# Ecological Management: Terminology and Contentious Situations

by

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## Introduction

Ecological restoration is a process where degraded, damaged, or destroyed ecosystems are aided to achieve recovery (Society for Ecological Restoration, 2004). Ecological restoration has growing importance in environmental policy, and it is widely agreed that restoration can provide many benefits, including establishing complex interactions within ecosystems (Suding et al, 2015). The universal understanding of the benefits of ecological restoration is demonstrated by initiatives taken on by many countries to achieve restoration goals. For example, at the UN's 2014 Climate Summit, many countries, such as Ethiopia, Uganda, Guatemala, Columbia, and others, committed to restoring a combined 350 million hectares of land by 2030 (Suding et al, 2015).

Humans have historically influenced ecosystems in substantial ways. Intensity of impacts vary widely, but almost no terrestrial or aquatic ecosystem has avoided being affected to some degree. An important aspect of successful restoration is to determine an appropriate target for restoration efforts. One way to identify these targets is to look to the ecological history and determine the causes of damage to that system. However, monitoring of these ecosystems rarely spans over a couple of decades and ongoing changes may make restoration targets unsustainable soon. Due to all the changes seen in ecosystems, including climate change, the environment has started to shift, and so will the targets (Jackson & Hobbs, 2009). Ecological restoration efforts should aim to achieve restoration of historic ecosystems when applicable, however, emerging noel ecosystems must also be considered to ensure the sustainability of ecosystem services (Jackson & Hobbs, 2009).

When making decisions about pursuing ecological restoration, the following principles can be used to determine the trade-offs and value of the project: restoration increases ecological integrity, restoration is sustainable in the long term, restoration is informed by the past and future, and restoration benefits and engaged society. Researchers drawing on knowledge and experience from restoration projects around the world have outlined four process-based principles to guide restoration projects that are undertaken to success. These four principles are: target root causes of habitat and ecosystem change, tailor restoration action to local potential, match the scale of restoration to the scale of the problem, and be explicit about expected outcomes. Using these two sets of principles together will help to take on projects that will benefit from restoration and to create successful and sustainable restoration solutions (Suding et al, 2015).

Restoration projects are done to recover some sort of ecological integrity, while also providing some standard value back to the ecosystem. The standards of ecological restoration connect social, community, productivity, and sustainability goals (Gann et al, 2019). Stakeholders can make or break a project and it is important to have them engaged early and often as the process unfolds (Gann et al, 2019). Stakeholders are an important part of any restoration because they help define the goals of the projects. By defining these goals, people will be informed on which type of restoration project takes place, informing them on the cost, estimated time to completion, and anticipated ecological changes that will take place.

In this paper, chapter 1 introduces a standard of terminology to use across all ecological management projects. By creating this standard, stakeholders will be informed on the economical and environmental impacts that these projects will have as well as providing a general idea of the end goals for each project. Chapter 2 provides case studies that support these terms as well as studies that help readers consider other nontraditional management strategies.

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# Chapter 1: Terminology of Ecological Restoration

Chad Raimer and Laura K. Reynolds

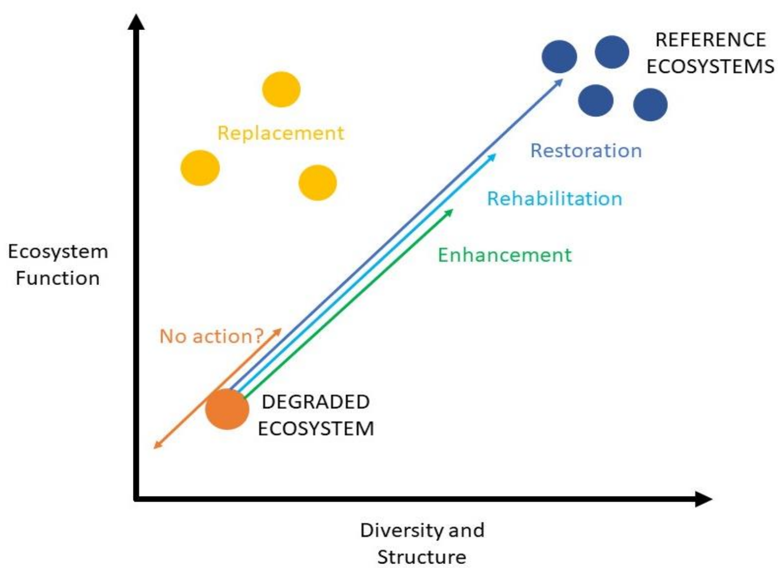
## Introduction

Ecological restoration is a common tool used to assist ecosystems in recovery. Restoration aims to reestablish a self-organizing environmental structure to create a positive trend towards full ecosystem recovery. Efforts towards recovery can be difficult because ecosystems are dynamic, and the environment can change over the course of a project or due to other factors such as major storms that can alter its recovery. Climate is continuing to change and sometimes the environment has changed with it, so restoring the ecosystem to what it used to be is not possible. For these reasons, projects repeatedly fall short of the restoration definition stated above. These environmental changes function as a basis for terminology that is introduced in this chapter.

The term restoration often gets used to both describe restoration projects and projects whose aim is different — not to re-establish a pre-existing system. Here we present the terms frequently confused with restoration that have distinct and important deviations from pure ecological restoration.

## A standard of terms to help communicate about ecological management across all projects

The terms were first introduced in the Society for Ecological Restoration (2004). Here we will define each term and the context on when to use them. These terms can be used in a variety of different contexts and this paper will discuss the reasons why stakeholders should be using terms beyond restoration when discussing ecological plans.



## Restoration

The Society for Ecological Restoration defines restoration as the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. An ecosystem has been restored when it has enough biotic and abiotic resources that can sustain and develop themselves without further assistance. That ecosystem will be resilient to normal ranges of environmental stressors will interact with adjacent ecosystems in terms of abiotic and biotic activity (SER, 2004)

Ecological restoration projects base their success on a **reference ecosystem**[1]. These reference ecosystems should be untouched landscapes away from human activity; however, some literature suggests that these ecosystems may not even exist in nature. In practice, if a suitable reference does not exist, qualities are pulled from reference ecosystems. This serves two purposes in a project, first as a model for planning and later as an evaluation of that projects success in meeting its target ecosystem. Restoration projects can be considered a success if they meet partial or full recovery based on the measured traits compared to their reference ecosystem (SER, 2004).

There have been many success stories with restoration projects. One is the Great Green Wall project in Africa. This project started in 2007, initially to improve the environmental quality across the continent. Population increase, land degradation, and climate change have created a desert dry area that has negatively affected the health and happiness of people in the region. The land has become degraded by the slow process of desertification that has plagues central and southern Africa. Deforestation, drought, and poor agricultural practices have sped up the process and the Great Green Wall seeks to alleviate these strains. The restoration effort includes planting 180 native species of shrubs and trees in over fifty thousand hectares of degraded land and has provided work for thousands of Africans and volunteers (O'Connor and Ford, 2014). As they approach their end goal, the Great Green Wall and its reference ecosystem should look similar and provide the same ecological benefits (Goffner, Sinare and Gordon 2019).

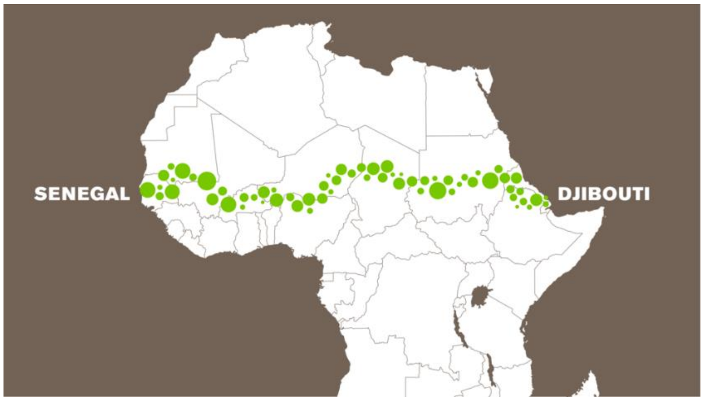



*Figure 1:The Great Green Wall in Africa. An ambitious plan to create 8000 km of nature below the Sahara Desert.* *https://www.greatgreenwall.org/about-great-green-wall*

Restoration projects, and projects that represent the other terms mentioned below, fall under two categories, active and passive. Active and passive restoration have differing philosophies that look to reach the same goal. Active restoration is creating a new ecosystem through human intervention. These changes use a combination of biotic and abiotic factors to intervene in a degraded ecosystem. Some of these assisted restoration practices include active remediation of the soil and habitat creation (abiotic) as well as invasive species management and the reintroduction of species (biotic). Passive restoration seeks to end degradation on the site through human intervention. There are a variety of “passive” techniques, some of which include removing contaminated water, removing restricted water flow such as the removal of a dam, and modifying agricultural use to reduce nutrient runoff. Passive restoration looks to promote natural succession at sites without extensive intervention by humans (Atkinson and Bonser, 2020). Differences in active and passive restoration are demonstrated by comparing the restoration of seagrass populations in Tampa Bay, Florida, and the coastal bays of Virginia.

Coastal waters have been significantly impacted by nutrients that have continually been input into the system by growing human populations. Tampa Bay has seen its population quadruple since 1950. The increased nutrient loads cause eutrophic conditions and phytoplankton and seagrasses losses became evident. Models were developed that showed that there was a relationship between increased nitrogen loads and chlorophyll concentrations in the seagrass. Managers assessed the coastal areas and with the reduction of nutrient levels and the constant maintenance of chlorophyll levels, seagrass acreage has increased 25% since 1982. Restoration goals were achieved due to passive management and the reduction of problems at the source that allowed the natural recovery of the seagrass community (Greening and Janicki, 2006).

Sometimes passive restoration does not work. In Virginia, seagrasses declined because of a storm and a disease. While the water quality was still good, seagrasses did not recover because there was not a natural seed source nearby. Researchers instead actively seeded the bay areas with eelgrass to boost recovery. Using genetics, researchers estimate that active restoration achieved recovery and genetic diversity 10 years when it would have otherwise taken between 125 to 185 years to achieve naturally (Reynolds, Waycott and McGlathery, 2013). This is an example of when active restoration was necessary and successful.

## Rehabilitation

In some instances, there are not adequate reference ecosystem to compare the project to and rehabilitation seeks to narrow the project goals to specific improvements rather than fully restoring the system to its original state. It is a term that means to repair and replace the primary or essential functions of the ecosystem that have previously been altered or eliminated due to a disturbance. Stakeholders that look to rehabilitate an ecosystem take a comprehensive approach to the project by looking to not only improve ecosystem health, but also includes an emphasis on reestablishing important or missing species back into the habitats while reducing external stressors.

A well-publicized rehabilitation project is the reintroduction of the grey wolf to Yellowstone National Park. Ecological managers recognized that a vital species was missing from the ecosystem and by assisting it with an apex predator reintroduction, they repaired essential functions back to the park (Cooke, 2005). This case study is not considered restoration because human intervention did not restore the region back to its reference ecosystem and only provided a pathway for recovery in the area. Yellowstone will also still have impairments. For example, the wolves could not correct issues such as water quality. Wolves are an apex predator that provided population control to elk that have overgrazed the Park. By decreasing elk population, it provided opportunity for essential plants to recover and as a result, small animals to return to sustainable levels (White and Garrott, 2005). Rehabilitation was successful because the degraded Yellowstone plant community improved but falls short of restoration because it did not fully recover. The addition of the predator helped the park improve on its natural recovery trajectory back to its historic reference ecosystem.

## Enhancement

Enhancement is the process of improving a specific component of an ecosystem. Enhancement can be a viable alternative to restoration when one environmental change can create a substantial positive effect on the environment. Stakeholders can find enhancement to be a more viable option because they may want to improve a single function in a habitat instead of improving the entire ecosystem. This alternative is also a faster and cheaper option for restoration practitioners compared to a full restoration or rehabilitation project. Ecological enhancements consist of improving a single environmental function such as improving water quality, mitigating flood water retention, or increasing wildlife habitat. Enhancement restoration projects seek to steer the habitat in a direction where biological process can return or become more efficient. These projects are not full restorations and therefore will not significantly contribute to creating a habitat like its reference ecosystem.

Enhancement has become a major contributor to stormwater treatment projects. Stormwater treatment has become an essential part of any construction project. These projects seek to provide treatment to runoff from impervious surfaces that would otherwise go to wetlands and waterways as polluted water. Water pollution varies depending on region, in the Northeast it could be salt and metals and, in the south, it could be nitrogen and phosphorus runoff. Runoff is treated in a variety of ways but the two of the most used techniques are constructed treatment wetlands and soil filtration. In both cases, stormwater is treated enough so that the suspended solids can be filtered out and the clean water can return to the waterways. These techniques constitute enhancement because they focus on providing a positive function to one specific issue without making wholesale changes to the entire ecosystem. (Headley and Council, 2008).

## Replacement

Replacement is the establishment of a new functioning ecosystem on a site where it did not previously exist (SER, 2004). Replacement restoration can be particularly effective when it is impossible to bring the ecosystem back to a historic form. This can happen for many reasons but is usually a result of permanent human impacts. Projects such as bridge/road construction, deforestation, and mining create needs for replacement habitats. In the United States, replacement projects are required under law when disturbing or destroying key habitats. These replaced ecosystems must provide similar functions to plants and animals that were affected when their native habitat was disturbed or destroyed, but they are typically in a different place. Replacement restoration can also be effective in areas of degradation due to human impact.

When required by law, replacement projects are called **mitigation**[2]. Humans continue to degrade the environment to exploit the riches that it provides and to combat those changes, we need to provide some environmental benefits to the project area. These benefits can be provided from the creation of habitat that did not exist before. An example of this is constructed wetlands. Constructed wetlands are treatment systems that use natural process to improve water quality. Additional benefits include habitat for flora and fauna. Standard procedure for stormwater managers is to create these habitats in areas adjacent to the project area, replacing the unused land with a benefit to the environment.

During the construction of the San Francisco Bay Bridge, large mitigation measures were put in place to combat the loss of acres worth of seagrass. These measures were put in place because the impacts of building the bridge made it so that eelgrass communities could no longer be supported in the area due to the permanent shading. Restoration would not make sense to have in that area, so researcher instead replaced that community in another suitable area. By planting in another part of the bay, the eelgrass got to continue providing substantial ecosystem functions and was able to populate rapidly with the help of active management strategies.

Conservation restoration usually consists of reintroducing organisms from either the wild or captive stocks back into their historical ranges and habitats. This approach makes a lot of sense and if the original reasons for the species decline have been identified and resolved, organisms that once existed there can have a good chance of establishing. But what if the species that you need to reintroduce no longer exists? Researchers in New Zealand have found themselves in this situation and produced an alternative. Replace the extinct New Zealand quail with the extant Australian brown quail. This replacement would allow the introduced species to fill the same niche and function that the extinct quail left behind. This special replacement meant that instead of creating an entire newly functioning ecosystem where it did not previously exist, researchers found a way to reestablish a degraded historical ecosystem. This example shows that there are not always clearcut examples of restoration ecology (Parker et al, 2010).

**<u>Considerations</u>**

A major factor for all the standard terms of ecological management is their connection to environmental permitting and the legal system. When starting any new project, environmental planners analyze potential risks for many issues including, wetlands, water quality, noise, and other factors. The National Environmental Policy Act (NEPA) was created to take environmental factors into account when making decisions on projects. If projects move forward into the construction phase, mitigation is vital to the project. Mitigating issues such as increased run off or impacts on minority communities provides opportunities to increase the overall quality of the project area. Environmental permitting also creates an avenue for legal documents to be used in case of environmental harm. Modern permitting systems also combine discretionary powers of regulators with the transparency that comes with public participation. In Massachusetts, a major part of permitting involves public outreach. Public outreach ensures that people in the project area not only are aware of the project but also give them a voice to provide questions and concerns that construction may bring. Restoring natural habitats or increasing an ecological function in these ecosystems is not only positive for humans and these species, but it also keeps builders accountable for the actions that they impose on the environment.

## **Conclusion**

Each of the ecological restoration term's main goal is to provide a pathway for natural recovery of the ecosystem. Some restoration uses more in depth or active management techniques as others are more passive or restore parts of an ecosystem. All these methods are important, but which one is preferred may be determined by multiple factors, including monetary costs, time needed, extent of degradation, monitoring, etc. It is important to have different terms for these techniques and understand how they differ to recognize the strengths and drawbacks to each one, which will help stakeholders determine the best management for an ecosystem.

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[1] A reference ecosystem is a model adopted to identify the ecosystem target of the restoration project. Many projects look at specific functions that a reference ecosystem brings to the location. The reference model can but does not need to exist in nature.

[2] The act of reducing the severity, seriousness, or painfulness of something (Oxford Dictionary).

# Chapter 2: Dichotomies of Ecosystem Management- when species are desirable vs when they are a nuisance

Chad Raimer and Laura K. Reynolds

## Introduction

We manage ecosystem for a variety of reasons, to maximize ecosystem functions, to provide essential benefits to humans and to increase the over health of the environment. As human activity and climate change alter the environment, we need to adopt a fundamentally different approach to combat these changes. Further, stakeholders may have different priorities which complicates goals of ecosystem management.

Ecosystem managers will need to produce fresh ideas that focus on what makes a desirable **native**[3] or **nuisance**[4] species, and what type will provide the biggest benefit to the ecosystem. These decisions are made for the benefit of the environment and as projects evolve, public opinion may be in opposition of the greater good.

Nuisance species are species that may be native or non-native, which cause ecological and economic harm to an area. Not all invasive plants are created equal; some are worse than others. Many invasive plants are loved and utilized by home gardeners who may not be aware of their invading nature. Others are recognized as weeds but are difficult for property owners to control. Some do not even become invasive until they are neglected for an extended period. Some aggressively colonize small areas. Others spread indefinitely and eventually dominate large areas in just a few years.

Conversely, desired species are species that become targets for ecological success. These species can be native or nonnative and are chosen because of the benefits they provide to the environment. Some desired native species allow wildlife to reintegrate into the habitat by providing foraging and nesting areas to the animal. Some nonnative desired plants provide beneficial ecological functions, such as carbon sequestration, which allows managers to clean up the target region. Both examples provide advantageous effects on the local environment and are tools managers can use to complete their goals.

The goal for ecosystem managers is to assist in the recovery of damaged habitats. These projects not only need scientists and researchers to succeed—they need land managers, local officials, and stakeholders, too. These stakeholders will have different values and goals about a project and what needs to come from restoration to make it a success. Because of the inherent value that ecosystem restoration projects bring, project success differs from person to person. Some stakeholders may want to bring back native flora and fauna while others may want to have better recreational use. When success of a project differs between stakeholders, conflicts arise. A famous example is the conflicting views that locals had during the ongoing restoration of Chesapeake Bay (Oyster vs Zebra mussels described below). This example and other contentious choices demonstrate some of the conflict that arises in ecological management projects.

## Oysters vs. Zebra Mussels

In the Mid-Atlantic region, watermen have made a living harvesting and selling oysters to local restaurants and wholesalers. Up until the Mid-1980s, Chesapeake Bay was one of the most valuable locations for oyster harvesting. Overharvesting oysters, pollution and the destruction of habitat caused a drastic ecological decline in the Bay that destroyed oyster populations. With the addition of the invasive zebra mussels in the community, native oyster populations continued to decline. When protection and restoration projects were finally proposed, people took two sides. Some locals who lived on the Bay loved the clean water that the filter feeding zebra mussels provided. Others, namely the watermen, argued that their way of life was changed due to the degraded environment. The watermen's argument worked and has gone on to provide both jobs and food security to the Mid-Atlantic Region. The Chesapeake Bay study shows the complexities that stakeholders bring to a project by blurring the lines between having aesthetically pleasing, degraded ecosystem from the invasive zebra mussel and having the healthier Bay habitat with the oyster communities (Wilberg et al, 2011)

## Destroying native habitat for new opportunity

Massachusetts developed a Forest Action Plan to help protect the public and wildlife by managing forested areas that provide benefits such as clean air and water, recreation, and wildlife habitat. Healthy, productive forests are diverse forests, meaning they have a mix of age and species. The DCR's current forest portfolio is not as well balanced as experts prefer with over 80% of the forest area composed of stands between 70 and 120 years old as shown below. While it is important to have older stands that hold substantial amounts of carbon, these carbon stocks are at risk from severe weather, diseases, and pests. A diverse forest includes younger stands that grow vigorously and rapidly accrue carbon along with older stands that store copious amounts of carbon, creating a balance between short-term benefit and long-term gain. So as part of the long-term project, managers removed some of the desirable old growth trees to provide opportunity for new growth habitats such as thick stands of young birch or shrub habitats. These shrub ecosystems are important for many of the nesting migratory songbirds that move through the region. The removal of old growth forest helps prevent forest fires, creating a direct beneficial relationship to stakeholders while also providing an ecological benefit. Massachusetts's active management strategy has helped provide opportunity and resilience for species in the state as well as provide many public benefits. The Massachusetts's Forest Action Plan is an example of managing ecosystems by removing a desired species for a more desirable alternative.

A complete look at the Massachusetts forest action plan can be found here:

https://www.mass.gov/doc/massachusetts-forest-action-plan/download

## Mangrove expansion

Mangroves are a halophytic woody plant species that live in tropical and subtropical areas and are limited in their range by sensitivity to certain environmental factors, such as the cold (Saintilan et al, 2014). Tropical mangroves provide many ecosystem functions and are ranked among the most productive ecosystems in the world. They provide numerous functions and services to the ecosystem and to humans (Lee et al, 2014). Over the past few decades, research on mangroves has expanded and functions such as carbon fixation and storage, nursery habitat, shoreline protection, storm impact mitigation and the land building capacity of mangroves are all recognized as established ecosystem functions (Lee et al, 2014). The importance of mangrove ecosystems is well-known, and the uncertainty associated with their future, such as continued urbanization of the coasts, sea level rise and climate change underscore the importance of protecting and maintaining these ecosystems (Lee et al, 2014).

Although mangrove ecosystems are of extreme importance, their range has been observed to be shifting poleward on at least five continents over the last few decades (Saintilan et al, 2014). In numerous places such as the US Atlantic Coast, Peru, and Mexico, the most cold tolerant species of mangrove (*Avicennia germinans*; black mangrove) has expanded northward into salt marsh. This is due to the lower frost frequency and intensity of frosts in places such as the Southern United States. The shift from salt marsh ecosystems to those dominated by mangroves will have implications for tropical and subtropical coastlines as well as for the ecological structure and function of those areas (Saintilan et al, 2014). Mangroves provide many ecosystem services and important habitats, but they are different from those provided by salt marsh and will ultimately have consequences if they overtake other important ecological systems.

Beyond the ecological problems that mangroves may pose, they also become a nuisance to stakeholders in many coastal communities. Salt marsh habitats and coastal regions have great economic benefits to real estate. With the expansion of these mangrove forests, valuable land is being converted and made unusable for human consumption. These thick forests also block ocean and bay views, further creating problems to people and property. There are many areas where mangroves are highly sought for and an abundance of areas where these species are unwelcomed.

## Cattails, Hydrilla and the misunderstood nuisance species

In the Everglades, native cattail quickly dominates wetland areas that have been nutrient enriched, outcompeting native sawgrass species that inhabit the area. This can seem detrimental, but cattails play a vital role in the ecosystem of the Everglades. The Everglades have a unique **ridge and slough system**[5] that makes it one of the most biologically diverse locations on the planet. One of the reasons that this system exists is due to the labile, or easy to breakdown, carbon content that exists in the cattails and the recalcitrant, resistant to breaking down, carbon that exists in sawgrass. After the growing season ends, cattails will die off and quickly break down while the sawgrass remains. This dichotomy between the two species is vital to the overall quality of Everglades ecosystem and the Everglades would not exist in its current state without the cattail species.

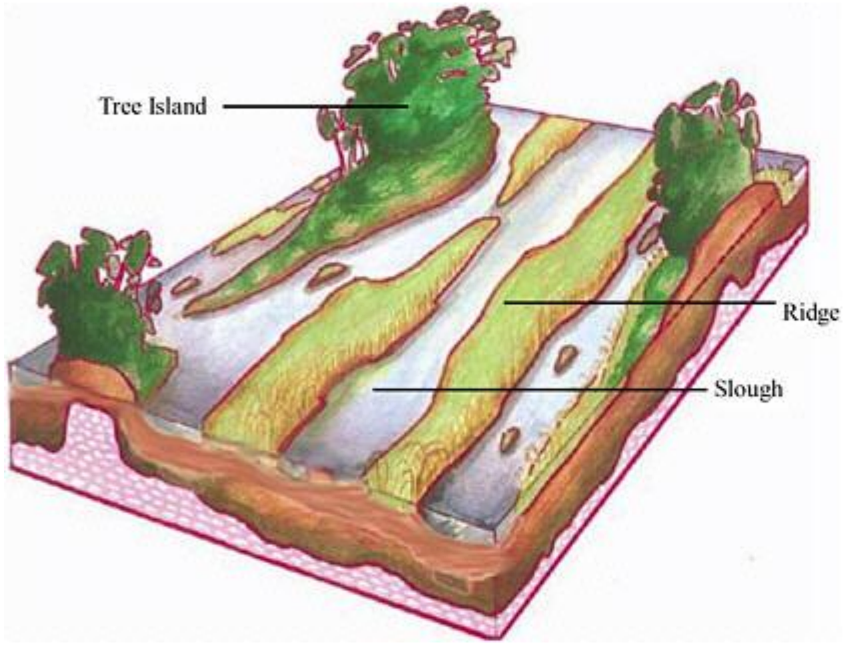


*Figure 2:National Academies of Sciences, Engineering, and Medicine. 2003. Does Water Flow Influence Everglades Landscape Patterns?. Washington, DC: The National Academies Press. https://doi.org/10.17226/10758.*

The everglades ridge and slough system isn't the only role that cattail plays in the ecosystem. In the northern everglades, managers plant cattails that remove nutrients from the water that would otherwise impair the sensitive Everglades habitats. The fast proliferation and spread of cattails make it a highly desired species for nutrient removal projects. For those same reason, it can quickly become a nuisance species and take over an ecosystem. In regions that managers want a diverse group of native species, cattails can tend to outcompete others, creating a degraded monoculture habitat. Consequently, managers and stakeholders must decide what will make the project a success and then determine if cattails will help or hamper their plans.

*Hydrilla*

Hydrilla are another invasive species that can provide benefits under certain conditions. Hydrilla have the capacity to grow and compete effectively with other aquatic macrophyte species, causing problems in lakes and waterways that highlight the highly invasive nature and threat that it has on native plants. After it outcompetes these native species, Hydrilla creates a monoculture mat in waterbodies that drives away vegetation and the native animals that rely on it. This species poses additional threats because of its resistance to herbicides that are used to control it (Evans and Wilkie, 2010). Furthermore, even if the stalks are removed, Hydrilla creates propagules that can survive in sediment for seven years, producing am outlet for regrowth and reinfestation in the area (Hofstra et al, 1999). For these reasons, ecological managers actively look to remove Hydrilla from the ecosystem. This does not mean Hydrilla is not useful in some circumstances. Hydrilla provide some benefits in the form of habitat for shellfish and increased water quality. The biggest benefit of this invasive species is its ability to take in nutrients.

Stormwater managers may seek to add hydrilla to their constructed wetlands because of its fast-growing nature and ability to take in toxic nutrient loads. Hydrilla is an invasive species that could become an integral part of reducing eutrophication and nutrient retention in a freshwater wetland system and is a contributing factor to why managers introduce this species into an ecosystem (Maroti, 2021).

## **Conclusions**

As climate changes and the global ecosystem reacts to it, land managers will have to continue to develop new ways to create historic habitat from the existing land. Sometimes that may mean destroying habitat for new creations, other times it may mean embracing the "new normal." It is crucial to remember that long term success of ecological restoration projects may be quite different from short term shortfalls. As we continue to understand the complexities of the natural system, we must build upon our earlier successes and failures to promote a high-quality environment.

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[3] an organism, plant, or animal, that currently lives in an area due to naturally occurring acts without any human involvement

[4] may be native or non-native and may cause ecological and economic harm.

[5] Broad, shallow flowing sloughs with slightly higher elevation hill-like ridges.

Summary

As the global temperature increases due to the long-lasting effects of climate change, ecological restoration projects will have to change with it. Future mitigation efforts for replacement, rehabilitation and enhancement projects will no longer be able to replicate the past landscapes, instead humans will have to create environments that suit a certain role whether that be for a social, ecological, or productive goal. Ecological management is difficult, with context and stakeholder dependent challenges that further complicate each project. For this reason, engineers will need to utilize special circumstances to rethink what constitutes restoration ecology and how can we provide a habitable and beneficial environment for all life on this planet.