Title: Designing an Urban Green Infrastructure Network: Balancing Biodiversity and Stakeholder Needs

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Teaching Notes

Summary:

In an increasingly urban world, the sustainability and resiliency of human settlements will depend on our ability to understand and manage urban landscapes as socio-environmental systems. This case draws students into these issues by putting them in the role of environmental managers charged with protecting species of conservation interest in urban landscapes. In groups, students will be asked to design a green infrastructure network to conserve one particular species across a network of parks, open spaces and natural areas that act as patches of habitat (or hubs) and linkages (or corridors) between those patches. Students will choose from a set of potential sites in a particular geography (this case study was designed for the Jamaica Bay watershed of New York City but can be adjusted for different geographies) to establish new parks and/or restore degraded natural areas or vacant lots. They will be given a budget limit and will have to incorporate stakeholder concerns and needs at different scales (i.e., neighborhood, city, state, and federal) into their designs. A field trip and/or an opportunity to interview a park manager can be incorporated into the case study, at the instructor's discretion. Then groups will be rearranged so that each contains one member of each original single species groups. The multiple species groups will redesign the network to protect all of the species at once. This will require the students to balance the sometimes opposing needs of different species in finding an optimal design. Finally, the groups will balance the needs of their group of species with stakeholder interests to explore the political, economic, and social realities associated with natural resources management and land use planning in human dominated landscapes. Groups will present their proposed networks to their peers using posters in a gallery walk presentation format. The case study implemented in its entirety requires approximately eight three-hour periods (or one month of a typical college laboratory science course). With significant modifications, the case study can take up to half this amount of time.

What course(s) might this case be appropriate for?

The case was designed for initial use in a small (20 students), 200 level (i.e., second year) General Ecology course at a community college with primarily biology and environmental science majors. With modifications, the course could be appropriate for disciplinary courses in ecology (including urban ecology) or interdisciplinary courses in human dimensions of the environment (i.e., environmental studies, sustainability, biodiversity/conservation, natural resources management, etc.) at a broad range of undergraduate institutions.

What level is this case appropriate for?

The case was initially designed for first- and second-year students but with modifications could be used for upper level undergraduate and graduate students.

SES Learning Goals:

SESYNC's S-E Synthesis Learning Goals are presented in italics, followed by a description of how our case addresses each goal and relevant sub-elements of those goals.

1. *Understand the structure and behavior of socio-environmental systems.*
    a. *Identify the environmental and social components of the system and their interactions.*
    b. *Identify feedbacks and explain the dynamics of an S-E system.*
    c. *Use tools and modeling approaches to understand dynamics of an S-E system.*

In this case students will construct a conceptual model describing biodiversity and ecosystem services in New York City's network of parks, stream corridors, greenstreets, and coastal greenways (i.e., green infrastructure network). The model will include biophysical and social components of this green infrastructure network, drivers of biodiversity and ecosystem services in these components, and interactions among them. After lecture/discussion exercises and background reading (and perhaps a field trip), students in single species groups will develop targeted concept maps that will be used to communicate their species requirements and stakeholder concerns/needs to their peers. In their final multiple species groups, students will have to reconcile the sometimes competing needs of different species and stakeholder groups in order to design an optimized green infrastructure network (within budgetary and political constraints). This exercise will require students to consider tradeoffs among different ecosystem services, different species, and stakeholder groups, as well as non-synergistic effects of different management options (for example, the choice to restore one park to optimize salamander vernal pool habitat may reduce potential upland forest habitat for an endangered plant species).

2. *Consider the importance of scale and context in addressing socio-environmental problems.*
    a. *Understand that ecological and social processes often vary across differing contexts, including space, time, and conditions (e.g. economic or political).*
    b. *Understand that ecological and social processes interact across different scales.*

In researching and synthesizing information about biophysical requirements and stakeholder issues related to a range of target species, students will have to explore and understand differences in social and ecological processes and interactions that occur across geographies (city boroughs and/or neighborhoods), types of green spaces (upland forests, stream corridors, salt marshes, greenway parks, roadways, green roofs, etc.), and stakeholder groups (city, state and federal government agencies, academic institutions, non-profit organizations, neighborhood associations, business groups, etc.). They will have to apply this understanding to the design of single species and multiple species green infrastructure network designs.

3. *Co-develop research questions and conceptual models in inter- or trans-disciplinary teams.*
    a. *Identify disciplines and approaches relevant to the problem.*
    b. *Understand the value of different knowledge sources and ways of knowing.*

When students are first broken into single species groups, they will be required to complete a "what do we need to know" exercise before they begin to tackle summarizing their species needs and proposing a related network of green spaces. They will have to produce a conceptual map of the biophysical and social components and drivers and also map stakeholder issues related to their species. This will require them to identify different disciplines and approaches that are relevant to species requirements and understand and value different knowledge sources.

4. *Find, analyze, and synthesize existing data, ideas (e.g. frameworks or models), or methods.*
    a. *Identify data sources and appropriate tools, evaluate quality of data, and manage data.*
    b. *Understand the different kinds of data and research methods used by relevant disciplines in the natural and social sciences.*

c. *Integrate different types of data (interdisciplinary integration).*

In single species groups students will have to acquire information and data about species life history and habitat requirements, particular needs related to fragmented landscapes, species population dynamics, and structure and function of ecosystems that provide habitat to target species. They may also need to integrate this information with basic neighborhood demographic information, economic information related to costs of restoration and park creation/management, and social survey data about park users in order to make decisions about which sites to restore/create in order to best meet the needs of species and people. Data integration methods will be more qualitative at the level of first- and second-year students but could be increasingly quantified for more advanced students.

Learning Objectives:

1. Students will describe the environmental and social components of New York City's parks and protected areas and the interactions between them
    a. Students will explain the needs/attitudes/concerns of various stakeholder groups
    b. Students will explain biophysical requirements for target species
2. Students will evaluate the tradeoffs among ecosystem services and biodiversity objectives to design a green infrastructure network that addresses species requirements and stakeholder needs
3. Students will evaluate the multifaceted aspects (i.e., scientific, social, economic, and political) of natural resource management issues that managers have to balance
4. Students will identify types of information needed to address an S-E problem, find and evaluate relevant sources of information, and synthesize important findings

Table 1. Learning Outcomes Mapped to Social-Environmental Synthesis Goals and General Education Learning Objectives

Student Learning Outcome	Relationship to S-E Synthesis Goals	Relationship to General Education Learning Objectives
1. Students will describe the environmental and social components of New York City's parks and protected areas and the interactions between them (Bloom's Understand)	Goal 1: Understand the structure and behavior of socio-environmental systems Sub-element: identify the social and environmental components of the system and their interactions Sub-element: use tools and modeling approaches to understand dynamics of an S-E system Goal 2: Consider the importance of scale and context in addressing socio-environmental problems.	3: Scientific Reasoning and Knowledge 5: Society and Human Behavior
1a. Students will explain the needs/attitudes/concerns of various stakeholder groups	Sub-element: identify the social and environmental components of the system and their interactions	5: Society and Human Behavior

(Bloom's Understand and Apply)	Sub-element: use tools and modeling approaches to understand dynamics of an S-E system	
1b. Students will explain biophysical requirements for target species and habitats (Bloom's Understand and Apply)	Sub-element: identify the social and environmental components of the system and their interactions Sub-element: use tools and modeling approaches to understand dynamics of an S-E system	3: Scientific Reasoning and Knowledge
2.Students will evaluate the tradeoffs among ecosystem services and biodiversity objectives to design a green infrastructure network that addresses species/habitat requirements and stakeholder needs (Bloom's Apply and Analyze)	Sub-element: identify the social and environmental components of the system and their interactions	3: Scientific Reasoning and Knowledge
3.Students will evaluate the multifaceted aspects (i.e., scientific, social, economic, and political) of natural resource management issues that managers have to balance (Bloom's Evaluate)	Goal 3: Co-develop research questions and conceptual models in inter- or trans-disciplinary teams Sub-element: Identify disciplines and approaches relevant to the problem Sub-element: Understand the value of different knowledge sources and ways of knowing	3: Scientific Reasoning and Knowledge 5: Society and Human Behavior 8: Global and Cultural Awareness
4.Students will identify types of information needed to address an S-E problem, find and evaluate relevant sources of information, and synthesize important findings (Bloom's Understand, Apply and Analyze)	Goal 4: Find, analyze and synthesize existing data, ideas or methods Sub-element: Identify data sources and appropriate tools, evaluate quality of data, and manage data	2: Quantitative Knowledge and Skills Integrated Goals: Information literacy

Introduction:

Education in environmental studies/science and ecology at undergraduate institutions must not only focus on training students for academic and research careers but also for careers in environmental management. As environmental professionals with consulting firms, non-profit organizations, or governmental agencies, they will need to take transdisciplinary approaches to difficult natural resources management issues, which by their very nature are socio-environmental systems. Environmental professionals must grapple with complex technical issues, including non-synergistic ecological functions, as well as competing agendas of different stakeholder groups and economic realities that constrain the range of management options and the quality of implementation and maintenance. Students will need to learn how to work in groups, integrate different types of information and data (including qualitative and quantitative) gathered at mismatched scales, and balance stakeholder concerns with technical expertise and technical challenges.

Urban ecology is an emerging field and represents a great opportunity to engage students in socio-ecological systems due to the complex spatial organization of natural and built environments, predominance and proximity of human interests, and opportunities for city dwellers and organizations to benefit from a range of ecosystem services provided by improved urban design practices. As the world's landscapes continue to urbanize, environmental professionals will increasingly have to engage in natural resource management issues in urban environments and instituting practices that optimize ecosystem services. Because socio-ecological synthesis explicitly addresses both ecological and sociological components of systems, students will greatly benefit from learning about urban ecosystems from a socio-ecological perspective and having the opportunity to practice using socio-ecological principles to address natural resource management issues. Many undergraduates are drawn to wildlife, biodiversity, and conservation issues as environmental issues that are important to them and visible in their local communities as well as on the global scale. Educators can use urban wildlife issues to draw students in and engage them in larger questions about natural resources management in urban landscapes, restoration goals, and balancing opposing needs and perspectives.

Cities and regional units like counties and states are developing policies and strategic plans to facilitate the provision of ecosystem services, including biodiversity, through green infrastructure networks. The funds required to create and maintain these networks are justified by identifying a range of benefits to residents, from ecosystem services like floodwater management, provision of clean air and water, microclimate regulation, as well as human use and health benefits such as recreation and aesthetic appreciation of nature. Designers of these networks must prioritize the protection and restoration of green and blue spaces (i.e., aquatic features like lakes, streams, and rivers) in order to optimize the provision of this wide range of services and uses within socio-cultural, political and economic realities and constraints.

This case focuses on New York City's efforts to manage a variety of green and blue spaces for biodiversity and other ecosystem services as well as human use, health and well-being. PlaNYC is New York's main strategic plan focused on issues of sustainability across multiple sectors, including parks, open spaces, and protected areas. The plan identifies some key locations in all five boroughs for improvement or restoration of existing green/blue spaces or creation of new spaces, but stops short of outlining a comprehensive open space network. Despite New York's highly urban context, the city's five boroughs are home to a surprisingly large number of rare and endangered species as well as other species of particular conservation interest. Examples include the peregrine falcon, lady's slipper, and a newly discovered species of leopard frog which has so far only been found in highly populated areas of New York, Connecticut and New Jersey. This case study will focus on the Jamaica Bay neighborhood spanning the border of Brooklyn and Queens. After the severe flooding, tidal inundation, and resulting destruction caused by Hurricane Sandy in New York City in October, 2012, city, state and federal agencies have focused additional attention on the Jamaica Bay watershed because of its coastal landscape setting and location within important migratory bird flyways, existing salt marsh and freshwater wetland ecosystems protected within city (for example, Marine Park in Brooklyn) and federal parks (Gateway National Recreation Area), dense urban residential neighborhoods spanning a wide range of socio-economic circumstances, some with cultural and historical significance, and existing and historical industrial development that impacts water and soil quality in ecosystems used by species of concern and humans for recreation. Recovery efforts have helped some homeowners rebuild in coastal communities that are vulnerable to future flooding and sea level rise associated with climate change. There is interest from a wide range of local, state and federal stakeholders and agencies in focusing rebuilding and recovery efforts on designing resilient landscapes that will reduce these risks and promote ecosystem services like floodwater management and provision of clean water for human and ecosystem uses. These efforts encompass conservation of species of concern, such as migratory birds and threatened or endangered species of fish, amphibians, reptiles, and plants, as well as conservation and restoration of critical wetland, grassland, and forested ecosystems that provide important ecosystem services.

New York City is not the only example of a metropolitan area taking steps to promote biodiversity and ecosystems services through the use of green infrastructure design and planning. These efforts are currently being undertaken by large cities including Chicago and Cleveland as well as states such as Maryland, Virginia, and New York. This case can be adapted for other places, perhaps using a blend of real and hypothetical scenarios. The case was designed to use in a small classroom of first- and second-year ecology and environmental science students that in previous coursework have become familiar with key ecological issues in the New York/New Jersey region, such as the overabundance of deer and prevalence of invasive species and the consequences of both for forested and wetland ecosystems. The case is designed to address issues of urban biodiversity and green infrastructure planning from a conceptual perspective, making use of a wide variety of mostly qualitative information and data. The case could be modified to incorporate quantitative information in order to make the case more appropriate for upper level undergraduate and graduate students.

Classroom Management:

This case is designed to be completed within eight three-hour long periods (or approximately one month of a typical college laboratory science course), but could be compressed into approximately four three-hour long periods by using hypothetical parks and vacant lands and classroom materials prepared with the key pieces of information students need rather than using real parks and working with actual park managers and researchers that are making decisions about actual open space areas. This would eliminate the need for the field trip and reduce the time needed for students to gather site-specific information. Another way to reduce the time needed to complete the case study would be to use the case in a course in which many of the necessary background concepts had already been covered (i.e., conservation biology, urban ecology, ecosystem services, restoration ecology, etc.). Also, the stakeholder assessment assignment could be scaled down in scope and included as an element of the multiple species assignment rather than remaining as a full, separate assignment.

Table 2. Student Learning Outcomes Mapped to Activities and Assessments

Student Learning Outcome	Activities	Assessment
1.Students will describe the environmental and social components of New York City's parks and protected areas and the interactions between them	Lecture and discussion of example case (in another place) and profile of one species (red tailed hawk or leopard frog); this is intended to elicit core social and ecological concepts related to green infrastructure network design and stakeholder issues Saturday field trip to Jamaica Bay, NYC to see sample parks and meet park managers Concept mapping (initial and final in synthesis proposal) Jigsaw case method: small groups become experts on environmental and social components related to individual target species (what do we need to know exercise) Synthesis: peer-to-peer sharing of components related to multiple target species	Muddiest point (from lecture and discussion) Peer and instructor feedback on concept maps and information needs assessments Single species presentations Single species stakeholder assessment Multiple species group green infrastructure network paper and presentation
1a. Students will explain the needs/attitudes/concerns of various stakeholder groups	Stakeholder mapping Plus elements of activities under SLO 1	Peer and instructor feedback on stakeholder assessment
1b. Students will explain biophysical requirements for target species and habitats	Elements of activities under SLO 1	Instructor feedback on single species presentations and concept maps
2. Students will evaluate the tradeoffs among ecosystem services and biodiversity objectives to design a green infrastructure network that addresses species requirements and stakeholder needs	Synthesis: peer-to-peer sharing of components related to multiple target species Synthesis: proposed protected areas network with justification (group paper and final presentation)	Single and multiple species network presentations will have to address tradeoffs and justify suggested approach
3.Students will evaluate the multifaceted aspects (i.e., scientific, social, economic, and political) of natural resource management issues that managers have to balance	Synthesis: peer-to-peer sharing of components related to multiple target species Synthesis: proposed protected areas network (proposal and presentation)	Peer and self evaluation (summative) Instructor feedback on proposals and presentations Individual reflection papers (summative)

	Debrief: discussion of similarities and differences among synthesis proposals Individual reflection on challenges that managers face; what else did they need/want to know	
4.Students will identify types of information needed to address an S-E problem, find and evaluate relevant sources of information, and synthesize important findings	Jigsaw case method: small groups become experts on environmental and social components related to individual target species Synthesis: peer-to-peer sharing of components related to multiple target species	Information needs assessment Single and multiple species presentations Peer and self evaluation

Suggested Background Readings

Students will need to become familiar with basic concepts in urban ecology, urban wildlife, biodiversity and conservation biology, restoration ecology, ecosystem services, and green infrastructure network design principles. The list of suggested readings below is illustrative and can be tailored to the needs and expertise of individual instructors. Instructors may also supplement this list with excerpts from ecology textbooks used in their courses.

List of suggested background readings for students:

Urban Ecology and Urban Wildlife

- Pickett, S.T.A et al. 2001. Urban ecological systems: Linking terrestrial, ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics* 32: 127-157
- Pickett, S.T.A. et al. 2011. Urban ecological systems: Scientific foundations and a decade of progress. *Journal of Environmental Management* 92: 331-362
- Winn, M. Red-Tails in Love: A Wildlife Drama in Central Park. New York: Vintage Departures, 1999.
- "Where the Birds Are is Not Where You'd Think", by Robert Krulwich, July 28, 2014. http://www.npr.org/blogs/krulwich/2014/07/28/335142374/where-the-birds-are-is-not-where-youd-think
- PBS Nature. 2014. "Meet the Coywolf." http://video.pbs.org/video/2365159966/

Biodiversity and Conservation Biology

- Dearborn, D.C. and S. Kark. 2010. Motivations for conserving urban biodiversity. *Conservation Biology* 24(2): 432-440
- Kinzig, A.P. et al. 2005. The effects of human socioeconomic status and cultural characteristics on urban patterns of biodiversity. *Ecology and Society* 10(1): 23-36

- DiGiulio, M. et al. 2009. Effects of habitat and landscape fragmentation on humans and biodiversity in densely populated landscapes. *Journal of Environmental Management* 90: 2959-2968
- E. Kiviat and E.A. Johnson. 2013. Biodiversity Assessment Handbook for New York City. American Museum of Natural History and Hudsonia, Ltd.
- Feinberg, J.A. et al. 2012. Cryptic diversity in metropolis: Confirmation of a new leopard frog species (Anura: Ranidae) from New York City and surrounding Atlantic coastal regions. PLoS ONE 9(10): e108213. doi:10.1371/journal.pone.0108213
- NatureServe Explorer, a website that contains information about rare and endangered species in the United States and Canada; http://explorer.natureserve.org/
- US Department of Agriculture, Natural Resources Conservation Service plants database, website that contains information about plant species found in the United States; http://plants.usda.gov/java/
- Pinelands Preservation Alliance, Special Plants of New Jersey Fact Sheets; http://www.pinelandsalliance.org/ecology/plants/specialplantsnjfactsheets/

Green Infrastructure Networks and Design Principles

- Benedict, M.A. and E.T. McMahon. Green Infrastructure: Linking Landscapes and Communities. Washington, DC: Island Press, 2006
- M. Hostetler et al. 2011. Conserving urban biodiversity? Creating green infrastructure is only the first step. *Landscape and Urban Planning* 100(4): 369-371
- Dale et al. 2000. Ecological principles and guidelines for managing the use of land. *Ecological Applications* 10(3): 639-670
- Svendsen, E. 2012. Integrating grey and green infrastructure to improve the health and well-being of urban populations. *Cities and the Environment* 5(1): 1-9
- E. Gies. 2006. The Health Benefits of Parks: How Parks Help Keep Americans and Their Communities Fit and Healthy. San Franciso, Trust for Public Land.

City Planning and Jamaica Bay Documents

- “How Cities Use Parks for Green Infrastructure,” City Parks Forum Briefing Papers, American Planning Association, 2003 https://www.planning.org/cityparks/briefingpapers/greeninfrastructure.htm
- plaNYC Progress Report: Sustainability and Resiliency 2014. City of New York http://www.nyc.gov/html/planyc2030/downloads/pdf/140422_PlaNYCP-Report_FINAL_Web.pdf
- US Fish and Wildlife Service. Significant habitats and habitat complexes of the New York Bight Watershed: Jamaica Bay and Breezy Point. http://nctc.fws.gov/resources/knowledge-resources/pubs5/web_link/text/jb_form.htm
- US Department of the Interior, National Park Service. 2014. Gateway National Recreation Area Final General Management Plan and Environmental Impact Statement. Selected chapters/sections. http://www.nps.gov/gate/parkmgmt/gmp-2012.htm

- New York City Department of Environmental Protection. 2007. Jamaica Bay Watershed Protection Plan. Selected chapters/sections. http://www.nyc.gov/html/dep/html/dep_projects/jamaica_bay.shtml

Part I: Introduction to case, urban ecology, and wildlife ecology in urban landscapes (1 hour and 20 minutes)

During this class period the instructor will present the introduction to the case and the hook. The hook involves using the conservation of urban wildlife to explore larger concepts of habitat fragmentation in urban environments and the socio-ecological considerations that go into the design of networks of protected areas to provide multiple benefits for species, ecosystems, and people. Because the case study is designed using New York City, and specifically the Jamaica Bay area of Brooklyn, as a real-life example of park management, the hook is also based in New York City – specifically the story of Pale Male, a red tailed hawk famous for being the first documented case of a raptor nesting on a building rather than in a tree in an area as urban as New York City. The students will read a short excerpt from the book Red-Tails in Love: A Wildlife Drama in Central Park, by Marie Winn, 1999 and watch excerpts from the film "The Legend of Pale Male" (YouTube videos can also be used to save time; examples include the trailer for the feature length film http://www.youtube.com/watch?v=OKqvXvpQX9I, a clip of the red tails mating on the balcony of Woody Allen's apartment http://www.youtube.com/watch?v=9glyi3LA_d4, and a clip of successful red tail chicks after three years of mating attempts http://www.youtube.com/watch?v=7M8JU8EezjE). These excerpts should focus not only on the ecological issues of wildlife use of urban landscapes but also the social aspects of human-wildlife interactions in cities and people's perceptions and attitudes toward urban wildlife. Using the New York City red tailed hawk example, the ecological components will include issues related to nesting and reproduction in urban landscapes, and the social components will include the Central Park birder community that followed the red tails, interacted with building residents and managers to protect nests and follow the progression of hatching and fledging, and documented their findings for the scientific community (i.e., citizen science).

For instructors in different geographies or who are looking for other potential hooks, another useful resource is a 2014 PBS Nature special entitled "Meet the Coywolf", which is available at http://video.pbs.org/video/2365159966/. This documentary chronicles the spread of coyotes and hybrid coywolves into urban areas, particularly in and around Chicago, with an emphasis on the specifics of how these animals use different types of urban spaces and travel among elements of the urban landscape.

After reading the book excerpt and watching film/video clips, the instructor will facilitate a group discussion about wildlife in urban environments and document some of the students' impressions and ideas. Questions to consider include:

1. What kinds of problems do species have to deal with and adapt to in urban ecosystems?
2. What kinds of species do well, which ones struggle? (make sure they think beyond mammals)
3. What aspects of urban environments can support wildlife? (make sure here they think beyond buildings and streets to urban parks, natural areas, coastlines, etc.)
4. How do urban residents feel about wildlife? (make sure here that they think about both positive and negative perceptions)

During this introductory period the instructor should also provide some context on urban ecosystems as socio-ecological systems. The review paper, Pickett, S.T.A et al. 2001. Urban ecological systems: Linking terrestrial, ecological, physical, and socioeconomic components of metropolitan areas. *Annual Review of Ecology and Systematics* 32: 127-157, can be used to illustrate the basic concepts of urban ecology, particularly (instructors may also want to refer to a more current reference, Pickett, S.T.A. et al. 2011. Urban ecological systems: Scientific foundations and a decade of progress. *Journal of Environmental Management* 92: 331-362):

- How researchers study urban ecosystems ("ecology IN the city" versus "ecology OF the city") and how they conceptualize humans as part of urban ecosystems (commonly used conceptual frameworks)
- The importance of studying the ecology of urban landscapes as global urbanization continues to increase and the ubiquity of human influence on ecosystems is increasingly acknowledged
- Definitions of "urban" and "urban ecosystems"
- Key findings about biophysical components of urban ecosystems that make them different from rural or pristine landscapes (i.e., climate, hydrology, soils, vegetation, fauna)

Specific examples of urban wildlife may be used to dispel myths that only pigeons, rats and cockroaches have figured out how to successfully use urban landscapes as habitat. Suggested examples are Marzluff's studies of urban/suburban/rural bird biodiversity (students may explore these themes using popular media representations of the research conducted by the Marzluff lab: "Where the Birds Are is Not Where You'd Think", by Robert Krulwich, July 28, 2014

http://www.npr.org/blogs/krulwich/2014/07/28/335142374/where-the-birds-are-is-not-where-youd-think

or scientific papers published by Marzluff et al.), and coyotes in Chicago and other urban areas (http://urbancoyoteresearch.com/FrontPage; also see the following video https://www.youtube.com/watch?v=kbYIPXIX5f8 for a humorous popular media take on urban coyotes in Chicago).

Students will have completed some textbook readings on basic concepts of landscape ecology to prepare for this lecture. See illustrative list in the "Classroom Management" section above.

The "muddiest point" tool can be used to assess student understanding of the material covered during this class (see detailed description in the "Assessments" section at the end of this document).

Part II: Introduction to biodiversity and conservation biology in the urban context (3 hours)

During this class period the instructor will introduce the concept of biodiversity and conservation biology in the urban context. The students will have completed background readings from their textbook and additional scientific papers on urban biodiversity patterns, effects of habitat fragmentation and socioeconomic and cultural characteristics on urban biodiversity, island biogeography, latitudinal patterns of species richness, and historical and regional drivers of biodiversity. Suggested readings include:

- Dearborn, D.C. and S. Kark. 2010. Motivations for conserving urban biodiversity. *Conservation Biology* 24(2): 432-440

- Kinzig, A.P. et al. 2005. The effects of human socioeconomic status and cultural characteristics on urban patterns of biodiversity. *Ecology and Society* 10(1): 23-36
- DiGiulio, M. et al. 2009. Effects of habitat and landscape fragmentation on humans and biodiversity in densely populated landscapes. *Journal of Environmental Management* 90: 2959-2968.

The instructor will cover basic biodiversity concepts, including biodiversity issues at different scales (i.e., about rare and endangered species, species that are endemic to particular places/geographies, and ecosystems of significance to particular places/geographies), and why people are interested in conserving biodiversity in cities. See the "Background" section towards the end of this document for a brief summary of key concepts and references in urban biodiversity. The lecture period will also introduce some species and ecosystems of interest in the New York City metropolitan area based on information from New York City's Biodiversity Assessment Handbook (E. Kiviat and E.A. Johnson. 2013. Biodiversity Assessment Handbook for New York City. American Museum of Natural History and Hudsonia, Ltd.). The new species of leopard frog discovered in Staten Island may be used as an illustrative example (Feinberg, J.A. et al. 2012. Cryptic diversity in metropolis: Confirmation of a new leopard frog species (Anura: Ranidae) from New York City and surrounding Atlantic coastal regions. PLoS ONE 9(10): e108213. doi:10.1371/journal.pone.0108213). Discussion should touch on habitat and biophysical requirements for these species and ecosystems in order to preview some of the issues students will have to consider when they are assigned their own species to evaluate. For this section, the instructor will choose species that will not be assigned to the student groups. Concepts to introduce/cover include:

1. What are the requirements for this species? Climate, habitat, food resources, life history strategy, movement patterns, predators, competitors.
2. What is the conservation status of the species? Is it thriving in the city (if so, why?)? Is it struggling, why? How do we know? Present population trends data.
3. What are the threats to these species in New York City?
4. How does the species adapt to the urban environment and proximity to people in NYC?
5. What are people's perceptions of the species?
6. What could NYC do to support and conserve the species in NYC? What kinds of actions can NYC take to make the city better meet the requirements of the species and convince people that it's worth doing?

During the second half of the class, the students will work through the published case study "Do Corridors Have Value in Conservation" by Andrea Bixler, Clark University (published in the National Center for Case Study Teaching in Science's collection of case studies). This will help the students work through the concepts of habitat fragmentation and use of corridors to connect fragmented areas for the promotion of gene flow and larger population sizes of species of interest. Students will be asked to review and analyze data collected for several different species as part of a corridor study conducted in South Carolina. This will begin to introduce students to the idea that management solutions can not necessarily be designed to meet the needs of all species of interest in all places and that tradeoffs may need to be made. Students will also have to grapple with real life data and make sense of findings published in the scientific literature. The Corridors case study is estimated to require 60-75 minutes of class time, depending on whether the instructor decides to use all four segments of the case study in their entirety. If the case study will be used in its entirety, the students should be prepared by understanding some basic concepts from conservation biology, specifically population dynamics in small populations, habitat fragmentation, and island biogeography theory. The case study can be accessed at http://sciencecases.lib.buffalo.edu/cs/ by navigating to the pages for the case collection. Instructors will need to create an account in order to access the answer key for the Corridors case study.

The "muddiest point" tool can be used to assess student understanding of the material covered during this class (see detailed description in the "Assessments" section at the end of this document).

Part III: Green Infrastructure Networks and Design for Ecological Function and Human Use; Preparation for Field Trip, and Introduction to Concept Mapping (2 hours)

During this class period the instructor will introduce the concept of green infrastructure networks and techniques and best practices used by natural resource managers to design these networks to optimize multiple benefits for ecosystem function and human use. Students will have prepared for class by reading:

- excerpts from Benedict, M.A. and E.T. McMahon. Green Infrastructure: Linking Landscapes and Communities. Washington, DC: Island Press, 2006
- M. Hostetler et al. 2011. Conserving urban biodiversity? Creating green infrastructure is only the first step. *Landscape and Urban Planning* 100(4): 369-371
- Dale et al. 2000. Ecological principles and guidelines for managing the use of land. *Ecological Applications* 10(3): 639-670
- Svendsen, E. 2012. Integrating grey and green infrastructure to improve the health and well-being of urban populations. *Cities and the Environment* 5(1): 1-9

Students will explore key design concepts, including the size, shape, number, and spatial arrangements of hubs and corridors, edge effects and interior habitat considerations, buffers, use of matrix habitat, greenways, and criteria for identifying potential areas to include in a green infrastructure network. The multiple benefits of green infrastructure networks will also be discussed, including biodiversity and conservation, promotion of ecological function and ecosystem services to meet ecological and human needs, and promotion of human health and well-being. The use of ecological restoration to promote ecological function and ecosystem services in degraded lands will also be discussed in the context of green infrastructure networks in the urban context.

During this class period students will also be introduced to concept mapping (the instructor may refer to it as system mapping to ease student comprehension). One of the main assessment tools used during later parts of the case study will be student-generated concept maps, so the concept will be introduced at this point with some time for students to practice mapping a system they are intimately familiar with – their campus. The instructor will show an example concept map and point out the key features (i.e., system components in boxes, relationships shown as arrows or lines, spatial arrangements to indicate relatedness of concepts/components, etc.). Students will then go outdoors to observe an area on campus and, in groups, create a concept map of the social and ecological components of the campus system. Back in the classroom groups will present their concept maps and the instructor will facilitate class discussion about the accuracy and effectiveness of each map. If the weather is bad that day, the activity can be modified to focus on the social and ecological components of the classroom space instead of the campus or can be done as a thought experiment. More information on concept mapping can be found here: http://cmap.ihmc.us/docs/conceptmap.html. There are many free programs online that students can use to construct concept maps digitally; a couple of examples include Mental Modeler (http://www.mentalmodeler.org/) and XMind (http://www.xmind.net/).

The final portion of the class period will be devoted to preparation for the upcoming field trip. The instructor will assign readings specific to the place(s) that will be visited, discuss logistical issues, and give a preview of some of the sites that will be visited and activities to be completed during the trip. The following list are examples of readings that were assigned to students for the Jamaica Bay field trip:

- US Fish and Wildlife Service. Significant habitats and habitat complexes of the New York Bight Watershed: Jamaica Bay and Breezy Point. http://nctc.fws.gov/resources/knowledge-resources/pubs5/web_link/text/jb_form.htm
- US Department of the Interior, National Park Service. 2014. Gateway National Recreation Area Final General Management Plan and Environmental Impact Statement. Selected chapters/sections. http://www.nps.gov/gate/parkmgmt/gmp-2012.htm
- New York City Department of Environmental Protection. 2007. Jamaica Bay Watershed Protection Plan. Selected chapters/sections. http://www.nyc.gov/html/dep/html/dep_projects/jamaica_bay.shtml
- New York City Department of Environmental Protection. Ecological Restoration of Pennsylvania and Fountain Landfills fact sheet. (acquired from contact at NYC DEP)
- New York City Department of Environmental Protection. Paerdegat Basin Restoration fact sheet. (acquired from contact at NYC DEP)US Department of Agriculture – Forest Service. 2014. The Jamaica Bay Social Assessment: Understanding Park Users. Marine Park Profile. (acquired from a contact at USFS)
- "How Cities Use Parks for Green Infrastructure," City Parks Forum Briefing Papers, American Planning Association, 2003 https://www.planning.org/cityparks/briefingpapers/greeninfrastructure.htm
- plaNYC Progress Report: Sustainability and Resiliency 2014. City of New York http://www.nyc.gov/html/planyc2030/downloads/pdf/140422_PlaNYCP-Report_FINAL_Web.pdf

Part IV: Field Trip to Illustrative Sites for Green Infrastructure Network (4-6 hours)

Students will visit existing parks and document socio-ecological components that they observe. Students will also visit city-owned properties (such as vacant lots) that could be converted into city parks and restored to support species or ecosystems of interest. Lastly students will visit examples of ecosystems of interest (for example, freshwater wetlands, salt marshes, etc.) and elements of the built environment that could support wildlife or serve as corridors (i.e., green roofs, bioswales, rain gardens, etc.) to understand their ecological function and landscape context. Ideally, city park managers and/or researchers will accompany the group to give guided tours, provide historical context of the sites, discuss some of the realities of park management (budgetary constraints, understaffing, balancing needs of various stakeholders), and be available to take questions from students. Individually, students will develop concept maps to describe the socio-ecological components of the Jamaica Bay area and write a short paper describing their ideas for how properties and landscape elements could be managed to support urban biodiversity. In particular, students should document ecological functions, ecosystem services, and indications of human use and incorporate these into their concept maps. Students may be asked to interview the park managers, using a structured survey instrument, and may be asked to perform a qualitative analysis of the data (i.e., transcribe responses and identify key themes).

Part V: Introduction to Designing a Green Infrastructure Network (3 hours)

During this class period students will be introduced to the first part of the group work they will engage in for the remainder of the case study. First, the class will discuss their concept maps and information gathered from the field trip. The objective at this point is to ensure that the students are able to conceptualize the places they visited as socio-ecological systems and to articulate aspects of ecological function, ecosystem services, human use, stakeholder concerns, and best practices in park design.

Students will then be assigned to small groups. Each group will be assigned a species of interest and will be given information about potential city-owned sites that could be converted into parks and/or restored natural areas in the Jamaica Bay area. Information will be in the form of city reports, fact sheets, and maps. Groups will be given a budget and information about costs per unit area to restore specific ecosystem types and construct recreational amenities in parks (see student handouts document for these details). Students will have access to documents about Jamaica Bay, including the ones assigned for reading prior to the field trip (see above in Part III: Preparation for Field Trip). Additional resources that will help students research their species include:

- E. Kiviat and E.A. Johnson. 2013. Biodiversity Assessment Handbook for New York City. American Museum of Natural History and Hudsonia, Ltd.
- NatureServe Explorer, a website that contains information about rare and endangered species in the United States and Canada; http://explorer.natureserve.org/
- US Department of Agriculture, Natural Resources Conservation Service plants database, website that contains information about plant species found in the United States; http://plants.usda.gov/java/
- Pinelands Preservation Alliance, Special Plants of New Jersey Fact Sheets; http://www.pinelandsalliance.org/ecology/plants/specialplantsnjfactsheets/

The groups will be charged with designing a green infrastructure network using their available budget to promote conservation of their assigned species. First the students will have to generate an information needs assessment to determine what kinds of information they will need to find in order to complete the assignment (for more information, see the student handouts document and the "Assessments" section at the end of this document). Types of information they should consider include: species requirements, life histories, distribution, current status of species, threats specific to their species, and information about how the species uses urban environments. Groups will work on their information needs assessment in the classroom with input from the instructor, and will be given time in the classroom to begin gathering information. The instructor will assist groups with locating useful information, making additional materials available to students, suggesting useful websites, and contacting park managers to get answers to specific student questions. Students will organize their ideas into a concept map and will prepare a presentation for the next class period.

Part VI: Group Presentations of Single Species Proposed Networks (3 hours)

Students will be given some time in class to put the final touches on their concept maps and presentations. The remainder of the class period will be devoted to group presentations and class discussion facilitated by the instructor. A rubric for assessment of the presentations has been included in the "Assessment" section at the end of this document. Students will also provide comments on the presentations using the peer feedback form (included in the student handouts document). The instructor should ensure that key themes are addressed, including:

- Similarities and differences among the proposed networks (i.e., number of sites, sizes, spatial arrangement, buffers, connectivity, etc.)
- Variation in habitat requirements for different species
- Range of likely social and ecological benefits for each proposed network beyond just species conservation
- Information that was difficult to find, gaps in knowledge, and instances in which information was uncertain, not detailed enough, or otherwise inadequate for good decision making
- Degree to which budget realities were an obstacle to designing an optimal network

Part VII: Human Dimensions of Conservation and Stakeholder Analysis (3 hours)

During this class period students will explore the human dimensions of conservation and green infrastructure network design. Up to this point students have mostly focused on ecological and biophysical considerations when proposing a green infrastructure network design. Now they will be asked to integrate human needs and interests, including political, economic, and cultural, into their thinking and approaches for conserving species and systems. Ideally a guest lecturer (most likely a city park manager, researcher, or similar present in person or by Skype) will present information about stakeholder issues at multiple scales and political, economic, social and cultural realities that impact park management efforts and may play a role in the future of the city parks, natural areas, and city-owned lots the students have been considering for their green infrastructure networks. Existing data on trends in human use at the sites the students are considering will be presented. This will require the instructor to contact a park manager and make arrangements for an in-person or Skype guest lecture. If this is not possible, the instructor may be able to present an example of stakeholder conflict related to green infrastructure planning and/or conservation biology that will illustrate how stakeholder issues can either negatively or positively impact species and/or open space conservation. The objective is to get students thinking about stakeholder issues, ideally by relating actual examples that environmental managers have encountered during their careers.

Students will then work in their groups to integrate stakeholder concerns into their concept maps and consider how they might alter their proposed networks to address these issues. They will complete the stakeholder assessment (see the student handouts document and the "Assessments" section at the end of this document for more information). If instructors have been able to develop a relationship with a park manager, they may consider making arrangements for students to interview or otherwise contact that person to ask specific questions about stakeholder interests in order to complete this assignment.

Students should utilize the Jamaica Bay documents to find information about stakeholder issues, as well as documents they find in their own research. Additional resources that have not been mentioned already include:

- E. Gies. 2006. The Health Benefits of Parks: How Parks Help Keep Americans and Their Communities Fit and Healthy. San Francisco, Trust for Public Land.

Part VIII: Putting it All Together – Multiple Species Green Infrastructure Network Design (6 hours over multiple class periods)

During this class period new groups will be formed. Each group will include one member from each of the single species groups. The job of the new multiple species groups is to harmonize all of the proposed networks designed to conserve individual species or ecosystems in order to arrive at one optimized proposed network that will balance the needs of all of the species and ecosystems and also factor in the human dimensions that may impact individual sites. Groups will have to grapple with non-synergistic biophysical requirements of multiple species, mismatches in scale, and stakeholder issues that may interfere with species or ecosystem needs. This exercise is meant to simulate some of the challenges faced by managers and researches dedicated to conserving natural resources. Students will have time in class to decide on their proposed network, seek guidance from the instructor, and prepare their final presentation materials. Partway through, groups will informally report out to the class on their progress and challenges to share notes and seek feedback and guidance from their peers and the instructor.

Part IX: Final Presentations

Students will present their work via a gallery walk poster presentation. Each multiple species group will prepare a poster exhibiting their proposed network and a description of the socio-ecological issues they had to address in balancing species needs with human needs and political and economic realities. Each group will designate an initial presenter. Small groups will visit each poster simultaneously and interact with the presenters. After a set interval of time, the groups and presenters will rotate. Rotations will continue until everyone has had a chance to visit each poster and provide feedback and most of the group members have had a chance to present their group’s work. The instructor will facilitate one final class discussion to document student observations, reflections, and reactions to the exercise and the outcomes. Students will complete a self and peer evaluation during class time (see student handouts document). Groups will submit final reports documenting and addressing the feedback they received during the gallery walk and comparing their proposed networks and decision making to the other groups in the class. Students will also submit short, individual reflection papers to demonstrate their grasp of the concepts and exhibit their individual learning. The specific assignments for the final reports and individual reflection papers are included in the student handouts document. A rubric that can be used for evaluating the final presentations and reports is included in the “Assessment” section at the end of this document. Students will also provide comments on the poster presentations using the peer feedback form (see students handouts document).

Background:

Urban Ecology

Urban ecology is the study of ecological processes in urban systems. Understanding ecological processes in cities allows us to better plan and manage cities that are sustainable for humans and nature. Today over 50% of the human population lives in urban areas (closer to 80% in the US), resulting in the rapid expansion of urban landscapes around the world (Martine 2007). Cities are often located in naturally species-rich regions (Luck 2007, Kuhn et al. 2004, Cincotta et al. 2000) where native species and habitats are threatened by an array of anthropogenic factors, including habitat loss and species introductions (Williams et al. 2009) that present serious conservation challenges (McKinney 2002). The restoration and creation of green spaces in cities is inarguably the primary way to enhance ecological function of cities. Recent research has shown that cities with more green space not only supports more birds and plants, but also that more green space in a city reduces the loss in bird and plants as a city undergoes development (Aronson et al. 2014). Green spaces are not only important for supporting biodiversity, but also for ecosystem processes such as water and nutrient cycling.

Urban Biodiversity

As the world becomes more and more urbanized, there is increasing concern over the loss of natural habitats and native species as well as the introduction of alien species. Urban regions have unique habitats and constraints on the persistence of plant and animal species. Four main processes affect biota of urban areas: habitat transformation; habitat fragmentation; habitat degradation due to urban environmental effects; and the spread of non-native invasive species (Williams et al. 2009). Habitat transformation in the form of urbanization changes agricultural and natural habitats into urban, suburban, commercial, and industrial land uses. Habitat transformation is considered the leading cause of species loss worldwide (Wilcove et al. 1998). This process decreases the availability of natural habitats and is the main process increasing the subsequent fragmentation and degradation of remnant habitats. Degradation of remnant habitats changes the structure and function of urban habitats compared to rural ones. The structure and function of urban habitats is linked to the unique abiotic conditions of urban environments, such as elevated temperatures, greater air and soil pollution, and nutrient and water stresses (Gilbert 1989; McDonnell et al. 1997; Grimm et al. 2008). Ecosystem processes, such as decomposition rates and nitrogen mineralization, also change along the urban to rural gradient (Pouyat et al. 1997). Species composition and the structure of habitats respond to these ecosystem changes.

Designing urban habitats for plants and animals requires planning and management at multiple spatial scales: the city, the neighborhood, and the local habitat. At the city-wide scale issues such as increasing native green space and connectivity are important (Ignatieva et al. 2011). At the neighborhood scale we should take into consideration the design and management of neighborhoods, with an understanding that private yards and gardens can connect ecologically to green spaces (Goddard et al. 2010; Hostetler et al. 2011). At the habitat scale, the restoration of soil, vegetation structure (herbs, shrubs, trees) and composition (native plants that provide flowers, fruits, and other resources for wildlife), and management of invasive plant and animal species are important components of increasing biodiversity in green spaces.

Green Infrastructure Networks

A green infrastructure network is defined as “an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife” (Benedict and McMahon 2006). It is a type of green space planning that emphasizes parks as interconnected systems that provide ecosystem services in landscapes that span a range of human dominance and human population density. In this context green infrastructure is not viewed as a luxury but rather a necessity – the networks are viewed as the natural life support system for human populations (Benedict and McMahon 2006). Green infrastructure acknowledges the need for engineered structures (i.e., gray infrastructure) and land development to support human needs for housing, work, transportation, commerce, and recreation and uses a systematic approach to balance the need for conservation and open space with the need for land development; in so doing it provides a framework for making land use decisions (Benedict and McMahon 2006). Networks typically consist of hubs, larger patches that can serve as habitat and perform other key ecosystem services, and corridors, spaces that serve as linkages between multiple hubs (Ignatieva et al. 2011).

Ecosystem Services

There is a growing appreciation of the benefits that greener and more ecologically diverse urban areas have for humans. The services that nature provides to humans are often referred to as ecosystem services. The importance of ecosystem services in cities can provide justification to city officials for preserving and initiating new green spaces. Ecosystem services are often divided into four categories: supporting services, regulating services, provisioning services, and cultural services (MA 2005). Supporting services include processes such as soil formation, primary production, nutrient cycling, and water cycling. Regulating services include air quality regulation, climate regulation, water regulation, erosion regulation, water purification and waste treatment, disease regulation, pest regulation, pollination, and natural hazard regulation. For example, wetlands are well known to increase water quality. Additionally, heat island effects are ameliorated by more green space in cities and more trees by lowering ambient temperatures through less heat absorption, evapotranspiration and shade. Provisioning services include food, fiber, genetic resources, biochemical, natural medicines, pharmaceuticals, and fresh water. Restoring vacant lots can increase pollinator abundances in the city, thus increasing pollination success of plants in urban gardens. Finally, cultural services include spiritual and religious values, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation, and ecotourism (MA 2005).

Restoration Ecology

According to the Society for Ecological Restoration (SER 2004),"ecological restoration is the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed". An ecosystem is restored when it supports biotic and abiotic resources and processes characteristic of the target ecological community (the target is the ecological community the site is to be restored to). Restoration ecologists and practitioners look to restore not only characteristic assemblages of species, but also the physical environment capable of sustaining plant and animal populations and ecosystem function. Additionally, the most successful restorations are integrated into the landscape, interacting with the surrounding landscape through abiotic and biotic flows and exchanges. Finally, the restoration needs to be sufficiently resilient to endure the normal periodic disturbances in the local environment. The Society for Ecological Restoration (SER 2004) recommends several steps when planning a restoration project: 1) a clear rationale as to why restoration is needed; 2) an ecological description of the restoration site; 3) stated goals and objectives of the restoration project; 4) a designation and description of the target ecological community; 5) how the proposed restoration will integrate with the landscape; 6) explicit plans, schedules and budgets for installation; 7) monitoring protocols to evaluate the project; and 8) long-term protection and maintenance strategies.

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Assessments:

Several types of formative and summative assessments will be used to gauge students' progress, make adjustments as needed while the case study is in progress, and evaluate the degree to which the student learning outcomes have been achieved at the close of the case study. These assessments have been mapped to student learning outcomes and case study activities in Table 2 above. This section will explain each assessment instrument in more detail.

Formative assessments include:

- **Muddiest point:** following key lectures or presentations designed to provide necessary background on topics like urban wildlife, green infrastructure network design and benefits, restoration ecology, etc. or guest lecturer presentations on stakeholder and park management issues, students will be asked to write a short paragraph on an index card explaining one point that they had trouble understanding. This will be used at the instructor's discretion in order to gauge student learning and comprehension at several key points during the progression of the case study. This will help the instructor make needed adjustments and review salient points to ensure students have integrated the necessary background context to be able to fully engage in the network design process.

- **Peer and instructor feedback on individual and group concept maps**: students will generate two concept maps towards the beginning of the case study. One will be accomplished during Part III as practice. Students will create a concept map of a familiar system, such as their campus or classroom, and will provide peer feedback in small groups. The instructor will provide informal feedback (not a grade, but check/check-minus/check-plus with written comments) to promote student comprehension and learning. During Part V students will create group concept maps explaining their proposed green infrastructure network and how it addresses their particular species in terms of some or all of the following components/considerations: species requirements, life histories, distribution, current status of species, threats specific to their species, locations of known populations or patches in the New York City area, pertinent information about existing parks and potential park sites not contained in the provided materials, and stakeholder issues. Peers will provide feedback during class discussion during Part VI of the case study, and groups will have the opportunity to refine their concept maps before submitting for instructor comments. This will be treated as a formative assessment, designed to give students feedback as they move into later, synthesis-oriented sections of the case study. Instructors can use their discretion to assign letter grades or point values to these assessments or instead give check/check-minus/check-plus indicators.
- **Information needs assessment:** Groups will submit their information needs assessment for instructor feedback during Part VI. This will be treated as a formative assessment, designed to give students feedback as they move into later, synthesis-oriented sections of the case study. Instructors can use their discretion to assign letter grades or point values to these assessments or instead give check/check-minus/check-plus indicators.
- **Single species group presentations:** During Part VI the initial groups will present their proposed green infrastructure network designed to protect a single species or ecosystem. They will use their concept map as one component of their presentation, along with other visuals to convey which sites they chose, their spatial orientation, and how that network will effectively protect their assigned species. The instructor will provide comments and feedback on the group presentations; this will help the future multiple species groups refine their final presentations, which will comprise a major portion of their summative assessment. Students will provide comments on the presentation using a peer feedback form (included in the student handouts document). A suggested rubric for evaluating the presentations is provided below:

Criterion	4	3	2	1
1.Group used the concept map to explain their species requirements, conservation status, and threats	Made extensive use of map, effectively interpreted the components and connectors, and used the map to convey relevant	Made good use of map, quality of interpretation and relevance of information included was good but not excellent	Referred to the map only glancingly and made minimal efforts to interpret the map for the audience OR the information was not	Did not refer to the map

	information about the species		relevant to the assignment	
2.Group described habitat and life history requirements of their species	Discussed habitat requirements at multiple life history stages, including ecosystem type, plant community, and/or fresh vs. brackish water, food resources, nesting preferences, refuge from predators; related these factors to urban environment; discussed adaptability of species	Discussed many elements of habitat and life history requirements but with less detail and quality	Discussed some elements of habitat and life history requirements, but did not provide a rich understanding of habitat requirements at different life stages; did not adequately consider the urban context; did not discuss species adaptability	Did not mention habitat and life history requirements
3.Group described the current conservation status and threats to conservation for their species	Classified the conservation status as endangered, threatened, rare or special concern in NY State; described current abundance and population trends in NYC, NY State, and/or northeastern US; adequately explained range of threats on multiple scales, from local habitat disturbance and destruction to global processes like climate change	Classified the conservation status as endangered, threatened, rare or special concern in NY State; described current abundance and population trends in NYC, NY State, and/or northeastern US to some extent; explained threats on some scales but lacked quality and depth in explanation of 4	Classified the conservation status as endangered, threatened, rare or special concern in NY State; did not describe current abundance and population trends; explained some threats on a limited number of scales; discussion lacked quality and depth of 3 and 4	Did not classify the conservation status as endangered, threatened, rare or special concern; did not describe current abundance and population; did not describe threats on any scale
4.Group described how the species uses urban environments	Described how the species uses a range of urban environments on multiple scales, including a range of natural areas and elements of the built environment	Described how the species uses a range of urban environments on some scales, including some natural areas and perhaps some elements of the built environment	Inadequate description of how species uses urban environments; considered only most obvious elements such as interiors of natural areas; did not consider elements of built environment	Did not describe how the species uses urban environments

5.Group described how they gathered information to complete the assignment	Described process used to gather information; used elements of information needs assessment to illustrate their process; indicated which pieces of information were easy to find and which were harder; included several entries for each category of information on the info needs assessment	Described process used to gather information; used elements of information needs assessment to illustrate their process; indicated to some degree which pieces of information were easy to find and which were harder; some categories of information were assessed more completely than others	Described process used to gather information; did not use the information needs assessment to illustrate their process; did not specify which pieces of information were easy to find and which were harder; included only one or two entries for categories of information on the info needs assessment	Did not describe how they gathered information
6.Group showed visualization of the spatial arrangement of sites selected in the proposed network	Used a visually appealing and easy to understand visualization of the spatial arrangement of sites; helped audience members interpret the visualization	Used a visualization that showed the spatial arrangement of sites in a less visually appealing manner; interpretation for the audience was of lower quality than 4	Used a visualization that was unclear or difficult to understand; little or no attempt to help the audience interpret the visual	Did not show visualization of the spatial arrangement of sites
7.Group explained justification for site selection	Provided robust explanation for each site selected; explanation was grounded in ecological understanding of species and ecosystem types and appropriate interpretation of aerial photos; addressed connectivity and spatial arrangement of sites in site selection	Provided explanations for all or nearly all of the sites; explanations were of good but not excellent quality in terms of ecological understanding; interpretation of aerial photos was adequate or near adequate; efforts to address connectivity and spatial arrangements were less well developed than 4	Attempted to justify selection of some but not all of the sites; justifications were arbitrary and not grounded in ecological understanding; interpretation of aerial photos was incorrect or incomplete; did not address connectivity and spatial arrangement of sites at all or in a meaningful manner	Did not justify site selection
8.Group described challenges in site selection	Described challenges in site selection including difficulty in interpreting aerial photos, deciding	Described some challenges but with less detail and quality than 4	Described very few challenges and with little or no detail	Did not describe challenges in site selection

	how much area to restore vs. leave alone vs. dedicate to active human use, problems with providing adequate connectivity, problems with restoring sites to the required ecosystem type, problems coming in within budget			
9.Group predicted how well the network will function to protect the species	Provided a prediction for the effectiveness of the network grounded in ecological understanding (i.e., landscape ecology, island biogeography theory) and best practices in green infrastructure design (i.e., design principles)	Provided a prediction for the effectiveness of the network but with lower quality description and less or lower quality use of ecological understanding and best practices to inform the explanation	Provided a prediction for the effectiveness of the network but gave little or no explanation	Did not predict the effectiveness of the network
10.Quality of slides and visual presentation	Very visually appealing, good use of color and photographs, did not overuse text, consistent use of templates, patterns, backgrounds and/or layouts	Reasonably visually appealing, use of color and photographs on some slides, too much use of text on some slides, mostly consistent use of templates, patterns, backgrounds and/or layouts	Somewhat visually appealing, limited use of color and photographs, somewhat excessive use of text, somewhat excessive white or blank space, little or inconsistent use of templates, patterns, backgrounds or interesting layouts	Not visually appealing, little or no use of color and photographs, excessive use of text, excessive white or blank space, little or no use of templates, patterns, backgrounds or interesting layouts
11.Quality of oral presentation	Speakers were very clear and easy to understand, the group made significant efforts to make the presentation interesting (i.e., use of videos, stories, highlighting interesting information about species, etc.)	Nearly all the speakers were clear and easy to understand for the most part, the group made some efforts to make the presentation interesting	Most of the speakers were not clear and were difficult to understand, the group made limited efforts to make the presentation interesting	Speakers were not clear and were difficult to understand, little or no effort to make the presentation interesting

- **Stakeholder assessment:** During Part VII of the case study, students will synthesize their understanding of human dimensions (political, social, cultural, and economic) of park management into a matrix. The matrix will be specific to their single species/ecosystem proposed networks and will consider stakeholders at multiple issues (local, city, state, federal). The instructor will provide comments and feedback on the stakeholder matrices. The future multiple species groups will address stakeholder issues in their final presentations, so the feedback at this stage will help the students effectively incorporate these considerations into their final presentations.

Summative assessments will include:

- **Multiple species final presentations and reports:** The final multiple species groups will construct a proposed green infrastructure network designed to protect all of the individual species considered during the previous exercises. During Part IX of the case study, the multiple species groups will present their proposed networks via a gallery walk poster presentation. Groups will be required to include a concept map as part of their final poster presentation. The instructor will provide a letter grade or point value to each group with comments. Students will provide comments on the presentation using a peer feedback form (included in the student handouts document). The groups will also produce final reports responding to the feedback from their peers and comparing their final proposed network to other groups'. A suggested rubric for evaluating the final presentations and reports is provided below:

Criterion	4	3	2	1
1.Paper included a justification for the sites chosen for the network	Clear and comprehensive justification included for each site, a map or other visualization was used to show the location and spatial arrangement of the selected sites, justifications included species habitat requirements and need for connectivity, justifications were ecologically valid	Justification for all sites included, some type of visualization showing spatial arrangement was included, justifications were of lower quality than 4 in terms of clarity, ecological validity, and consideration of habitats and connectivity	Justification for most but not all sites included, visualization showing spatial arrangement was not included, justifications were of comparatively poor quality (i.e., problems with clarity, ecological validity, and/or did not consider both habitats and connectivity)	No justification included
2.Paper included budget description	Budget description included, outlines costs for restoration and recreational amenities, effort made to include other potential	Budget description included, outlines costs for restoration and recreational amenities, cost estimates were reasonable, group	Budget description included but confusing, incomplete, unreasonable or otherwise inadequate	Budget description not included

	costs to promote connectivity, hire technical experts, design features specific to particular species, educational facilities, etc., cost estimates were reasonable	made reference to other potential costs but made little or no effort to estimate them		
3.Paper discussed tradeoffs among species and other difficult choices	Discussion of tradeoffs among species included, described how they balanced different habitat and connectivity needs, justified how they addressed those tradeoffs in selecting sites, discussed other difficult choices (i.e., budget, opposing needs of different stakeholders or stakeholders vs. species, etc.)	Discussion of tradeoffs among species included, description and justification of lesser quality and less comprehensive than 4, other difficult choices referenced but discussed in less detail	Some discussion of tradeoffs among species included, but not comprehensive and problems with clarity, no justification or reasoning presented for how tradeoffs were addressed, little or no attempt to discuss other difficult choices	Discussion of species tradeoffs and other difficult choices not included
4.Paper included a discussion of ecosystem services provided by the proposed network	Paper included clear and comprehensive description of potential ecosystem services provided by the network, wide range of services considered and described, discussion was ecologically valid, group considered human health	Paper included description of many potential ecosystem services, but discussion not comprehensive, discussion was mostly ecological valid, group may or may not have considered human health	Paper included description of some potential ecosystem services, but discussion was not comprehensive, and there were problems with clarity and ecological validity, group did not consider human health	No discussion of ecosystem services included
5.Paper included discussion of how stakeholder interests were addressed	Paper included thoughtful analysis of stakeholder interests and discussed how network addresses stakeholders, three questions were answered completely and	Paper included good analysis of stakeholder interests but of lesser quality than 4, discussed how network addresses stakeholders, questions answered but responses were	Paper included analysis of stakeholder interests but not clear or reasonable, little or no attempt to answer the three questions, did not consider	No discussion of stakeholder interests

	clearly, group considered stakeholders on multiple scales (i.e., local, city, federal, etc.)	of lesser quality than 4, group considered stakeholders on some different scales	stakeholders on different scales	
6.Paper included prediction of effectiveness of proposed network	Prediction of network effectiveness included, explanation and reasoning was clear and ecologically valid	Prediction of network effectiveness included, explanation and reasoning was good but of lesser quality than 4	Prediction of network effectiveness included, problems with clarity and ecological validity of explanation	Did not include prediction of effectiveness of proposed network
7.Presentation included concept map to show group's thought process	Concept map included in presentation, group actively used concept map to illustrate how species needs are similar and/or opposing and/or other aspects of group's thought process, concept map was visible to the audience, group interpreted the concept map for the audience, map was ecologically valid, map included components and connecting words	Concept map included in presentation, group used concept map to illustrate thought process, but explanation and interpretation were of lower quality than 4, elements of concept map difficult for audience to see, map included components and connecting words but was of lower quality than 4	Concept map included in presentation, group made little or no use of the concept map, some problems with ecological validity, concept map did not contain connecting words, elements of concept map difficult for audience to see	Did not include concept map
8.Presentation included key points from final papers	Poster and presenters summarized key points from all six required elements, summaries were sufficient to illustrate the key points without going into unnecessary detail	Poster and presenters summarized key points from 4 or 5 of the required elements, almost all of the summaries were sufficient to illustrate the key points, unnecessary detail was mostly avoided	Poster and presenters summarized key points from 3 or 4 of the required elements, some of the summaries were not sufficient to illustrate the key points, some unnecessary detail included	Poster and presenters summarized key points from 1-3 of the required elements, some or all of the summaries were not sufficient to illustrate the key points, much unnecessary detail included
9.Quality of poster	Visually appealing, good use of color, drawings and/or photos to illustrate points and engage	Visually appealing but to a lesser degree than 4, some use of color, drawings and/or	Not very visually appealing, some but not much use of color, drawings and/or photos, too	Not very visually appealing, little or no use of color, drawings and/or photos, too much

	the audience, good amount of text used to convey key pieces of information, well organized and executed	photos, for some points too much or too little text included, mostly well organized and executed	much or too little included for most points, problems with organization and execution	or too little text included for all points, messy and disorganized
11.Quality of oral presentation	Speakers were very clear and easy to understand, the group made significant efforts to make the presentation interesting and engage the audience, speakers addressed audience questions in substantive manner	Speakers were clear and easy to understand for the most part, the group made some efforts to make the presentation interesting, speakers addressed most audience questions in substantive manner	Speakers were not clear and were difficult to understand, the group made limited efforts to make the presentation interesting, speakers had difficult addressing audience questions	Speakers were not clear and were difficult to understand, little or no effort to make the presentation interesting, speakers did not address audience questions

- **Individual reflection papers:** Because so many of the assessments are produced by groups, it will be important to capture the learning process and outcomes of individual students. The reflection papers are intended to be relatively short and give the students space to demonstrate their understanding of the key concepts as well as catalog their reflections on the exercise.
- **Peer and self evaluations:** Because the final presentations will assign grades/points to groups, the peer and self evaluations will be used to assess the contributions of individuals to the final group presentations as well as other group work that was completed during the course of the case study. Students will be given a rubric to evaluate their own work as well as their peers from their single and multiple species groups. The instructor will incorporate this information into the final grade for each student at his/her discretion.

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