Graduate Program in Environmental Conservation Comprehensive Exam Topics

This document provides a comprehensive list of topics associated with the core area requirements for all students seeking candidacy for a Master of Science (MS) degree in Environmental Conservation (ECo). The purpose of this document is to provide students with a comprehensive list of study topics to help in preparation for the comprehensive exam. The actual exam will involve a randomly drawn set of questions from this list of topics (example questions provided below).

All MS students must pass the comprehensive exam to advance to candidacy for an MS degree in ECo. See the student handbook for the graduate program in ECo for a detailed description of the comprehensive exam requirement, including procedures for taking the exam and what to do if part or all of the exam is failed.

This document is organized into six major sections. The first section pertains to the general knowledge requirement for ALL students and is based on two core courses required of ALL ECo graduate students seeking an MS degree: 1) research concepts, and 2) analysis of environmental data. ALL students are responsible for section 1, and a portion of the comprehensive exam (40%) will be allocated to this section. Sections 2 through 6 correspond to the five areas of concentration within the ECo graduate program: 1) Wildlife, Fish and Conservation Biology, 2) Forest Resources and Arboriculture, 3) Water, Wetlands and Watersheds, 4) Environmental Policy and Human Dimensions, and 5) Building Systems. Each section consists of three sub-sections corresponding to the three core topic areas: 1) environmental science, 2) quantitative science, and 3) human dimensions. The topics listed under each sub-section are tailored to match the corresponding concentration. For example, the topics listed under the core topic areas for Wildlife, Fish and Conservation Biology are selected to reflect the basic knowledge expected of all students in this concentration. Each student is responsible for the section corresponding to his/her concentration and a portion of the exam (60%) will be allocated to this section (20% each from the three core topic areas).

IMPORTANTLY, to accommodate the diversity of academic backgrounds among students within each concentration, students will be allowed to choose from among a set of questions within each section of the exam; e.g., "choose 2 of the following 5 questions". Thus, each student will have the opportunity to answer questions pertinent to their particular academic background and still deemed core knowledge for the entire concentration. In addition, we realize that through the course of the program students will gain in-depth knowledge in some, but not all of the topic areas listed in the concentrations below. Thus, we are not expecting students to have mastered each topic area. We do, however, expect students to have at the very least, some general knowledge of the concepts or ideas listed in the general knowledge section and the section corresponding to their concentration. To help in areas where students were not exposed to topics via coursework, we will eventually provide a list of one or two readings for each topic (although this is currently only completed for the building systems concentration). Additionally, we will eventually provide a list of courses regularly offered in ECo or other departments that cover the various topics (although this is currently only partially completed for the water, wetlands and watershed concentration and environmental policy and human dimensions concentration.

Section 1. General Knowledge Section (All students)

This section consists of two sub-sections or topics based on core courses required of ALL ECo graduate students seeking an MS degree. All students will be required to answer a set of questions drawn at random from each of these subsections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 40% to the general knowledge section. Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section.

A. Research Concepts

1. Definition(s) of science and other related terms (hypothesis, theory, fact, etc.)
2. History of science: perspective, timeline, important events, issues and people
3. Philosophy of science: major lines of thought, evolution of thought, key people and ideas
4. Science and the scientific method
5. Deductive and inductive approaches and the role of empiricism
6. Approaches to research design (e.g., observational versus experimental)
7. Induction, retroduction, and hypothetico-deductive methods
8. Biological and statistical hypotheses
9. Null hypotheses: approach and issues
10. Formulating research questions, including the question "why?"
11. The concept of reproducibility of results: what is it, who originated it, and its current role
12. Definition and goal of study design
13. Observational/experimental units, statistical population, and scope of inference
14. Sources of variability
15. Pseudoreplication: issues, importance, who brought this to our attention
16. Purpose, approach, and issues related to scientific literature review
17. Basic and advanced experimental design (e.g., simple random, stratified random, etc.)
18. Concepts in basic research design (e.g., randomization, replication, interspersion, control)
19. Issues and trade-offs associated with randomization vs. interspersion of plots
20. Sample size: how defined, why is it important, issues related to
21. Issues related to authorship, co-authorship, and peer-review of scientific papers

Example questions:

1. Who is credited as the founder of modern science, and what 3 premises did he promote?

2. You are going to design an experiment where you are testing mechanical control (label **M**) vs. chemical control with the product Roundup (label **R**) of an exotic invasive woodland plant. Your study plot is on a hillside that slopes from right to left in the diagram below. Pretend you had a random numbers table, and label each cell with a treatment (label the 3 columns as well):

(a)

_____	_____	_____
Plot 1	Plot 2	Plot 3

Plot 4	Plot 5	Plot 6
Plot 7	Plot 8	Plot 9

(High Side) > > > > > GRADIENT > > > > > (Low Side)

(b) In this design, which entity serves as the experimental unit? _____
(c) This is an example of what kind of research design? _____
(d) To incorporate 2 gradients into your study, you might use a design called? _____

B. Analysis of Environmental Data

1. Role of statistics: description versus inference
2. Population (statistical) versus sample
3. Types of environmental data (as it pertains to the choice of statistical model): continuous, count (simple and cross-classified), proportion, binary, time at death, time series, and circular
4. Types of variables based on their relationship: dependent, independent, and interdependent
5. Parameter versus statistic
6. Common measures of central tendency (mean, median, mode), spread (variance, standard deviation, coefficient of variation, range, median absolute deviation, interquartile range) and non-normality (skewness and kurtotsis)
7. Accuracy versus precision
8. Quantiles: what are they
9. Common single variable distribution plots (empirical distribution function, empirical cumulative distribution function, histogram, box-and-whisker plot, normal quantile plot)
10. Covariance versus correlation (Pearson's product-moment *r* and Spearman's *rho*)
11. Imputation: what is it, and common approaches
12. Data transformation versus standardization: what is a z-score?
13. Statistical outliers: what are they, and approaches for dealing with them
14. Deterministic versus stochastic model
15. Mechanistic versus phenomenological model
16. Probability distribution: what is it, and what is its purpose in statistical models
17. Typees of error (observation versus process)
18. Discrete versus continuous probability distribution
19. Probability mass versus probability density function
20. Cumulative probability distribution (especially as it pertains to the calculation of p-values)
21. Quantile distribution (especially as it pertains to identifying critical values of test statistics).
22. Parametric versus nonparametric inference
23. Frequentist versus Bayesian inference paradigms
24. *p*-value: what is it, how is it computed
25. One-sided versus two-sided test (especially as it pertains to the calculation of *p*-values)
26. Alpha, Beta and statistical power
27. Type I versus type II error

28. Ordinary least square estimation
29. Numerical versus analytical solutions to parameter estimation and hypothesis testing
30. Point versus interval estimate
31. Standard error and confidence interval
32. Bootstrap resampling (especially as it pertains to interval estimation)
33. Randomization (Monte Carlo) testing
34. Autocorrelation (spatial and temporal)
35. Interpolation versus extrapolation
36. Penalized goodness-of-fit and model selection
37. Likelihood (and maximum likelihood)
38. Bayes theorem and posterior probabilities

Example questions:

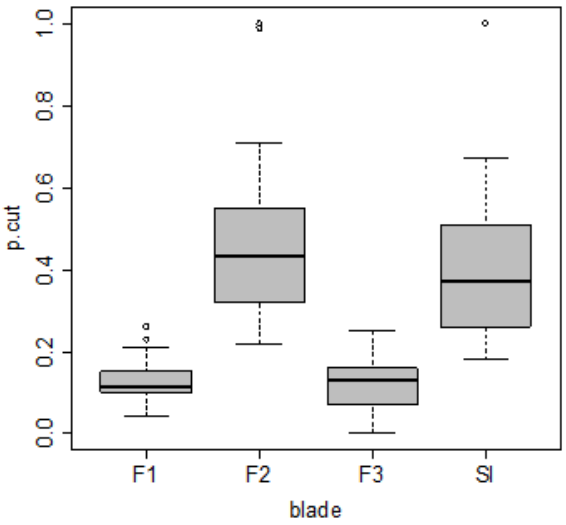
1. (Type of environmental data). In a field study on factors affecting the likelihood of heart rot occurrence in oak trees, you are considering three ways to collect data. What type of *dependent* data (continuous, count, binary, proportion, time to death/failure, time series, circular) are each of the following:

   a) In a sample of *n* variable-radius *plots*, you count how many out of the nearest *m* oak trees have heart rot (each tree is recorded as "present" or "absent") and measure a suite of independent environmental variables at the *plot* scale.

   b) In a sample of *n* oak *trees*, you determine the presence/absence of heart rot and measure a suite of independent environmental variables at the *tree* scale.

   c) In a sample of *n* fixed-area *plots*, you count the number oak trees with heart rot and measure a suite of independent environmental variables at the *plot* scale.

2. (Measurement versus process error). In a manipulative laboratory experiment on the effect of saw blade type (independent variable) on the percent of the climbing rope cut by accidental injury (dependent variable), you record considerable variability about the group means (see figure). What are the two types of *error* represented here and give an example of each in the context of this study?



Section 2. Wildlife, Fish and Conservation Biology Concentration

This section consists of three sub-sections corresponding to the three core topic areas required of ALL ECo graduate students seeking an MS degree. All students in the Wildlife, Fish and Conservation Biology concentration will be required to answer a set of questions drawn at random from each of these sub-sections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 60% to this section. Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section. General reference books that cover many of the topics are provided at the end.

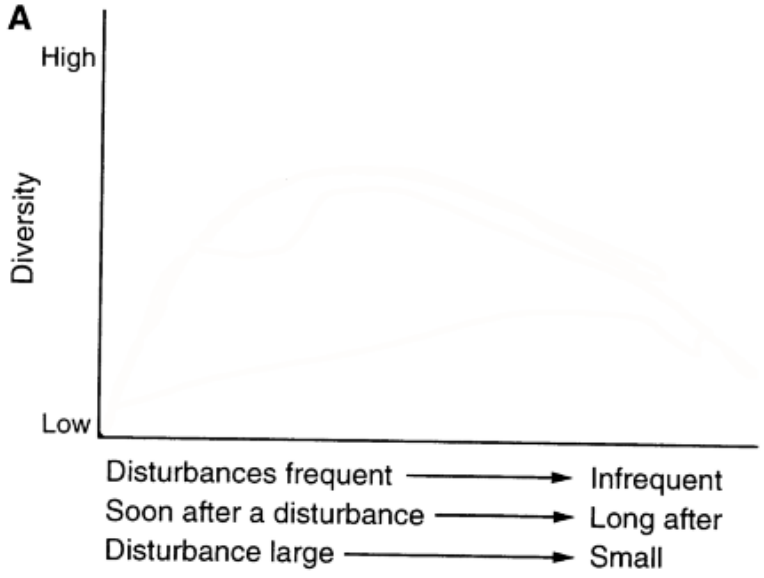
A. Environmental Science

1. Intermediate disturbance hypothesis
2. Minimum dynamic area
3. Single Large or Several Small (SLOSS) debate
4. Conservation of species at the core versus periphery of their range
5. Exponential and logistic population growth
6. Metapopulation dynamics
7. Source-sink population dynamics
8. Succession and community concepts (Clements and Gleason)
9. Focal species concepts: keystone, umbrella, indicator, flagship, surrogate
10. Habitat fragmentation
11. Island biogeography
12. Ecological niche
13. Ecological resiliency and integrity
14. Top down versus bottom up regulation
15. Food webs and nutrient flows
16. Functional versus numerical response
17. Trophic cascades
18. Natural selection
19. Adaptive radiation
20. Convergent evolution
21. Theory of punctuated equilibrium
22. Local adaptation
23. Adaptive capacity
24. Genetic drift
25. Inbreeding depression
26. Extinction vortex (demographic vs. genetic causes of population extinction)
27. Effective population size
28. Prominent anthropogenic impacts on ecosystems: what are they?
29. Adaptive (resource) management
30. Role of zoos in conservation
31. Definitions of "urban" and urbanization gradients? (Rebele 1994, Picket et al. 2001)

32. Key characteristics of urban environments: such as urban heat island, high spatial heterogeneity, and elevated basal resources in food webs (Shochat et al. 2006, Pickett et al. 2011)
33. "Ecology in the city" versus "ecology of the city" (Pickett et al. 2001)
34. Diversity versus abundance along urban gradients (McKinney 2002, Shochat et al. 2006)
35. Typical characteristics of urban wildlife (DeStefano & DeGraaf 2003)
36. Socioeconomic drivers of biodiversity (Pickett et al. 2011)

Example questions:

1. (Intermediate disturbance hypothesis). On the plot below, draw a line representing the expectation under the intermediate disturbance hypothesis. Also, briefly describe a mechanism(s) for the hypothesized pattern in the context of a specific example.



2. (Inbreeding depression). In Illinois, the greater prairie chicken population was estimated to be 25,000 in 1933, in 1962 it was 2,000, and in 1993 it was down to 50 individuals. In addition, in 1960 the hatching success rate was 90%, and by 1990 the hatching success rate was down to 74%. Lastly, between 1960-1990 genetic variation in the population declined by 30%. In the early 1990's individuals from Minnesota and Kansas were introduced to the population and shortly thereafter hatching rate success increased to 94%. What genetic phenomenon does this case study demonstrate and what is the mechanism(s) behind the process?

B. Quantitative Science

1. Biological versus statistical significance
2. Population viability modeling (PVA)
3. Spatially explicit population modeling (SEPM)
4. Leslie population transition matrix
5. Decision-support systems (DSS)

6. Remote sensing: sensor resolution; multispectral & hyperspectral data; airborne & satellite sensors; application to wildlife and fisheries science
7. Geographic information systems (GIS): main types of data representation (vector versus raster); application to wildlife and fisheries science
8. Global positioning systems (GPS): application to wildlife and fisheries science
9. Animal tracking devices: radio telemetry, acoustic telemetry, GPS telemetry, PIT tags, etc.
10. Environmental tracking devices: light, temperature and depth meters, etc.
11. Open source software versus proprietary software, open standards, interoperability
12. Metadata and XML: what are these, and why are they important for quantitative science
13. Database structures: difference between a "flat file" database and a "relational database"; the three types of relationships found in data; the idea of "normalizing" of data
14. Internet technologies: FTP; Http; the so-called "Web 2.0" technologies (such as content management systems); the emerging idea of "cloud computing" and "web services."

Example questions:

1. (Leslie population transition matrix). You are studying population dynamics of species X and you want to parameterize a Leslie population transition matrix so that you can simulate population growth. Species X is a short-lived species with three distinct life stages: 1) juvenile, 2) sub-adult, and 3) adult. Set up a Leslie matrix for this population, label the cell entries, and define or describe each parameter.

2. (Remote sensing). You are interested in using remote sensing to map habitat conditions for a forest-dwelling species that has an average home range size of 1 ha (100x100 m) and differentiates between coniferous and deciduous forest of varying successional or structural stages (e.g., early, mid, and late-seral). What are some of the principal considerations in selecting a satellite-based remote sensing product for this application in terms of both *spatial* and *thematic* resolution? Also, what is likely to be a key limitation of any satellite imagery in mapping important habitat conditions for this species?

C. Human Dimensions

1. Environmental conservation agencies: names and major responsibilities (e.g., Fish and Wildlife Service, Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Geological Survey)
2. Environmental conservation laws: date of enactment, purpose, and major regulations (e.g., Lacey Act, Migratory Bird Treaty Act, Endangered Species Act, National Environmental Policy Act, Clean Water Act, Clean Air Act, Pittman-Robertson Act (Federal Aid in Wildlife Restoration), Dingell-Johnson Act (Federal Aid in Sport Fish Restoration))
3. Environmental conservation pioneers: names and major contributions (e.g., Aldo Leopold, Gifford Pinchot, John Muir, Theodore Roosevelt, E.O. Wilson)
4. History of natural resource conservation in the United States
5. Role of non-governmental organizations (NGOs) in wildlife and fish conservation
6. Conservation easement: what is it and how is it used in wildlife and fish conservation
7. Nuisance wildlife: what are they and what are some management options

8. Conflict resolution methods

Example questions:

1. (Environmental conservation agencies). A federal dam on the Connecticut River has been proposed for removal to improve aquatic connectivity and ecosystem integrity. Atlantic salmon, an federally endangered anadromous fish species, is known to migrate past the dam. Also, dwarf wedge mussels, also federally endangered, are known to occur in the river segment below the dam. Briefly, what federal agencies would have a principal role in the review and permitting of the dam removal project, and what would be their major responsibilities?

2. (Conservation easement). Let's say that you are an active conservationist seeking to protect land and natural resources from development in the Connecticut River valley in Massachusetts. The land is almost entirely privately owned and is used for a variety of purposes, including agriculture and forestry. A chief threat to the biodiversity of the region is the increasing development of natural lands by urban growth. What is a conservation easement (i.e., how does it work) and how might this tool be employed to address this threat?

General reference books and articles:

Ricklefs RE, and GL Miller. 1999. *Ecology* (4th edition). Freeman, W.H. & Company, New York. 822 pages.

Gotelli NJ. 2008. *A Primer of Ecology* (4th edition). Sinauer Associates, Sunderland, MA. 265 pages.

Primack, RB. 2010. *Essentials of Conservation Biology* (4th edition). Sinauer Associates, Sunderland, MA. 535 pages.

Bolen EG, and WL Robinson. 2003. *Wildlife Ecology and Management* (5th Edition). Prentice Hall, New Jersey. 634 pages

DeStefano S, and RM DeGraaf. 2003. Exploring the ecology of suburban wildlife. Frontiers In Ecology And The Environment 1:95-101.

McKinney ML. 2002. Urbanization, biodiversity, and conservation. BioScience 52:883-890.

Pickett STA, ML Cadenasso, JM Grove, CH Nilon, RV Pouyat, WC Zipperer, and R Costanza. 2001. Urban ecological systems: Linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual Review of Ecology and Systematics 32:127-157.

Pickett STA, ML Cadenasso, JM Grove, CG Boone, E Irwin, PM Groffman, SS Kaushal, V Marshall, BP McGrath, CH Nilon, RV Pouyat, K Szlavecz, A Troy, and P Warren. 2011. Urban ecological systems: Foundations and a decade of progress. Journal of Environmental Management 92:331-362.

Rebele F. 1994. Urban Ecology and Special Features of Urban Ecosystems. Global Ecology and Biogeography Letters 4:173-187.

Shochat E, PS Warren, SH Faeth, NE McIntyre, and D Hope. 2006. From pattern to emerging processes in urban mechanistic ecology. Trends in Ecology and Evolution 21:186-191.

Section 3. Forest Resources and Arboriculture Concentration

This section consists of three sub-sections corresponding to the three core topic areas required of ALL ECo graduate students seeking an MS degree. All students in the Forest Resources and Arboriculture concentration will be required to answer a set of questions drawn at random from each of these subsections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 60% to this section. Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section.

A. Environmental Science

1. Compartmentalization of Decay in Trees (CODIT)
2. Right tree, right place
3. Installation & establishment
4. Pruning
5. Tree nutrition
6. Plant health care (PHC) and Integrated Pest Management (IPM)
7. Sustained yield
8. Forest health (disease and insect vectors)
9. Forested watersheds
10. Forest ecology
11. Timber management
12. Timber harvesting

Example questions:

1. (Right tree, right place). Trees are often planted in such a way that they will become liabilities in the landscape (e.g., frequently needing to be pruned). Describe three scenarios where a particular tree species would become a liability, violating the principle of "right tree, right place." Suggest two alternative species that would not become liabilities in the scenario you described.

2. (Silviculture). Define silviculture and describe how it is used to produce public benefits.

B. Quantitative Science

1. Tree inventory
2. Forest inventory
3. Tree risk assessment
4. Tree valuation (CTLA)
5. Benefits provided by trees (iTREE)
6. Remote sensing: sensor resolution; multispectral and hyperspectral data; airborne and satellite sensors; application to forestry and arboriculture
7. Geographic Information Systems (GIS): main types of data representation (vector versus raster); metadata; application to forestry and aboriculture

8. Global Positioning Systems (GPS): application to forestry and arboriculture

Example questions:

1. (Tree risk assessment). The house in Amherst that you and several friends rent has a few large trees. Describe four key elements that you would assess to determine the risk each tree presents. In addition, if the landlord has a limited budget, how would you suggest prioritizing remedial action?

2. (GIS). You have been hired as a technical consultant by a consortium of non-governmental conservation organizations, such as The Nature Conservancy and Trustees of Reservations, to prioritize forest parcels for conservation in the state of Massachusetts. Briefly discuss how you might use GIS to aid you in this endeavor with respect to data storage, management and analysis.

C. Human Dimensions

Safety:

1. ANSI Z.133
2. OSHA 1910.269
3. EHAP
4. PPE

Legal:

5. MGL Chapter 87
6. Negligence & liability
7. "Shall" versus "should"
8. EPA labels for pesticides

Other:

9. Benefits provided by trees
10. Ownership patterns and landowner characteristics
11. Land use history of southern New England
12. 3rd party certification of forests and forest products
13. Forest ecosystem services
14. TRIAD approach to sustainable forest management
15. Forest Best Management Practices (BMPs)
16. The "illusion of preservation"

Example questions:

1. (Negligence & liability). A recent tree failure on campus killed a student, whose estate is now suing the University. A secretary who's desk overlooks the location of the tree failure did not notice anything unusual about the tree a few days before it failed, but the tree had recently been inspected by the campus arborist, who noticed fruiting bodies around the buttress roots. Was the secretary or campus arborist negligent for not taking action in this situation? Briefly justify your answer.

2. (Land use history of southern New England). You are giving a talk at an international forest resources conference about your thesis research on the role of climate and landform in determining the distribution of plant communities in southern New England. In the introduction and background, to provide the necessary historical context for your research, you need to briefly describe the human land use history of southern New England in relation to land cover. In this context, briefly describe the dominant periods of human land use in southern England beginning with the early European settlers, including the period dates (roughly) and the dominant land cover patterns that characterized each period.

Section 4. Water, Wetlands and Watersheds Concentration

This section consists of three sub-sections corresponding to the three core topic areas required of ALL ECo graduate students seeking an MS degree. All students in the Water, Wetlands and Watersheds concentration will be required to answer a set of questions drawn at random from each of these subsections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 60% to this section. Numbers in the parenthesis after each topic refer to the course that covers the basics of each topic (see course list at the end of the section). Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section.

A. Environmental Science

1. Water properties (3)
2. Water budgets (1,2)
3. Surface runoff (1,2)
4. Groundwater recharge (1,2)
5. Precipitation process (1,2)
6. Soil processes (1,2)
7. Land use hydrology (1,2)
8. Hydrologic pathways of Stream flow (1,2)
9. Riparian functions (1,2)
10. Hyporheic functions (1,2,4)
11. Eutrophication process (1,2)
12. Sediment dynamics (1,2)
13. Hydric soils formation and characteristics (1,4)
14. Wetland classification and National Wetland Inventory(4,6)
15. Wetlands - status and trends (4,6)
16. Biological adaptation to aquatic conditions (4,6)
17. Wetland ecosystem development and succession (4,6)
18. Wetland functions and evaluation (1,4,6)
19. Wetland restoration and replication (2,4,6)
20. Wetland definitions and characterizations (6)
21. Wetland biogeochemistry and nutrient cycling (6)
22. Wetland hydrology

Example questions:

1. (Hyporheic functions). Discuss the role of hyporheic zones in aquatic food webs.

2. (Hydric soils formation and characteristics). Describe the chemical reducing sequence that takes place within saturated soils after oxygen is fully consumed and no longer available for microbial respiration. How do these biogeochemical processes affect wetland water quality functions and hydric soil morphology?

3. (Wetland functions and evaluation). Briefly explain why wetlands are referred to as "kidneys of the landscape" in terms of their geographic setting AND list three ways in which they improve water quality.

B. Quantitative Science

1. Water balance equations (1,2)
2. Hydrologic equations in practice (1,2)
3. Hydrograph analysis (1,2)
4. Frequency analysis of rainfall (1,2)
5. Spatial analysis of water resources using GIS (2)
6. Sediment modeling (2)
7. Runoff estimation (2)
8. Riparian (stream-side) survey (1,2)
9. Stream flow analysis (1,2)
10. Wetland delineation (4)
11. Wetland water balance (1,4,6)
12. Water demand analysis (3)
13. Demand forecasting (3)
14. Water planning and permitting methods (3)
15. Groundwater assessment and safe yield (2,3)
16. Water supply assessment (3)
17. Discount rates, cost benefit analysis (2,3)
18. Sustainable versus safe yield (2,3)
19. Probability assessment of disasters (2)
20. Wetland vegetation analysis (4)
21. Wetland functional assessment (4)
22. Wetlands condition assessment (4)
23. Field assessment of road-stream crossings (4)
24. Wetlands wildlife habitat evaluation (4)

Example questions:

1. (Water balance equations). A lake in Massachusetts is declining in volume over years and the water supplier is worried about this. How would you develop a water budget for the lake, and how would you use this budget in identifying the water loss problem facing the lake?

2. (Hydrograph analysis). Describe a hydrograph and how it is useful in flood analysis. Give specific examples.

3. (Water planning and permitting). Can National Wetlands Inventory (NWI) wetland maps be used to establish the boundaries of jurisdictional wetlands. Why or why not?

C. Human Dimensions

1. Dublin-Rio principles (3)

2. Water as a basic right (3)
3. Markets and pricing (2,3)
4. Demand side management (3)
5. Water pricing (3)
6. Spatial and temporal water use patterns (2,3)
7. Water appropriation (inter-sectoral and jurisdictional) (3)
8. Watershed and water quality: TMDL's, 303d listing, clean water act (2,3,4)
9. Federal wetland regulations and the 404 process (2,3,4)
10. International programs for wetland conservation
11. Water quality regulation: pollution trading, best available technology/best practice (2,3)
12. Water quality standards (2)
13. Emerging contaminants (2)
14. Dams: benefits and drawbacks (2,3)
15. Instream flows, environmental water rights (2,3)
16. Conservation strategies (2,3,4,6)
17. Water markets (2,3)
18. Wetland mitigation banking and *in lieu* fee programs (2,4,6)
19. Watershed planning methods (2)
20. Failure: government and markets (3)
21. Common pool resources (3)
22. Water institutions (3)
23. Water security (3)
24. Federal wetlands jurisdiction, constitutional issues and the SWANCC decision (6)
25. The Massachusetts Wetlands Protection Act jurisdiction, general procedures and terms (4,6)
26. Wetland functions and values and the history of public perspectives of wetlands (6)
27. Similarities and differences among various agency definitions of wetlands (4,6)

Example questions:

1. (Conservation strategies). Explain the four types of strategies used to conserve wetlands at the national level in the U.S. Which one of the four do you think is most effective? Why?

2. (Composite of many topics). The Mississippi River drains over 40% of the U.S. and Canada and is the most extensive navigation artery in North America. Yet, the river itself and the communities that live along it are faced with many resource management challenges and is typical of most major river systems. Briefly discuss at least 4 major ways in which the system has been modified and discuss the problems associated with these modifications to the river.

3. (Federal wetland regulations and the 404 process). Distinguish between Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act. Be sure to identify what activities are regulated by each, AND identify what federal agencies have authority for implementing each?

Potential Courses (Course numbers are referred in topics listed above):

1. Forest and Wetland Hydrology
2. Watershed Science and Management
3. Water Resources Management and Policy

4. Wetland Assessment and Field Techniques
5. Ecosystem Modeling and Simulation
6. Wetlands Ecology and Conservation (eventually to become Wetland Science)

Section 5. Environmental Policy and Human Dimensions Concentration

This section consists of three sub-sections corresponding to the three core topic areas required of ALL ECo graduate students seeking an MS degree. All students in the Environmental Policy and Human Dimensions concentration will be required to answer a set of questions drawn at random from each of these subsections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 60% to this section. Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section.

All readings will be made available in a bound, hardcopy folder available to borrow from the Concentration Coordinator (Schweik). Most readings are also available in a u:drive folder in pdf format. Also available is a downloadable EndNote archive with attached pdfs. Contact Charlie Schweik or Anita Milman for access.
https://udrive.oit.umass.edu/amilman/ECO%20HD%26EP%20Comp%20Exam%20Readings.

A. Concepts in Environmental Conservation (the "Environmental Science" section for students in this concentration)

Conceptual foundations of "sustainability" :

1. Defining sustainability
   Readings:
   (1) United Nations (1987) Our Common Future. Report of the World Commission on Environment and Development.
   (2) Toman, M. (1992) "The Difficulty in Defining Sustainability," Resources, 106(winter): 3-6.

2. Debates over limits to growth, resource scarcity, and innovation
   Readings:
   (1) MacKenzie (n.d.) "Finite resources and the future" Essay (http://www.udel.edu/johnmack/frec424/424_lec01c_malthus.html)
   (2) Ohlsson L (2000) "Water conflicts and social resource scarcity." Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere 25 (3):213-220

Environmental ethics:

3. Philosophies of conservation, culture and the environment
   Readings:
   (1) Leopold, A. (1970). "Part IV: The Land Ethic, Wilderness, and Conservation Esthetic" Sand County Almanac (pp. 237-294): Ballentine.
   (2) Van Dyke, F. (2008). Chapter 1: The History and Distinctions of Conservation Biology. Conservation Biology. Foundations, Concepts, Applications. 2nd Edition: 2-26.

4. Decision-making: risk and the precautionary principle
   Readings:

(1) O'Riordan T, Jordan A (1995) '"The Precautionary Principle in Contemporary Environmental Politics." Environmental Values 4 (3):191-212
(2) Fairbrother, A. and R. S. Bennett (1999). "Ecological Risk Assessment and the Precautionary Principle." Human and Ecological Risk Assessment: An International Journal **5**(5): 943-949.

5. Environmental justice
   Readings:
   (1) Bullard RD. Environmental Justice in the 21st Century.
   www.ejrc.cau.edu/ejinthe21century.htm.
   (2) Williams RW (2005) "Getting to the Heart of Environmental Injustice: Social Science and its Boundaries." Theory and Science 6 (1)

Science and the policy process:

6. Useful vs usable knowledge
   Readings:
   (1) Dilling L, Lemos MC (2011) "Creating usable science: Opportunities and constraints for climate knowledge use and their implications for science policy. "Global Environmental Change 21 (2):680-689
   (2) Sarewitz D, Pielke Jr. R (2007) "The neglected heart of science policy: reconciling supply of and demand for science." Environmental Science & Policy 10 (1):5-16. doi:10.1016/j.envsci.2006.10.001

7. Boundary Work
   Readings:
   (1) Clark WC, Tomich TP, van Noordwijk M, Guston D, Catacutan D, Dickson NM, McNie E (2011) "Boundary work for sustainable development: Natural resource management at the Consultative Group on International Agricultural Research (CGIAR)." Proceedings of the National Academy of Sciences of the United States of America. doi:10.1073/pnas.0900231108

8. Post-normal science
   Readings:
   (1) Funtowicz SO, Ravetz JR (1993) "Science for the post-normal age." Futures 25 (7):739-755

Environmental and policy economics:

9. Useful definitions
   Readings:
   (1) Markandya A, Perelet R, Mason P, Taylor T (2001) Dictionary of Environmental Economics. Earthscan, London and Sterling, VA

10. The "theory of goods": private, public, toll and club, common pool
    Readings:
    (1) Ostrom, E., Gardner, R., & Walker, J. (1994). Rules, Games and Common Pool Resources. Ann Arbor: University of Michigan Press. Chapter 1 pages 6-8 only!
    (2) Ciriacy-Wantrup, Siegfried V. and Bishop, Richard C. (1975), "Common Property' as a Concept in Natural Resource Policy." Natural Resources Journal, 15: 713-727.

11. Common-pool resources, "tragedy of the commons," collective action
    Readings:
    (1) Hardin, G. (1968). "The Tragedy of the Commons." Science. 162:1243-48.
    (2) Mulder, M.B and Coppollillo, P. 2005. "Chapter 6. Rational Fools and the Commons." In Mulder, M.B., and Coppollillo, P. Conservation. Princeton, NJ: Princeton University Press. Pp. 129-155.

12. Pareto efficiency and Coase's Theorem
    Readings:
    (1) Definition of pareto efficiency: http://www.econguru.com/what-is-pareto-efficiency
    (2) Weimer, D. L., & Veining, A. R. (2011). Chapter 2. What is Policy Analysis *Policy Analysis* (pp. 23-38). Boston: Longman Publishers.
    (3) Friedman, D. 1980. The World According to Coase, The Law School Record, University of Chicago Law School. Available at http://www.daviddfriedman.com/Academic/Coase_World.html.

13. Government failure, market failure
    Readings:
    (1) Mintrom, M. 2012. "Chapter 10. Analysis of Market Failure." In Mintrom. M. Contemporary Policy Analysis. NewYork, NY: Oxford University Press. Pp. 149-188.
    (2) Mintrom, M. 2012. "Chapter 11. Analysis of Government Failure." In Mintrom. M. Contemporary Policy Analysis. NewYork, NY: Oxford University Press. Pp. 189-208.

14. Social capital
    Readings:
    (1) Pretty, J. and Ward. 2001. "Social Capital and the Environment." World Development. 29(2): 209-227.

15. History of natural resource conservation in the United States
    Readings:
    (1) Kraft, M. E. 2000. "U.S. Environmental Policy and Politics: From the 1960s to the 1990s." Journal of Policy History, 12(1): 17-42.

Example question:

1. (Theory of goods). How we manage a natural resource is often based on how we treat it as a "good." Use the table below to describe the characteristics of the four general categories of goods. Label A-F appropriately.

		(A)	
		Yes	No
(B)			

	Yes	(C)	(D)
	No	(E)	(F)

2. (Social capital). Define the concept of "social capital". What concepts fall within it? Why is this concept important to environmental management?

B. Research and Analytical Methods (equivalent to the "Quantitative Science" section in other concentration areas)

Research Methods:

1. Data Collection & Analysis: interviews, focus groups, expert elicitation, participant observation, survey design and implementation, case study, comparative case studies, coding, content analysis, discourse analysis, social network analysis. Note, for the exam we are not expecting you to know how to do each one of these, but you should at least know generally what each of these are.
   Readings:
   (1) Bert BL (2004) Qualitative Research Methods. Pearson Boston, New York, San Francisco [*In library: H61 B4715 -- particularly useful for data collection methods*]
   (2) Babbie E (2001) The practice of social research. Wadsworth, Belmont [*In library H62 B2 -- particularly strong on conceptualizing research, developing scales, and analysis methods*]
   (3) Ragin C (1987) The comparative method: moving beyond qualitative and quantitative strategies. University of California Press, Berkeley, Los Angeles, London [*In library: H61 .R216 -- addresses comparative case studies*]

2. Participatory action research
   Readings:
   (1) Walter M (2009) Chapter 21: Participatory Action Research. In: Social Research Methods. Oxford University Press, London,

3. Human Subjects Institutional Review Board
   Readings:
   (1) http://www.umass.edu/research/human-subjects-trainingciti-training-course

Analytical Methods:

4. Frameworks for conceptualizing and analyzing socio-ecological systems. Two examples:
   Readings:
   (1) Ostrom, E. et al. 2009. A General Framework for Analyzing Sustainability of Social-Ecological Systems. Science 325, 419
   (2) Machlis, G.E., Force, J.E. and Burch, W. 1997. The human ecosystem Part I: The human ecosystem as an organizing concept in ecosystem management, Society & Natural Resources: An International Journal, 10:4, 347-367
   (3) Make up your own

5. The general idea of "Policy analysis"
   Readings:
   (1) Bardach, E. 2011. A Practical Guide for Policy Analysis. Part I: The Eightfold Path". Pp. 1-59. Washington D.C. CQ Press. Second Edition. (this entire book is useful)
   (2) Weimer, D.L. and Veining, A.R. 2011. Policy Analysis. Chapter 2. What is Policy Analysis? Boston: Longman publishers. Pp. 23-38.

6. Environmental Impact Assessments
   Readings:
   (1) UNU Course Module on Environmental Impacts Assessments:
   http://eia.unu.edu/course/?page_id=173

7. Cost-Benefit analysis: consumer/producer surpluses, quotas vs taxes, non-market valuation
   Readings:
   (1) S Shapiro 2012. The evolution of cost–benefit analysis in US regulatory decision making - Handbook on the Politics of Regulation, Chapter 28. http://tinyurl.com/cavtfbd
   (2) Krugman, P. and R. Wells (2010). Chapter 6: Consumer Surplus. Economics. W. Publishers**:** Sections 1 and 4.
   (3) Melichark, J. and M. Ščasný (2004). Introduction to non-market methods and critical review of their application in the Czech Republic. Development of the Czech society in the European Union. Part V: Nonmarket methods in environmental area. J. Melichark and M. Ščasný. Prauge, Matfyzpress, Charles University Environment Center: 43-94.

8. Geographic Information Systems (GIS). General understanding of what GIS is, and general data structures.
   Readings:
   (1) Bolstead, P. 2008. GIS Fundamentals. Chapter 1 (An Introduction to GIS) and Chapter 2 (Data Models). White Bear Lake, MN: Eider Press. Pp. 1-61.

9. Communication Methods
   Readings:
   (1) Roberts, L. 2011. "Engaging with Policy-makers: Influencing Sustainability Policy through Academic Research" in A. Franklin and P. Blyton (eds.) Researching Sustainability. New York: Earthscan, pp 242-259.
   (2) Frater, L. 2011. "Engaging the Media: An Academic's Sojourn in the Newsroom" in A. Franklin and P. Blyton (eds.) Researching Sustainability. New York: Earthscan, pp 277-294.

Example question:

1. (Key issues related to survey design and implementation). You work for a city in Massachusetts that is considering the deployment a bank of solar panels for energy production on some public land (over a landfill, perhaps). To help decide whether to move forward with the project they ask you to implement a survey of local residents to gauge citizen reaction to such an idea. Describe key steps and issues related to implementing such a survey.

C. Environmental Governance and Policy (equivalent to the "Human Dimensions" section in other concentration study guides)

Policy types, process, formation, & implementation:

1. The policy process: problem definition/agenda setting, formation and legitimization, budgeting, implementation, program evaluation (assessment and reformulation), termination
   Readings:
   (1) Rosenbaum, W. A. 2011. Environmental Politics and Policy. 8th Edition. Chapter 2. Making Policy: The Process. Washington, D.C.: Sage. Pp. 32-72.

2. Implementation of policy. Budgeting, Rule-making.
   Readings:
   (1) Anderson, J. E. (2011). Chapter 5: Budgeting and Public Policy Public Policy Making (pp. 169-193). Boston, MA: Wadsworth.
   (2) Anderson, J. E. (2011). Chapter 6: Policy Implementation Public Policy Making (pp. 209-239). Boston, MA: Wadsworth.

Governance alternatives to command and control:

3. Regulatory, market-based, voluntary, incentive-based, labeling/certification
   Readings:
   (1) Goulder and Parry, Instrument Choice in Environmental Policy, Rev Environmental Economics and Policy Volume 2, Issue 2, Pp. 152-174.
   (2) Gayer, T. and J. Horowitz (2006). Market-Based Approaches to Environmental Regulation. Hanover, MA, Now Publishers Inc.

4. Adaptive management
   Readings:
   (1) Folke C, Hahn T, Olsson P, Norberg J (2005) Adaptive Governance of Social-Ecological Systems Annual Review of Environment and Resources 30:441-473
   (2) Engle NL, Johns OR, Lemos MC, Nelson DR (2011) Integrated and Adaptive Management of Water Resources: Tensions, Legacies, and the Next Best Thing. Ecology and Society 16 (1). doi:19

5. Collaborative policy, participatory processes
   Readings:
   (1) Innes JE, Booher DE (2003) Collaborative policymaking: governance through dialog. In: Hajer M, Wagenaar H (eds) Deliberative Policy Analysis: Understanding Governance in the Network Society. Cambridge University Press, Cambridge, pp 33-59

Environmental laws, organizations, and key figures:

6. Executive, judicial, legislative branches
   Readings:
   (1) Rosenbaum, W. A. 2011. Environmental Politics and Policy. 8th Edition. Chapter 3. Making Policy: Institutions and Politics. Washington, D.C.: Sage. Pp. 77-124.

7. U.S. environmental conservation agencies: names and responsibilities (e.g., Fish and Wildlife Service, Forest Service, Bureau of Land Management, National Park Service, Bureau of Indian Affairs, Environmental Protection Agency, National Oceanic and Atmospheric Administration, Geological Survey, Nuclear Regulatory Commission, Department of Energy)

8. U.S. environmental conservation laws: date enactment, purpose, main elements (e.g., Migratory Bird Treaty Act, Endangered Species Act, National Environmental Policy Act, Clean Water Act, Clean Air Act)
   Readings:
   (1) US Environmental Laws: http://www.nrdc.org/reference/laws.asp (or check out wikipedia)

9. Key International Environmental Agreements (e.g., Date of enactment, purpose, and description of: Montreal Protocol on Substances that Deplete the Ozone Layer, Convention on the International Trade in Endangered Species of Wild Flora and Fauna (CITES), United Nations Framework Convention on Climate Change (UNFCCC/Kyoto), Convention on Biological Diversity (CBD), Basel Convention on Control of Transport of Hazardous Wastes and Their Disposal)
   Readings:
   (1) This page provides information that looks reasonably good:
   http://en.wikipedia.org/wiki/List_of_international_environmental_agreements

10. U.S. land conservation context and challenges (state and local)
    Readings:
    (1) Berlik, M. M., Kittredge, D. B., & Foster, D. R. (2002). The illusion of preservation: a global environmental argument for the local production of natural resources. *Journal of Biogeography, 29*(10-11), 1557-1568. doi: 10.1046/j.
    (2) National Forest Service. (2008). Who Owns America's Forests.
    (3) Stein, S. M., McRoberts, R. E., Alig, R. J., Nelson, M. D., Theobald, D. M., Dechter, M., & Carr, M. (2005). Forests on the Edge: Housing Development on America's Private Forests: U.S. Department of Agriculture. http://www.fs.fed.us/openspace/fote/fote-6-9-05.pdf
    (4) DeNormandie, J., Corcoran, C., & Clarkey, J. C. (2009). Losing Ground Beyond the Footprint. Patterns of Development and their Impact on the Nature of Massachusetts: Massachusetts Audubon.
    (5) Foster, D. R., Donahue, B. M., Kittredge, D. B., Lambert, K., Hunter, M., Hall, B., . . Hart, C. (2010). Wildlands and Woodlands: A Vision for the New England Landscape: Harvard Forest, Harvard University.
    (6) American Farmland Trust. (2010). Cost of Community Services Study: Farmland Information Center.

Example question: Describe a public policy related to environmental conservation that you are familiar with. Provide examples of the various stages of the public policy process. This could be a policy at the federal, state or local levels. If you are unfamiliar with issues at various stages for one particular policy, you can also answer this question by describing the public policy cycle stages and use examples from a variety of public policies you are familiar with, or worst case, explain what each of the stages are and what they involve.

Recommended further reading on sustainability

- Club of Rome (1972) The Limits to Growth
- Ehrlich, P. (1968) The Population Bomb
- Ehrlich PR, Holdren JP (1971) Impact of Population Growth. Science 171 (3977):1212-1217
- Commoner, Barry (May 1972) "A Bulletin Dialogue: on "The Closing Circle" - Response". Bulletin of the Atomic Scientists: 17–56.
- Solow, Robert (1974) "The Economics of Resources or the Resources of Economics" American Economic Review
- Simon, Julian (1981) The Ultimate Resource
- Berry, Wendell (1982). "The Ecological Crisis as a Crisis of Character." p17-26 in The Unsettling of America: Culture and Agriculture. Avon, New York, 228pp
- Berry, Wendell (2012). It All Turns On Affection. 41st Jefferson Lecture in the Humanities. National Endowment for the Humanities. http://www.neh.gov/about/awards/jefferson-lecture/wendell-e-berry-lecture

Section 6. Building Systems Concentration

This section consists of three sub-sections corresponding to the three core topic areas required of ALL ECo graduate students seeking an MS degree. All students in the Building Systems concentration will be required to answer a set of questions drawn at random from each of these sub-sections. Each sub-section will comprise 20% of the exam questions, for a total allocation of 60% to this section. Suggested readings are provided for select topics. Example questions similar in nature to those that will be given on the exam are provided at the end of each sub-section.

A. Environmental Science

1. Vectors, forces and moments
   Readings:
   (1) "Statics and Strength of Materials for Architecture and Building Construction" – Onouye and Kane, Chapter 2;
   (2) "Engineering mechanics for structures" - http://web.mit.edu/emech/dontindex-build/full-text/emechbk_2.pdf
2. Structural properties of materials
   Readings:
   (1) "Building Construction: Principles, materials and systems" – M. Mehta et. al, Chapter 4
3. Structural equilibrium
   Readings:
   (1) "Statics and Strength of Materials for Architecture and Building Construction" – Onouye and Kane, Chapter 3;
   (2) Engineering mechanics for structures" - http://web.mit.edu/emech/dontindex-build/full-text/emechbk_2.pdf)
4. Constitutive behavior of construction materials
   Readings:
   (1) "Statics and Strength of Materials for Architecture and Building Construction" – Onouye and Kane, Chapter 5
5. Thermodynamics
   Readings:
   (1) Thermodynamics: An Engineering Approach (Cengel), Chapter 6, "The second law of thermodynamics", pp 277-330.
   (2) ASHRAE Fundamentals, Chapter 2, "Thermodynamics and refrigeration".
6. Energy
   Readings:
   (1) Thermodynamics: An Engineering Approach (Cengel), Chapter 2, "Energy, Energy Transfer, and General Energy Analysis", pp. 51-110.
   (2) ASHRAE Fundamentals, Chapter 34, "Energy Resources"
   (3) ASHRAE Fundamentals, Chapter 35, "Sustainability"
   (4) Introduction to Architectural Science: The Basis of Sustainable Design (Szokolay), Part 4, "Resources", pp. 264-320.
7. Wood light-frame construction (floor, roof, wall assemblies)
   Readings:

(1) "Building Construction: Principles, materials and systems" – M. Mehta et. al, Chapter 13

8. Lumber and engineered wood products (manufacturing, benefits and applications)
   Readings:
   (1) "Building Construction: Principles, materials and systems" – M. Mehta et. al, Chapter 12
9. Structural insulated panels
   Readings:
   (1) "Building Construction: Principles, materials and systems" – M. Mehta et. al, Chapter 15
10. Photosynthesis and CO_2
    Readings:
    (1) "Climate Change 2001: The Scientific Basis" - Summary,
    http://www.grida.no/publications/other/ipcc_tar/?src=/CLIMATE/IPCC_TAR/wg1/
    http://www.grida.no/CLIMATE/IPCC_TAR/wg1/pdf/WG1_TAR-FRONT.pdf)

Example Questions:

1. (Constitutive behavior of construction materials). Stress-strain curves embody the characteristic mechanical behavior of construction materials. Draw, in a single comparative graph, a typical compressive stress-strain curve for: i) ductile rolled steel, ii) concrete, and iii) timber. Compare and contrast the three curves with respect to the critical structural properties.

2. (Photosynthesis). What are the steps that lead from the photosynthetic reaction within a tree leaf to the production of wood? What role does Carbon-Dioxide (CO_2) play in this process? Discuss the impacts of this process on the Earth's atmosphere and the well-being of humans.

B. Quantitative Science

1. Structural loads on buildings
   Readings:
   (1) "Building Construction: Principles, materials and systems" – M. Mehta et. al, Chapter 3
2. Environmental benefits of wood
   Readings:
   (1) Wood handbook, Chapter 1,
   http://www.fpl.fs.fed.us/documnts/fplgtr/fplgtr190/chapter_01.pdf;
   (2) "Science Supporting the Economic and Environmental Benefits of Using Wood and Wood Products in Green Building Construction" – M Ritter et. al,
   http://www.fs.fed.us/news/2011/releases/09/green-building-report.pdf
3. Factors that influence physical and mechanical behavior of wood
   Readings:
   (1) "Design of wood structures" – Breyer et. al, Chapter 4.14-4.21
4. Building Information Modeling (BIM)
   Readings:
   (1)"Green BIM" - Chapter 2, Krygiel / Nies, Sybex;
   (2) "BIM Handbook" - Chapter 1, Eastman / Teicholz / Sacks / Liston;
   (3) *"BIM and integrated design", Deutsch, Wiley*
5. Building energy loads
   Readings:

(1) Introduction to Architectural Science: The Basis of Sustainable Design (Szokolay), Part 2, "Heat: The Thermal Environment", pp. 6-76.
(2) ASHRAE Fundamentals, Chapter 17, "Residential Cooling and Heating Load Calculations"
(3) ASHRAE Fundamentals, Chapter 18, "Non-Residential Cooling and Heating Load Calculations"
(4) Mechanical and Electrical Systems in Buildings (Janis & Tao), Chapter 2, "HVAC Fundamentals", pp. 21-74.
(5) Building Technology (Stein), Chapter 2, "Thermal Balance of Buildings", pp. 21-79.

6. Climate responsive building design
   Readings:
   (1) The Green Studio Handbook (Kwok & Grondzik), Chapter 4, "Design Strategies", pp. 21-174.
   (2) Heating, Cooling, Lighting (Lechner), Chapter 6, "Passive Solar", pp. 141-170.
   (3) Heating, Cooling, Lighting (Lechner), Chapter 10, "Passive Cooling", pp. 245-278.
7. HVAC systems
   Readings:
   (1) Green from the Ground Up (Johnston & Gibson), Chapter 9, "Heating, Ventilation, and Air-Conditioning", pp. 173-196.
   (2) Heating, Cooling, Lighting (Lechner), Chapter 16, "Mechanical Equipment for Heating and Cooling", pp. 471-520.
   (3) Heating, Ventilating and Air Conditioning (McQuiston et al), Chapter 2, "Air- Conditioning Systems", pp. 22-48.
   (4) Mechanical and Electrical Systems in Buildings (Janis & Tao), Chapter 4, "Cooling Production Equipment and Systems", pp. 107-139.
   (5) Mechanical and Electrical Systems in Buildings (Janis & Tao), Chapter 5, "Heating Production Equipment and Systems", pp. 141-163.
8. Economics and Building Decision-Making
   Readings:
   (1) The Built Environment (Bradshaw & Vaughn), Chapter 16, "Design Economics", pp. 437-452.
   (2) Energy Management Handbook (Turner & Doty), Chapter 4, "Economic Analysis", pp. 41-86.
   (3) Guide to Energy Management (Capehart et al), Chapter 4, "Economic Analysis and Life Cycle Costing", pp. 131-172.

Example Questions:

1. (Building information modeling). What are the possible advantages of using Building Information Modeling (BIM) for building planning? Name five specific benefits that a planner could see if they switched to a BIM-based process. Are there any drawbacks or hampering factors that could prevent the success of such an approach?

2. (HVAC systems). Buildings consume up to 40% of the energy used in the United States. A significant portion of this energy is needed to run HVAC systems in buildings, to ensure occupant comfort. Calculations to size HVAC systems are typically based on design loads (i.e., the maximum energy loads the system can handle). These rely on a number of base assumptions,

like the number of degree days in a region. Explain why design load calculations often result in oversized systems. How might one correct for the inaccuracies in design load calculations?

C. Human Dimensions

1. Green building rating systems
   Readings:
   (1) Guide to Green Building Rating Systems (Reeder)
   (2) Sustainable Construction (Kibert), Chapter 3, "Green Building Assessment", pp. 55-78.
2. Energy policy
3. LEED Rating system
   Readings:
   (1) LEED 2009 for New Construction and Major Renovations. U.S. Green Building Council Inc. Copyright 2009.
   (2) Solomon, Nancy B. AIA. "How Is LEED Faring After Five Years in Use?" Architectural Record. Web. 10 Dec. 2009.
   (3) Schendler, Auden. "LEED is Broken- Let's Fix It." 5 Aug. 2005. Web. 18 Nov. 2009. http://www.igreenbuild.com/cd_1706.aspx
   (4) Gifford, Henry. "A Better Way to Rate Green Bulidngs" can be viewed at http://www.henrygifford.com
4. Residential Energy Conservation (Retrofit) Policy
   Readings:
   (1) L. Lutzenhiser, "Innovation and organizational networks Barriers to energy efficiency in the US housing industry," Energy Policy, vol. 22, pp. 867-876, 1994.
   (2) S. Banfi, et al., "Willingness to pay for energy-saving measures in residential buildings," Energy Economics, vol. 30, pp. 503-516, March 2008.
   (3) Office of the Vice President of the U.S. 2009. "Recovery Through Retrofit" 11p.
5. Building environmental impacts
   Readings:
   (1) Ecological Design (Sim Van Der Ryn)
   (2) Sustainable Design (Williams), Chapter 5, "Architectural Design", pp. 103-127.
   (3) Sustainable Construction (Kibert), Chapter 5, "Ecological Design", pp. 99-127.
6. Building codes on building energy
7. Public policy on building energy
8. The building delivery process (phases of how buildings come into being)
   Readings:
   (1) "Building Construction: Principles, materials and systems' – M. Mehta et. al, Chapter 1
9. Material certification systems (FSC, SFI, etc.)
   Readings:
   (1) FSC International Standard: "FSC Principles and criteria for forest stewardship" FSC-STD-01-001 (version 4-0) EN

10. Conceptual foundations of "sustainability" (and the Brundtland Report)

Example Questions:

1. (LEED rating system). What are the pros and cons or limitations of the LEED Rating system in promoting environmental and energy efficiency goals (i.e., reductions in GHG emissions)?

2. (Public policy on building energy). Identify three public policies (currently operating or not) that can influence building energy use. Which of these has the greatest likelihood of rapidly reducing energy use in new buildings or existing buildings? Why?