ECOLOGICAL SITE ASSESSMENT

BRACKENRIDGE PARK

Brackenridge Park Conservancy
San Antonio, Texas

August, 2019

Lady Bird Johnson Wildflowercenter
The University of Texas at Austin

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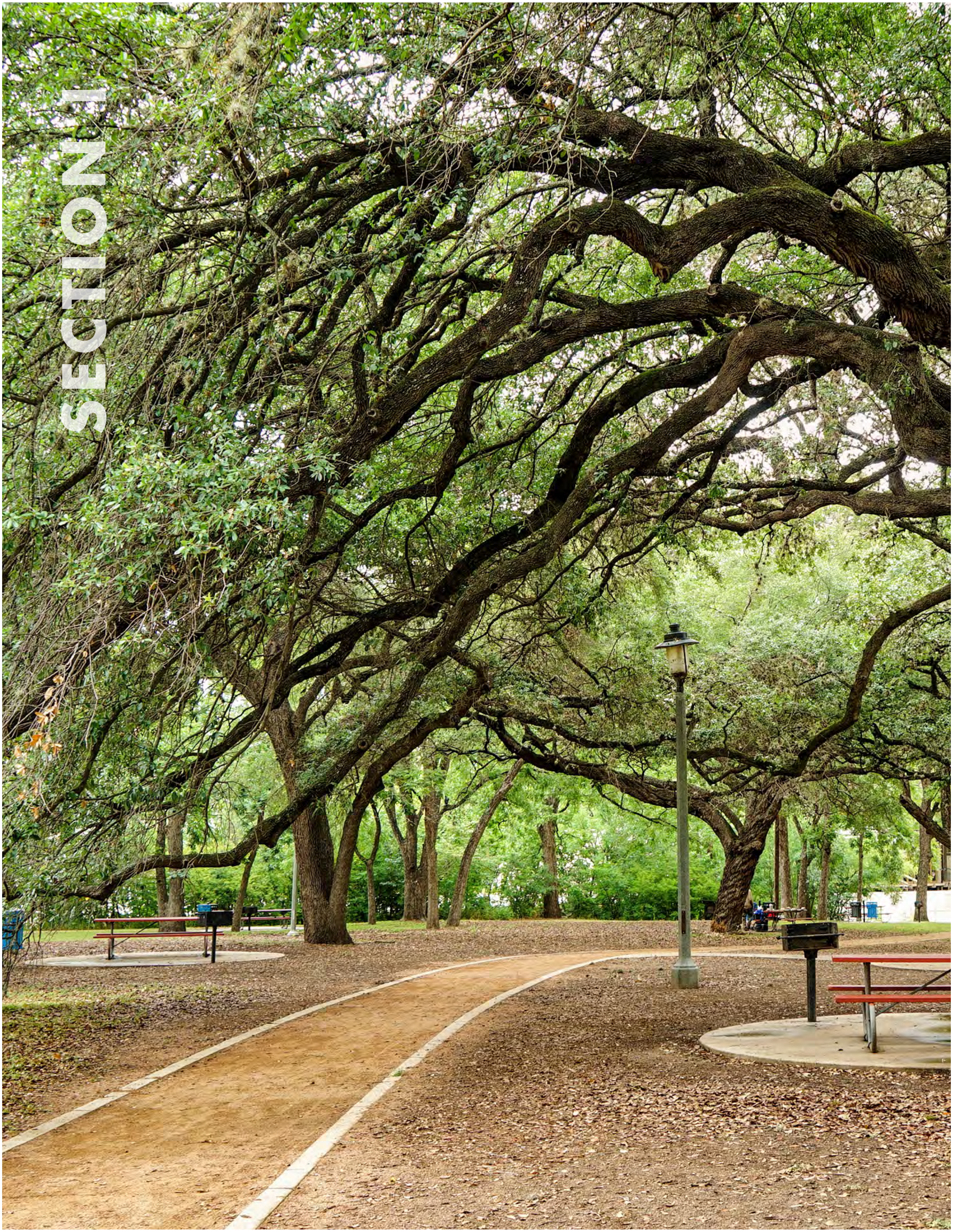


Introduction

A. Purpose and Intent of Document

The Wildflower Center conducted an ecological assessment of Brackenridge Park in San Antonio, Texas on July 30th and July 31st 2018. Previous detailed inventories of flora and fauna have been conducted on the site, such as the 2012 Brackenridge Park Biodiversity Study (Bio-West 2012) referenced throughout this report. The assessment conducted by the Wildflower Center takes a broader view, providing an overview of existing plant communities, soil surface condition, analysis of site drainage and relationship of the site to the surrounding area. The assessment examines current conditions and seeks to identify opportunities to improve the overall ecological health of the site, improve the resilience of natural communities and enhance hydrologic function. The assessment brings together multiple aspects of ecology (soils, vegetation, hydrology), with human use and maintenance parameters.

Thus, this report combines on-the-ground analysis with an understanding of the larger ecological region in order to take a step past documentation and suggest a series of interventions ranging from basic restoration and land management to more intensive actions such as installing filter strips and rain gardens. The intent is not to prescribe specific interventions, but rather to illustrate the possibilities the site holds, which can then be integrated, and enhance, with the broader cultural resources inventory.

The goals of all interventions center on the following:

- Enhancement of overall ecological health, with an emphasis on hydrology. Actions will seek to reinforce the connection between upland and riparian areas and to enhance the land's capacity to capture, infiltrate and clean water.
- Enhancement of visitor experience + tie in with the Zoo School's work in outdoor learning environments
- Human safety and plant community resilience (ability to adapt to changing conditions and recover from damage)

Layout of Document

Potential interventions are summarized in Section 1B and referenced throughout the document.

The site assessment is presented in two parts: Ecological Context (Section II) and Current Condition (Section III). The Ecological Context section explains the dynamics, history and important parameters of the ecological system Brackenridge Park is embedded within. Current Condition describes Brackenridge Park itself. Descriptions are brief to enhance readability. Supporting details and information on the mechanics of restoration and land management are found in Restoration Principles (Section IV).

B. Potential Interventions

Potential interventions are summarized here and referred to through the rest of the document.

There are many opportunities to improve the ecological health of Brackenridge Park while creating beautiful and engaging spaces. Restoration of ecosystem function involves not only replacing components, but restoring processes that allow natural systems to repair themselves and thrive. In practice, the assessment and repair of natural processes begins with the soil. Healthy soil, and the healthy plant communities it supports, is the foundation of functional ecosystems.

Interventions are intended to enhance ecological health through:

- Supporting or enhancing plant diversity
- Supporting soil health through plant community management and direction of traffic

Basic restoration includes invasive species management, diversity enrichment, creating a riparian buffer, protecting tree roots and improving soil condition.

Restoration and management strategies vary between riparian, bottomland and upland areas. Soil moisture and flood frequency decrease with distance from the waterway's edge and this influences the plant community. The ecological function performed by the landscape changes along this gradient as well, with bank stability and organic inputs more important near the water and flood mitigation more important in the uplands (Figures I.1& 1.2). Plant species vary in the services they are able to provide and should be selected and arranged accordingly. Basic restoration strategies are fairly straightforward and will be further discussed in the Restoration Principles section (IV).

Facing page, top **Figure 1.1 Riparian buffer width and ecosystem function**

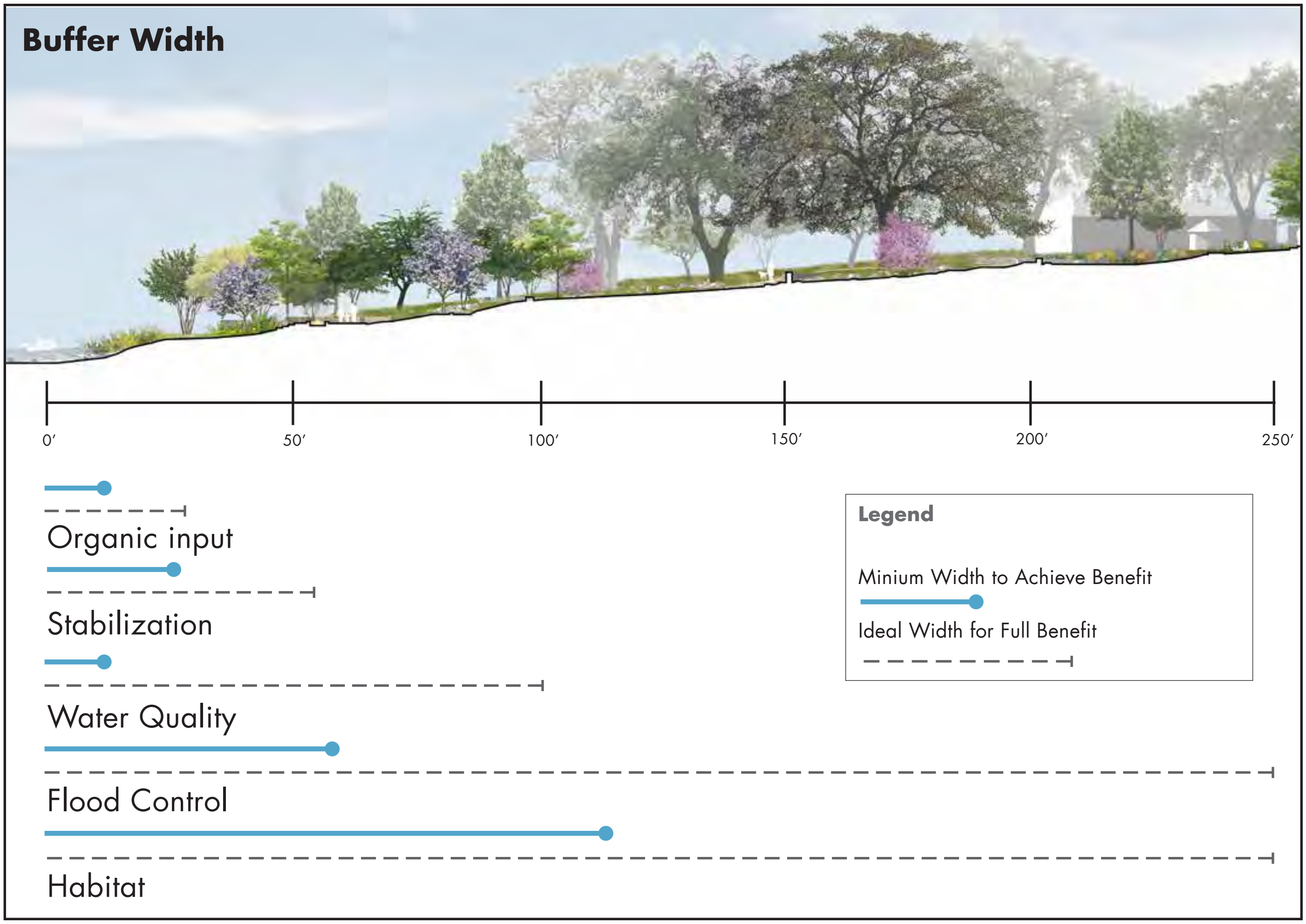
Riparian buffers are protective bands of vegetation lining a river. The width of the buffer partially determines the ecosystem services it can provide. Buffer widths of 100-300' provide a full suite of services, while narrower buffers provide fewer services. The dotted line represents the minimal width required for a given service. The solid bar represents the widths at which the full benefit is realized.

Ideally, buffers combine woody and herbaceous colonizer and stabilizer plants. The woody species can be thought of as the skeleton of the bank as their larger diameter roots help hold the bank in place. Herbaceous stabilizer plants have dense fibrous roots that intertwine with the woody species further enhancing stability. The above ground growth of both woody and herbaceous plants serve to slow water and capture sediment. Herbaceous plants provide additional protection during flood events because top growth lays down, protecting the soil and allowing them to remain in place during high flow events. Colonizers quicky cover bare ground. The community as a whole helps to clean and capture runoff. The buffer should also include a mix of obligate wetland, facultative wetland and facultative species so that the community can adapt to changing water availability.
Image: Adapted from the City of Austin's Citizen Riparian Monitoring Protocol

Facing page, bottom **Figure I.2 Ecological Function Zones**

The functions performed by an ecosystem vary by plant community, location and soils. Uplands perform the most substantial flood mitigation, capturing runoff. Bottomland and riparian zones play a direct role in river health, moderating water temperature, providing the last chance to remove contaminants from runoff, stabilizing the bank and enhancing terrestrial and in-stream habitat.

Buffer Width

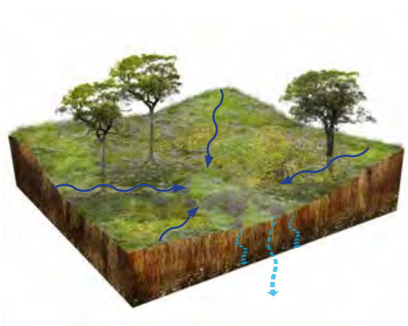


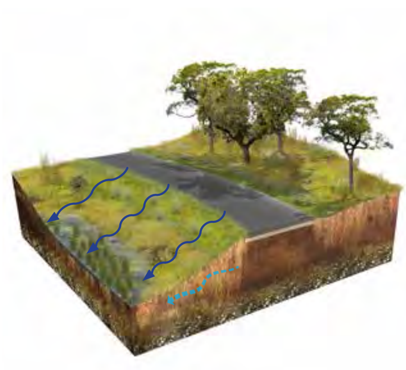
Ecological Function Zones

Upland Zone
- flood mitigation
- water capture & cleaning
- acts as a sponge

Bottomland Zone
- slowing & cleaning runoff
- terrestrial habitat & corridor
- floodplain & deposition zone

Riparian Buffer Zone
- bank stabilization
- slowing & cleaning runoff
- stream cooling
- adding organics to in-stream habitat
- terrestrial habitat & corridor





top: **Figure I.3 Rain garden**
Rain gardens capture and filter water.

middle: **Figure I.4 Bioswale**
Bioswales convey water while providing filtration and infiltration.

bottom: **Figure I.5 Filter strip**
Filter strips capture sediment and filter water as it moves through them. Frequently placed parallel to parking lots and roads.

Low Impact Development (LID) is a set of interventions designed to repair hydrologic processes. The goal of LID is to reduce runoff and improve water quality by capturing and treating it in a series of dispersed, but interconnected, systems such as rain gardens, bioswales and filter strips. LID strategies help mitigate high runoff volume and contamination from impervious cover such as roads, parking lots and trails. Many opportunities exist for improvements that could position Brackenridge Park as a leader in water quality protection, conservation and stormwater management. Ideally a park-wide average annual runoff capture goal will be set and a system of integrated LID elements and ecological restoration areas will be designed to realize the goal. Capturing 90% of average annual runoff, or the runoff from 1.5 to 1.8 inch rain events, would significantly improve the health of the San Antonio river.

Rain gardens (or bioretention) function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological and chemical treatment processes (Figure 1.3). Rain gardens allow water to be retained in a basin shaped landscape area with plants and soil where the water is allowed to pass through the plant roots and the soil column. These features normally consist of a filtration bed, ponding area, organic or mulch layer and plants. Rain gardens provide stormwater treatment that enhances the quality of downstream water bodies by infiltrating runoff, or when designed with liner or underdrain, temporarily storing runoff and releasing it over a period of days to the receiving water. The vegetation within the rain garden can provide shade and wind breaks and help absorb noise. These systems are easily integrated into site landscaping and their design can be formal or informal in character. The exact design requirements for this technology depend on many variables including whether or not they are designed for infiltration, desired function and aesthetic qualities.

Bioswales are linear bioretention features that convey water and are constructed and vegetated to provide filtration and infiltration (Figure 1.4).

Filter strips function as pass-through devices that do not hold water for a significant amount of time, rather cleansing the water as it moves through the element (Figure 1.5). Frequently installed along roadways, parking lots and trails, filter strips provide the first level of filtration.

These technologies are not stand alone systems. Benefits can be maximized by coupling these approaches into what is known as a treatment train approach. A treatment train consists of several stormwater practices installed in a series. Having multiple systems provides several benefits including a level of redundancy in case one system is not functioning properly. The configuration for a treatment train can take many different forms. Common applications include the use of a vegetated swale to convey stormwater to or from other treatment systems, such as a rain garden. In this scenario, swales can provide some level of pretreatment when installed upstream of other facilities.

Outdoor Learning Environments use natural elements to create engaging spaces that encourage exploration and creative play among children. Many of the elements called for in outdoor learning environments could also improve site hydrology and habitat value. For example, grass mazes (Figure I.6) can be designed and placed so they act as filter strips. The San Antonio Zoo School is engaged in creating these types of spaces and Brackenridge Park may be able to support those efforts.

Figure I.6 Grass maze

Common elements of outdoor learning environments, such as this grass maze, offer opportunities to combine engaging human experiences with enhanced ecological function. Image: G Brown Design Inc.

SECTION II

Ecological Context

Land management requires an understanding of current conditions as well as the project's ecological context. *This section is focused on context, not on-site conditions*. Two useful sources of contextual information are Ecoregion descriptions, developed by the U.S. Environmental Protection Agency (EPA), and the Ecological Site framework, developed by the Natural Resources Conservation Service (NRCS). Both are classification and descriptive systems. *Ecoregions* provide insight into the elements that influence ecosystem quality and integrity on a regional scale. *Ecological sites* classify landscapes on a finer scale, at the level of soil type.

Ecological site descriptions explore how and why ecosystems found on a given soil type shifted in the past and explore the processes that continue to be relevant to the site. This insight is invaluable while assessing the integrity of an ecosystem and evaluating appropriate management actions. Understanding both ecoregions and ecological sites is a useful starting point for land management and master planning. Together they shed light on historic communities and on the parameters influencing ecological health. For example, the amount of bare ground provides insight into nutrient cycling, runoff verses infiltration and overall soil health. But the amount of bare soil considered normal varies. 5-15% bare ground would be considered normal in the dry, rocky Low Stony Hill ecological site, but is a sign of a significant problem in the deeper soiled, moister Clayey Bottomland ecological site. Ecological site descriptions help managers tailor assessments to the local system.

A. Ecoregion: EPA level III

The ecoregions of Texas have been defined at two hierarchical levels that are compatible with the U.S. Environmental Protection Agency framework. Twelve level III ecoregions and 56 level IV ecoregions have been mapped for Texas. Level III is the most useful starting point for land management decision making. The ecoregions have been described in detail in other assessments and will be only briefly touched on here.

Brackenridge Park is located within the Texas Blackland Prairie ecoregion (Figure II.1). The Blackland Prairie is characterized by rich, deep, heavy clay soils that historically supported tall grass prairie and, to a lesser extent, savanna (scattered trees in a grassland matrix) communities. These soils are well suited to agriculture, and much of the ecoregion has been converted to that purpose. Historically, this ecoregion was primarily grassland with forested areas typically restricted to drainages, waterways and steep slopes. Live oak (*Quercus virginiana*) was the most common woody species, though post oak (*Quercus stellata*), blackjack oak (*Quercus marilandica*), cedar elm (*Ulmus crassifolia*), hackberry (*Celtis laevigata*) and honey mesquite (*Prosopis glandulosa*) were also present.

Bottomland forests found within floodplains have alluvial soils and contain bur oak (*Quercus macrocarpa)*, Shumard oak (*Quercus shumardii*), hackberry, elm (*Ulmus* spp.), ash (*Fraxinus* spp.), eastern cottonwood (*Populus deltoides*) and pecan (*Carya illinoinensis*).

ECOLOGICAL REGIONS OF TEXAS

Brackenridge Park is located within the Texas Blackland Prairie Ecogregion (No. 11).

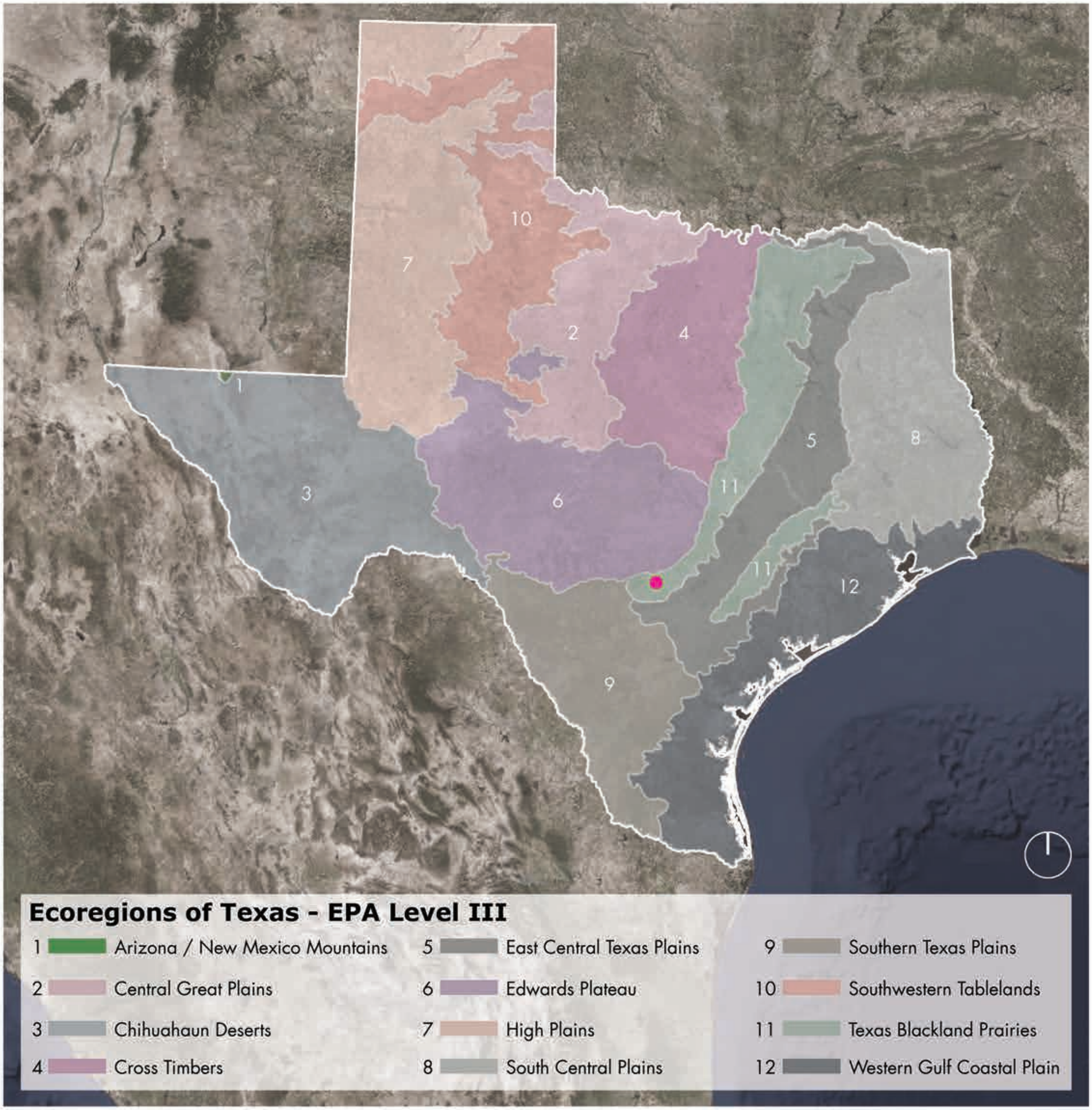


Figure II.1 Ecoregions of Texas

B. Ecological Site: Natural Resources Conservation Service (NRCS)

Ecoregions provide a useful starting point, but land management requires more specific information. One source of this information can be found in the Soil Survey. Ecological sites, **detailed within the soil survey**, are tied to soil types and have characteristic soils, hydrology (particularly infiltration and runoff) and plant communities and respond similarly to natural processes and land management (USDA-NRCS)[2].

Ecological site descriptions provide insight into the natural dynamics of a site by providing descriptions of the different plant communities supported by the ecological site, including the Historic Climax Plant Community (HCPC or reference community), describing the natural disturbance regimes, and discussing how communities shift with changing conditions. **Seating existing conditions within this dynamic structure helps land managers gain insight into the project area's ecological health and helps inform management decisions**.

Brackenridge Park contains three primary ecological sites—Clayey Bottomland, Southern Clay Loam, and Low Stony Hill, as well as several minor ecological sites (Figure 11.2)

The primary sites are summarized here, **using excerpts from the Bexar County soil survey, following a brief orienting paragraph by the Wildflower Center.** These descriptions are not detailing Brackenridge Park specifically, but rather the Ecological Sites that are associated with the park's soils. The descriptons are included to facilate the discussion of current conditions found in section III.

Summary figures for each ecological site (Figures II.3–II.5) contain three elements: State transition diagrams, plant community reference photos from the soil survey, and examples of healthy communities in the most likely target state or states for Brackenridge Park.

State Transition Diagrams summarize the dynamics of the site. Descriptions of each state, transition, plant community and pathway follow this model. Experts base this model on available experimental research, field observations, professional consensus and interpretations. Canopy cover can drive the transitions between communities and states because of the influence of shade and rainfall interception.

2. Soil Survey Staff, Natural Resources Conservation Service, United States Dept. of Agriculture. Web Soil Survey. Available online at the following link: https://websoilsurvey.sc.egov.usda.gov

BRACKENRIDGE PARK: ECOLOGICAL SITES

Ecological sites are tied to soil type and have characteristic soils, hydrology and plant communities. Areas within ecological sites respond similarly to natural processes and land management and so provide a useful starting point for land management decisions. Ecological sites are detailed within the soil survey compiled by the Natural Resources Conservation Service (NRCS).

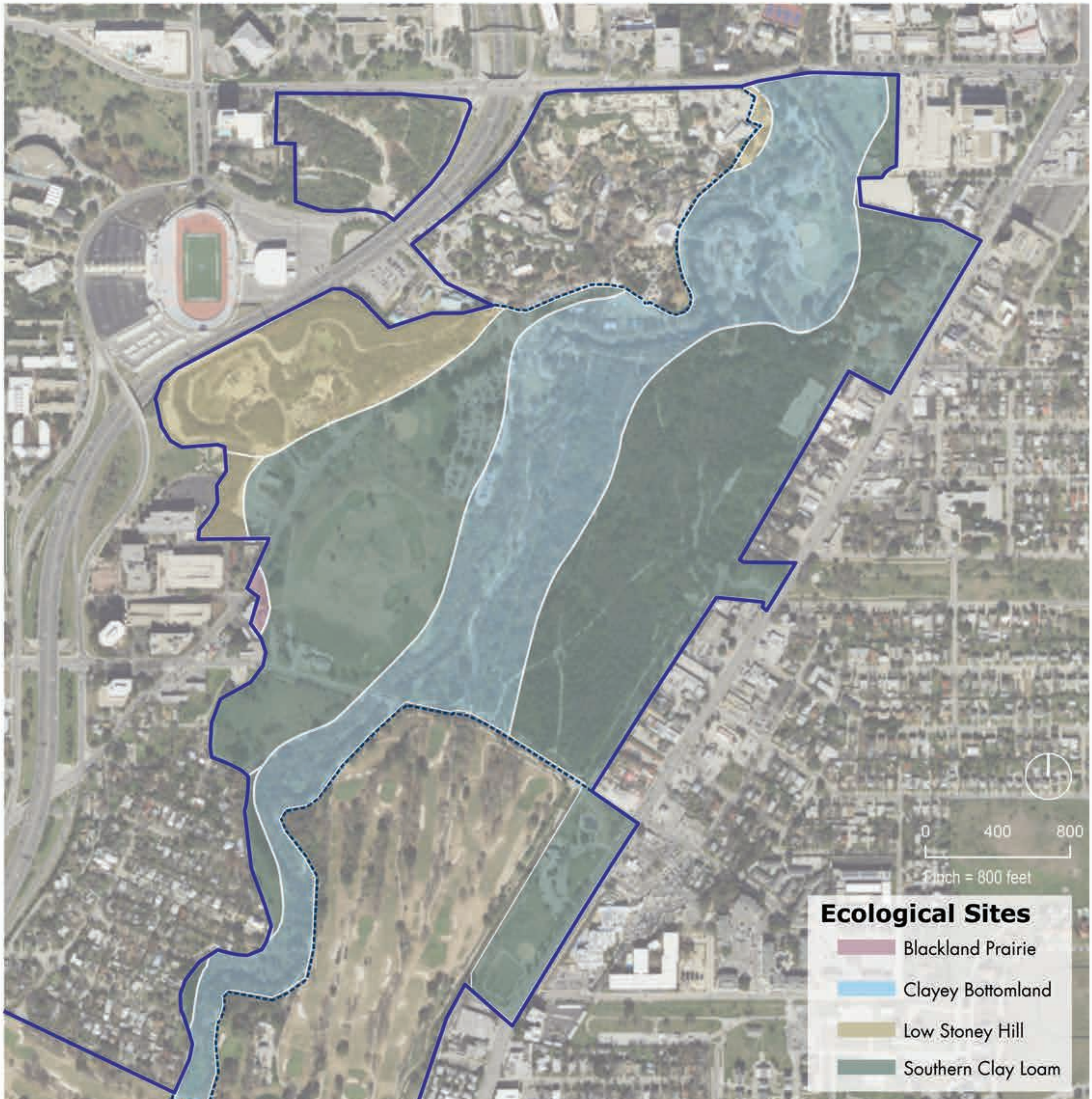


Figure II.2 Ecological sites

Clayey Bottomland (Figure II.3)

Clayey Bottomland runs through the heart of Brackenridge Park. The description below is drawn from the Bexar County soil survey (USDA-NRCS).

Introduction — The Northern Blackland Prairies are a temperate grassland ecoregion contained wholly in Texas, running from the Red River in North Texas to San Antonio in the south. The region was historically a true tallgrass prairie named after the rich dark soils it was formed in. Other vegetation included deciduous bottomland woodlands along rivers and creeks.

Background—Natural vegetation on the uplands is predominantly tall, warm-season, perennial bunchgrasses with lesser amounts of midgrasses. This tallgrass prairie was historically dominated by big bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*) and little bluestem (*Schizachyrium scoparium*). Midgrasses such as sideoats grama (*Bouteloua curtipendula*), Virginia wildrye (*Elymus virginicus*), Flordia paspalum (*Paspalum floridanum*), Texas wintergrass (*Nassella leucotricha*), hairy grama (*Bouteloua hirsute*) and dropseeds (*Sporobolus* spp.) are also abundant in the region. A wide variety of forbs add to the diverse native plant community. Mottes of live oak and hackberry (*Celtis* spp.) trees are also native to the region. In some areas, cedar elm, eastern red cedar (*Juniperus virginiana*) and honey locust (*Gleditsia triacanthos*) are abundant.

During the first half of the nineteenth century, row crop agriculture lead to over 80% of the original vegetation to be lost. Urban development has caused greater decline in remaining prairie. Today, less than one percent of the original tallgrass prairie remains.

Fire Regimes — The prairies were a disturbance-maintained system. Prior to European settlement (pre 1825), fire and infrequent, but intense, short duration grazing by large herbivores (mainly bison and to a lesser extent pronghorn antelope) were important natural landscape-scale disturbances that suppressed woody species and invigorated herbaceous species (Eidson and Smeins 1999). The herbaceous prairie species adapted to fire and grazing disturbances by maintaining below-ground penetrating tissues. Wright and Bailey (1982) report that there are no reliable records of fire frequency occurring in the Great Plains grasslands because there are no trees to carry fire scars from which to estimate fire frequency. Because prairie grassland is typically of level or rolling topography, a natural fire frequency of 5 to 10 years seems reasonable.

Disturbance Regimes — Precipitation patterns are highly variable. Long-term droughts, occurring three to four times per century, cause shifts in species composition by causing die-off of seedlings, less drought-tolerant species and some woody species. Droughts also reduce biomass production and create open space, which is colonized by opportunistic species when precipitation increases.

Historic Climax Community — Tallgrass Savannah Community.

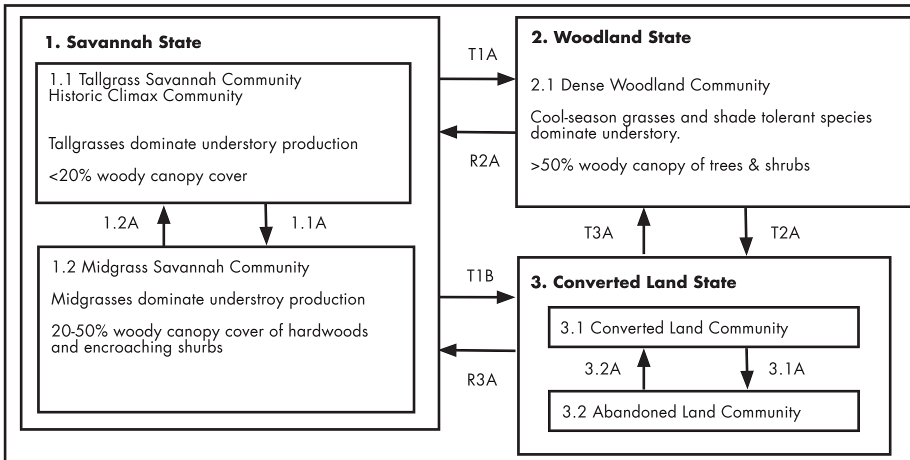
The Tallgrass Savannah Community (1.1) is characterized as a hardwood savannah with up to 20 percent tree and shrub canopy cover. Historic records of the 1700's do, however, indicate that early settlers and explorers found portions of this site to be heavily wooded. The Woodland community (2.1) occurred as a stable community on portions of this ecological site. Other reports (Mann 2004) discuss the importance of human caused fire as an important factor in keeping open grasslands prior to European settlement. It is assumed the Tallgrass Savannah Community occurred over the majority of this ecological site in a dynamically shifting mosaic over time with other communities in the Savannah State. Canopy cover drives the transitions between plant communities and states because the influence of shade and interception of rainfall.

Sedges, Virginia wildrye and rustyseed paspalum (*Paspalum langei*) dominate the herbaceous plant community in shaded and wet areas. The herbaceous community in the drier, open areas is dominated by beaked panicum (*Panicum anceps*), switchgrass (*Panicum virgatum*), Indiangrass etc. The balance of warm and cool season tallgrasses will be driven by the amount of canopy cover from large trees, particularly the amount and size of stands with closed canopy. When the site is open and tree cover is less than 10 percent, warm season tallgrasses will approach 30 percent species composition by weight, while cool season grasses approach 10 percent. As tree cover approaches the upper limit of the reference community (20 percent), cool season grasses and grasslikes will approach 30 percent and warm season tallgrasses will approach 10 percent species composition by weight.

Large trees create 20 percent canopy cover. The overstory canopy is densest adjacent to watercourses. Continuous, year-long grazing for a succession of years will tend to move the reference herbacoues community towards a herbaceous community of Bermudagrass (*Cynodon dactylon*), dallisgrass (*Paspalum dilatatum*), carpetgrass (*Axonopus affinis*), giant ragweed (*Ambrosia trifida*) and annual sumpweed (*Iva annua*).

The reference Savannah community will shift to Midgrass Savannah Community under the stresses of improper grazing. Unless some form of brush control takes place, woody species will increase to the *50% canopy cover level that indicates a state change.* This is a continual process that is always in effect. The drivers of the transition (lack of fire and lack of brush control) constantly pressure the system toward the Woodland State.

FIGURE II.3 CLAYEY BOTTOMLAND ECOLOGICAL SITE



1.1 A Improper grazing management, no fire, no brush management, long-term drought
1.2A Proper grazing management, prescribed burning, brush management
T1A Improper grazing management, no fire, no brush management, long-term drought
T1B Land clearing, crop cultivation, pasture planting, range planting, tree planting
R2A Proper grazing management, prescribed burning, brush management
T2A Land clearing, crop cultivation, pasture planting, range planting, tree planting
R3A Proper grazing management, brush management, prescribed burning
T3A Improper grazing management, no brush management, no fire, long-term drought
3.1A Improper grazing management, no brush management, idle land
3.2A Proper grazing management, pasture/range/cropland management, crop cultivation, pasture planting, range planting

top right: **Tallgrass Savannah***
Historic Climax Plant Community.

middle right: **Midgrass Savannah***

bottom right: **Dense Woodland***

top left: **Healthy Bottomland Hardwood/Wooded Riparian****
Target state for much of the Loamy Bottomland within Brackenridge Park.

bottom left: **State Transition Diagram**

*Image: Bexar County soil survey
**Image: Lady Bird Johnson Wildflower Center

Southern Clay Loam (Figure II.4)

The Southern Clay Loam ecological site is very similar to the Clayey Bottomland site, sharing much of the species composition and dynamics. However, it is an upland site so flooding is less important and it does not have the additional water availability that would be found closer to watercourses. This difference is reflected in the species composition and plant community structure. The historic woody cover for much of this site would have been close to 10%, though scattered dense woodlands were present. The description below is drawn from the Bexar County soil survey (USDA-NRCS).

The ***Historic Climax Plant Community***, the Tallgrass Prairie Community (1.1) is a true prairie with a few large live oak, elm, and hackberry trees along the draws and in occasional mottes. It is characterized by deeper soils dominated by warm-season, perennial tallgrasses, with warm-season, perennial midgrasses filling most of the remaining species composition. The warm-season, perennial forb component varies between 5 and 15 percent depending on climactic patterns and local precipitation. Woody species make up a minor component of the community, 5 percent by weight (up to 10 percent cover), even in the short term absence of fire (two to five years).

This plant community has very little bare ground. Plant basal cover and litter make up almost 100 percent ground cover. Soils are fertile with good permeability.

The reference prairie community will transition to a midgrass-dominated community under improper grazing management, with increasing dominance of species such as silver bluestem (*Bothriochloa laguroides*), Texas wintergrass and less palatable forbs.

Fire suppression, overgrazing and lack of brush management will encourage transition to a Shrubland State. *State change is considered to have occurred when woody cover reaches 35 percent.* Once woody species begin to establish, returning fully to the reference prairie community is difficult. During the transition from prairie to shrubland, soil fauna and organic mulch are reduced, exposing more of the soil surface to erosion in interspaces. The exposed soil crusts readily. However, within the woody canopy, hydrologic processes stabilize and soil organic matter and mulch begin to increase and eventually stabilize under the shrub canopy. The Mixed-Brush Community (2.2) can provide good cover habitat for wildlife. At this stage, highly intensive restoration practices are needed to return the shrubland to prairie.

FIGURE II.4 SOUTHERN CLAY LOAM ECOLOGICAL SITE

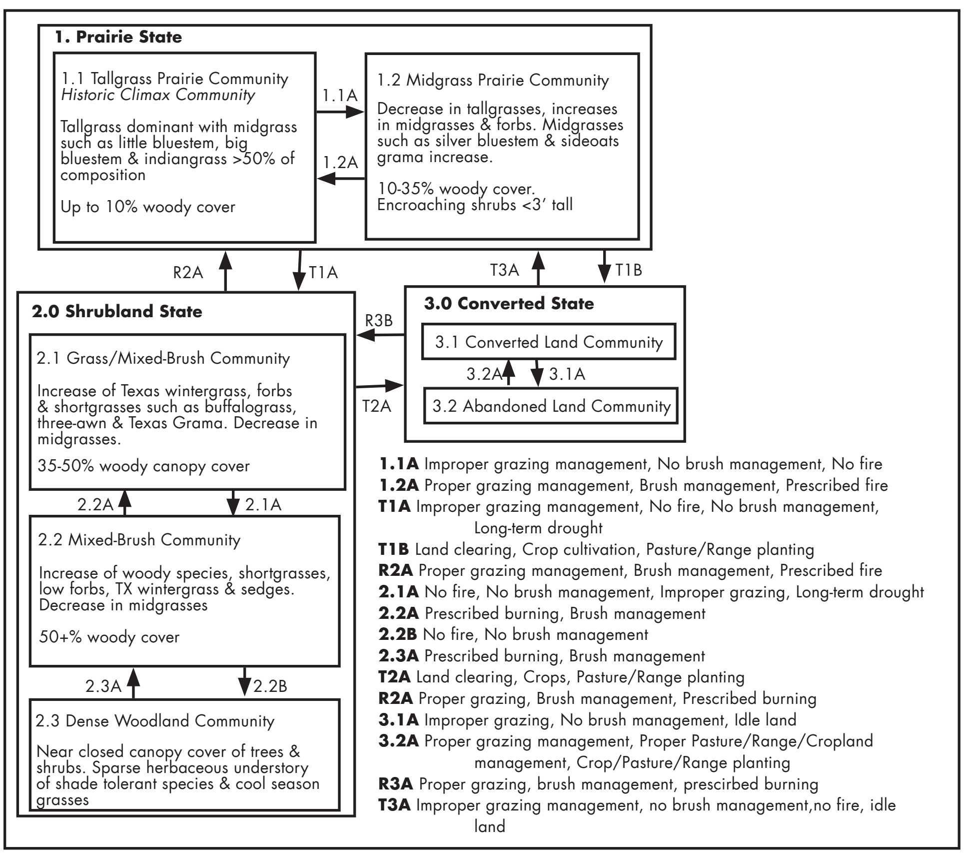


*Image: Bexar County soil survey

**Image: Lady Bird Johnson Wildflower Center

top right: **Tallgrass Prairie***
Historic Climax Plant Community.

middle right: **Midgrass Prairie****

bottom right: **Dense Woodland***

top left: **Mixed Woodland****
Mixed woodland with a diverse age structure and appropriate woody density is a resonable target state for much of the Southern Clay Loam in Brackenridge Park.

bottom left: **State Transition Diagram**

Low Stony Hill (Figure II.5)

The Low Stony Hill site occupies the foothills, carries thinner soils and is much drier than Southern Clay Loam or Clayey Bottomland. The site follows a similar dynamic pattern, shifting between open savanna and woodland states, but tend to rest more frequently in a wooded state, often carrying 50 percent woody cover or more. The description below is drawn from the Bexar County soil survey (USDA-NRCS).

The ***Historic Climax Reference Community*** is the Grassland Savannah Community, a fire-climax, open grassland with scattered oak mottes with about 10 to 20 percent tree canopy. The live oak is most abundant along water courses, where elm and hackberry trees also grow. Under a fire regime, the live oak can exist both as a tree and as a motte or thicket as it is a vigorous root sprouter. The herbaceous plant community is dominated by little bluestem. Also native to the site, but occurring less frequently are the wildryes (*Elymus* spp.), sideoats grama, tall dropseed (Sporobolus compositus) feathery bluestems (*Bothriochloa* spp.), green sprangletop (*Leptochloa dubia*), vine mesquite (*Panicum obtusum*), Texas wintergrass and Texas cupgrass (*Eriochloa sericia*). The site also grows an abundance of forbs, shrubs and woody vines.

Overstocking can cause a decline and even elimination of numerous plants from this community. As the plant community degenerates, big bluestem, little bluestem, Indiangrass and the wildryes decrease. Sideoats grama, tall dropseed, silver bluestem, Texas wintergrass, and buffalograss (*Bouteloua dactyloides*) are initial increasers on the site. Prolonged overuse results in a community of Texas wintergrass, curlymesquite (H*ilaria belangeri*), buffalograss, and woody species. The following grasses and forbs are commonly found on this site in a deteriorated condition: coneflower (*Ratibida columnifera*), snow-on-the-mountain (*Euphorbia marginata*), silverleaf nightshade (*Solanum elaegnifolium*), milkweeds (*Asclepias* spp.), Leavenworth eringo (*Eryngium leavenworthi*i), gray goldaster (*Heterotheca canescens*), horehound(*Marrabium vulgare*), evax (*Evax* spp.), Texas grama (*Bouteloua rigidiseta*), hairy tridens (*Erioneuron pilosum*), red grama (*Bouteloua trifida*), tumblegrass (*Schedonnardus panniculatus*), windmillgrasses (*Chloris* spp.) and annual brome grasses (*Bromus* spp.).

FIGURE II.5 LOW STONY HILL ECOLOGICAL SITE

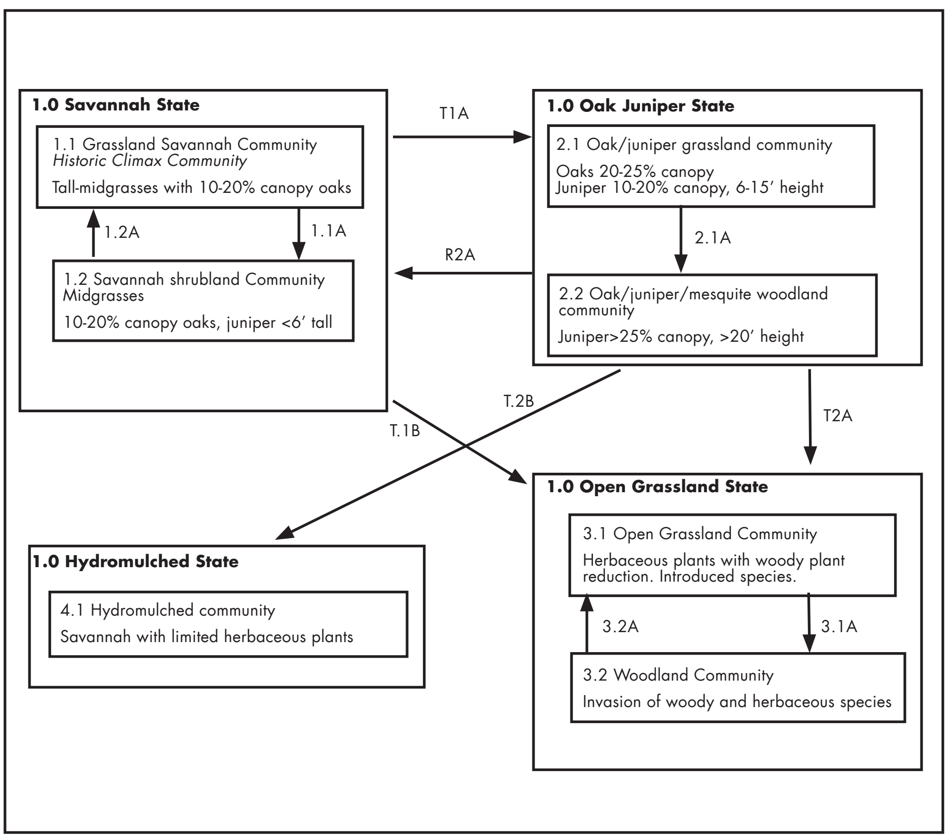


*Image: Bexar County soil survey

**Image: Lady Bird Johnson Wildflower Center

top right: **Grassland Savannah Community***
Historic Climax Plant Community.

middle right: **Savannah Shrubland Community***

bottom right: **Oak/juniper/mesquite Woodland Community***

top left: **Savannah Shrubland***
Maintain current condition.

bottom left: **State Transition Diagram**

SECTION III

Current Conditions

The Wildflower Center conducted an ecological assessment of Brackenridge Park in San Antonio, Texas on July 30th and July 31st 2018. Brackenridge Park lies on the banks of the San Antonio River within an urban commercial and residential area. The property can be divided into four broad ecological types:

- Riparian areas and Bottomland hardwood within the Clayey Bottomland ecological site
- Upland deep soil areas within the Clayey Loam ecological site
- Upland thin soiled areas within the Low Stony Hill ecological site.

Riparian areas are where rivers and streams meet the land. The riparian community is the biological community found along the river banks. This is a relatively wet and disturbance prone environment, and this is reflected in the plant community. Riparian communities contain a high percentage of water loving plants (obligate wetland species), plants capable of handling wet and dry conditions (facultative species) and quick establishing, fast growing species (early successional) as well as longer lived, slower growing species (late successional). A healthy riparian community contains a diverse mix of trees, shrubs and herbaceous species, though the ideal composition will vary between ecological sites. The integrity of the riparian area strongly influences the health of the waterway. Healthy riparian areas stabilize the bank, clean water entering the river, shade and add organic matter to in-stream habitat, and serve as important habitat and travel corridors.

Bottomland areas and the plant communities they support are characterized by frequent flooding and often by rich alluvial soils deposited as water flows over the floodplain. They often contain a substantial population of facultative species that can handle wet or dry conditions. Bottomland areas are frequently characterized by gallery forests with long lived, slow growing trees, interspersed with shrubs, grasses and perennials. Bottomlands flood often, but are not as frequently disturbed as riparian areas and are a bit drier.

Upland begins outside of frequently flooded area. They are drier than bottomland and riparian areas and are more fire prone in the Blackland Prairie and Edwards Plateau ecoregions. Healthy uplands function like a sponge, protecting rivers by capturing and slowing water during rain events, and slowly releasing it to the river as sub-surface, or below the ground, flow. This allows the river to receive the water over a longer period of time, and the water is cleaner when it arrives.

The property can also be divided by human use/management type. For discussion, areas maintained in a more open condition for access – such as the picnic areas – will be referred to as park maintenance areas while areas that receive less vegetative management – such as the wilderness area—will be referred to as wildland maintenance areas.

top: **Figure III.1 Combined Protection and Recreation Areas.**

middle: **Figure III.2 Armored Access Point**

bottom: **Figure III.3 Riparian Edge**

A. Overview

The goal of the site assessment is to identify elements of the site to protect or enhance as well as any problems (erosion, invasive species etc.) that can be addressed. Frequently, the best opportunities for enhancement of a site grow from the site's challenges. The primary elements considered during the on-site portion of the assessment are: drainage patterns, impervious cover, soil type and surface condition, plant community type, arrangement and composition, and bank condition.

Areas were given a subjective ecological health rating based on:

- Complexity of the plant community—is it diverse compositionally and structurally, what proportion of native or useful species verses problematic specie are present, in woodlands is the age structure appropriate?
- Soil surface condition—are organic matter and nutrient levels within expected ranges, does soil have a well-developed structure, is it compacted or exposed?
- Is there evidence of erosion, how severe is it?

Riparian Areas

- Challenges: Steep slopes indicating severe erosion, bank exposure and lack of a vegetative buffer is evident in many areas. Compacted soil is contributing to loss of bank stability and reduced water infiltration and filtration capacity. Substantial populations of invasive species are present throughout the riparian area. It should be noted that these conditions are quite common in urban parks.
- Opportunities: Moderate plant diversity remains along the bank in some areas and the soil retains a reasonable amount of organic matter (~5%), despite being compacted by heavy use. Thus, vegetative buffers along much of the bank could be reestablished with the use of mowing set-backs and defined river access and viewing points. Plantings can be added where funding allows in areas deemed high priority based on hydrologic or human use metrics.

Bottomland Hardwood – maintained open woodland adjacent to riparian areas

- Challenges: Low compositional and structural plant diversity and compacted soil combine to reduce the infiltration capacity of the soil. Additionally, low diversity reduces the resilience, or ability to respond to changing conditions and extreme events of the plant community. Communities are not regenerating, as evidenced by the lack of young individuals.
- Opportunities:
  - o Low Impact Development techniques to manage stormwater are appropriate for many of these areas. Features can be designed to also enhance pollinator habitat, provide more interest and help direct foot traffic to allow soil recovery. Maintenance capacity should be a key decision-making parameter.
  - o Simpler restoration interventions can be employed to enhance overall plant diversity, adding resilience and building soil over

time. For example, site-appropriate, knee-high plantings over tree critical root zones cool them, provide some foot-traffic protection and increase soil health time.

Figure III.1, Figure III.2 and Figure III.3 Illustrate possible restorative options for the combined riparian/recreational areas within the park. These photos were taken at Blue Hole Regional Park in Wimberley, TX.

Upland Woodland—low maintenance, closed woodland

- Challenges: The tree/shrub density is too high which reduces the health of individual trees and shrubs and increases the risk of catastrophic wildfire.
- Opportunities: High compositional and structural plant diversity is present and soils are in good condition. Selective thinning to create a diverse age structure, reduce fuel loads and allow remaining trees and shrubs to thrive would increase the woodland's health and resilience. Nature has begun the thinning process with several trees lost to drought. Some of these can be removed to reduce fuels, but some should be left standing to provide habitat.

Park wide recommendations

Soils/Vegetation/Hydrology

- Establish a park-wide goal for average annual runoff capture. *The suggested target is 90% average annual runoff, or capture of runoff generated by 1.5 to 1.8 inches of rain over 24 hours.* Accomplish this goal through a park wide system of ecological management areas and LID features that is tightly integrated with the circulation system. Manage runoff from existing and new impervious cover and set an upper limit on impervious cover within the park. Severely compacted soil behaves like impervious cover in many ways - reducing or eliminating infiltration and restricting root growth. Establish soil protection zones to reduce extent and severity of compaction and integrate them with the circulation system. Plantings, decking/grating systems and even mowing patterns can be used to strategically direct traffic away from critical root zones and ensure sufficient healthy soil in high traffic areas to achieve runoff capture goals. Directing traffic away from one area will concentrate it in others, so soil protection will need to be evaluated in tandem with reinforcement options in heavily trafficked areas.
- Establish riparian buffer, with integrated viewing and access points, along the full length of the river and coordinate with circulation planning. Set minimum and preferred buffer widths weighing hydrologic, use and maintenance requirements. 20 feet is the minimum buffer width required for basic function but 100 to 300 foot buffers provide a more complete suite of services. *The recommended minimum width for buffer in a walled, high use area is 20 feet and the preferred width is 50 feet. The minimum with for natural bank areas is 50 feet, expanding to 100-300 feet where possible.*
- Restore ecosystem integrity and overall plant and animal diversity. Accomplish this goal by creating an invasive management plan, increasing plant diversity with an emphasis on species and associations that build/bind soil or provide habitat value, increasing plant community structural diversity (i.e. restore midstory and herbaceous layers), and create a woodland management plan focused on woodland health and fire readiness.

Wildlife

- Increase in-stream habitat complexity/repair or create riparian buffer
- Reduce negative impacts on small mammal, bird, reptile and amphibian populations by aggressively managing the feral cat population
- Discourage feeding
- Increase efforts to relocate the rookery
- Support wildlife in natural areas by increasing structural diversity which includes increasing plant sturcutal diversity but also abiotic diversity. For example, creating small rock and brush piles for bird, reptile and amphibian habitat, leaving some downed wood and snags where appropriate, encouraging plant species with wildlife value and reconstructing midstory and herbaceous plant community layers.

B. Soils

The site contains five soil types (Figure III.4)

Heiden-Ferris complex (HoD3) is a minor component of the project area (0.1%). The soil is well drained, with very low to moderately low (Ksat 0.00 to 0.06 in/hr) capacity to transmit water and a moderate available water storage capacity (about 9.0 inches). The ecological site associated with Heiden is Blackland and the ecological site associated with Ferris is Eroded Blackland.

Branyon clay (Htb) is a minor component of the project area (0.1%). The clay soil is considered prime farmland. The soil is well drained with a very low to moderately low capacity to transmit water (Ksat 0.00 to 0.06 in/hr) and high available water storage (about 10.2 inches). The soil's associated ecological site is Loamy Bottomland.

Lewisville silty clay (LVA & LVB) is an alluvial soil. The silty clay soil is well drained with negligible to low runoff, a moderately low to moderately high (Ksat 0.06 to 0.20 in/hr) capacity to transmit water, and a high available water storage in profile (about 9 inches). The ecological site associated with the soil is Southern Clay Loam.

Eckrant cobbly clay (TaB & TaC) is an upland soil. The soil is well drained with medium runoff, a moderately low to moderately high (Ksat 0.06 to 0.57 in/hr) capacity to transmit water, and very low available water storage in profile (about 1 inches). The soil profile is shallow, cobbly clay underlain by bedrock. The ecological site associated with the soil is Low Stony Hill.

Tinn and Frio soils (TF) is a complex floodplain soil. The soil is moderately well drained to well drained. The clay Tinn portion has very low to moderately low (0.00 to 0.06 in/hr) capacity to transmit water, while the silty clay loam Frio portion has moderately high (0.20 to 0.57 in/hr) capacity to transmit water. Both Tinn and Frio have high available water storage. The Tinn associated ecological site is Clayey Bottomland and the Frio ecological site is Loamy Bottomland.

BRACKENRIDGE PARK: SOILS CLASSIFICATION

Soils are drawn from the USDA-NRCS soil survey for Bexar County.

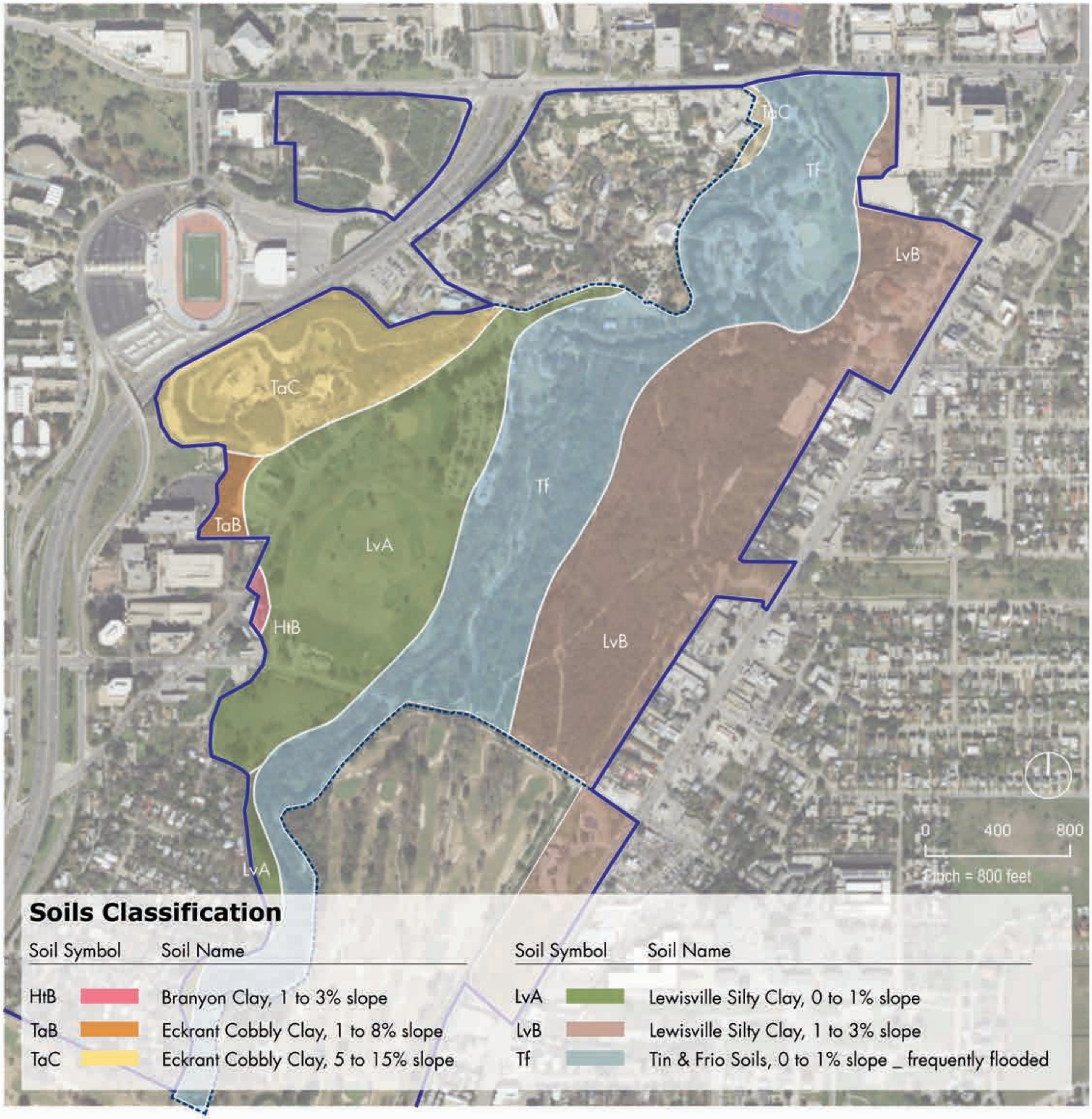


Figure III.4 Soils Map

BRACKENRIDGE PARK: SOIL HYDROLOGIC GROUP

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipiation from long duration storms. Group A solls have the highest infiltration rates. Group B soils have moderate infiltration rates. Group C soils have low infiltration rates. Group D soils have very low infiltration rates.

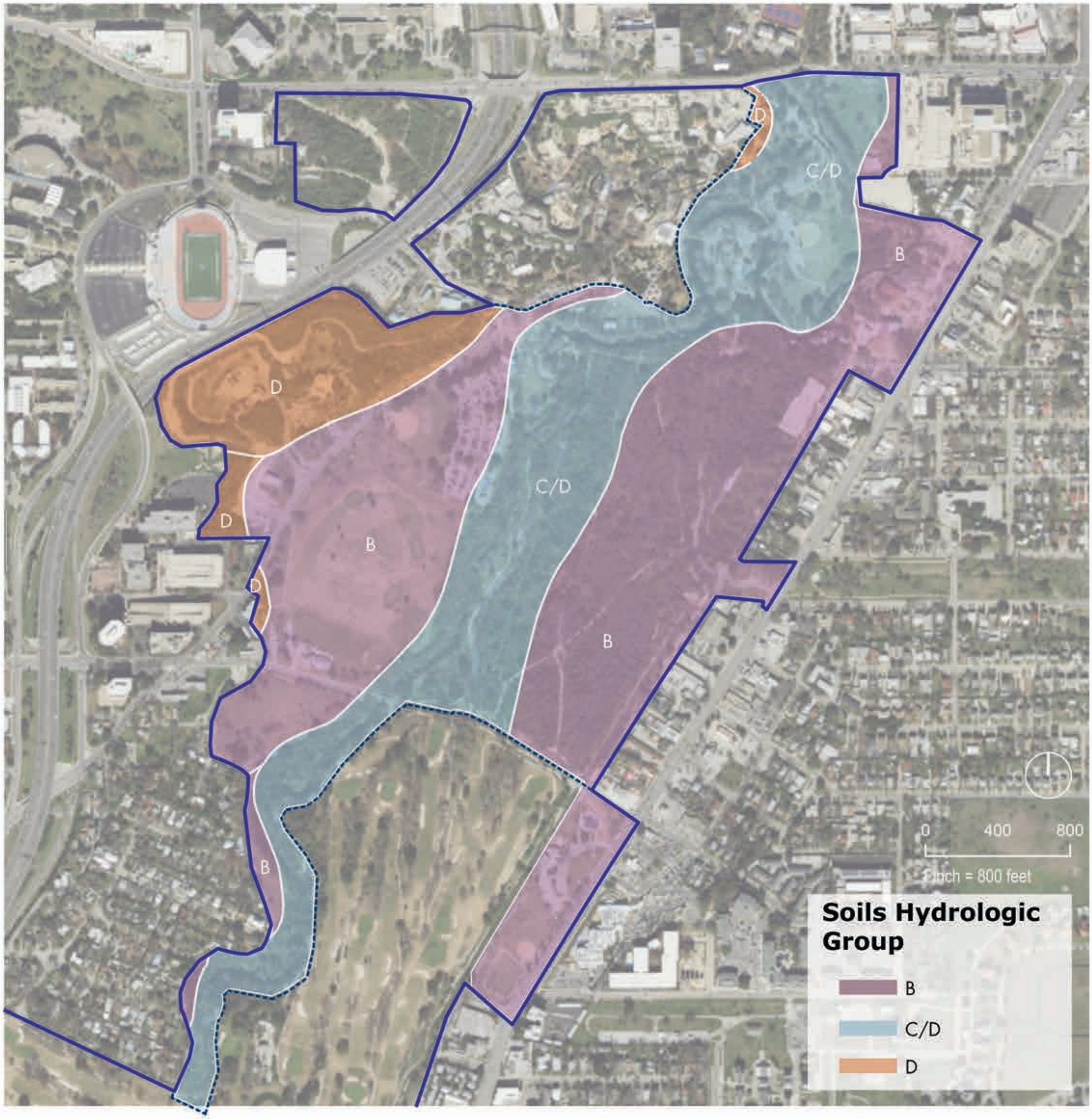


Figure III.5 Hydrologic soil map

Hydrologic soil groups
Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms. The soils in the United States area assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D).

Brackenridge Park's hydrologic soil groups are mapped in Figure III.5

Group B soils have moderate infiltration and consist of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately course texture. These soils have a moderate rate of water transmission.

Group C soils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.

Group D soils have a very slow infiltration rate and consist chiefly of clays that have high shrink-swell potential, a high water table, a claypan or clay layer at or near the surface and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Soil testing
Four soil samples were taken from areas (see Appendix for test reports). Compaction levels were very high in high use areas and were within normal levels in the wilderness area and the train tunnel picnic area. Organic matter was considerably higher in the train tunnel picnic area (13.5%) than the other areas, and it is possible that the sample was contaminated with surface litter. However, the visual inspection of the soil supports the test results. The soil in this area was darker and the soil had noticeably better structure than that found in similarly programmed areas nearer to the river.

C. Vegetation Communities

Riparian corridor — partially reinforced (R1)
The narrow riparian community is dominated by bald cypress (*Taxodium distichum*) in the overstory and black willow (*Salix nigra*) in the midstory. Hackberry, boxelder (*Acer negundo*) and pecan are common. A herbaceous layer is present. Evidence of regeneration is present, with seedlings of hackberry and boxelder common and young bald cypress uncommon. Invasive species are a significant portion of the community. Japanese privet (*Ligustrum japonica*), catclaw vine (*Macfadyena unguis-cat*i) and Britton's ruellia (*Ruellia caerulea*) are the most common.

Riparian corridor — reinforced bank, park mainteance (R2)
The riparian community is absent in this area. Widely spaced, mature overstory trees such as bald cypress, live oak and cedar elm, dominate the area. Non-native grasses and bare soil are common and no midstory or seedlings are present.

Riparian corridor—natural bank, park maintenance (R3)
A narrow band of riparian species exists on the bank slope and along the top of bank in the picnic areas, though many gaps exist. Fast growing species such as black willow, boxelder, green ash (*Fraxinus pennsylvanica*) and the invasive Japanese privet are the most common species in these bands. The riparian community is allowed to expand on the west side of the river, adjacent to the driving range.

Riparian corridor—natural bank, wildland maintenance (R4)
A mixed riparian community with overstory, midstory, and herbaceous layers as well as evidence of regeneration extends beyond the edge of the river bank. The overstory is dominated by pecan, hackberry, boxelder and the invasive Chinaberry (*Melia azedarach*). The midstory is dominated by the invasive Japanese privet, with the native hackberry and gum bumelia (*Sideroxylon lanuginosum*) common. Peppervine (*Nekemias arborea*), ragweed and inland seaoats (*Chasmanthium latifolium*) dominate the herbaceous layer.

Bottomland Hardwood — park maintenance (B1)
This community is composed of scattered overstory trees and a low diversity herbaceous layer. Live oak, cedar elm and pecan are the most common overstory species with a ground layer of Bermudagrass and straggler daisy (*Calyptocarpus vialis)*.

Bottomland Dense Woodland —wildland maintenance (B2)
Bottomland soils extend partially into the wilderness area and the community becomes a diverse mixed woodland with all layers present. Red oak (*Quercus buckleii*), cedar elm, hackberry and Chinaberry are common in the overstory. Texas persimmon (*Diospyros texana*), elbowbush (F*orestiera pubescens*), and gum bumelia dominate the midstory. A healthy herbaceous layer is present. Invasive species including Chinaberry and Japanese privet are common in all layers.

Upland Dense Woodland — wildland maintenance (U2)
The dense woodland community is live oak and cedar elm dominated diverse woodland with overstory, midstory and herbaceous layers present and very little bare soil. Significant populations of invasive species exist.

Upland Shrubland (U1)
This community falls within the Low Stony Hill ecological site and is more similar to an Edwards Plateau community type than to the Blackland Prairie types found in the rest of the park. The community has transitioned from grassland savannah to savanna shrubland, but is closer in composition and structure to its historic climax community than any other community in the park. Scattered shrubs, dominated by natives such as mesquite (*Prosopis glandulosa*), granjeno (C*eltis ehrenbergiana*) and brasil (*Condalia hookeri*), lie within a matirx of. The invasive buffelgrass (*Pennisetum ciliare)*.

Upland Savanna—park maintenance (U3)/Upland Recreational (S1):
These simplified savanna communities consist of scattered mature trees in a matrix of primarily non-native grasses, artificial surfaces and bare soil. Bermudagrass is the most common grass, though St. Augustine (*Stenotaphrum secundatum*) exists in some areas with shade and higher moisture content. In high traffic areas, the herbaceous layer gives way to bare soil.

BRACKENRIDGE PARK: VEGETATION COMMUNITIES

Vegetative communities within Brackenridge park are determined by soil, water availability, use history and current maintenance..

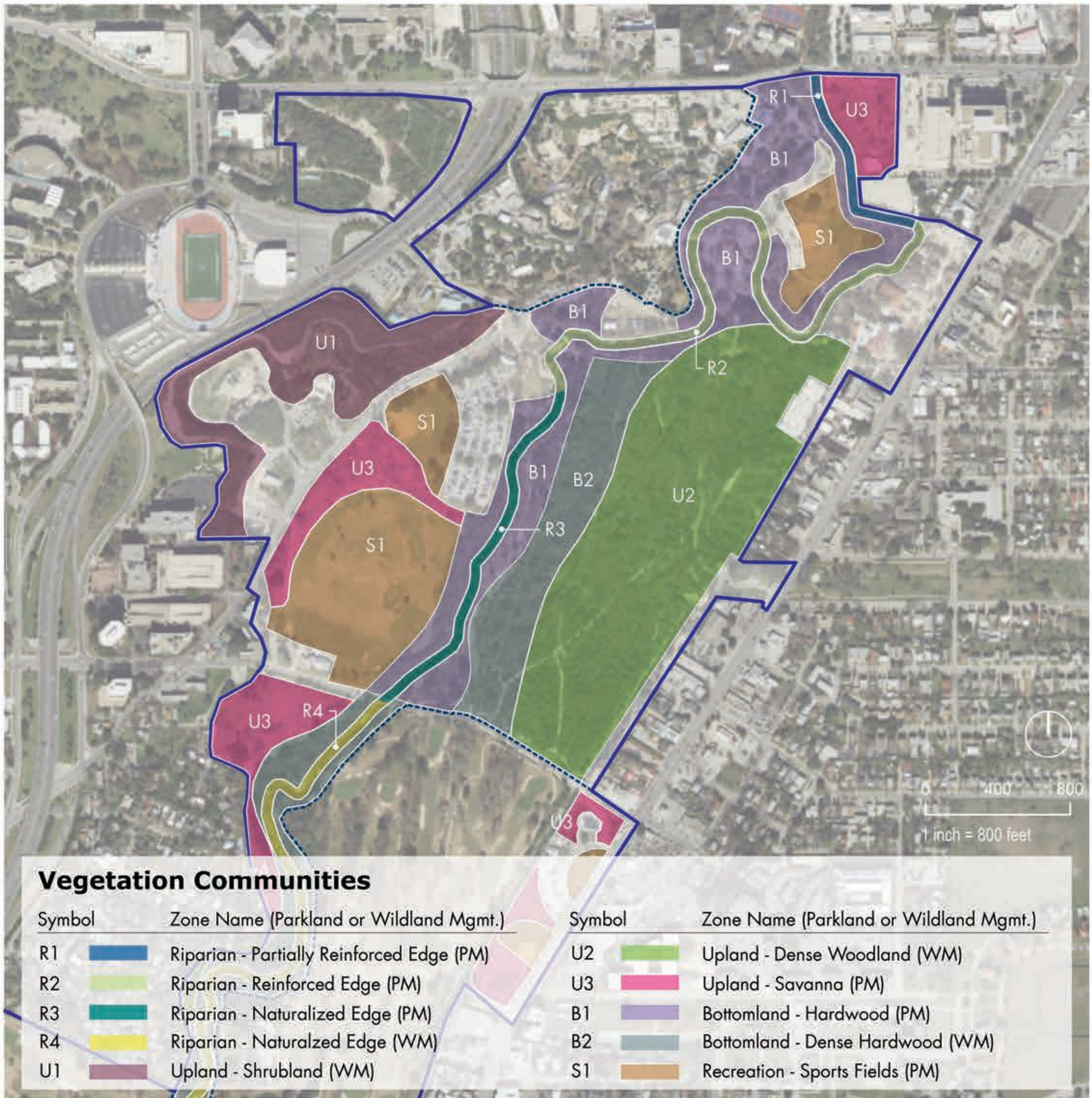


Figure III.6 Brackenridge Park Vegetation Communities

D. Management Zone Descriptions and Recommendations

BRACKENRIDGE PARK: MANAGEMENT ZONES

Management Zones are delineated based on ecological site, current soil condition, plant community integrity, current use and expected use. Management Zones represent areas with similar ecologic needs, recommended interventions and maintenance expectations.

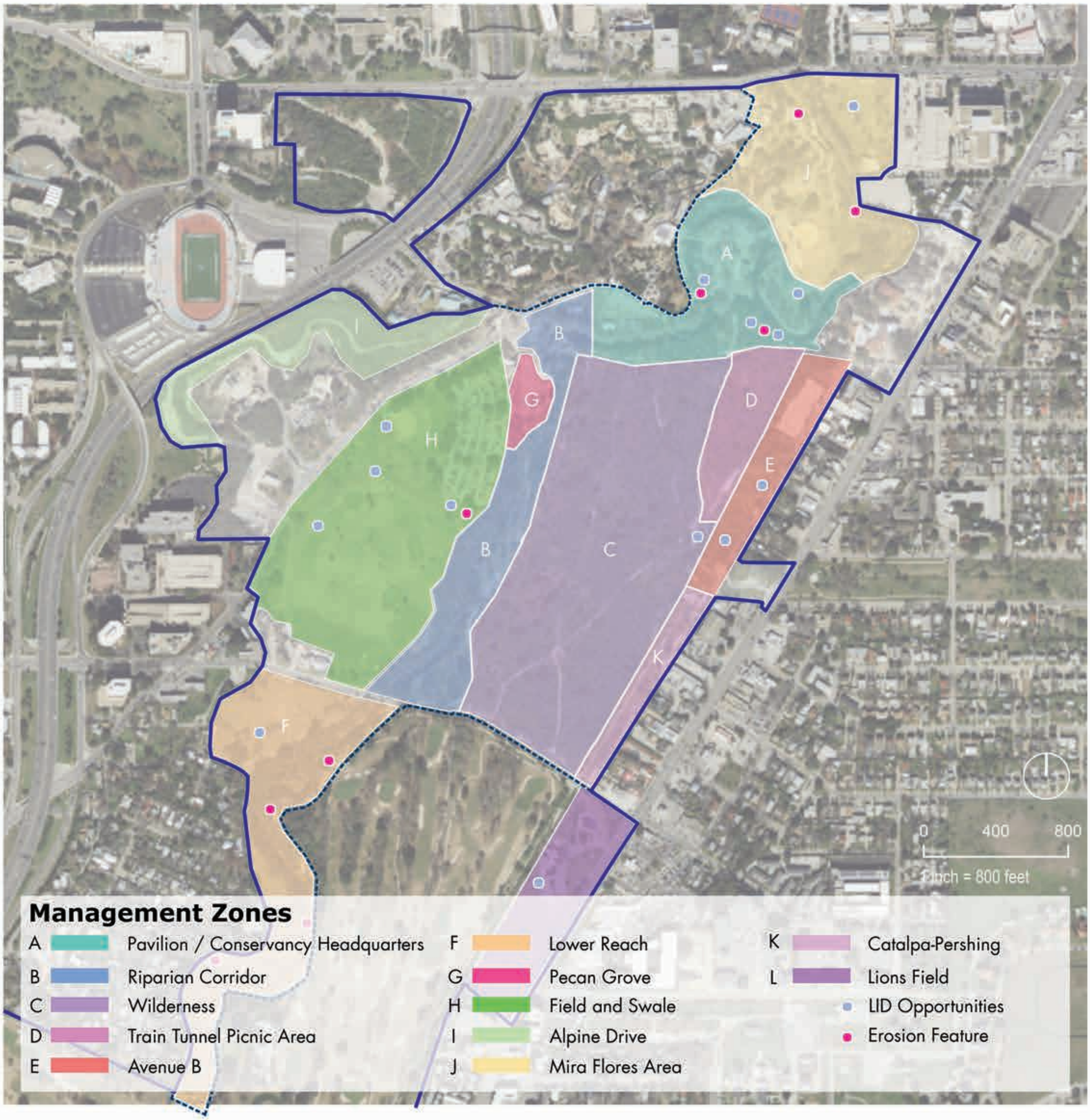


Figure III.7 Brackenridge Park Management Zones Map

BRACKENRIDGE PARK: ECOLOGICAL HEALTH

Ecologic Health estimations are based on current soil, plant community, and hydrologic condition. Soil surface condition is evaluated based on structure, degree of exposure, compaction, organic matter content and nutrient profile. Plant community is evaluated on species diversity, proportion of valuable vs. problematic species, structural integrity, and age structure in woodlands. Hydrologic condition is based on extent and severity of soil erosion and infiltration capacity. River bank condition is evaluated based on the health and extent of the riparian community and associated soil as well as bank morphology. In-stream habiat was assessed during the 2012 Biological Survey (Bio-West 2012) and is referenced here.

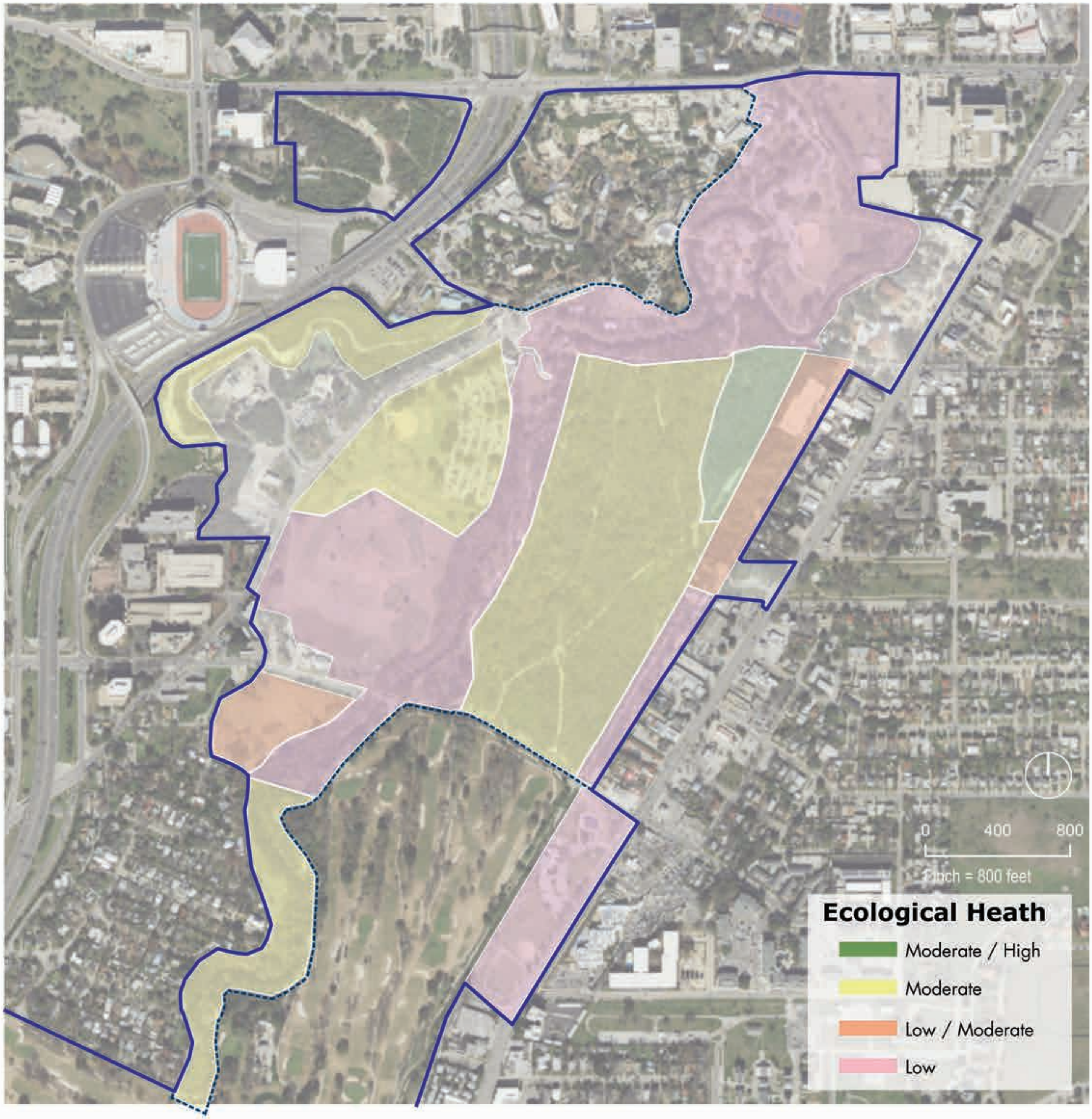


Figure III.8 Brackenridge Park Ecological Health Map

Management Zone Descriptions and Recommendations

Brackenridge Park has been broken down into descriptive management zones that contain similar ecological conditions and management considerations (Figure III.7). Ecological health ratings have been assigned as described previously (Figure III.8).

Zone A—Pavilion/Play area/Conservancy Headquarters area
Ecologic health: low

This area contains Lambert Beach, Pump House 1, Bird Island, the Brackenridge Park Conservancy Headquarters, Joske Pavillion and a play area.

Description: This is a high use, high visibility, area within the Clayey/Loamy Bottomland ecological sites and is currently in the bottomland hardwood state. The picnic area between Brackenridge Way and the river is illustrative of the condition of much of the near-river areas in Zone A. The community retains overstory trees, predominantly bald cypress, which shade approximately 75% of the area (Figure III.9). Midstory woody species and the herbaceous layer are largely absent. In particular, perennial, densely rooted, grasses that play an important role in soil building, infiltration and water cleansing are absent. The herbaceous layer that is present is predominantly the non-native Bermudagrass. The site has a significant amount of bare soil (>50%). Soils retain a reasonable amount of organic matter (~5%). However, the soils are compacted and have poor structure which is associated with reduced infiltration rates, permeability (capacity of the soil to conduct water), increased runoff and resistance to root growth. Moderate to severe sheet erosion is evident between the road and the river, with rills forming. Lambert Beach, across the river, is in a similar condition. The lack of healthy bottomland and riparian plant communities and soils compromise river health in several ways. The river receives a higher volume of runoff more quickly after rain because the bottomland communities cannot absorb it. The water quality is lower because contaminants are not filtered before reaching the river

The plant community is at risk. Few species are present making the community unable to respond to changing conditions and less able to perform basic ecological functions such as nutrient cycling, energy capture and mediating infiltration and runoff. Young and middle aged individuals to replace the current generation are absent. Bare soil temperatures fluctuate more than covered soil, stressing roots. Compacted soil limits root growth and the soil's ability to store water and gasses, further stressing plants. The lack of structural diversity, i.e. the missing midstory and herbaceous layer, puts both the plant community and the river bank at risk. Mature trees can hold through many flood events, however they can fail under enough pressure. Young saplings and herbaceous plants lay down during high flow events and can often stay in place. Additionally, tree roots tend to spread out at the surface, while grasses and sedges develop dense networks of fibrous roots that intertwine providing high stability. Riparian buffers containing both herbaceous and woody vegetation are more stable.

The area east of Brackenridge Way, containing Conservancy Headquarters, Joske Pavilion, and the play area similarly lacks midstory and a functional herbaceous

top: **Figure III.9 Zone A**

middle: **Figure III.10 Zone A**

bottom: **Figure III.11 Zone A**
Erosion undercutting sidewalk

layer. Mature trees include live oak, cedar elm, and pecan. Also present are mature crape myrtles (*Lagerstroemia indica*). Bermudagrass and straggler daisy make up the herbaceous layer, when present. The soil is severely compacted.

Southeast of this area, north of Tuleta Drive, lies a wooded picnic area. This bottomland hardwood site lies between the wilderness area and the high use area adjacent to the river. The overstory cover is 100%, dominated by cedar elm and live oak. The site lacks midstory woody species and has no herbaceous layer. The site has good litter cover of soil (80-90%) and very little bare ground, but the soil has poor structure and moderate compaction. The critical root zones of the trees have no protection from compaction and the poor soil structure does not support infiltration or water cleansing. No erosion is evident in the area.

The area adjacent Joske Pavilion trail, along the river's edge (Figure III.10) shares high use and visibility with the Conservancy area and is experiencing significant erosion (Figure III.11).

Area A is experiencing considerable pressure from the Rookery located in the area. The high concentration of avian waste from the Rookery is likely reducing water quality as well as degrading human experience of the site by creating unsanitary conditions and an unpleasant smell. The existence of such a dense concentration of birds in a high use area is not ideal, and it is recommended the rookery be encouraged to relocate to a lower use area. The park and zoo are employing harassment techniques to make the area less attractive for the rookery, with limited success. The next option would be to increase habitat value in a more appropriate location, while decreasing it in the current location by discouraging feeding, dislodging nests prior to egg laying and modifying the plant community.

The aquatic habitat of the river in the northern portion of the park, downstream of Hildebrand Avenue to Tuleta Drive crossing, was found to have the lowest Habitat Quality Index Score of the park (16) which translates into an Intermediate Aquatic Life Use Designation (Bio-West, 2012, p. 8). According to the report, "Channel sinuosity is low, instream cover is low, and the riparian buffer is narrow or absent…instream habitat is extremely limited" (Bio-West 2012, p. 7). Current conditions are in line with these observations.

Opportunities: Zone A's combined human use and hydrologic/ecological conditions make it a good candidate for a set of connected stormwater management features that also behave as amenities and educational tools (Figures III.12-III.13). Plantings in these features can reflect the historic communities of the site by highlighting lost species while providing hydrologic, pollinator and experiential value.

The Wildflower Center has created an illustrative design for this zone to demonstrate combining human use and ecological goals in a high use area which is illustrated in the following pages.

Figure III.12 Bioswale
Bioswales, coupled with rain gardens, can capture and slow water, helping to mitigate impervious cover.

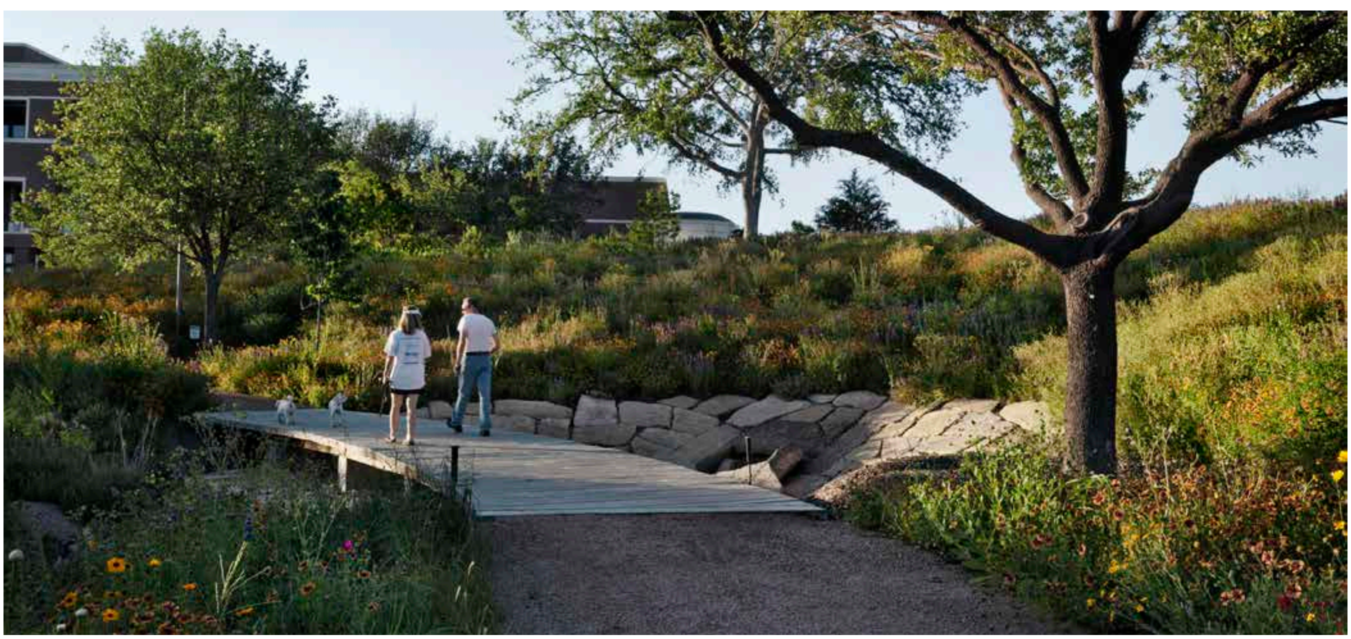


Figure III.13 Filter strip
Filter strips can provide beauty as well as stabilize soil and clean water. Ideally placesd adjacent to hardscape, or upslope of sensitive features.

Design narrative

Brackenridge Park is a complex space serving many needs that can sometimes come into conflict. This design is intended to illustrate balancing ecological and experiential goals in a high use area. Points of intersection between modern land and river stewardship and the larger historic and cultural narrative of Brackenridge Park are touched on here, but these topics are best explored in the Cultural Landscape Report which takes a more global view of the park.

Ecological goals for this design include: improving river health by slowing runoff velocity, increasing runoff capture and filtration capacity and creating a riparian buffer; enhancing plant and soil community health and resilience (ability to respond to changing conditions) by increasing diversity, introducing high functioning species, repairing soil condition and reducing erosion.

Experiential goals include: enhancing walking, water viewing and picnicking experience and reducing vehicular/pedestrian conflict; improving Joske Pavilion's value as an amenity and rentable space; preserving vehicular access for events, camping and picnicking

The most critical intervention river health throughout the park is creating a *riparian buffer* to slow and filter water, help build soil, provide shade and organic matter for in-stream habitat, and typically to provide bank stability. The riparian buffer here is integrated with a series of reinforced pathways and access points allowing people to approach and see the river while protecting critical functions (Figure III.14). Buffer plantings respond to aesthetic needs of this high use area with simplified texture, more uniform height and inclusion of showier plants. Drier conditions, created by the walled nature of the river here, necessitate selecting plants capable of handling both inundation and dry periods. The river bank wall limits the woody plantings that can be included nearby because roots could damage it.

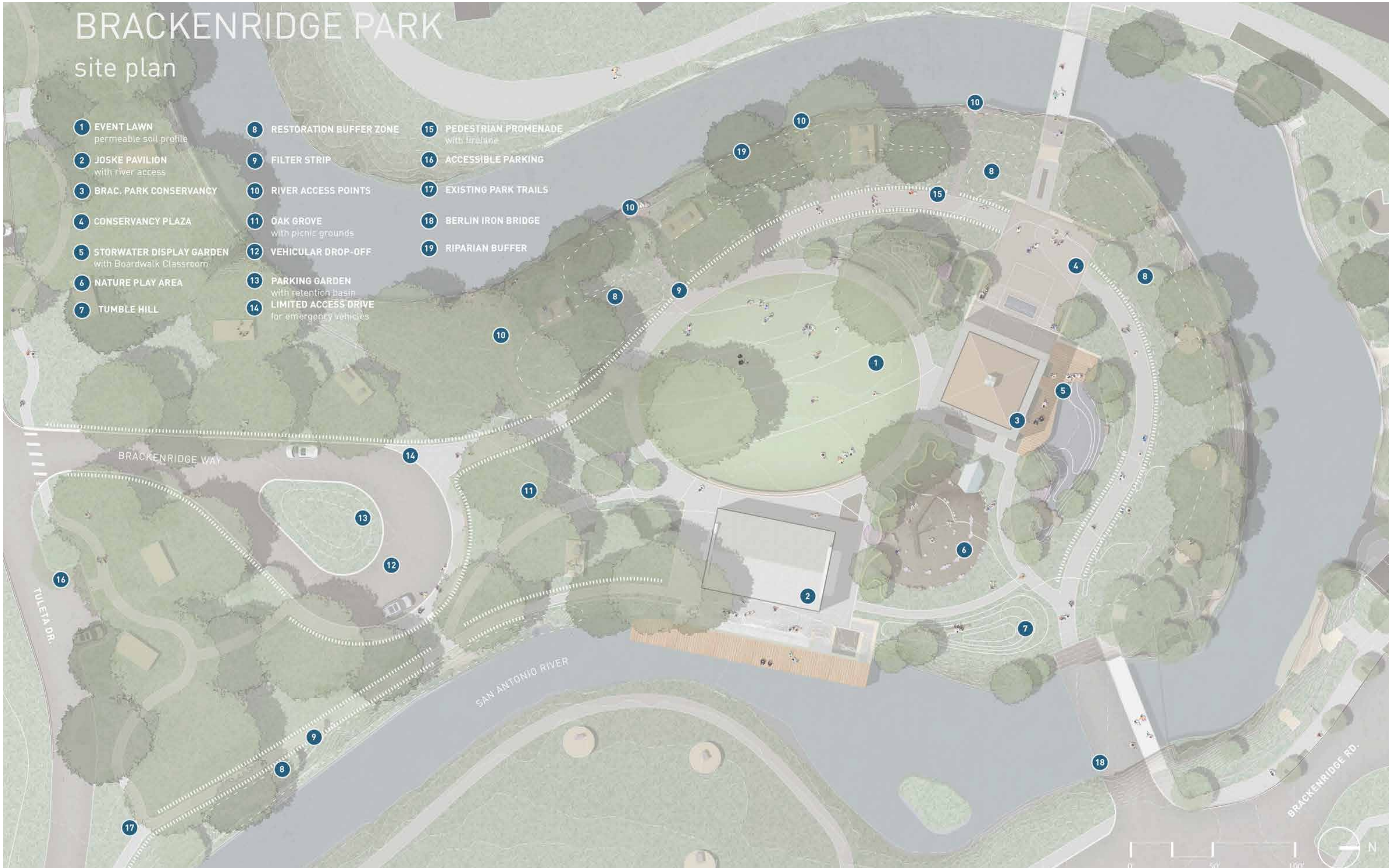
The design seeks to optimize recreational space and water capture by weaving together trails, bioswales, raingardens and soil protections areas. All roads and most trails are bounded by filterstrips to slow runoff velocity, reduce channelized flow and to capture contaminants.

Soil protection areas are strategically placed to improve the infiltration capacity and to protect tree critical root zones. Low plantings help direct foot traffic away from critical root zones and soil protection areas, while leaving enough open ground for recreational uses. The infiltration lawn is constructed with absorbent soils and hardy, deep rooted species to support both use and infiltration.

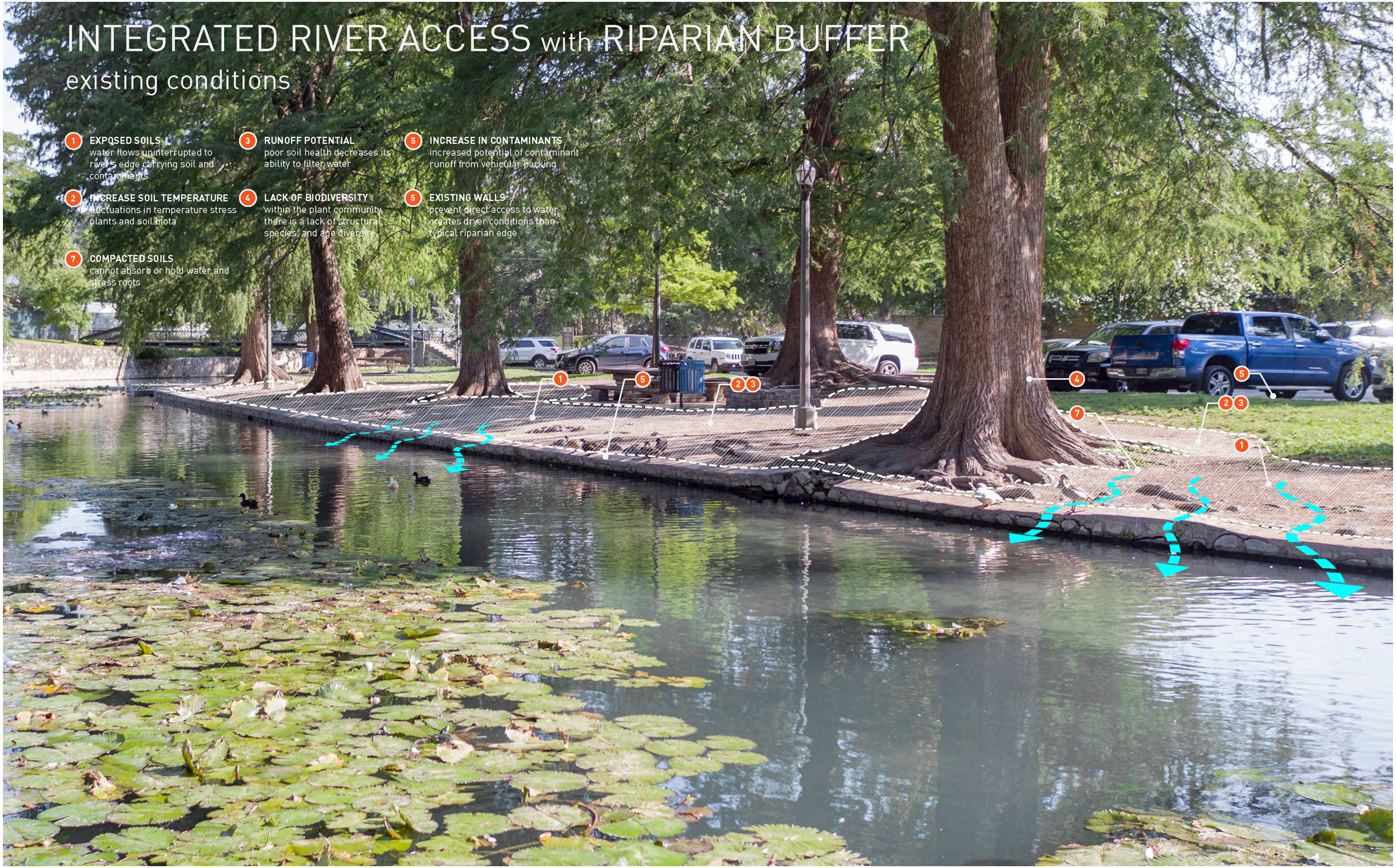
A system of raingardens can increase runoff capture substantially. However, existing mature trees and possible archeological sites limit the space available for excavation. The conflict between retaining vehicular space, protecting pedestrian experience and caring for the river is felt most keenly when locating and sizing raingardens. Parking spaces and roads close to the river substantially increase contaminants, runoff and erosion. However, commentary provided during the master plan process made it clear that close in vehicular access is important during events like the Easter camping because it allows people to bring equipment to the camp site as well as providing access to people who cannot make a long walk.

We suggest a flexible solution. The road is narrowed and converted to a maintenance road. Several parking spots are removed to accommodate raingardens and more pedestrian friendly paths. The road can be opened to accommodate one way public traffic during events. A new circular drive and drop-off zone allows close in access for equipment and people before the vehicle is moved to adjacent parking or to one of the new garages called for in the Master Plan.

The Master Plan called for this area, as part of the historic and walkable district, to incorporate historic and interpretive walks. This design would fit comfortably into a narrative connecting people's past relationship with water to the current and future stewardship of the resource. Narrative journeys are possible beginning with early Native American gatherings and settlements, to the acequia system, historic use of the water for drinking and recreation and on to the future in which the park can lessen the negative consequences of urbanization while creating a landscape in which nature and people thrive.



BRACKENRIDGE PARK
site plan
1 EVENT LAWN permeable soil profile
2 JOSKE PAVILION with river access
3 BRAC. PARK CONSERVANCY
4 CONSERVANCY PLAZA
5 STORWATER DISPLAY GARDEN with Boardwalk Classroom
6 NATURE PLAY AREA
7 TUMBLE HILL
8 RESTORATION BUFFER ZONE
9 FILTER STRIP
10 RIVER ACCESS POINTS
11 OAK GROVE with picnic grounds
12 VEHICULAR DROP-OFF
13 PARKING GARDEN with retention basin
14 LIMITED ACCESS DRIVE for emergency vehicles
15 PEDESTRIAN PROMENADE with firelane
16 ACCESSIBLE PARKING
17 EXISTING PARK TRAILS
18 BERLIN IRON BRIDGE
19 RIPARIAN BUFFER
BRACKENRIDGE WAY
TULETA DR.
SAN ANTONIO RIVER
BRACKENRIDGE RD.
N


INTEGRATED RIVER ACCESS with RIPARIAN BUFFER
existing conditions
1 EXPOSED SOILS
water flows uninterrupted to river's edge carrying soil and contaminants
2 INCREASE SOIL TEMPERATURE
fluctuations in temperature stress plants and soil biota
7 COMPACTED SOILS
cannot absorb or hold water and stress roots
3 RUNOFF POTENTIAL
poor soil health decreases its ability to filter water
4 LACK OF BIODIVERSITY
within the plant community, there is a lack of structural, species, and age diversity
5 INCREASE IN CONTAMINANTS
increased potential of contaminant runoff from vehicular parking
5 EXISTING WALLS
prevent direct access to water, creates dryer conditions than typical riparian edge


INTEGRATED RIVER ACCESS with RIPARIAN BUFFER
proposed restoration
1 BUFFER ZONE
mixes woody and herb. community protects the bank, slows and cleans water
3 GRASSES
holds soil during storm events and cools down the soil
5 HARDWORKING PLANTS
whole system can adapt to changing conditions due to plant diversity
2 ARMORED ACCESS POINTS
helps keep people off critical root zones of trees and protects the bank
4 HERBACEOUS PLANTS
fibrous roots armor bank & add organic matter to soil, increasing water retention
6 AESTHETIC PLANTINGS
hardy plants can deal with people walking, quick regeneration rates
7 SPONGING LAWN
helps infiltrate stormwater by utilizing a permeable subsoil
8 EXISTING WALLS
prevent direct access to water, create dryer conditions than typical riparian edge
STORMWATER BASIN
7 SPONGING LAWN
EVENTS SPACE
1 BUFFER ZONE
WATER INFILTRATION


INTEGRATED RIVER ACCESS with RIPARIAN BUFFER
existing conditions
1 UNDERCUTTING SIDEWALK
erosion of surrounding soil weakens hardscape features
2 SHALLOW-ROOTED PLANTS
3 CONTAMINANTS
no barrier to keep contaminants from theroad flowing straight into river
4 LACK OF BIODIVERSITY
within the plant community, there is a lack of structural, species, and age diversity
5 HIGH VISIBILITY
3
5
1
2 4


INTEGRATED RIVER ACCESS with RIPARIAN BUFFER
proposed restoration
1 FILTER STRIP
interrupts water to clean it
3 BIOSWALE
catches and cleans water before it reaches the river
2 VARIED PLANTINGS
mid-short plants bold and build the soil
4 SUN EXPOSURE
allows pollinator habitat
STORMWATER INFILTRATION
1
2
3
4

ZONE A SPECIES PALETTE

BUFFER (walled)


Chasmanthium latifolium


Malvaviscus arboreus


Muhlenbergia linheimeri


Solidago altissima


Sorghastrum nutans


Gaillardia pulchella


Carex blanda

FILTER STRIP


Schizachyrium scoparium


Bouteloua curtipendula


Aristida purpurea


Elymus canadensis


Chasmanthium latifolium


Bouteloua dactyloides


Coreopsis species

RAIN GARDEN


Andropogon glomeratus


Physostegia virginiana


Muhlenbergia reverchonii


Vernonia baldwinii


Equisetum species


Chasmanthium latifolium


Phyla nodiflora

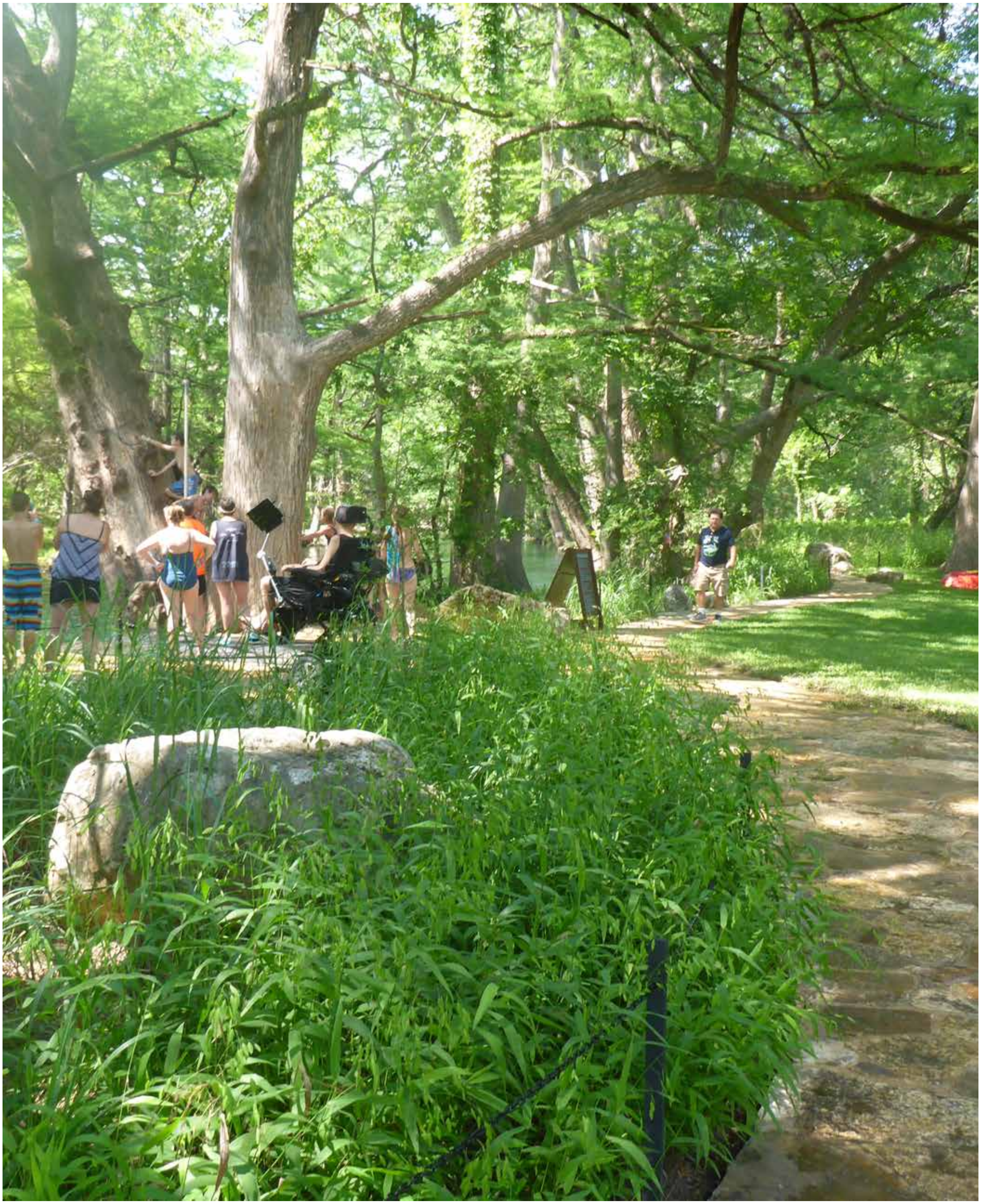


Figure III.14 Precedent Project - Blue Hole Regional Park, Wimberley, Texas
Create a system of restored riparian buffers, focusing on stability plantings with high aesthetic value and moderate maintenace requirements, paired with reinforced access and viewing points. Couple with network of LID features and upland restoration.

Zone B—Riparian Corridor - middle reach
Ecologic heath: variable

Description: The grounds and the river are maintained for access in this zone. The river is walled in the northern portion of the zone and no riparian community exists here. Beginning just south of the Pecan Grove (G), the river has a natural bank. A narrow riparian band is present in this area, flanked by park areas maintained for access. Woody cover varies between 50 and 100%, with bald cypress dominant and pecan and elm locally dominant. Cedar elm and walnut are common. Midstory species are rare and the herbaceous layer, when present, lacks diversity. Bermudagrass and straggler daisy dominate much of the herbaceous layer. Riparian vegetation lacks diversity and sufficient root mass to hold the bank (Figure III.15, Figure III.16). Riparian vegetation is frequently absent on the east bank, though it is present along the west bank, and allowed to expand adjacent to the driving range. The riparian vegetation that exists is frequently dominated by invasive species, particularly Chinaberry and Japanese privet. Chinese tallow (*Triadica sebifera*) and bamboo (*Phyllostachys aurea*) are locally dominant in some areas. Soils are severely compacted along the eastern bank of the river. Generally picnic areas are mowed to the edge of the river and social trails are common parallel to the river (Figure III.17), resulting in compacted soil and the absence of plants in the in the area that is most critical for bank stability. Future circulation pattern planning should consider, and possibly incorporate, these desire lines while reducing compaction overall. Moderate to severe erosion is present throughout, with the bank exhibiting severe downcutting in many areas. Evidence of sheet erosion is common in high use areas with occasional rill and gully erosion on surrounding areas.

The riparian community is allowed to expand beyond the top of bank along the western side of the river adjacent to the driving range. Species composition is similar to northern areas, however a regenerating layer of saplings is present and the age structure in this segment is more uneven.

The aquatic habitat along this reach is more complex than other areas giving it the highest overall habitat Quality Index sore (18) which translates into an intermediate ALU designation (Bio-West 2012, p 7). Channel sinuosity is low, but gravel bars and riffles are common, interspersed with runs of various depths. In-stream cover is present including bald cypress. However, the invasive Britton's wild petunia is also present in-stream.

Species of concern include Chinese tallow, Chinaberry, Arundo (*Arundo donax*), catclaw vine, Japanese privet, Guinea grass (*Urochloa maxima*), Kleingrass (*Panicum coloratum*), Britton's wild petunia and bamboo.

Opportunities: Creating or enhancing riparian buffer along the river with defined access and viewing points would improve river health. This zone can accommodate wider buffers than zone A while still allowing use. A minimum width of 20 feet in walled sections, 50 feet in natural bank sections, and a preferred width of 50 to 100 feet is recommended for this zone. People's desire to walk along and see the river should be considered within the buffer/access/circulation system or social trails will simply reform. Physical barriers and interpretive signage should be used to prevent

top: **Figure III.15 Zone B**
Compacted and eroding bank. Compacted soil limits root growth, reducing bank stability.

middle: **Figure III.16 Zone B**
Eroded bank lacking root mass

bottom: **Figure III.17 Zone B**
Social trail related soil compaction and lack of riparian buffer is compromising bank stability.

top: **Figure III.18 Protective planting**
Low to knee high plantings can be used to cool and protect critical root zones and to influence traffic patterns. Maintenance requirements of plantings must be matched with maintenance capacity for the area.

maintenance encroachment into buffers and soil protection zones and to counter impressions that these areas are neglected.

Riparian buffers can be created activily through planting or passively through no mow, or low frequency mow, zones along the river. Existing riparian buffers should be allowed to expand to the recommended 50 feet or beyond where possible. Invasive species dominate the canopy in some areas and treatment here will require a staged approach paired with revegetation and temporary erosion prevention measures.

The appropriate buffer for an area will need to balance ecological, aesthetic and maintenance needs, and be integrated with circulation patterns. Naturalistic buffers require the least maintenance, but can appear messy and wild. Formal buffers appear more intentional, but require more maintenance. Planted areas that are not consistently wet need to be supplied with temporary irrigation during establishment, ideally for at least one year.

Appropriate species for natural bank areas with parkland type maintenance include native trees and shrubs such as bald cypress, pecan, buttonbush (*Cephalanthus occidentalis)*, little walnut (*Juglans microcarpa*) and retama (*Parkinsonia aculeatea*). Appropriate herbaceous species include Emory sedge (*Carex emoryi*), bushy bluestem (*Andropogon glomeratus*), inland seaoats, and whitetop sedge (*Rhynchospora colorata*).

Appropriate species for areas with a natural bank and wildland type maintenance include the species above as well as large stabilizer grasses such as Eastern gamagrass (*Tripsacum dactyloides*) and switchgrass, as well as colonizer woody species such as black walnut (*Juglans nigra*) and cottonwood.

In addition to riparian buffer, develop soil protection zones concentrated on the critical root zones of existing trees. Line roads and parking areas with vegetative filter strips. Root zones can be protected with moderate height plantings of species such as inland seaoats, Virginia wildrye or low shrubs (Figure III.18), raised walking surfaces and well defined walking and recreational spaces.

Zone C – Wilderness area
Ecologic health: moderate

Description: The wilderness area, an upland community within the Southern Clay Loam ecological site, has completed the transition from the Prairie State to the Shrubland State and represents a Dense Woodland Community (Figure III.19). The overstory canopy cover is 75—100% and is dominated by live oak and cedar elm. The mid-story covers approximately 75% of the area. The invasive Japanese privet is locally dominant and Chinaberry is occasional. Natives such as elbow bush, cedar elm, hackberry and Texas persimmon are common. Soapberry (*Sapindus saponaria*), sotol (*Dasylirion texanum*) and Eve's necklace (S*typhnolobium affine*) are occasional. A healthy herbaceous layer is present, making up 50 to 75% of the area and containing desirable species such as Virginia wildrye. Very little bare soil exists and litter covers approximately 75% of the soil (Figure III.20). The woody component is quite diverse and healthy. The invasive bamboo is locally dominant, as is catclaw vine. These

top: **Figure III.19 Zone C**
Dense woodland of Wilderness area

middle: **Figure III.20 Zone C**
Healthy herbaceous and litter cover

bottom: **Figure III.21 Precedent woodland**
Precedent image of healthy upland woodland with diverse age structure and lower density.
Image: Lady Bird Johnson Wildflower Center

species along with Japanese privet and Chinaberry are the most important targets for continued invasive management.

Opportunities: Overall, the community is healthy. However, the woody density is too high, which reduces the vigor of existing individuals and places the woodland at higher risk for a stand replacing fire. The stands of invasive bamboo pose a particular threat because they ignite easily, conduct fire readily, and inhibit water application by firefighters. Selective thinning of the woodland to reduce fuel loads, encourage a healthy, uneven, age structure and to support overall diversity is recommended (Figure III.21). Thinning approximately 30% of existing stems, over 3-5 years, would enhance the overall health of the site. The primary focus of thinning should be removing invasive species, reducing ladder fuels under larger trees, and ensuring an uneven age structure for remaining species. Enhanced diversity will encourage healthy soil, which will increase the uplands ability to capture, infiltrate and clean water, thus supporting river health. Following initial thinning, density maintenance will need to occur on an ongoing basis. It is recommended that a woodland management plan be created for this area with a focus on woodland health and firewise management.

The soils of this area and the adjacent Zone E are prairie soils and represent an opportunity to increase runoff capture in the upland. One of the stated goals of the master plan was to create a greater sense of entrance. Another stated goal was to increase visibility and safety. The park could combine these goals by creating an oak savanna restoration beginning behind Avenue B and continuing along Brackenridge Drive, gradually becoming more dense as one approaches the heart of the park. Oak savanna restoration would involve preserving the large, well scattered trees, but significantly thinning smaller trees and shrubs and encouraging a community of densely rooted prairie grasses and flowers. This could serve as an enlarged filter strip, capturing water entering from the Broadway St. side of the park, allowing visibility and reviving a community lost to the park today, but familiar to earlier peoples.

Zone D –Train tunnel picnic area.
Ecologic health: Moderate to high

Description: This upland Southern Clay Loam site is currently a Dense Woodland Community (Figure III.22). The overstory approaches 100% and is dominated by live oak and cedar elm. A diverse midstory exists and shades approximately 25% of the site. Mid-story species include Texas persimmon, anaqua (*Ehretia anacua*) and hoptree (*Ptelea* trifoliata) (Figure III.23, Figure III.24). Most mid-story species are 4"DBH (diameter at breast height) or less. Very little bare ground is present (<5%), and litter cover approaches 100%. The soil surface condition is good, with high organic matter (13%), good structure and limited compaction. Bamboo is locally dominant near the former nursery area and is serving to conceal a feral cat colony.

Feral cats are recognized as one of the worst invasive species in the world because of the severe toll they take on small mammal, bird, reptile and amphibian population. A literature review by the Smithsonian's Migratory Bird Center and the U.S. Fish and Wildlife center estimates that free-ranging domestic cats kill 1.3-4 billion birds and 6.3-

top: **Figure III.22 Zone D**
Appropriate density of larger trees. Young woody individuals are emerging and should be allowed to groww, while maintining the overall density.

middle: **Figure III.23 Zone D**
Cluster of Texas persimmon

bottom: **Figure III.24 Zone D**
Native Mexican buckeye

22.3 billion mammals annually in the United States[3] (Loss, Will & Marra 2013). It is probable that the feral cat population within Brackenridge Park is seriously impacting the small mammal, avian and reptile populations within the park. The cat population is being managed through capture, sterilization and release, which reduces the growth of the population. The cats are being fed, though cats continue to hunt even when receiving supplemental feeding, and so will continue to damage wildlife populations in the park as long as the colony exists.

Opportunities: The soil and vegetative community are in good condition. Monitoring, maintaining current density, and encouraging appropriate age structure among the woody species will keep the site in good condition. Young shrubs and trees are emerging and should be allowed to grow, while maintianing the overall current density of the area. Shade tolerant perennial grasses and forbs can be added to enhance the site's ability to infiltrate and clean water if desired.

Ideally, the invasive bamboo will be removed eventually. However, given its role as a screen and the challenges associated with bamboo removal, preventing its spread may be the best short term course of action. One strategy is the installation of a bamboo barrier around the current colony. Typically this is made of high density polyethelyene (HDPE) or similar and is sunk 3 to 4 feet deep in the soil forming a barrier to prevent vegetative spread. New establishment beyond the barrier should be treated immediately using integrated pest management.

Zone E – Avenue B
Ecological health: low to moderate

Description: This area has examples of mature elms and live oaks, but the plant community is dominated by invasive species, predominantly bamboo, compromising the ecological health of the area (Figure III.25).

Opportunities: Invasive management will be a significant undertaking in this area and should be done in stages, coupled with revegetation efforts. These efforts open the possibility of reintroducing the lost savanna community as discussed in Management Zone C (Figure III.26). The area along Avenue B is well positioned to serve as an initial water capture zone and the soils are compatible with this goal. LID and oak savanna restoration strategies must work around existing large trees, but the combination could open views into the park and provide a more inviting entrance sequence, with the community gradually transitioning into a healthy woodland in Management Zones C and D. Interpretive signage and education, highlighting the value of the restoration would help counter the impression that the mid and tallgrasses are simply un-maintained.

Zone F—Lower Reach
Ecologic health: moderate

Description: Riparian buffer exists here to a greater extent than anywhere else in the park (Figure III.27). Overstory, midstory, herbaceous and regenerating layers are present, though invasive species make up much of the cover. Japanese privet

3. Scott Loss, Tom Will, Peter Marra. 2013. The impact of free-ranging domestic cats on wildlife of the United States. Nature Communications. DOI: 10.1038/nccomms2380

top: **Figure III.25 Zone E**
The invasive species bamboo and Ligustrum dominate this area

middle: **Figure III.26 Precedent oak savanna**
Oak savanna precedent image for Zone E and portions of zone C
Image: Pleasant Valley Conservancy, State Natural Area

bottom: **Figure III.27 Zone F**
Riparian community

top: **Figure III.28 Zone F**
Riparian vegetation as been removed for access, resulting in accelerated erosion

dominates the overstory and midstory. Chinaberry and giant cane (*Arundo donax)* are common. Severe erosion exists at several points where the buffer has been removed to facilitate access (Figure III.28). Native species contribute less than 30% to overall cover. The overstory contains scattered pecans and live oaks and the midstory hosts hackberry, boxelder and an elderberry thicket (*Sambucus nigra*) on the western bank. The ground story is dominated by the native poison ivy (*Toxicodendron radicans)* and ragweed, with occasional frogfruit (*Phyla nodiflora*), turkscap (*Malvaviscus arboreus*), and inland sea oats. Seedlings are predominantly invasive Japanese privet and native boxelder. The buffer is narrow on both sides of the creek, limited on the east by Avenue A and to the west by mowed areas adjacent to River Road.

According to the 2012 Biological Survey the low water crossing creates a long pool resulting in relatively low aquatic habitat complexity, though the area downstream of the crossing is a riffle. Channel sinuosity is low and bank stability is moderate. A Habitat Quality index score of 17 results in an intermediate ALU designation.

The area between River Road and the riparian buffer contains a park-like community of the non-native grasses St. Augustine and Bermudagrass and scattered, recently planted, native trees (Figure III.28, Figure III.29).

Davis/Allison Park is an upland site within the Southern Clay Loam ecological site. The park has scattered overstory trees, no mid-story and a non-native grass herbaceous layer. A footpath connects E. Huisache Ave. to E Mulberry Ave along the western boundary. Gully erosion is present on the southern boundary of Davis Park and River Road and is expanding toward the interior (Figure III.30).

Opportunities: Davis/Allison Park could be more fully integrated into the ecosystem of the river, providing an upland area to slow water through LID or simply through managing the parcel as a more diverse savanna community, including densely rooted perennial grasses and forbs to increase the area's water capture capacity. Short-statured prairie species such as buffalograss, curly mesquite and pink evening primrose would bring some of the benefits of deep, dense root systems while allowing the park to maintain its current aesthetic. Mowing higher (4-6 inches) and less frequently would allow better root development and adding pollinator friendly species would further enhance the area. Rerouting River Road to the western edge of the park would help to reintegrate Davis Park with Brackenridge Park as a whole and with the river's ecology. The current portion of the road dividing Davis Park from Brackenridge Park could be converted to a trail. The gully erosion beginning near River Road needs to be addressed through regrading and establishing more densely rooted species here and upslope. Ideally, this swale and its immediate contributing zone will be allowed to contain taller species such as side-oats grama, little bluestem, bushy bluestem in wetter areas, wintergrass, Texas bluegrass (*Poa arachnifera*), Virginia or Canada wildrye, Liatris species and goldenrod (*Solidago* spp.).

The area between the river and neighborhood represents a secondary opportunity for educational LID features – these focusing on beauty, techniques homeowners can apply and engaging the neighborhood in river stewardship. Areas supporting St Augustine grass indicate sufficient water to maintain a raingarden.

middle: **Figure III.28 Zone F**
Stormwater gardens and swales could be incorporated here as an opportunity to increase cooperation with neighbors as serve as ean educational opportunity

bottom: **Figure III.29 Area F**
Exsisting swale adjacent to neighborhood supporting St. Augustine

bottom: **Figure III.30 Zone F**
Davis Park swale beginning to erode

The riparian area stands to gain substantially from restoration efforts. The reach would benefit from widening the buffer to 50 to 100 feet on both sides with integrated landings for fishing and river viewing. Narrowing the mowed area to the west and the road to the east would allow the buffer to expand enough to influence bank stability and water quality. The bank is nearly vertical in many areas and re-contouring to reduce slope and reconnect the river to the floodplain is needed. This work, combined with invasive species removal, will significantly reduce overall vegetative cover and must be accompanied by revegetation and temporary erosion control. Revegetation should combine seeding and live planting. Temporary irrigation for establishment is strongly encouraged. Revegetation efforts should include a high proportion of colonizer and stabilizer grasses and sedges to cover and hold the bank quickly while woody species grow in. Sideoats grama, green sprangletop and goldenrod provide quick coverage in dryer, sunny areas. Nearer to the bank Emory sedge, Eastern gammagrass and switchgrass, installed as a live plantings, are important stabilizers. Shaded areas can include inland seaoats and Virginia wildrye. Black willow and boxelder, already present in the area, spread quickly and can provide initial coverage. Both species can become overabundant at times and may require thinning. The woody community can be enhanced with buttonbush, little walnut, sycamore, pecan and bald cypress.

The low water crossing degrades the aquatic habitat by creating a large up-stream pool with little habitat complexity, but provides a much-loved cultural experience. Replacement with a bridge would allow more natural flow and increase up-stream habitat value while still allowing walking, fishing and observation across the river.

Zone G—Pecan grove near train station
Ecologic health: low

Description: This maintained area is in a park-like, savannah state. The pecan dominated overstory shades 25% of the site (Figure III.31). No midstory exists and the herbaceous layer is predominantly Bermudagrass, with 80 % cover. Bare areas exist near the BBQ grill and train track and the soil is moderately compacted.

Opportunities: Similar opportunities exist here as in Zone A, but on a smaller scale. Filter strips integrated into the lower portion of the slope adding mid-story shrubs would add interest and provide some vegetative complexity. Consider soil protection over mature tree critical root zones.

Zone H—Field, swale and driving range
Ecologic health: Moderate

Description: The area has 100% herbaceous cover consisting mainly of Bermudagrass, though the native buffalograss and several native forbs are present within the swale (Figure III.32). Most of the site has no evidence of erosion, except a point of gully erosion near the eastern end of the swale (Figure III.33).

Opportunities: SARA conducted an overland flow analysis of the area which reveals that a substantial area is draining to this swale and converging on the erosion point.

top: **Figure III.31 Zone G**
Pecan grove near train station

middle: **Figure III.32 Zone H**
Swale

bottom: **Figure III.33 Zone H**
Erosion feature where several flows converge

A system of stormwater gardens and restored landscape in this area could reduce the flow. Enhancing swale diversity and mowing at a higher level would increase its functionality. Ideally the swale and immediate contributing zone will contain densly rooted mid-grass species that can better tolerate the level of flow.

The flow from the parking lot, softball field and driving range can be managed with a series of filterstrips and rain gardens to ensure the water reaching the river is clean. The parking lot can be redesigned to incorporate internal bioretention. The road's beauty could be enhanced with linear shrub/midgrass plantings intended to capture water as well as provide seasonal color with flowering shrubs. Similarly, the green islands east of St. Mary's St. could be enhanced with diverse upland plantings of mid-grasses and flowering shrubs intended to build soil, increase water holding capacity and present a more visually interesting sense of arrival. Within the driving range, it may be possible to incorporate diversity islands and strips to improve water holding capacity and provide some pollinator habitat in out-of-play areas

Zone I—Alpine drive
Ecologic health: Moderate

Description: This area is quite different than the rest of the park. The Low Stony Hill ecological site more closely resembles ecosites from the Edwards Plateau ecoregion than the others in the park. Zone I also retains more of the historic (pre-European settlement) plant community than any other area in the park and diversity is high (Figure III.34). Mesquite, granjeno and Brasil are common in the overstory and mid-story. Red oak, Monterrey oak (*Quercus polymorpha)*, huisache (*Vachellia farnesiana*), kidneywood (*Eysenhardtia texana*), dense patches of agave (*Agave* sp.), soapberry, whitebrush (*Aloysia gratissima*) and cedar elm are present. Sideoats grama is present. Buffelgrass is the primary invasive species of concern here.

Opportunities: Little management is needed here beyond invasive management.

Zone J—Mira Flores Area
Ecologic health: Low

Description/Opportunities: A riparian community of varying width exists in this area, though it is generally narrow, lacking complexity and heavily infested with invasive species. The aquatic habitat is moderate here, with limited meander and low vegetative cover. Primary invasive species of concern include the dominant Japanese privet, catclaw vine, Chinaberry, Chinese tallow, Johnsongrass and Guineagrass along the bank. Brittons wild petunia, umbrella sedge and giant cane are locally dominant is several areas near or in the water. Raintree, white mulberry and loquat are present but populations are small and are of lower priority. Native species include bald cypress, pecan and live oak in the overstory. Black willow and boxelder are common in the midstory. Green ash, redbud (*Cercis canadensis*), possumhaw (*Ilex decidua*) and dogwood (*Cornus drummondii*) are present. Peppervine, giant ragweed and straggler daisy are abundant in the groundstory. Seedlngs are primarily boxelder, hackberry and Japanese privet. Poison ivy is common. Erosion is common along the bank (Figure III.35, Figure III.26). Exposed honeycomb erosion matting is visible


top: **Figure III.34 Zone I**
Current community is simialr to the reference community for the site


middle: **Figure III.35 Zone J**
Eroded bank adjacent to Mira Flores


bottom: **Figure III.36 Zone J**
Lily pond

adjacent to the AT&T parking lot. The area the park controls here is too narrow to mitigate the runoff from the parking lot causing the erosion. Addressing it requires slowing and capturing runoff further up-slope, which will necessitate cooperation with the current owner.

The Lily pond and dam area outside of at the entrance of Mira Flores has significant erosion, a high complement of invasive species and limited riparian buffer (Figure III.36). The site would benefit from enriching the riparian buffer and continued invasive management. In addition, many social trails exist linking the road to the acequias. The site has significant historical value and represents a second option for educational restoration and interpretation, linking historic, current and future water management.

Riparian buffer should be expanded to a minimum of 50 feet within Miraflores by establishing a mowing setback and be managed with wildland type maintenance. The buffer along the western side of the river should be expanded to a minimum of 20 feet, with a preferred width of 50 feet. Adjacent to Lambet Beach Field and picnic area, establish buffer/pollinator habitat a minimum of 20 feet wide with reinforced access points and Park-type maintenance.

Miraflores itself is a formerly planted area which is reflected in its current make-up. The site's position between greater San Antonio and the river, as well as the existence of springs on the site, suggest that measures to increase water quality here would be well placed, whether that be through LID features or simply through increasing the vegetative complexity of the site. Currently the site has limited diversity, and many of the species are not well suited to the site under dry conditions. Scattered pines, palms, some willow and the invasive Chinaberry shade 10-15% of the area. The herbaceous cover is 100% and is dominated by Bermudagrass with scattered King Ranch bluestem (*Bothriochloa ischaemum*). The soil has poor structure and low organic material. As Miraflores is re-imagined, incorporate only non-invasive species that are adapted to the wider variations in rainfall and temperature found in current conditions, or plan to include irrigation. Also, incorporate the ecological story, especially the springs, into the interpretation developed for the area.

Zone K—Catalpa - Pershing
Ecologic health: Low

Description: This segment of Catalpa-Pershing is a steeply sloped concrete channel (Figure III.37). Vegetation lining the channel to the west is predominantly invasive bamboo and Japanese privet. Large diameter trees appear to be set back from the channel on the west side. The eastern side of the channel is bounded by a narrow Bermudagrass turf strip.

Opportunities: Restoration of Catalpa Pershing will require a multidisciplinary design team including engineers, design professionals, ecologists, soil scientists, maintenance professionals and members of owner organizations. The recommendations made here assume that naturalization of the channel is the goal as described in the master plan, and pertain only to ecological considerations. Engineering, human experience, historical/cultural considerations and connectivity will need to be considered as well.

middle: **Figure III.36 Zone J**
Moderate sheet and gully erosion

bottom: **Figure III.37 Zone K**
Catalpa-Pershing

The natural channel design should be based on hydrologic and hydraulic modelling to ensure the channel conducts stormwater appropriately and to determine the appropriate ratio and location of naturalized vs. reinforced banks. The goal is to incorporate meander, reduce bank slope, allow for bank revegetation and create complex in-stream habitat. If allowable within modelling constraints, incorporate obstructions to simulate the role of large woody debris in creating further habitat complexity and varied depositional patterns.

Pending engineering evaluation, it does not appear that sufficient width exists on the eastern side of the channel to allow the banks to lay back enough for naturalization. However, the western bank is dominated by invasive species and there is some distance between the channel and the large diameter trees found in the woodland. Consider retaining the eastern concrete slope and regrading the western bank to allow for some meander and reduced slopes. The meander pattern will need to be matched on the eastern bank, perhaps by building out from the existing channel.

Naturalized slopes will likely require complete reconstruction of the plant and soil community. Soils must contain sufficient organic matter and clay content to support vigorous riparian communities, and compaction following construction cannot exceed levels that allow root growth. The maximum allowable compaction varies with soil composition and moisture content, but a useful rule of thumb is that proctor densities beyond 80-85% significantly impede root growth. Soil and plant specification will need to be tightly integrated, and sourcing needs to begin early in the design process to ensure sufficient volume of both plant and soil amendments at construction. New soil tends to be low in organic matter, which will need to be rectified with static aged, low nutrient compost. This product is difficult to find. Most composts are turned frequently and sold while still young. Static aged compost can be purchased, or young compost can be purchased and then aged. Regardless, set aside funds and time for testing and storage. Including a soil scientist on the design team is strongly recommended.

Plant communities along the bank need to be assembled according to expected conditions and required function. In addition, communities should be assembled with natural bank community composition and diversity as a guide, though modified to fit the unique conditions present in a constructed, urban waterway. Appropriate reference communities within the Blackland Prairie and Edwards Plateau ecoregions should be identified and assessed for soil and plant community structure and composition.

> *Conditions to consider includ*e: expected soil moisture patterns, shade/sun, flood frequency and expected shear stress.
>
> *Functions to consider include:* enhancing bank stability, capturing and cleaning runoff, shading and cooling in-stream habitat, providing organic matter to in-stream habitat, providing terrestrial habitat, providing varied and interesting user experiences.

Bank communities will require both woody and herbaceous species. However, in order to preserve Catalpa Pershing's ability to transmit water quickly during flood events, the woody component of these communities will need to be lower than that found in natural drainages in the frequently flooded zone. Again, community design should respond to the conditions defined during hydrologic and hydraulic modelling. To allow for increased shading on trails, it is suggested that trails be constructed primarily at the top of bank and allowed to meander into and out of the adjacent woodland. Trees can also be planted at strategic intervals to provide shade and enhance bank stability so long as they are sufficiently spaced to allow appropriate flow during flood events.

Multiple communities can be designed and installed to suit varied conditions. Alternately a single, highly diverse community can be assembled for each soil moisture condition and allowed to differentiate over time in response to the varied conditions present.

Consider a staged approach to installation. Conditions following grading favor early successional species and it is important that soil be vegetated as quickly as possible. However, longer lived, late successional species are desirable as the bank community matures. One strategy is to achieve quick coverage initially with species such as side-oats grama and green sprangletop, returning later to add more diversity and species that need more mature soil. Alternately, later successional species can be added as live plantings during initial installation.

The level and type of maintenance the bank communities will receive should be considered early in the design process because it will affect the type and arrangement of plantings. Regardless of long term maintenance plans, temporary irrigation must be installed during the 1-3 year establishment period for bank communities. Similarly, aggressive invasive management will be required during the installation and establishment period, with longer term maintenance scheduling beginning in the second year

Zone L—Lions Field
Ecologic health: Low

Description/Opportunites: Lions Field is managed as a sports field and play area and has high vegetative coverage, but very low diversity. The site offers another opportunity for stormwater capture features that also improve amenity space. Native and well-adapted, non-invasive, species should be used for any plantings. The playground offers an opportunity to incorporate natural play elements that evoke the natural character of Brackenridge Park.

					Ecological Management Zone											
Species	**Common name**	**Native**	**Non-native**	**Invasive**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Acer negundo	boxelder	X				X				X				X		
Agave univittata	agave												X			
Aloysia gratissima	whitebrush	X											X			
Alternanthera caracasana	mat chaff flower		X	X								X				
Amaranthus palmeri	carelessweed	X												X		
Ambrosia trifida	giant ragweed	X				X	X			X			X	X		
Ampelopsis arborea/ Nekemias arborea	peppervine	X					X	X		X	X			X		
Aristida purpurea	purple three-awn	X											X			
Arundo donax	giant reed		X	X	X	X				X				X	X	
Bernardia myricifolia	mouse ears	X											X			
Boerhavia erecta	erect spiderling	X												X		
Bothriochloa ischaemum	King ranch bluestem		X	X									X	X		
Bouteloua curtipendula	sideoats grama	X											X			
Bouteloua dactyloides	buffalograss	X										X				
Calyptocarpus vialis	straggler daisy	X			X	X		X	X	X	X	X		X		X
Carya illinoinensis	pecan	X			X		X			X	X			X		
Celtis ehrenbergiana	granjeno	X											X			
Celtis laevigata	hackberry	X					X			X		X	X	X		
Cercis canadensis	redbud	X								X				X		
Chasmanthium latifolium	inland sea oats	X					X			X				X		
Chloris sp.	windmill grass	X												X		
Cocculus carolinus	snailseed	X					X	X			X			X		
Colubrina texensis	hog plum	X											X			
Condalia hookeri	brasil	X											X			
Cornus drummondii	dogwood	X												X		
Crataegus mollis	downy hawthorn	X					X									
Cylindropuntia leptocaulis	tasajillo	X											X			
Cynodon dactylon	bermudagrass		X	X	X	X	X		X	X	X	X	X	X	X	X
Cyperus involucratus	umbrella sedge		X	X		X				X				X		
Dasylirion texanum	Texas sotol	X											X			
Desmanthus virgatus	wand bundleflower	X												X		
Diospyros texana	Texas persimmon	X					X			X			X			
Echinochloa sp.	barnyardgrass		X	X										X		
Ehretia anacua	anacua	X					X						X	X		
Elymus virginicus	Virginia wildrye	X					X						X	X		
Eriobotrya japonica	loquat		X											X		
Eysenhardtia texana	kidneywood	X											X			
Forestiera pubescens	elbowbush	X					X									
Fraxinus pennsylvanica	green ash	X								X				X		
Ilex decidua	possumhaw	X					X							X		
Ilex vomitoria	yaupon	X					X							X		
Ipomoea cordatotriloba	tievine	X														
Juglans nigra	walnut	X			X									X		
Justicia pilosella	tube-tongue	X								X						
Koelreuteria bipinnata	goldenrain tree		X	X									X	X		
Lagerstroemia indica	crepemyrtle		X		X											

Figure III.38: Species documented

Brackenridge Park site visit July 2018

Species	Common Name	Native	Non-native	Invasive												
					A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Lepidium virginicum	Virginia pepperweed	X												X		
Leucaena leucocephala	popinac		X	X									X			
Ligustrum japonicum	Japanese privet		X	X		X	X	X		X			X	X	X	
Ludwigia octovalvis	seedbox	X												X		
Macfadyena unguis-cati	catclawvine		X	X			X							X		
Magnolia grandiflora	southern magnolia	X					X							X		
Malvastrum coromandelianum	three-lobe false mallow		X						X			X		X		
Malvaviscus arboreus	Turk's cap	X					X									
Maurandella antirrhiniflora	snapdragon vine	X											X			
Melia azedarach	Chinaberry		X	X			X			X			X	X		
Merremia dissecta	Alamo vine	X											X			
Mimosa nuttallii	sensitive-briar	X			X											
Morus alba	white mulberry		X	X			X			X				X		
Nandina domestica	nandina		X	X				X								
Nekemias arborea/ Ampelopsis arborea	peppervine	X					X	X		X	X			X		
Nuphar lutea	spatterdock	X								X						
Oplismenus hirtellus	basketgrass		X					X								
Opuntia engelmannii	Texas prickly pear	X											X			
Panicum coloratum	Kleingrass		X	X										X		
Parkinsonia aculeata	Paloverde	X											X			
Parthenium hysterophorus	false ragweed	X			X	X	X		X	X	X	X		X	X	
Parthenocissus quinquefolia	Virginia creeper	X								X				X		
Paspalum sp.	Paspalum species															
Passiflora foetida	Corona de Cristo	X												X		
Pennisetum ciliare	buffelgrass		X	X									X			
Phyla nodiflora	frogfruit	X								X		X				
Phyllostachys aurea	bamboo		X	X			X	X		X				X	X	
Platanus occidentalis	sycamore	X								X				X		X
Polygonum sp.	knotweed species													X		
Prosopis glandulosa	mesquite	X										X	X			
Ptelea trifoliata	hoptree	X					X									
Quercus buckleyi	red oak	X						X					X	X		
Quercus nigra	wateroak									X				X		
Quercus polymorpha	Monterrey oak												X			
Quercus virginiana	live oak	X			X	X	X	X	X	X		X	X	X		
Ruellia caerulea	Brittons wild petunia		X	X	X	X				X				X	X	
Ruellia sp.	Petunia species				X		X									
Sabal mexicana	palmetto	X					X							X		
Salix nigra	black willow	X			X	X				X				X		
Salvia ballotiflora	mejorana	X											X			
Sambucus nigra	elderberry	X								X						
Sapindus saponaria	soapberry	X					X						X			
Schaefferia cuneifolia	desert yaupon	X								X						
Senegalia roemeriana	catclaw acacia	X											X			
Senna lindheimeriana	Lindheimer's senna	X											X			
Sideroxylon lanuginosum	gum bumelia	X					X			X						
Smilax bona-nox	saw greenbrier	X					X	X						X		
Solanum americanum	American nightshade	X					X	X								

					Ecological Management Zone											
Species	**Common name**	**Native**	**Non-native**	**Invasive**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**
Sophora secundiflora	Texas mountain laurel	X					X		X				X			
Sorghum halepense	Johnsongrass		X	X								X		X		
Stenotaphrum secundatum	St. Augustine grass		X		X					X						
Styphnolobium affine	Eve's necklace	X					X	X								
Taxodium distichum	bald cypress	X			X		X			X				X		
Taxodium mucronatum	Montezuma cypress	X												X		
Tecoma stans	esperanza	X			X											
Tillandsia usneoides	Spanish moss	X					X									
Torilis arvensis	hedgeparsley		X	X		X				X			X			
Toxicodendron radicans	poison ivy	X					X			X				X		
Tradescantia sp.	spiderwort	X								X						
Triadica sebifera	Chinese tallow		X	X	X	X				X		X		X		
Typha domingensis	cattail species	X												X		
Ulmus crassifolia	cedar elm	X			X	X	X	X					X	X		X
Ulmus parvifolia	Chinese lacebark elm		X											X		
Ungnadia speciosa	Mexican buckeye	X					X	X						X		
Urochloa maxima	Guineagrass		X	X										X		
Vachellia farnesiana	huisache	X										X	X	X		
Vitex agnus-castus	vitex		X	X									X			
Vitis sp.	grapevine species	X					X							X		
Wedelia acapulcensis	zexmenia	X											X			
Yucca treculeana	Spanish dagger	X											X			
Ziziphus obtusifolia	lotebush	X											X			

SECTION IV

Restoration Priciples

The goal of restoration is to restore ecosystem processes, not simply to replace components. Ecosystem processes allow natural systems to repair themselves and to remain relatively stable. In practice, the assessment and repair of natural processes begins with the soil. Healthy soil, and the healthy plant communities it can support, comprise the foundation for functional ecosystems. After restoration is complete, the resulting spectrum of plant communities viewed at Brackenridge Park will represent the region's structural diversity, from savanna to woodland to riparian areas.

The restoration principles are included to help make the connections between information present in the context section and the site specific information, and to help readers understand how this information relates to future planning efforts. Developing a restoration and maintenance plan that correlates with the cultural and interpretive goals of the park will be necessary for successful implementation, maintenance and educational impact. This section provides an overview of restoration techniques and strategies appropriate to the areas within the park. This is followed by a proposed plant palette, a spectrum of native plants appropriate for the various site landscape zones.

Basic Restoration and Management

It is often beneficial for restoration to occur incrementally so that the vagaries of climate do not overwhelm a significant investment or effort. This incremental approach will allow for fine tuning the restoration methods to what works best on site. Initial efforts should begin in high priority areas, for example Area A. Further, combining restoration areas with trail locations will increase accessibility, facilitate monitoring and add to the interpretive and educational experience for site users and visitors. The intent of this section is not to be overly prescriptive, but to provide an overview of restoration strategies that could be employed.

Riparian Health

Since riparian health is such an important component of the project, a brief overview of some of the considerations of riparian restoration is provided here. Riparian vegetation is a major source of energy and nutrients for stream communities. Overhanging riparian vegetation keeps streams cool which is important to aquatic life. The target community in riparian areas is frequently a properly functioning gallery forest, dominated by bottomland hardwood species with an herbaceous layer beneath, composed primarily of species that will enhance bank stability. Historically, the riparian areas in the Blackland Prairie were of this community type, and the current plant community of Brackenridge Park along the river contains the its basic components. Gallery forest supports the goals of enhanced water quality along stream channels by enhancing bank stability, removing nutrients and other pollutants, helping to grade stream channels, and slowing water velocities. However, it is important to maintain a canopy which is predominantly shade, but which also has some open areas where sunlight can reach the stream.

Riparian Plant Community Considerations

For riparian restoration, a healthy, diverse native plant community adjacent to receiving waterbodies and riparian zones help control erosion, filter sediment and pollutants carried in stormwater, supports the health of aquatic ecosystems, and provides habitat. The root system of the vegetated area is crucial for achieving this health status. Increased native diversity can be encouraged through selective removal of invasive species and seeding or plugging of native woody and herbaceous species. Primary goals guiding species selection in riparian areas are enhanced bank stability and water quality. Many species found in central Texas have been give draft stability ratings based on their contribution to bank stability (Nelle 2009). Stability ratings range from 1 to 10, with 1 approximating the bare ground and 10 anchored rock. Ideally, riparian areas will be dominated by plants with stability ratings between 6 and 9. Stability ratings of 7 or higher are considered to be the minimum for acceptable bank stability. However, combinations of species, particularly woody species in association with grasses or sedges, can provide higher stabilities than reflected in individual species ratings (Nelle 2009).

In addition to stability ratings, USFWS wetland indicator status should be considered. Riparian areas should contain a mix of obligate wetland, facultative wetland and facultative species, dependent on water availability. Regardless of the mix, all areas should contain some facultative species to provide stability as conditions change.

Establishment of species can be done passively or actively. Passive establishment is the regeneration of an existing vegetated buffer through the succession of native plants and natural seed dispersal. This is facilitated through the control of invasive species, selective thinning where appropriate and allowing buffer areas to be un-mowed, or mowed less frequently.

Active establishment is a technique used with little or no existing riparian buffer. This technique involves the creation of a site specific plan detailing the species and location of proposed vegetation. For Brackenridge, a combination of the two approaches can be used, with active planting saved for high priority areas.

The active approach requires several steps for effective buffer improvements and establishment. Re-establishing the riparian zone should take place in coordination with circulation planning, including the identification of appropriate access and viewing points for the river. It is important to continue efforts to manage invasive species, while keeping soil disturbance to a minimum. Erosion control techniques should be implemented adjacent to the riparian buffer, especially when any construction or modifications to the larger site occur. It is then important to establish different vegetation planting zones: an inner, middle and outer zone (See Figure IIIX)

The inner zone often contains less managed vegetation, while the outer zone contains more managed vegetation, but this will vary with the site. For woody species it is recommended to plant a mix of containerized trees and bare root saplings or cuttings. Bare root saplings and cuttings are best used in areas in which the soil remains moist near the river on a natural bank. Areas in which the river is contained within masonry, limiting amount of water that seeps into the bank, are not appropriate for this planting technique. Planting density will vary with the site and resources available, but a reasonable starting density is to plant saplings at 15'intervals. Smaller individuals are more likely to establish and require less care during the initial establishment phase and the bulk of installed woody plantings should be in the sapling stage. Similarly, herbaceous species can be installed with a combination of seed, containerized plantings and plugs, depending on resources available and the specific intent of the site.

A final consideration is the determination of riparian buffer width. The riparian buffer area should be as large as possible, while supporting access needs. A minimum width of 20 feet on either side of the river is ideal, but any buffering that can be provided will improve the health of the river. A wider buffer is more effective at filtering and reducing pollutant levels, specifically nitrogen (Mayer et al, 2005), and will allow for improved bank conditions having a larger buffer zone will also allow for improved bank conditions.

Broad Plant Palette

The graphic tables on the following pages provide a broad set of recommendations for plants suitable for the various landscape areas of Brackenridge Park. All species listed are native to the Blackland Prairie ecoregion. The list below provides a set of recommended species specific to the stormwater gardens proposed throughout the site to help manage stormwater flows. Stormwater areas used to convey water, such as swales, should be planted with native turfs and sedges. Stormwater areas designed to hold and inflitratio stormwater, such as rain gardens should be planted with a diverse mix of grasses, forbs, and trees.

Stormwater Gardens

Plant selection will be made based on the function of the area, the expected inundation period, and the aesthetic qualities of the raingarden and biofiltration areas. Plants should be selected as drought tolerant species that can handle periods of inundation. Many dry creek bed species fit this requirement. Plants will be selected which:

- Are adapted to sedimentation camber or raingarden hydrology (i.e. periodic flooding and drought)
- Are adapted to the soil type
- Are suitable to their specific function (e.g. erosion control, filtration, etc.)
- Are durable, resilient and resistant to pests and disease
- Are tolerant of the expected pollutant load in stormwater runoff
- Have root systems of the desired type, mass and depth
- Require minimal maintenance
- Are not invasive