WETLAND RESTORATION

SUMMARY: Wetland restoration is a process that helps to protect and re-establish degraded wetlands. Wingfield Pines is a floodplain wetland located near Pittsburgh, Pennsylvania that was restored in 2009, after centuries of neglect. In the past decade, Wingfield Pines has changed from an open meadow into a patchwork of young trees and wetland plants. Although the wetland is progressing well, long-term management is necessary to control non-native plants.

Introduction

Wetlands are transition zones where the flow of water, the cycling of nutrients and the energy of the sun meet to produce a unique ecosystem characterized by hydrology, soils and vegetation. They rival the likes of tropical rain forests in biodiversity, providing home to 31% of plant species and one-half of all North American bird species. Hence, the protection and restoration of wetlands is essential for conserving biodiversity.

Restoration is a complementary activity that, when combined with protection and preservation, can help maintain the benefits of wetlands and their surrounding ecosystems. Restoration is necessary when a wetland has been disturbed by natural causes or human development. For example, the federal government regulates the discharge of dredged or fill materials into wetlands and other waters of the United States through Section 404 of the Clean Water Act. Development activities such as water-control projects require an application for a Section 404 permit, which includes detailed plans on how to mitigate any detrimental effects to a wetland caused by the project's construction.

Wetland mitigation is a broader term used by the federal government that includes restoring a former wetland, as well as, conserving an existing wetland or creating a new wetland (Figure 1). Mitigation can be conducted on a case-by-case basis or through a banking system. In a case-by-case scenario, mitigation may require that a developer create a wetland as close as possible to the site where a wetland is to be destroyed by development. A banking system uses a designated wetland that is created, restored or enhanced to compensate for future wetland loss through development.

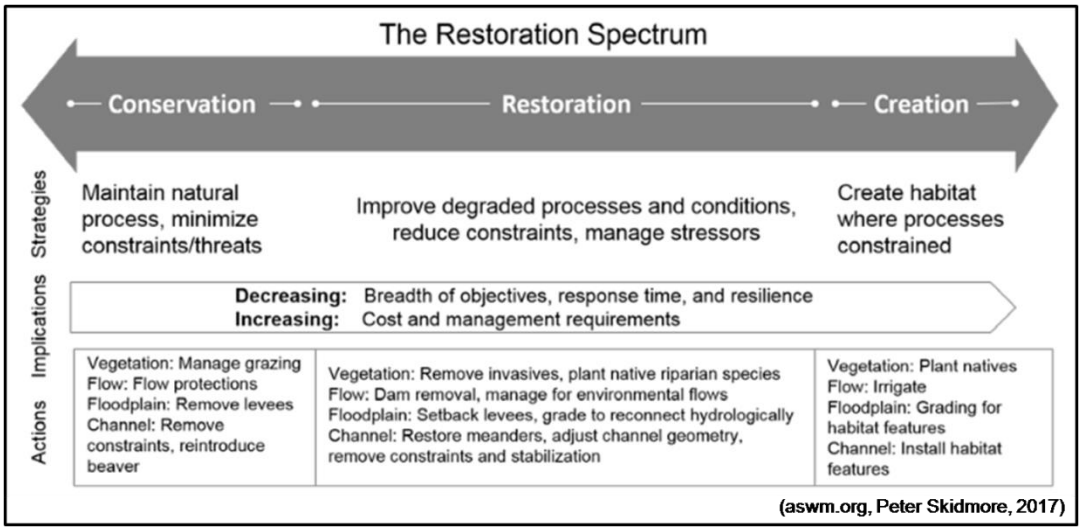


Fig. 1. The restoration spectrum illustrates the differences between conservation, restoration and creation of wetlands.

Regardless of the reason for restoring a wetland, restoration should re-establish the structure, composition and natural processes of its biotic communities and physical environment. This can often

prove challenging if the hydrology has been significantly altered or if the soil conditions have deteriorated due to dredging. In a published review of 621 restored wetlands, some over a century old, it was found that the structure, composition and natural processes were on average 26% poorer in restored wetlands compared to reference wetlands [1]. The publication suggested that wetland size and the environmental setting significantly affected the rate of recovery. Recovery was more affective if more than 100 contiguous hectares of wetland were restored. Disturbed wetlands either recover slowly or progressed toward alternative states that differ from the desired conditions. To accomplish a successful restoration, detailed planning and performance criteria are necessary, as well as, collection of baseline conditions, suitable site selection and a commitment to long-term management.

RESTORATION OF WINGFIELD PINES

Wingfield Pines is a restored **floodplain wetland** located in Bridgeville, Pennsylvania approximately 15 miles southwest of Pittsburgh (Figure 2). It has a long history of degradation, which includes farming in the 19th century and being surface mined for coal in the middle of the 20th century. It was than managed as a swim and golf club during the latter half of the 20th century, until being purchased by Allegheny Land Trust in 2001.

Fig. 2. Wingfield Pines in early 2000s, before the installation of the wetland treatment system.

Centuries of abuse makes the restoration of Wingfield Pines an on-going challenge. As a first step, Allegheny Land Trust contracted the University of Michigan to develop a Master Plan for the property. The planning process led to the construction of a mine drainage treatment system that now occupies nearly one quarter of the 80-acre wetland. The treatment system treats underground mine drainage by sending the drainage effluent through a series of ponds to settle out the iron in the water (Figure 3). Previously, the drainage effluent flowed across the northern end of the property and was directly discharged into nearby Chartiers Creek, which had a negative impact on aquatic life. The installation of the treatment system required a Section 404, Clean Water Act permit, which included plans to restore the wetland at the southern end of the property.

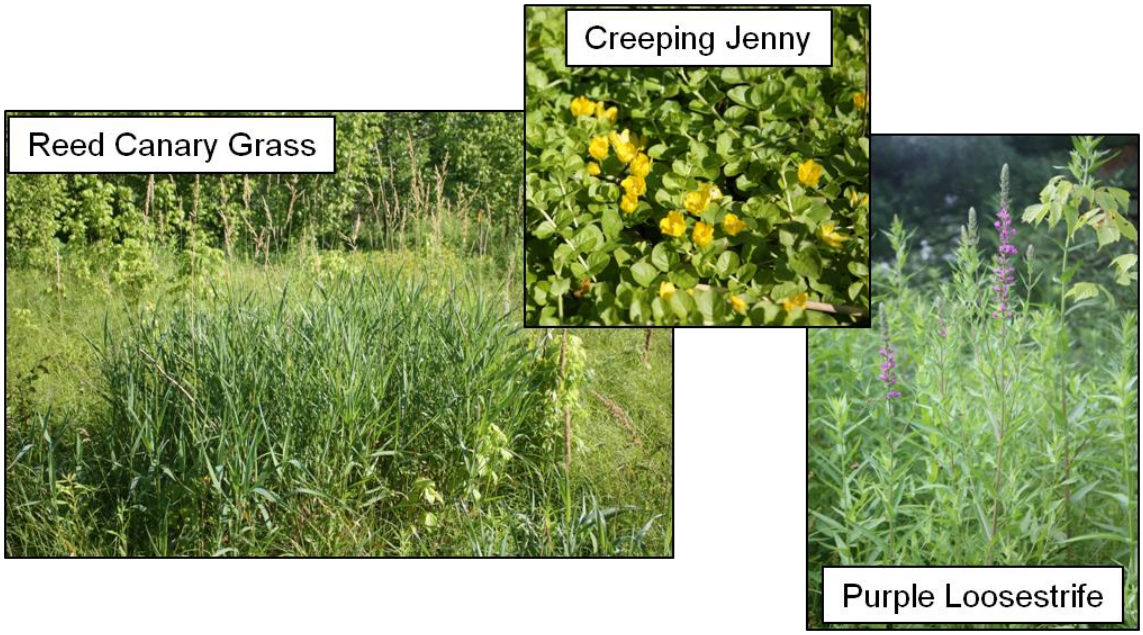
Fig. 3. Wetland treatment system.

Restoration of the southern wetland began in 2009, when approximately 450 woody plants were planted throughout Wingfield Pines, resulting in a 130% increase in biodiversity of woody plants. Some of the species planted include silver maple (*Acer saccharinum*), pin oak (*Quercus palustris*) and buttonbush (*Cephalanthus occidentalis*). Unfortunately, by 2010 half of all plantings had died. In addition, non-native species such as purple loosestrife (*Lythrum salicaria*) were competing with native

plants for resources and space. If Allegheny Land Trust had only invested one year on the project, Wingfield Pines would be inundated by non-native species. A wetland dominated by non-native species exhibits poor resilience and contains low biodiversity. Fortunately, Allegheny Land Trust has committed to long-term management and monitoring of the site.

Periodic monitoring of restored wetlands is a critical step in the restoration process. Plant growth and reproduction is an indicator of the success of a restoration project. Plant surveys at Wingfield Pines began in 2008, before the start of the restoration project. This first survey provides baseline data that can be used to evaluate the development of the wetland. The two most common sampling methods for surveying plants is transects and random sampling plots. A transect is a straight line through a wetland, with sampling points equally spaced along the line. At each point, plants are identified and quantified. Random sampling plots are randomly located throughout a wetland, with plot sizes ranging from 1 square meter for non-woody plants to 500 square meters for large woody plants. Transects are used to show the zonation of a species along some environmental gradient such as changes in plant species away from a roadside. Random sampling is best applied where the habitat being sampled is fairly uniform. Wingfield Pines is surveyed using random sampling.

Surveys of non-woody plants have shown that **species richness** has been relatively stable since 2010. However, nearly 35% of all species are non-native, which threatens the survivorship of the native plants and disrupts the ecological food web. The two most abundant non-native species are creeping jenny (*Lysimachia nummularia*) and purple loosestrife. Creeping jenny is a prostrate plant that creeps along the ground. There is little that can be done to control its growth without the use of herbicides that would also kill native plants. However, Allegheny Land Trust does have a management plan to control purple loosestrife. Every summer, volunteers visit Wingfield Pines to physically pull out the emergent plants before they go to seed; but after their purple flowers have opened and been fertilized. Without any action, purple loosestrife would dominate the plant community.



Another non-woody plant of significance is reed canary grass (*Phalaris arundinacea*). Its high density prevents any other plants from growing. There is a quarter of an acre of reed canary grass at Wingfield Pines, with no other plants growing in that area. Allegheny Land Trust has chosen not to manage the reed canary grass.

Surveys of woody plants have shown that species richness and density is relatively stable after 2011, pending a grace period during which the planted saplings and shrubs have become

established. The three most successful planted woody plants are dogwoods (*Cornus spp.*), buttonbush and silver maple, which account for 15% of all species. However, it is the non-planted species that are the most successful, with American elm (*Ulmus americana*), boxelder (*Acer negundo*) and Eastern cottonwood (*Populus deltoides*) accounting for 55% of all species.

The woody plants are dominated by pioneer species. Every plant community has a developmental history, which is called **plant succession** (Figure 4). A plant community first comes into existence with the colonization of a bare area by **pioneer species**. At Wingfield Pines, colonization of a disturbed area occurred several times in the past, once after surface mining for coal and another after the closing of the golf and swim club. The first stage consists of pioneer species that are adapted to grow and reproduce quickly, with little tolerance for shade or competition from other plants. Over time, the death of pioneer species enriches the soil, which helps establish the next stage in plant succession consisting of **intermediate species**. The final stage consists of climax species. **Climax species** are the representatives in old-growth forests, which are slow growing and perform well with competition. Reaching a climax stage can take anywhere from 100s to 1,000s of years to occur. It has been nearly two decades since the closing of the swim and golf club at Wingfield Pines; and the plant community is still in its pioneer stage. The slow rate of plant succession is due to the historical abuse of the property. To achieve a mature, floodplain wetland, Allegheny Land Trust must commit to a long-term investment on the restoration project.

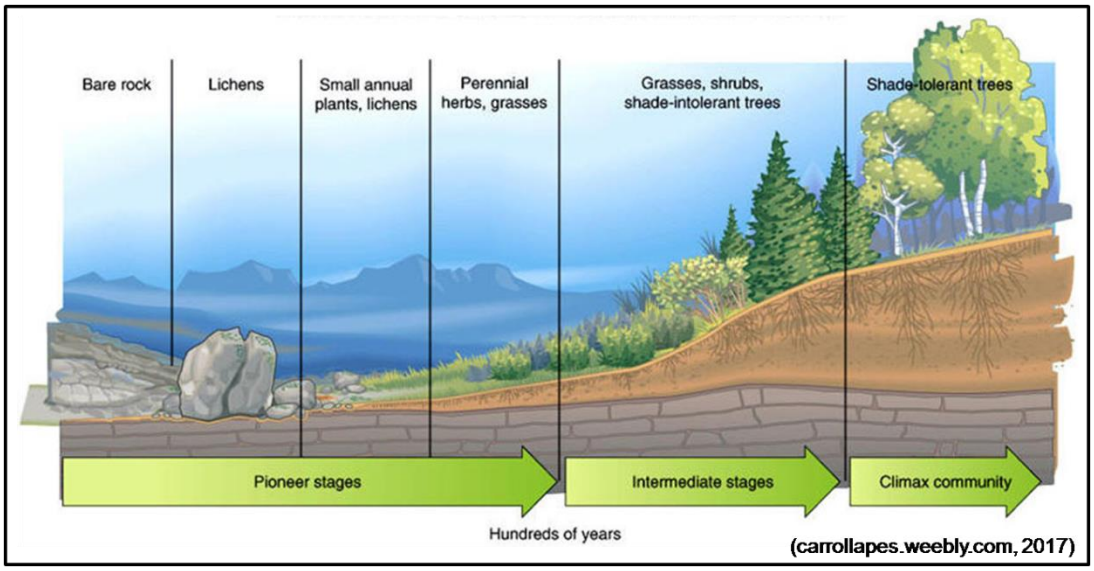


Fig. 4. Plant succession.

REFERENCES

[1] Moreno-Mateos, D., M.E. Power, F.A. Comín, and R. Yockteng. 2012. Structural and functional loss in restored wetland ecosystems. PLoS Biol 10:e1001247. doi: 10.1371/journal. pbio.1001247.

DISCUSSION QUESTIONS

GigaPan technology is an informative way of recording visual images of sampling plots. A robot is set on top of a tripod and directs a digital camera to capture multiple pictures, which are then stitched together to form a high-resolution panoramic image. The technology allows users to zoom into different parts of the image in more detail than a single photograph. Visit the GigaPan images below and answer the questions. In the bottom left corner of the image you will see an icon for "snapshots." Click on the icon to make the snapshots available. When a snapshot is clicked on, the image will be magnified as well as a text box, which will help you in answering the questions. Some of the questions will require additional literature research.

1. What was the most abundant sapling at Wingfield Pines before 2016? What type of adaptations does this pioneer species have, which allows it to thrive in disturbed areas?
   http://gigapan.com/gigapans/134133

2. American sycamore trees have been dated using a process called dendrochronology. How old are the mature trees and what primary factors have controlled their growth?
   http://gigapan.com/gigapans/134133

3. Name two non-native plants found at Wingfield Pines. What method(s) would you recommend to manage non-native plants, without sacrificing the native plants?
   http://gigapan.com/gigapans/134137

APPLICATION ACTIVITY

Restoring a wetland requires extensive training in areas of hydrology, plant biology and soil science. When determining what plants should be planted in a disturbed wetland, a scientist must consider several factors such as choosing a pioneer species, species that are native to the region, species that are suited for the given soil conditions and species that are adapted to wetland conditions. Species that are best adapted to wetland conditions are called obligate or facultative wetland species. Species that can survive short periods of flooding are called facultative; and those not suited for wetlands are called facultative upland or upland species. A good start for researching factors that determine the suitability of plants in a wetland is the U.S. Department of Agriculture, Natural Resources Conservation Service's PLANTS Database (https://plants.usda.gov/).

Data on the survivorship of five of the trees planted in 2009 to restore the Wingfield Pines wetland is provided in the table below.

Tree Species	**Average Lifespan in the Past 7 Years**	**Average Mortality Rate**
Silver Maple (Acer saccharinum)	5	50%
Red Maple (Acer rubrum)	4	60%
Swamp White Oak (Quercus bicolor)	2	100%
Bitternut Hickory (Carya cordiformis)	0	100%
Black Tupelo (Nyssa sylvatica)	0	100%

1. Conduct literature research on each of the trees and explain why the trees did or did not do well.

2. Conduct a literature review on suitable trees for growing in a wetland and list two trees, other than those in the table above, that you would recommend planting. Discuss what adaptations make them suitable for growing in a wetland.

Periodic monitoring of plants is essential for determining if a restoration project is successful. As a restored wetland progresses from an open meadow, the density and diversity of plants will initially increase until the area can no longer support any more plants. Two tables below provide data on the diversity and density of trees at Wingfield Pines.

	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Tree Species Richness	16	20	22	22	23	23	23

	Mean Density (per 400 square meters)						
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Amercian Elm (*Ulmus americana*)	43	62	68	69	77	77	81
American Sycamore (*Platanus occidentalis*)	4	7	5	5	4	4	4
Boxelder (*Acer negundo*)	106	95	88	81	75	69	58
Eastern Cottonwood (*Populus deltoides*)	4	4	88	95	103	105	111
White Ash (*Fraxinus Americana*)	8	8	8	8	7	5	4

3. Plot the above two tables on separate bar graphs using software such as Microsoft Excel. The second table will require you to plot a grouped bar graph. Make sure to properly label all axes and include a legend. Submit a hard copy of your two graphs.

4. Discuss the results of your plot and develop hypotheses about all trends or lack of trends that are observed.