UHCL Habitat Restoration and Nature Trail

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Final Report

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Prepared By:

Wendy Reistle and Rowena McDermid
UHCL/Environmental Institute of Houston
2700 Bay Area Blvd. Box 540
Houston, TX 77058
reistle@uhcl.edu
281-283-3045

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Project Background and Summary

The Environmental Institute of Houston (EIH) at the University of Houston-Clear Lake (UHCL) researched the best restoration techniques on a two-acre site within the project area, which is a 25-acre nature park adjacent to Horsepen Bayou. This area lies at the juncture of four coastal natural resource areas: tall-grass prairie, post oak savanna, riparian forest, and freshwater tidal marsh. The grassland component of the prairie and savanna has been lost to woody encroachment due to the lack of a natural fire regime and overgrazing, with the probable loss of more than half of the plant species native to this habitat. The study site retains its native soils and topography, including a significant area of mima mounds and wetlands, and proved an ideal location for this pilot study of best restoration techniques.

The study was conducted on a two-acre site within the 25-acre nature park. The site was divided into four plots—Plot A, Plot B, Plot C, and Plot D—with each plot receiving a different treatment method. Four methods were tested in half-acre restoration plots. The four methods included: (1) Plot A: removal of woody plants and debris; seeding of prairie plants with a seed drill, and hand planting of tree seedlings. Herbicide for control of invasive species was applied via a backpack sprayer on an "as needed" basis. (2) Plot B: removal of woody plants and debris; followed by herbicide for invasive species applied via backpack sprayer on an "as needed" basis. (3) Plot C: removal of woody plants without debris removal; followed by herbicide applied via back sprayer on an "as needed" basis. (4) Plot D: the control area. Prescribed fire, if possible, is part of the management plan for all four plots.

Changes to the plant community were carefully monitored and the most successful and cost-effective restoration method for Texas' coastal oak savanna habitat was determined. Lessons learned from this pilot study include: (1) seeding is required because there is no longer a viable seed bank, (2) mulch must be removed for the seed to make good soil contact, and (3) vigilant efforts are required to monitor for invasive species control.

This project increased public access to the site by improving the nature trail to be Americans with Disabilities Act (ADA) compliant, refurbishing the educational pavilion, installing interpretative signage, and building an observation bird blind.

The method for Plot B and Plot C relies on prairie species remaining in the soil (i.e., seed bank), which would grow naturally after the tree canopy was removed. This is a technique that has been used on nearby properties.

Task 1 Summary: Demarcation of Plant Communities

At the beginning of the project, EIH staff and volunteers demarcated the two-acre project site using historic and current aerial photo interpretation (Figures 1-5). Soil sampling was conducted to ground-truth the Natural Resource Conservation Service (NRCS) soil series boundaries within the project site. The team documented the existing plant community and any changes to it through systematic surveys. Also, the team created a comprehensive map and documented the existing habitats with photographs (Figures 6 and 7).

Historic and Current Aerial Photos

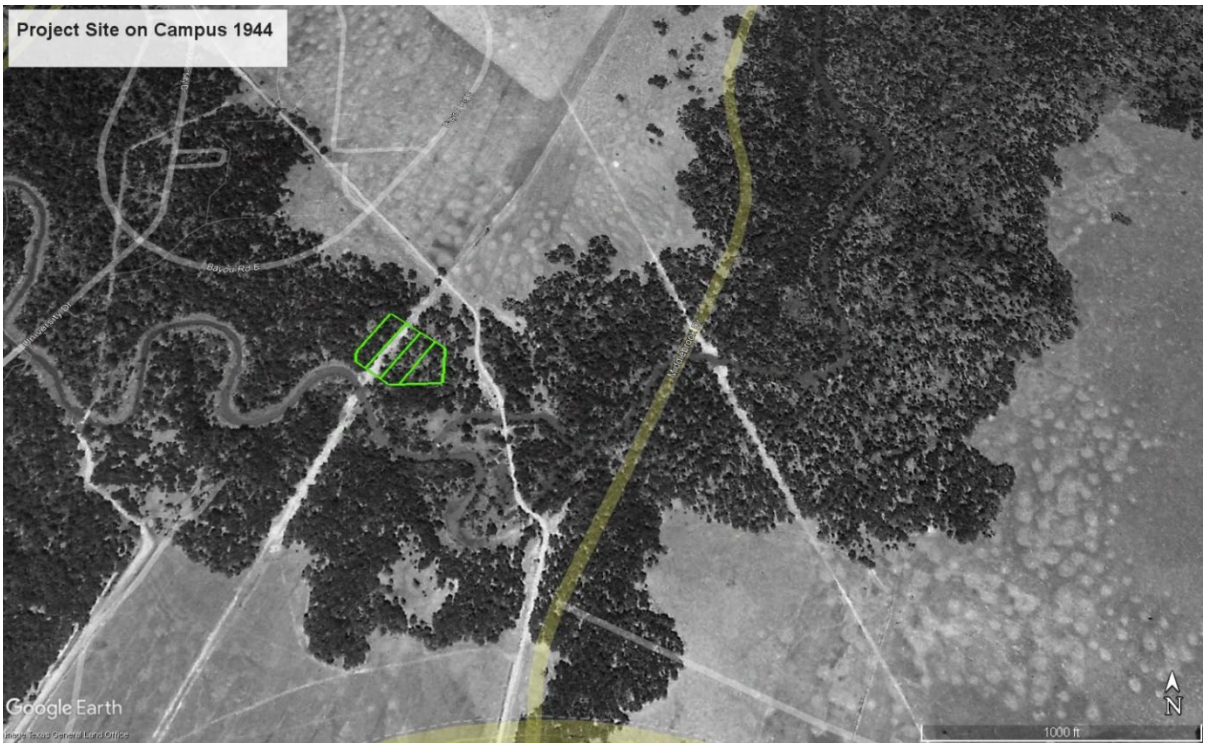


Figure 1. 1944 Aerial View of the Project Site

Figure 2. 1978 Aerial View of the Project Site

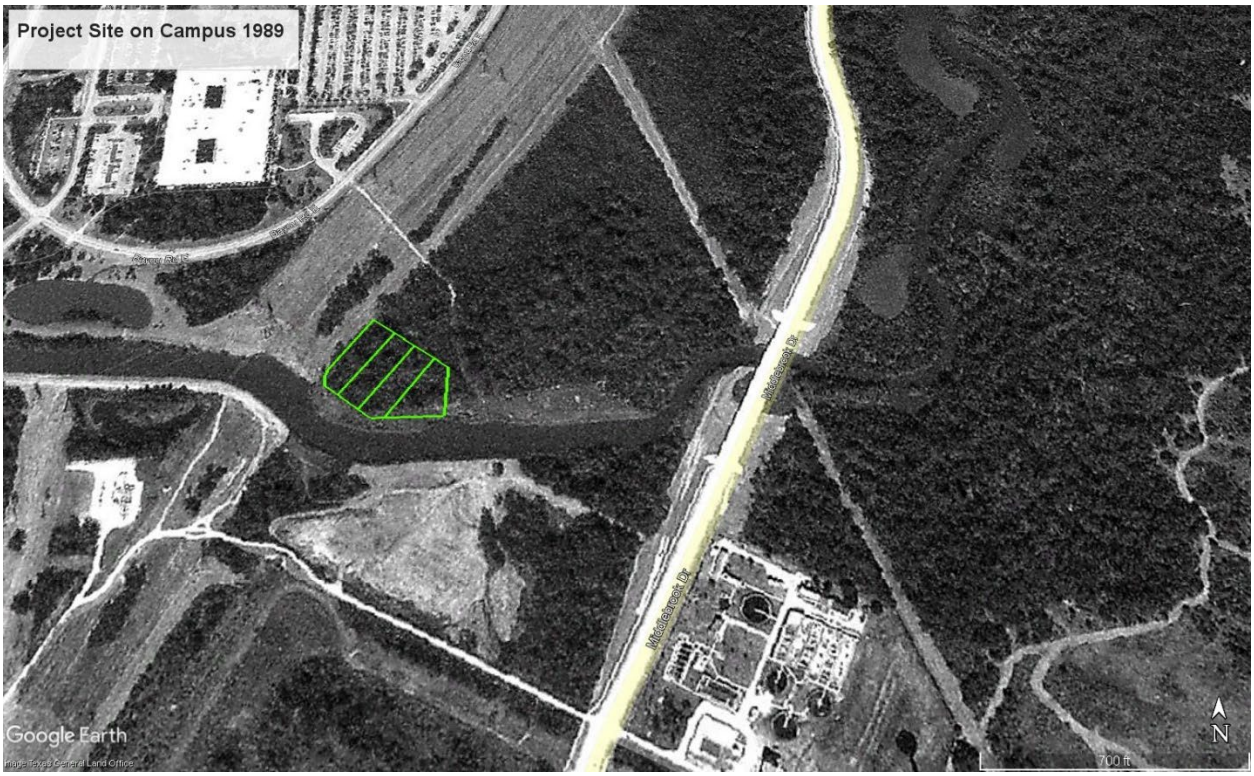


Figure 3. 1989 Aerial View of the Project Site

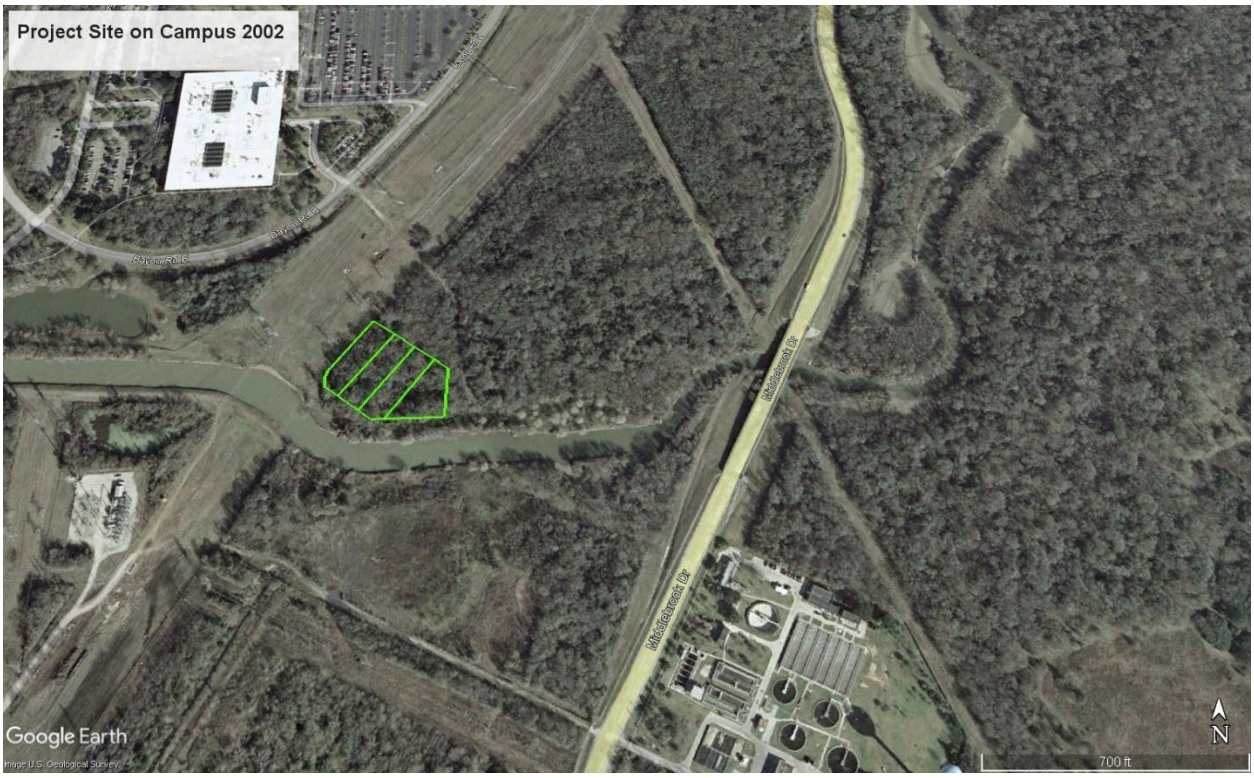


Figure 4. 2002 Aerial View of the Project Site

Figure 5. 2020 Aerial View of the Project Site

Current and Proposed Maps

Georeferenced maps and ESRI shape files show historic, current and proposed restored plant community boundaries of the two-acre site.

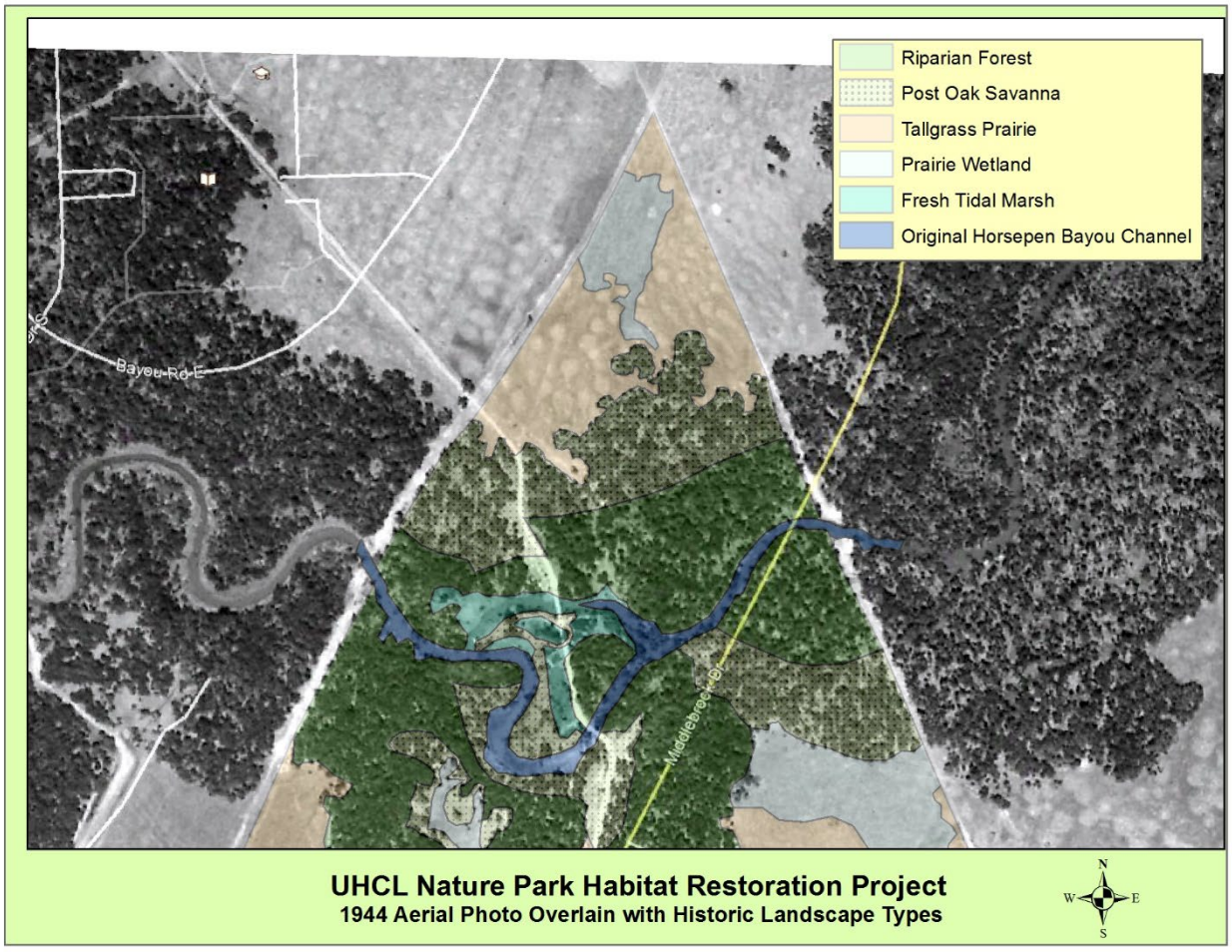


Figure 6. 1944 Aerial Photo Overlain with Historic Landscape Types

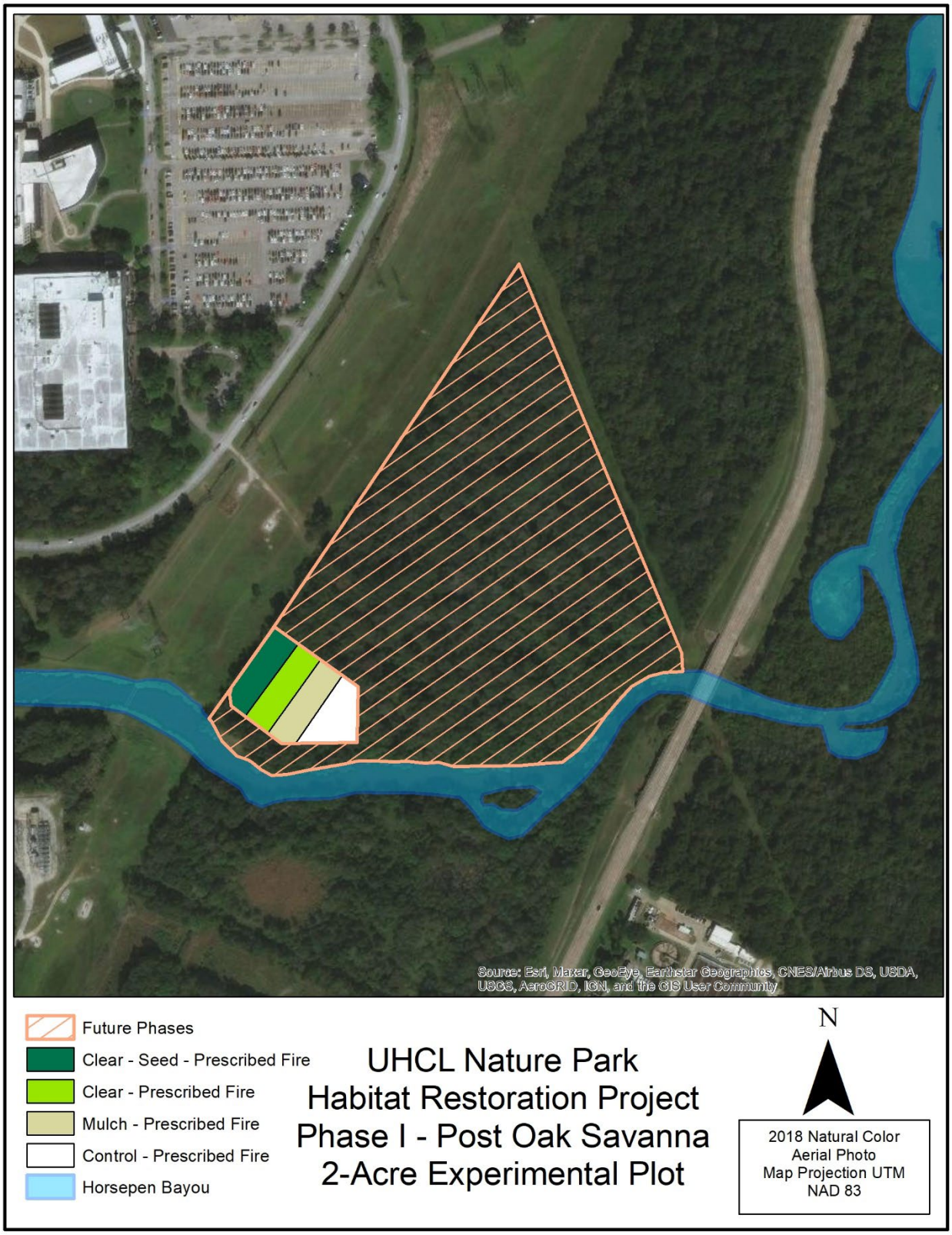


Figure 7. Phase I - Post Oak Savanna Two-Acre Experimental Plot

Soil Series Verification Report and Maps

As depicted in Figure 8, the NRCS soils map shows four soil series on or in the vicinity of the UHCL Nature Trail restoration area. We found that the soils on the site didn't match those depicted on the NRCS map; however, they do match series found nearby or are known to be geographically associated with those nearby (within 75m). The soils on the two-acre site were verified by excavating pits just deep enough to match a soil that could possibly occur on the site given the geomorphologic setting. We didn't dig deep enough (2m) or perform the chemical and physical tests on the soils used to describe a series; however, the textures, colors, and strata (horizons) observed in the excavated pits were successfully matched to the NRCS series description.

Two different soil types were found to occur. Neither match what the NRCS has mapped for the site (Dylan Clay and Lake Charles Clay 0 – 1% Slopes). This is not surprising as the NRCS uses widely spaced soil cores to develop the maps. Aerial photography (1970s or earlier for this area) was used to interpolate between the cores, and areas of soil inclusions (a soil series surrounded by different ones) smaller than 10 acres were not mapped.

Each of the NRCS soil series form under different climate, parent material, vegetation, and inundation regimes. The series determinations (see below) made using soil pits, match the

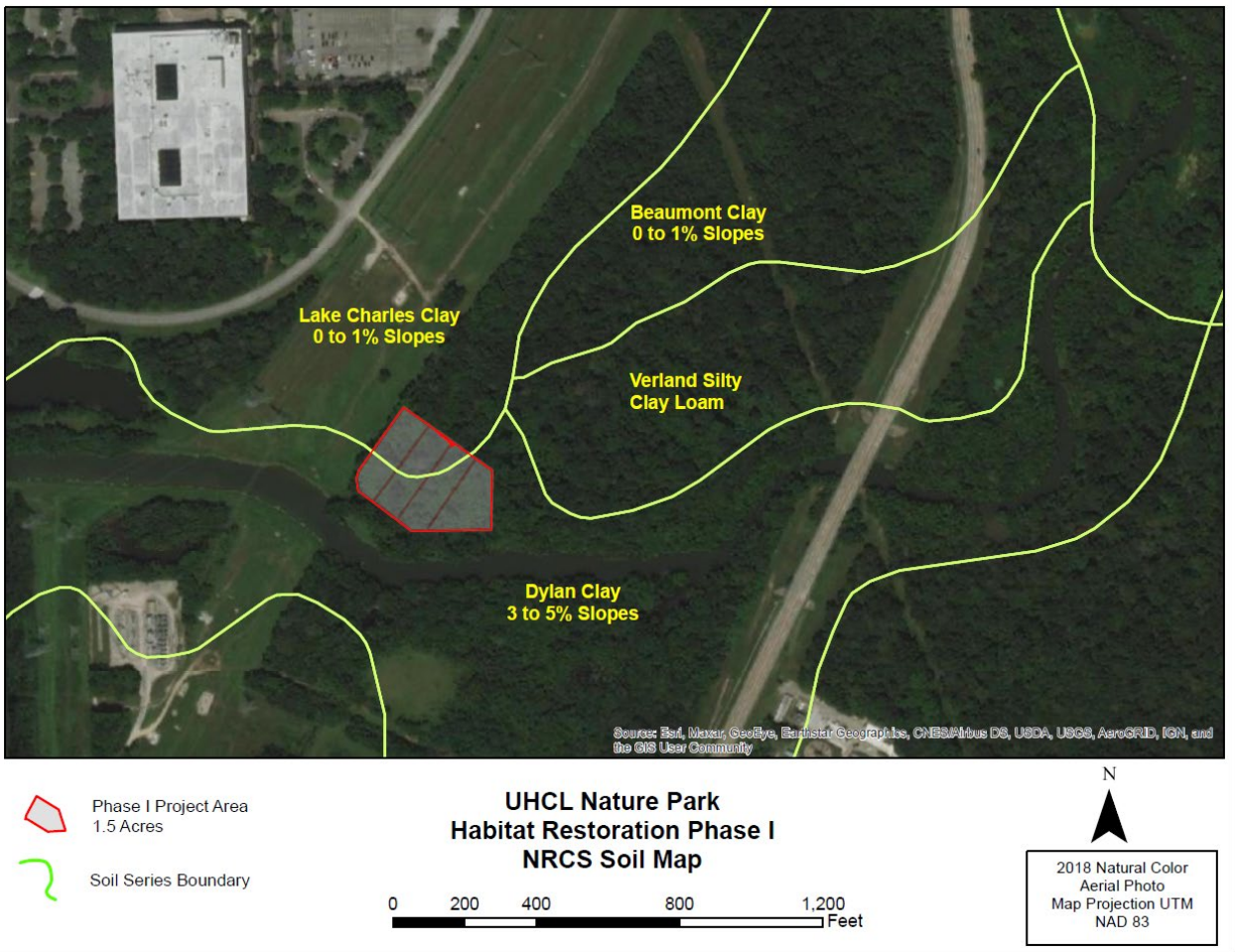


Figure 8. NRCS Soil Map

Figure 9. Verified Soil Map

regimes observed on site, and are known to produce the soils we mapped. The boundaries were mapped using a handheld GPS unit with an accuracy of +/- 5 feet and are shown in Figure 9.

Bernard-Edna Complex, Edna Fine Sandy Loam Component: This soil series is not shown as occurring in the area, however; it is geographically associated with the Verland Silty Clay Soil which is mapped just northeast of the site. The Edna Fine Sandy Loam Soil Series is associated with a very specific geomorphic structure that was observed on the site; mima mounds, or coppice dunes. These are relatively recently formed (8,000 years before present or less) small, 1-to-2-foot tall, circular dunes that often occur in large groupings. The dunes are deposited on top of a different soil type and the abrupt boundary between the light brown sandy loam and light brown clay layer at 13 inches was diagnostic. In this case, the Edna Series mima mounds were deposited on top of a Beaumont Clay soil which outcrops beneath the dune field to the north and occupies a small portion of the northern end of the Phase I site within a small wetland.

The native vegetation of this soil type is upland prairie though it sometimes supports motts of trees. Within the UHCL natural area, post oak (*Quercus stellata*) and southern red oak (*Quercus falcata*) are most often restricted to these mounds along with thickets of yaupon (*Ilex vomitoria*). These make up the tree and shrub component of the savanna, whereas the prairie occupies the more clay rich adjoining soils which suffer more frequently from drought stress due to lower soil

water availability. At the project site the mounds are coalesced into a large area of sandy loam soil due to its presence near the sand source, a Pleistocene channel scar that Horsepen Bayou has usurped for this portion of its channel.

Beaumont Clay 0 – 1% Slopes: This soil series is shown as occurring northeast of the site, but actually touches the northern boundary of it. This is a hydric (wetland) soil type that forms under upper Gulf coast prairie wetlands and is lighter in color than the similar Lake Charles Clay 0 -1% Slopes due to iron depletion and less organic matter content. The light brown clay in the upper part and lighter layer of clay below 12 inches was diagnostic and shows that the deeper layer is depleted of iron due to prolonged inundation and resulting anoxic condition. Abundant mottles in the upper part and freshly deposited iron oxide along living root pores is also diagnostic and confirms this is a hydric (wetland) soil.

The Beaumont Clay is most often a wet prairie soil, but it is also found beneath flatwoods wetlands, especially where trees have encroached on the prairie. Whereas Lake Charles Clay forms only beneath upland prairie, Beaumont Clay is a smectitic vertisol with very low percolation rates and trees growing on it are subject to periodic drought stress. The presence of prairie or forest on this soil is dependent upon recent fire history. Beaumont Clay soil occurs on very flat lands along a strip lying just above the banks of Horsepen Bayou within the UHCL natural area. Dylan Clay occurs on the bank slopes which are not flooded often enough to be hydric. At the UHCL natural area, Beaumont Clay supports a mix of oak savanna and flatwoods forest and is peppered with mima mounds (Edna Fine Sandy Loam). Because it is so flat, it drains poorly and is often ponded through the winter and early spring, as well as temporarily following heavy summer and fall rains. The numerous mima mounds also impede drainage and seep water onto the topographically lower Beaumont, adding to its wetness.

Task 2 Summary: Wetland Delineation and Prescribed Fire Plan

In November 2021, EIH staff, students, faculty members and natural resources professionals conducted a wetland delineation following the current U.S. Army Corps of Engineers protocols (Figure 10 and 11). Two small wetland areas were found on the edge of the pilot project area, which were delineated and mapped (see Figure 12).

Prescribed fire was removed from the project.

Figure 10. Wetland Delineation Class

Figure 11. Student Using a Munsell Soil Color Book

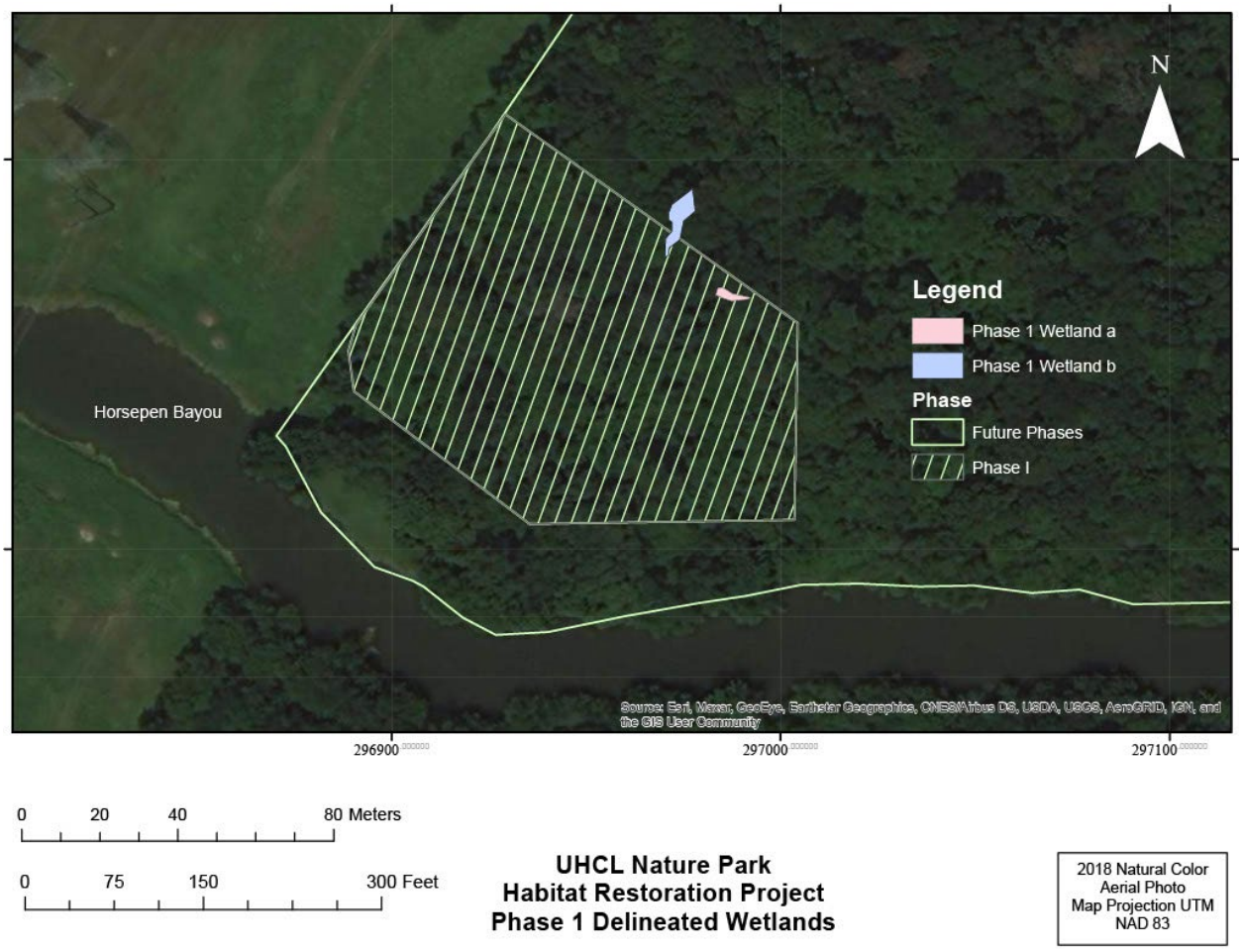


Figure 12. Delineated Wetlands

Task 3 Summary: Native Plant Acquisition

UHCL, along with EIH's established volunteer group, hand and mechanically collected 38 different species of native grass and forb seeds from the native prairies and savanna remnants located within 50 miles of the UHCL restoration site (Figure 13). Additionally, 12 pounds of commercially available native grass and forb seeds were purchased for the project (Table 1).

UHCL germinated and planted 16 local native savanna tree species including Post Oak, Loblolly Pine and Mulberry (Figure 14).

Figure 13. Locally Collected Native Seed

Figure 14. Native Trees

Table 1. Hand-collected seed by species and weight.

Seed collected and bought (with prices)

Seed collected by hand locally and cleaned					
Grass (14 species)		**Grams**	**Lbs**	**Price**	Estim.Value
Big Blue Stem	*Andropogon gerardii*	2.9			
Brown Seed Paspalum	*Paspalum plicatulum*	45			
Cherokee Sedge	*Carex cherokeensis*	19			
Gulf Coast Muhly	*Muhlenbergia capillaris*	5			
Inland Sea Oats	*Chasmanthium latifolium*	28			
Little Bluestem	*Schizachyrium scoparium*	279			
Longspike Tridens	*Tridens strictus*	382			
Lovegrass	*Eragrostis sp.*	2			
Mix		129			
Side Oats Grama	*Bouteloua curtipendula*	12			
Silver Bluestem	*Bothriochloa laguroides*	13			
Splitbeard Bluestem	*Andropogon tenarius*	1			
Virginia Wildrye	*Elymus virginicus*	6			
White Topped Sedge	*Rhyncospora colorata*	7		NAS D-pak price ($15/0.1lb)*	
Yellow Indian Grass	*Sorghastrum nugans*	638		Coastal Prairie Mix	
Grass total		1568.9	3.46lbs	$150/lb	$519.00
Forbs (24 species)					
Am. Basketflower	*Centaurea americana*	19			
Aster sp.	*Symphyotrichum sp*	1			
Baptesia Spherocarpa	*Baptesia Spherocarpa*	4			
Black-eyed Susan	*Rudbeckia hirta*	79			
Blue Mist	*Conoclinium coelestinum*	6			
Bushy Goldentop	*Euthamia graminifolia*	21			
Eupatorium sp.	*Eupatoreum sp.*	8			
False Foxglove	*Agalinus sp.*	4			
Frostweed	*Verbesina virginica*	64			
Gayfeather	*Liatris spp.*	199			
Goldenrod	*Solidago spp.*	228			
Illinois Bundleweed	*Desmanthus illinoensis*	1			
Indian Blanket	*Gallardia aestevalis*	27			
Lyre leaf sage	*Salvia lyrata*	2			
Maximilian Sunflower	*Helianthus maximiliani*	46			
Meadowpink	*Sabatia campestrus*	1			
Milkweed	*Asclepias spp.*	17			
Missouri Ironweed	*Vernonia missurica*	44			
Mix		46			
Narrowleaf Sunflower	*Helianthus angustifolius*	135			
Palafoxia sp.	*Palafoxia sp.*	4			
Rattlesnake Master	*Eryngium yuccifolium*	40			
Rosinweed	*Silphium spp.*	16			
Sneezeweed	*Helenium sp.*	3		NAS D-pak price ($16/0.1lb)*	
Texas Coneflower	*Rudbeckia texana*	2000		Native Texas Mix	
Forb Total		3015	6.66lbs	$160/lb	$1,065.60
Total Seed Collected		4583.9	10.12lbs		$1,584.60

Seeding at 40lbs/acre: (40/60 mix) need 8lbs grass seed and 12lbs forb seed

Purchased Seed (NAS)	Quantity	Item #	Price
Have approx 3lbs grass - order 5lbs			
Gulf States Little Blue	2lbs	2058	$31.90
Purple 3 Awn	D-Pak**	2015	$17.00
Sideoats grama	1lbs	2004	$15.00
Big Bluestem	1lbs	2002	$22.50
Purpletop	D-pak	2048	$19.00
			$105.40
Have approx 5 lbs forb seed - order 7lbs			
American Basketflower	D-pak x2	1010	$58.00
Partridge Pea	1lbs	1016	$18.00
Black-eyed Susan	1lbs	1007	$24.00
Mexican hat	1lbs	1004	$39.00
Pink evening primrose	D-pak x2	1022	$58.00
Plains coreopsis	1lbs	3119	$19.00
lemon mint	0.25lbs	1006	$29.00
Asclepias tuberosa	0.25lbs	3139	$65.00
Illinois Bundleflower	0.25lbs	3075	$9.00
Clasping coneflower	0.25lbs	1013	$8.00
Prairie parsley	D-pak	3156	$29.00
Spotted Beebalm	D-pak	3136	$29.00
			$385.00
Purchased Seed - Douglas King			
Zizotes Milkweed	PKG x10		$150.00
Zapata Rio Grande Clammyweed	2 lbs		$41.70
Sand Lovegrass	1lbs		$13.78
Texas Maroon Bluebonnets	2lbs		$164.00
Earl Big Bluestem	4lbs		$85.56
			$455.04

* NAS = Native American Seed
Prices correct as of March 2022

** D-pak = 0.1lbs

Task 4 Summary: Invasive Plant Removal, Prescribed Fire, and Seeding

All work was conducted within the two-acre site of former oak savanna on UHCL property. UHCL contracted with HLM, Inc. to remove woody plants from 1.5 acres of the site. Figure 15 shows the site prior to mulching. Selected trees and underbrush were removed and mulched by HLM, Inc., as seen in Figure 16. They also performed the initial removal of mulch on one acre of the property (Plots A and B) and left the mulch in place on Plot C. Additionally, volunteers and staff removed mulch because smaller pieces remained after the mechanical removal process (Figures 17 and 18). Herbicide was applied to the total 1.5 acres (Plots A, B, C) to treat woody plants and invasive non-native grass growth on an as needed basis (Figure 19).

Again, prescribed fire was removed from the UHCL work plan.

UHCL contracted with Native Texas Wildlife Service to use a seed drill to plant ½ acre (Plot A) with native seed (Figure 20). A total of 16 native savanna tree seedlings were planted on the two-acre site (Figure 21). Figures 22 through 25 show plant growth after the seeding.

In addition, UHCL installed temporary CMP signs (Figure 26) during the work phases and permanent signs when the work was completed (Figure 27).

Figure 15. Site Before Mulching

Figure 16. Site After Tree Removal and Mulching

Figure 17. Volunteers Removing Remaining Mulch

Figure 18. After Much Removal

Figure 19. Invasive Species Removal on Plot C

Figure 20. Inspecting the First Pass of the Seed Drill, Spring 2022

Figure 21. Planted Oak Tree

Figure 22. Grasses and Forbes, Spring 2023

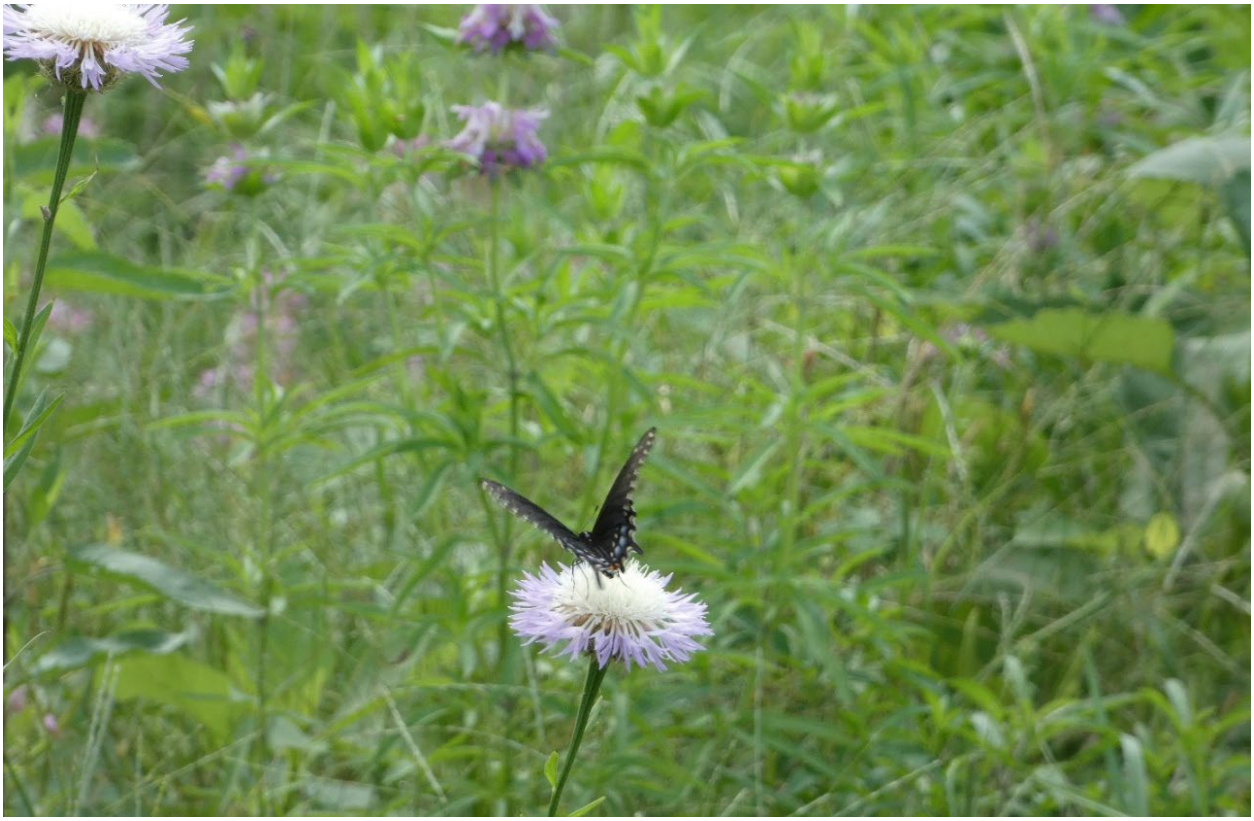


Figure 23. Swallowtail Butterfly Nectaring on American Basketflower, Spring 2023

Figure 24. Grasses and Forbes, Fall 2023

Figure 25. Grasses and Forbes, Fall 2023

Figure 26. Temporary CMP Signage

Figure 27. Final CMP Signage

Task 5 Summary: Data Collection and Dissemination

UHCL has monitored the two-acre site to measure the progress of the restoration, success of maintenance protocols, and to ensure the early detection and retreatment of invasive species. Surveys were conducted to document plant community changes using our established protocol (Task 1).

UHCL has completed the report on plant community changes with maps, site photographs, and comparisons between treatments (Plots A, B, C). The report also includes UHCL's recommendation for the most successful and cost-effective restoration methods for Texas' coastal grassland habitat.

UHCL presented the report to the Coastal Prairie Partnership, Native Prairie Association of Texas, Texas Master Naturalists, and the Clear Lake Chapter of the Native Plant Society of Texas. A report was also prepared and submitted to the Texas Society for Ecological Restoration.

The findings regarding the plant community are detailed in Appendix I.

Task 6 Summary: Trail Construction and Interpretation Signage

UHCL contracted with Beck Landscaping LLC to improve a portion of the current nature trail for a total of 925 linear feet of walking trail that is Americans with Disabilities Act (ADA) compliant (Figures 28-30). A registered accessibility specialist inspected and certified the trail as compliant with Texas Accessibility Standards (TAS).

UHCL also improved the existing pavilion by repairing the roof and providing an outdoor classroom space with additional seating for a total of 20 seats (Figures 31-33). Additionally, a community youth group constructed an observational bird blind at the site (Figure 34).

Finally, UHCL contracted with Pannier Graphics to produce five interpretative signs that educate visitors about restoration and the importance of coastal ecosystems. The signs, shown in Figures 35 through 39, are located along the trail and at the pavilion.

Figure 28. Nature Trail

Figure 29. Nature Trail

Figure 30. Observation Area

Figure 31. Pavilion Before Improvements

Figure 32. Bench Painted by Students

Figure 33. Benches were Installed to Provide Seating

Figure 34. Bird Blind Built by Community Youth Group

Figure 35. Coastal Prairie and Oak Savanna Interpretive Sign

Figure 36. Prescribed Fire Interpretive Sign

Figure 37. Keystone Species Interpretive Sign

Figure 38. Invasive Species Interpretive Sign

Figure 39. Pollinators Interpretive Sign

Task 7 Summary: Project Monitoring and Reporting

UHCL prepared and submitted progress reports, deliverables, and requests for reimbursement as required. This final report describes the work completed under each task and includes pictures of the restored two-acre site.

Appendix I

UHCL Habitat Restoration Project – Plant Community Results

UHCL Habitat Restoration Project – Plant Community Results

Background and Introduction

Historically there were over 6.5 million acres of grassland on the Texas coast, but now this beautiful and diverse ecosystem is nearly absent. Restoration of this habitat is important to conservation scientists, but it is difficult to achieve a vegetatively diverse result here on the Gulf Coast. There is little published research on the subject that is done in our area, and that done in other parts of the country is difficult to apply here because of several challenges that include: xeric/hydric clay rich soils that often pond water for long periods; a longer growing season, higher average rainfall, a lack of locally sourced seed, and competition from invasive species.

The University of Houston-Clear Lake has plans to restore twenty-five acres of what used to be savanna, coastal prairie, and wetland habitats. We are doing this to increase the diversity of birds on campus and to involve students in a project that will help them recognize our local ecosystems and have a better understanding of their role not just in wildlife conservation, but also community resilience in facing the consequences of climate change.

This pilot restoration project took place at the UHCL nature park/trail area adjacent to Horsepen Bayou. Study of historic photographs and ground truthing showed that coastal prairie and savanna habitat at the site and on campus had degraded to woodland that included an overgrowth of *Ilex vomitoria* (native Yaupon holly), *Celtis laevigata* (native Sugar Hackberry), *Triadica sebifera* (the non-native and highly invasive Chinese Tallow), and various species of the non-native and invasive *Ligustrum* genus (Privet species.)

This pilot project, explored the results of different locally used coastal prairie restoration techniques (with various unpublished results) on a two-acre portion of the now wooded nature park/trail. In this report oak savanna and prairie are used interchangeably because the understory of oak savannah comprises prairie species. On UHCL campus oak savanna occurs as riparian woodlands transition into prairie. Historic aerial photographs of the project area show that it was Post Oak savanna as recently as 1944, so surviving Oaks and other species of trees appropriate for this type of habitat were left in place. We removed invasive trees such as *Triadica sebifera* (Chinese Tallow) and *Ligustrum spp*. as well as overgrowth of *Ilex vomitoria* (Yaupon holly) and *Celtis laevigata* (Sugar Hackberry.) This opened the tree canopy to allow the growth of native savanna/coastal prairie grassland species.

Historic Google images can be found in Appendix A

Method

At the start of the pilot project, before any trees were removed, we surveyed the project area for wetlands. Two small wetland areas were found on the edge of the pilot project area, which were delineated and mapped.

The wetland delineation map can be found in **Appendix C**

Verification of the NRCS soils map also took place. The soils verification report can be found in **Appendix C**

The two-acre project site was divided into four plots, named Plot A, Plot B, Plot C, and Plot D. Each plot underwent a different treatment:

Plot A: Plot A comprises an area of approximately half an acre. Tree removal was done by mulching and the area was cleared of the mulch chippings. Additional material was removed by hand raking to provide a clean seeding bed. The plot was seeded with a mixture of hand collected and purchased seed using a seed drill. Seed was sowed at a rate of thirty-six pounds per acre which corresponds to the highest setting on the seed drill. The high sowing rate was a decision we made to ensure that there were as few spaces as possible for invasive species to become established. The mix comprised sixteen species of grass and thirty-five species of forbs. A lot of annual species were included in the mix so that they "could fill the space" before the slower growing perennials were established. Control of invasives was by hand and herbicide applied by backpack on an "as needed" basis.

A full breakdown of the seed collected and purchased can be found in **Appendix B**

Plot B: Plot B comprises an area of approximately half an acre. Tree removal was done by mulching and the area was mechanically cleared of mulch chippings. No seeding took place. Control of invasives was by hand and by using herbicide applied by backpack on an "as needed" basis.

Plot C: Plot C comprises an area of approximately half an acre. Tree removal was done by mulching, and all the mulch/chippings were left in place. Control of invasives was by hand and by using herbicide applied by backpack on an "as needed" basis.

The method for Plot B and Plot C relies on prairie species remaining in the soil (i.e. a seed bank) which would grow naturally once the tree canopy was removed. This is a technique that has been used on other nearby properties.

Plot D: Plot D comprises a control area of approximately half an acre, where no action was taken.

Prescribed fire, if possible, is part of the management plan for all four plots

Project maps can be found in **Appendix C**

Vegetation Surveys

Three vegetation surveys were done, a baseline survey in December 2021, three months after seeding in May 2022, and nine months after seeding in November 2022.

Sampling was conducted using quadrat plots. Five $1m^2$ plots were randomly placed within five meters either side of a central transect line within each plot (twenty in total.) The quadrat plot

size allowed for accurate sampling in an area with many trees and brushy growth, but is also sparsely vegetated. All trees, shrubs, vines, grasses, sedges, and forbs in these plots were identified, counted, and recorded. The Shannon-Wiener Diversity Index (H) for each plot was calculated using the following equation:

$$H=-\sum[(p_i)\times\log(p_i)]$$

where:

- p_i - proportion of individuals of i-th species in a whole community;
- $\sum$ - sum symbol
- $\log$ - the natural logarithm.
- $p_i=N/n$
- n - individuals of a given type/species; and
- N - total number of individuals in a community,

Results

Invasive species

The growth of invasive species was significant. Plot A had the greatest percentage of plants that were of an invasive species at the Baseline survey before any of the tree clearing took place. This was probably because Plot A is closest to the pipeline corridor and at the edge of the study area and was overgrown with *Ligustrum spp.* After removal of the bushy overgrowth this was no longer the case. The regrowth of invasive species was greatly reduced in Plot A after seeding with native plant species. The overgrowth of invasive species in the unseeded Plot B and Plot C was noticeable. Despite repeated applications of both glyphosate 2% and trichlopir Plot C became overgrown with *Triadica sebifera* (Chinese Tallow) and *Melia azedarach* (Chinaberry), even though *M. azedarach* was not a common plant before mulching. The thick layer of mulch left behind after tree removal did not protect against the regrowth of invasive species. (See Graph 1.)

Introduction of native species

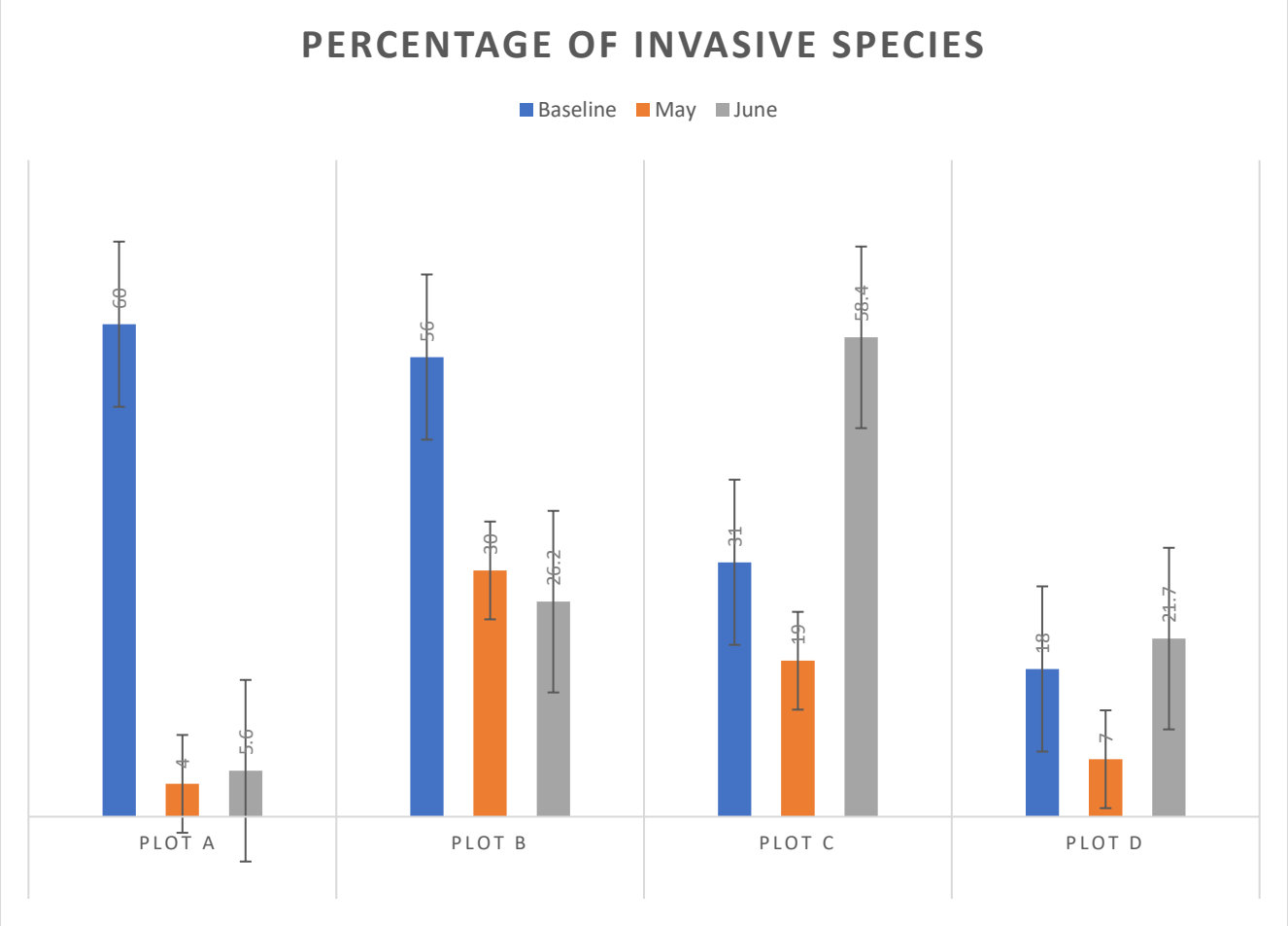
Only Plot A showed a significant increase in native species. We concluded that this was the result of planting native seed. There was no significant increase in native species in Plot B or Plot C which had not been seeded. We conclude that there is no significant seed bank in the soil and that seeding is necessary in coastal prairie habitat on UHCL campus. (See Graph 2.)

Plant Diversity

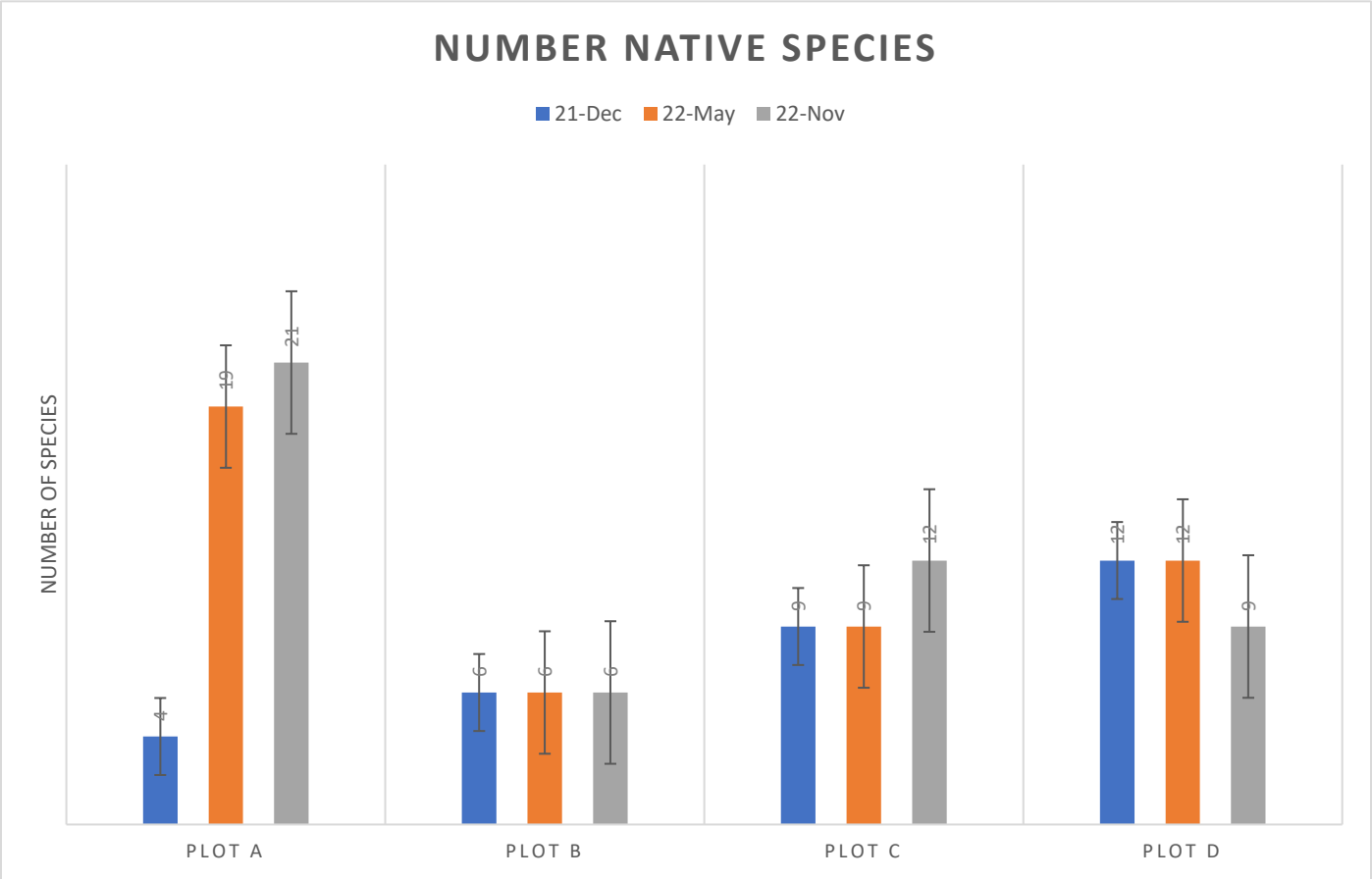
Plot A showed significant changes as measured by the Shannon-Weiner Diversity Index. (See Graph 3.) A total of sixteen grass species and thirty-five forb species were in the planting mix in varying amounts. A total of four grass species and seventeen forbs species were counted during the November 2022 survey. Only species found in the quadrat plot were recorded so it is possible that not all species were counted.

Raw vegetation data from vegetation surveys can be found in **Appendix D**

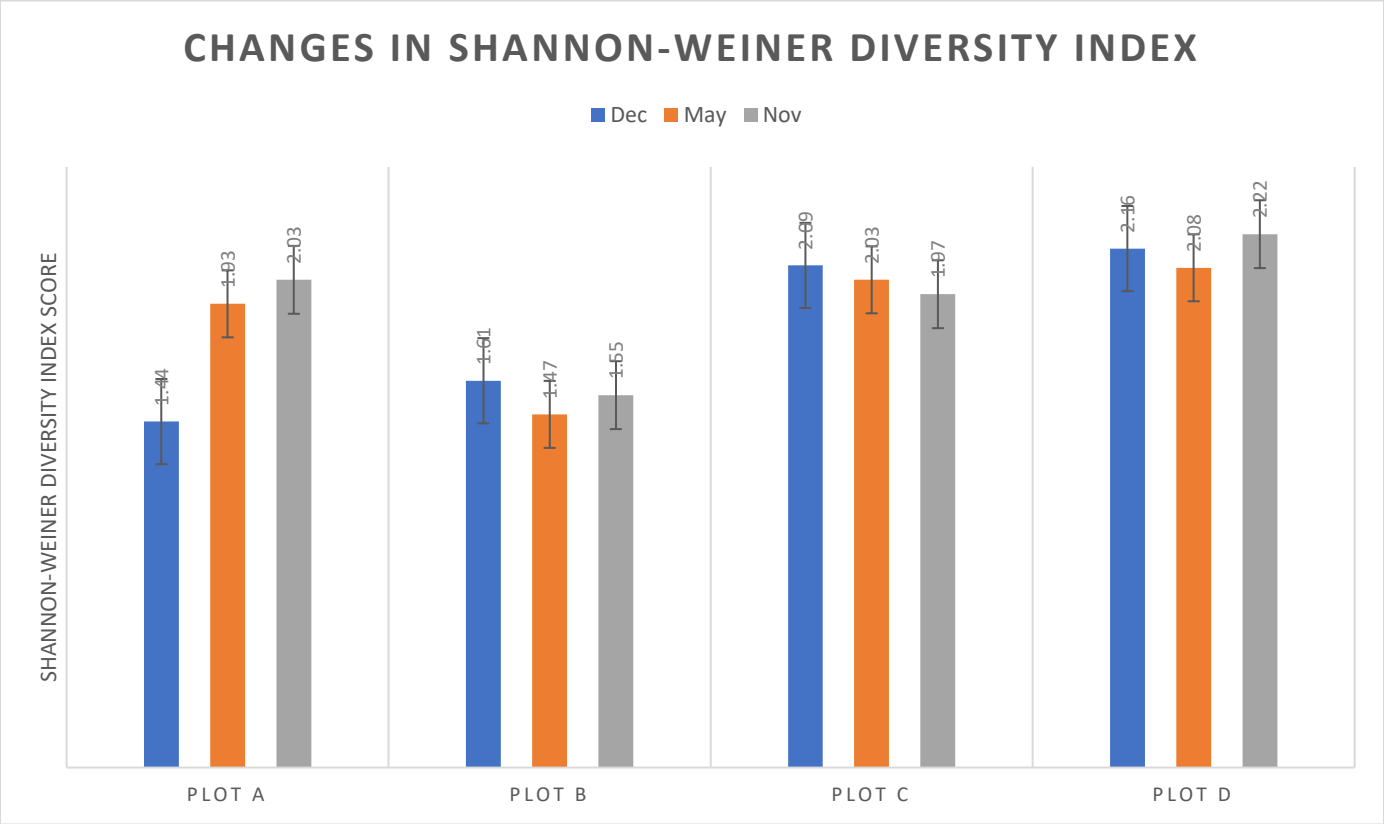
Photographs from the project can be found in **Appendix E**



Graph 1. The percentage of plants counted that were non-native species. The differences were significant at the baseline survey (December 2021) at Plot A, at the May 2022 survey at plot B, and at the November 2022 survey at Plot C. There was no significant difference at Plot D (the untreated plot.)



Graph 2: Number of native species identified. Significant increases were only found in Plot A which had been seeded with a native seed mixture.



Graph 3. Only Plot A, planted with native seeds, shows a score on the Shannon-Weiner Diversity Index significantly different to the score of the baseline survey.

Costs

Summary of Expenses for pilot project – UHCL Nature Trail Habitat Restoration

Mulching (tree removal)	$12,500
Seed	$945.44
Seed Drill	$900
2 x Backpack Sprayers + herbicide (expense ongoing)	$338.32
Volunteer hours	220 hours+

Breakdown of expenses of Plots A, B, C, and D

Expense	Plot A	Plot B	Plot C	Plot D	Total
Mulching	$4,167	$4,167	$4,167	$0	$12,500
Seed	$945.44	$0	$0	$0	$945.44
Seed Drill	$900	$0	$0	$0	$900
Herbicide w/out sprayer purchase (estimate)	$30	$70	$140	$0	$240
Total	$6,042.44	$4,237	$4,307	$0	$14,585.44

Discussion

The costs of the pilot project were high on a per acre basis since much was attributed to equipment mobilization. Mulching of shrubs and trees was the largest expense. Mulching was cheaper than other options. The removal of the wood chips from Plots A and B with a skid steer loader was an additional cost, and did not do a good job of creating a clean seed bed. Labor intensive hand raking was required. Fortunately, we had a group of committed volunteers who worked very hard to make this project succeed. Another labor-intensive endeavor was the collection of local seed by hand and the cleaning of that seed so that it did not clog up the seed drill. We used almost twice the recommended seeding rate and spent more than most projects on purchasing additional seed. This was because we had little idea of how viable the seed we collected by hand would be, and also bought seed of individual species to supplement our mix rather than buy a generic mix. It was important to us that we get good germination on year one to prevent the invasion of non-native species.

It is apparent that seeding is necessary to see the benefits of opening the canopy. Any seed left in the soil (i.e. the seed bank) at this site was no longer viable or was not in sufficient quantities to outcompete invasive species. The site's canopy appeared to close and shade out the native grassland component by approximately 1995, or 25 years prior to the restoration. Although we drenched Plot A in seed in an attempt to preempt any invasion of the soil bed by invasive species, we did not completely succeed and control of invasives by individual plant treatment still had to be carried out. Germination in Plot A was excellent. We attribute this to the favorable weather conditions, the good loamy soil, and the clean seed bed to plant into.

Our apprehension about being able to control invasive species was well founded. The regrowth of *Triadica sebifera* (Chinese Tallow) from the mulch left on the ground was a lot to deal with. We used the Individual Plant Treatment (IPT) approach using both glyphosate and triclopyr and had to repeat applications twice (for a total of three applications) over the summer. The herbicide treatments worked well on the plants they were applied to, but new plants kept appearing. We also had to deal with a lot of *Sorghum halepense* (Johnson Grass) that was blowing in seed from the pipeline easement. Our control measures include removing tallow from the neighboring woodland using the slash and spray method with triclopyr by Master Naturalist volunteers, as well as treatment of Johnson Grass in the pipeline easement by IPT with glyphosate. We requested and received extra support from the grounds crew at UHCL by means of frequent mowing of the pipeline easement near the project site.

Using a diverse seed mix has resulted in a diverse plant community. We anticipate that in future years, seed that is slower to germinate will add to the mix.

Conclusions and Recommendations

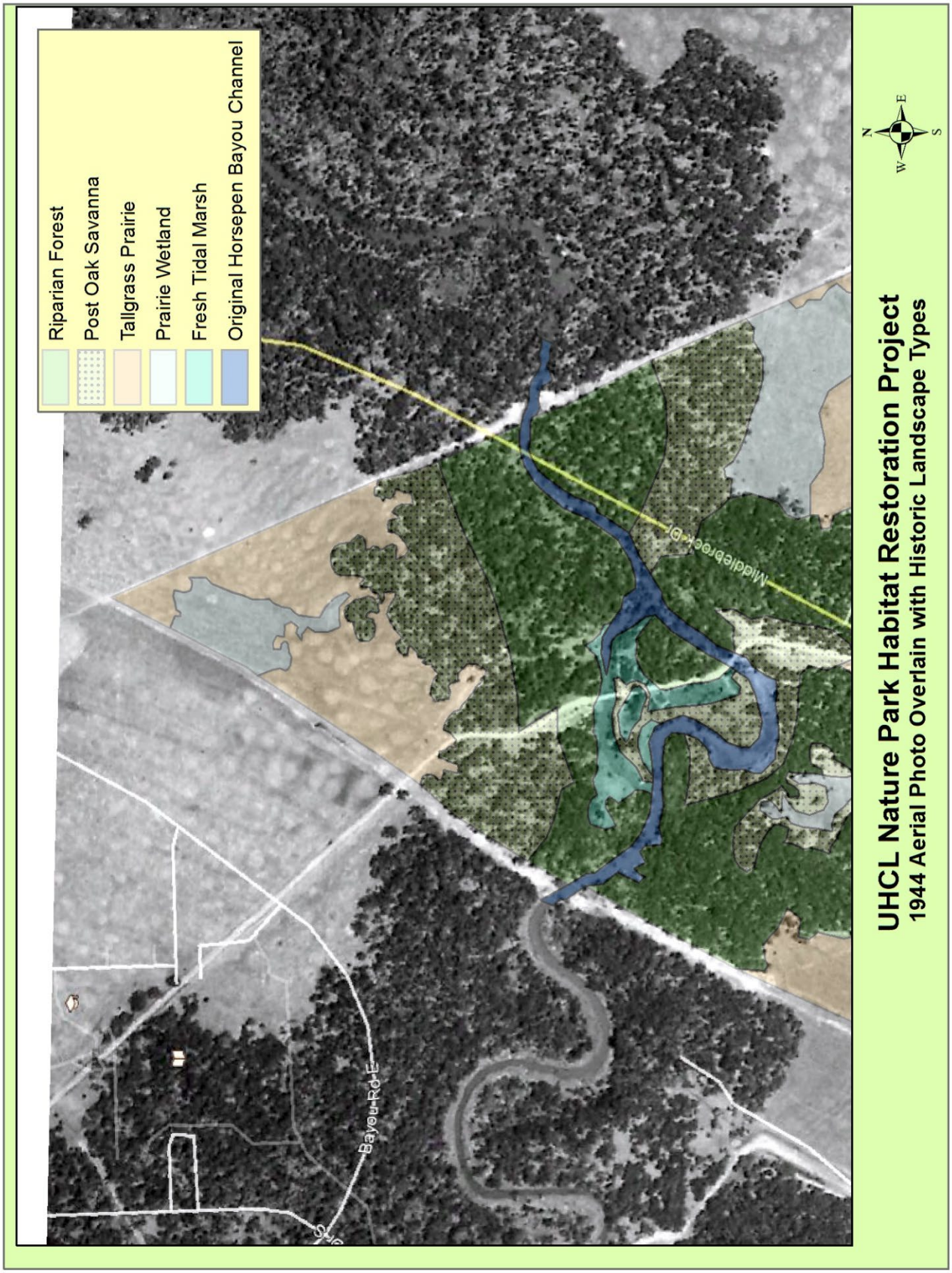
We conclude that sowing seed is necessary in land cleared of trees or invasive species on the campus of UHCL to restore the grassland component lost to shading. The seed bank is depleted and invasive species too aggressive for habitat restoration to be successful otherwise.

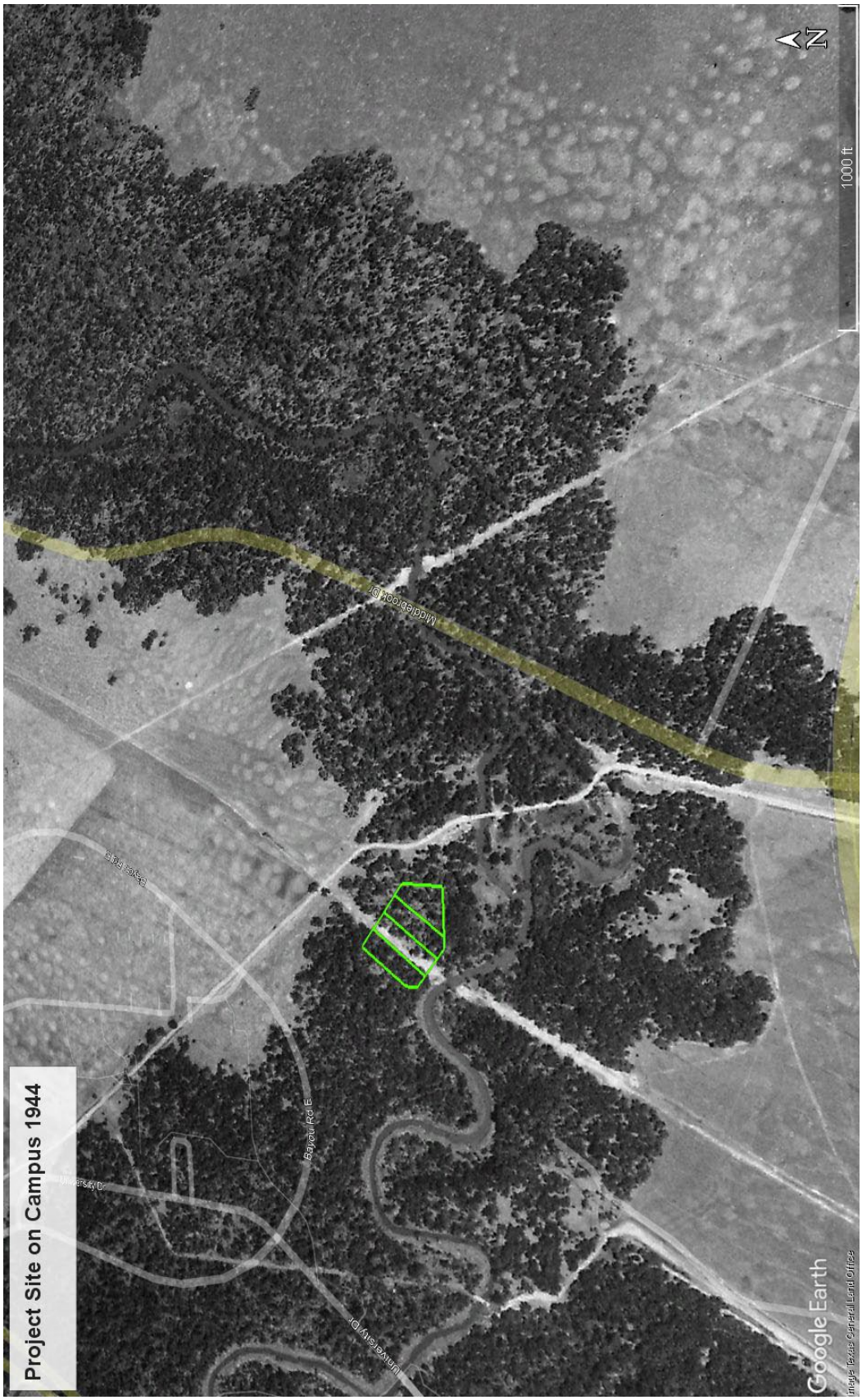
We have also concluded that further restoration on campus will not involve the mulching of trees overcrowding the canopy. We anticipate better results removing trees and shrubs individually either by hand (chainsaw) or with an excavator.

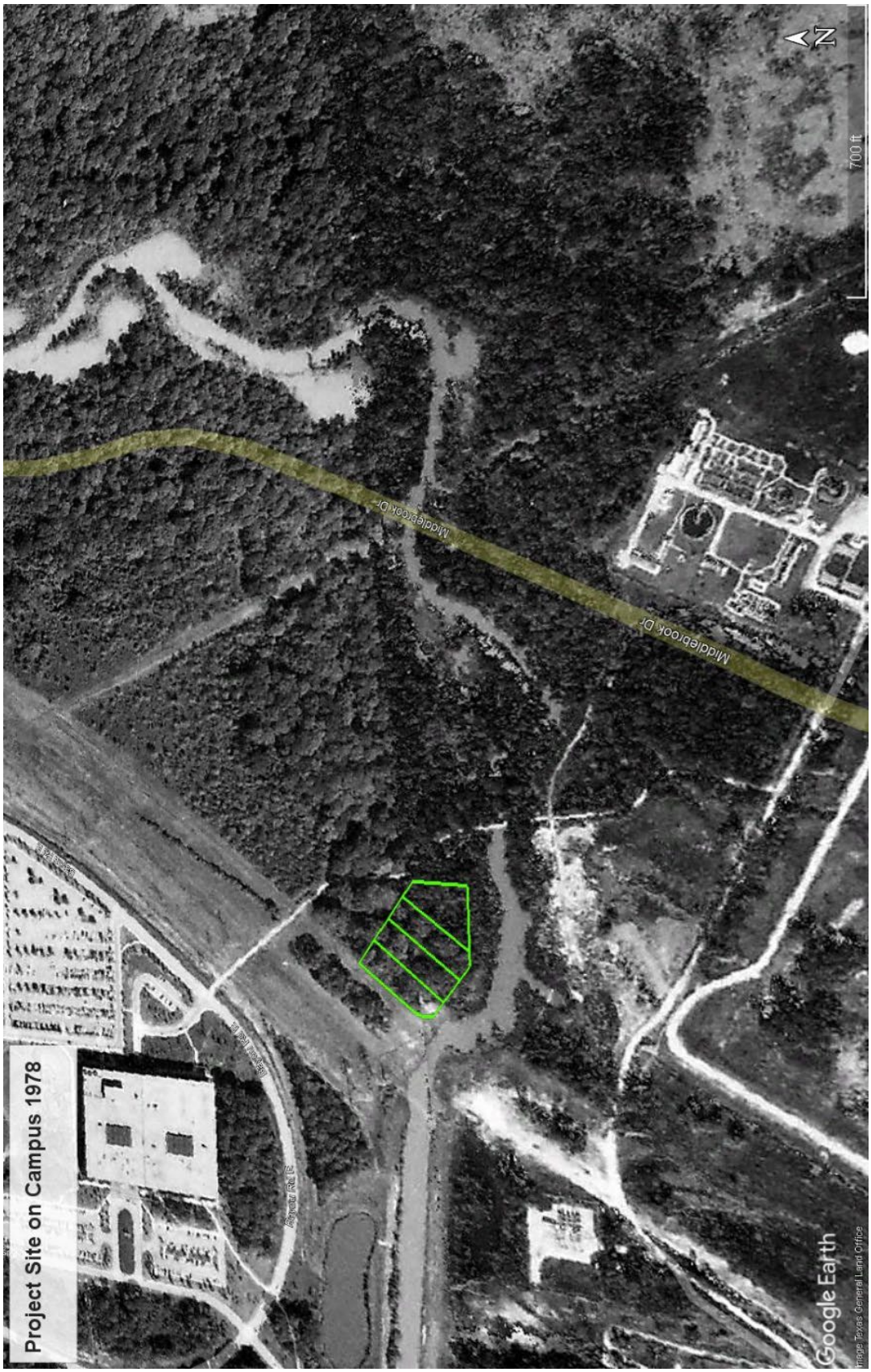
We recommend the collection of local seed, and purchase of additional seed to compliment a commercial seed mix. This does add to the expense, but adds to the diversity of restored habitat. We will continue to monitor the plant community in years to come.

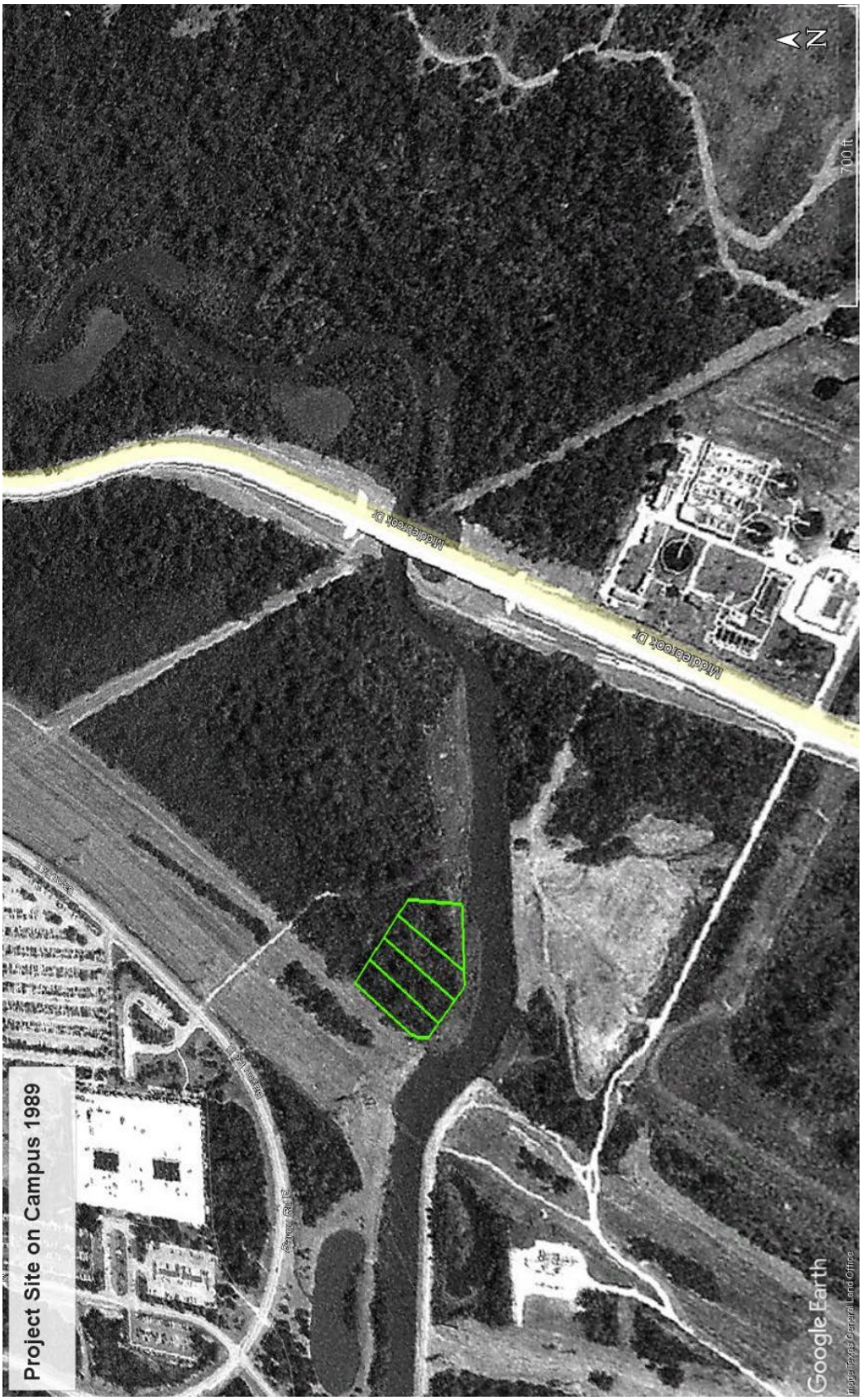
We look forward to using and evaluating prescribed fire as a fire management tool.

Appendix A

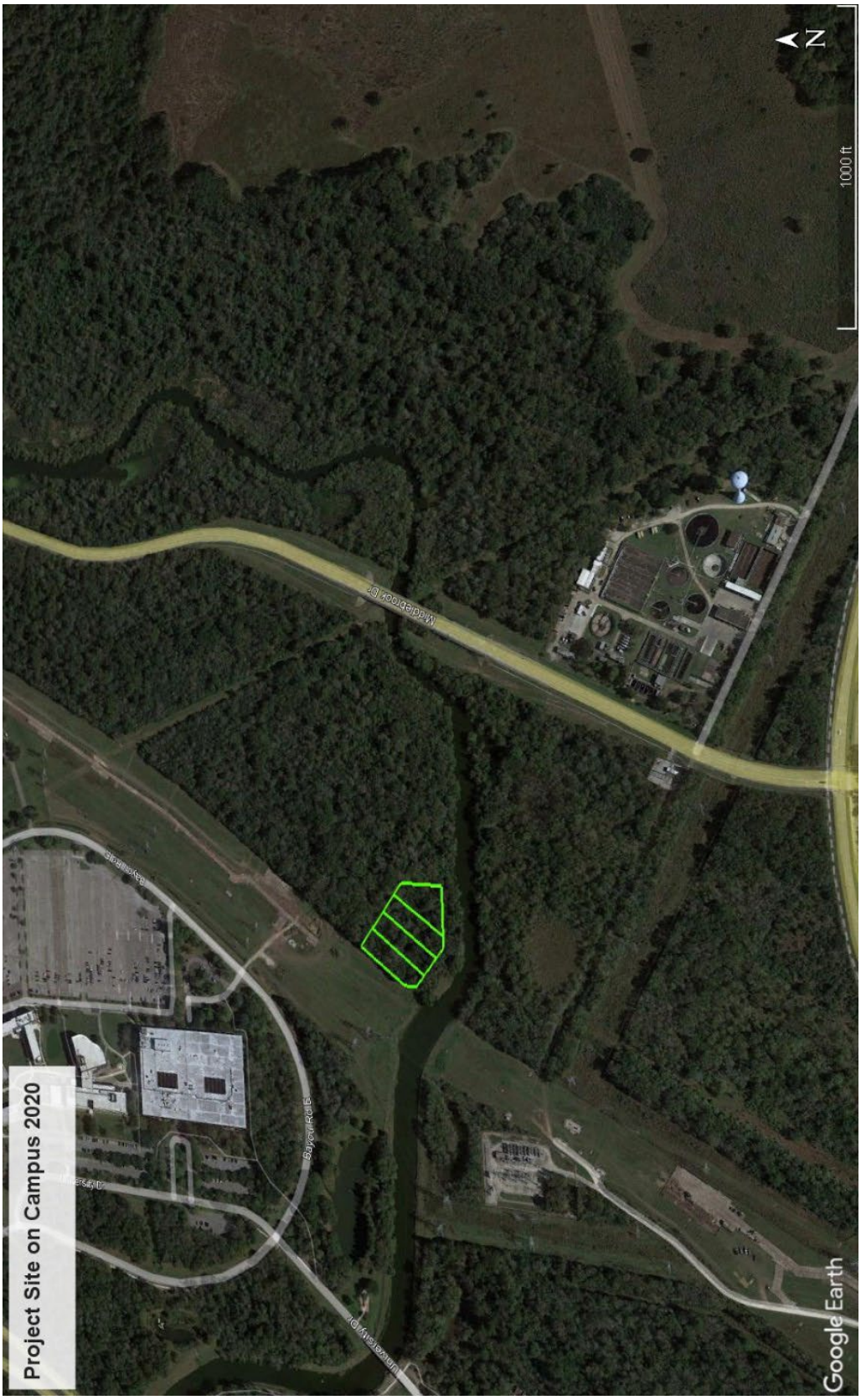

UHCL Nature Park Habitat Restoration Project
1944 Aerial Photo Overlain with Historic Landscape Types
Riparian Forest
Post Oak Savanna
Tallgrass Prairie
Prairie Wetland
Fresh Tidal Marsh
Original Horsepen Bayou Channel
Middlebrook Dr
Bayou Rd E
N
E
S
W


Project Site on Campus 1944
N
1000 ft
Middlebrook Dr
Bayou Rd E
University Dr
Google Earth


Project Site on Campus 1978
Middlebrook Dr
700 ft
Google Earth


N
700 ft
Middlebrook Dr
Middlebrook Dr
Project Site on Campus 1989
Google Earth


Project Site on Campus 2002
Middlebrook Dr
Middlebrook Dr
700 ft
N
Google Earth


N
1000 ft
Project Site on Campus 2020
Google Earth

Appendix B

- Seed collected and purchased- Spreadsheet…pg18

Seed collected and purchased for 2022 TGLO funded pilot project

Grass (15 species)		gram	lbs	Price	Value
Gulf Coast Muhly	*Muhlenbergia capillaris*	5		$6/g	$30.00
Little Bluestem	*Schizachyrium scoparium*	279	0.62	$120/lb	$74.40
Brown Seed Paspalum	*Paspalum plicatulum*	45	0.1	$3/g	$135.00
Lovegrass	*Eragrostis sp.*	2		$3/g	$6.00
Big Blue Stem	*Andropogon gerardii*	2.9		$3/g	$8.70
Longspike Tridens	*Tridens strictus*	382	0.84	$3/g	$1,146.00
Yellow Indian Grass	*Sorghastrum nugans*	638	1.41	$120/lb	$169.20
Silver Bluestem	*Bothriochloa laguroides*	13	0.03	120/lb	$3.60
Cherokee Sedge	*Carex cherokeensis*	19	0.04	$3/g	$57.00
Virginia Wildrye	*Elymus virginicus*	6		$3/g	$18.00
Inland Sea Oats	*Chasmanthium latifolium*	28	0.06	$240/lb	$14.40
Side Oats Grama	*Bouteloua curtipendula*	12	0.03	$90/lb	$2.70
Splitbeard Bluestem	*Andropogon tenarius*	1		$6/g	$6.00
White Topped Sedge	*Rhyncospora colorata*	7		$6/g	$42.00
Mix		129	0.3	$290/lbs	$87.00
		1568.9	3.3lbs		$1,800.00
Forbs (23 species)					
Palafoxia sp.	*Palafoxia sp.*	4		$6/g	$24.00
Lyre leaf sage	*Salvia lyrata*	2		$6/g	$12.00
Indian Blanket	*Gallardia aestevalis*	27	0.06	$6/g	$162.00
Narrowleaf Sunflower	*Helianthus angustifolius*	135	0.3	$3/g	$405.00
Baptesia Spherocarpa	*Baptesia Spherocarpa*	4		$3/g	$12.00
Missouri Ironweed	*Vernonia missurica*	44	0.1	$6/g	$264.00
Texas Coneflower	*Rudbeckia texana*	2000	4.41	$3/g	$6,000.00
Blue Mist	*Conoclinium coelestinum*	6		$6/g	$36.00
Sneezeweed	*Helenium sp.*	3		$6/g	$18.00
Goldenrod	*Solidago spp.*	228	0.5	$6/g	$1,368.00
Black-eyed Susan	*Rudbeckia hirta*	79	0.17	$3/g	$237.00
Aster sp.	*Symphyotrichum sp*	1		$6/g	$6.00
Frostweed	*Verbesina virginica*	64	0.14	$3/g	$192.00
Maximillian Sunflower	*Helianthus maximiliani*	46	0.1	$3/g	$138.00
Meadowpink	*Sabatia campestrus*	1		$6/g	$6.00
Bushy Goldentop	*Euthamia graminifolia*	21	0.05	$6/g	$126.00
Eupatorium sp.	*Eupatoreum sp.*	8		$6/g	$48.00
Gayfeather	*Liatris spp.*	199	0.44	$6/g	$1,194.00
False Foxglove	*Agalinus sp.*	4		$6/g	$24.00
Illinois Bundleweed	*Desmanthus illinoensis*	1		$3/g	$3.00
Milkweed	*Asclepias spp.*	17	0.04	$3/g	$51.00
Rattlesnake Master	*Eryngium yuccifolium*	40	0.09	$6/g	$240.00
Am. Basketflower	*Centaurea americana*	19	0.04	$3/g	$57.00
Rosinweed	*Silphium spp.*	16	0.04	$3/g	$48.00
Mix		46	0.1	$3/g	$138.00
		3015	5.1 lbs		$10,809.00

Seeding at 40lbs/acre: (40/60 mix) need 8lbs grass seed and 12lbs forb seed

		Quantity	Item #	Price	
Have approx 3lbs grass - order 5lbs					
Gulf States Little Blue		2	2058	32	
Purple 3 Awn	D-Pak		2015	9	
Sideoats grama		1	2004	15	
Big Bluestem		1	2002	9	
Purpletop	D-pak		2048	19	
				84	dollars
Have approx 5 lbs forb seed - order 7lbs					
American Basketflower		1	1010	49	
Partridge Pea		1	1016	18	
BES		1	1007	24	
Mexican hat		1	1004	39	
Pink evening primrose		1	1022	19	
Plains coreopsis		1	3119	29	
lemon mint		0.25	1006	29	
Asclepias tuberosa		0.25	3139	65	
Illinois Bundleflower		0.25	3075	8	
Clasping coneflower		0.25	1013	12	
Yellow Puff	1 pkt		1013	6	
Prairie parsley	D- pak		3156	29	
Spotted Beebalm	D pak		3136	39	
				366	dollars

$/lb based on D-pak price Native American seed
$/g based on packet (1g) price Native American Seed.

Appendix C

Nature Trail Restoration

University of Houston Clear Lake

Soil Series Verification Report and Maps

The NRCS soils map shows four soil series on or in the vicinity of the UHCL Nature Trail restoration area. We found that the soils on the site didn't match those depicted on the NRCS map, however they do match series found nearby or are known to be geographically associated with those nearby (within 75m). The soils on the 2-acre site were verified by excavating pits just deep enough to match a soil that could possibly occur on the site given the geomorphologic setting. We didn't dig deep enough (2m) or perform the chemical and physical tests on the soils used to describe a series, however; the textures, colors, and strata (horizons) observed in the excavated pits were successfully matched to the NRCS series description.

Two different soil types were found to occur. Neither match what the NRCS has mapped for the site (Dylan Clay and Lake Charles Clay 0 – 1% Slopes). This is not surprising as the NRCS uses widely spaced soil cores to develop the maps. Aerial photography (1970's or earlier for this area) was used to interpolate between the cores, and areas of soil inclusions (a soil series surrounded by different ones) smaller than 10 acres were not mapped.

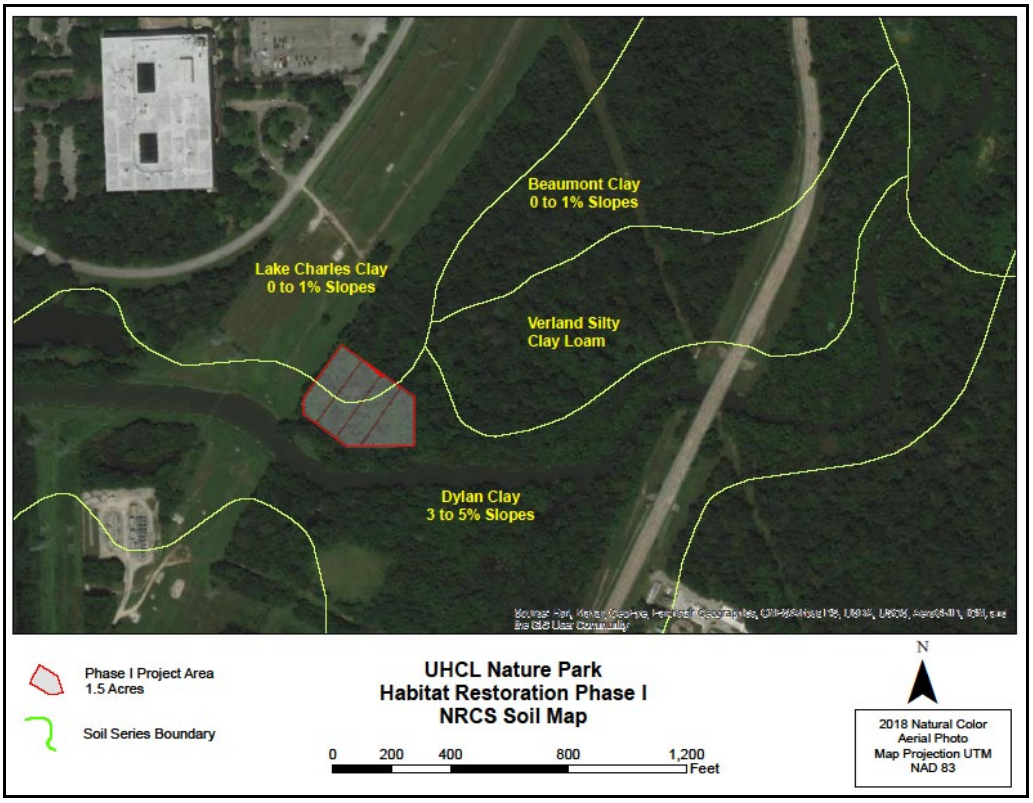
Each of the NRCS soil series form under different climate, parent material, vegetation, and inundation regimes. The series determinations (see below) made using soil pits, match the regimes observed on site, and are known to produce the soils we mapped. The boundaries were mapped using a handheld GPS unit with an accuracy of +/- 5 feet and are shown on the attached figure. Soil pit descriptions follow.

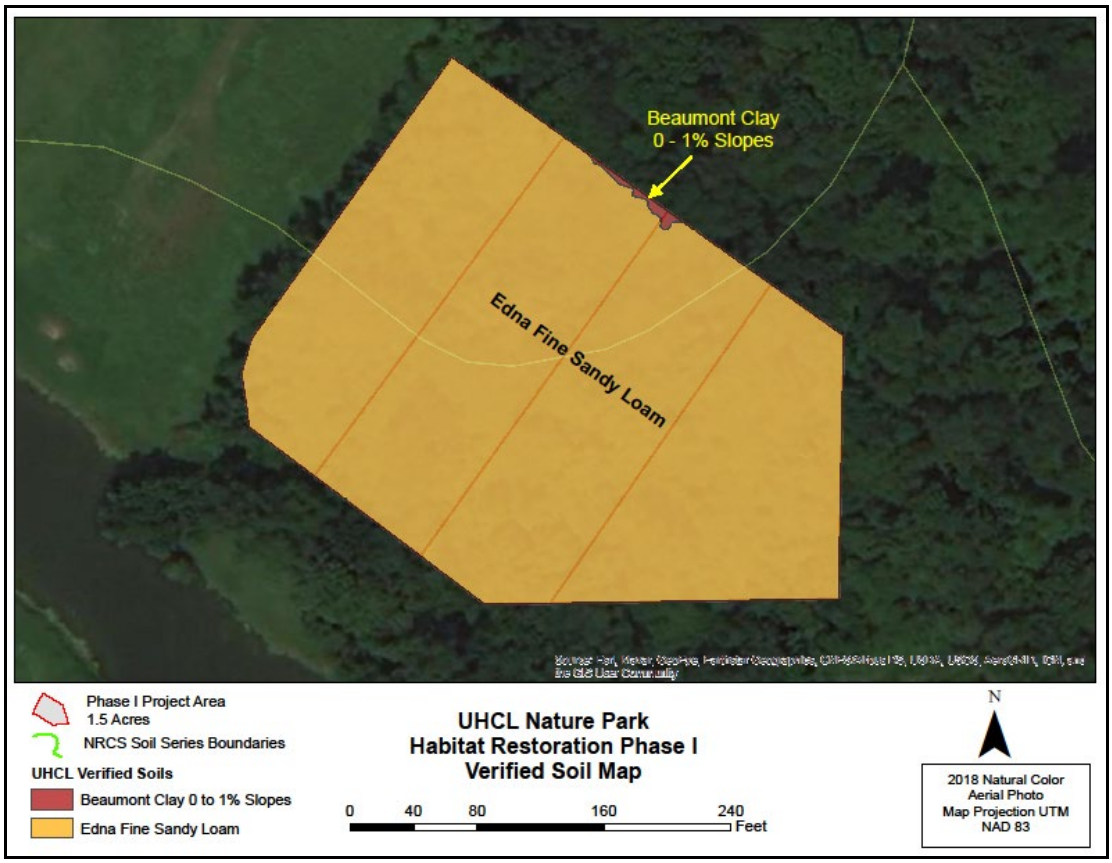
Bernard-Edna Complex, Edna Fine Sandy Loam Component: This soil series is not shown as occurring in the area, however; it is geographically associated with the Verland Silty Clay Soil which is mapped just northeast of the site. The Edna Fine Sandy Loam Soil Series is associated with a very specific geomorphic structure that was observed on the site; mima mounds, or coppice dunes. These are relatively recently formed (8,000 years before present or less) small, 1-to-2-foot tall, circular dunes that often occur in large groupings. The dunes are deposited on top of a different soil type and the abrupt boundary between the light brown sandy loam and light brown clay layer at 13 inches was diagnostic. In this case the Edna Series mima mounds were deposited on top of a Beaumont Clay soil which outcrops beneath the dune field to the north and occupies a small portion of the northern end of the Phase I site within a small wetland.

The native vegetation of this soil type is upland prairie though it sometimes supports motts of trees. Within the UHCL natural area, post oak (*Quercus stellata*) and southern red oak (*Quercus falcata*) are most often restricted to these mounds along with thickets of yaupon (*Ilex vomitoria*). These make up the tree and shrub component of the savanna, whereas the prairie occupies the more clay rich adjoining soils which suffer more frequently from drought stress due to lower soil water availability. At the project site the mounds are coalesced into a large area of sandy loam soil due to its presence near the sand source, a Pleistocene channel scar that Horsepen Bayou has usurped for this portion of its channel.

Beaumont Clay 0 – 1% Slopes: This soil series is shown as occurring northeast of the site, but actually touches the northern boundary of it. This is a hydric (wetland) soil type that forms under upper Gulf coast prairie wetlands and is lighter in color than the similar Lake Charles Clay 0 -1% Slopes due to iron depletion and less organic matter content. The light brown clay in the upper part and lighter layer of clay below 12 inches was diagnostic and shows that the deeper layer is depleted of iron due to prolonged inundation and resulting anoxic condition. Abundant mottles in the upper part and freshly deposited iron oxide along living root pores is also diagnostic and confirms this is a hydric (wetland) soil.

The Beaumont Clay is most often a wet prairie soil, but it is also found beneath flatwoods wetlands, especially where trees have encroached on the prairie. Whereas the Lake Charles Clay forms only beneath upland prairie. The Beaumont Clay is a smectitic vertisol with very low percolation rates and trees growing on it are subject to periodic drought stress. The presence of prairie or forest on this soil is dependent upon recent fire history. Beaumont Clay soil occurs on very flat lands along a strip lying just above the banks of Horsepen Bayou within the UHCL natural area. Dylan Clay occurs on the bank slopes which are not flooded often enough to be hydric. At the UHCL natural area the Beaumont Clay supports a mix of oak savanna and flatwoods forest and is peppered with mima mounds (Edna Fine Sandy Loam). Because it is so flat, it drains poorly and is often ponded through the winter and early spring, as well as temporarily following heavy summer and fall rains. The numerous mima mounds also impede drainage and seep water onto the topographically lower Beaumont, adding to its wetness.





Soil Pit Description for Edna Fine Sandy Loam

0 – 4” Fine sandy loam, 10YR 5/2 with 10 YR 3/2 bodies (darker organic-rich areas)

4 – 13” Fine sandy loam, 10YR 5/2 to 10YR 5/3

13”+ Sandy clay, 10YR 5/2 matrix with 2.5YR 4/8 soft masses of iron oxide precipitates, appearing as mottles

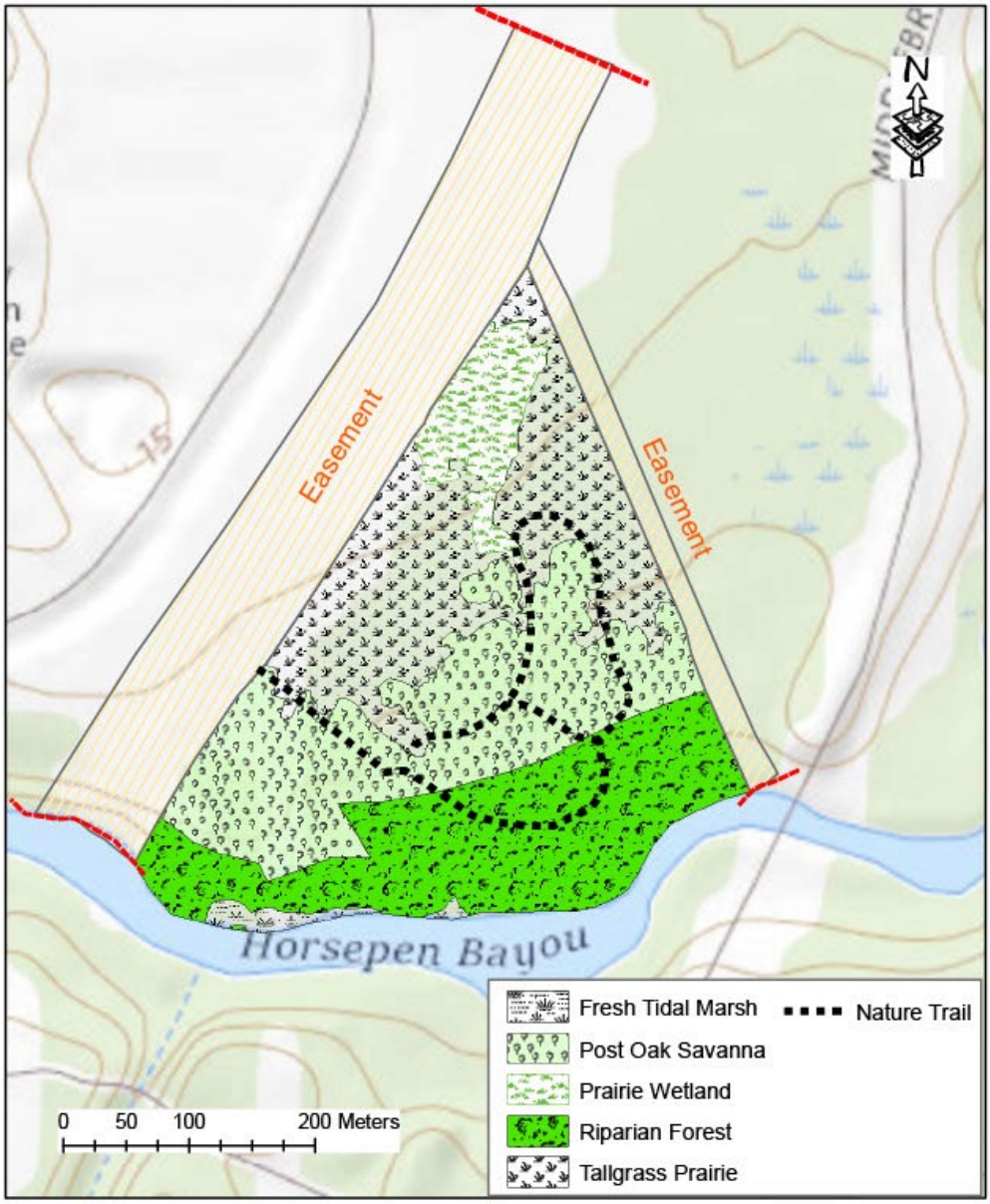
Soil Pit Description for Beaumont Clay 0 – 1% Slopes

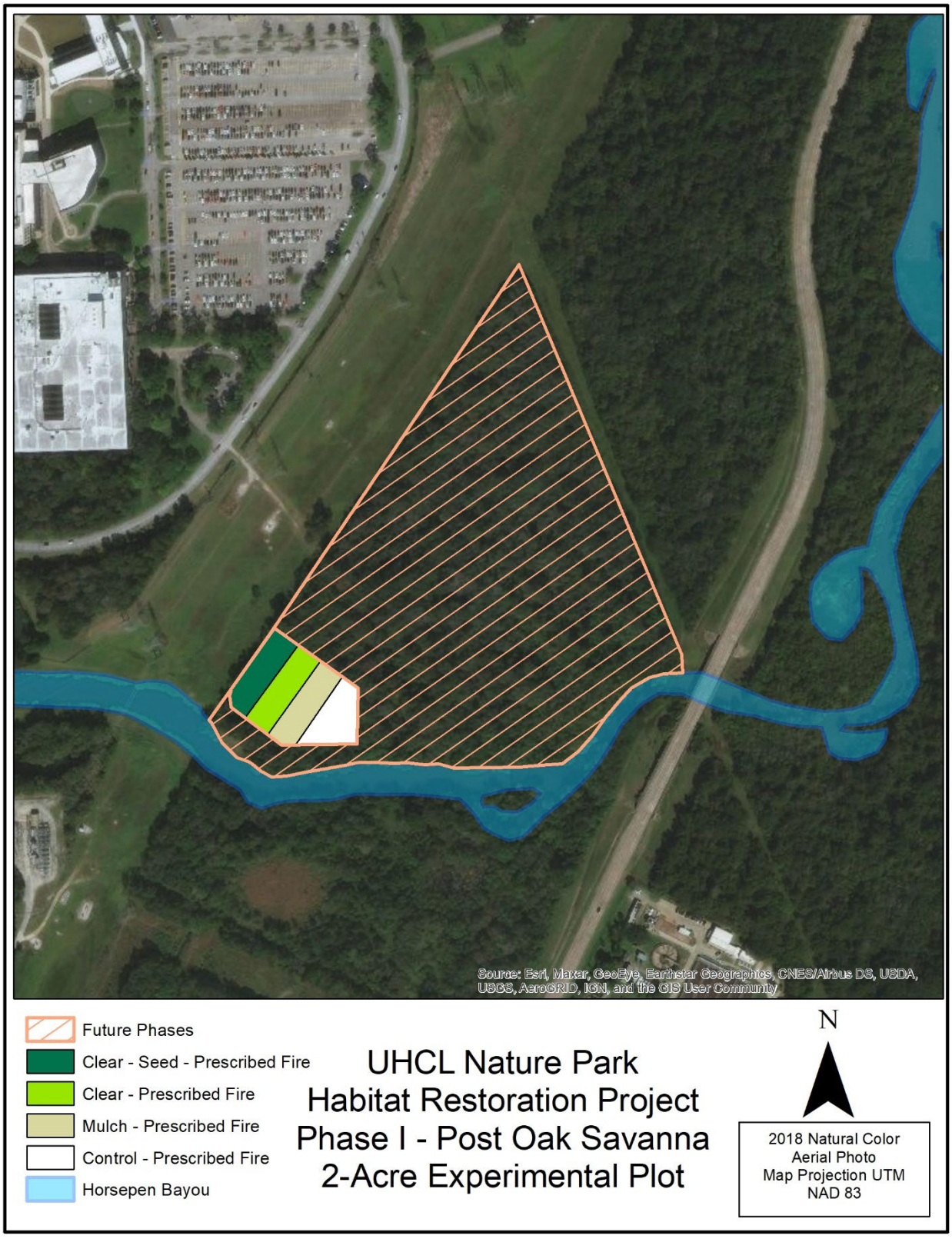
0 – 7” Clay, 10YR 4/1 matrix with 7.5YR 5/6 soft masses of iron oxide precipitates, appearing as mottles

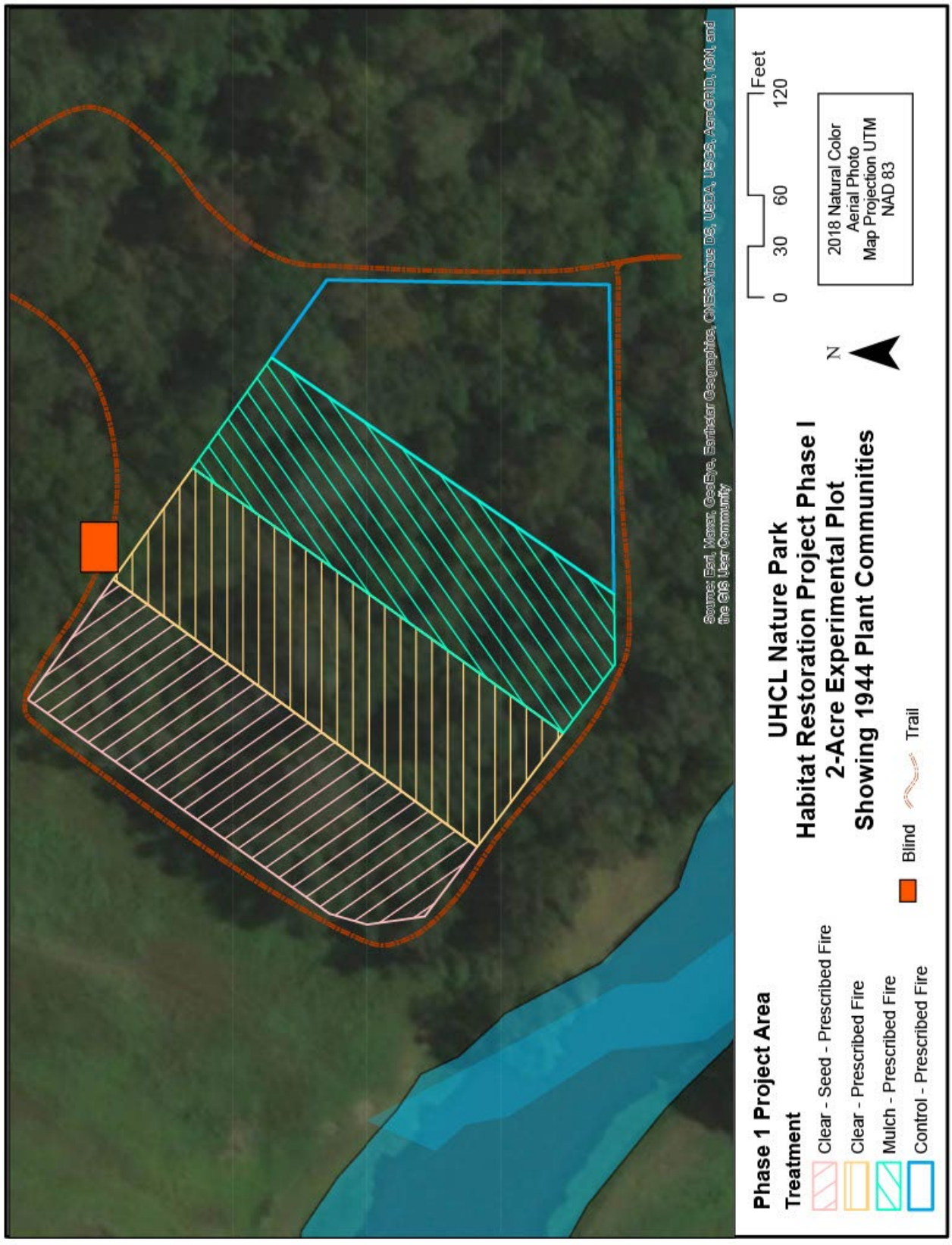
7 – 12” Clay, 10YR 4/2 matrix with 10YR 5/8 iron oxide precipitates appearing as pore linings on live roots

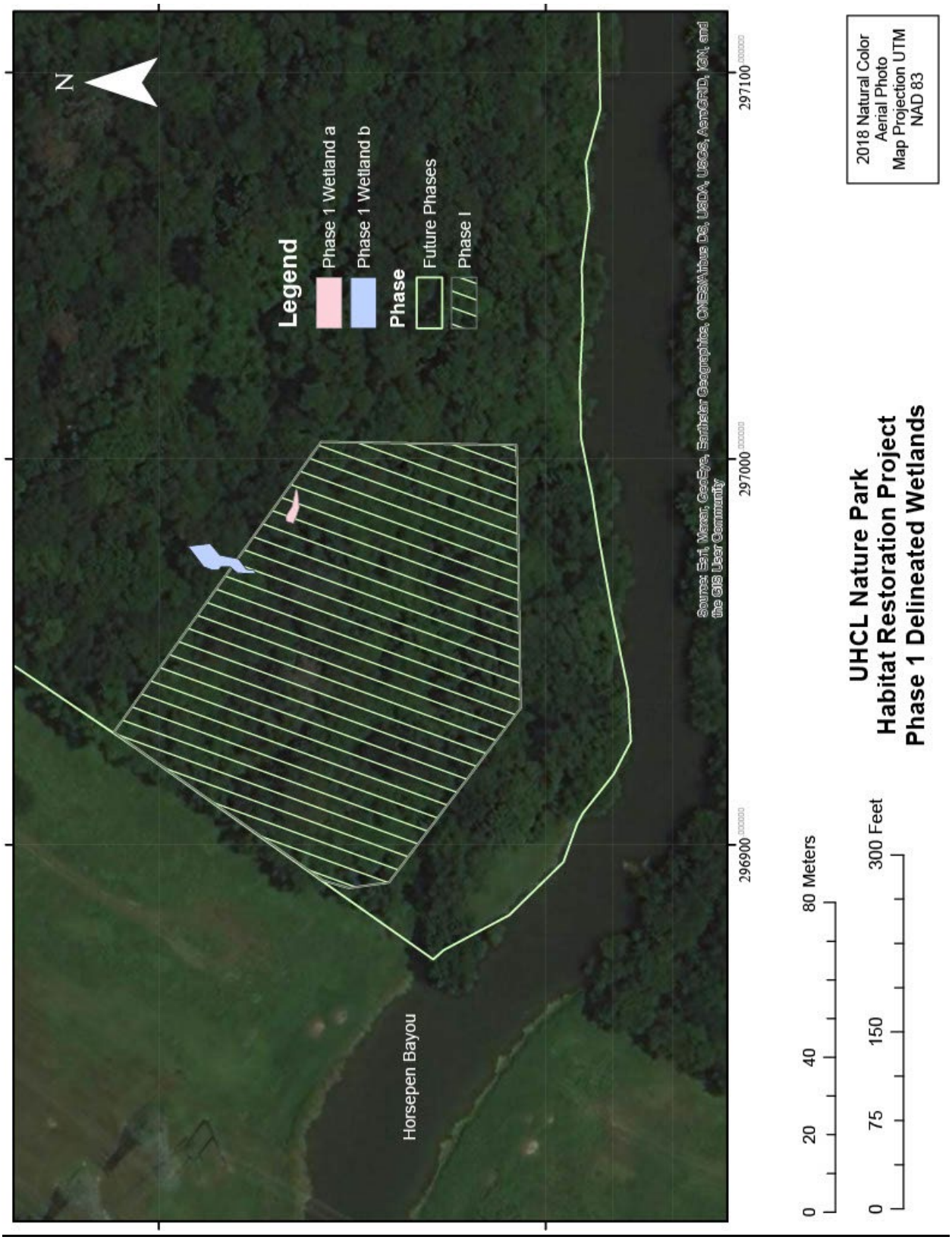
12”+ Clay, 10YR 6/1 matrix with 7.5YR 5/8 soft masses of iron oxide precipitates appearing as mottles

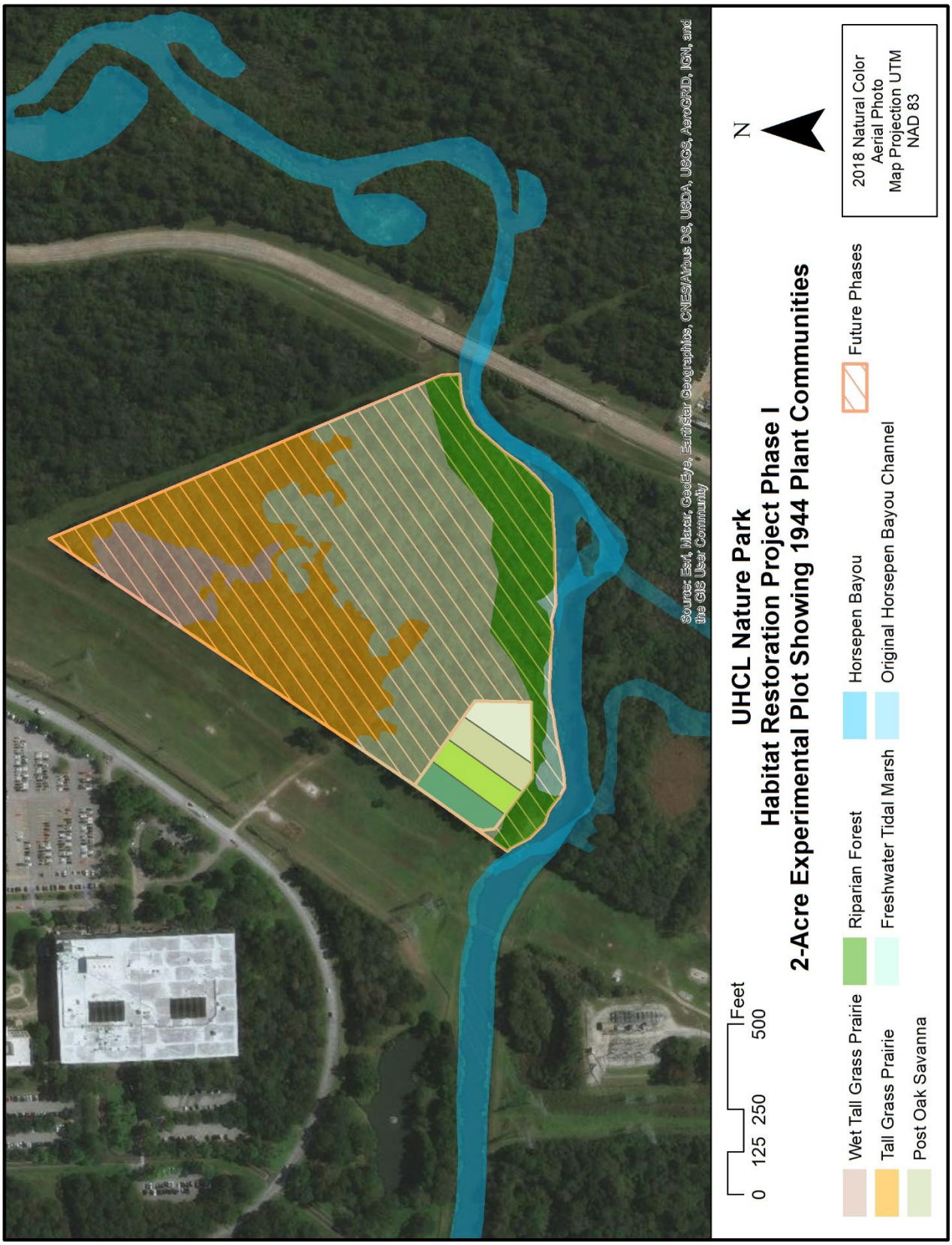
UHCL Nature Park Habitat Restoration Project
(Historical Landscape Types)




Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Future Phases
Clear - Seed - Prescribed Fire
Clear - Prescribed Fire
Mulch - Prescribed Fire
Control - Prescribed Fire
Horsepen Bayou
UHCL Nature Park
Habitat Restoration Project
Phase I - Post Oak Savanna
2-Acre Experimental Plot
N
2018 Natural Color
Aerial Photo
Map Projection UTM
NAD 83


Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
UHCL Nature Park
Habitat Restoration Project Phase I
2-Acre Experimental Plot
Showing 1944 Plant Communities
N
0 30 60 120
Feet
2018 Natural Color Aerial Photo
Map Projection UTM NAD 83
Phase 1 Project Area
Treatment
Clear - Seed - Prescribed Fire
Clear - Prescribed Fire
Mulch - Prescribed Fire
Control - Prescribed Fire
Blind
Trail


N
Legend
Phase 1 Wetland a
Phase 1 Wetland b
Phase
Future Phases
Phase I
Horsepen Bayou
Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
296900
297000
297100
0 20 40 80 Meters
0 75 150 300 Feet
2018 Natural Color Aerial Photo
Map Projection UTM NAD 83
UHCL Nature Park
Habitat Restoration Project
Phase 1 Delineated Wetlands


Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
UHCL Nature Park
Habitat Restoration Project Phase I
2-Acre Experimental Plot Showing 1944 Plant Communities
N
0 125 250 500 Feet
Wet Tall Grass Prairie
Tall Grass Prairie
Post Oak Savanna
Riparian Forest
Freshwater Tidal Marsh
Horsepen Bayou
Original Horsepen Bayou Channel
Future Phases
2018 Natural Color Aerial Photo
Map Projection UTM NAD 83

Appendix D

December 1 2021

*Non- Native		TRANSECT A						TRANSECT B						TRANSECT C						TRANSECT D						
Image Number	N=Nikon/I=Ipad	N9919	N9927	N9929	N9931	N9933		I0416	I0419	I0420	I0423	I0426		N9943	n/a	N9956	N9966	N9970		N9971	N9973	N9978	N9981	N9983		
Species	Common Name	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	A Totals	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	B Totals	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	C Totals	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	D Totals	
Callicarpa americana	American Beautyberry						0						0						0		1				1	*Callicarpa americana*
Toxicodendron radicans	Poison Ivy						0						0			1			1						0	*Toxicodendron radicans*
Oplismenus hirtellus	Wavyleaf Basketgrass		4				4		1	10	12	10	33	5		7	3	3	18	6	3	6	1	5	21	*Oplismenus hirtellus*
Ranunculus sp	Buttercup sp						0						0		3			3	6			6	3		9	*Ranunculus sp*
Rubus sp	Blackberry						0						0						0						0	*Rubus sp*
Coccultus carolinus	Carolina snailseed	1					1						0	1	1		2		4			1	1		2	*Coccultus carolinus*
Dichondra carolinensis	Carolina ponyfoot						0						0			2			2						0	*Dichondra carolinensis*
Chasmanthium sessiflorum	Longleaf woodoats						0						0						0						0	*Chasmanthium sessiflorum*
Carex cherokeensis	Cherokee Sedge						0						0		21	1			22	9	4				13	*Carex cherokeensis*
Elephantopus sp.	Elephantsfoot						0						0						0						0	*Elephantopus sp.*
Ulmus sp	Elm sp.						0						0						0						0	*Ulmus sp*
Verbesina virginica	Frostweed						0						0			7		3	10	1		6			7	*Verbesina virginica*
Fraxinus pennsylvanica	Green Ash						0			1	1		2						0						0	*Fraxinus pennsylvanica*
Smilax bona-nox	Saw greenbrier					5	5					7	7						0	1			6	8	15	*Smilax bona-nox*
Lygodium japonicum	Japanese Climbing Fern						0						0				3		3						0	*Lygodium japonicum*
Ligustrum japonicum	Japanese Privet					1	1						0		1	2	5		8						0	*Ligustrum japonicum*
Ligustrum sinense	Chinese Privet	14	7	3		1	25	2	1	3			6	14	3				17	1					1	*Ligustrum sinense*
Youngia japonica	Oriental False Hawksbeard						0						0						0		4				4	*Youngia japonica*
Phanopyrum gymnocarpon	Savannah panicum						0						0						0						0	*Phanopyrum gymnocarpon*
Paspalum setaceum	Thin paspalum						0						0						0			1			1	*Paspalum setaceum*
Toxicodendron radicans	Poison Ivy						0						0						0					1	1	*Toxicodendron radicans*
Quercus sp	Red oak						0						0						0	1		1			2	*Quercus sp*
Celtus laevigata	Sugar hackberry						0				12		12						0						0	*Celtus laevigata*
Campsis radicans	Trumpet vine						0						0						0						0	*Campsis radicans*
Malvaviscus arboreus	Turk's cap						0						0			2			2						0	*Malvaviscus arboreus*
Parthenocissus quinquefolia	Virginia creeper						0			1			1						0						0	*Parthenocissus quinquefolia*
Quercus sp.	Water oak						0						0						0			1			1	*Quercus sp.*
Allium sp	Wild onion						0						0						0					10	10	*Allium sp*
Quercus sp.	White oak						0						0						0						0	*Quercus sp.*
Oxalis sp	Woodsorrel	3	8				11	3		3			6		3	1	1	3	8	20	1	3	5	4	33	*Oxalis sp*
Ilex vomitoria	Yaupon holly				2	1	3		1			2	3	17	3	5	17	7	49	9	4	2		6	21	*Ilex vomitoria*
	Total Individual Plants per Plot	18	19	3	2	8	50	5	3	18	25	19	70	37	35	28	31	19	150	48	17	27	16	34	142	Total Individual Plants
	# species						7						8						13						15	
	# invasive species						3						2						4						3	
	# invasive plants						30						39						46						26	
	invasive % #invasive plants/# plants						60%						56%						31%						18%	
Shannon diversity index							1.44						1.61						2.09						2.16	
Evenness							0,739						0.772						0.816						0.796	
Richness (# of species)							7						8						13						15	
Average population size							7.14						8.75						11.5						8.47	

UHCL Nature Trail Habitat Restoration Project - Spring Vegetation Survey (18 May 2022)(1m x 1m quadrats)

*Non- Native		TRANSECT A						TRANSECT B						TRANSECT C						TRANSECT D						
Sample Number		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		1	2	3	4	5		
Image Number	N-N Non-/I-Ipad	634	639	641	644	646		650	653	654	656	657		1029	1033	1036	1040	1047		1100	1109	1116	1121	1134	G.Total	
Species	Common Name																									
Callicarpa americana	American Beautyberry						0						0						0						0	Callicarpa americana
Alcalypsa perennis	Aquatic Milkweed	1	1	5	4	11	0						0						0						0	Alcalypsa perennis
Toxicodendron radicans	Poison Ivy						0						0						0						0	Toxicodendron radicans
Opiismenus hirtellus	Wavyleaf Basketgrass		10	9		19	25	4	22	1			27			3			3	1		2			3	Opiismenus hirtellus
Ranunculus sp.	Buttercup sp.						0						0						0						0	Ranunculus sp.
Rubus sp.	dewberry		1				1						0						0			1			1	Rubus sp.
	Deep Rooted Sedge						0						0	1	1				2						0	
	Black-eyed Susan	18	49	44	26	21	146						0						0						0	
	Bluestem reit			1			1						0						0						0	Cocculus carolinus
Cocculus carolinus	Carolina snailseed						0						0						0						0	Cocculus carolinus
Dichondra carolinensis	Carolina ponyfoot						0						0						0						0	Dichondra carolinensis
	Rio Grande Clammyweed	1			10		11						0						0						0	
	Carpetgrass		4	3		7	14						0						0						0	
Chamaesaracha sonnafforum	Longleaf woodoats						0		3				3						0			4	4		8	Chamaesaracha sonnafforum
Carex cherokeensis	Cherokee Sedge		1				1						0						0			1			1	Carex cherokeensis
	Chinese Tallow				1		1	6	2				8	2	6	2		1	11						0	
Euphorbia sp.	Elephantsbit						0						0						0						0	Euphorbia sp.
Ulmus sp.	Elm sp.	17	4	23	9	3	56	18	4		6	2	30	7	4				11				1		1	Ulmus sp.
	Frogfruit						0				3		3						0						0	
Verbena urvigenica	Frostweed						0						0						0						0	Verbena urvigenica
	Goldenrod spp																					12			12	
	Grapevine					1	1						0				4		4			1		1	2	
Fraxinus pennsylvanica	Green Ash	1	1	2	1	2	7						0						0						0	Fraxinus pennsylvanica
	Illinois Bundleflower												0						0						0	
	Inland Sea Oats												0				1		1						0	
Smilax spp.	smilax spp.		1	3	5	33	42	3	5	7	8	8	31	7	5		3	7	22	8	2	5	4	7	26	Smilax bona-nox
Lagodium japonicum	Japanese Climbing Fern						0						0						0	0					0	Lagodium japonicum
Liquidambar sp.	Prickly Liquidambar						0						0						0	2	1				3	Liquidambar sinensis
Youngia japonica	Oriental False Hawksbeard						0						0						0						0	Youngia japonica
	Narrow leaf Sunflower		1		1		2						0						0						0	
	Partridge Pea	2	7	3	6	3	21						0						0						0	
	Salvia sp					2	2						0						0						0	
Phanopyrum gymnocarpon	Seaside bahiagrass						0						0						0						0	Phanopyrum gymnocarpon
	Sorrell sp.															1			1				1		1	
Aeschynomene sp.	Thin pea plant						0						0						0						0	Aeschynomene sp.
	Texas Coneflower		4				4						0	1	1		4	2	8			1	1		2	
Toxicodendron radicans	Poison Ivy				4		4						0						0						0	Toxicodendron radicans
Quercus spp	Oak sp p						0						0						0						0	Quercus sp
	Rye Grass																					2			2	
Celtis laevigata	Sugar hackberry						0						0						0						0	Celtis laevigata
Campsis radicans	Trumpet vine						0						0						0						0	Campsis radicans
Melia azedarach	Turk's cap						0						0						0						0	Melia azedarach
	Vasey grass																	1	1						0	
Parthenocissus quinquefolia	Virginia creeper						0	1	2	1			4						0						0	Parthenocissus quinquefolia
Quercus sp.	Water oak						0						0						0						0	Quercus sp.
Allium sp.	Wild onion						0						0						0						0	Allium sp.
Quercus sp.	White oak						0						0						0						0	Quercus sp.
Oxalis sp.	Wood sorrel						0						0						0						0	Oxalis sp.
Nantus Grasses unidentified		35	62	39	30	40	256		10				10						0						0	
Unidentified plants		8		1	2	3	14	1		1			0	1	1				2			1	5		6	
Bryozoans	Yaupon holly				13		13	3			2	2	0		4	2	42	2	38	8	3	6	3	22	37	Bryozoans
	Total Individuals Plants per Area	26	153	128	155	120	634	36	48	10	32	12	135	19	22	2	48	13	84	19	3	7	34	22	85	Total Individuals Plants
# species							21						8						8						14	
# invasive species							2						2						2						2	
# invasive plants							30						35						12						6	
invasive % (# invasive plants/ # plants)							4%						30%						15%						7%	
Shannon diversity index							1.93						1.47						2.08						2.08	
Evenness							0.633						0.838						0.817						0.788	
Richness (# of species)							21						8						12						14	
Average population size							30.2						15.5						8.67						6.07	

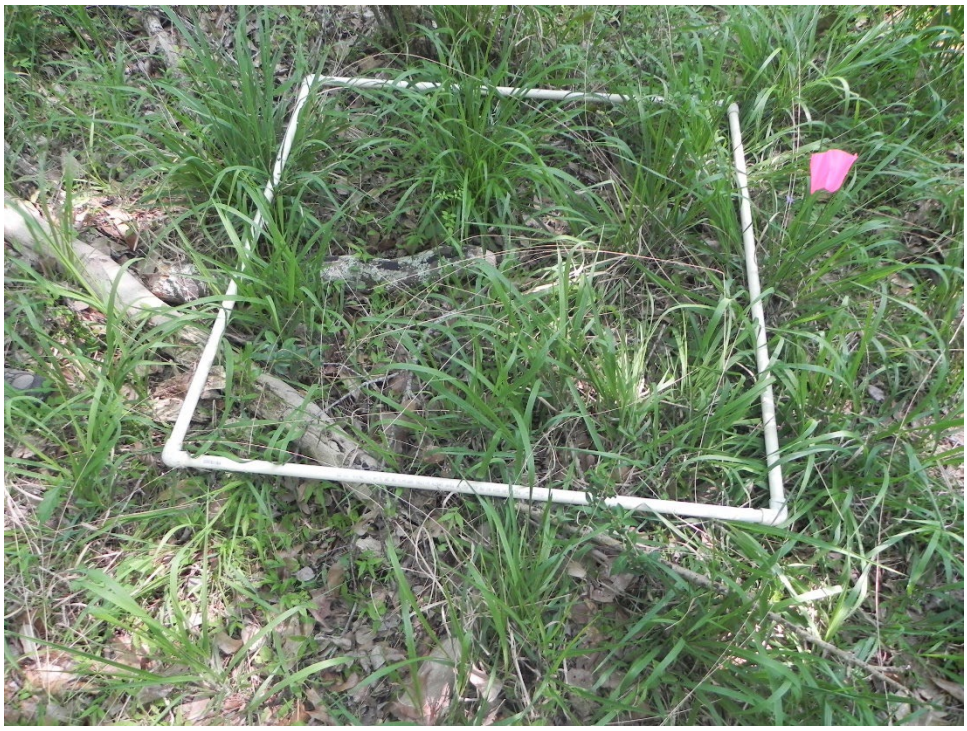
Appendix E

Photograph 1: Project site before mulching

Photograph 2: Volunteer work day – removing tires.

Above: Photograph 3: Quadrat plot – baseline survey.

Below: Photograph 4: Quadrat plot 3 months after seeding



Above: Photograph 5: Wetland delineation class.

Below: Photograph 6: Student using a soils color book

Above and below: Photographs 7 & 8: Removal of trees shrubs by mulching.

Above: Photograph 9: Plot A after mulching, and mechanical and hand mulch removal.
Below: Photograph 10: Plot B after mulching, and mechanical mulch removal.

Above: Photograph 11: Plot C after mulching – mulch remaining.
Below: Photograph 12: Volunteers hand raking Plot A

Above: Photograph 13: Finished seed mix.
Below: Photograph 14: Creating the seed mix.

Above: Photograph 15: Seed drill used for planting.
Below: Photograph 16: Rows of planted seed

Above: Photograph 17: Deterring foot traffic prior to arrival of temporary CMP signs.
Below: Photograph 18: Inspecting seed dispersal.

Above: Photograph 19: Inspecting seed dispersal.
Below: Photograph 20: Plot A: *Asclepius tuberosa* (Butterfly milkweed).

Above: Photograph 21: Plot A: *Passiflora incarnata* (Passion vine.)
Below: Photograph 22: Plot A: *Asclepius perennis* (Aquatic Milkweed.)

Above: Photograph 23: Plot A showing *Polansia dodecandra ssp riograndensis* (Rio Grande Clammy-weed) and emerging *Triadica sebifera* (Chinese Tallow.)
Below: Photograph 24: Scenic view of Plot A.

Above and below: Photographs 25 & 26: Plot A showing *P.dodecandra ssp. riograndensis* (Rio Grande Clammy-weed) and *Boueloua curtipendula* (Side-oats Grama.)