ECOLOGICALLY-BASED CITY PARK MASTER PLAN

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project summary

City Park is a 320 acre park centrally located in the city and serving eight adjacent neighborhoods and the metropolitan area. It is considered a regional park as 85% of all Denver residents live within a five-mile radius. The Denver Zoo, Museum of Nature and Science, and the City Park Golf Course are located in the park. Recreation is a significant use in the park with multiple athletic fields and tennis courts, picnic areas, playgrounds, and paddleboat rentals. The park also has historical significance as seen through its monuments and structures, views to downtown Denver and the Rocky Mountains, formal gardens, lakes, and an expansive tree canopy.

Popular summer events such as Jazz in the Park, races, cultural festivals, and other annual activities are hosted in City Park. While the park has evolved to be one of the most popular destinations in the city since its opening in 1882, it still serves ecological functions through its important role in stormwater management, wildlife habitat and vegetation, and circulation. However, significant degradation of this ecological function has occurred to create complex challenges today – including impaired water quality, a lack of connectivity within the park for all modes of transportation resulting in confusing navigation, and low diversity in vegetation due to grass monoculture and the lack of native species.

This plan presents recommendations to maximize the ecological function of City Park in Denver within its context as a large, urban park. With City Park's location and size, it has the potential to become a model for urban park sustainability for the Denver metro area and beyond. Background research focuses on determining criteria toward achieving this sustainability model concept.

These criteria are used to evaluate existing plans for the park and identify gaps in these plans. Literature is then used to provide supplemental information that directs future analysis and provides a foundation for recommendations in our Ecologically Based Plan. Utilizing the Sustainable Urban Site Design Manual as guidance, we decided to use the criteria of stormwater management, wildlife habitat and vegetation, and circulation to direct the ecological and sustainable future of City Park (to read further about this process, see Appendix A). We applied these same three criteria to an existing conditions analysis to evaluate the current state of the park.

existing conditions

stormwater management

The lakes, fed from recycled City Ditch water, suffer from elevated pH, decreased dissolved oxygen concentrations, and high levels of ammonia from the rookeries on Duck Lake and Ferril Lake. Pollution in runoff from surrounding areas also contributes to impaired water quality. Shorelines of Little Lake and the eastern half of Ferril Lake are barren and present an opportunity for improvement aiding in provision of habitat and water filtration. Duck Lake's previously constructed wetland is also drastically degraded and requires restoration.

circulation

Road and path surface materials have been changed over time, road closures have occurred, and gates have been implemented at entrances. The Denver Zoo and the Museum of Nature and Science have also become entities whose interests potentially compete with those of the park rather than being mutually beneficial.

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These changes have disconnected paths between amenities and made navigation confusing, as well as detracted from the use and character of paths for pedestrian/bicycle circulation. The Regional Bicycle Route is difficult to find with unclear connections and conflicts with vehicles at highly active areas, while pedestrian paths have insufficient wayfinding and surface material degradation and inconsistency. Visual and physical connections are deficient within the park, and pedestrian access between the Zoo and the Museum is missing. Connectivity is lacking within the park, among entities such as the park itself, the Museum, and the Zoo, as well as connection to City Park from adjacent neighborhoods.

wildlife habitat and vegetation

Wildlife habitat and vegetation within the park is provided by the water bodies, tree canopy, and historic gardens and vegetation. Today, a Black Capped Night Heron rookery is present on the islands in Duck and Ferril Lake, as well as the fourth largest Doubled-Breasted Cormorant Rookery in Colorado on Duck Lake's island. A majority of City Park's open water lacks development of wetland or riparian habitat, making the area attractive to Canada Geese but not to most other waterfowl. The wetland constructed along Duck Lake's shoreline requires restoration as the function is not being realized to its fullest extent. City Park has also suffered from duck weed blooms in Duck Lake and bouts of avian botulism annually at times depending on conditions.

Tree-lined paths, roads, and edges are part of the original design of City Park but over the past few decades, original plantings have disappeared and either been left without replacement or been replaced with incompatible species.

Garden plantings such as the Botanical Garden (including the lilac plantings, some of which are missing and have no access from the adjacent pedestrian path), perennial, and native collections are also historically and ecologically significant to the function of City Park. Native plantings have been utilized in gardens to attract native butterfly species as well but there is no evidence of its success.

Tree canopy plays an important role in roosting and nesting as well as providing a food source for bird populations in the Denver region. Historically and ecologically, cottonwood, pine, spruce, and crabapple species that are present in the park are serving these purposes for migratory birds, songbirds, and other bird species – these trees account for around 31% of the tree inventory in City Park.

areas of ecological importance

From the existing conditions analysis, the following areas were identified as being significant to maximizing the ecological functioning of City Park. They will be used as a foundation for the analysis moving forward.

- **Waterways**: DeBoer Waterway, Lily Pond, Little Lake, Ferril Lake, and Duck Lake.
- **Formal Gardens**: Burns Garden, Sopris Garden, the Perennial Garden, Benedict Garden, the Botanic Gardens including the Lilac Collection, Prunus Collection, Box Canyon, and the Pinetum, as well as the Flowering Shrub Collection.
- **Vegetative Areas**: The DeBoer Natural Area, the Crabapple Collection, and the Cottonwood Grove.
- **Golf Course**: Detention plans, water features, and vegetation adjacent to the water.

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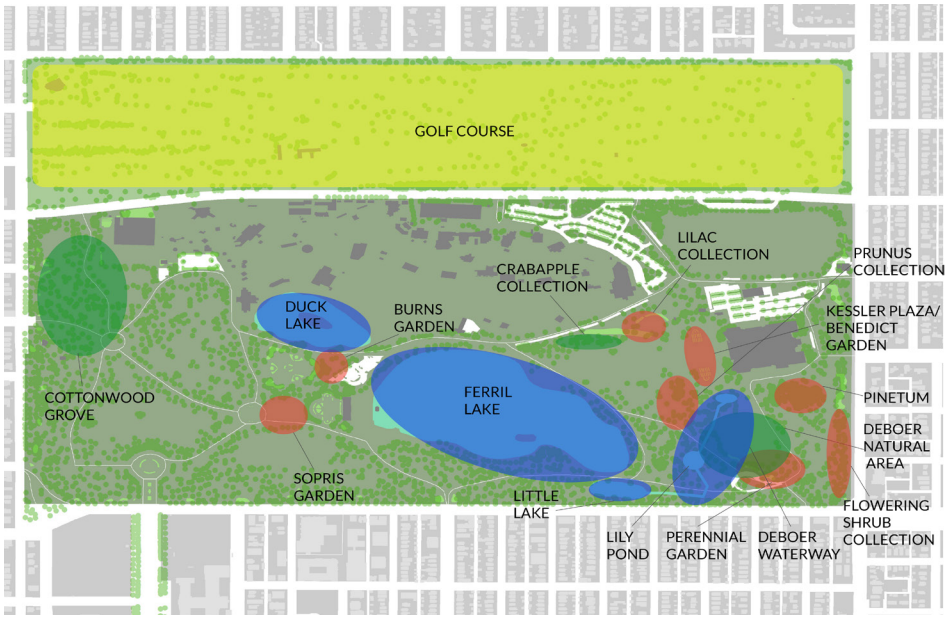

analysis

The plan recommendations are outlined in six sections; each includes multiple recommendations for 24 in all. These sections are organized into the large-scale context of the park, circulation/ connectivity within and to the park, and the Areas of Ecological Importance. They are then grouped by section, and generalized cost and time estimates per recommendation are given to create a framework to prioritize future implementation. The following are the recommendations for each section:

large-scale context

- For areas not utilized for recreation, replace turf with native prairie grasses, such as Buffalo grass, and wildflower meadows to help decrease the amount of pollutants entering waterways and improve water quality, irrigation and maintenance necessity, and provide habitat enhancement.
- Increase tree cover of flowering crabapple species and species in the pine, spruce, and cottonwood families to provide bird habitat in the park, aid in natural cooling, and decrease overall stormwater runoff.

circulation/connectivity

- Improve physical and visual connection between the park and the Denver Zoo by extending the braided path concept envisioned for the zoo into the park to create the Zoo Loop, re-opening the east and west entrances to the zoo, and improving the visibility offered through the fence around the zoo.
- Increase signage in the park to better facilitate easy navigation and potentially design signage in a way that evokes zoo signage to increase connectivity between the two entities while improving circulation, placemaking, and wayfinding.
- Create consistency of surface materials on park paths and trails to indicate use and help visitors easily navigate through the park.
- Increase connectivity and circulation in the park by better incorporating sometimes underutilized entities, such as the Graham Bible House, into the park for use potentially as a vendor location to maintain park visitation when there are not specific events being held.

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waterways

- Restore the DeBoer Waterway and its use as a water feature.
- Replant the Lily Pond with water lilies from Berkeley Lake.
- Implement subsurface aerators in Duck and Ferril Lakes.
- Implement constructed wetlands using gravel filters on the slopes of Little and Ferril Lakes to improve water quality of both
- Implement end-of-pipe filtration to treat for nutrient and pathogen pollution in the pipe between Ferril and Duck Lake that empties into the latter.

formal gardens

- Include native flower and grass species into existing formal gardens to makes the gardens more substantial and appropriate for native species' habitat, food, and shelter, as well as infiltration and drought tolerance.
- Retrofit existing formal garden beds to serve as rain gardens with either overflow or underdrain pipes to aid in stormwater quality and management.
- Implement milkweed plantings into the DeBoer Natural Area, south of the Lily Pond, and meadows not utilized for recreation to provide Monarch butterfly reproductive habitat.
- Implement a rain garden with native species that support butterfly populations in the area south of the Lily Pond.
- Incorporate flowers that attract adult butterflies into existing gardens to aid in the rebound of Monarch butterfly populations.
- Utilize improved butterfly habitat to educate park users about the status of Monarch butterfly populations and efforts undertaken in City Park to aid in their survival.

vegetative areas

- Utilize turf alternatives in the DeBoer Natural Area, the southwestern edge of the Big Meadow, and open areas not used for recreation to increase native grasses, vegetation, and plantings.
- Replace turf along shorelines with a vegetative fringe to decrease the Canada Goose population and attract native bird species to the area, as well as to improve water quality in the lakes.
- Preserve existing trees and replace trees that have died over time in the Cottonwood Grove and Crabapple Collection.

golf course

- Daylight channels that follow the storm pipe network, as well as the Hale Parkway to improve detention, mitigate flood events in the area, and create additional habitat for birds and other wildlife
- Relocate Bogey's Restaurant out of the future detention area and to higher ground.
- Implement vegetated swales in low lying areas and water channels to slow stormwater flow and increase stormwater quality.
- Increase native cottonwood plantings in riparian areas around waterways/detention areas.

project introduction

THE CLIENT

We were hired by the City Park Alliance to compose the Ecologically-Based City Park Master Plan for City Park in Denver, Colorado. The City Park Alliance is a non-profit run by a volunteer board of directors, including our client contact Greg Davis. Their goals are to collaborate with the community, mobilize partners and resources for capital improvements, programs, and events, and advocate for and communicate with stakeholders on issues affecting City Park. The board consists of representatives from Denver Parks and Recreation, the Denver Zoo, the Museum of Nature and Science, as well as community members that are interested in and committed to issues surrounding the park.

PURPOSE AND ISSUE

As Denver's largest urban park, City Park has public interest groups with polarized goals surrounding the use of the park. Contention exists around issues such as events, urban culture, protection of natural resources, historic form and preservation, and development. As Denver grows, external pressures on City Park also increase. The City Park Circulation Plan's propositions surrounding the creation of additional vehicular movement have the potential to contribute to significant habitat fragmentation as well as create additional impervious surfaces that generate concern for stormwater drainage. The current condition of the park coupled with these changes have caused concern over its future.

GOALS AND OBJECTIVES

The Ecologically-Based City Park Master Plan includes an assessment of the existing conditions that will guide an analysis resulting in recommendations that aim to resolve the issues experienced by the park and maximize its ecological function. The outcome is a holistic plan that considers the park uses, both current and potential, from an ecological perspective that is conscious of both the park's historic past and environmental future. The plan will serve as a valuable basis for discussion and future recommendations for the upcoming City Park Master Plan update being drafted by Denver Parks and Recreation.

PROPOSED APPROACH

With City Park's location and size, it has the potential to become a model for urban park sustainability for the Denver metro area and beyond. Background research focuses on determining criteria toward achieving this sustainability model concept. These criteria are used to evaluate existing plans for the park and identify gaps in these plans. Literature is then used to provide supplemental information that direct future analysis and provide a foundation for recommendations in our Ecologically-Based Plan. Utilizing the Sustainable Urban Site Design Manual as guidance, we decided to use the criteria of stormwater management, wildlife habitat and vegetation, and circulation to direct the ecological and sustainable future of City Park (to read further about this process, see Appendix A). We applied these same three criteria to an existing conditions analysis to evaluate the current state of the park. Areas of Ecological Importance that were identified from this analysis include: Waterways, Formal Gardens, Vegetative Areas, and the Golf Course. Using the lenses of the large-scale context, circulation/connectivity, and the four Areas of Ecological Importance to approach our analysis led to recommendations for each section. The plan concludes with a matrix grouped by section that creates a framework for future prioritization of implementation by cost and time.

EXISTING CONDITIONS

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introduction

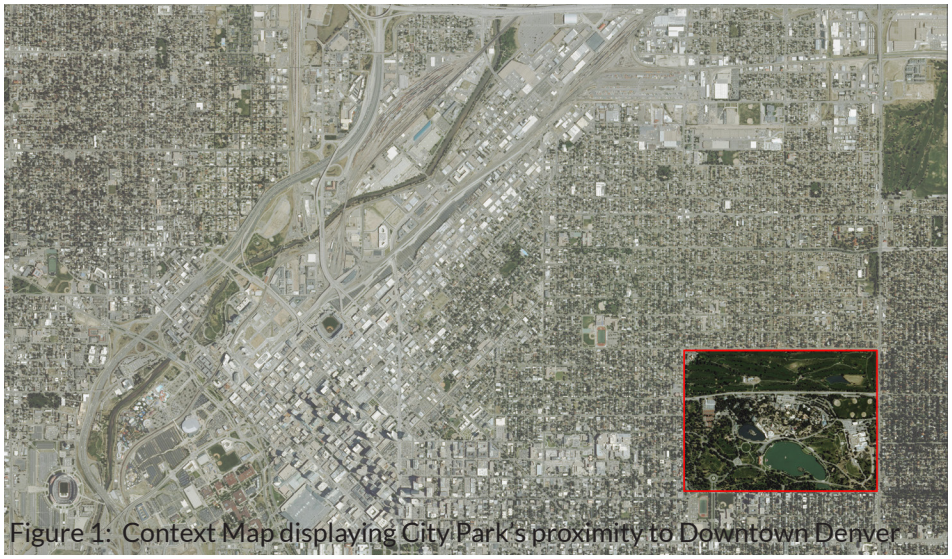
Figure 1: Context Map displaying City Park's proximity to Downtown Denver

City Park, centrally located in the city of Denver, serves eight adjacent neighborhoods and the metropolitan area. It is considered a regional park as 85% of all Denver residents live within a five-mile radius. The 320 acres of the park encompass the following:

- Denver Zoo
- The Museum of Nature and Science
- The City Park Golf Course
- 15 athletic fields
- 14 tennis courts
- Four picnic areas
- Nine historically significant monuments and structures such as the bandstand and City Park Pavilion
- Three lakes
- Five ornamental fountains including an interactive water feature
- Paddle boat rentals
- Five formal gardens
- Two playgrounds
- Over 3,500 trees comprising over 40 different species
- Significant views and vistas to Downtown Denver and the Rocky Mountains

City Park also hosts popular summer events such as Jazz in the Park, races, cultural festivals, and other annual activities. Since its opening year in 1882, City Park has evolved; while it is still a refuge from the city with its winding paths and historic nature, it is one of the most popular destinations in Denver (City Park Facts, 2016). In addition to these functions, the park serves an important role in stormwater management, migratory bird rookeries, and habitat creation for native species.

a brief history

As early as 1878, what is currently City Park was envisioned as the "east city park" after it was received as a gift from the state of Colorado. City Park was showcased as the primary park space for the City, and specifically for east Denver. In the park's first decade, Henry Meryweather laid out a sinuous road system through the park. The City Beautiful Movement had a direct influence on City Park expressed in the sculptural and architectural elements installed at entry points and in significant spaces in the 1900s. The other significant influence on the park in the 20th century was the Olmsted Brothers landscape architectural firm; the design philosophies put forth by Frederick Law Olmsted—the park serving as a haven, large and expansive, full of vegetation, walking paths and scenery, and protected from other development—was continued by the brothers. The overall character of the park lies in its curving roads and paths lined by trees, landscapes of small to large spaces that were not organized, important vista points and viewsheds, historic gardens, plazas, sculptures, and architecture (Revitalizing the Legacy of City Park, 2001).

Ecologically, early accounts say that the land that would become City Park was relatively flat and covered by prairie grasses, shrubs, and grazed by cattle. Elevation change across the park causes water to flow southeast to northwest; due to this water channel, wildlife

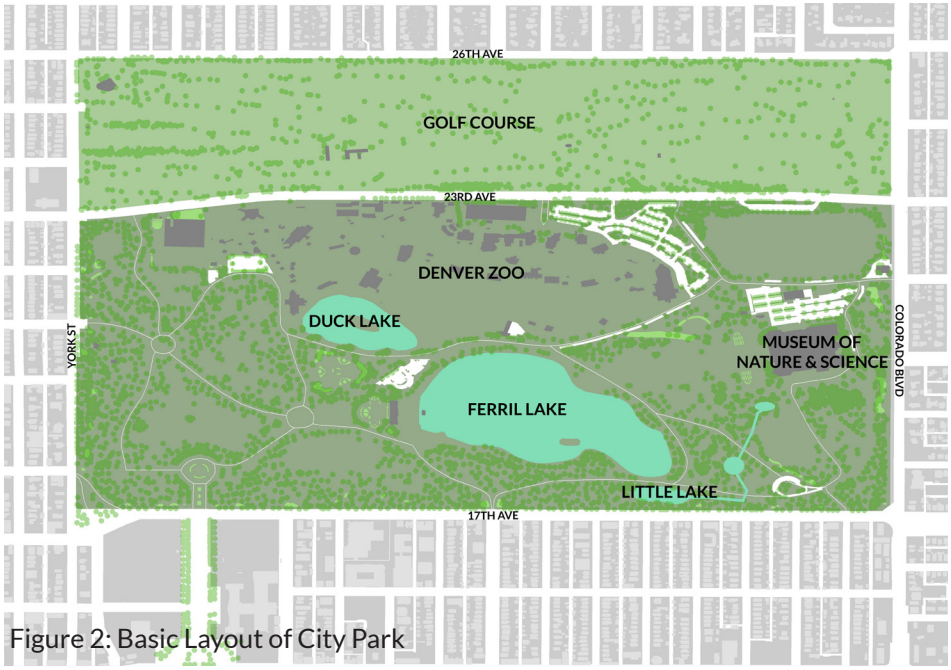

Figure 2: Basic Layout of City Park

migration also follows the same directional pattern. The only improvement on the site, City Ditch, is an encased underground pipe that flows into City Park from 17th Avenue where it joins a storm sewer and combined flow enters the park. The terrain is gently rolling and slopes toward the west. The ecological purposes that were intended historically are wildlife habitat and stormwater drainage/management. The notion of an urban park serving as wildlife habitat is congruent with Olmsted's refuge concept, as the park serves as an ecological refuge within the urban environment. This is exemplified in the park's urban forest and open water ecosystems, such as the Ferril and Duck Lakes' islands which host migratory bird rookeries.

local vs. regional context

The size, urban context, and central location of City Park make it necessary to consider it in a regional context as well as the local context. Regionally, the park is part of larger systems of migration for a variety of species including birds, butterflies, and bees. The park has the presence of coyotes, foxes, rodents, and fish, all of which are subject to impacts inherent to an urban park: habitat fragmentation due to roads and paths utilized for recreation, lack of vegetative cover in areas where plants have died and not been replaced, as well as a lack of diversity in the plants and grasses that are present in the park. Due to the area's management as an urban, regional park, City Park has been removed from its original, natural state and is unable to achieve the full ecological function it would otherwise have had.

In order to assess and evaluate the barriers that prevent City Park from achieving optimal ecological function, the Rocky Mountain Arsenal will be used as a reference condition. The Arsenal is a wildlife refuge of about 15,000 acres of prairie, wetland, and wildlife habitat located northeast of Denver. The land has transitioned from farmland, to wartime manufacturing, to a wildlife sanctuary over time and provides an accurate comparison of what City Park's natural condition would be pre-development. It was originally created to protect Bald Eagle nesting and roosting habitats but now it attracts other raptors, migrating songbirds, wintering ducks, and geese. It also provides habitat for a variety of mammals including bison, coyotes, and deer. These mammals are supported by the combination of short- and mixed-grass prairie, woodlands, and diverse wetlands, a condition that does not exist in City Park due to its grass monoculture and limited plant diversity. The variety of land cover present in the Arsenal also provides habitat for a variety of amphibians and reptiles that are largely absent in City Park. Soil in the Arsenal ranges from clay-like in some areas to sandy in others, contributing to a rich variety of plant life that, due to irrigation practices, fertilization, and decreased plant diversity, is not present in City Park.

stormwater management

Historically, stormwater management in City Park has been primarily directed to lakes that lie along the natural drainage line through the park; this includes Ferril Lake, Duck Lake, Lily Pond, and Little Lake (also known as the Sediment Pond). Little Lake, Ferril Lake, and Duck Lake are all fed from City Ditch. Outflow from Duck Lake enters the Children's Zoo Lake which overflows into the Park Hill storm sewer and is conveyed to Sand Creek. Impaired or poor water quality in Duck and Ferril Lake has been increasingly of concern since the lakes have been sustained with recycled City Ditch water since 2004. Utilizing recycled water yields consequences in water quality such as algae and vegetation growth causing elevated pH and decreased dissolved oxygen concentrations (Ferril Lake, 2015). Duck Lake also suffers from high levels of ammonia from the rookery present on its island (Duck Lake, 2015). The open water systems fed from City Ditch have also served as drainage for the park and surrounding area (Revitalizing the Legacy of City Park, 2001). With increased urbanization in Denver, the lakes used for detention must be improved to also manage water quality and volume, and other strategies independent from the lakes should be implemented to holistically manage runoff and storm events for the park and surrounding neighborhoods.

Figure 3: Eastern half of Ferril Lake's shoreline exhibiting potential for restoration and water quality improvements

Figure 4: Degraded Duck Lake Wetland Area

Water quality has been intervened through projects such as the Duck Lake Enhancements Project, accomplished through the Better Bonds Program, which aimed to improve the lake's poor water quality. This project drained the lake and removed sediment/built-up organic debris, removed dead trees on the island and replanted trees, restored the island edges, and renovated the south shoreline to create a wetland slope for improved filtration capacity. However, Canada Geese have significantly destroyed this restoration, creating an opportunity to improve this wetland area. Other than the wetland construction included in the Duck Lake Enhancement Project, water filtration in these lake edge ecosystems has been relatively nonexistent due to the primarily constructed edges and turf lawns surrounding the water bodies. However, Ferril Lake's edges present an opportunity for improvement with constructed wetlands due to the absence of a concrete wall around the eastern half. Little Lake also presents this opportunity with its barren shorelines.

circulation

The park's circulation began with the intention of being a sinuous and winding system of roads and trails. Entryways were given gateways with monuments that play on views and vistas that were instrumental in the placement of plazas, memorials and statues, as well as gardens throughout the park. As different professionals and designers have been involved in the evolution of City Park, materials of roads and paths have been changed, road closures have occurred, gates have been implemented at entrances, and the Museum of Nature and Science and the Denver Zoo have become entities whose interests potentially compete with those of the park rather than benefitting each other. With newer projects, such as the Mile High Loop, wayfinding has been implemented and improved to some extent, but connections to and within the park are lacking.

Figure 5: Mile High Loop Signage

Figure 6: Mile High Loop Distance Marker

As stated in the City Park Master Plan, paths and roads were originally gravel, and over time have been transitioned to asphalt; this includes pedestrian paths, roads, and bike routes. With the addition of the Mile High Loop, a multi-use pedestrian trail surfaced with crusher fine material completed in 2009, pervious paths were utilized for a comprehensive pedestrian trail throughout the park; however, crusher fine material is relatively short-lived, but has typically high infiltration rates, low installation costs, and the ability to withstand the freeze-thaw cycles experienced in Colorado's arid climate (McKain, 2016).


Figure 7: Bike Route with Bollards that detracts from Route's Character

With these changes, roads have been converted to one-way streets that are confusing and make navigation through the park difficult, as do Sunday road closures, permanent road closures, and gates. Although the gates are being utilized to deter vehicular movement, they detract from the use and character of these paths for pedestrian and bicycle circulation as seen in Figure 7.

Road closures have also contributed to disconnected pedestrian paths between amenities. Certain entrances to the park are closed, unclear, or confusing such as the McClellan Gateway at 21st Avenue and the York Street gateway which is currently designed as an exit only (Circulation and Use Plan for Denver's City Park, 2010). Although there is a Regional Bicycle Route that goes through the park, it is difficult to find, connections through the neighborhood are unclear, and it conflicts with vehicles at highly active areas (Revitalizing the Legacy of City Park, 2001).

Circulation within the park is deficient based on visual and physical connections. There is no pedestrian link between the ball fields and the main portion of the park, and pedestrian access between the Zoo and the Museum is missing (Revitalizing the Legacy of City Park, 2001). The Zoo Master Plan proposes a braided trail for circulation and education within the zoo boundaries; however, a continuation of this concept into the park could help to improve the interface between the two entities.

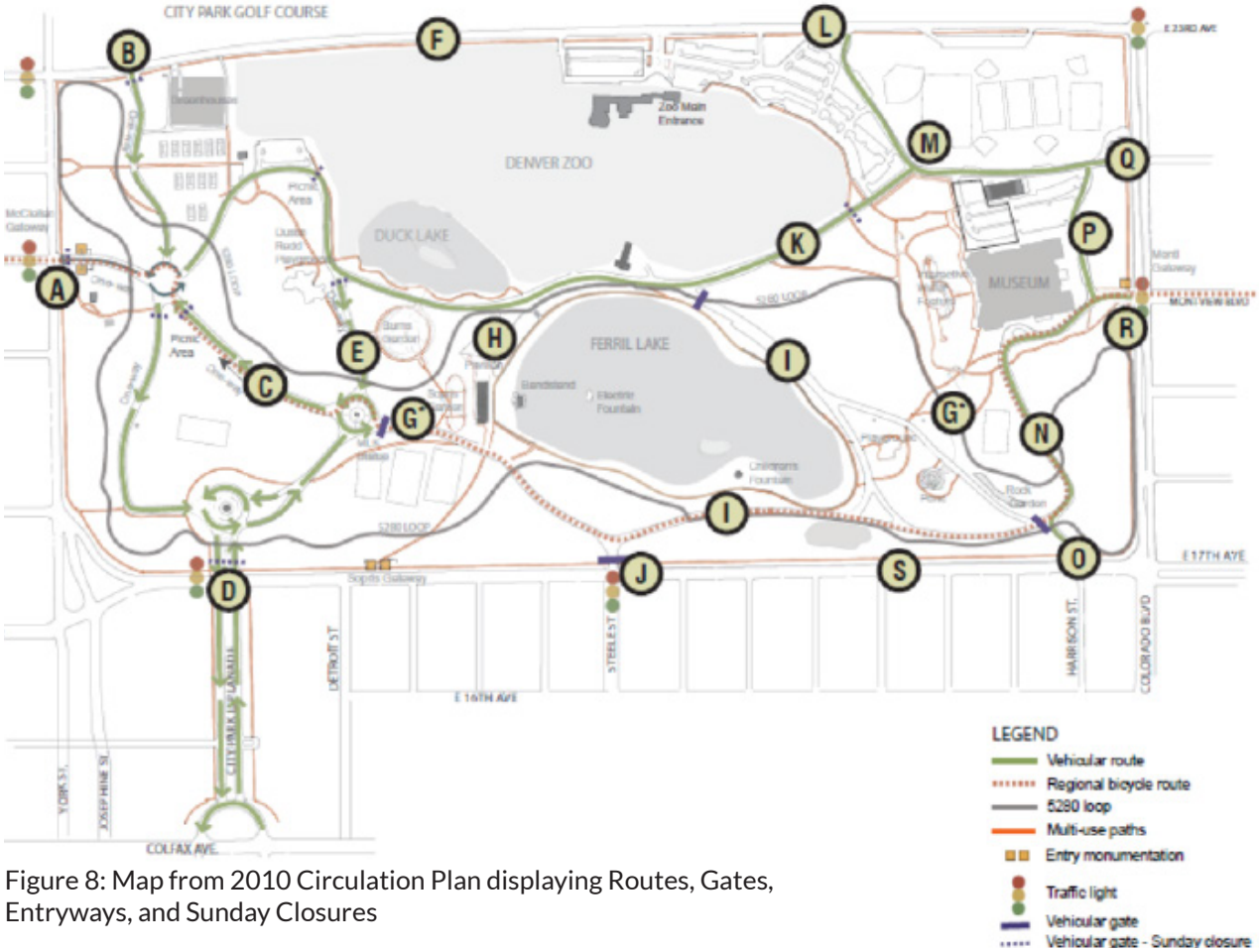

Figure 8: Map from 2010 Circulation Plan displaying Routes, Gates, Entryways, and Sunday Closures

Zoo and Museum roads also primarily serve as entrances to parking lots rather than entrances to the park. The intersection of the road north of the Zoo and west of the Museum is confusing because it encourages drivers to pass the park entrance toward the Zoo or Museum. In addition to lacking a sense of connectivity within City Park and among entities such as the park itself, the Museum, and the Zoo, connections to City Park from adjacent neighborhoods are insufficient. Crossing 23rd Avenue, Colorado Boulevard, and 17th Avenue is difficult with limited locations to cross at a crosswalk (Circulation and Use Plan for Denver's City Park, 2010).

wildlife habitat and vegetation

Figure 9: Degraded Duck Lake Wetland

From its inception, Duck Lake was intended to provide a "natural" bird refuge. The island was built to provide a breeding ground for birds and was heavily planted with willows and evergreens. Today, a Black Capped Night Heron rookery is present on the islands in Duck and Ferril Lake, as well as the fourth largest Doubled-Breasted Cormorant Rookery in Colorado on Duck Lake's island (Duck Lake, 2015). Ferril Lake also hosts breeding Snowy Egrets. Shade trees and evergreens found in City Park are suitable to attract migrant birds. Ferril Lake and Duck Lake also attract a collection of waterfowl, including the Long-Tailed Duck, Black and Surf Scoters, and Cattle Egret (City Park - Denver County, 2016). A majority of City Park's open water lacks development of wetland or riparian habitat, making the area attractive to Canada Geese but not to most other waterfowl. Ecologically, a large body of water should attract Great Blue Herons and Kingfishers, although none have been observed (Revitalizing the Legacy of City Park, 2001). The Duck Lake Enhancements Project provided a wetland area on the south shoreline, corrected erosion on the island edges through the placement of new boulders and riprap, and removed dead trees on the island and replanted new trees. Although the restoration to the island's edges is apparent, the wetland area that was constructed is lacking vegetation for filtration and is often littered with garbage; the function is not being realized to its fullest extent.

City Park hosts a variety of original and important trees and species that are significant historically and for the park's vegetation. Tree-lined paths, roads, and edges are part of the original design of City Park. Over the past few decades, original plantings have disappeared and have either been left without replacement or have been replaced with incompatible species. A historically significant cottonwood grove is located in the northwest corner of the park that includes a few silver maples. The natural swale in the center of the City Park Golf Course also features large plains cottonwoods that may be the earliest tree plantings on the course (Revitalizing the Legacy of City Park, 2001). Important plantings include species such as green ash, catalpa, kentucky coffeetree, cottonwood, crabapple, american elm, hackberry, hawthorns, maples, and ponderosa pine. Garden plantings such as the Botanical Garden (including the lilac plantings, some of which are missing and have no access from the adjacent pedestrian path), perennial, and native collections are also historically and ecologically significant to the function of City Park. Native plantings have been utilized in gardens to attract native butterfly species as well, but there is no evidence of its success (City Park Arboretum Master Plan, 2009).

City Park has suffered some degradation in its ecological function such as duck weed blooms in Duck Lake and bouts of avian botulism experienced annually at times depending on conditions. Denver Parks and Recreation is installing aerators in Duck Lake to prevent stagnation, but other measures should be considered to prevent future occurrences caused by environmental conditions.

Figure 10: Map displaying trees in the Spruce Family present in City Park

Tree canopy plays an important role in roosting and nesting as well as providing a food source for bird populations in the Denver region. Historically and ecologically, cottonwood, pine, and crabapple species that are present in the park are serving these purposes for migratory birds, songbirds, and other bird species. Spruce species will be included in this evaluation of existing canopy because of their provision of nesting, roosting, and winter cover for small birds (CSU, 4). According to 2014 tree inventory data, there are 287 trees in the spruce family, of which 267 are Colorado native blue spruce.

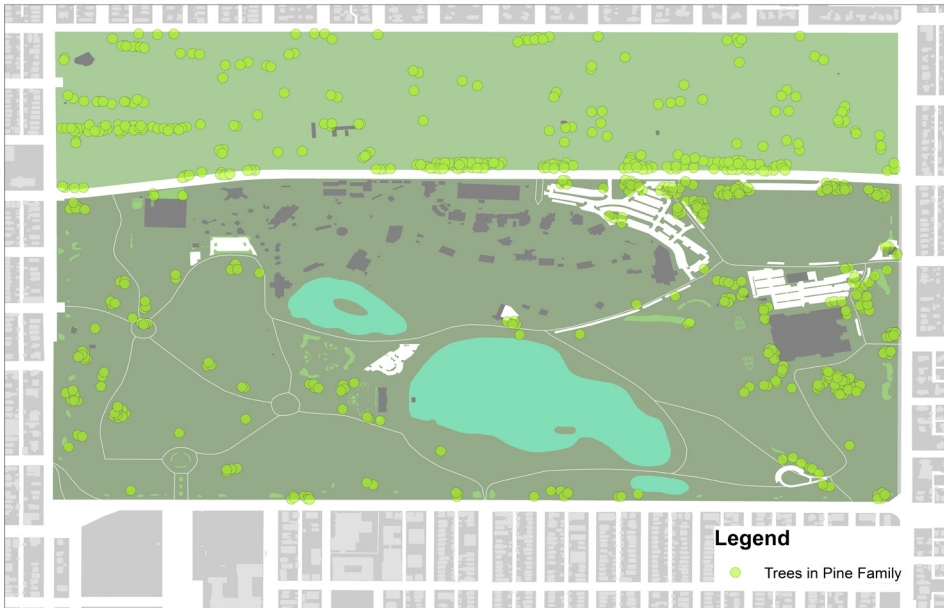

Figure 11: Map displaying trees in the Pine Family present in City Park

In the pine family, there are 680 trees present in the park spanning 11 different species. Bristlecone, Pinyon, Limber, and Ponderosa Pines are native to Colorado. Limber and Pinyon pines share a mutualistic relationship with Clark's Nutcrackers, a bird native to the Rocky Mountains. Data suggests that each nutcracker gathers 30,000 limber pine seeds in the summer and fall and recovers around 15,000 of them for a food source through the winter; the unrecovered seeds are left to germinate and grow (Mitton, 2014). However, the mountain pine beetle has negatively impacted limber pine populations in the last decade and recent drought and record high temperatures have increased pinyon pine mortality. With the pine populations dwindling, the nutcracker is put at risk (Mitton, 2014). An increase in limber pine trees in City Park could be explored to combat this threat.

Figure 12: Map displaying Flowering Crabapple trees present in City Park

The Flowering Crabapple, an important historic collection donated by S.R. DeBoer in the 1950s, has 195 trees with concentrations around the Thatcher Fountain and where the Crabapple Collection is planted north of the Big Meadow. Cottonwood species, significant both historically and for bird habitat, are second in occurrence with 269 trees.

Figure 13: Map displaying trees in the Cottonwood Family present in City Park

The hybrid cottonwood (27 trees) and the narrowleaf cottonwood (17 trees) are the most valuable species for habitat provision. narrowleaf, plains, and lanceleaf cottonwoods are native to Colorado.

Of the 4,711 total trees in City Park, trees significant for bird habitat account for around 31% of the tree inventory at 1,431 trees.

Figure 14: Map displaying trees in the Pine, Spruce, and Cottonwood Families and Crabapples in City Park

swot analysis

Figure 15: Map displaying Major Park Elements

strengths

- Strong historic character
- Extensive foundation for circulation
- Islands in Duck Lake and Ferril Lake as important breeding grounds for migratory birds
- Expansive nature of the park
- Diversity of uses
- Prime location in central Denver (views, proximity to downtown, etc.)

weaknesses

- Degraded best management practices (BMPs) for stormwater quality and management
- Disconnect within park and among the park, zoo, and museum
- Lack of signage/wayfinding
- Condition of surface materials

opportunities

- Implementation of stormwater BMPs in and around park lakes
- Improve interface between the zoo and park
- Improvements to connectivity to and within the park including existing path network
- Use of natural vegetation and tree canopy to support migratory bird and butterfly habitat
- Preservation of historic tree species and groves, consistency in park entrances and signage

threats

- Gates and bollards controlling road closures and one-way traffic movement create confusion
- Lack of consistency in surface material to designate path uses
- Lack of signage to connect such an expansive area
- Physical disconnect between the park and the zoo
- Harmful disease to wildlife populations caused by environmental conditions
- Lack of riparian habitat around open water to attract other bird species that are deterred by turf lawn and constructed shorelines
- Lack of maintenance on restoration/management projects
- Parking is not cohesively integrated into park environment

areas of ecological importance

The following areas were marked as significant in the existing conditions study and they will be used as a foundation for the analysis moving forward.

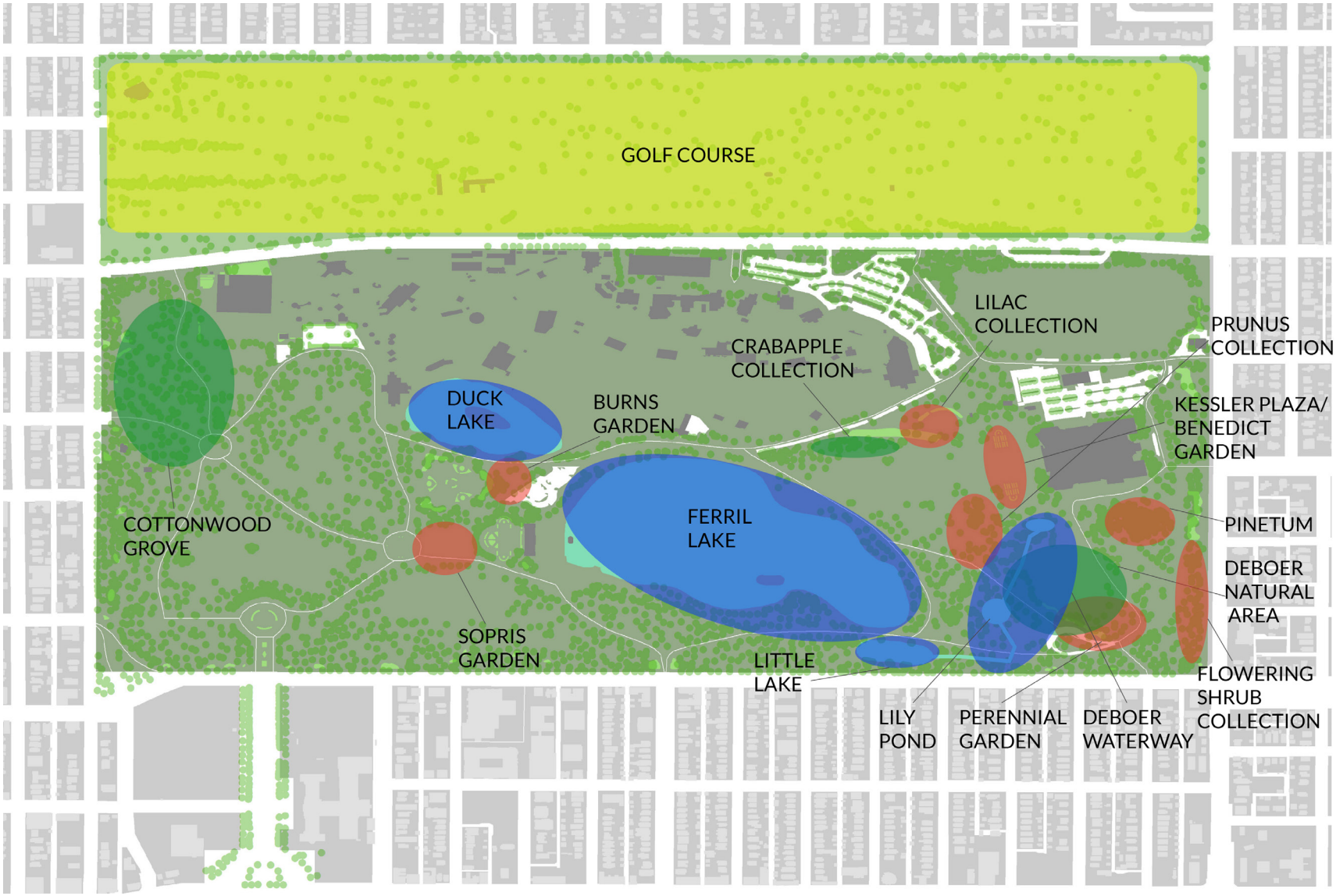

Figure 16: Map of the Areas of Ecological Importance

Waterways: DeBoer Waterway, Lily Pond, Little Lake, Ferril Lake, and Duck Lake.

Formal Gardens: Burns Garden, Sopris Garden, the Perennial Garden, Benedict Garden, the Botanic Gardens including the Lilac Collection, Prunus Collection, Box Canyon, and the Pinetum, as well as the Flowering Shrub Collection.

Vegetative Areas: The DeBoer Natural Area, the Crabapple Collection, and the Cottonwood Grove.

Golf Course: Detention plans, water features, and vegetation adjacent to the water.

ANALYSIS

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large-scale context

urban tree canopy

As stated in the existing conditions analysis, the tree species identified as ideal bird habitat in City Park are the flowering crabapple and trees in the cottonwood, pine, and spruce families. Cottonwoods, a historically significant species to City Park, are trees adapted for moist areas, and provide food to birds in winter and early spring and important nesting and roosting habitat (Wildlife Values of Conservation Trees & Shrubs, 2003). Trees in the pine family are important because all parts of the tree are used, pine seeds are important food sources, and pine-bird mutualism is prevalent in the Front Range. The Clark's Nutcracker is an example of this relationship as it disperses the seeds of the Limber and Pinyon Pines to germinate and seed, as well as utilizes the seeds as their food source. These pines are adapted to the relationship with the Clark's Nutcracker (Mitton, 2014). Although species in the spruce family provide little food value, they are significant for nesting, roosting, and winter cover for smaller bird species (Wildlife Values of Conservation Trees & Shrubs, 2003). Flowering crabapple trees, also a historically significant species and collection in the park, provide food to bird species.

The current inventory of these specific types of trees in City Park accounts for 31% of the stock. In Figure 17 below, a comparison of aerials of City Park dated 1993 and 2015 illustrate that the golf course and the DeBoer Natural Area have experienced an increase in tree cover, while the areas west, south, and southwest of the greenhouse have experienced a decline in tree cover. An increase in tree cover, and specifically of the species identified as well-suited to provide bird habitat, would improve the bird habitat in the park, aid in natural cooling, and decrease overall stormwater runoff. In addition to serving as food sources and habitat for birds, trees

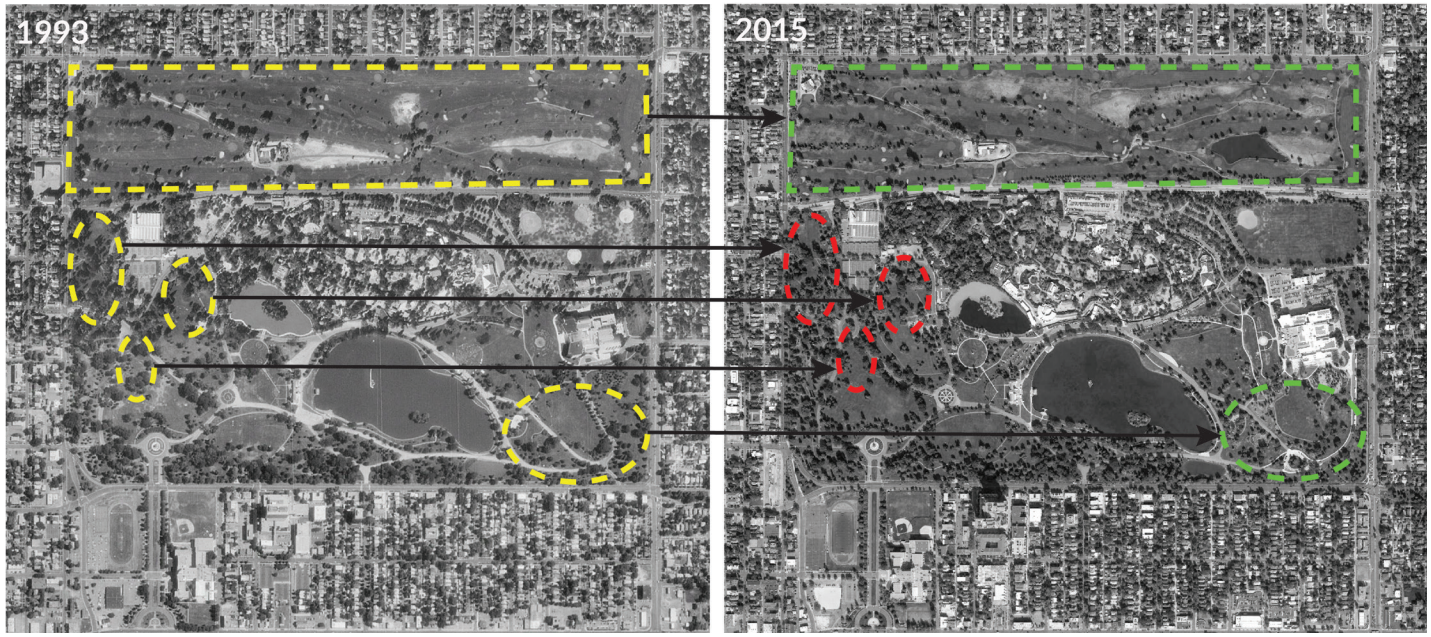

Figure 17: Comparison of Tree Cover in 1993 and 2015 in City Park

provide shade, utilize the sun's energy for photosynthesis, and dissipate latent heat of vaporization through evapotranspiration – all functions that provide natural cooling. In a mid-sized city, these natural cooling capabilities are important to mitigate the urban heat island effect (Gruzen Samton Architects LLP et al, 2008). Trees contribute to stormwater management in an urban park by reducing flow through the catchment of rainfall on leaves, branches, and trunks which evaporates and reduces the amount of runoff (Gruzen Samton Architects LLP et al, 2008). Historically, an increase in urban tree canopy is cohesive with the historic intent for tree-lined paths and as a barrier from the urban surroundings.

meadows and grass monoculture

City Park has evolved into a center for recreation and leisure, and as an urban park has developed a grass monoculture of turf, such as Kentucky bluegrass. While this ground cover is favorable for recreation, it requires extensive chemical intervention through fertilization and use of pesticides and herbicides which contributes to high nutrient levels in waterways, contributing to eutrophication (Gruzen Samton Architects LLP et al, 2008).

Turf is also water intensive, with Kentucky bluegrass requiring 18,500 gallons of water per month for only 5,000 square feet of turf (deGREENdenver). For areas not utilized for recreation, replacing turf with native prairie grasses, such as buffalograss, blue grama, or junegrass would help decrease the amount of pollutants entering waterways to improve water quality, and irrigation and necessary maintenance. Wildflower meadows, effective for habitat enhancement through their provision of food and shelter for species of birds, butterflies and other insects, and small mammals, can also be used as an alternative to turf (Gruzen Samton Architects LLP et al, 2008). The Vegetative Areas section of Areas of Ecological Importance discusses the locations prime for turf alternatives and native trees, vegetation, and plantings.

recommendations

- For areas not utilized for recreation, replace turf with native prairie grasses or wildflower meadows to help decrease the amount of pollutants entering waterways and improve water quality, decrease irrigation and maintenance necessity, and provide habitat enhancement
- Increase tree cover of flowering crabapple species and species in the pine, spruce, and cottonwood families to provide bird habitat in the park, aid in natural cooling, and decrease overall stormwater runoff

circulation/connectivity

connectivity

zoo interface

As City Park is large and contains a variety of uses, circulation and appropriate connection between those uses is very important. In particular, the interface between the park and the zoo has surfaced as a potential opportunity for improvement. Currently there is not a sidewalk along the edge of the zoo for most of the way, to get from parking areas to the zoo's main and only entrance, visitors walk on a dirt path of sorts around the edge of the zoo. There are also paths from the park that dead end in a parking lot and the fence at the edge of the zoo. These all represent opportunities to improve upon this important connection.

In the Denver Zoo's Master Plan Draft (2015), a braided path through the zoo is discussed that would be designed to offer an immersive, choice filled educational experience. It also states that this path would feature stormwater processes and management as design elements. This braided path idea represents a potential opportunity for further connection between the park and the zoo. This path could be extended into or mimicked in the park as well, specifically near Duck Lake where there is already a connection to the zoo. The City Park Circulation and Use Plan discusses a Zoo Loop, a path around the outside perimeter of the zoo, which is an opportunity to extend the braided path idea from the zoo out into the park, better facilitating the connection between the two. The proposed zoo loop also offers multiple opportunities for increased biomimetic function as it would be made of crusher fines which would help with water infiltration. It could also better facilitate migration by incorporating a wiggle in the trail, which encourages animal species as they prefer not to travel in straight lines where they are more vulnerable to attack. The trail would also include specific plantings aimed at bird and animal species as well as additional vegetative cover.

The implementation of the zoo loop around the zoo perimeter and Duck Lake, extending the concept of the braided trail into the park, increases the ecological functioning of the park and would be utilized as an opportunity to educate park users about features of the trail and its role in the improvements of ecological function. The proposed zoo loop can be seen in the figure below.

Figure 18: Proposed Zoo Loop with Possible New Entrances Marked

If visually similar signage is used in the park and the zoo, this education signage would be another way to create a greater sense of cohesion between the park and the zoo. Within the zoo, there are signs that have a certain and consistent design style to them; additional signs added in the park near the zoo could utilize a similar style to create a stylistic consistency between the two entities. These signs would remind park visitors of the presence of the zoo and could entice them to include a visit to the zoo as well. Below are some examples of zoo signage that could serve as ideas to incorporate into City Park near the periphery of the zoo.

Figure 19: Denver Zoo Signage

Visitors to the zoo must enter through its one front entrance, which is primarily aimed at accommodating visitors who arrive by car. In the past there were three entrances, including east and west entrances that have since been closed. These entrances allowed for families to walk to the zoo on the weekends and avoid the weekend traffic jams that are now a common part of getting to the zoo. If these entrances were re-opened, the zoo would have a better pedestrian connection with City Park and would attract visitors using alternative modes of transportation.

Another potential way to improve on the interface between the zoo and City Park relates to the fence around the zoo's perimeter. Currently there is an ivy-covered chain link fence that surrounds most of the zoo and separates it from the park. The fence is necessary for security reasons, but modifications to the fence allowing a visual connection from the park to the zoo would improve the interface and benefit both entities.

circulation

park-wide

City Park can be a difficult place to navigate, for vehicles, pedestrians and bikes. One simple way to improve this would be increased signage at major intersections so that visitors would have a greater sense of where landmarks or parts of the park are located and how to get there. These signs could help orient guests to the zoo or the museum, for example, or to other places within the park that they might wish to go. Some examples of other park signs that could serve as models for additional wayfinding signage in City Park can be seen in Figure 21.

Another way to help create better circulation would be through consistent use of various surface materials to denote which paths are ideal for which uses. For example, roads that are primarily for cars and bikes could be asphalt while paths of crusher fines could be for jogging/running, and concrete could be used for walking trails. This would be a simple way of designating which routes are designed for which users and of delineating routes to destinations. An example of this type of path use delineation can be seen in Figure 22.

Many of the entrances and gates into the park could also be improved so that they better fit the park's character. The entrances are a visitor's first interaction with the park. As such, they should make a statement and set the tone for the experience of the park. Some of them, such as those with monuments, do this well but there are others that are so unmarked as to not even make it clear that they are park entrances. Specifically, the entrances at 23rd Avenue, Colorado Boulevard, and 17th Avenue could be improved to fit the character of the park and enhance the visitor's experience. These areas can be better seen in Figure 20; the purple star represents the location of the Graham Bible House, the white dashed rings designate areas for improved intersection signage, red is entrances to improve, green is entrances and the orange is an alternate bike path entrance.

vehicular

The Sunday gate closures in the park make it difficult for cars to have reliable and consistent circulation and parking, leading to confusion and decreased safety in the park for all. Another thing that creates confusion for vehicles in the park is the one-way circulation, especially in the West Meadow. Conversion of this system into a continuous loop would clarify circulation and help with this issue. Increased signage and consistency in the materials and the cross sections of roads throughout the park, as previously mentioned could also help improve the vehicular experience.

pedestrian/bike

Many of the pedestrian and bike paths throughout the park are confusing and lack clear separation from vehicular traffic. In some places, they have become fragmented and unclear. Clarifying these paths and creating a consistency between them, through materiality as mentioned previously, would help with this issue and greatly improve the visitor experience in the park. Increased signage could also help clarify which paths go where and would also be an opportunity to incorporate educational signage where appropriate. There could be signs along the paths that would provide additional information about particular features or destinations in the park, such as actions taken to enhance ecological functioning or areas of particular significance in the park.

Other areas that could benefit from increased circulation and connectivity in the park would be the park maintenance building and the Graham Bible House. The park maintenance building and Graham Bible House could be incorporated into the implementation of a braided trail around Duck Lake to improve their utilization and recognition by park users. The Graham Bible House was originally built in 1892 as a private residence for the first superintendent of the park. It was then renovated in 1999 but is now largely underutilized. It would benefit from the implementation of educational classes or programs hosted in the building, potentially linked to the greenhouse and its operation. Another use of the space would be as an area for temporary food vendors. This would help to build an identity for City Park that would encourage people to spend a whole day as opposed to only coming for specific events, the zoo, or the museum and not visiting the park holistically.

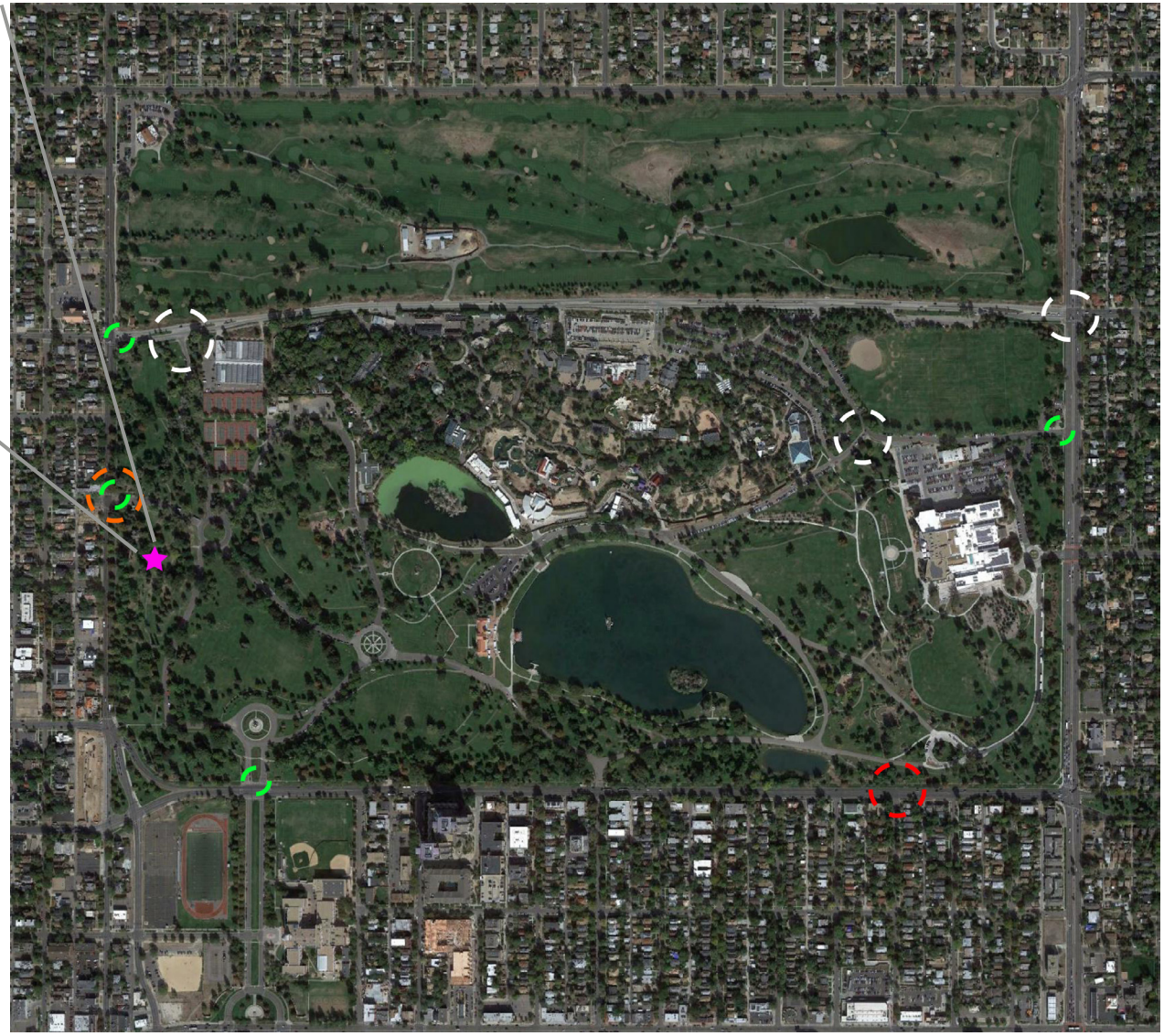

Figure 20: Circulation Diagram and Location of the Graham Bible House

Figure 21: (above) Examples of Park Signage

Figure 22: Path Delineation using Surface Materials

recommendations

- Improve physical and visual connection between the park and the Denver Zoo by extending the braided path concept envisioned for the zoo into the park to create the Zoo Loop, re-opening the east and west entrances to the zoo, and improving the visibility offered through the fence around the zoo
- Create consistency of surface materials on park paths and trails to indicate use and help visitors easily navigate through the park
- Increase signage in the park to better facilitate easy navigation and potentially design signage in a way that evokes zoo signage to increase connectivity between the two entities while improving circulation, placemaking, and wayfinding
- Increase connectivity and circulation in the park by better incorporating sometimes underutilized entities, such as the Graham Bible House, into the park for use potentially as a vendor location to maintain park visitation when there are not specific events being held

areas of ecological importance

waterways

The water flow through the park is consistent with the elevation change that occurs from southeast to northwest. Along this channel, stormwater flows down the DeBoer Waterway through the Lily Pond, into Little Lake, and then to Ferril Lake which feeds Duck Lake. Ferril Lake is fed directly from recycled City Ditch water. Recycled City Ditch water has been utilized in City Park waterbodies since 2004, resulting in water quality issues including high pH and decreased dissolved oxygen levels from algae and vegetation growth. Duck Lake also suffers from ammonia toxicity due to the cormorant rookery on its island (Duck Lake, 2015). Ferril Lake has historically been stocked with bluegill, rainbow trout, catfish, croppie, and chad by Colorado Division of Wildlife for recreational fishing, but over the past decade high pH and temperature has resulted in the water quality not being suitable for trout (City Park Information). However, largemouth bass were added to enhance the fish stock in 2014 (Ferril Lake, 2015). The movement of stormwater across the park and the degraded water quality in the lakes stemming from recycled City Ditch water can be improved through the restoration of the DeBoer Waterway and its use as a water feature, replanting the Lily Pond, implementation of best management practices (BMPs) in stormwater quality such as aeration, pretreatment, and end-of-pipe treatment, and the use of these BMPs in an artistic way to stimulate placemaking in City Park.

Currently, the DeBoer Waterway is underutilized in that it is empty for purposes of directing heavy rainfalls and preventing flooding. While it serves this purpose effectively, its historic intent is as a water feature that feeds the Lily Pond and Little Lake, which serves as a forebay (or an area to settle out sediment before reaching the main waterbody) for stormwater flowing

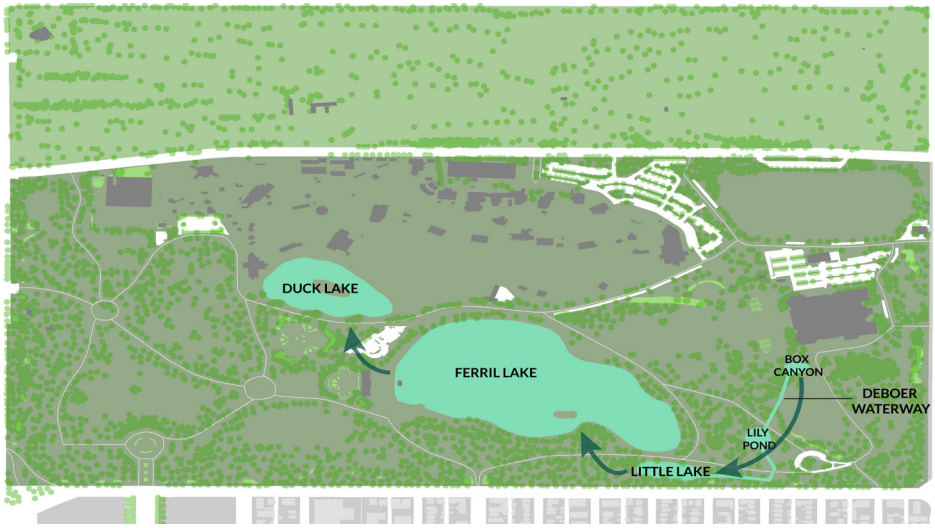

Figure 23: Water Flow across City Park

down the DeBoer natural area and from City Ditch before reaching Ferril Lake (USDCM Volume 3, 2010). Reinstating the DeBoer Waterway as a water feature would not inhibit its use as a stormwater management feature due to the shut off valve that ceases water flow in preparation for a storm event, but would aid in water circulation among the lakes which would consequently improve water quality made worse from stagnation of the already impaired recycled water and runoff from urban areas. Replanting the Lily Pond with water lilies from Berkeley Lake in northwest Denver, as done historically, would help to control the temperature of the water while also providing a food source to local waterfowl from their seeds.

The electric fountain in Ferril Lake is an icon of City Park; however, its use for aeration of the lake to improve water quality is insufficient for the lake's size. The water quality of Ferril Lake has in fact caused the fountain to need frequent maintenance

since its construction in 1908. In 2008, the fountain was altered to become a computerized prismatic electric fountain, with 11 geysers around a central plume lit by colored LED lights. A short five years after its restoration, the algae in the water had broken valve mechanisms such as the pressure-regulating valve (O'Connor, 2013).

Figure 24: Prismatic Electric Fountain in Ferril Lake

Improving water quality in the lake through subsurface aerators is the preferred method to improve the condition of the water in the lake by decreasing algae, increasing lake circulation, and providing dissolved oxygen to maintain healthy levels in the ecosystem (Texas Lake Management, 2006). In addition to being beneficial ecologically, aeration would also aid in preventing degradation to the historically significant prismatic electric fountain in Ferril Lake. These subsurface aerators would also be ecologically beneficial to Duck Lake, as it suffers from the same issues as Ferril Lake but to a greater extent due to the rookery present on its island.

Although Ferril and Duck Lake both have a maximum depth of around nine feet, the size of Ferril Lake at 24 acres justifies the need for more than one subsurface aerator. At 4.9 acres, one aerator would suffice to improve the water quality of Duck Lake (Duck Lake and Ferril Lake, 2015). Avian botulism has been a threat to waterfowl in City Park for decades, and this increased oxygenation and circulation of the waterbodies would keep water temperatures lower with destratification, lessening the likelihood of the presence of the bacteria that requires warm temperatures and an anaerobic environment to become active (USGS, 2015).

Pretreatment as a BMP for water quality would also be applicable to the already existing Little Lake, which is a forebay to Ferril Lake (or a body of water that settles out sediment before reaching the main waterbody), and the eastern half of Ferril Lake. The current state of Little Lake and the shorelines of Ferril Lake that lack walls are not improving the water quality. Constructed wetlands on the slopes of the lakes, specifically the northeast slope where the DeBoer Waterway empties and the south slope of Little Lake closest to 17th Avenue, and the eastern half of Ferril Lake, would filter runoff from the perimeter road and treat the water flowing from the waterway into Little Lake, as well as filter runoff entering Ferril Lake (USDCM Volume 3, 2010).

BMPs for this construction would be either sand or gravel filtration. While sand filtration has proven effective in semi-arid climates with the presence of a detention area upstream of the filter (which in the context of City Park would be the Lily Pond for Little Lake and Little Lake for Ferril Lake), the use of gravel filters for constructed wetlands are better suited for this climate because it reduces evaporation and achieves high removal rates of pollutants (Stormwater Strategies for Arid and Semi-Arid Watersheds, 48). End-of-pipe treatment for stormwater is also logical between Ferril and Duck Lake due to pipe size and retention time; Duck Lake experiences extreme algal blooms and end-of-pipe, or in pipe, filters would decrease the nutrient loads flowing into the lake as well as pathogen pollution.

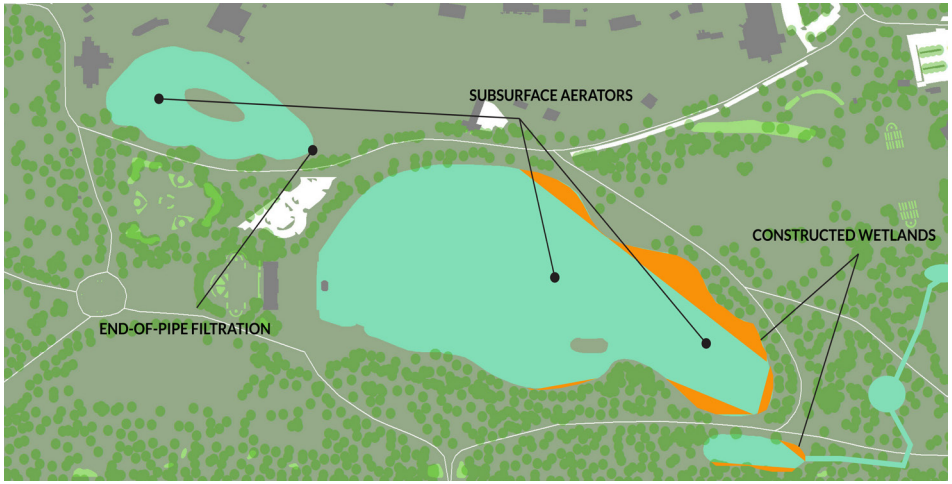

Figure 25: Stormwater BMPs for the Lakes Recommended for Implementation

recommendations

- Restore the DeBoer Waterway and its use as a water feature
- Implement subsurface aerators in Duck and Ferril Lakes
- Implement constructed wetlands using gravel filters on the slopes of Little and Ferril Lakes to improve water quality of both
- Replant the Lily Pond with water lilies from Berkeley Lake
- Implement end-of-pipe filtration to treat for nutrient and pathogen pollution in the pipe between Ferril and Duck Lake that empties into the latter

areas of ecological importance

formal gardens

The Formal Gardens of City Park are the Kessler Plaza and Benedict Garden, Burns Garden, Sopris Garden, and the Botanic Gardens. Other formal plantings are the Perennial Garden, and the Flowering Shrub Collection. These include historic plantings, statues, water features, and significant viewpoints. The Kessler Plaza hosts Meryweather's vista point toward downtown and the Rocky Mountains from the Museum of Nature and Science. The Gates Fountain is a part of this Plaza, as well as Benedict Garden and the "Grizzly's Last Stand" bronze statue. The Benedict Garden is formally arranged parallel to and centered on the Museum building. Evergreen and deciduous trees define the space flanked by formal rose gardens on each side. The 2001 Master Plan recommends the formal gardens in the Benedict Garden include more substantial plantings than just roses. The Sopris Garden, located on the west façade of the City Park Pavilion, holds the Elizabeth Ellen Sopris Memorial featuring a sundial, formal flower beds, and a circular row of crabapple trees completing the garden's formal space. The Burns Garden is comprised of the Burns statue and flower garden northwest of the City Park Pavilion. It consists of a small formal flower garden encircled by evergreen and deciduous trees with three cannons and a bronze central statue. The Botanic Gardens include the Pinetum, which is south of the Museum and has mature juniper and pine trees; the Box Canyon, which is part of the DeBoer Waterway; the Lilac Hedge, which is north of the Big Meadow and is lacking in pedestrian access and experiencing deterioration of the plantings; and the Prunus Collection southeast of the Big Meadow, which consists of plum and cherry trees as well as miscellaneous plantings of crabapple tree (Mundus Bishop Design, Inc. et al, 2001). The existing state of the formal gardens in City Park can be improved through the inclusion of native species and butterfly plantings as well as the implementation of BMPs in the garden beds.

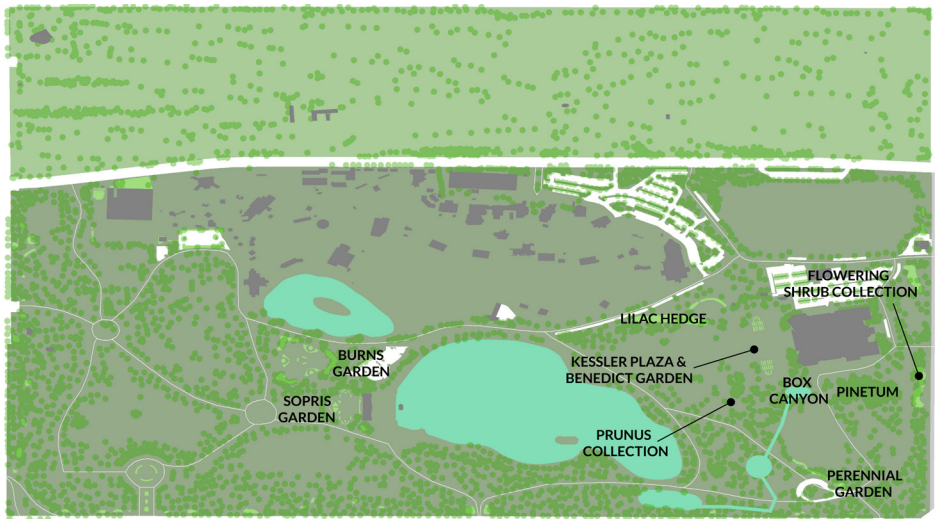

Figure 26: Locations of Formal Gardens

The 2001 Master Plan states that these formal gardens require restoration of their plantings. To make these gardens more substantial and more appropriate for native species' habitat, food, and shelter, as well as infiltration and drought tolerance, bolstering the gardens with native species in addition to their historically significant plantings would improve their ecological function. Native flowers such as purple poppy mallow, rocky mountain penstemon, bee balm, spiderwort, harebells, prairie coneflower, prairie sage, and sundrops would be choices to increase the representation of the native plants common to the landscape. Grasses such as prairie dropseed, sideoats grama, and big bluestern are native and ornamental, and can also be utilized in formal garden plantings (Colorado Native Plant Society, 2008).

In Denver's semi-arid climate, flooding following large storm events is a primary issue for the City. To help mitigate flooding, existing formal garden beds can serve as rain gardens that have spillways for overflow or underdrain pipes. Rain gardens are a low impact strategy to remove pollutants from impervious surface runoff and improve water quality. The garden is layered with planting soils, stone, and native soils to achieve a high infiltration rate (Gruzen Samton Architects LLP et al, 2008). Utilizing already existing gardens beds for this purpose would leave the historic nature of the beds unaffected while serving a greater ecological purpose for local and regional stormwater management. The area south of the Lily Pond is a suitable location for a rain garden that hosts native species and those that support butterfly populations.

Figure 27: Rain Garden Example (Source: Gruzen Samton Architects LLP et al, 2008)

This location, because it lies in the water channel, is highly saturated making the conditions ideal to support a rain garden without additional irrigation requirements.

While Colorado falls between two of the Monarch butterflies main migration paths, the western side of Colorado is the edge of the Monarchs' western migration route. The Western monarch population has seen around a 50% decline from the long term average (Plumer, 2016). This is thought to be caused by prairie conversion and use of herbicides that kill milkweed which serves as habitat for pollinators such as butterflies, bats, and bees. While Monarchs pollinate many flowers before laying eggs, their caterpillars can only survive on milkweed. President Obama launched a White House initiative to save pollinators in 2014 and those working on the strategy are leaning toward mobilizing individual communities to restore plant diversity through plantings in farm fields, parks, on federal land, along roads and under powerlines, and at schools and senior centers (Finley, 2014). City Park, as Denver's largest park hosting expansive meadows that are not officially used for recreation and many garden plantings, is a prime area for the location of milkweed for Monarch reproduction and flowers that provide food to adult butterflies including asters, bee balm, butterfly bush, butterfly plant, lilac, and marigolds (Cranshaw, 2010).

While there is one designated area for butterfly plantings north of the Big Meadow, as well as the Lilac Hedge which contributes food for butterflies, City Park is lacking in its provision of resources for Monarch butterflies. Milkweed plantings in the DeBoer Natural Area, south of the Lily Pond, and meadows not utilized for recreation, as well as the incorporation of flowers that attract adult butterflies into existing gardens would aid in the solution for the potential extinction of an important pollinator.

Figure 28 below illustrates where existing butterfly plantings are located and additional areas where butterfly plantings are appropriate; the white dashed line represents the already existing butterfly garden, dark purple are areas for milkweed plantings, and light purple represents existing garden beds that could include plantings of butterfly flowers. Incorporating Monarch butterfly decline, the role of pollinators, and maintenance of habitat educational signage around these areas for the public would be an ideal opportunity to inform the public about the ecosystem services that pollinators provide and efforts being taken to prevent their extinction.

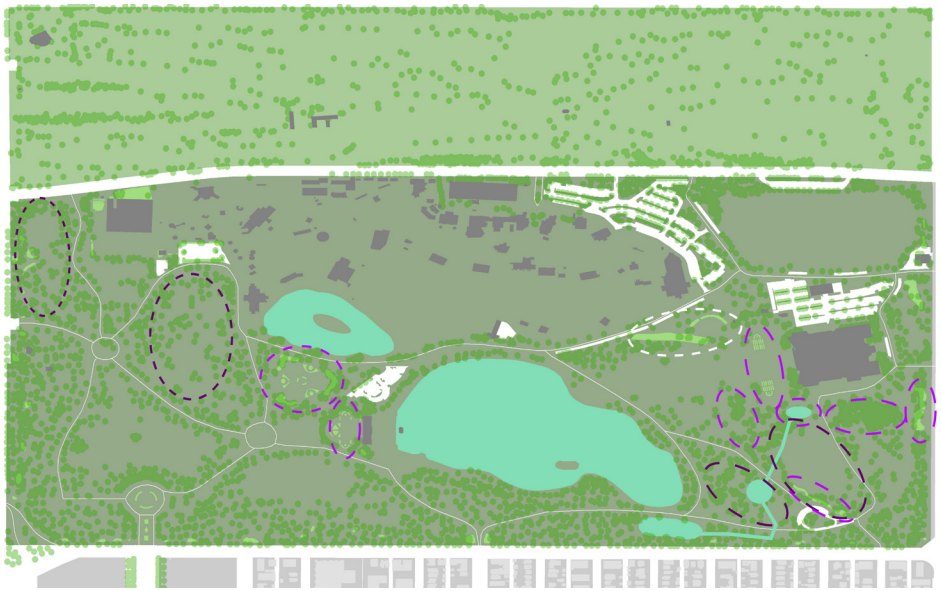

Figure 28: Areas of Existing Butterfly Plantings and Areas to Implement Additional Milkweed/Butterfly Plantings

recommendations

- Include native flower and grass species into existing formal gardens to makes the gardens more substantial and appropriate for native species' habitat, food, and shelter, as well as infiltration and drought tolerance
- Retrofit existing formal garden beds to serve as rain gardens with either overflow or underdrain pipes to aid in stormwater quality and management
- Implement milkweed plantings into the DeBoer Natural Area, south of the Lily Pond, and meadows not utilized for recreation to provide Monarch butterfly reproductive habitat
- Implement a rain garden with native species that support butterfly populations in the area south of the Lily Pond
- Incorporate flowers that attract adult butterflies into existing gardens to aid in the rebound of Monarch butterfly populations
- Utilize improved butterfly habitat to educate park users about the status of Monarch butterfly populations and efforts undertaken in City Park to aid in their survival

areas of ecological importance

vegetative areas

As previously stated in the large-scale context, City Park suffers from turf monoculture and the absence of native vegetation, plantings, and trees. Areas prime for turf alternatives are the DeBoer Natural Area, the southwestern edge of the Big Meadow, and additional open areas not utilized for recreation. The Crabapple Collection and Cottonwood Grove also serve as historically and ecologically significant areas in which existing trees should be preserved and replacement of trees that have died over time is required.

These areas, depicted in Figure 29, would benefit from soil improvement due to less chemical intervention, increased infiltration, and drought tolerance in Colorado's semi-arid climate. The DeBoer Natural Area could take advantage of this enhancement to emphasize its role in stormwater management and leverage the presence of native grasses and vegetation to educate park users about City Park's reference condition, the benefit of native landscaping to the natural ecosystem, and the historic significance of the DeBoer Waterway as a water feature and stormwater management channel.

While there has been planting of native grasses and vegetation between the museum and Ferril Lake, turf monoculture throughout the park could be improved through the replacement of turf with alternatives such as native grasses and wildflower meadows to attract native species and displace the nuisance species that thrive on turf to water habitat. The park's landscape suffers from the presence of a large Canada Goose population; the geese's attraction to the site is largely due to the turf in proximity to open water. The City Park Master Plan of 2001 states that the lack of wetlands or riparian buffers to the waterbodies in City Park has excluded bird species such as the Great Blue Heron and Kingfishers which

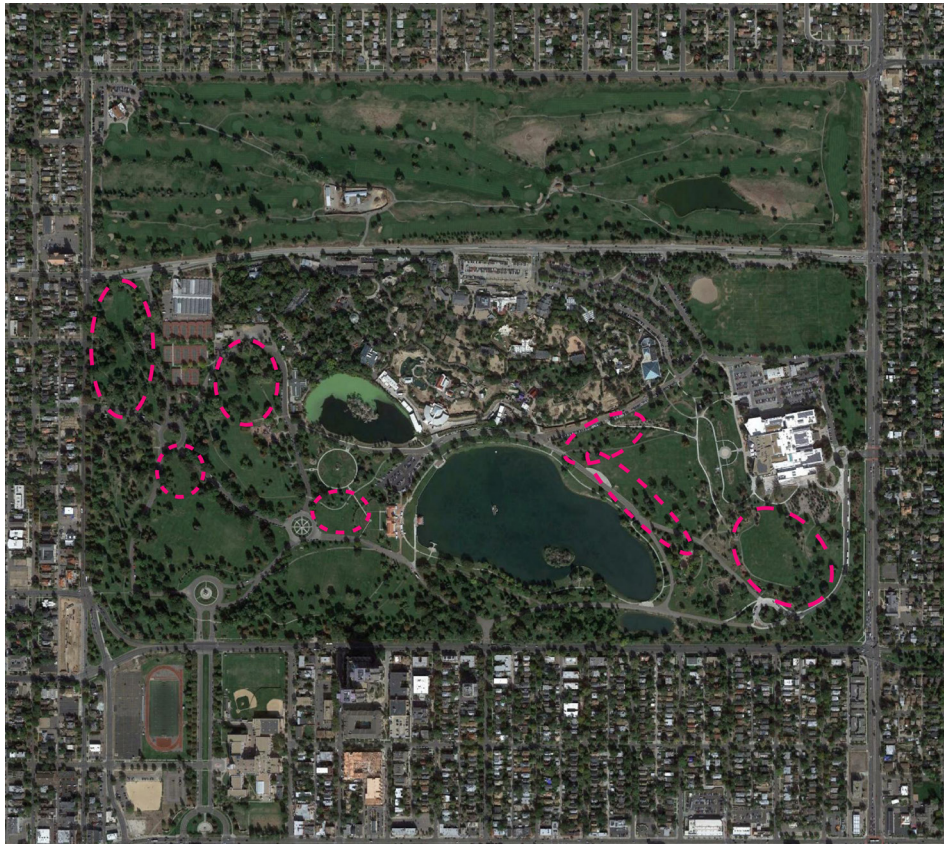

Figure 29: Areas Prime for Replacement of Turf with Native Grasses

Figure 30: Examples of Native Grasses (left to right: blue grama, buffalograss, junegrass)

have never been observed in the park; this condition has not improved park-wide, despite an attempt to create a wetland shoreline on Duck Lake that is mostly barren today (Mundus Bishop Design, Inc. et al, 2001). As an alternative to physically relocating this destructive species, replacing turf with alternatives and restoring shorelines to have a vegetative fringe would ideally decrease the goose population and cause native species to begin to utilize the area, in addition to the benefits it offers for water quality.

Through the restoration of native vegetation, it is possible to encourage a higher level of diversity in the park, as shown through the Rocky Mountain Arsenal, which would support a greater variety of native animals than are currently observed. Like the Arsenal, the presence of native vegetation would encourage the presence of wildlife native to the region such as black-footed ferrets, black-tailed prairie dogs, coyotes, eastern cottontails, mule deer, raccoons, and white-tailed deer. The range of soil types throughout the Rocky Mountain Arsenal also encourages an extreme level of plant diversity that in turn can support native species of birds, butterflies, bees, and animals (Service, 2016). The refuge is home to blue grama, plains cottonwoods along its lakes and streams, prickly poppies in short-grass prairies, rocky mountain bee plant, rubber rabbitbrush, sand bluestem, showy milkweed, and sideoats grama – all of which would add significant diversity and interest if planted in City Park. The introduction of or increase in a diversity of native plant and tree species, would help combat dwindling tree instances in the park and benefit the habitat and food sources for mammals, birds, and pollinators. Other than its positive impact on native animal species, an increase in native vegetation, grasses, and trees would also aid in stormwater management through the provision of greater infiltration rates than currently experienced.

recommendations

- Utilize turf alternatives in the DeBoer Natural Area, the southwestern edge of the Big Meadow, and open areas not used for recreation to increase native grasses, vegetation, and plantings

- Replace turf along shorelines with a vegetative fringe to decrease the Canada Goose population and attract native bird species to the area, as well as to improve water quality in the lakes

- Preserve existing trees and replace trees that have died over time in the Cottonwood Grove and Crabapple Collection.

areas of ecological importance

golf course

The City Park Golf Course has been a part of the park in a similar form to what is seen today since 1913. However, after analysis of technical considerations and public input, the City Park Golf Course was selected as the desired site for water detention due to the fact that it will be able to protect more homes and business, it is an existing city asset and it will reduce the need to acquire public property for the project, as well as it can also create better opportunities for further stormwater improvements that might need to be made in the future (Denver to Integrate Stormwater Detention) There are three variations for additional water detention facilities being discussed, each with differing impacts to the Golf Course during a flood event and to the trees currently in the area. This detention area "will be integrated into an updated design of the golf course and help protect some of the city's most at-risk neighborhoods from flooding. Outside of storms, the area will remain a dry, fully functioning golf course" (Denver to Integrate Stormwater Management).

Regardless of the exact details of the detention plan, there are a few actions that could be taken to make sure the detention project is as effective as possible both for the surrounding neighborhoods as well as the ecological functioning of the park. Instead of simply making the detention facility a simple, shallow excavation without any pretreatment, the project would present an opportunity to daylight the channels that follow the stormwater pipe network. This would have the dual benefits of creating more visual interest on the golf course as well as creating additional habitat for birds and wildlife along the natural migration corridor through the park. Plantings of native cottonwoods and other wetland species on the edge of the detention ponds, as well as along any additional water channels as has been done throughout the course already would also be beneficial in terms of slowing stormwater flows and

Figure 31: Proposed Vegetated Bioswales in the Golf Course

improving stormwater quality. Vegetated swales in the low lying areas of the golf course and water channels would be helpful for the same reasons and would also potentially decrease the water levels that need to be handled by the detention area in the event of a 100-year flood. This is done through catchment and infiltration as the stormwater moves across the golf course towards the detention areas. In the figure above, a general detention site is outlined in blue and channels to be daylighted are show as dashed blue lines.

Bogey's Restaurant would also be impacted by the detention plans. The proposed detention area is at the site of the existing restaurant, presenting the opportunity to relocate the restaurant to the highest point on the course. This would remove it from the detention area and would also afford the restaurant a better view, improving the experience and success of Bogey's as a whole.

The Hale Parkway could be another opportunity to increase detention, reduce flooding in the area, and increase the ecological functioning of the golf course. The Hale Parkway is one of the two major branches of the Montclair Creek, currently underground, which originates near George Washington High School and flows through Crestmoor Park, crossing 6th Avenue at Krameria Street and following 7th Avenue from Krameria to Grape Streets. The former Montclair Creek then follows the Hale Parkway from 8th Avenue to 12th and Albion Street, crosses Colorado Boulevard between 12th and 14th and flows through the National Jewish Hospital campus, across Colfax Avenue at Jackson Street and along Jackson into City Park as shown in Figure 32 (Hyde, 2012).

Daylighting a portion of this creek system could create additional channels for water during flood events and also create expanded riparian habitat for wildlife and water filtration. It would also create an additional amenity for the neighborhood to enjoy, both for education and recreation in a variety of forms. The Platte to Park Hill: Stormwater Systems project aims to create additional recreation opportunities in other areas such as open space along the Cole open channel with a bike/walking trail as well as an additional half acre of park land at Globeville Landing Park, providing greater park space and recreational opportunities to those neighborhoods (Department of Public Works, 2016).

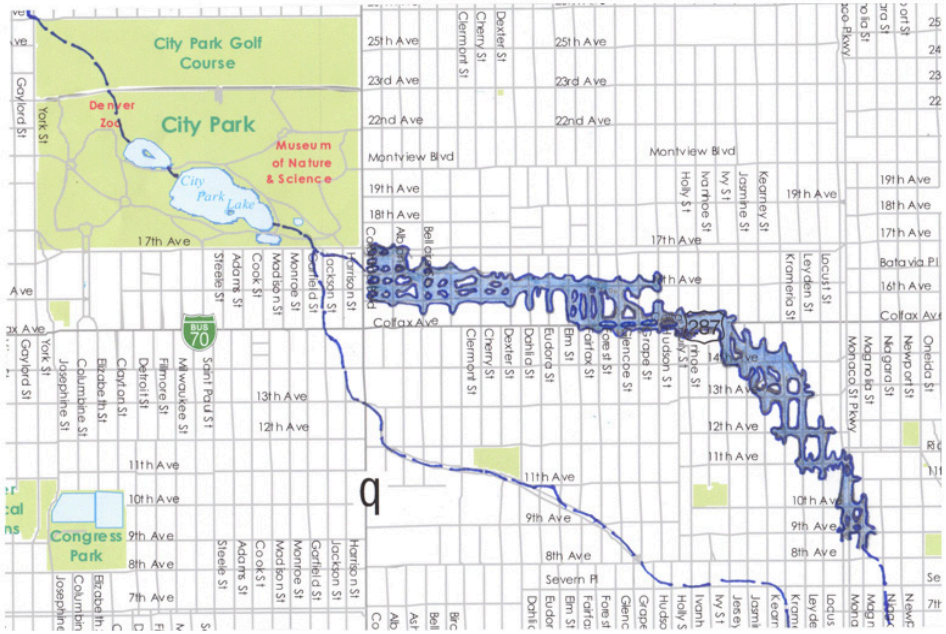

Figure 32: Hale Parkway Path

recommendations

- Daylight channels that follow the storm pipe network, as well as the Hale Parkway to improve detention, mitigate flood events in the area, and create additional habitat for birds and other wildlife
- Relocate Bogey's Restaurant out of the future detention area and to higher ground
- Increase native Cottonwood plantings in riparian areas around waterways/detention areas.
- Implement vegetated swales in low lying areas of the golf course and water channels to slow stormwater flow and increase stormwater quality

CONCLUSION

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recommendations matrix

To conclude, recommendations were arranged into one chart based on the six different sections used in the analysis of the report and high level estimates were given of the time and cost that might be associated with each recommendation. This was done in order to begin to inform implementation prioritization. The numbers are general ballpark figures with the time estimates divided into categories of "Under 1 year," "1-5 Years," and "Over 5 Years." The costs are divided into categories of "Under $20,000," $20,000-$100,000," and "Over $100,000."

RECOMMENDATIONS	TIME	COST	NOTES
LARGE SCALE CONTEXT			
Replace areas not utilized for recreation with native grasses or wildflower meadows	Under 1 year	Under $20,000	Per recommended area, dependent on areas done, etc.
Increase in tree cover of habitat providing for bird species	Under 1 year	Under $20,000	Average about $115/ tree, depeding on type of tree bought, pines and cottonwoods, generally pines are more expensive, spruce most expensive
CIRCULATION/ CONNECTIVITY			
Braided Path/ Zoo Loop	1-5 years (from when you start)	Over $100,000	Possible partnership opportunity
Reopen east and west entrances to the zoo	N/A	N/A	Dependent on zoo Potential opportunity for partnership
Improve visibility through fence around zoo perimeter	N/A	N/A	Dependent on signage but signs aren't very expensive
Increase signage near the zoo and for vehicular/ pedestrian movement	Under 1 year	Under $20,000	Per path; dependent on type of path, i.e. porous concrete, asphalt, crushed refines
Create surface material consistency in paths to indicate use	1-5 years	$20,000- $100,000	Dependent on any vendor specific alterations that might be needed, maybe partnership with vendors
Better utilize Graham Bible House as vendor location	N/A	N/A	Dependent on any vendor specific alterations that might be needed, maybe partnership with vendors
WATERWAYS			
Restore DeBoer Waterway as a water feature	Under 1 year	Over $100,000	From design to construction
Implement subsurface aerators in Duck and Ferril Lakes	Under 1 year	Under $20,000	Mentioned by planning staff as being currently under consideration
Implement constructed wetlands with gravel filtration on the slopes of Little and Ferril Lakes	1-5 years	Over $100,000	From design to construction
Implement end-of pipe filtration in pipe entering Duck Lake from Ferril Lake	Under 1 year	Under $20,000	Pipe is already there, so only need one filter for that pipe
FORMAL GARDENS			
Include native flower and grass species in existing formal gardens	Under 1 year	Under $20,000	
Retrofit existing formal garden beds to serve as rain gardens with overflow or underdrain pipes	Under 1 year	Under $20,000	Per rain garden; 1-5 for all rain gardens in the whole park estimated
Implement milkweed plantings into the DeBoer Natural Area, south of the Lily Pond, and meadows not utilized for recreation	Under 1 year	Under $20,000	Depend on seeds or pre-started milkweed plants
Implement a rain garden with native species to support butterfly populations south of the Lily Pond	Under 1 year	Under $20,000	Per rain garden; 1-5 for all rain gardens in the whole park estimated
Incorporate flowers that attract adult butterflies into existing garden beds	Under 1 year	Under $20,000	
Utilize improved butterfly habitat to educate park users using signage	Under 1 year	Under $20,000	
VEGETATIVE AREAS			
Utilize turf alternatives in the DeBoer Natural Area, the southwestern edge of the Big Meadow and open areas not used for recreation to increase native grasses, vegetation, and plantings	Under 1 year	Under $20,000	Per area
Replace turf shorelines with vegetative fringe	Under 1 year	Under $20,000	Per area
Preserve existing trees and replace trees that have died in the Cottonwood Grove and Crabapple Collection	Under 1 year	Under $20,000	Per area, see tree one above
GOLF COURSE			
Daylight channels that follow the storm pipe network, as well as the Hale Parkway	Over 5 years	Over $100,000	
Relocate Bogey's Restaurant out of the future detention area and to higher ground	1-5 years	Over $100,000	
Implement Vegetated Swales in low lying area of the golf course and water channels	1-5 years	$20,000-$100.000	
Increase native Cottonwood plantings in riparian areas around waterways/detention areas	Under 1 year	Under $20, 000	Per area

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appendices

BACKGROUND RESEARCH

As the centrally-located largest park in Denver, City Park has the potential to be the model for urban park sustainability for the metro area. For the purpose of this literature review, criteria toward making City Park a sustainability model were determined by our team. These criteria will be used to evaluate existing plans for the park, identifying gaps where it is lacking. Literature will then be used to provide supplemental information that fills these gaps that will direct future analysis and provide a foundation for recommendations in the Ecologically Based City Park Master Plan.

Utilizing the Sustainable Urban Site Design Manual, prepared for the NYC Department of Design and Construction Office of Sustainable Design (DDC) in 2008, as guidance this capstone will use the criteria of stormwater management, wildlife habitat and vegetation, and circulation to direct recommendations toward the improved ecological future of City Park. Although these criteria are defined with different titles in the manual, its sections of maximize vegetation, water management on urban sites, and materials in site and landscape design are being utilized as the foundation for the content for our criteria. Minimizing site disturbance is also a section of the manual; however, construction is not a consideration for City Park for the purpose of this plan so it is not being used. However, circulation is not included in this manual so the Best Management Practices Used at Urban Parks in National and International Locations will be used to evaluate the circulation criterion.

The Sustainable Urban Site Design Manual's sections include material that spans all necessary content related to City Park except circulation – maximize vegetation cover, pollution mitigation, respite and habitat, shading, windbreak, turf alternatives and use of native vegetation, habitat enhancement, and appropriate plant selection. The chapter, water management on urban sites, includes information about stormwater management in quantity and quality, water-efficient landscaping, impervious surfaces, irrigation strategies, and hardscape, pretreatment, structural, and bioengineered techniques and strategies. The chapter, materials in site and landscape design, covers utilizing recycled material and light-colored pavement and hardscapes to decrease the Urban Heat Island effect (Gruzen Samton Architects LLP et al, 2008). This basis described will be used to evaluate the park's 2001 Master Plan—Revitalizing the Legacy of City Park, the 2010 City Park Circulation Plan, and the 2009 City Park Arboretum Master Plan.

REVITALIZING THE LEGACY OF CITY PARK MASTER PLAN

Plan Review

The City Park Master Plan, published in 2001 by Denver Parks and Recreation, aims to provide a comprehensive strategy for preserving and enhancing the park. Recommendations for this plan are based on preservation and are separated into zones of City Park including City Park Proper, Ballfields Area, Esplanade, Denver Zoological Gardens, and City Park Golf Course. These recommendations focus on the condition and preservation of existing structures in the context of historically significant vegetation and plantings as well as compatibility with the historic purpose and plan for the park. The plan focuses primarily on restoring the historic nature of the park where it has degraded or been compromised, however it also provides recommendations for stormwater and bird habitat improvement. These recommendations include restoring a naturalistic character to Ferril Lake's shoreline through wetland/riparian plantings, preserving City Ditch as the course of water to the lakes, preserving and reestablishing riparian shorelines and role in water quality and stormwater management of Sediment Pond, and continuing the rehabilitation of Duck Lake through new plantings and habitat improvements (Mundus Bishop Design, Inc. et al, 2001). Wildlife habitat is mentioned as being present in the park's urban forest and open water. It lists

common wildlife such as Canada Geese, mallard duck, cormorants, ravens, magpies, starlings, flickers, and red squirrels. The plan also references the black capped night heron rookery on Duck and Ferril Lake's islands and the cormorant rookery on Duck Lake as ecological features of the park (Mundus Bishop Design, Inc. et al, 2001).

Other recommendations related to land use and circulation emphasize the importance of clarity and connectivity in park circulation, as well as strengthening the character and historic integrity of the park (Mundus Bishop Design, Inc. et al, 2001). Improving intersections, street parking and garage structures, vehicular traffic patterns, pedestrian access and environment, wayfinding, and transit access are also proposed and separated by park areas including park entries, perimeter roads, the northeast parking area, interior park spaces, the City Park Pavilion and Ferril Lake, west park, and the southeast area.

Gaps Analysis

Utilizing the criteria for evaluation, the plan exhibits strength in vegetation, but with insufficient emphasis on wildlife habitat. Although stormwater management is covered in regards to the lakes in the park, the recommendations are outdated because of the age of the plan. Plan recommendations for vehicular traffic movement in terms of lanes and on-street parking, intersection improvements, as well as pedestrian access and environment (i.e. condition of paths) and wayfinding to improve connectivity to and within the City Park are thorough; however, use of surface materials and multi-use paths for clarity, consistency in signage with visitor attractions and locations at entrances and major pedestrian and vehicle intersections is a gap in the plan's recommendations (Best Management Practices Used at Urban Parks in National and International Locations, 2007).

Recommendations from the Literature

The 2001 Master Plan's assessment of vegetation is strong and present throughout the plan in existing conditions, preservation recommendations, and recommendations in land use and circulation. However, the historic significance and compatibility is stressed more than any other function of vegetation in the plan. The existing conditions analysis of wildlife habitat is detailed and the observation that the excessive Canada Goose population is due to the lack wetland development or a vegetative fringe other than mown turf is astute. The plan states that large bodies of water such as Ferril Lake should attract great blue herons and kingfishers, though none have been observed in City Park (Mundus Bishop Design, Inc. et al, 2001). Despite this analysis, the recommendations for wildlife habitat are lacking. Recommendations are limited to vague suggestions for riparian plantings, shoreline restoration, and habitat improvements. The DDC Sustainable Urban Site Design Manual provides more in-depth strategies to supplement what the 2001 Master Plan lacks. The manual recommends specific strategies for shoreline restoration such as planting upland areas adjacent to the shore with native vegetation and riparian fringe to restore habitat. Unlike the plan, the manual describes the provision of wildlife habitat through connectivity to form natural networks, as well as highlights the importance of habitat enhancement through vegetation to attract and support birds, butterflies, and insects. It focuses on biological corridors for optimal species movement and dispersal for the maintenance of healthy populations; this is further supported by using native vegetation to encourage movement of native species within a corridor. The manual also emphasizes not only the use of vegetation for wildlife habitat, but also to cleanse stormwater runoff and act as natural flood control. Utilizing a combination of vegetation for wildlife habitat and stormwater management offers additional opportunities for multiple benefits (Gruzen Samton Architects LLP et al, 2008).

In the plan, stormwater management and water quality is only explicitly mentioned once in reference to the recommendations surrounding Sediment Pond. Recommendations toward riparian and vegetative fringe relate to stormwater quality and management because of its natural filtration capacity, but it is not recommended as part of stormwater management best management practices. The plan exhibits significant gaps in not including stormwater management practices in any capacity other than those incorporating the lake ecosystems. Water-efficiency landscaping is a key part of water and stormwater management in the DDC Manual. Not only does this type of landscaping decrease energy use and air pollution, it also reduces the demand for potable water used for irrigation and reduced runoff of stormwater that carries pollutants into water bodies. Stormwater strategies that the manual suggests are grouped into four categories; hardscape, pretreatment, structural, and bioengineered techniques. Hardscape techniques of porous pavements are effective for pedestrian pavements, plazas, or parking areas. Permeable pavers are also given as an option. Vegetative filters/buffers are recommended for parking lot islands and landscaped areas adjacent to paved areas which were not included in recommendations given in the plan because of the lack of parking structures that exist currently (Gruzen Samton Architects LLP et al, 2008). Bioretention and swale designs for stormwater catchment and infiltration are also outlined by the manual. The plan touches on restoration on the DeBoer Waterway (an ideal area for stormwater catchment and infiltration), but focuses on the historic nature of the water feature and not its function as a tool for stormwater management. The Urban Storm Drainage Criteria Manual (USDCM) Volume 3, another literature reference for stormwater management, provides Colorado specific tools for selected best management practices (BMPs). The USDCM also provides a comprehensive list of BMPs based on function, compatibility with surroundings, maintenance and sustainability, and cost. The manual describes targeted pollutants of BMPs as well as land use and context to correctly choose BMPs for specific projects. To properly make choices of appropriate BMPs for City Park, the manual provides data such as infiltration rates for different soil types and rainfall events for the Denver area (Urban Storm Drainage Criteria Manual: Volume 3 Best Management Practices, 2010). A combination of these literatures provides both broad practices and how to properly apply those practices to the Denver and urban park context.

The plan's gaps in the use of differing surface materials, multi-use paths, and consistent signage with visitor attractions and located at entrances and major pedestrian and vehicle intersections can be supplemented through the Best Management Practices Used at Urban Parks in National and International Locations literature. These recommendations state that pathway materials (such as crushed stone, gravel, stone pavers or bricks, concrete, or asphalt) should be built to accommodate expected use. Asphalt or similar materials are preferred in terms of maintenance and durability, but a mixture of surface materials to differentiate uses accommodate social paths. For example, in Chicago the Lakefront Path is a 10-foot wide bike path with three feet of gravel on either side for runners and walkers (Best Management Practices Used at Urban Parks in National and International Locations, 2007). The multi-path concept is supported further by the literature by stating that these types of trails designated for pedestrians, bikes, and even cars controls congestion and confusion. Like City Park which experiences weekend closures, the literature states that road closures and free shuttles during weekends and busy periods can put a focus on the pedestrian environment (Best Management Practices Used at Urban Parks in National and International Locations, 2007). Signage is also emphasized as a circulation strategy by aiding in eliminating confusion through consistent and clear orientation signs. The literature recommends consistent signage design among visitor attractions in the park as well as locations of signage at entrances and major pedestrian and vehicular intersections (Best Management Practices Used at Urban Parks in National

and International Locations, 2007). Although the confusion in circulation is discussed in the 2001 Master Plan, specific strategies for subtle improvements in connectivity within the park are provided through the literature.

CIRCULATION AND USE PLAN FOR DENVER'S CITY PARK

Plan Review

The City Park Circulation Plan was prepared in 2010 for Denver Parks and Recreation as an update and supplement to the 2001 Legacy Plan. The fourth goal of that plan was to "create a clear circulation system with a hierarchy of trails, roads, and walks" (City Park Circulation Plan, 6) so the circulation study sought to provide recommendations for safe multi-modal access to various users and use types that exist within the park. The plan also looks to recommend ways to update the infrastructure of the park to better serve its users today. Each of the recommendations in the plan was evaluated based on the goals of improving the experience for park users, increasing safety for users and being fair and equitable for all types of park users (City Park Circulation Plan, 6). The circulation study and plan focuses on four main areas:

- Refining and restoring City Park's historic circulation routes to provide equitable access to all users; including the creation of an interior, one-way vehicular circulation system using historic routes and a two-way park boulevard, improved clarity of entrances and way finding, and the creation of a network of paths with a clear hierarchy
- Assess the demand for parking at the zoo and museum and ease conflicts between Park users and zoo – or museum – goers who park along Park roadways; improve quality and quantity of parking and integrate access and circulation throughout the park
- Evaluate the master plan (Revitalizing the Legacy of City Pak) recommendation to create a "pedestrian promenade" for pedestrians and bicyclists on historic carriage roads
- Improve circulation routes to enhance visitor experience while avoiding conflicts between cars, bikes, and pedestrians and reducing the number of fragmented zones and the extent to which those zones are fragmented by circulation routes (City Park Circulation Plan, 6)

The plan further identifies issues and opportunities related to entries, roadways, parking and pedestrian and bike routes. It states that the main monumented entries are under used and confusing; the vehicular circulation through the park is confusing and inefficient and the roads lack a park feel as well as create major divisions in the East and West Meadows; parking is not usually an issue for park users except for the areas right around the zoo and museum where it can be an issue at certain times; and the pedestrian and bike routes can be difficult to safely navigate due to the lack of signage and the condition of the paths in general (City Park Circulation Plan, 10).

Recommendations are also divided into four categories: park entries, vehicular circulation, parking and pedestrian and bicycle circulation. Those categories are then divided into further categories that are largely the same but not completely. The park entries section gives recommendations related to the West Meadow, Park Boulevard, East Meadow, Museum and Zoo Roads, and Pedestrian Promenade. Vehicular circulation is concerned with the West Meadow, Park Boulevard, East Meadow, and Museum and Zoo Roads. Parking also looks at the East and West Meadows, the Park Boulevard and the Museum and Zoo Roads in addition to the Pavilion Parking Lot and the pedestrian and bicycle recommendations also center around the East and West Meadows, the Park Boulevard, the Museum and Zoo, Pedestrian Promenade and signage (City Park Circulation Plan, 22). The plan then ends by discussing implementation, including prioritization and cost estimates as well as phasing recommendations.

Gaps Analysis

In terms of the criteria of stormwater management, wildlife habitat and vegetation, and circulation, the plan obviously by its nature is entirely focused on circulation. It does not deal with stormwater management or wildlife habitat and vegetation but it is not meant to deal with those things. The plan addresses issues related to pathway design for multimodal use and ease of navigation for park users but it doesn't do much to address trail or path surface types or the protection of landscape elements in its recommendations (Best Management Practices Used at Urban Parks in National and International Locations, 2007).

Recommendations from the Literature

In the Best Management Practices Used at Urban Parks in National and International Locations three main key points are identified related to controlling circulation and access: control access for safety and the protection of landscape elements, design pathways and entrances to accommodate visitors' needs, and reduce damage to the landscape through the use of fencing, social trail reduction tactics, edging and corner treatments (Best Management Practices Used at Urban Parks in National and International Locations, 2007). In the City Park Circulation Plan it discusses issues of safety and ease of access for visitors but it doesn't address issues of protection of landscape elements that could be damaged by circulation.
The circulation plan does address the need for changes and modifications to entries in the Park, which is something that is also covered in more detail in Best Management Practices Used at Urban Parks in National and International Locations. The best practices manual also addresses different paving materials and surface types that can be used in parks depending on the use which is something that is not addressed in the circulation plan but that would present an interesting opportunity and could also potentially be used the create the hierarchy of paths and trails that the circulation plan identifies as being desirable in the park.

CITY PARK ARBORETUM MASTER PLAN

Plan Review

The City Park Arboretum Master Plan was written in 2009 and establishes the vision that "The City Park Arboretum will provide the public an educational tree collection that is diverse, sustainable, and honors City Park's historic landscape legacy" (City Park Arboretum Master Plan, 2009). Overall the plan focuses on the trees within the park, although it acknowledges the importance of the shrubs and herbaceous collections and suggests further studies be undertaken to address those specifically. The plan looks at six main things in particular:

- Document and evaluate the existing conditions of the park's tree collection
- Establish a vision for an arboretum that complements the park's overall mission and the 2001 City Park Historic Landscape Assessment and Master Plan
- Establish a tree planting framework that preserves existing collections and incorporates new collections
- Identify park improvements to implement the arboretum objectives
- Promote public awareness and education about the values of the park's trees
- Develop management strategies to sustain healthy and long-lived tree plantings (City Park Arboretum Master Plan, 2009)

This arboretum plan also identifies values related to historic landscape values, park values and tree values before going on to conceptually divide the park into various zones with distinct characteristics and desired purposes. These zones are the woods zone, meadow zone, historic structure zone, garden zone, natural area zone, and development zone (City Park Arboretum Master Plan, 2009). It looks specifically at new tree plantings,

plant collections, the Mile High Loop Tree Walk and outdoor educational displays such as tree labels and interpretive displays in order to arrive at recommendations (City Park Arboretum Master Plan, 2009). These recommendations include things like formal recognition for the arboretum, modifications for how the arboretum is overseen, and potential partnerships between groups like the Denver Museum of Nature and Science, the Denver Zoo, the Denver Botanic Gardens, City Park Alliance, the Cooperative Extension Service, and East High School with each party being able to potentially provide some specific service or services for the creation, enhancement, or maintenance of City Park and its arboretum in the future (City Park Arboretum Master Plan, 2009).

Gaps Analysis

Based on the criteria found in the Sustainable Urban Site Design Manual, 2008, stormwater management, wildlife habitat and vegetation, and circulation, this plan is heavily focused on vegetation, specifically trees. It does not address stormwater management or the additional criteria of circulation in its recommendations as it is not meant to do that. The arboretum plan does a good job of identifying the different areas of the park that might dictate different plant types and it also looks at using plants that are native to the area as suggested in the manual however it deals more with the specific trees themselves as opposed to the role that those trees play in the larger context of the park (Gruzen Samton Architects LLP et al, 2008).

Recommendations from the Literature

The City Park Arboretum Master Plan focuses most of its discussion on the preservation and maintenance of the trees in the park for primarily for historic, educational, and moral reasons, which are all extremely important however the Sustainable Urban Site Design Manual looks more extensively at other factors and benefits that come from maximizing vegetation in parks. It looks at the effects of vegetation on shade and cooling, which is briefly mentioned in the arboretum master plan but not discussed in depth. It also discusses stormwater runoff mitigation possibilities which are not addressed at all in the City Park plan but would be a tremendous benefit to the park since stormwater management is a concern for the area in general. The Sustainable Urban Site Design Manual also talks about the potential pollution mitigation and wind mitigation services that can be provided by mature, maximized vegetation, neither of which are addressed in the City Park Arboretum Master plan at all but would be interesting additions to such a document. The potential for habitat creation in the vegetation is briefly mentioned in the City Park Arboretum Master Plan but is not addressed in detail as it is in the Sustainable Urban Site Design Manual. This is mentioned and implied in some cases throughout the arboretum master plan but it is an important aspect of vegetation in parks that could be further explored.

DENVER ZOO MASTER PLAN (DRAFT)

Plan Review

Another plan that is not necessarily as relevant in its entirety but has parts that should be considered is the Denver Zoo's Draft Master Plan. The zoo is located in the park and its plan states that "cooperation and coordination between the Zoo, the Museum and Denver Parks and Recreation is increasingly important as the visitation to the park continues to increase" (Denver Zoo Master Plan, 2015). The plan also addresses the fact that all parking is shared among all entities in the park, including the zoo and the museum so those things must be managed together.
Most importantly however is the discussion of the interface between the Zoo and the park and the interaction between them. The Zoo Master Plan includes measures to address what it refers to as the Zoo/Community Interface which are things like parking,

the zoo entry frontage and the zoo park frontage, which looks at possible improvements to the fence and the community connections (Denver Zoo Master Plan, 2015). The plan lays out specific design proposals that would address the unique situations present at each of the different frontages that the Zoo shares with both the park and the surrounding community. This also includes the waste management building that would be located adjacent to Duck Lake in the park (Denver Zoo Master Plan, 2015).

CONCLUSION

Together the 2001 City Park Master Plan, the 2010 Circulation Plan and the 2009 Arboretum Plan present a comprehensive view of the conditions in the park both existing and desired. Together they all cover, to some extent, the criteria identified through research as being important to the ecological functioning of the park: stormwater management, wildlife habitat and vegetation, and circulation. They offer great starting points from which additions and modifications can be made based on reference materials to enhance the functioning of the park for all of its users.

City Park is a very large park that contains an extremely diverse array of uses, those traditionally associated with a park in an urban area, such as leisure and recreation, as well as a museum and a zoo. All of these plans reflect that diversity and all of them together represent the full picture of the larger system of the park. The stormwater management, wildlife habitat and vegetation and circulation functions can be improved in order to create a park that can realize its full ecological potential and be maximized for all of its users both now and into the future as the park continues to evolve and change.

METHODOLOGY

NECESSARY DATA TO COLLECT

In order to address the problem described in the introduction, data falling into the categories of stormwater management, wildlife habitat and vegetation, and circulation needs to be gathered. Data regarding stormwater drainage patterns, flood elevations, flow rates, detention areas, current mitigation measures, and cost of restoration and improvements projects is necessary to comprehensively evaluate the existing stormwater management system and make recommendations for optimal ecological function. Data for historically and ecologically significant tree and vegetation species that aid in the creation of migratory bird habitat and improvement of flow and infiltration rates for water movement through the park. This type of data will be gathered from sources at different entities (including the City of Denver and Urban Drainage and Flood District). Data for circulation will be pulled from Denver Open Source data on trails and sidewalks, parks, lakes, streets, pedestrian routes, building outlines, locations of restrooms, bike racks, and historic landmarks, and tree canopy. Additionally, data illustrating the location of the Regional Bike Route in City Park will be mined through Denver Regional Council of Government's (DRCOG) open data catalog.

METHOD FOR DATA COLLECTION

Strategies to gather this data are utilizing open source data from the City of Denver and DRCOG, as well as connecting with representatives from Denver, the Urban Drainage and Flood District, and other contacts suggested by our client. Other than site visits, no surveys or interviews will be administered for the purpose of data collection throughout the course of this project.

Most contact with individuals will be made via e-mail; however, meetings will be set up to further the conversation and give the contact a complete picture of the data we hope to gather. This will require contact with multiple individuals in different areas of expertise to create a well-rounded set of data for multiple levels of analysis.

DATA ANALYSIS

The focus of this plan is on implementation and on-the-ground strategies to recommend for the future success of City Park in its ecological function and connectivity. Therefore, the data collected will primarily be utilized in spatial analysis of the park. Spatial analysis will be utilized to determine existing conditions found in City Park as well as for recommendations for implementation strategies. Through this type of analysis, it will allow us to correctly place best management practices in the areas that are most benefitted, identify structures and areas (such as shorelines) for improvements or restoration that would increase the ecological function of the park. For example, a filter on the drainage pipe emptying into Duck Lake could improve water quality and the renovation of the shoreline along Ferril Lake as a riparian buffer/ wetland habitat can attract native bird species that are currently not present in the park as well as aid in water filtration. In addition to spatial analysis, renderings and site plans will be utilized to illustrate the potential of the recommendations. Data on costs for best management practices will be analyzed statistically to allow for a cost/benefit analysis of implementation of recommended strategies and long-term maintenance.

Data analysis using these methods will allow for a comprehensive analysis of the ecological function of the park as well as connectivity for users as a regional and neighborhood park for Denver. The data allows for an analysis of existing conditions, implementation strategies, and cost to shape feasible and creative solutions to improve the park's function as a natural system as well as a hub for recreation, entertainment, and education through the presence of the Museum and Zoo.