LANDSCAPE CHANGE AND RESTORATION ECOLOGY: A FIELD TRIP TO MONTANDON MARSH

BUCKNELL UNIVERSITY – BIOLOGY 208 LAB –MARCH 31 & APRIL 2, 2014

Lab Report Due in One Week: April 7 or 9, 2014

> *A March morning is only as drab as he who walks in it without a glance skyward, ear cocked for geese. I once knew an educated lady, branded by Phi Beta Kappa, who told me that she had never heard or seen the geese that twice a year proclaim the revolving seasons to her well-insulated roof. Is education possibly a process of trading awareness for things of lesser worth? The goose who trades his is soon a pile of feathers.* — Aldo Leopold, A Sand County Almanac

To bring: appropriate **footwear** (rubber boots or other waterproof shoes/boots), long **pants**, (we may encounter mud, brambles, stickers, and downed trees), binoculars, a bird identification book if so inclined, hat, sunglasses, sunblock, water, a notebook and pencil.

Lab introduction

This week we are going to visit the Montandon Marsh wetlands complex, located just across the river from Bucknell University. This wetland is incredibly productive, with extensive plant communities that include several rare or endangered species. It also feeds and shelters many resident and migratory bird species as well as a diverse assemblage of other animals. As a wetland, it provides important ecosystem services to humans, including moderation of storm runoff, water purification, erosion control, and food and refuge for economically important animals.

The marsh is vulnerable to damage from surrounding land use. Agriculture, mining, trailer courts, a railroad line, and a state highway (with its winter salt runoff) surround it. The marsh is owned by Central Builders Supply, Inc. (CBS), which maintains a sand and gravel mining operation on a portion of it. CBS, which is owned by Bucknell alum Tony Markunas and his father, has been an excellent steward of this property. In 2004, they granted a permanent conservation easement for the wet marsh to the Merrill Linn Conservancy, a local land trust non-profit. The marsh offers us an excellent opportunity to see examples of concepts from our class. We will visit the portion of the marsh that is south of Route 45. An extensive tract also exists on the north side of the highway, including a portion owned by the Linn Conservancy. Some of the marsh north of Route 45 has been drained and used for agriculture. Attempts were made to drain the marsh south of Route 45, but these failed, perhaps due to the quantity of water present.

CBS and the Markunas family are dedicated to maintaining, creating, and restoring high-quality wetlands on this site. They are working on a restoration plan that will turn the exhausted mine pits into wetlands similar to those that naturally exist in the conserved portion of the marsh. Over the past several years, a team of aquatic and restoration biologists and geologists has been convened by the Bucknell University Environmental Center (BUEC) and the Linn Conservancy, and work has now begun in earnest to restore the mined lands *as they are being mined*. There will be many opportunities for students to participate in this process in coming years, including internships and independent research. We will use this project as an example of the challenges faced by restoration ecologists.

Your **lab report** will consist of a brief marsh restoration and reclamation plan. You will need to gather information and make observations during the field trip that you will then incorporate into your report. **Read the questions below before our field trip so that you know what kinds of information you need to gather.**

Our goals for the lab this week are to:

1. Observe the characteristics of the natural wetlands and consider how the mined lands can be reclaimed in order to mimic them.
2. Explore the biological importance of wetlands including their high productivity, the refuge they offer rare and endangered species, and their importance on a continental scale to migratory species.
3. Witness the tension that can exist between varied land-use practices, including mining, farming, human habitation, transportation, and conservation, and the possibility for win-win outcomes illustrated here.
4. Examine threats to the ecological integrity of wetlands.
5. Appreciate the importance of marshes to regional hydrology, including their role as **biological filters** that purify ground and surface water.
6. See and discuss examples of concepts from class, including microclimates, intraspecific competition (territoriality), migration, succession, adaptation, diversity, community structure, landscape ecology, field sampling, ecological niches, etc.

Restoration Ecology: An introduction

Humans have had dramatic impacts on most of the world's natural ecosystems. Restoration Ecology is a discipline focused on **manipulating altered biological systems in order to return them to a historical condition** (Meffe and Carroll 1997). Restoration ecology may be practiced on nearly any scale: from the reclamation and rehabilitation of a parking lot in a national park to the restoration of an entire river drainage through dam and road removal, soil rehabilitation, and revegetation. For example, the Provo River Restoration project in Utah has rehabilitated nearly ten miles of severely degraded river and riparian zones, and has involved the work of dozens of scientists. The total cost is estimated at $30 million. (see http://www.mitigationcommission.gov/prrp/prrp.html for details).

Hobbs and Norton (1996) have outlined the important steps to any restoration project.

1. Identify and deal with processes leading to degradation in the first place.
2. Determine realistic goals and measures of success.
3. Develop methods for implementing the goals.
4. Incorporate these methods into land management and planning strategies.
5. Monitor the restoration and assess success.

As you can see, any restoration project must be a deliberate and well-planned undertaking, with realistic, measurable goals and an appropriate level of follow-through and monitoring to ensure success. Such efforts are often expensive, but notable successes have been achieved. Establishing realistic and measurable goals is an important first step. A relatively pristine site can often help establish goals, since it can serve as an example and source for the restoration of a nearby impacted site.

Montandon Marsh: An introduction

Dr. Abrahamson, who has worked extensively in the marsh over the years, wrote the following paragraphs about the Montandon Wetlands complex as part of a successful conservation proposal. If you'd like, you can visit the course webpage to find a link to a more **detailed paper** on the marsh.

> The wetlands complex is located just east of Lewisburg, Pennsylvania and north and south of Montandon, Pennsylvania within the broad floodplain of the West Branch of the Susquehanna River. The substrate is unusual for central Pennsylvania being composed of sands and gravels associated with glaciation. Its vegetation contains elements of two geographically different

communities: glaciated wetlands and ocean coastal plain, and contains a half-dozen rare plant species (*Carex bullata*, bull sedge; *Juncus scirpoides*, scirpus-like rush; *Ludwigia polycarpa*, false loosestrife; *Digitaria cognatum*, fall witchgrass; *Rotala ramosior*, tooth-cup; and *Scirpus fluviatilis*, river bulrush). Vegetation associations include shrub marsh, sedge marsh, hardwood swamp, riverine forests as well as moist and dry upland hardwoods. A year-round flowing stream that winds through the Linn Conservancy-owned Bellis tract and adjacent properties carries most of the surface water north of Route 45. Geologically, the Montandon wetlands complex contains well-drained sand dunes interspersed with swamp forests and marshes. The dunes were formed by winds lifting Ice Age outwash from the bed of the Susquehanna River during low-flow periods. Low gradients on sands combine with a near-surface but fluctuating water table to produce broad zones of inconstant hydrology. The result is a biological association that most closely resembles an ocean coastal plain or back-dune community both in structure and species. This unusual vegetation persists as a relict after plant populations were isolated during interglacial climate warming.

These unique features of the Montandon area's ecology are well known to Pennsylvania naturalists and conservationists, and references to its natural history appear in floral, faunal, and geomorphological listings. For example, breeding-bird surveys have recorded 70 bird species nesting within the wetlands complex, including the state-threatened least bittern and rare marsh wren. A 1984 report by The Nature Conservancy reported a total of 148 species of shorebirds, raptors, and land birds seen within the wetlands complex. Each autumn and spring sees heavy use of the wetlands by migrating waterfowl. The sandy but wet soils make the Montandon wetlands complex Pennsylvania's premier site for the unusual spadefoot toad. Geologically, the area is noted for its highly unusual (for non-coastal areas) series of sand dunes. This unique riverine dune field, up to 1-mile wide, extends eastward from the Conrail right-of-way to Route 147 and contains over 100 parabolic dunes (they are oriented to winds that blew from the northwest – averaging 287º). Geologists and physical geographers from Bucknell University and the Pennsylvania State University have identified these dunes as the best-developed, well-preserved riverine dune system south of the Pleistocene glacial boundary in the eastern United States.

The biodiversity of the region belies a history of intensive human activity – plowing, timbering, sand and gravel mining, and drainage attempts. In spite of these land uses, the hydrology and vegetation present today are in remarkably good condition. Housing development is restricted to the eastern edge of the wetlands complex and a single-track railroad bisects the portion of wetlands north of Route 45. While the Conservancy-owned Bellis tract provides a core of protected landscape, it is imperative that we protect lands adjacent to the Bellis tract by easement or outright purchase. The Linn Conservancy has been working since the early 1990s to educate landowners and Township residents about the uniqueness and values of the nearby wetlands. There is a genuine opportunity at hand to protect the wonderful natural beauty of this landscape.

Activities and observations – Questions in this section are for partner discussion and/or preparation for the formal lab report (see below).

1. As you visit the different sites today, take notes comparing the physical and biological qualities of the marsh and mining pits. Think about the steps that will be needed to turn the mine into a productive marsh. Today you are on a **mission to gather information** and you should ask questions and make observations to strengthen your lab report.
2. We will begin at the southern end of the marsh and approach it by crossing corn fields now owned by CBS and leased to a local farmer. CBS is required by their permits to maintain agricultural activities on a portion of the land for as many years as possible. They are quite pleased by the current arrangement, which allows a farmer to keep an eye on the property, as well as maintaining it in good condition. The farmer also benefits from this arrangement.
3. On our left (north) we will see an old gravel quarry that was excavated about 45 years ago. In years past, this quarry was characterized by steep sides and a lack of organic soils. Though this quarry

supported bird and invertebrate species, it was not a good replacement for a natural wetland, in part because it lacked extensive zones of **emergent vegetation** (plants arising from shallow water). Why were these zones missing?

4. We will next cross corn fields that CBS plans to excavate over the next 20-25 years in order to obtain the sand and gravel sequestered beneath. The restoration plans developed by the BUEC, CBS, and Linn Conservancy outline how to turn this mined land into a productive 80-acre lake and wetland complex once mining is finished. The human community will suffer a net loss of agricultural land, however. Do the potential gains outweigh this loss?
5. We will proceed to the marsh and a portion of it that has permanent open water. This area is also owned by CBS, but it is protected into perpetuity by a legally binding **conservation easement** that prohibits development and hunting, and controls all other activities that can take place here.
6. The water you see arises from springs, and is fed by subterranean drainage that passes from distant Montour Ridge through a porous limestone layer. Dr. Craig Kochel of Bucknell's Geology Department and the BUEC has drilled many test wells to better understand the subterranean flow of water on this site. His data will guide mining and restoration work.
7. On the other side of the open water marsh is a canal that was in use in the pre-railroad era of the early 1800's. A towpath runs along it, and the ruins of a lock can be found about 200 meters from where we are standing.
8. Aldo Leopold, the father of modern ecology, has said that to have an ecological education is to live in a "**world of wounds**." You now have the solid foundation of an ecological education. What did Leopold mean by this? Do you agree with him? (Thought questions only – not for lab report.)
9. We will finish our visit with a stop at the active Central Builder Supply sand and gravel quarry. CBS is now using heavy equipment to change the face of recently mined areas, and Bucknell students will work during summers to establish an aquatic plant nursery near here for use in reclaiming the mined lands. Restoration of the mined lands will begin soon, and proceed behind the active mining. We will speak with the plant manager about efforts to conform activities to the needs of the biological community. Old methods of gravel mining often created steep-sided pits that are not conducive to supporting the diverse plant communities found in natural wetlands. Remember, you need all the information you can get to write your lab report, so **ask lots of questions**!

Lab Report (follow these instructions carefully!)

Dr. Robert Brooks of the Penn State Cooperative Wetlands Center, and a member of the Montandon Marsh restoration team, has outlined important considerations for the creation of wetlands on former gravel mines (Brooks 1990). The following notes are based on his work and the references therein, which is **available for you in pdf form on the Biology 208 Lab website**. (**DO NOT** copy from this scientific paper. Turnitin will recognize it if you do. Use appropriate citation procedures.) The most relevant portion of this article begins on page 536.

Please review the considerations below and **outline a plan** for reclaiming the Montandon mine pits. Entitle your lab "A Plan for the Creation of Wetlands from the Montandon Gravel Mine" or something equally suitable. Write it in paragraph format, including an **introduction**, **goals**, and **paragraphs corresponding to the issues outlined below**. Use the same headings as those included below (*i.e.*, **Goals**, **Wetland Attributes** and **ALL subheadings**, and **Monitoring and Management**). Your narrative should answer the questions below, but in a logical and easily-read fashion. Total **words** should **not exceed 1500** (choose them carefully!) or about three pages. Imagine that you are going to present your finished plan to CBS to guide their efforts. You are welcome, but not required, to use outside resources. If you do, be sure to include a complete **Works Cited** section. Several books are available in the library to guide your writing, and links are available on the course web page to background information on the marsh. Please note, however, that it is **entirely possible to complete this lab without referring to extra information**. These resources are for optional enrichment only.

Use the list of wetland attributes below as a guide while you inspect the existing marsh and talk to your instructors and the mine personnel. A worthy goal for any restoration project is to attempt to **mimic nature as much as possible**. With that guiding principle in mind, use the existing marsh as a model for the future wetlands to be created on the site. Use attributes of the current and former mine pits as models for what *not* to do.

Goals

In a few sentences, state several succinct and **measurable** goals for your restoration project. What will the final product look like? How will you know if restoration has succeeded? Hint: **use the biotic** (plants, animals, etc.) and **abiotic** (water, soil, morphometry, etc.) **attributes of the existing marsh as a guide**. Should any baseline information on this area be gathered at the outset, before construction and mining begin? You may want to revise this section after you have finished with the others.

Wetland Attributes:

Basin Morphometry **(use all the headings and subheadings below in your proposal)**

Size – About 80 acres of terrain is slated to be mined and reclaimed as wetlands over the next 30 years. Should these 80 acres be configured into multiple small bodies of water or one large, contiguous wetland?

Depth – How deep is the water in the existing wetland? How deep should water be in the new wetlands? Should they have a uniform depth? Should there be permanent standing water over the entire wetland, or some dry land? Should the water levels fluctuate? If so, would it be a good idea to include water-level control devices (e.g., ditches and small dams)?

Slope – Should the sides of the wetland have steep slopes, gentle slopes, or both? Are there plants and animals that appear to have particular needs in this respect?

Shape – The shoreline of a wetland is an **edge** – a topic we will soon discuss in lecture. Edges can be important to organisms as sources of cover and food. Should the new wetlands be round, or should they have a broken shoreline? Are coves, peninsulas and islands important? What effect will the shape have on wave action and exposure to wind?

Soils – Topsoil is a complex mixture of organic and inorganic substances. How can soils be managed during mining to ensure that plants will be able to grow both in the wet and dry areas of the new wetlands? (Hint: **this is a good question for the mine manager**.) Will the bare pit floors be suitable for plant growth? Should they all be covered? When the wetlands are first created, what kinds of **supplements** might the soils need in order to support new plant growth?

Buffers – Why might vegetated buffers around wetlands be important? What might be the size and shape of the buffer around the new wetland? What kinds of plants might these buffers contain?

Flora

Examine specimens of *Scirpus*, the river bulrush. Is it a grass? What other vegetation appears to be important to the marsh? Duckweed, one of the smallest of all flowering plants, is abundant. Can you recognize any non-native species that occur in the marsh? Do certain plants seem to favor a particular water depth? How can we decide **which plant species are important** to the new

wetlands? Some important species will grow as volunteers (without planting). Should we rely on volunteers only? If not, what would be the **most logical source of seeds** and rootstocks for planting in the new wetlands? What role might an on-site **aquatic plant nursery** play in the restoration process? What role do topographic diversity and water depth play in plant growth and survival? Some **alien species** are excellent colonizers of disturbed terrain. Purple loosestrife (aka "beautiful killer" and "marsh monster") is a pernicious potential invader of newly created wetlands. When it becomes established, it can quickly drive out native species. What steps might be taken to deter the invasion of alien species?

Fauna

The Susquehanna River and its valley are a major artery of the Atlantic Flyway, which is essentially an aerial highway for migrating birds. Waterfowl that pass through our region include tundra swans, snow geese, Canada geese, and several species of ducks. These birds need wetlands to rest and refuel on their journey north. The bulk of these birds passed through the region a few weeks ago, but some should still be in the area. Make note of the wetland features that support these birds and the many other species of aquatic and terrestrial birds that can be found here as transients or nesters.

In addition to birds, productive wetlands can harbor hundreds of vertebrate and invertebrate species. For example, in the fall, the marsh can teem with migrating monarch butterflies. What features of the existing wetland support birds, fish, reptiles, mammals, amphibians, and invertebrates (worms, insects, crustaceans, etc.)?

Can the features you've noted be replicated in the new wetlands? Will any special efforts need to be taken to introduce animals to the wetlands, or will they come on their own? How? What role might corridors to existing habitats play? Could artificial structures (*e.g.*, nesting boxes) play a role?

Monitoring and management

How will we know when the restoration and reclamation project is finished? What aspects of the new wetlands should be monitored in order to gauge their health? Should we expect the new wetland to house 100% of the species found in the old?

Note the competing land-use demands on this small tract. What threats do you see? Will they continue to exist in the future? How can the new and existing wetlands be properly managed? Would they be better off if they weren't managed it at all?

Works Cited

Brooks, R. P. 1990. Wetland and waterbody restoration and creation associated with mining. Pp. 529-548 *in* J. A. Kusler and M. E. Kentula, eds. Wetland Creation and Restoration: The Status of the Science. Island Press, Washington, D.C.

Hobbs, R. J., and D. A. Norton. 1996. Towards a conceptual framework for restoration ecology. Restoration Ecology 4:93-110.

Meffe, G. K., and C. R. Carroll. 1997. Principles of Conservation Biology, Second Edition. Sinauer Associates, Sunderland, Mass.

One of the penalties of an ecological education is that one lives alone in a world of wounds. Much of the damage inflicted on land is quite invisible to laymen. An ecologist must either harden his shell and make believe that the consequences of science are none of his business, or he must be the doctor who sees the marks of death in a community that believes itself well and does not want to be told otherwise.

— Aldo Leopold, Round River