ABSTRACT

Title of Thesis: ECO-HABITATS - USING ECOLOGICAL DESIGN FOR AMPHIBIAN AND REPTILE HABITATS ON GOLF COURSES: CASE STUDY AT LANGSTON GOLF COURSE, WASHINGTON, D.C.

Lotoia Simpson
Master of Landscape Architecture, 2019

Thesis Directed By: Dr. David Myers
Department of Plant Sciences
and Landscape Architecture

Habitat restoration is useful to address the loss of amphibian and reptile habitats in the built environment. Golf courses provide the opportunity to implement best management practices and best development practices features to improve habitats for amphibians and reptiles. In addition, golf courses, through creative programming offer opportunities to provide education about amphibians and reptiles. This research project focuses on the application of vernal pools and regenerative stream conveyance (RSC) interventions for Langston Golf Course, a historically designated golf course in Washington, D.C. In addition, the implementation of additional programming allows for educational opportunities about amphibians and reptiles for expanded variety of users beyond golfers.

ECO-HABITATS - USING ECOLOGICAL DESIGN FOR AMPHIBIAN AND REPTILE HABITATS ON GOLF COURSES: CASE STUDY AT LANGSTON GOLF COURSE, WASHINGTON, D.C.

By

Lotoia Odesscia Simpson

Thesis submitted to the Faculty of the Graduate School of the
University of Maryland, College Park, in partial fulfillment
of the requirements for the degree of
Master of Landscape Architecture
2019

Advisory Committee:
Dr. David Myers, Chair
Dr. Peter May
Dr. Joseph Roberts

Dedication

This thesis is dedicated to my two children, Jaydon and Sade. All children should be inspired by nature and investigate wildlife, instead of fearing it. Amphibians and reptiles are known as pest and poisonous or dangerous species, which kids tend to run from. Some amphibians and reptiles have poisonous traits, but most that live near our playing areas do not. I also wanted to find areas other than traditional playgrounds to have them explore and play and not worry about Wi-Fi connections in order to have fun. I also wanted to research the benefits that these species provide for humans and be more familiar with their traits or specifications to educate my children.

Acknowledgements

I would like to thank my thesis Chair, Dr. David Myers for helping me through this multifaceted thesis project. Without his knowledge, organizational inputs, and expertise in GIS, my presentation and thesis would not have worked out so well. I would also like to thank Dr. Peter May for his ecological knowledge and connections to the National Parks Service. This thesis's foundation and structure relied heavily on the history and connections of the National Parks Service. I appreciated his enthusiasm to explore as much as possible for the wildlife species that are a part of Langston Golf Course. I would also like to thank Dr. Joseph Roberts. His knowledge of current golf course trends and issues that may promote or work with my overall proposal was paramount to my thesis question being answered positively. All my committee members supported my goals for educating humans, while still being able to enjoy outdoor places that are not regularly utilized beyond the standard golf course programming. I really appreciate all the time spent and knowledge learned and hope to do more in the future in relation to advocating for amphibian and reptile species and creating additional landscape features on golf courses.

Table of Contents

List of Figures

Chapter 1: Introduction

This thesis explores how selected best management practices can be implemented on a golf course setting for the conservation and restoration of amphibian and reptile habitats. The loss of amphibian and reptile habitats, in particular for threatened and endangered species, is a national problem and the design and implementation of habitats in the built environment is critical for these species and their existence in the landscape.

This thesis explores the application of research on 1), the causes of amphibian and reptile loss, 2) best management practices (BMPs) and best development practices (BDPs), 3) current golf course environmental trends, and, 4) federal, state, and local efforts supporting biodiversity through habitat creation for amphibians and reptiles. The overall design goals for the Langston Golf Course, Washington, D.C. case study include: 1) the analysis, the guidelines for selecting location, and design of vernal pools in selected areas, 2) the design and integration of regenerative stream conveyance (RSC) on the golf course, and 3) exploration and creating interventions to provide educational opportunities about amphibians and reptiles for the users of the golf course, including proposed new users for the golf course.

The thesis is organized in five chapters. The first chapter introduces the purpose and organization of the thesis. The second chapter, the literature review, discusses the causes of amphibian and reptile loss, BMPs, BDPs and current golf course environmental trends that contribute to creating habitats for amphibians and reptiles. Federal, state and local efforts which promote amphibian and reptile habitats are also explored in Chapter 2. The third chapter discusses the context of the case study site, Langston Golf Course, the inventory of the site and a suitability model for locating proposed vernal pools. The fourth chapter documents the proposed master plan, design features and proposals, and educational programming. The final chapter is a summary and conclusion of the thesis.

Chapter 2: Literature Review

This chapter is organized into four sections. The first section discusses crucial ecological influences that support declines, due to human activities. Amphibians and reptiles natural habitats have been comprised by humans through fragmentation, roadways, and development. The second section discusses best management practices (BMPs) and best development practices (BDPs) for productive habitats for amphibians and reptiles. The third section recognizes precedent studies that implemented natural and environmental features on golf courses, due to cooperative partnerships with Audubon International and the United States Golf Association (USGA). The partnerships are undertaken in order to better manage golf courses and promote environmental stewardship. The final section discusses federal, state, and local regulations which address herpetofauna species.

Crucial Ecological Human Land Use Influences

This section discusses three crucial ecological human land use influences. The first section covers fragmentation. The second section discusses roads and their influence on wildlife species. The third and last section explores habitat issues as a result of development related to human infrastructure.

Fragmentation

Current and prior human land use activities affect the landscape by causing a lack of connectivity through ecosystems. Amphibians and reptiles are usually not considered relevant factors in the development and management of the built environment, so as a result these species are losing their habitats. Unfortunately, fragmentation affects the landscape by creating a lack of connectivity with ecosystems. In a case study Ramirez, et al. (2012) conducted at the edge of a single pond on the Hueston Woods State Park Golf Course in College Corner, Ohio, observers compared movement distance and patterns of frogs released close to the pond and the release of frogs on mowed grass to determine if habitat type and distance from a pond affected the movement of northern cricket frogs. The study suggested that habitat type influenced cricket frogs' deflection angle (movement toward or away from the pond), which may indicate how habitat influences colonization rates. The results revealed that frogs in un-mowed grass moved toward the pond, and frogs released in other habitats did the opposite. The study concluded that the movement of northern cricket frogs through green spaces like golf courses helped increase the distance they travel and improved their ability to orient toward a pond (Ramirez, et al. 2012). This study suggested that habitats that resemble natural habitats of cricket frogs may help create movement toward other suitable environments. Human activities like mowing suggest the opposite for these frogs. The lack of distance between suitable patches leads to isolation and possible extinction. Population isolation occurs when habitats change, as a result of degradation, fragmentation, or succession, and limits movements of individuals between populations (Rittenhouse, et.al. 2007). Usually efforts like translocation are implemented to help reverse the reduction of population. However, the success of relocation efforts often is species-specific and depends on ecological, social, and economic factors (Rittenhouse, et.al. 2007). Rittenhouse, et.al. (2007) found that Three-Toed Box Turtle's (*Terrapene carolina triunguis)* responses to translocation were compared to determine the movements of translocated and resident turtles of the same species. The study took place in Missouri at a fragmented site, the Prairie Fork Conservation Area in Callaway County, and a continuously forested site, the Thomas S. Baskett Wildlife Research and Education Center. The study resulted with adult Three-Toed Box Turtles (*Terrapene carolina triunguis)* translocating from a continuous forested area to a high fragmented area, and increased movement distances and home-range sizes compared to resident turtles. Rittenhouse, et.al, (2007) also noted a decrease in residence turtles, probably due to translocation turtle's increase of density to the site or competition with resident turtle mates, food, or other resources. In their hypothesis they stated, turtles accustomed to continuous forested habitat may increase movements in fragmented habitats as they search for non-fragmented forest. They tested for differences among translocated and resident turtles but did not find a difference in movement patterns or space use. Scientists are also making efforts through evolutionary lineage to conserve endangered species that have been impacted by fragmentation. Efforts to restore habitat are ongoing and a program for captive breeding and reintroduction has been set up by the San Diego Zoo Institute for Conservation Research (Schoville et.al. 2011). A case study in Southern

California explores the declines of two-endangered species of frogs (mountain yellow-legged frog; *Rana muscosa*) and True frogs (*Ranidae spp.*), due to human activity, fire, pollution, stream channelization, flooding, and invasive trout. The authors, Schoville et al. (2011) identified the crisis of amphibians being endangered worldwide. They used genetic conservation methods to restore species to habitats. They attempted to answer: 1) what are the levels of genetic variations in Southern California, 2) what are the genetic variations among populations at a local and regional scale, and, 3) what is the history of population divergence and gene flow in southern mountain yellow legged frogs. The study used sampling survey methods which were provided by the USGS in 2003-2009. Frog tissues and tail clips of tadpoles were also used in the experiment. The test results were considered less significant, since only adult frogs were found. Based on the observation of genetic structure and biogeographic history, the remaining populations of these species seven distinct populations had separate lineage within each of the nine mountain ranges tested. They suggest that efforts should be made to ensure the integrity of these lineages to maintain a workable gene pool.

Roads

Additional human activities are causing declines and extinction among these semi-aquatic species. For example, roads are a major problem in human infrastructure and they adversely influence the ecology of terrestrial and aquatic ecosystems through direct habitat loss, fragmentation and associated human impacts as a result of increased access (Wisdom, et al. 2000). Reptiles and amphibians, during migration periods, cross roads within landscapes, which leads to either their mortality or long-term population health declines, due to lack of connectivity. Conversion of natural habitats to impervious surfaces may result in altered hydrologic regimes (Ferguson, 1994). Roads impact terrestrial and aquatic habitats by also causing stormwater runoff that carry pollution into streams and other water resource areas. Efforts are already being made among public and private land managers in the United States and Canada to restore habitat connectivity and ecosystem processes through road removal. Road removal projects have been undertaken for several reasons including: to restrict access, increase hillslopes stability, minimize erosion, restore natural drainage patterns, protect endangered plants and wildlife and restore aquatic and wildlife habitat (Switalski, et.al. 2004). This involves ripping of roadbeds, and as result restoring stream crossings, and fully re-contouring hillslopes to allow infiltration and promote revegetation on degraded land. In addition, research experiments conducted to address road mortality (Langen et al., 2009) in the northeastern region of New York, involved surveys along the highway recording road-kill of herpetofauna classes of species. Throughout the rural northeastern United States and southeastern Canada, the herpetofauna community and landscape are similar to the regions of northeastern New York State that were surveyed (Langen et al. 2009). The study surveys took place from July 2002 to June 2007. The study results revealed that both classes of species experience road mortality and are spatially clustered, and road-kill hot spots of these classes of species overlap. Road-kill hot spots of reptiles and amphibians are associated with sites that have wetlands within 100 meters of the road (Langen et al. 2009). Configuration of wetlands within 100 meters of the road is a valid indicator of reptile and amphibian road mortality hot spots; roadkill is more likely to be present, and present in numbers, at causeways than at points with wetlands limited to one side of a road (Langen et. al. 2009). Their study did not involve testing of road mortality breeding for herpetofauna vernal pools habitats because, the time period of the survey was not around early spring which is the breeding period for certain herpetofauna who use vernal pools.

Development

Development is another way that human activities, such as infrastructure and buildings, interrupt amphibian and reptile richness. Urban and suburban development patterns have contributed to the elimination and degradation of both aquatic and terrestrial habitat. In Howard County Maryland, a habitat management plan (HMP), based in part by Howard County Green Neighborhoods Program guidelines proposal identifies critical impacts associated with these land uses (Biohabitats 2010). Planned residential development in Locust Chapel Woods has caused the Lower Patapsco River watershed aquatic and terrestrial habitats to experience degradation in many portions of the watershed. Development activities often lead to the creation of new wetlands, as a result of regulations intended to mitigate loss of natural wetlands (Calhoun, et.al. 2005). Newly created wetlands often lack structural diversity, microhabitats, and hydrology to support pool-breeding amphibians. Such wetlands can intercept amphibians as they disperse to breeding pools; eggs laid in these “decoy” wetlands often do not survive (Calhoun, et.al. 2005). With that being said, it is safe to say that development actions are also associated with fragmentation and successional changes in the landscape. Landscape separating populations can strongly influence the movement of individuals (dispersal and gene flow) among populations (Richardson 2012). Dispersal and gene flow are processes that ultimately influence the demography, evolution and long-term viability of populations (Richardson 2012). In a study conducted in an area of the Pawcatuck River watershed in southern Rhode Island, concerns from wildlife biologists for pond-breeding amphibians triggered the scientist to investigate the effects that human-dominated landscape habitats have on amphibians (Skidds et al., 2007). The wood frog (*Rana sylvatica*) and spotted salamander (*Ambystoma maculatum*) were used in the study because they shared common egg masses within a 3 to 4 week period after laying their eggs. The study’s results suggested that wood frogs had higher egg masses than spotted salamanders. It also showed that wood frogs experienced negative results with high canopy covers and buildings within 1 kilometers of residential development. Also, the wood frog had no association with shrub covers. The results were inconclusive with spotted salamanders for residential development for buildings within 1 kilometer of wetland, and showed no association to canopy, shrub, and non-woody plant cover. Many amphibian species are known to have meta-population spatial dynamics, so their populations and species richest characteristics tend to be negatively affected by human-altered habitats (Woodford, J., and M. Meyer. 2003).

According to a lake shore development study (Woodford, J., and M. Meyer. 2003) in northern Wisconsin, adult green frogs, *Rana clamitans melanota,* had higher abundance within a 100 meters measurement on undeveloped lakes than on developed lakes. The authors also analyzed adult abundance with a two-factor ANOVA technique, which referenced shoreline house density and suitable habitat factors, plus interactions between these two factors. The ANOVA analysis suggested that green frog abundance was affected by the amount of suitable habitat available, but not development density. However, house density along the lakeshore did significantly reduce the amount of suitable habitat (Woodford and Meyer, 2003). The study was conducted to determine if human- altered habitats in development is a key component in lake shore decline of amphibians. The Wisconsin Department of Natural Resources (WBNR) raised concerns about impacts on water quality and lakeshore dependent wildlife species (Woodford and Meyer, 2003). The authors, (Woodford and Meyer, 2003) suggested that housing or cottage density is not the key reasons for the declines but alterations to the habitat, such as human-caused riparian and littoral zone alterations. Development also causes numerous problems to amphibians after construction. For example, post-construction issues following development include: the attraction or introduction of amphibian predatory species, increase of pesticides, and light spillage.

<u>Best Management Practices and Best Development Practices</u>

The section second of the literature review discusses the need to educate and identify best management practices (BMPs) and best development practices (BDPs) to practitioners and residents in the community.

General BMPs and BDPS

Best management practices are sustainable strategies that support the built environment and the organisms that live in it. Many amphibians in the northeast region of the United States depend on vernal pools as their primary habitat. Vernal pool species include: frogs, salamanders, fairy shrimp, and newts. According to Thomas Biebighauser, author of "a guide to Creating Vernal Ponds," approximately one-half of all frogs and one-third of all salamander species rely on seasonal or temporary wetlands for development (Biebighauser 2002). Langston's vernal pool proposal aids in habitat creation that helps conserve and restore wildlife around the course. The site already has protected wetlands, so the addition of vernal pools adds to wildlife habitat areas. According to the U.S. Environmental Protection Agency (EPA) small areas of habitat which are connected by corridors typically receive greater wildlife use than isolated habitats. Additional habitat creation promotes biodiversity through site ecology and supports existing landscapes while linking corridors. Some BMPs are tailored for stormwater runoff, pond creation and restoration, and increased vegetation cover. These BMPs contribute to these species' survival and overall environmental resources for reptiles and amphibians. Best development practices are a critical part of these species' life too. BDPs are recommended strategies for conserving wildlife habitat value of seasonal forest pools and their adjacent terrestrial habitat (Calhoun, et.al. 2005). Most developers and users that develop and occupy areas with ponds lack education on how to maintain these habitats for themselves and the wildlife that live there. It is important that design and planning practitioners have a strong organized argument in their presentation to appeal to stake holders. Conservation biologists should therefore structure and explain their models in a way that addresses, or at least acknowledges, key assumptions and alternatives (Brier, et.al. 2008). Implementation of BDPs allows citizens to identify wetland types and save specific threatened species in their communities. Knowledge of current ecological regulations for buffers is critical to gain advocacy to improve regulations. For example, typical buffers around wetlands range from 15 to 30.5 meters to adjacent terrestrial area, which isn't sufficient for pool-breeding amphibian life cycles (Burke, V., and J. Gibbons. 1995). Regulatory strategies that focus on protecting only the breeding pools will most likely fail to maintain healthy amphibian populations, protection of critical terrestrial habitat must also be a priority. In northeastern regions of North America, protection, restoration, and creation of vernal pools are a core strategy for helping breeding habitats for amphibians. Vernal pools are also known as temporary ponds, woodland vernal pools, seasonal forest pools, small ponds and ephemeral wetlands, which allow pool breeding habitat creatures to adapt or live in temporary water. Creation of vernal pools is different from restoration because, creation involves a compensatory mitigation requirement then removal of an existing natural vernal pool, or as a proactive program to increase biodiversity by building new vernal pools. Vernal pool restoration is an attempt to return a pool from altered or degraded condition to a pre-existing condition. It is important to also classify vernal pools as being free of permanent fish populations. While replacing a hectare of natural wetland with a hectare of created wetland may result in no net loss of wetland area, there is likely to be a net loss of ecological functioning. As a result, the Environmental Protection Agency (EPA) created the “Mitigation Rule in 2008. Under most circumstances, U.S. federal and some state wetland regulations require that both area and functional impacts to vernal pools be mitigated (Calhoun, et.al 2014). Due to the hydrological characteristic of vernal pools being a seasonal water source for wetland ecosystems, they are very difficult to create and restore. Some practitioners seeking guidance on how to construct these vernal pools share misleading advice that they are easy to construct. Some manuals for vernal pool creation suggest creating pools is easy yet peer-reviewed papers to date report generally poor or ambiguous results in terms of providing breeding habitat to vernal pool-associated amphibians (Calhoun et. al., 2014). Therefore, proving functionality must be part of the construction and design process and post-construction process. Even though the authors (Calhoun et. al., 2005) stated their literature summary is not intended to be a “how to” manual for vernal pool creations, their recommendations are critical sources for validation for practitioners. Vasconcelos and Calhoun (2006) define successful vernal pool creation as a successful reproduction and metamorphosis by key indicator species such as wood frogs and mole salamanders for five or more years of monitoring periods. Hydrological factors to consider for amphibians include: pollution, fish, pool surface area, canopy cover, volume, depth, and connection to groundwater. Canopy cover is essential to avoid drying of the pool within in a particular season. Also, amphibian diseases are likely to occur in permanent versus seasonal wetlands. Being aware of specific species egg mass and nursey schedules plays a critical role in watering and drying periods. Vernal pools may be developed in multiple hydro-geomorphic settings: riparian areas, surface water depressions, and groundwater depressions in low-lying areas, which all depend on the hydroperiods. "Hydroperiod regimes, e.g., percentage of time a site is inundated, exert critical control in the creation of niches for different plant species in wetlands" (PNAS 2012). Water chemistry and temperature will affect rates of embryo and larval development in pools (Newman 1998). Plant species are an intricate part of designing a vernal pool because they help supply shade, refuge, and possible egg attachment locations. Vascular plants are the ideal match but not all pools have them, so surrounding landscape should incorporate coarse woody materials and shrubs. Invasive weed like plants like cattail (*Typha latifolia*), common reed (*Phragmites australis*), purple loosestrife (*Lythrum salicaria*), and duckweed (*Lemna)* are common in vernal pools, but controlling their colonization is important to avoid fill-in or dried out pools. Recent studies have indicated that some native amphibians respond more to plant traits than to whether or not plants are native (Martin and Blossey 2013). Reed canary grass (*Phalaris arundinacea*) is one of the most widespread, and well-studied, introduced plants

(Holzer and Lawler 2015). Holzer and Lawler (2015) completed a case study in Portland, Oregon and the University of California, Davis. The study revealed positive benefits for invasive vegetation within amphibian habitats. They explored four questions concerning native amphibians' relationship with reed canary grass: 1) how are native amphibians associated with reed canary grass cover in field surveys? 2) Do adult amphibians have a preference for or against reed canary grass for breeding? 3) Is tadpole performance affected by the presence of reed canary grass? 4) What mechanisms underlie preference and performance results? The study areas were performed near the city edge and adjacent to mixed suburban development and upland. Ponds used in the experiments were isolated ponds and mesocosm tanks for recording egg masses or larvae, and native species. Natural water bodies and wetlands were used to deposit species after recording and counting. Testing and surveying was conducted through May 2010 to July 2013. Both sites used an outdoor study called the mesocosm experiment to separate and distance animal and plant species. The Pacific chorus frog (*Pseudacris regilla*), was selected as the focal species because it is most common in this area. They conducted two experiments, first quantifying adult amphibian preference for breeding sites, and the second experiment assessed the survival of eggs and tadpoles. The four native amphibians used in the study included: Pacific chorus frog (*Pseudacris regilla*), northern red-legged frog (*Rana aurora*), long-toed salamander (*Ambystoma macrodactylum*), and northern salamander (*Ambystoma gracile*). The native and introduced plants used in the study included: Harstem bulrush (*Scirpus acutus*) (native), Baltic rush (*Juncus balticus*) (native), narrow leaf cattail (*Typha angustifolia*) (native) and the reed canary grass (*Phalaris arundinacea)* (introduced). Native amphibian associated with reed canary grass cover in field surveys results had a positive correlation after larvae grouping with the plant. The frogs showed non-significant changes when compared to other aquatic plants, but salamanders had positive abundance. As for the results, for adult amphibians having a preference for or against reed canary grass for breeding, they discovered on average about five times more males calling in reed canary grass than in other native vegetation ponds. It also showed six times as many egg masses in reed canary grass than other ponds. The grasses association with tadpole performance revealed that more than half of all tadpoles that survived were in reed canary grass. The Pacific chorus frogs showed more breeding activity and greater tadpole survival in mesocosms tanks with invasive grass compared with other common aquatic plants. As a result of the study, the authors feel that plant morphology was important to species habitat selection. Reed canary grass thin stems and leaves (<5 mm wide) served as intricate branching structure above and below the waterline for male frogs standing position. The stems and leaves also help with egg masses for ideal oviposition by easily attaching as opposed to the other plants, which are limited to debris attachment. Holzer and Lawler (2015) could not determine the mechanism for higher tadpole survival in reed canary grass, but results indicated it was not due to factors including: water quality, food availability, or differences in predator communities. Water quality measures were well within the tolerance of most frogs. Food availability did not differ among treatment tanks and plenty of nutrients were available. Increased predatory species did not differ between tanks. However, the authors did note that it was more difficult to detect tadpoles in reed canary grass, due to its dense characteristic. Predators may have also had greater difficulty detecting tadpoles.

Canopy cover is also important in vegetation implementation of BMPs and BDPs. The lack of canopy cover is vital to avoid drying of pools, rise in temperature, refuge from predators, and algae buildup due to limited light infiltration. Limiting removal of adjacent trees and root damage during construction will preserve canopy cover and reduce soil compaction, which helps to facilitate colonization by herbaceous plants and trees (Calhoun, et.al. 2014). Another complicated part of creating vernal pools is determining slope parameters. Studies indicate that steep or abrupt slopes may limit the growth of vegetation (Simon et al. 2009; Shulse et al. 2012) or the rate of melting ice cover in northern climates. Created vernal pools that do not mimic the slope of natural pools may be less suitable for amphibian recruitment (Porej and Hetherington 2005; Croshaw and Scott 2006). Unfortunately, slopes vary for each pool because winter and fall rain, and water levels cause sensitivity to some amphibians. Soil deposits depend primarily on the particular hydro-period. The authors advise to recycle the soils and mimic the hydro-geomorphic setting as close as possible to the natural wetland for a successful pool. Soil compaction success depends on if the soil has sufficient clay to hold water within the hydro-period. After pools are created it is important to take in consideration some additional information about landscape setting and pool context. It is generally accepted that the area within 300 meters of a breeding pool is core foraging and migration habitat for most adult pool-breeding species (Rittenhouse, et.al. 2007; Harper et al. 2008), but this area can exceed 1,000 meters (e.g., Humphries and Sisson 2012). A case study in western France attempted to mimic the original ponds with depth, size, soil, and some vegetation to see if recovery of anuran species communities after construction is feasible. They recorded species in the old ponds and compared it to the species in the new ponds. The results of the 4year study had a loss of one anuran (*Aylets obstetrician*) Midwife toad, which was rare in the original pond. The new ponds recovered the (*Pelodytes punctutus*) Parsley frog also known as the spadefoot frog. The authors concluded that the study did show that the ponds worked for some anuran species like the tree frogs and a couple other frogs, but would show more improvement with time, due to the breeding time and adult frogs' presence. Also, temporal fluctuations in the restorative ponds maybe based on nutrition and habitat surroundings associated with vegetation implementation and square footage. It was suggested by Calhoun, et.al. (2005), a positive method to protect a wide diversity of pool-breeding invertebrates and amphibians is to include pools that target land uses on public land, not-for-profit lands, or in large tracts of relatively undistributed private ownership for best development practice conservation efforts.

Studies Involving Golf Courses

Most golf courses in urban areas are privately managed lands that are usually owned by local clubs. Golf courses are classified as green spaces that need management to control interactions among humans and wildlife. Golf course organizations like, Audubon International's Cooperative Sanctuary Program for Golf Courses, help golf courses manage their natural areas in ways that benefit wildlife. Golf course landscapes were tested in Columbia, Missouri to test the effect and benefits courses have on wildlife. They tested how biodiversity can be affected through testing exotic species like bullfrog, and human negative influences such as chemicals to native amphibians of the United States such as, spotted salamanders (*Ambystoma masculatum),* southern leopard tadpoles (*Lithobates sphenocephalus*), and American toad (*Anaxyrus americanus*). They used two control reference ponds and two golf course ponds. The results showed that the bullfrogs effected the survival for all native species. It was concluded, they serve as competitor species for nutrient sources. The results revealed that golf courses were better for the native species than controlled reference ponds. They believe this can be based on more opportunities to escape invertebrate species, which prey on these amphibians. As for the chemical affects, they really couldn't say much from the test because none were detected in high enough levels to show a negative effect. Also, amphibians are less sensitive to pesticides and fertilizers than invertebrates, which may explain why survival in golf courses was better than controlled reference ponds. The invertebrates probably didn't get to complete their full larva cycle, due to contamination. The results revealed that golf courses with vernal ponds would be a better way to manage the survival of native species preventing the bullfrog and other predators such as fish and invertebrates to prey on them. Golf courses are also classified as recreational land in suburban areas. Golf courses can be both naturalistic and centered around residential development. The demands for golf course recreational use were high in urban populations. The number of golf courses was likely to increase in the years to come, with a current estimate of over 31,500 courses worldwide (Tanner and Gange 2005). Unfortunately, many courses closed in 2009 following economic declines. Currently the number of course closures is slowing down. Furthermore, in suburban areas the total area dedicated to golf courses may exceed most nature reserves in overall size (Colding et al. 2009). Several recent investigations have indicated that golf courses and their aquatic habitats support diverse animal populations including amphibians (Colding and Folke 2009). These studies suggest that golf courses may provide a refuge for many semi-aquatic species in suburban environments. Reptiles such as turtles are semi-aquatic species that live in suburban environments. A study in Charlotte, North Carolina wanted to assess ponds on golf courses as semi-aquatic turtle habitat and compared turtle population with golf courses, residential and rural ponds. They decided to study the Charlotte metro area in North Carolina, due to the region showing a large growth of land cover of residential, agriculture, pasture land, and second-forest land, within the last 40 years. They tested two species that showed the highest abundance in the area. The two-turtle species observed were the painted (*Chrysemys picta)* and slider turtles *(Trachemys).* The experiment tested female and male abundance as well and air temperature and pond areas. Testing methods involved using hoop-net traps baited with sardines in shallow water around the perimeter of the pond. The results revealed that male and female painted turtles were equally abundant in golf courses and farm land, and negatively affected in residential development areas. The results also revealed female slider turtle's abundance was higher in farm land than golf courses and still reflected negatively in residential development. After the result, the authors concluded that golf course and farm land share the same characteristics with the exception of some golf courses being developed near residential development. This exception seems to explain why possible migration of the female slider turtle is lower at golf courses. Also, golf courses having roads nearby increase the mortality of the female during migration periods. Even though the authors identified the benefits for semiaquatic amphibian habitats on golf courses they suggest the need for more naturalistic golf course ponds. Another study in Stockholm, Sweden examined the potential of recreation land use of golf courses in natural conservation with a focus on wetland fauna. The study was in Stockholm, Sweden because, the location prohibits the use of chemical applications in the management of parklands for public access, with the exception of treatment of invasive vegetation, and completely avoided in nature-protected areas. They compared land uses on permanent ponds and off-course ponds. The study revealed that golf courses are highly suitable habitats for two internationally red-listed species (great crested newt and large white-faced darter dragonfly). As for anuran species only one pond detected the common toad and moor frog, which lacked the great crested newt, and no anurans were found in ponds which great crested newt occurred. The use of pesticides did not seem to negatively affect any of the organisms examined. The authors felt this could be contributed to possibly random selection of sites as insecticides have been known to increase food resources for amphibians by reducing competition among aquatic insects and reduction of insect predators that consume amphibian eggs. “In addition to open water areas in ponds, removal of vegetation allows for continuous uptake of phosphorus and nitrogen by fast-growing plants such as cattail (Typha spp.) and the common reed (Phragmites australis), which were frequent in the ponds of this study. This practice contributes to nutrient retention because plant material is continuously harvested and removed, lowering eutrophication, which is considered to be one of the major impairments of small standing water bodies, with associated negative effects on amphibian (Coldin et. al., 2009). Eutrophication is the process by which a body of water becomes enriched in dissolved nutrients (such as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen. The authors suggest that golf courses with ample wetlands on them can significantly contribute to wetland fauna support. It is apparent that golf courses help support habitat efforts for amphibian and reptiles. However, designing these green spaces should include guidelines for best practice strategies like being cautious about hydroperiods, exclusion of fish, and non-native species with the exception of reed grass.

<u>Audubon Cooperative Sanctuary Program (ACPS), and Precedent Examples</u>

This portion of the thesis will discuss how the United States Golf Association and Audubon programs have developed resources beyond golf to manage environmentally suitable and natural habitats for wildlife. Audubon International and the United States Golf Association (USGA) partnered together to promote ecologically sound land management and conservation of natural resources. The partnership is called, the Audubon Cooperative Sanctuary Program (ACSP). The Audubon Cooperative Sanctuary Program started in 1991 and constitutes positive impacts beyond golf and helps benefit communities through partnering with organizations and businesses to protect the environment. The program is designed to have golf courses work toward certificates to be publicly recognized in six categories. Audubon International (2019) is not affiliated with the National Audubon Society. ACSP is completely independent, separately incorporated, and guided by their own board of directors. The ACSP offers one-on-one assistance to make sure the program is easily fulfilled. Audubon International refers to this approach as the "plan-to-check-act." For golf courses to gain public recognition and be certified through the Audubon Sanctuary Program, they are required to complete six categories of environmental stewardship: 1) environmental planning, 2) wildlife and habitat management, 3) outreach and education, 4) chemical use reduction and safety, 5) water quality management, and 6) water conservation. The first category allows each golf club to generate a written plan, which outlines their goals and proposed projects. This helps the golf course keep track of their progress. The following category emphasizes providing proper habitat for wildlife in non-play areas of the golf course. It reinforces management to consider the importance of wildlife habitat locations, size layout, and type of property. The third category, outreach and education focus on educating golfers about environmental programs. Generating public interest of environmental well-being will keep the program in force. Category four finds safe and better ways to reduce chemical usage of pesticides and fertilizers to relieve environmental issues that relates to humans and wildlife. The fifth category of the program monitors water quality impact in relation to chemicals in lakes, streams, and groundwater. This category also protects wetlands, reduces erosion, filters runoff, and in some cases improves the related water quality issue. The final category, water conservation pays close attention to reducing and reusing water resources. It places emphasis on better maintenance practices, and turfgrass selection. According to Dodson (2002), The Audubon Cooperative Sanctuary Program for Golf Courses ACSP increased wildlife habitat on golf courses by 22 acres on average with in the first two years the program was introduced. Each golf course averaging 45 acres increased wildlife habitat areas to 67 acres. Environmental features like wetlands challenged the game of golf through water hazard zones and at the same time created biodiversity. Within the first fiscal year, the program grew from 27 to 36 golf courses, and 15 of the courses were in the United States and Portugal. The statistics came from 2,094 golf courses (US states, Portugal, Canada, and Puerto Rico). These results were achieved without a loss in playing quality and golfer satisfaction. The

EPA (2013) noted the Audubon Sanctuary Program in their efforts to find common ground between the golf industry and the environmentalist since 1995.

Charlotte Country Club, Charlotte, NC

As a result of the Audubon Cooperative sanctuary Program, Charlotte Country Club, Charlotte, NC gained environmental recognition and saved on cost and maintenance on their golf. The club planned and monitored their course for a three year window of success. The program helps the course save approximately two thousand dollars annually. The annual saving for implementing native grasses was $1,250. The course switched to two methods to help save and aid the environment through turfgrass maintenance. They hand seeded with native plants: fine fescue (*Festuca*), little bluestem (*Schizachyrium Scoparium*), sideoats grama (*Bouteloua curtipendula*), and blue grama (*Bouteloua Gracilis*). The golf course also, used different herbicides. The challenge faced by the golf course to transform ecologically was the constant need to keep pedestrian and vehicle traffic on the course to a minimum for the first three years. In the three years the course benefited by reduced economical cost, and environmental sustainability of native grasses.

Widow's Walk Golf Course

In 2002, Widow's Walk Golf Course (2009) is located in Scituate, Massachusetts and became a Certified Audubon Cooperative Sanctuary course. It was publicly recognized for its stewardship in wildlife habitats, and environmentally sustainable management. Widow's Walk Golf Course was transformed from a landfill or dumping ground to a golf course. It was an abandoned gravel quarry that was minded out and became an illegal dumping ground. The communities in Scituate, Massachusetts are prominent bird lovers. The pollution on the site caused many birds to lose their home, but the golf course was able to reverse the damage for birds, and other wildlife, and trees that were destroyed. The 120 acre course turfgrass initiative only uses 30 acres of irrigated turf. The course reduced fifty percent of their usage of fertilizer, pesticides, and water. They are also, monitoring their putting green through a native soil technique, "push up technique", and other putting green construction techniques to find out, which as the fewest inputs of water, fertilizer and pesticides. Also, developers selected drought and disease resistant grasses. Widow's Walk has added avian nesting boxes, and as attracted 75 different species of migratory birds to the course. This site continues to educate the golfers and all users of the site through education guidebooks with information on wildlife in the pro-shop. The guidebook also produces a dollar for each sale of a book.

Golf Course Bunkers

The construction of sand traps on golf courses is a challenging feature that golfers appreciate. Even though this feature may bring exciting competition to golfers, it is a maintenance issue, when the weather brings excessive rain falls. In recent years, golf course managers are implementing a technique known as the "Better Billy Bunker" method (2019). The method involves using a patented geo-synthetic bunker edge system called the Durabunker with two inches of gravel of which will later cover and protect the sand trap to relieve maintenance issues and save cost on golf courses. The product was adopted on 4 continents and was built at PGA, LPGA and Ryder Cup Venues. It protects the edge of the bunker. The entire process includes eight steps: 1) excavate the and remove the turf from the perimeter of sand trap, 2) shaping the perimeter, 3) add two placing cuts on dura-turf concaved or convex, 4) install tile, 5) re-install turf, 6) two inches of a gravel layer is placed across entire bunker, 7) BBB polymer application which is done by certified installers, and, the edge should remain clean, and is cured in 24 hours, and 8) the final step is to enjoy your sealed system.

Federal, State, and Local Regulation Efforts

The final section of the literature review will discuss how federal, state, and local efforts to support amphibian and reptile habitats are working towards helping these species.

Federal Efforts

Federal and state efforts primary goals focused towards wetland policy requirements: 1. Preservation of stable flood zones; 2. Maintenance of water filtration processes; 3. Conservation of the diverse and unique species assemblages associated with wetland habitats (Salvasen 1990). Unfortunately, little to no protection has been regulated by both federal and state authorities for seasonal pools, and other small wetlands. Despite vernal pools being part of the forested landscape and significant to biodiversity conservation, federal protection laws are lacking, and only 6 states (Indiana, Ohio, Tennessee, Virginia, Washington, and Wisconsin) explicitly regulate activities in hydrologically isolated wetlands (Denton and Richter 2013). The reason for many federal regulations excluding isolated wetlands is because the hydrological land setting of an isolated wetland has no link to interstate commerce water systems, which would be a violation of the federal Clean Water Act, (CWA). The U.S. Supreme Court decision, known as the "SWANCC decision" (Solid Waste Agency of Northern Cook County v. United States Army Corps of Engineers et al., 531 U.S. 159), excluded many isolated wetlands from federal regulation. According to the Department of Ecology of Washington State the wording of navigable water violates the federal CWA, so the high court ruled that federal protection extends to wetlands located on or adjacent to navigable "waters of the U.S." or their tributary systems. Today the regulation requires applicants and consultants to coordinate all projects affecting potential isolated wetlands with the Army Corps of Engineers and receive a written jurisdictional determination. Consultants can provide information to state agencies including ecology, but the final determination must be made by the Corps.

State and Local Efforts

Wetland conservation efforts only include two options: land use regulation and preservation, but Calhoun, et.al. (2005) proposed a third pathway which involves local land-use planning. States in the northeast region of the United States have wetland protection statutes that regulate human activities in jurisdictional wetlands at a level equal to, or more stringent than, federal regulations (Calhoun et al., 2005). They suggested that preservation efforts should be applied wherever high-quality pools exist because preservation can be more successful than regulations. They suggest incorporating state preservation plans with local land use planning efforts in a voluntary manner. Sprawl and poorly planned land development also effects habitat loss and threatens biodiversity. Many of the decisions related to sprawl are made at local levels by town planners, planning and zoning board members, and others who lack knowledge of basic ecological principals and site-specific natural resources (Calhoun, et.al. 2005). Local governments are often unable to plan proactively for pool conservation as they lack the necessary data. The development of vernal pool conservation plans is proving to be more successful at the local level (Oscarson and Calhoun 2007). Citizens are often motivated to become involved at the local level because today many local governments play a lead role in land use. Oscarson and Calhoun proposed translating BDPs practices also called “best available sciences” according to Calhoun and Oscarson. BDPs translated to citizens help identify the function of vernal pools and other habitats and identify negative alterations activities caused by post construction. The guidelines for BDPs include: 1) identifying seasonal pool resources, 2) ranking pools according to their ecological value, and 3) developing management procedures that correspond to the ranking protocol. They also include additional information on pool by pool basis according to various landscape scales. The strategies Oscarson and Calhoun (2007) propose for BDPs of local conservatory pools include: 1) mapping and inventory of pools, 2) ecological assessment of pools, and 3) development of conservation plans. Local mapping plans will allow decision-makers, developers, and citizens to understand which sites have significant importance to community resources. Oscarson and Calhoun (2007) recognize that it is not economically or politically practical for local governance to protect every pool, so prioritization to determine each pool's regional or local importance will need to be established. They suggest concentrating on pools that have low or undeveloped adjacent terrestrial habitat and ecological significance in either size or hydroperiod. Trained volunteers, town officials, or professional biologist can collect biological data to make this feasible. In local efforts for BDPs several case studies in the northeastern region of the United States were coordinated by the University of Maine (UME). UME, partnered with environmental, non-governmental organizations (ENGOs) to facilitate project logistics and planning activities. The northeastern states included: Connecticut, Maine, Massachusetts, Rhode Island, and New York. In Connecticut the ENGOs include: Farmington River Watershed Association (FRWA), a local non-profit organization, and the Metropolitan Conservation Alliance (MCA), a program of the Wildlife Conservation Society (WCS). As the project coordinators, UME established volunteer recruitment and training through town coordinators. Project coordinators were successful in recruiting citizen-scientist by contacting naturalists, and ecologists, educators, and other active members of the community. The BMPs and *(*BDPs) in municipality's guidelines help land use planning and the identification of existing vernal pool conservation efforts (Calhoun, et.al. 2005). The guidelines help address the need of local data collection for amphibians. Citizen-scientist can be trained to collect ecological data. Program methods used to help citizen-scientist establish BDPs involving: 1) mapping and inventory of the pool resources, 2) recruitment and training, 3) data collection using citizen-scientist, 4) ecological assessment of inventoried vernal pools, and 5) use of the study results for implementing vernal pool protection plans. Calhoun et.al. (2005) believe the citizen-scientist are a good approach for BDPs because, local communities shape themselves. The method results show some misidentification from citizens of wetland pools, but very similar to the inconsistencies of biologist. Most pools had at least 50 percent of the land undeveloped up to 230 meters from the pool edge. Calhoun et.al. (2005) stated that they cannot provide a set formula for effective conservation efforts in any given community but can provide a successful example that supports the process of the citizen-scientist. Additional local urban efforts have been made addressing awareness of habitat among human, amphibian and reptile communities. For example, Davidson College in North Carolina wants to bring awareness to undergraduate studies to get involved as early as possible in research efforts. Involvement of undergraduates in meaningful research, especially early in their undergraduate careers, greatly increases the probability that they will attend graduate school and eventually become successful scientists (Nagda et. al. 1998). They described how urbanized environments offer undergraduate student's unique opportunities for the development of research to conservation initiatives that focus on urbanized environments and amphibian and reptile habitats. The study area is Davidson College, which is in the Charlotte-Metro Area in Mecklenburg County, NC. The Charlotte-Metro area has experienced rapid urban development within the last decade and is expected to continually increase. The area has a rich diversity of amphibians and reptiles and is experiencing rapid urbanization. They feel that urban environments are ideal settings to help develop research-based projects that focus on reptiles and amphibian populations for undergraduates. They discussed strategies that will aid in the success of undergraduate research: 1) using technology to facilitate research, 2) focusing on ecosystems in which students have previous classwork (i.e., biology), 3) establishing long-term projects, 4) collaborating outside organizations, and 5) involving the community in our research program. Many undergraduate students are computer literate and are able to adapt quickly to landscape related technology such as geographic information systems (GIS). They found that undergraduate students were able to analyze the consequences of landscape disturbances with amphibian and reptiles using GIS. Undergraduate students also, used radio telemetry, global positioning systems (GPS), and other technologies in their field projects of herpetological habitats. These site studies integrate the study of biology, aquatic ecosystems, impervious site areas (parking lots), and wetland and pond systems. Establishing long-term project goals allow students to complete projects in a short period of time and use collected data for former and future students. Davidson College established the Davidson College Ecological Preserve (DCEP) in 2001 to provide a large, protected area for multiple long-term projects for amphibian and reptile lessons. Davidson College's collaborations involved undergraduate students with other organizations. Students collaborate with: 1) faculty and students from other colleges, 2) government organizations, and 3) private companies and institutions. Collaborations not only benefit students, but the outside inter-organizational collaborators too. The students conducted research on certain properties, such as conservatories provides, which provides the college information to on land stewardship. DCHL community involvement allows students to be involved on conservation -based research through outreach within their community. Davison College established two programs to motivate students to be involved public conservatory-based amphibian and reptile research. The two DCHL community Programs include: 1) Catawba River Corridor Cover Board Program, and 2) Box Turtle mark-recapture program. The author said it is a challenge for undergraduate versus graduate students to conduct research primarily because of lack of research experience. Additional challenges for undergraduate students are only having a short period of time to research. However, they found that meaningful projects can be developed within the constraints posed by an undergraduate-based research program and that some undergraduate students can produce work that rivals typical research conducted by graduate students (Dorcas and Price 2008).   The author concluded, although they were focused on the strategies and accomplishments of the Davidson College Herpetology Laboratory (DCHL), achievements have been achieved at other primarily undergraduate institutions. For example, the herpetology program at Stetson University in Florida serves as an outstanding example of a laboratory that has provided opportunities for many undergraduate students to become involved in research, since mid-1990s (Dorcas and Price 2008). Harding University in Arkansas also, was able to complete research projects, due to collaborations by undergraduate students. Herpetological research can provide opportunities for undergraduate students and give constructive context to the study of herpetology. Other local efforts have been made through biologists. Krajick (2005) wrote about, Michael Klemens, a biologist advocate, whose goal was to shape plans down to the smallest details to fit a site's biology. Klemens argues that developers are focused on converting large lots to accommodate suburbia living that infringe exurbia habitats of biodiversity for animals and plants. Klemens is also the head of the Metropolitan Conservation Alliance (MCA) in Rye, New York. He speaks about, how developers should use the cluster planning system, so they don't interrupt habitats. Klemens recommends conservation easements and outright purchasing of open spaces by government or non-profits as one method. Most suburban areas use a lot of land because they are rich not because they need it, which as a result spreads out lots. Klemens is proposing in his plan to connect locally because ultimately the people in the neighborhood are the decision makers but they are not aware of it. The people usually don't speak because they are ignorant about biology and the environment. His work includes: five Hudson River Valley towns to incorporate the Croton-to–Highlands Biodiversity Plan, working towards a master plan for conservation habitats mapped by MCA (Krajick 2005). In December, other towns formed a similar coalition, which targeted specifics species of local concern to steer development through mutual agreement to upgrade local environmental laws in concert with one another to pass uniform zoning regulations (Krajick 2005). Klemens wants each town or coalition to adopt its own local rare, threatened, and endangered species list. He is working with Robinson and Col, a powerful Connecticut law firm that helps big developers navigate their way through permitting processes. He convinced them to reconfigure the homes into two tight clusters, saving space by building duplexes and leaving 60 percent of the site open. The law firm realizes that his plan for taking out curbing in places where amphibians are likely to migrate and handling water drainage with grassy, graded swales, not plugging drains is cost saving because, “some of these things don’t even cost anymore” (Krajick 2005). Krajick agrees with Klemens pointing out on compact development, which states traditional neighborhood design should provide a mixture of housing types for a broad diversity of people and recreate old neighborhoods of yesterday with people who are less auto-dependent and have a greater connection to where they live. These case studies and reviews help illustrate how advocacy through science help local citizens build their community the way they chose to and save amphibian and reptile habitats as well.

A rapid increase in residential development in urban, suburban neighborhoods interrupts breeding, and migration life cycles that can lead to a steady decline and extinction of these species. Sustainable techniques have been tested and researched in field studies, which are intended to revitalize amphibian and reptile habitats. Amphibian and reptile conservation and restoration planning requires practitioners and town coordinators to concentrate on hydroperiods, hydro-geomorphology, vegetation selection, soil compaction, and slope parameters. It also recommends being careful in design implementations by not introducing fish and other predatory wildlife such as macroinvertebrates. Additional considerations are accessed through a pool by pool basis. Herpetological ecology advocacy is essential to conserve and restore amphibian and reptile habitats in rapidly growing urbanized communities. Federal and State efforts are limited by regulations associated with the Solid Waste Agency of Northern Cook County (SWANCC) and federal Clean Water Act (CWA), so local recruitment and training is needed.

A case study in Carolina Bay wanted to determine if the required federal and state conservation laws were truly effective. The study area was a wetland located at the U.S Department of Energy's Savannah River in West-Central South Carolina. The authors (Burke and Gibbons 1995) decided to use freshwater turtles, since their life cycle takes place in wetland and upland habitats. They compared turtles in protected wetlands and outside the delineation areas with a buffer range of 30.5 meters. The test results revealed an additional 275 meter of buffer is needed because freshwater turtles need more aquatic space to protect the turtles during nesting. The results suggest that conservation efforts can be better if required legislation mandate large, buffer zones around wetlands. The authors argue that preservation efforts should be applied wherever high-quality pools exist because preservation can be more successful than regulations. They also, suggest incorporating state preservation plans with local land use planning efforts in a voluntary manner. The author proposed translating BDPS also called "best available sciences" to citizens by identifying the function of vernal pools and other habitats then identify negative alterations activities. Their guidelines include: 1) identifying seasonal pool resources, 2) ranking pools according to their ecological value, and, 3) developing management procedures that correspond to the ranking protocol. They also include additional information on pool by pool basis according to various landscape scales. Their strategies for BDPs for local conservation of pools include: 1) mapping and inventory of pools, 2) ecological assessment of pools, and 3) development of conservation plans. Local mapping plans will allow decision-makers, developers, and citizens to understand which sites have significant importance to community resources. The study recognized that it is not economically or politically feasible for local governance to protect every pool, so prioritization to determine each pool's regional or local importance will need to be established. They suggest concentrating on pools that have low or undeveloped adjacent terrestrial habitat and ecological significance in either size or hydroperiod. Trained volunteers, town officials, or professional biologist can collect biological data to make this feasible. The authors concluded stating the citizen-scientist approach is a good approach for BDPs because local communities shape themselves. The author also, stated that they cannot provide a set formula for effective conservation efforts in any given community, but can provide a successful example that supports the process of the citizen-scientist. Additional local urban efforts have been made to address aware of habitat among humans and amphibian and reptile communities.

Literature Review Conclusion

In conclusion, all of these studies validate the role of conserving and restoring amphibian and reptile habitats, among our built infrastructure and it should be viewed has ecologically sound because, these creatures deserve to live and grow in healthy sustainable environments among us. Human activities have degraded amphibian habitat by fragmentation, roadways, and development on or adjacent to urban edges. The introduction of streets, roads, curbs, and highways are human intrusions that have caused amphibian and reptile mortality to rise and sometimes rapid declines and extinction. Roads and other human access areas are key contributors to these species losing their natural resources and the introduction of harmful factors within their habitat. Sustainable practices like best management practices and BDPs provide landscape architectures and other interdisciplinary fields with sustainable strategies that support the built environment and the organisms that live in it. Sustainable techniques have been tested and researched in field studies, which are intended to revitalize amphibian and reptile habitats. Amphibian and reptile conservation and restoration planning requires practitioners and town coordinators to concentrate on hydroperiods, hydro-geomorphology, vegetation selection, soil compaction, and slope parameters. It also recommends being careful in design implementations by not introducing fish and other predatory wildlife such as macroinvertebrates. Additional considerations are accessed through a pool by pool basis. Herpetological ecology advocacy is essential to conserve and restore amphibian and reptile habitats in rapidly growing urbanized communities. Federal and State efforts are also, limited to only larger wetland types, which are regulated through wetland conservation and delineation laws. Little to no efforts addressing concerns for smaller ponds like vernal pools is being addressed for conservation. Fragmentation, roadways, and development on or adjacent to urban edges impacts amphibian and reptile communities and can lead to rapid declines and extinction. Amphibian and reptile conservation and restoration planning requires practitioners and town coordinators to concentrate on hydro-periods, hydro-geomorphology, vegetation selection, soil compaction, and slope parameters. The northeastern regions of the United States are creating positive outcomes that help spread knowledge and educate individuals through local communities. Biologists and other scientists that study and advocate for these species have created unique programming, research projects in undergraduate studies, and recruitment and training in our own back yard. Amphibian and reptile habitats can be incorporated on landscapes, such as golf courses and be shared with humans and wildlife. More outreach, early intervention, and education in residential communities needs to be increased to make habitat creation to maintain sustainable homes for amphibians and reptiles.

Chapter 3: Site Methods, Inventory and Analysis

Chapter 3 is the application of research principles to a case study design: the Langston Golf Course in Washington D.C. This chapter is organized into three parts after a discussion of the methods: 1) the context the site including location and history, 2) the abiotic, biotic, and cultural inventory of the site, and, 3) the development of a suitability model for the site selection of vernal pools for the improvement of reptile and amphibian habitat on Langston Golf Course.

Methods

The process used in the design application for habitat creation and golf course concepts included three steps: 1) site inventory, 2) site analysis, 3) design models. The site inventory was gathered through site visits in the summer and winter, and reports from the NPS National Capital Parks-East, and ArcGIS mapping data. The site analysis involved looking for safe and sustainable management practices for effective habitat systems. The suitability models assumed proximities to selected criteria to determine the most suitable locations for constructed vernal pools. In addition, the suitability also took into account the requirements to play the golf course.

Location

Langston Golf Course is located in the Northeastern (NE) region of Washington D.C. Figure (3.1). It crosses Benning Road NE and 26th NE (Figure 3.2). The National Arboretum is located just due north of Langston Golf Course and Kingman Lake and Island are located to the south of Langston Golf Course. Benning Bridge is located on the southern boundary of the golf course (Figure 3.2). The course is 145 acres and is part of the open space system on the western side of the Anacostia River. The main branch of the Anacostia River is located on the eastern side of the golf course while an older alignment and wetland complex of the Anacostia River is located between two portions of the property. The open water body is the northern portion of what is called Kingman Lake.

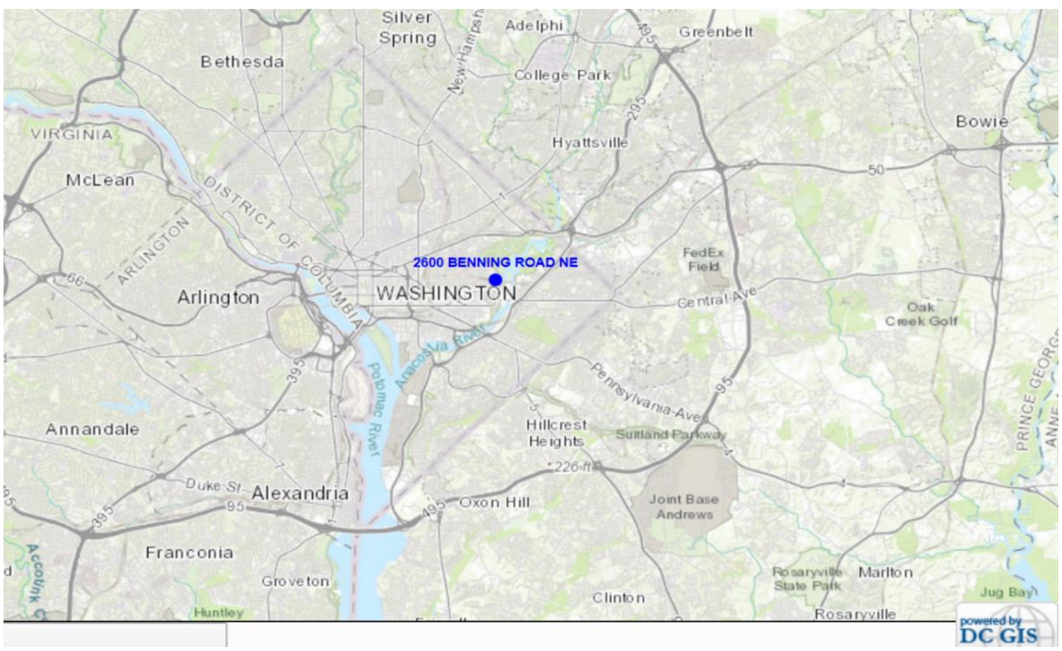


Figure 3.1: Location of Langston Golf Course in Washington, D.C
Source:(Data Source: DCGIS)

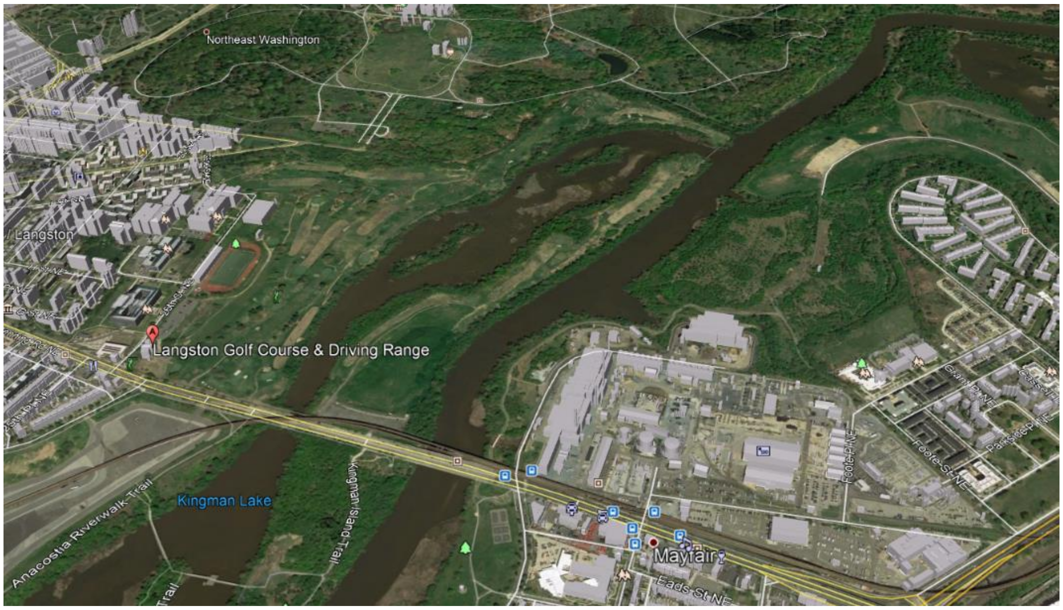


Figure 3.2: Aerial View of Langston Golf Course
Source:(Google Earth 2019)

History of Langston Golf Course

The Anacostia River was flooded in 1889, due to high urban development from runoff and deforestation that deposited sediment and waste. As a result, in 1890 the United States Congress passed an act to dredge the Anacostia River, and dredging material was stockpiled on adjacent flats in the general vicinity of the present location of the golf course. This project was led by the Army Corps of Engineers until 1930. During this project, a portion of the future golf course site was also used as a public dump. The McMillian Plan established the initial Anacostia Park that developed, in part, from 1902-1919. This waste was relocated to a different area of the future golf course in 1920. Planning and construction of Langston Golf Course took place from 1929-1939.

The golf course is named after John Mercer Langston, the first African American elected to the United States Congress and the first Dean of Howard University Law School (Figure 3.3). African American golfers relied on the golf course for recreational play (Figure 3.4). It is also the home course of the Royal Golf Club and the Wake Robin Golf Club, the nation's first golf clubs for Black men and women. The Wake Robin Golf Club was named after the purplish Wake Robin wild flower of the Mid-Atlantic Region (Babin 2017). Figure 3.5 are the members of the Wake Robin Golf Club at Moorland-Spingarn Research Center, Howard University in 1947.

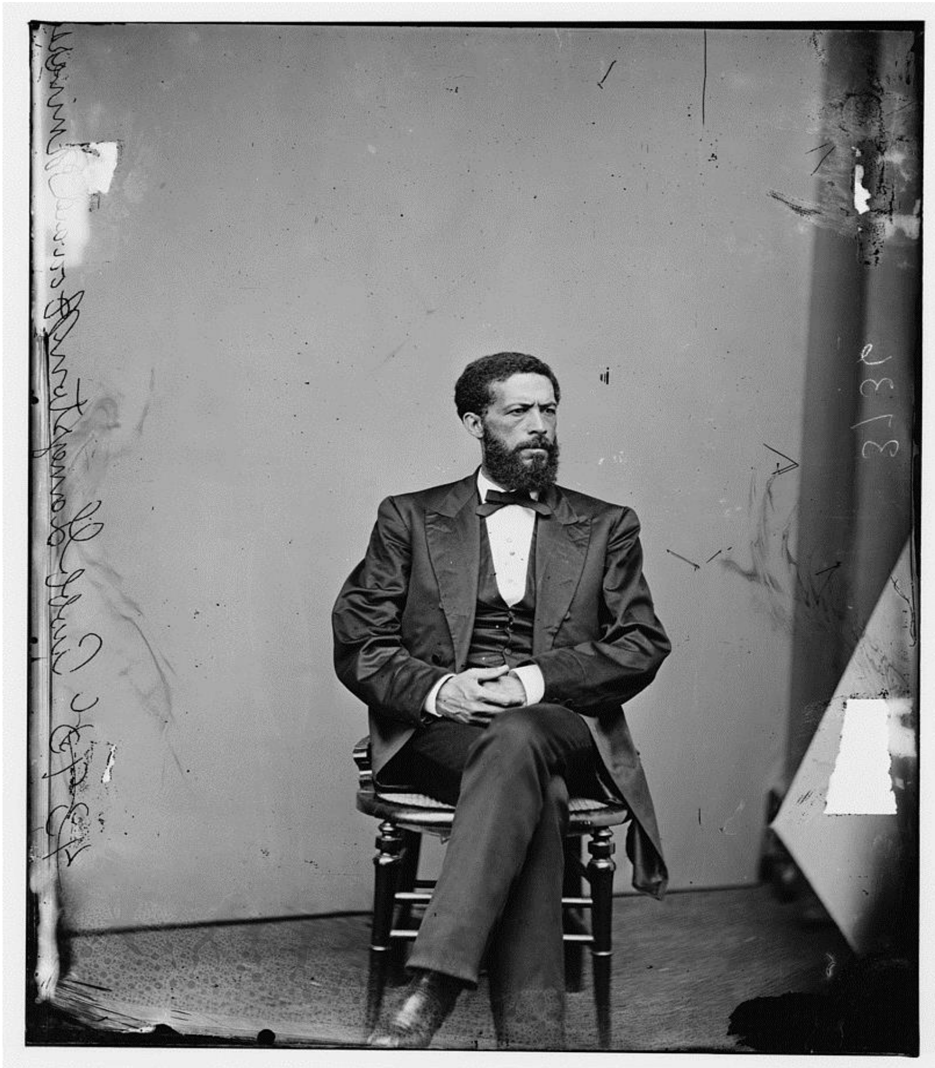


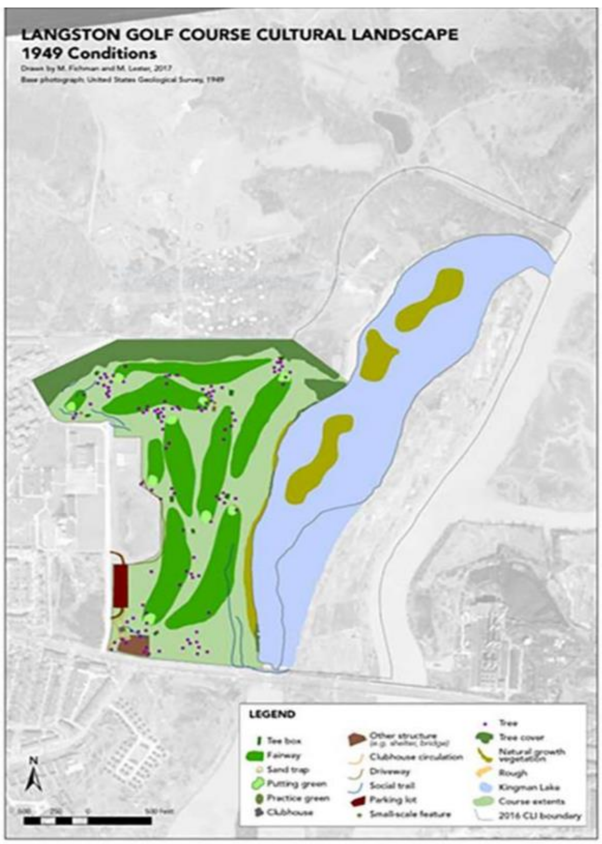
Figure 3.3: Professor John Langston, Howard University 1860-1875
Source: (Library of Congress, 1954)

Figure 3.4: Golf Pro and Local Youth at Langston Golf Course 1979
Source: (NPS 2017)

Figure 3.5: Members of the Wake Robin Golf Club 1947
Source: (Babin 2017)

The construction of Langston Golf Course's first 9 holes took place from 1935-1939, due to African Americans no longer being able to play golf on the Lincoln Memorial grounds because of the construction of the new Memorial Bridge across the Potomac River (Figure 3.6). The Civilian Conservation Corps (CCC) and the Works Project Administration (WPA) constructed the first nine holes. Langston Golf Course opened in 1939, and all nine holes were placed on the west side of Kingman Lake. The hazards generally consisted of greenside sand traps, instead of mounded bunkers. "Significant vistas from the original nine holes included general views toward Kingman Lake, and the spatial organization was oriented around the progression of play, which began in the southwest corner of the course and continued east and northeast along the edge of the course site, charting a counterclockwise route along the bank of the upper basin of Kingman Lake" (Babin 2017).

The club house, with construction starting in 1950, was completed in 1952. The last nine holes, on the east side of Kingman Lake on Kingman Island, were completed from 1952-1955. William F. Gordan and David W. Gordan designed the last nine holes. Figure 3.7 indicated conditions of Langston Golf Course in 1957



Langston Golf Course, 1949 condition. This map, adapted from plans of the course's first nine holes, indicates the design of the course as of 1949. For a larger view of this map, see Appendix A. (Map by Fichman and Lester, 2017, from data sources: "Golf C 1954)

Figure 3.6 Langston Golf Course 9-Holes (NPS 2017)

Langston Golf Course, 1957 condition. This map, adapted from plans of the course's expansion to eighteen holes, indicates the design of the course by the end of the period of significance (1935-1955). For a larger view of this map, see Appendix A. (Map by Fichman and Lester, 2017, from data source: Gordon and Gordon 1954).

Figure 3.7 Construction of all 18-holes completed (NPS 2017)

During the 1970s Langston Golf Course experienced issues in management, due to maintenance costs and not having enough revenue. "After 35 years of management, Leoffler's company released control of Langston's concessionaire contract in July of 1974" (Babin 2017). "Seven investors formed the Langston City Golf Corporation and took over the contract from Loeffler in 1974" (Babin 2017). Unfortunately, after a year they lost a large sum of money and closed the course. Lee Elder, the first black golfer to play in the Masters Tournament at the Augusta National Golf Club in 1975. He was interested in taking over management of Langston Golf Course to establish his Lee Elder Celebrity Tournament and a golf camp for inner- city children. In 1978, he won the concession after eight years of negotiation with National Parks Service. After winning the concession in 1978, he invested $100,000 in improvements for the course and clubhouse. He expanded the greens, redesigned sand traps, remodeled some areas of the clubhouse, introduced golf carts on the course, and constructed a golf cart shed addition on the clubhouse (Babin 2017). In 1981, he invests $160,000 more in improvements. "In December 1981 Elder's company canceled the course's insurance coverage claiming that it had been unable to respond to contractual disputes with the National Park Service" (Babin 2017). Unfortunately, the National Park Service had to close the golf course. In 1983, golf specialists acquired the course but were facing demolition, due to plans by Washington Redskins owner Jack Kent Cooke from the plans to build a new stadium on Langston Golf Course and replace the RFK stadium. In 1991, Langston Golf Course was listed in the National Register of Historic Places, after efforts from long-time players formed the "Committee to Save Langston." After Cooke failed to meet Secretary of the Interior, Manual Lujuan Jr.'s (1989-1993) deadline for negotiations of the stadium, Lujuan instructed National Parks Service to start repairing Langston Golf Course" (Babin 2017). The new stadium was built in Landover, Maryland, which is named FedEx Field. In 2007 Congresswoman Eleanor H. Norton, introduced the "Golf Course Reservation and Modernization Act," to allow the National Park Service to use a public-private partnership to modernize and rehabilitate its golf course (Babin 2017). Three golf courses were picked in D.C: 1) East Potomac Park, 2) Langston Gold Course, and, 3) Rock Creek park. In 2014, she renewed the bill with the hopes to have "world-class tournament-quality public courses, with playing fees commensurate with such courses" (Babin 2017). The National Park Service continues to make improvements on the site and provides affordable costs compared to private and semi-private clubs in the area.

Abiotic Inventory

Topography

The topography on the golf course is mostly flat around Kingman Lake and areas adjacent to the lake (Figure 3.8). There is a small hill rising to about 25 feet in elevation located on the southeastern portion of the property. The driving range is located here. The higher elevations can be found on the north-west area of the site that borders the National Arboretum.

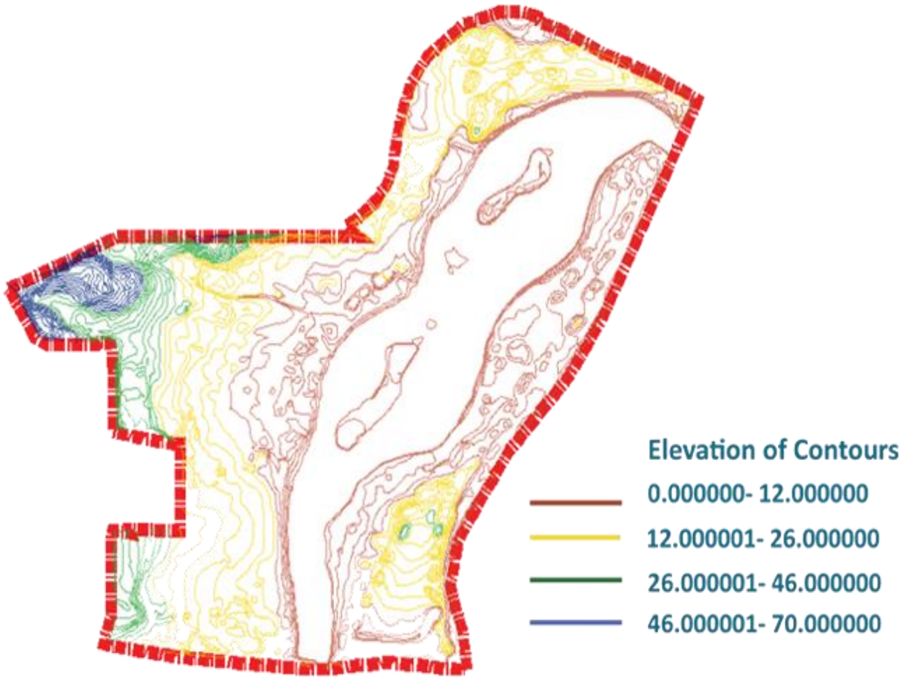


Figure 3.8: Langston Golf Course Contours (Data Source: DC GIS)

Slopes, Elevations, and Aspect

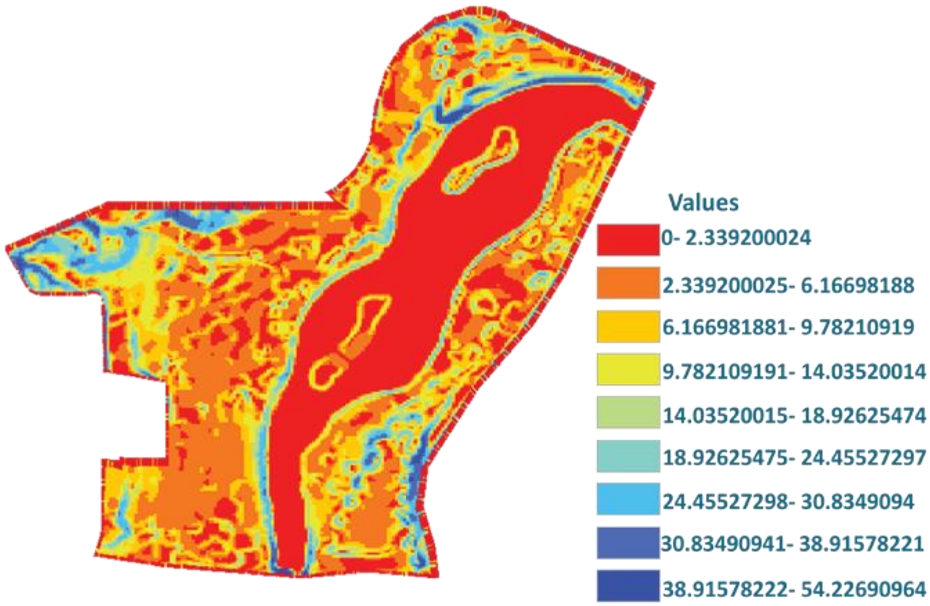


Figure 3.9: Langston Golf Course Slopes (Data Source: DC GIS)

Most of the slopes on the site are less than 6 percent (Figure 3.9). These relatively flat slopes provide for easy golf cart mobility and pedestrian walkability. There are steeper slopes adjacent to the water bodies and also located in the north-west area of the site. There is also a steep embankment and steep slope on the west side of the golf course along the Anacostia River.

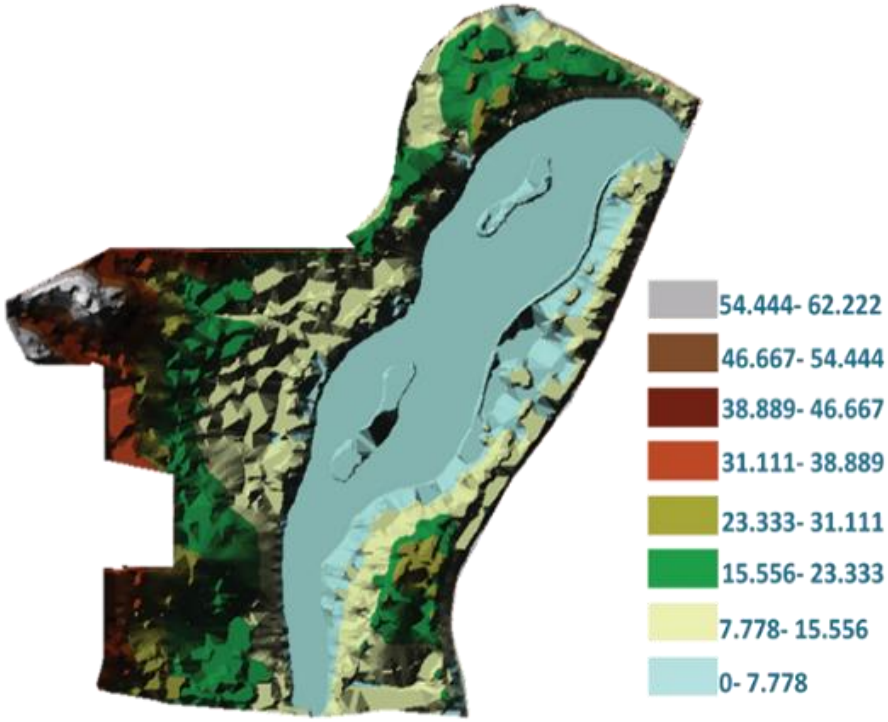


Figure 3.10: Relief Map (Data Source: DC GIS)

The relief map (Figure 3.10) indicates a change in elevation classes from 0 to 62 feet. The higher elevations can be found on the north-west area of the site that borders the National Arboretum.

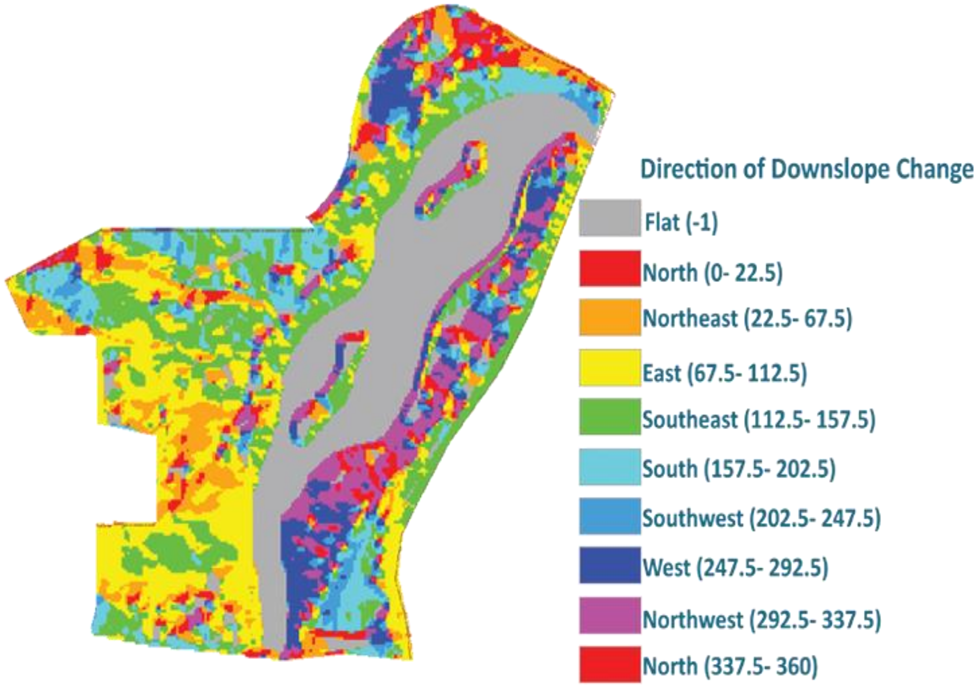


Figure 3.11: Aspect Raster (Data Source: DC GIS)

An aspect map (Figure 3.11) was created of the site with the possible use of the model. However, no definite research was found to use this criterion in the development of a vernal pool suitability model. Most of the eastern side of the property where the club house is located is facing east while the western side of the property, given a ridge down the middle is divided in its aspect. The western side of Langston Golf Course faces mainly north and west and the eastern side faces east to the Anacostia River.

Hydrology

The entire site is located in the 100-year floodplain (Figure 3.12) of the Anacostia River and is subject to flooding. The northern section of Kingman Lake bisects the property. There is a small pond located on the eastern area of the site (Figure 3.12)

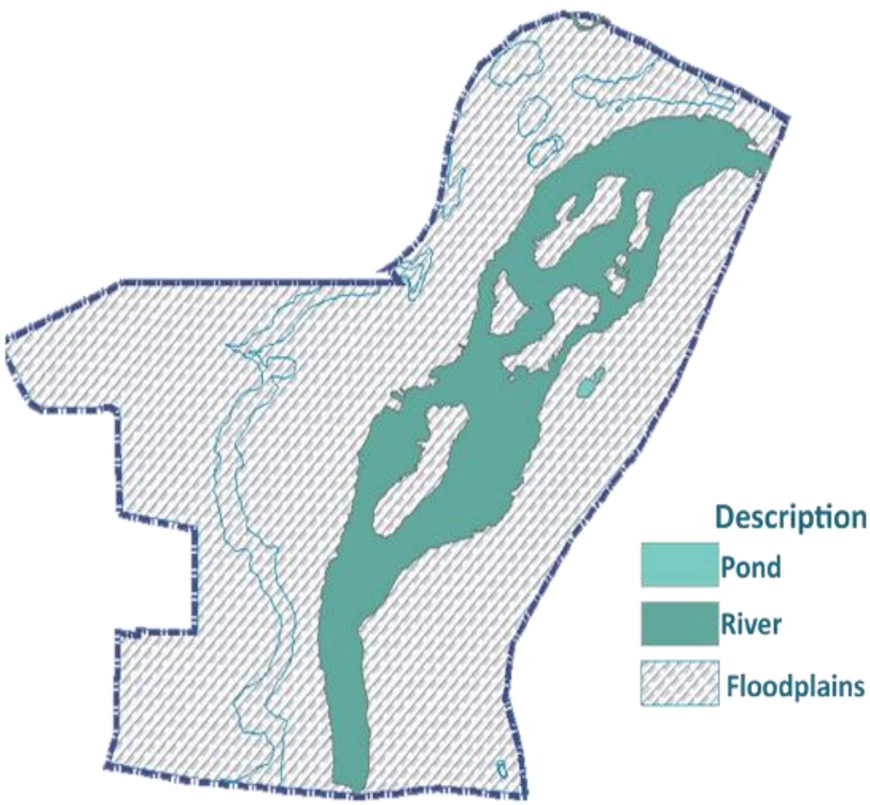


Figure 3.12: Langston Golf Course Hydrology (Data Source: DC GIS)

Soils

The soils in and around the golf course are sandy loam, udorthents, and Christiana silt loam (Figure 3.13). Sandy loam allows for good drainage for excess water but can hold significant amounts of water and nutrients for plants. Since the site is located within an urban landscape it is mainly composed of disturbed soils due to grading modifications. For example, udorthents soil, which is well-drained, gravel, and sand, so water does not hold long in pools. Christiana silt loam is a moist soil and holds water for a long time.

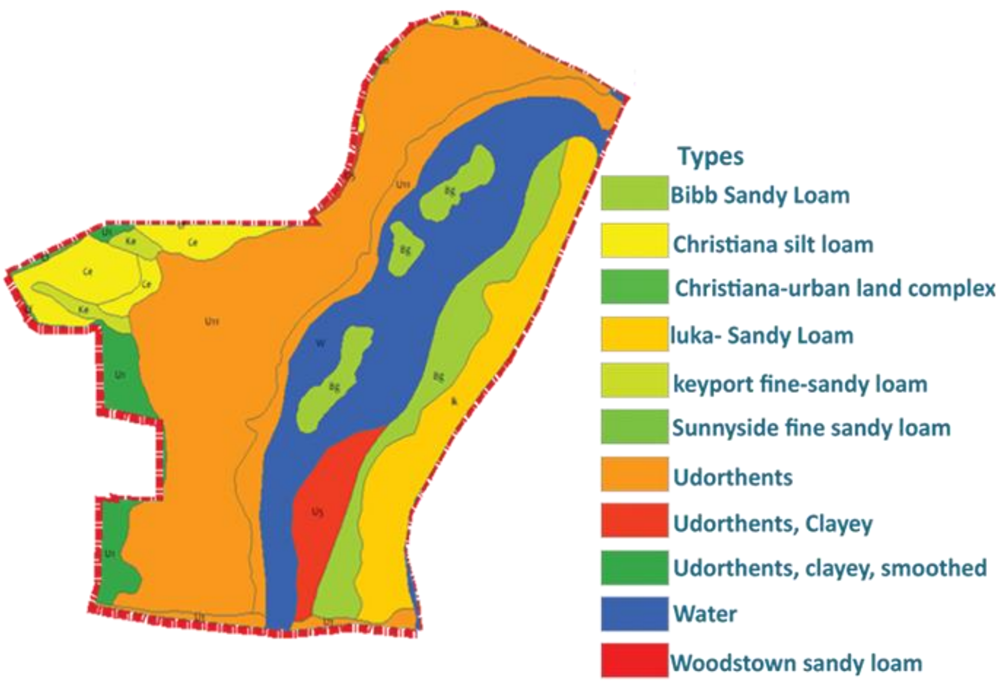


Figure 3.13: Langston Golf Course Soil Types (Data Source: DC GIS)

Biotic Inventory

The biotic inventory of the site includes the general vegetation and the wetland vegetation.

General Vegetation Patterns

Langston Golf Course consists mainly of forest patches, grassy open fields, wetlands, and scattered trees (Figure 3.14). Mature trees found on the site include native trees: willow oaks (*Quercus phellos*), sycamores (*Plantanus occidentalis*), American elms (*Ulmus Americana*), and tulip poplar (*Liriodendron tulipifera*) and other Mid-Atlantic native trees. Other vegetation includes vines, bushes, hydrophytes, and mowed grass. The non-native grasses on the golf course areas include rye grass (*Elymus Canadensis)* and Bermuda grass (*Cynodon dactylon* 'Sundevil'). Current vegetation patterns (Figure 3.17) indicate forest patches along the edges on the Anacostia River on both sides of Kingman Lake and on the northern area of the property adjacent to the National Arboretum. The Anacostia Watershed Society planted wild rice(*Zizania*) in and around Kingman Lake to aid the Sora rails, birds (*Porzana Carolina*) once common to this region and now are rare. Most of the open space and non-native or exotic grasses are managed for golfing activity.

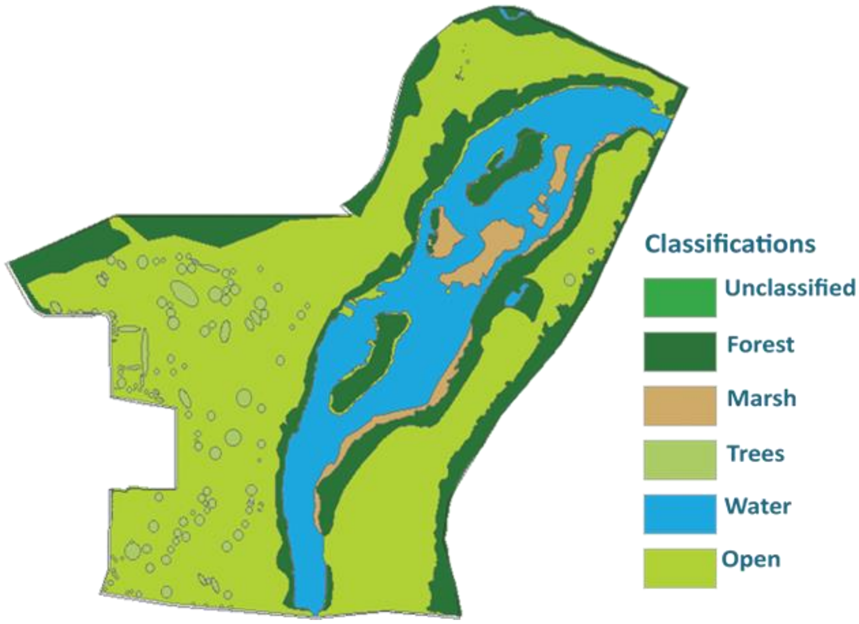


Figure 3.14: Langston Golf Course Vegetation (Data Source: DC GIS)

Wetlands

Currently the site includes a variety of wetlands (Figure 3.15) that support wildlife such as, birds, fish, turtles, frogs, and other reptiles, and insects. The waterbodies surrounding the site are dominated by tidal freshwater wetlands with some non-tidal wetland. Both wetland types share benefits for humans and wildlife. These benefits include: habitat for rare and threatened and endangered species, erosion control, stormwater or flood control, recreational opportunities and scenic beauty, filter rain water with chemicals and pollutes, and provides nutrients for species. The entire site is within a floodplain, and connects to tributary, and streams, so tidal wetlands are more dominant.

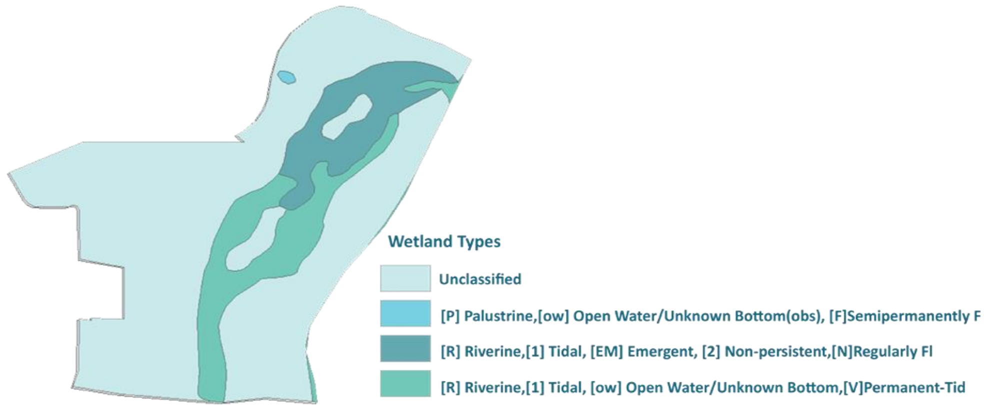


Figure 3.15: Langston Golf Course Wetlands (Data Source: DC GIS)

Many areas on the golf course connect to the water. For example, a pond was unintentionally formed, when I visited the site last fall due to excess water and a hidden drain (Figure 3.18). Additional aquatic zones are on the site (e.g.; marshes and existing wetlands). Figure 3.17 and Figure 3.19 are images I captured on my site visit of these types of existing habitat zones. This will help amphibians during their breeding season. Tidal water habitats assist reptiles like the red-eared slider during the spring, which is mating season for sliders. Amphibian and reptiles also rely on aquatic plants that flourish in these wetlands.

Figure 3.16: Forest Vegetation

Figure 3.17: Existing Wetland

Figure 3.18: Pond Formed by Drainage System

Figure 3.19: Marsh on the Edge of the Forest

Wildlife

The site has a diversity of wildlife including reptiles and amphibians. The golf course sand traps and mud paths on the site are utilized by turtles (Figure 3.20). Sand traps are good locations to lay and incubate turtle eggs due to their loose soil texture, were noted on site (Figure 3.21). The turtles place the eggs in the upper portion of the sand bunker to keep them safe. This is a hazard area for golfers to make the game more challenging, but the rules, usually do not allow clubs to touch the ground where the turtles place their eggs. The site visit in the summer revealed hatched eggs near semi-wet soil (Figure 3.22). These reptiles adapt well to the golf activity and survive. Tree frogs also, camouflage well into the scenery of the golf course (Figure 3.23).

Figure 3.20: Turtle Giving Birth

Figure 3.21: Hatched Turtle Eggs at Top of Bunker

Figure 3.22: Turtle Egg Hatched Shells

Figure 3.23: Tree Frog on Site

Cultural Inventory

The cultural inventory of Langston Golf Course includes the description of the 1) golf course holes and driving range, 2) sidewalks, and 3) existing buildings.

Golf Course Holes and Driving Range

In 1954, the bridge at northern opening of Kingman Lake was constructed to allow golfers to return from Kingman Island to the western side of the golf course. This connection is located between holes 13 and 14. In 1977, a second bridge construction was built at the southern end of Kingman Lake, which is parallel to Benning Road Bridge. This bridge allowed for the driving range and other holes at East Kingman Lake to be linked.

Sidewalks and Parking

The site has green open areas, so sidewalks and vehicular paths are limited on the golf course. Many paths are clay and dirt trails or aggregate, which helps balance the hardscape and soft cape areas on the site. Additional impervious surfaces are located in the parking lot and driving range, which is built to only accommodate non-event parking spaces. The main parking lot is not intended for event parking and most commuters and golfers are asked to park under the metro bridge tracks.

Buildings

The site does not have many buildings. The Langston Grille and Clubhouse, maintenance facility, and the driving range hut are the main buildings located on the site (Figure 3.24). In 1980, the driving range was added. Langston's driving range hut was built in 1985. The club house was built from 1950-1952 and still remains on the site of the temporary clubhouse structure. Langston's maintenance building was first constructed in 1947 west of Hole eight. It was later burned to the ground in 1957 and replaced with a new maintenance structure.

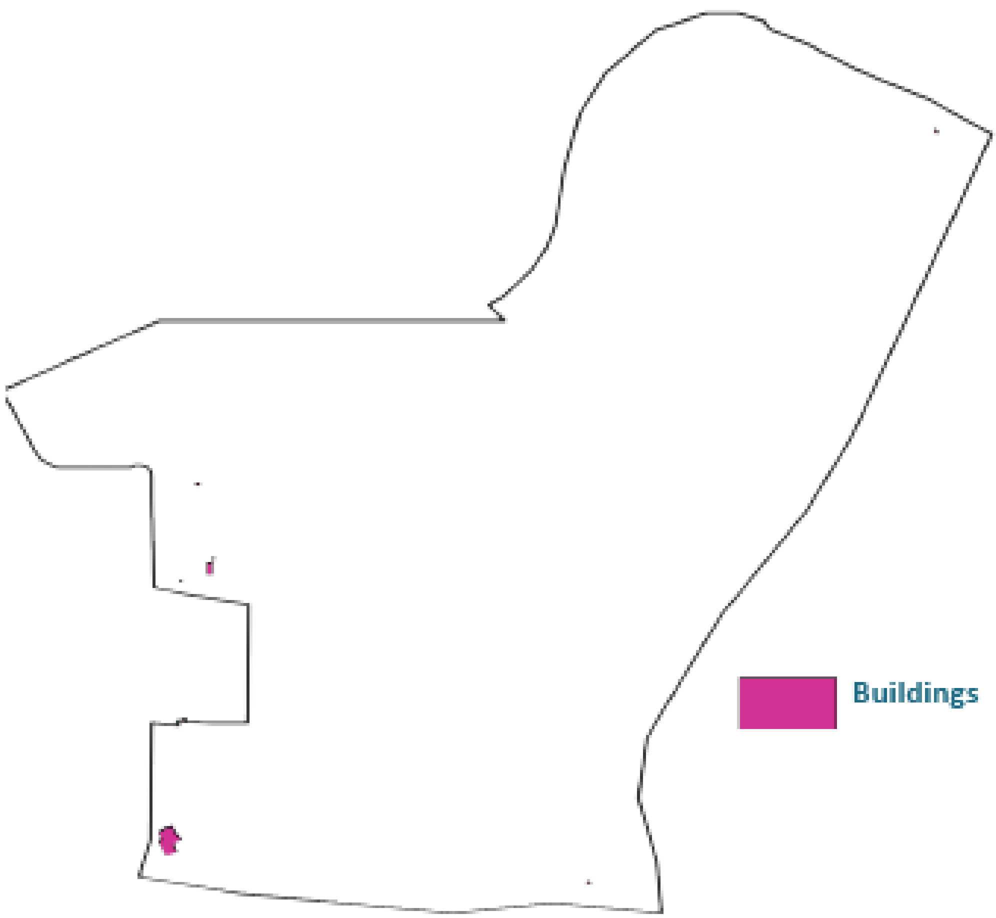


Figure 3.24: Langston Golf Course building footprint (Data Source: DC GIS)

Suitability Model for Locating Vernal Pools

This section includes the process of selecting criteria for the best location for potential constructed of vernal pools. This suitability model was executed with Spatial Analyst in ArcGIS Version 10.1. Three criteria were selected: 1) distance to mowing edged, 2) distance to water bodies, and, 3) slope

Mowing Edges

The placement of the proposed vernal pool habitat locations is assumed to be best suited approximately 90 feet away from mowing disturbance that occurs on the fairways and greens. The mowed edges are not suited for amphibians because it could be disturbed my human actives on the golf course. Figure 3.25 shows the placement of the holes and driving range, which humans use throughout the day. The distance raster shows mowing proximities to determine greater or equal to 90 feet (Figure 3.26). There few mowing edge areas, distances, since the course mainly values human activities (Figure 3.28).

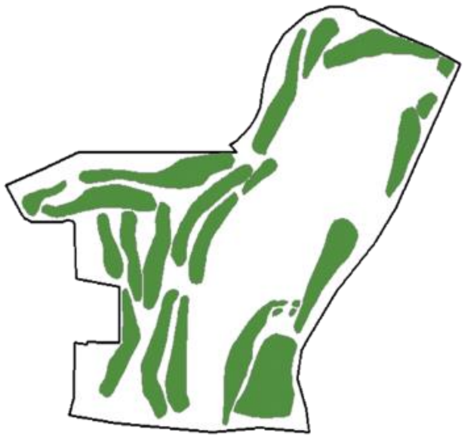


Figure 3.25: Golf Holes and Driving Range (Data Source: DC GIS)

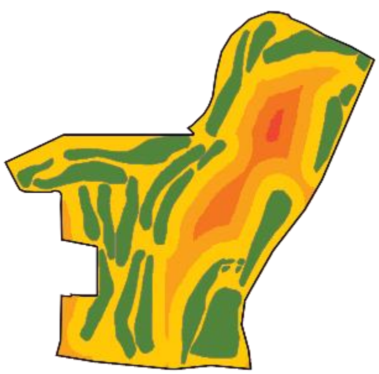


Figure 3.26: Distance Map Mowing Edges (Data Source: DC GIS)

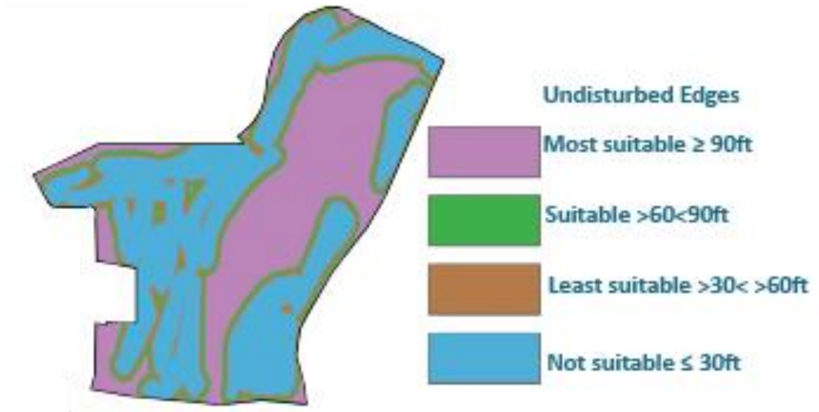


Figure 3.27: Mowing Edge Suitabilty Map
(Data Source: DC GIS)

Waterbodies

Vernal pools are seasonal habitats, so they are most successful with an amount of water only in a portion of the year. The water bodies distance model identifies the streams, rivers, and ponds areas on site (Figure 3.28). For amphibian habitats to remain suitable and resilient for many years the distance model proposed locations greater than 50 feet but less than 100 feet (Figure 3.30). The locations should not be too close to large waterbodies to prevent flooding and not too far away from water during dry seasons. This also helps with their breeding cycles by allowing amphibians to protect their eggs from predatory species. For example, fish are known to readily consume amphibian eggs. Vernal pool habitats are not ideal habitats for fish survival, due to wet and dry seasons of water levels. Figure 3.30 distance analysis represents the four categories, which range from most suitable to not suitable at all.

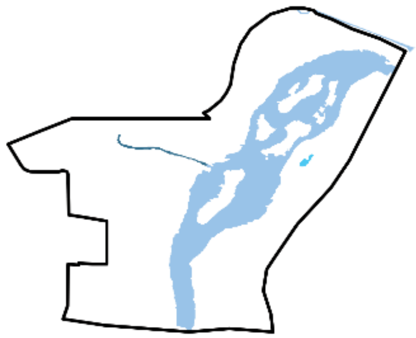


Figure 3.28: Water Bodies Map (Data Source: DC GIS)

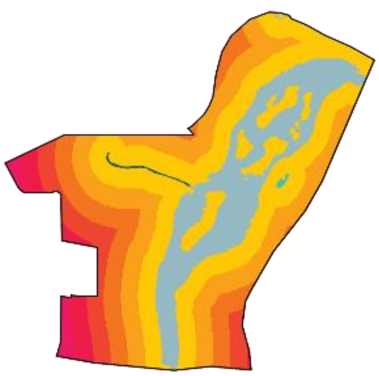


Figure 3.29: Water Bodies Distance Model
(Data Source: DC GIS)

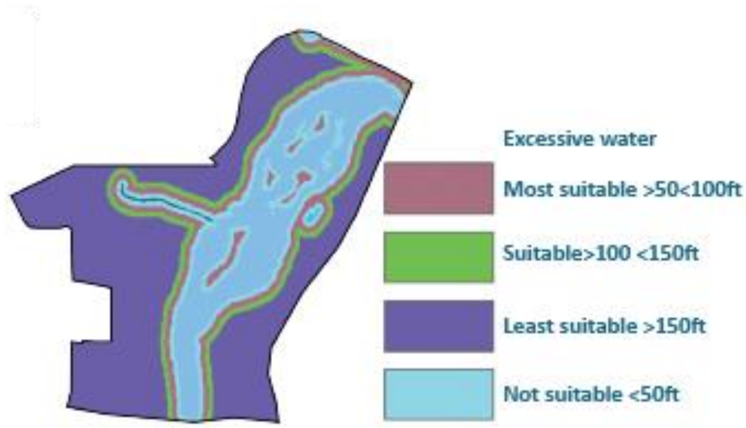


Figure 3.30: Water Bodies Suitability Model
(Data Source: DC GIS)

Slopes

Slope is an important criterion in determining the location of a vernal pool Figure 3.31 indicates the slope categories: 1) less than 1 percent, 2) 1-2 percent

For the slope distance map (Figure 3.32), flatness is the main indicator, since vernal pools have to be level. Vernal pools require less than 3 percent slopes for best suited habitat construction. The slopes support the water depth for habitat creation.

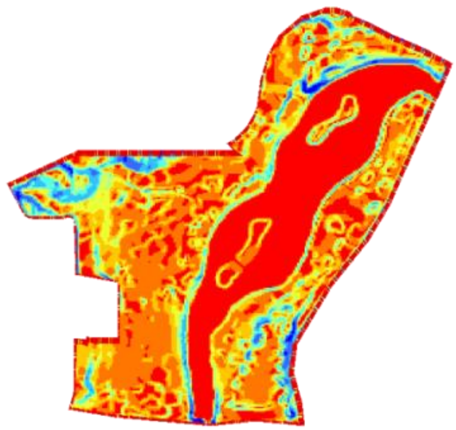


Figure 3.31: Slope Map
(Data Source: DC GIS)

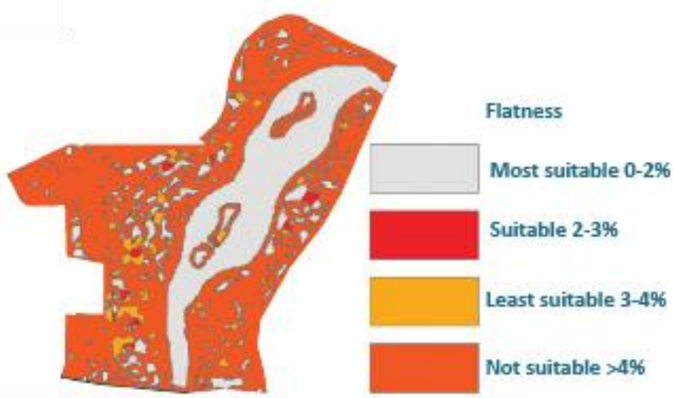


Figure 3.32: Slope Suitability Model
(Data Source: DC GIS)

Final Suitability Map for Locating Vernal Pools

The final suitability model was created by summing the three criteria into a final model: 1) most suitable for slope, 2) most suitable in relation to distance to mowing edge and, 3) most suitable in relation to distance from water bodies. The resultant calculation indicates the most suitable locations for vernal pools (Figure 3.33). The legend and map also explain the highest and lowest options for vernal pool selection with the red and yellow representing the prominent areas. The three most suitable locations for proposed vernal pools: 1) between holes 11 and 12, 2) near Hickey Run, and 3) the alongside the northern boundary of the U.S National Arboretum. These are designated graphically by the red boxes in Figure 3.33. The largest number of most suitable areas are located between holes 11and 12 on the eastern portion of the golf course near the existing pond. This area is the ideal place to build the first vernal pool if funding was limited. The second most suitable are would be near Hickey Run, since it is heavily forested and is away from human disturbance. The area along the northern border of the National Arboretum is also a suitable area. It is represented in a large yellow polygon in Figure 3.33. The design of a typical vernal pool is noted in Chapter 4: Final Plans and Designs.

Figure 3.33: Suitability Map for Location of Vernal Pools. Red Boxes Indicate the Most Suitable Locations for Vernal Pools Based on the Criteria (Data Source: DC GIS)

Chapter 4: Final Plans and Designs

Chapter 4 of the thesis will discuss the design concept for Langston Golf Course. It is organized in five sections: 1) vision and design goals, 2) master plan, 3) Eco-Golf, 4) proposed vernal pool, and, 5) proposed regenerative stream restoration.

Vision

My vision for Langston Golf course is to potentially have the course be recognized not only as a golf course venue, but also as an ecological habitat precedent for endangered species of the Mid-Atlantic. By conserving and restoring amphibian and reptile habitats within this golf course designers and users of the course can reestablish threatened and endangered species among golf course spaces. Golf courses are prime landscapes to be utilized and promoted for human and wildlife comingling. Langston golf Course is already unique, since it is a national landmark, so unlike other golf course transformations the golf course will remain and be programmed to fit the needs of humans and wildlife ecology.

Design Goals

The goals of the thesis are organized to meet three values of my proposal. These values are centered around human and amphibian co-existing on the golf course. The proposal introduces three focuses on three goals: 1) create, protect, and save habitat, 2) play, and 3) learn.

Create, Protect, and Save Habitat

The first goal is to create, protect and save habitat. I am proposing to create habitat zones for amphibians and reptiles. These habitat zones will be built according to the guidelines researched in my literature review. Along with creating places, I intend to protect and save places that promote current habitats. According to my research, saving existing wetlands on the course should be accounted for before introducing new habitat. All habitat areas that I am proposing are to establish practices which cater to natural systems. Best management practices require the least amount of maintenance and monitoring because they use natural environmental techniques and material, which will be incorporated in the proposal for the course.

Play

The second goal is to play. I am proposing to have all users of the site play in a place that promotes golf, learning and enjoying green spaces. The design features for these places promote playing golf, playing games and playing in a landscape focused on sustainable practices. The proposal also allows golfers to be a part of an Audubon Certified Course. Being active outdoors is very important for human physical and mental health, so having a place to play is essential for every neighborhood. This thesis introduces an option to implement creative play, which also functions as an outdoor classroom for surrounding schools from elementary to university level as well as the golfers. The proposal incorporates an ecological golf theme game which I chose to name eco-golf.

Learn

The final goal is to promote learning. I am proposing the users of the golf course learn ecological design practices and ecological system basics. Users of the site, especially children, will learn through environmental features. Along with educating children the proposal will appeal to golf enthusiasts and visitors to learn more about the history of John Mercer Langston and the original users of the golf course.

Users

The design of this thesis is to have introduced biodiversity for humans and wildlife functioning harmoniously, so the key users of the site are human and wildlife. This thesis design will invite many different users, which include, local residents, golfers, primary, secondary, and college and university students, and wildlife. Since, Langston Community Schools are integrated with Howard University Interpretive Education Center, the golf course establishing cognitive play events on the course for school aged children and professional students will promote awareness for wildlife on the site. The Audubon Sanctuary Program is also tailored to bring recognition to the sites they partner with. Local community members and golfers from all areas will be able to enjoy playing on a historic landmark. The Audubon Sanctuary Program will support Langston Golf Course stewardship with all six categories, which will increase their audience.

Master Plan and Design Proposals

This thesis features several design proposals that met my design goals. All of these design proposals are tailored to both promoting Langston Golf Course and to develop and promote ecological sustainable design practices on Langston Golf Course. The master plan (Figure 4.1) includes the following design interventions:

- Development of an educational game : Eco-Golf
- Creating vernal pools
- Restoring the existing stream to a RSC ,
- A Golf Park Meadow
- Sculpture Park Garden
- Wayfinding banners

After a discussion of the Golf Park Meadow, Sculpture Park Garden, and the wayfinding banners, the focus of this of the chapter is on 1) the development of an educational game, 2) vernal pool and 3) regenerative stream conveyance.

Figure 4.1: Illustrative Master Plan

Golf Park Meadow

The Golf Park Meadow is proposed at the main entrance adjacent to 26th street near the clubhouse building and main parking lot. The Golf Park Meadow can serve an aesthetic amenity, inviting to the public, and as a pollinator garden, which will attract pollinators. This Golf Park Meadow would also be a feature providing for educational opportunities for golfers and school children.

Sculpture Park Garden

Placing a statue on a podium within a garden path along the interior of the site, which is fenced at Benning Road, will help represent John Langston and his achievements. John Mercer Langston achievements for the African American community helps Langston Golf Course highlight their national historical presence in the District of Columbia. John Langston was a well-educated congressman, and founder of Howard University Law School, which still collaborates with the golf course interpretative learning center. The efforts of the founders like the Royal Golf Club and Wake Robin Golf Club, and Lee Elders are vital to the site's establishment and should be commemorated at all times. The members of the clubs were part of the city's black elite, which included businessmen, attorneys, and civil leaders. The podium being placed in a garden passage way with stone and meadow accents brings an inviting presence to all visitors of the site. Also, since the Wake Robin Golf Club is named after the purplish wake robin wild flower (*Trillium)* of the Mid-Atlantic, it supports the landscape and gives a signature touch of the women.

Wayfinding Banners

Wayfinding banners incorporated in the parking lot inform D.C. commuters of John M. Langston and the other African American founders of the site. Some banners will highlight the wildlife species too. Amphibian, reptiles, and birds are all part of the golf course and the new programming aimed to attract school aged, college students, and golfers about environmental concerns that work best for wildlife and humans to co-exist can be showcased on the banners with individual species. Important people of the past that advocated for the site like Lee Elders, Royal Golf Club members, and the Wake Robin Golf Club can be placed on the banners for the golf course enthusiast. In addition, the bright colors and illustrative representations of green golf courses on the banners will help market Langston to the local residence in D.C and the golf community.

Eco-Golf Game: Learning About Amphibians and Reptiles

Langston Golf course and other golf course programming should incorporate learning through an ecological golf theme. A golf course is a great place to introduce more play in the form of biodiversity. The constraints and opportunities in my proposed programming were mindful of not incurring any liability or injuries. While ecological outdoor learning is great for everyone it needs to be considered closely on a golf course. By planning outdoor playing and learning activities in advance liabilities are minimized. I am proposing the golf course managers and parks planning advisors or authority create an event in advance for the community and children. Many nature related activities have successful learning days with the help of supervised adults and instructors, so grouping children with responsible peers is needed in the proposal. The golf course users are welcome to participate, because this helps all parties that visit the landscape through education and play. The game I am proposing is called Eco-golf because it addresses ecological habitat and environmental concerns and provides different uses for golf course landscapes. The programming is envisioned to begin at the clubhouse, where children and adults will receive a map in a brochure format for a scavenger hunt on the golf course. I am proposing several planned days in the spring and summer to teach all site users about ecological habitats pertaining to amphibian and reptiles and other species that utilize the golf course. The children and adults through my programming will go through a map quest to advance to ten holes on the course. There will be replicate statues of frogs, turtles, salamanders, and other species of the site in habitat zones near or adjacent to my proposed BMPs. Each zone will include interpretative zones and specific materials like egg types as clay or a molding, and common names, sounds, etc., for specific species. This Eco-golf Game allows all the intended users of the proposal to share environmental learning. It also places emphasis and concerns on saving the species that live on the golf course. Each user of the site that participates will gain knowledge of how golf courses can be primary habitats for ecosystems they knew little about through several planned days of the year. Figure 4.2 outlines the sequence of the game from start to finish of each habitat zone and activity.

Eco-Golf:	**10 Hole Scavenger Hunt**
Club House	Children and adults will get a map and brochure to start their exploration
	walking to the first habitat zone (Hole 10)
Zone 1	will see a sculpture of a salamander, with interpretative board next it -board will have a picture that shows how the salamander's eggs look
zone 2 & 3	Will locate four eggs with 3 Mid-Atlantic salamander 1 newt molded in it; blue –spotted salamander, mole tiger salamander, marbled salamander, and red-toed newt.(Holes 11 and 12) This will be near the vernal pools that were created in my design. The four eggs will be part of a prize to continue to the next zone
zone 4 & 5	Look at a map that leads them to a sculpture near a sand trap. Near the sand trap they will locate four different Mid-Atlantic turtle sculptures (box turtle, red-eared slider, painted turtle and wood turtle) (Hole 13, 14) In the brochure there will be facts about these turtles, which includes a crossword puzzle with 4 facts for them to solve to advance to the next hole (2 different holes).The children and adults will advance to the next hole after finishing the turtle's crossword.
zone 6	Next, they will discover a path that leads them to another sculpture of a frog with an interpretative board along the path. There will be two demos of a croaking frog wooden instrument close to the edge of the forest and interpretative board with the chorus frog mating call for the children to touch and play on. They will advance after completing the path where a female wood craved chorus frog is located. (Hole 3)
zone 7	The map will lead them to the stream with a wooden word board that spells out some words affiliated with benefits for stream habitats for amphibians and reptiles. After spelling out three benefits they will advance. (Hole 17)
zone 8	The final hole (Hole 2) will have a willow tree with flags hanging with information on it; the flags have a letter on it that spell out a word to solve the final clue of the map quest. The group to spell out the word correctly WINS!

Figure 4.2: Eco-Golf Sequence Guide

Creating Vernal Pools

Vernal pools incorporate many endangered animals and plant species who strive well in sustainable habitat. Figure 4.3 is an example of a Wyoming vernal pool image provided by the USGA. In Figure 4.4 is a photo of a vernal pool within Phoenix Park with heavy meadow like vegetation is provided by USFWS.

Figure 4.3 Wyoming Vernal Pool (USGA 2017)

Figure 4.4 Phoenix Park Vernal Pool (USFWS 2017)

Vernal pools serve as temporary pools for amphibians and collect water in depressions, usually in late winter or early spring, due to snow melt, heavy rains, and seasonally raised water tables. Since, fish are not present in the pools, which are predators of amphibians it serves as feasible habitats for amphibians. Vernal pools can be constructed in many shapes and sizes. The best time to construct vernal pools is in the fall because, the soil isn't wet, and it is the driest time of the year. They are typically small in area compared to many types of permanent wetlands. Ephemeral pools usually range from 30-60 feet wide. According to Biebighauser's guidelines it is difficult to make a wetland larger than 30 feet to wide and 40 feet long with a liner

(Biebighauser 2012). He recommended using commercial liners that are used for landfills because; liners are heavy and challenging to move into position. The water in the vernal pool usually holds for a time period to allow for breeding cycles. Vernal pools are most often at their maximum depth during the springtime. According to Biebighauser, most vernal ponds are built on sites that do not have high water tables, which are usually uncommon in many areas (Biebighauser 2002). High water table sites usually already have an existing wetland. It is also recommended to check the elevation of the water in the soil during different times of the year to determine when the ephemeral wetland will possible have water. Typical constructed vernal pool maintenance should be inspected at least once a year. According to the Pennsylvania Natural Heritage Program, eighty-five percent of vernal pool amphibians return each year to breed in the same pool where they were born (PNHP 2009). It takes at least 2 years of monitoring for successful vernal pools (Calhoun, et al. 2014) “Depending on the climate, it often takes constructed wetlands about five years to “heal” and to develop a natural appearance” (Biebighauser 2002). As a result, vernal pools mature into a nature hydrologic system and habitat. This habitat allows semi-aquatic species like turtles, and frogs to enjoy the benefits of terrestrial and aquatic areas throughout the year. These species require vernal pools for all or a portion of their life cycle but are unable to successfully complete their life cycle without vernal pools (Biebighauser 2002). Figure 4.5 is my proposed perspective rendering of a vernal pool being placed on the golf course.

Figure 4.5 Proposed Vernal Pool at Langston Golf Course

<u>Creating a Regenerative Stream Conveyance (RSC)</u>

Stream restoration provides a place for amphibian and reptile species to have additional habitat. It also helps human users of the site mediate the high velocity from stormwater runoff and erosion wear and tear. Many amphibians and reptiles in the Mid-Atlantic live in shallow streams or pools near the forest edge. Langston Golf Course has a closed stream, which I have proposed to be restored into an RSC. According to the (Biohabitats, 2019), Regenerative Stream/Stormwater Conveyance systems provide a combination of features and treatment benefits of swales, infiltration, filtering, and wetland practices. RSC systems incorporate stormwater management with wetlands and stream restoration. This BMP reduces the velocity of stormwater, and filters pollution, and provides diverse ecosystems for various plants, animals, amphibians, and insects. Figure 4.6 RSC-1 depicts a typical profile of alternating pools and riffles on the top view and three pools following cascades on the bottom view.

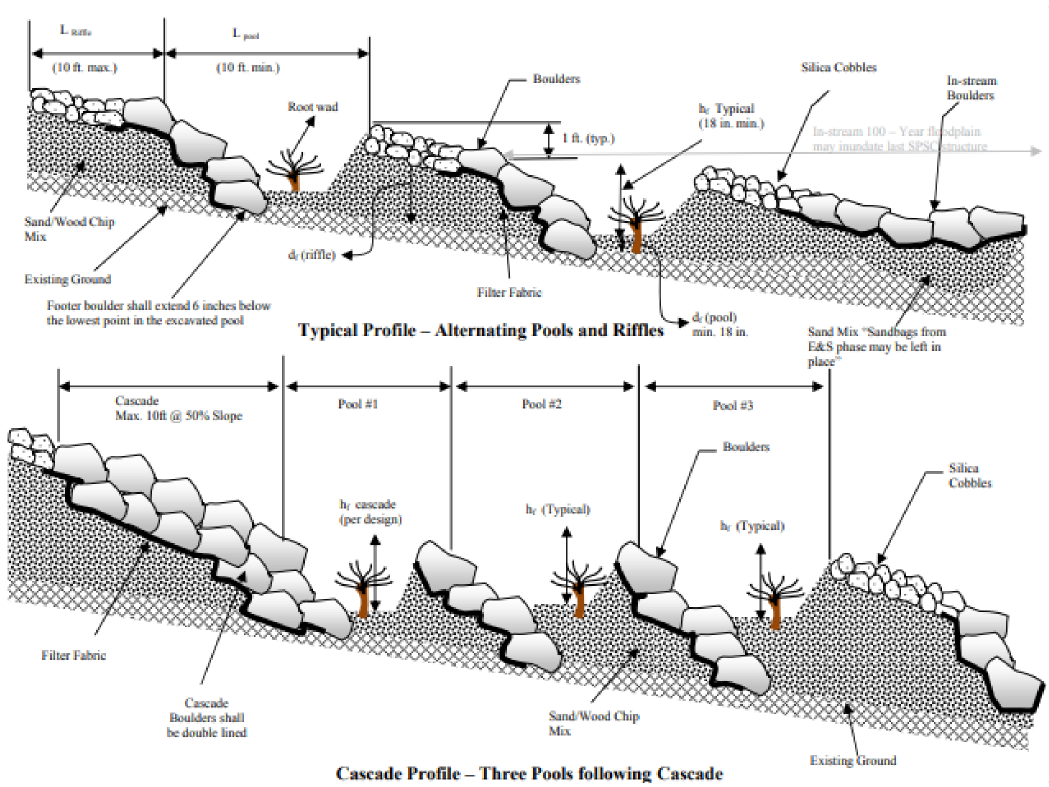


Figure 4.6 RSC-1 Typical Profile of Alternating Pools and Riffles (top) and Three Pools following cascade (bottom) (Anne Arundel County, 2011)

Including stream restoration practices on a golf course decreases erosion, controls excess stormwater runoff, and creates habitats for amphibians and reptiles. Regenerative Stream/Stormwater conveyances act as riparian buffers, so trees and vegetation aid in the creation of RSCs. The vegetation in and out of the water provides food, refuge and shelter. According to West Virginia Department of Environmental Service the construction of RSC systems requires the cobble apron should be approximately 5 feet wide and 3 feet long below the grade control structure. The construction depth of the pool following the cascade shouldn't be less than 18 inches to 3 feet. The medium mix such as, sand and woodchips are placed below the invert area of the pools and should be measure 18 inches. This treatment should not be designed to treat stormwater runoff from hotspot areas (West Virginia Department of Environmental Service 2012).

Figure 4.7 RSC-2 James Terrance is a 2016 final construction of a restored stream in James County Virginia. Figure 4.8 RSC-3 is also illustrates Kingspoint's new stabilized ditch, 2015.

Figure 4.7 RSC-2 James Terrance (James City County Virginia 2016)

Figure 4.8 RSC-3 Kingspoint (James City County Virginia 2015)

Figure 4.9 RSC-4 diagram illustrates open channels that consist of a porous sand media bed, shallow riffle/weir step pools, and native vegetation.

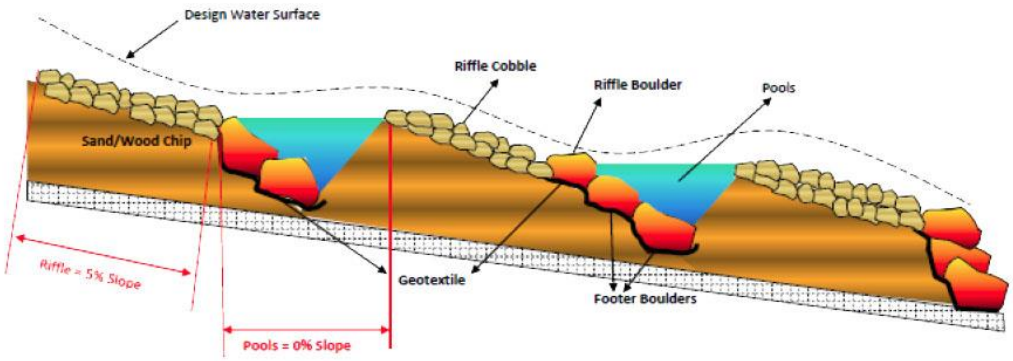


Figure 4.9: RSC-4 Diagram (Anne Arundel County 2011)

Figure 4.10 is my rendered proposed RSC design for Langston Golf Course.

Figure 4.10 Langston's Proposed Stream Restoration

Langston's new stream is a very inviting water habitat, which caters to wildlife and humans. It illustrates the how biodiversity is intrinsic to the qualities we value such as physical beauty and harmony. It also brings precedents for ecological systems for golf course innovation that can be used for environmental and national species decline wellness. Regenerative Stream Conveyance in this study addressed wildlife habitat creation but it also helps humans. Humans and golf course managers benefit better economically and environmentally. This natural stream system also functions as a mitigation system for stormwater and erosion control. It also, introduces more revenue for the site, and requires low maintenance cost. The stream also, helps incorporate interpretive learning and brings aesthetic curb appeal to the guests who visit the site.

Chapter 5: Conclusion and Summary

The objective of this research was to explore how ecological practices can be incorporated on a golf course to help create habitats for amphibian and reptiles. The support of amphibian and reptiles is critical to both address national population declines and to educate people about amphibian and reptiles. This thesis was divided into the following sections: 1) introduction and purpose, 2) the literature review, 3) site history and analysis, and, 4) the final design application and proposals for a case study demonstration – Langston Golf Course in Washington D.C.

The case study demonstration was supported by a literature review organized in four areas. The first area explored critical ecological influences that contributed to amphibian and reptile declines due to human activities. The second area documented best management practice (BMPs)and best development practices (BDPs) for amphibians and reptiles including a broad understanding of breeding and mating periods for amphibian and reptiles in the Mid-Atlantic region. Vernal pools and RSCs were the two important BMPs that are being created in built environments. The third area of the literature explored golf course trends that support environmental stewardship. The principles of the Audubon Cooperative Sanctuary Program and the case studies explored provided support for my proposals for Langston Golf Course. The last section of the literature review explored federal, state, and local regulations and efforts. Federal efforts are primarily limited to wetlands and not always to vernal pools. State and local efforts are more likely to be successful for vernal pools and stream restoration efforts because they give credits to residents and businesses.

The design application was organized into two Chapters. Chapter 3 provided the context, history and site inventory of the Langston Golf Course. A suitability model determining the most suitable location to create and construct a vernal pool was developed. A conceptual GIS model was developed to determine where to place these habitats on the site and have it function for both humans and wildlife. The applications were conceptual to proximities and species breeding and mating cycles throughout the year. Human inclusions and exclusions were liable to happen, so analysis and research revealed high species mortality within certain areas on the golf course. The GIS models simplified the locations to a few sites that were determined to be best suitable areas for habitat. This provides an example of a method for designs and golf course managers to locate vernal pools in other existing golf courses and protect existing areas for consideration in a proposed golf course or other open space.

Building on the inventory and suitability model in Chapter 3, Chapter 4 provides the master plan and design goals and demonstration of the proposal for both providing habitats for reptile and amphibian and educating users about amphibians and reptiles. The master plan also proposes additional elements to improve the golf course and commemorate John Langston and the other founders of the site.

The proposed habitats designs, vernal pools and RSCs, for Langston Golf Course provide examples of where habitat creation on golf courses can develop in non-play areas, thus supporting both humans and wildlife. These additions support both economic and environmental principles that the can be appreciated by all. Best management practices are a sustainable way to ensure these proposals can be implemented and monitored. Gaining stewardship through the Audubon Sanctuary Program not only gives Langston Golf Course users and managers recognition but saves them economically and environmentally.

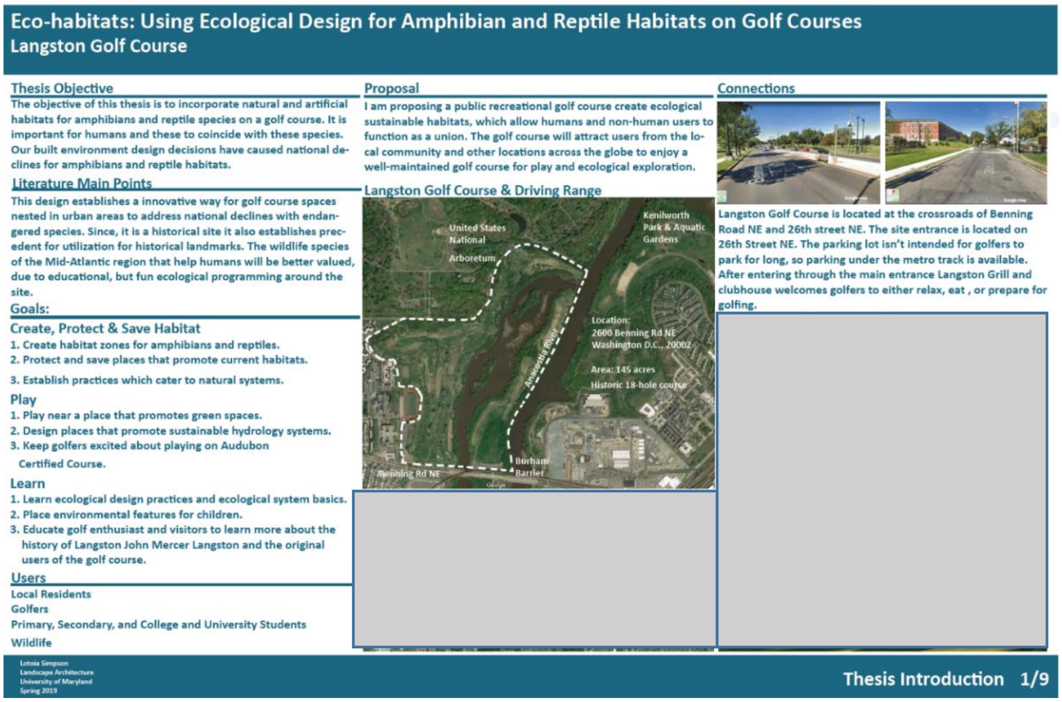
Creating habitat for amphibian and reptile species and supporting environmental education is a great way for golf courses to gain public recognition and increase users for both play and learning. Best development practices and outreach and education cater to children and adults. Children and adults' outdoor classrooms are very important for local communities and help golfers to be knowledgeable, while satisfying their time to play. I also propose an Eco-Golf game to promote an emphasis on incorporating educating programming on the golf course. The proposal supports different mode of habitat exploration for wildlife species and their traits through a fun learning method.

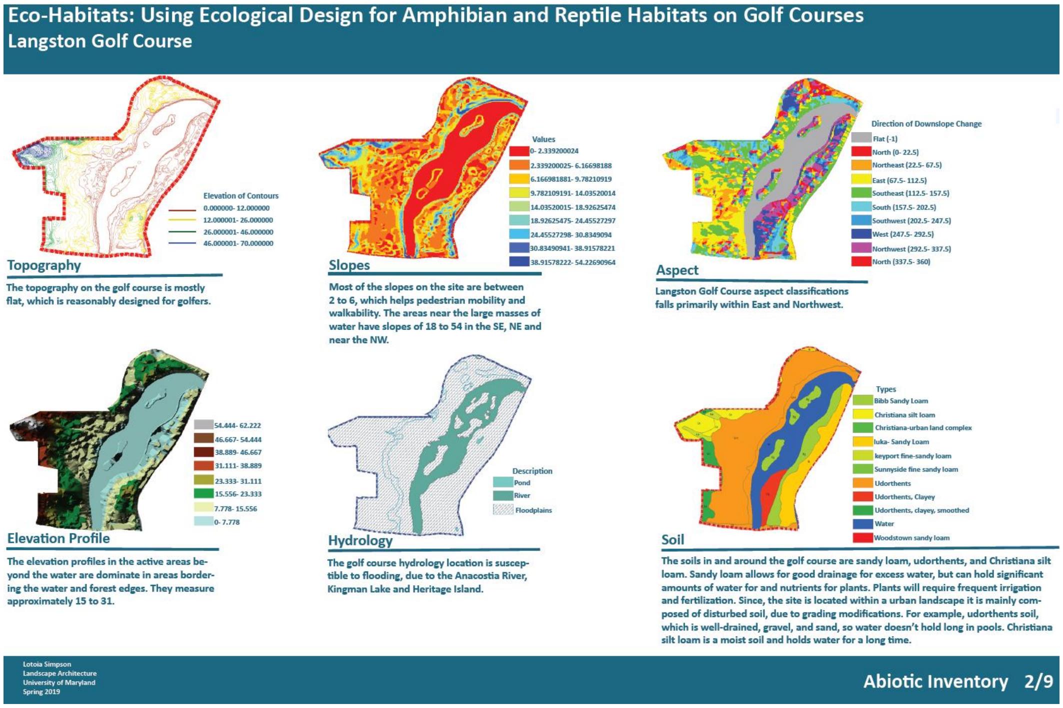
In summary, the conservation, restoration, and creation of amphibian and reptile habitats on golf courses is a practice that should be embraced by all golf courses designers and managers. Ecological habitats that help advocate for amphibian and reptile species can be incorporated into golf courses to benefit both humans and wildlife. Creating a golf course that provides the opportunities for people to be more interested in golfing and amphibian and reptiles provides a positive outlook for both golfers and wildlife.

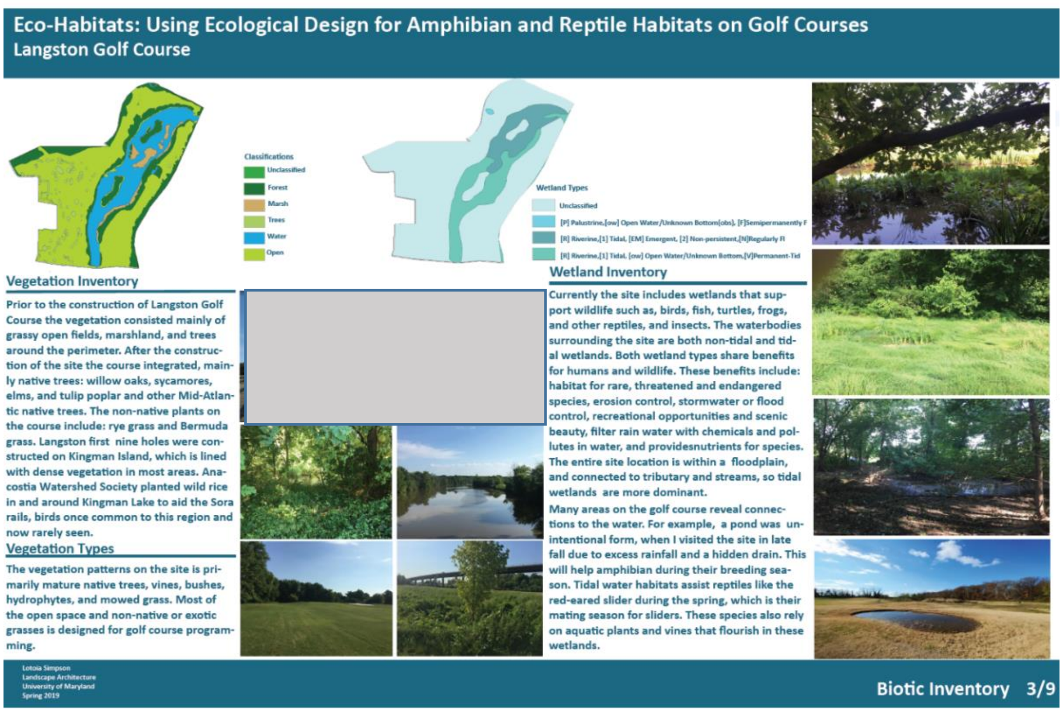
Appendices

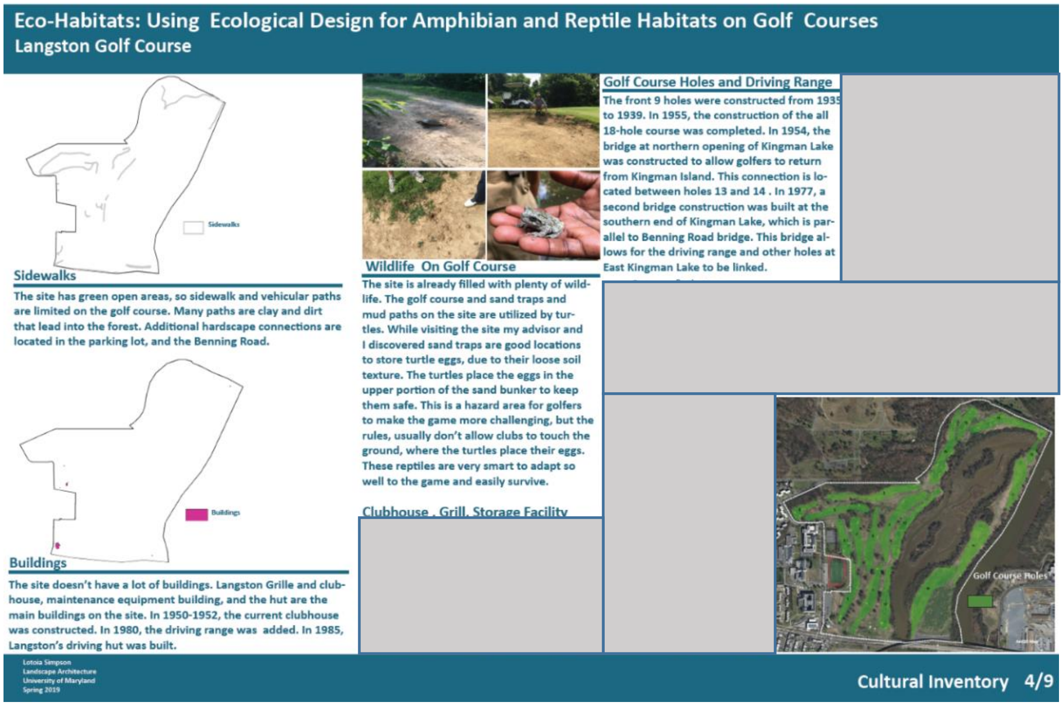
Appendix 1

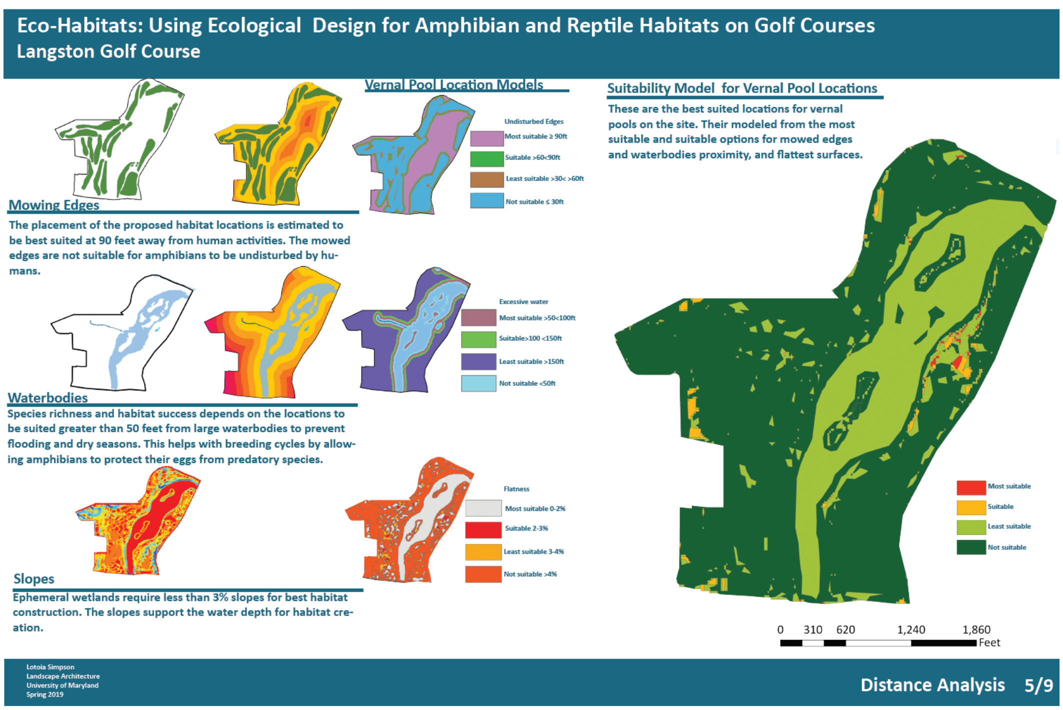
Boards 1-9




Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course
Elevation of Contours
0.000000- 12.000000
12.000001- 26.000000
26.000001- 46.000000
46.000001- 70.000000
Topography
The topography on the golf course is mostly flat, which is reasonably designed for golfers.
Values
0- 2.339200024
2.339200025- 6.16698188
6.166981881- 9.78210919
9.782109191- 14.03520014
14.03520015- 18.92625474
18.92625475- 24.45527297
24.45527298- 30.8349094
30.83490941- 38.91578221
38.91578222- 54.22690964
Slopes
Most of the slopes on the site are between 2 to 6, which helps pedestrian mobility and walkability. The areas near the large masses of water have slopes of 18 to 54 in the SE, NE and near the NW.
Direction of Downslope Change
Flat (-1)
North (0- 22.5)
Northeast (22.5- 67.5)
East (67.5- 112.5)
Southeast (112.5- 157.5)
South (157.5- 202.5)
Southwest (202.5- 247.5)
West (247.5- 292.5)
Northwest (292.5- 337.5)
North (337.5- 360)
Aspect
Langston Golf Course aspect classifications falls primarily within East and Northwest.
54.444- 62.222
46.667- 54.444
38.889- 46.667
31.111- 38.889
23.333- 31.111
15.556- 23.333
7.778- 15.556
0- 7.778
Elevation Profile
The elevation profiles in the active areas beyond the water are dominate in areas bordering the water and forest edges. They measure approximately 15 to 31.
Description
Pond
River
Floodplains
Hydrology
The golf course hydrology location is susceptible to flooding, due to the Anacostia River, Kingman Lake and Heritage Island.
Types
Bibb Sandy Loam
Christiana silt loam
Christiana-urban land complex
Iuka- Sandy Loam
keyport fine-sandy loam
Sunnyside fine sandy loam
Udorthents
Udorthents, Clayey
Udorthents, clayey, smoothed
Water
Woodstown sandy loam
Soil
The soils in and around the golf course are sandy loam, udorthents, and Christiana silt loam. Sandy loam allows for good drainage for excess water, but can hold significant amounts of water for and nutrients for plants. Plants will require frequent irrigation and fertilization. Since, the site is located within a urban landscape it is mainly composed of disturbed soil, due to grading modifications. For example, udorthents soil, which is well-drained, gravel, and sand, so water doesn't hold long in pools. Christiana silt loam is a moist soil and holds water for a long time.
Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019
Abiotic Inventory 2/9


Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course
Classifications
Unclassified
Forest
Marsh
Trees
Water
Open
Wetland Types
Unclassified
[P] Palustrine,[ow] Open Water/Unknown Bottom(obs), [F]Semipermanently F
[R] Riverine,[1] Tidal, [EM] Emergent, [2] Non-persistent,[N]Regularly Fl
[R] Riverine,[1] Tidal, [ow] Open Water/Unknown Bottom,[V]Permanent-Tid
Vegetation Inventory
Prior to the construction of Langston Golf Course the vegetation consisted mainly of grassy open fields, marshland, and trees around the perimeter. After the construction of the site the course integrated, mainly native trees: willow oaks, sycamores, elms, and tulip poplar and other Mid-Atlantic native trees. The non-native plants on the course include: rye grass and Bermuda grass. Langston first nine holes were constructed on Kingman Island, which is lined with dense vegetation in most areas. Anacostia Watershed Society planted wild rice in and around Kingman Lake to aid the Sora rails, birds once common to this region and now rarely seen.
Vegetation Types
The vegetation patterns on the site is primarily mature native trees, vines, bushes, hydrophytes, and mowed grass. Most of the open space and non-native or exotic grasses is designed for golf course programming.
Wetland Inventory
Currently the site includes wetlands that support wildlife such as, birds, fish, turtles, frogs, and other reptiles, and insects. The waterbodies surrounding the site are both non-tidal and tidal wetlands. Both wetland types share benefits for humans and wildlife. These benefits include: habitat for rare, threatened and endangered species, erosion control, stormwater or flood control, recreational opportunities and scenic beauty, filter rain water with chemicals and pollutes in water, and providesnutrients for species. The entire site location is within a floodplain, and connected to tributary and streams, so tidal wetlands are more dominant.
Many areas on the golf course reveal connections to the water. For example, a pond was unintentional form, when I visited the site in late fall due to excess rainfall and a hidden drain. This will help amphibian during their breeding season. Tidal water habitats assist reptiles like the red-eared slider during the spring, which is their mating season for sliders. These species also rely on aquatic plants and vines that flourish in these wetlands.
Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019
Biotic Inventory 3/9


Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course
Sidewalks
Sidewalks
The site has green open areas, so sidewalk and vehicular paths are limited on the golf course. Many paths are clay and dirt that lead into the forest. Additional hardscape connections are located in the parking lot, and the Benning Road.
Buildings
Buildings
The site doesn't have a lot of buildings. Langston Grille and club-house, maintenance equipment building, and the hut are the main buildings on the site. In 1950-1952, the current clubhouse was constructed. In 1980, the driving range was added. In 1985, Langston's driving hut was built.
Wildlife On Golf Course
The site is already filled with plenty of wild-life. The golf course and sand traps and mud paths on the site are utilized by tur-tles. While visiting the site my advisor and I discovered sand traps are good locations to store turtle eggs, due to their loose soil texture. The turtles place the eggs in the upper portion of the sand bunker to keep them safe. This is a hazard area for golfers to make the game more challenging, but the rules, usually don't allow clubs to touch the ground, where the turtles place their eggs. These reptiles are very smart to adapt so well to the game and easily survive.
Clubhouse , Grill, Storage Facility
Golf Course Holes and Driving Range
The front 9 holes were constructed from 1935 to 1939. In 1955, the construction of the all 18-hole course was completed. In 1954, the bridge at northern opening of Kingman Lake was constructed to allow golfers to return from Kingman Island. This connection is lo-cated between holes 13 and 14 . In 1977, a second bridge construction was built at the southern end of Kingman Lake, which is par-allel to Benning Road bridge. This bridge al-lows for the driving range and other holes at East Kingman Lake to be linked.
Golf Course Holes
Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019
Cultural Inventory   4/9


Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course
Vernal Pool Location Models
Undisturbed Edges
Most suitable ≥ 90ft
Suitable >60<90ft
Least suitable >30< >60ft
Not suitable ≤ 30ft
Mowing Edges
The placement of the proposed habitat locations is estimated to be best suited at 90 feet away from human activities. The mowed edges are not suitable for amphibians to be undisturbed by hu-mans.
Excessive water
Most suitable >50<100ft
Suitable>100 <150ft
Least suitable >150ft
Not suitable <50ft
Waterbodies
Species richness and habitat success depends on the locations to be suited greater than 50 feet from large waterbodies to prevent flooding and dry seasons. This helps with breeding cycles by allow-ing amphibians to protect their eggs from predatory species.
Flatness
Most suitable 0-2%
Suitable 2-3%
Least suitable 3-4%
Not suitable >4%
Slopes
Ephemeral wetlands require less than 3% slopes for best habitat construction. The slopes support the water depth for habitat cre-ation.
Suitability Model for Vernal Pool Locations
These are the best suited locations for vernal pools on the site. Their modeled from the most suitable and suitable options for mowed edges and waterbodies proximity, and flattest surfaces.
Most suitable
Suitable
Least suitable
Not suitable
0 310 620 1,240 1,860
Feet
Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019
Distance Analysis   5/9

Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course

Vision:
Langston Golf Course has the potential to become a well recognized public park that not only has a golf venue, but also a ecological habitat for endangered species of the Mid-Atlantic. By conserving and restoring amphibian and reptile habitats within this golf course designers and users of the course can reestablish these species existence among large open spaces. Golf courses are prime landscapes to be utilized and promoted for human and wildlife commingling.

Goals:

Create, Protect & Save Habitat
1. Create habitat zones for amphibians and reptiles.
2. Protect and save places that promote current habitats.
3. Establish practices which cater to natural systems.

Play
1. Play ina place that promotes green spaces.
2. Design places that promote sustainable hydrological systems.
3. Keep golfers excited about playing on Audubon Certified Course.

Learn
1. Learn ecological design practices and ecological system basics.
2. Place environmental features for children.
3. Educate golf enthusiast and visitors to learn more about the history of John Mercer Langston and the original users of the golf course.

Users
Local Residents
Golfers
Primary, Secondary, and College and University Students
Wildlife

Design Proposals :

Vernal Pools incorporate many endangered animals and plant species who strive well in sustainable habitat.

Stream Restoration provides a place for amphibian and reptile species to have additional habitat. It also helps human users of the site mediate the high velocity from sotormwater runoff and erosion wear and tear.

Golf Park Meadow placed at the main entrance adjacent to 26th street near the club house building and parking lot.

Sculpture Park Garden within the fenced area along side Benning Road. A statue within a garden path, which is craved in bronze represents John Langston and his achievements on a podium.

Wayfinding Banners incorporated in the parking lot inform D.C. commuters of John M. Langston and the other African American founders of the site. Some banners highlight the wildlife species too.

Inspirations




Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019

Master Plan 6/9

Eco-Habitats: Using Ecological Design for Amphibian AND Reptile Habitats on Golf Courses
Langston Golf Course

Introduction: Programming
Langston Golf Course and other golf course programming should incorporate learning through a ecological golf theme. A golf course is a great place to introduce more play in the form of biodiversity. The constraints and opportunities in my proposed programming was mindful of not incurring any liability or injuries. While ecological outdoor learning is great for everyone it needs to be considered closely on a golf course. By planning outdoor playing and learning activities in advance that problem is minimized. Many nature related activities have successful learning days with the help of supervised adults and instructors, so grouping children with responsible peers is needed in the proposal. The golf course users are also welcome to participate because, this helps all parties that visit the landscape through education and play.

Goals:

Create, Protect & Save Habitat
1. Create habitat zones for amphibians and reptiles.
2. Protect and save places that promote current habitats.
3. Establish practices which cater to natural systems.

Play
1. Play in a place that promotes green spaces.
2. Design places that promote sustainable hydrological systems.
3. Keep golfers excited about playing on Audubon Certified Course.

Learn
1. Learn ecological design practices and ecological system basics.
2. Place environmental features for children.
3. Educate golf enthusiast and visitors to learn more about the history of John Mercer Langston and the original users of the golf course.

Users
Local Residents
Golfers
Primary, Secondary, and College and University Students
Wildlife

Precedents


Proposed Programming
My programming proposal is called Eco-golf because, it addresses ecological habitat and environmental concerns, and provides different uses for golf course landscapes. Children and adults will receive a map at the clubhouse in a brochure format to begin a scavenger hunt. The map quest activity game will take place on the golf course on several planned days in the spring and summer to teach all site users about ecological habitats pertaining to amphibians and reptiles and other species that utilize the golf course. The children and adults through my programming will go through a map quest to advance through 10 holes on the course. There will be replicated statues of frogs, turtles, salamanders and other species of the site in habitat zones near or adjacent to my proposed BMPs. Each zone will include interpretive zones and specific in materials like egg types shaped as clay or moldings, and common names, sounds, etc, for specific species.

The programming allows all the intended users of the proposal to share environmental learning . It also places emphasis and concerns on saving the species that live on the golf course. Each user of the site that participates will gain knowledge of how golf courses can be primary habitat for ecosystems they knew little about through several planned days out of the year.

Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019

Proposed Programming 7/9

Creating Habitats

Introduction

Many amphibians and reptiles in the Northeast region of the United States depend on vernal pools for their primary habitat. Vernal pools species include, frogs, snakes, salamanders, fairy shrimp, turtles, and newts. According to Thomas Biebighauser,author of "a guide to Creating Vernal Ponds", approximately one-half of all frogs and one-third of all salamander species rely on seasonal or temporary wetlands for development. Langston Golf Course will aid in habitat creation that helps conserve and restore wildlife around the course. Eventhough, the site includes protected wetlands, adding vernal pools aid help create additional habitat areas. According to the EPA small areas of habitat that are connected by corridors typically receive greater wildlife use than isolated habitats. Adjacent areas are valuable habitats, planners can improve biodiversity by striving to create opportunities for the site ecology to support the existing regional landscape and habitat corridors.

Goals

Create, Protect and Save Habitat
Create habitat zones for amphibian and reptiles.
Protect and save places that promotecurrent habitats.
Establish practices that limit pesticide and other chemicals.
Play
At a place that promotes open green spaces.
Keep golfers excited about playing on green golf course.
Design places that promote sustainable hydrology systems.
Learn
Ecological design practices and ecological system basics.
Place environmental features for neighborhood children.
Educate golf enthusiast and visitors to learn more about the history of John Mercer Langston and the original users of the golf course.

User Groups

Local Residents
Golfers
Primary, Secondary, and College and University Students
Wildlife

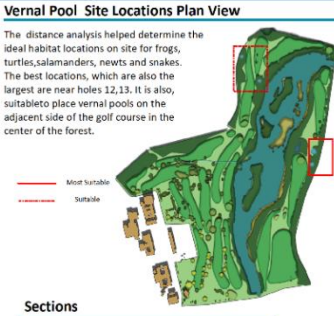
Precedent

Vernal pools service as temporary pools, for amphibian and reptiles, and collect water in depressions, usually in late winter or early spring due to snow melt, heavyrains, and raised water table. Since, fish are not present in the pools, non-predatory habitats are provided for many amphibian and reptiles. Vernal pools come in many shapes and sizes, but are typically small compared to many types permanent wetlands. The water in the pool usually holds for two consective months to allow for breeding cycles.

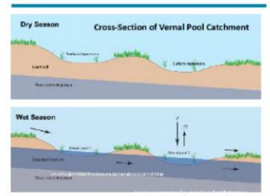
Perspective

Vernal Pool Site Locations Plan View

The distance analysis helped determine the ideal habitat locations on site for frogs, turtles,salamanders, newts and snakes. The best locations, which are also the largest are near holes 12,13. It is also, suitableto place vernal pools on the adjacent side of the golf course in the center of the forest.



Sections



This habitat allows semi-aquatic species like turtles, and frogs to have enjoy the benefits of terrestial and aquatic areas throughout the year.

Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019

Focus Best Management Practice: Vernal Pools

Eco-Habitats: Using Ecological Design for Amphibian and Reptile Habitats on Golf Courses
Langston Golf Course

Introduction: Creating Habitats

Many amphibians and reptiles in the Mid-Atlantic live in shallow streams or pools near the forest edge. Langston Golf Course has a closed stream, which I have proposed to be restored into a RSC. According to Biohabitats, Regenerative Stream/Stormwater Conveyance systems provide a combination of features and treatment benefits of swales, infiltration, filtering, and wetland practices. RSC systems incorporate stormwater management with wetlands and stream restoration. This BMP reduces the velocity of stormwater, and filters pollution, and provides diverse ecosystems for various plants, animals, amphibians, and insects.

Goals:

Create, Protect & Save Habitat

1. Create habitat zones for amphibians and reptiles.
2. Protect and save places that promote current habitats.
3. Establish practices which cater to natural systems.

Play

1. Play in a place that promotes green spaces.
2. Design places that promote sustainable hydrological systems.
3. Keep golfers excited about playing on Audubon Certified Course.

Learn

1. Learn ecological design practices and ecological system basics.
2. Place environmental features for children.
3. Educate golf enthusiast and visitors to learn more about the history of John Mercer Langston and the original users of the golf course.

Users

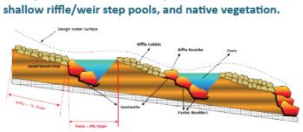
Local Residents
Golfers
Primary, Secondary, and College and University Students
Wildlife

Precedents

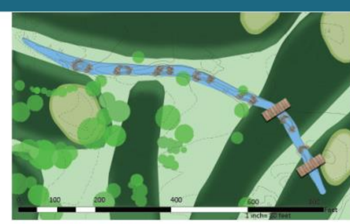
https://twitter.com/linksgems/status/942254429876649984?lang=en
https://ncseagrant.ncsu.edu/

Including stream restoration practices on a golf course decreases erosion, controls excess stormwater runoff, and creates habitats for amphibians and reptiles. Regenerative Stream/Stormwater conveyances act as riparian buffers, so trees and vegetation aid in the creation of RSCs. The vegetation in and out of the water provide food, refuge and shelter.

This open channel consist of a porous sand media bed, shallow riffle/weir step pools, and native vegetation.



https://ncseagrant.ncsu.edu/currents/2015/03/a-new-method-to-restore-streams-borrowed-from-maryland/



Proposed RSC Enlargement

The RSC and additional sand traps were placed on the course to create habitat for turtles eggs and as a corridors for all wildlife.

Langston's proposed stream restoration

Langston's new stream is a very inviting water habitat, which caters to wildlife and humans. It illustrates the concept how biodiversity is intrinsic to the qualities we value such as physical beauty and harmony. It also brings precedents for ecological systems for golf course innovation that can be used for environmental and national species decline wellness.

Lotoia Simpson
Landscape Architecture
University of Maryland
Spring 2019

Regenerative Stream Conveyance 9/9

Bibliography

Anne Arundel County, Maryland. 2011. Regenerative Step Pool Storm Conveyance (SPSC), Design Guidelines. Revision 3: July 2011. http://www.aacounty.org/DPW/Watershed/StepPoolStormConveyance.cfm

Audubon International. 2019 https://auduboninternational.org/acsp-for-golf/

Babin, P. 2017. *Links to the past: A historic resource study of national park service golf courses in the District of Columbia: East Potomac park golf course, rock creek golf course, Langston Golf course. Washington, DC:* US Department of the Interior, United States National Park Service. National Capital Region Office of Resource Stewardship and Science.

Better Billy Bunker. 2019. https://www.billybunker.com/copy-of-better-billy-bunker

Boone, M., R. Semlitsch, and C. Mosby. 2008. Suitability of Golf Course Ponds for Amphibian Metamorphosis When Bullfrogs Are Removed. *Conservation Biology* 22 (1): 172-179.

Beier, P., D. Majka, and W. Spencer. 2008. Forks in the road: Choices in procedures for designing wildland linkages. *Conservation Biology* 22 (4), 836-851.

Biebighauser, T. 2002. A guide to creating vernal ponds*:* All the information you need to build and maintain an ephemeral wetland. Morehead, KY: United States Forest Service. Retrieved from https://permanent-access-gpo-gov.proxy-um.researchport.umd.edu/lps51369/vernal.pdf.

Biohabitats, 2010. http://www.locustchapel.com/wp-content/uploads/2014/11/Habitat-Management-Plan.pdf

Burke, V., and J. Gibbons. 1995. Terrestrial Buffer Zones and Wetland Conservation: A Case Study of Freshwater Turtles in a Carolina Bay. *Conservation Biology* 9(6), 1365- 1369.

Calhoun, A., J.Arrigoni, R. Brooks, M. Hunter, and S. Richter. 2014. Creating successful vernal pools: A literature review and advice for practitioners.

Wetlands: *Official Scholarly Journal of the Society of Wetland Scientists*, 34 (5), 1027-1038.

Calhoun, A., N. Miller, and M. Klemens. 2005. Conserving pool-breeding amphibians in human-dominated landscapes through local implementation of best development practices. *Wetlands Ecology and Management* 13 (3), 291-304.

Colding, J., and C. Folke. 2009. The role of golf courses in biodiversity conservation and ecosystem management. *Ecosystems* 12 (2), 191-206.

Colding, J., J. Lundberg, S. Lundberg, and E. Anderson. 2009. Golf courses and wetland fauna. *Ecological Applications* 19 (6), 1481-1491.

Croshaw DA, D.E. Scott. 2006. Marbled salamanders (Ambystomaopacum) choose low elevation nest sites when cover availability is controlled. *Amphibia-Reptilia* 27:359–364

Denton, Robert D. and Stephen C. Richter 2013. Amphibian Communities in Natural and Constructed Ridge Top Wetlands with Implications for Wetland Construction. *Journal of Wildlife Management* 77 (5):886–896.

Dorcas, Michael E. and Steven J. Price. 2008. Effective Undergraduate-based herpetological research in an urban environment, *Herpetological Conservation* 3:541-547.

Dodson, Don. 2002. The Audubon Cooperative Sanctuary Program for Golf Courses. *USGA Turfgrass and Environmental Research Summary*. Audubon International.

EPA. 2013. Keeping it Green on a Golf Course. https://blog.epa.gov/2013/03/11/keeping-it-green-on-a-golf-course/

Ferguson, Bruce K. 1994. Stormwater Infiltration. CRC Press, Boca Raton, FL.

Guzy, J., Witczak, L., and Dorcas, M. 2013. Do ponds on golf courses provide suitable habitat for wetland-Dependent animals in suburban areas? An assessment of turtle abundances. Journal of Herpetology, 47(2), 243-250.

Harper EB, T.A.G. Rittenhouse, R.D. Semlitsch. 2008. Demographic con-sequences of terrestrial habitat loss for pool-breeding amphibians:predicting extinction risks associated with inadequate size of bufferzones. *Conservation Biology* 22:1205–1215.

Holzer, K., and S. Lawler. 2015. Introduced Reed Canary Grass Attracts and Supports a Common Native Amphibian. *The Journal of Wildlife Management*, 79 (7), 1081-1090.

Humphries W.J., M.A. Sisson. 2012. Long distance migrations, landscape use, and vulnerability to prescribed fire of the gopher frog (Lithobates capito). *Journal of Herpetology* 46:665–670

Krajick, K. 2005. Edge Walking on the Urban Fringe. *Conservation in Practice* 6: 87-93.

Langen, T., K. Ogden, and L. Schwarting. 2009. Predicting hot spots of herpetofauna road mortality along highway networks. *Journal of Wildlife Management,* 73(1), 104- 114.

Lesbarrères, D., M. Fowler, A. Pagano, and Lodé, T. 2010. Recovery of anuran community diversity following habitat replacement. Journal of Applied Ecology 47(1),148-156.

Marshall, John. 2013. "Indicator Species: Using Frogs and Salamanders to Gauge Ecosystem Health - Animals - GRIT Magazine." *Grit*, July 2013, Ogden Publications, Inc.www.grit.com/departments/indicator-species-zm0z13jazgou.

Martin, L. J. and B. Blossey. 2013. Intraspecific variation overrides origin effects in impacts of litter-derived secondary compounds on larval amphibians. – *Oecologia* 173: 449– 459.

Nagda, B.A., S.R. Gregerman, J. Jonides, W. von Hippel, and J.S. Lerner, 1998. Undergraduate Student- Faculty Research Partnerships Affect Student Retention. *The Review of Higher Education* 22: 55-72.

National Capital Parks-East- Anacostia Park. 2017. National Park Service Cultural Landscapes Inventory, Langston Golf Course.

Newman R.A. 1998. Ecological constraints on amphibian metamorphosis: interactions of temperature and larval density with responses to changing food level. *Oecologia* 115:9–16.

Oscarson, D. and A. Calhoun. 2007. Developing Vernal Pool Conservation Plans at the Local Level Using Citizen- Scientists. *Wetlands*, 27(1), 80-95.

Porej D, T.E. Hetherington. 2005. Designing wetlands for amphibians: the importance of predatory fish and shallow littoral zones in structuring amphibian communities. *Wetland Ecology Management* 13:445–455.

Ramirez, E., H. Puglis, A. Ritzenthaler, and M. Boone. 2012. Terrestrial movements and habitat preferences of male cricket frogs on a golf course. *Copeia* 2012(2), 191-196.

Richardson, J. L. 2012. Divergent landscape effects on population connectivity in two co-occurring amphibian species. *Molecular Ecology*, 21: 4437-4451.

Rittenhouse, C., J. Millspaugh, M. Hubbard, and S. Sheriff. 2007. Movements of translocated and resident three-Toed box turtles. *Journal of Herpetology* 41(1), 115-121.

Salvesen, D. 1990. Wetlands: mitigating and regulating development impacts. *Urban Land Institute*, Washington, D. C.

Schoville, S., T. Tustall, V. Vredenburg, A. Backlin, E. Gallegos, D. Wood, and R. Fisher. 2011. Conservation genetics of evolutionary lineages of the endangered mountain yellow-legged frog, rana muscosa (Amphibia: Ranidae), in southern California. *Biological Conservation* 144 (7), 2031-2040

Shulse, C., R. Semlitsch, K. Trauth, and J. Gardner. 2012. Testing wetland features to increase amphibian reproductive success and species richness for mitigation and restoration. *Ecological Applications* 22 (5), 1675-1688.

Simon J.A., J.W. Snodgrass, R.E. Casey, D.W. Sparling. 2009. Spatial correlates of amphibian use of constructed wetlands in an urban land-scape. *Landscape Ecology* 24:361–373

Skidds, D., F. Golet, P. Paton, and J. Mitchell. 2007. Habitat correlates of reproductive effort in wood frogs and spotted salamanders in an urbanizing watershed. *Journal of Herpetology* 41(3), 439-450.

Switalski, T., J. Bissonette, T. DeLuca, C. Luce, and M. Madej. 2004. Benefits and impacts of road removal. *Frontiers in Ecology and the Environment* 2(1), 21-21.

USGA. 2017. Converting Maintained Turf to Native Grasses. http://www.usga.org/course-care/water-resource-center/bmp-case-studies/2017/converting-maintained-turf-to-native-grasses.html

United States Fish and Wildlife Service (USFWS). 2017. Kids' Species Information. Sacramento Fish and Wildlife Office https://www.fws.gov/sacramento/es_kids/Vernal-Pool-Fairy-Shrimp/

Vasconcelos D. and A.J.K. Calhoun. 2006. Monitoring created seasonal pools for functional success: a six-year case study of amphibian responses, Sears Island, Maine, USA. *Wetlands* 26:992–1003

West Virginia Department of Environmental Service. 2012. http://dep.wv.gov/WWE/Programs/stormwater/MS4/Documents/Specification_4.2.7_Regenerative_Stormwater_Conveyance_WV-SW-Manual-11-2012.pdf

Widow’s Walk. 2019. https://www.scituatema.gov/widows-walk-golf-course

Wisdom, M. J., L. S. Mills, and D. F. Doak. 2000. Life stage simulation analysis: estimating vital rate effects on population growth for conservation. *Ecology* 81:628-641.

Woodford, J., and M. Meyer. 2003. Impact of lakeshore development on green frog abundance. *Biological Conservation* 110 (2), 277-284.