warren P, Wilson M. 2008. Beyond urban legends: An emerging framework of urban ecology, as illustrated by the Baltimore Ecosystem Study. ***BioScience*** 58: 139-150.

Stott I, Soga M, Inger R, Gaston K. 2015. Land sparing is crucial for urban ecosystem services. ***Frontiers in Ecology and the Environment*** 13: 387-393.

Lerman SB, Warren PS, Gan H, Shochat E. 2012. Linking foraging decisions to residential yard bird composition. ***PLoS ONE*** 7(8): e43497. doi:10.1371/journal.pone.0043497.

Oberndorfer E, Lundholm J, Bass B, Coffman R, Doshi H, Dunnett N, Gaffin S, Kohler M, Liu K, Rowe B. 2007. Green roofs as urban ecosystems: Ecological structures, functions, and services. ***BioScience*** 57: 823-833.

(15) RESTORATION ECOLOGY

Hobbs RJ, Hallett LM, Ehrlich PR, Mooney HA. 2011. Intervention ecology: Applying ecological science in the twenty-first century. ***BioScience*** 61: 442-450.

Suding KN, Gross KL, Houseman GR. 2004. Alternate states and positive feedbacks in restoration ecology. ***Trends in Ecology and Evolution*** 19: 46-53.

Marris E. 2009. Ragamuffin earth. ***Nature*** 460: 450-453.

Schulte DM, Burke RP, Lipcius RN. 2009. Unprecedented restoration of a native oyster metapopulation. ***Science*** 325: 1124-1128.

Benayas JMR, Newton AC, Diaz A, Bullock JM. 2009. Enhancement of biodiversity and ecosystem services by ecological restoration: A meta-analysis. ***Science*** 325: 1121-1124.