A Rapid Ecological Assessment of Linkhaw Farms

Lumberton, Robeson County, North Carolina

Prepared by:

Michael J. McGraw, MES, QAWB, ACE

Senior Wildlife Biologist and Ecologist

Draft Final Submittal Date:

October 03, 2023

Contents

Executive Summary

A rapid ecological assessment was conducted September 23rd and 24th, 2023 at the Linkhaw Farm site located in Lumberton, Robeson County, North Carolina. The site is a combination of active annual crop fields, fallow forested areas, and a series of linear ditches. During this rapid assessment, a total of 59 bird species, 4 amphibians, 2 reptiles, and 6 mammals were observed. Additionally, 104 plant species were identified comprising 79 native plants and 25 non-native/invasive plant species. These data were used understand the site's current ecological function, help envision and prioritize habitat stewardship, and to develop a series of recommendations for ecological restoration of portions of the site in concert with a proposed innovative residential/multi-use development.

The onsite relict natural areas retain structure for naturally occurring pine-oak and oak-pine forest ecosystems iconic to the region and, therefore, have a high potential for suitable ecological restoration. The ecological systems on site are fire-dependent and currently fire suppressed (at least 60-100 years). Additionally, the site hydrology has been largely modified (lowered water table) resulting in dewatered wetlands and vegetation community shifts. It appears there are multiple locations within the woodlots where uniform pine regeneration is occurring. This is the result of onsite logging (stumps detected in two areas) and abandonment of formally cleared/managed areas (ex. clearings near homestead, tractor and haybale storage areas, etc.).

Holistic ecological restoration in these woodlots as well as wetland and other natural areas restoration can catalyze and nurture local natural history (ex. biodiversity replenishment) and overlap with cultural (ex. Eastern Siouan, Algonquian, and Iroquoian speaking peoples'/Lumbee ancestors' relationship with the land), food systems production (ex. permaculture, regenerative agriculture, and other local food production strategies) and educational priorities. Further, stormwater management for site development could also be conceivably included within the onsite surface water wetland restoration strategy provided the concepts are well-conceived and metrics developed can demonstrate the net ecological benefits of concurrent wetland restoration, enhancement, and stormwater compliance.

Key recommended restoration actions include;

1. Implement prescribed fire as a critical management tool
2. Invasive species control/eradication
3. Wetland restoration and stormwater management
4. Species-specific habitat restoration
5. Habitat reintroduction (historically present ecologies)

In addition, this effort aimed to support a more systematic baseline data collection effort over the next calendar year through the establishment of fixed, permanent study plots for documenting various taxa.

Introduction

Linkhaw farms is an approximately 380-acre parcel located on the northeastern boundary of the city of Lumberton, North Carolina in central Robeson County. The entirety of the county is within the Inner Coastal Plain physiographic province. This area is typically underlain by a combination of ocean-deposited sands and eroded earth materials derived from the Piedmont to the west (typically river-deposited).

General Information

The property has been owned and farmed by the Linkhaw family for the past ~70 years, with a history of tobacco production then conversion to annual crops (primarily corn and soy rotations). Annual crop production in these sandy clayey soils requires notable physical and chemical modifications to the landscape and soils. The site has been cleared of natural vegetation over the majority of the site. Hydrology has been lowered and drained via terra cotta tiles that lead to linear cut ditches that average 2'-8' in depth. Regular (annual or biannual) applications of soil amendments (liming, organics, NPK, etc), herbicides, and pesticides are added to the fields each year as standard operating procedures. Further, the farmed portions of the site are tilled at least once annually.

The property supported a homestead and a series of buildings in support of agricultural production such as tobacco drying houses and chemical and tractor storage. The existing forest patches have generally been present for >70 years but with some notable changes over time (ex. old fields gone fallow, lumber harvesting, tree composition succession, etc.). Ruins of the homestead, tobacco houses, and equipment storage are still evident on the site.

The unfarmed portions of the site include linear ditches that convey water (generally) to north and west and a series of woodland patches that are in varying conditions of natural equilibrium.

Soils and Geology

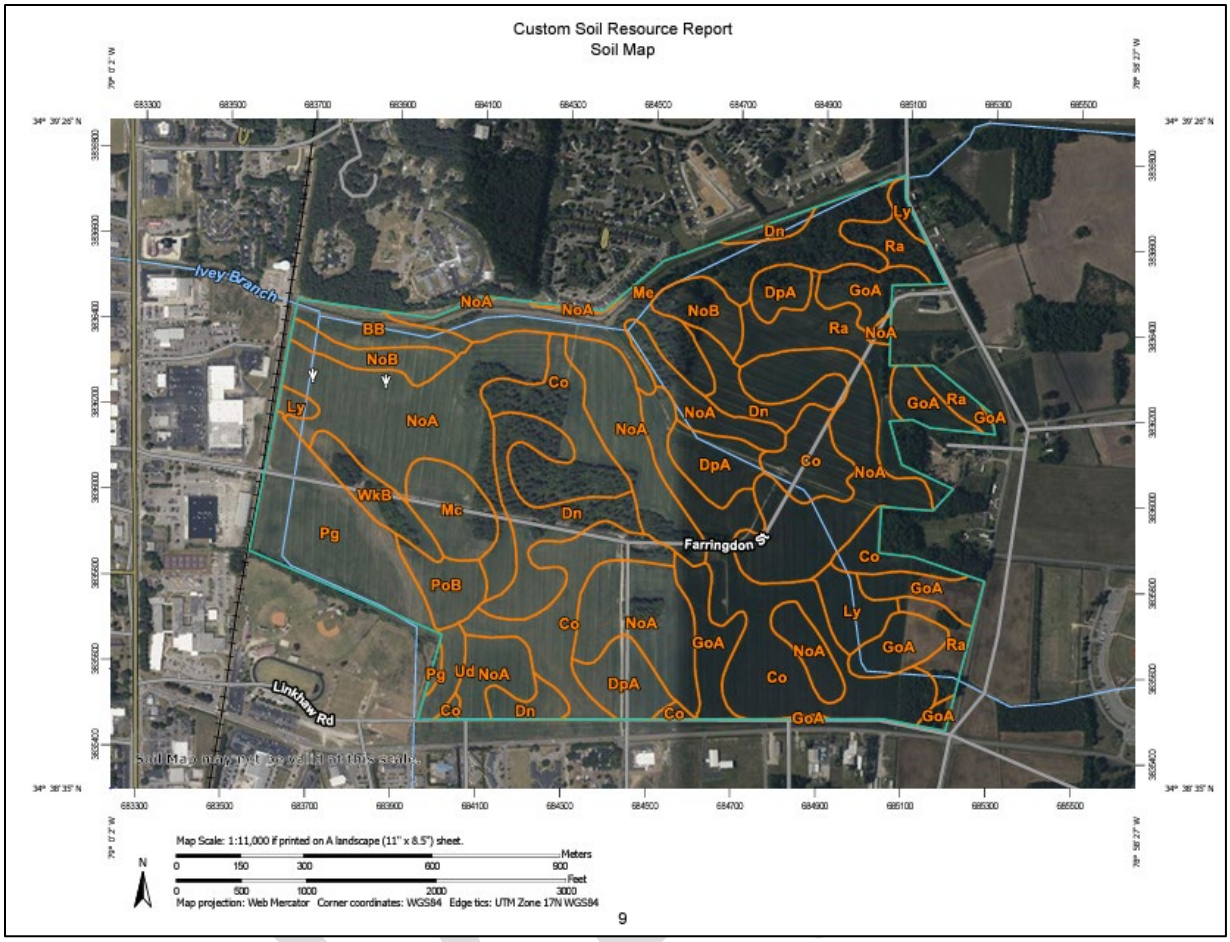
The entire site is underlain by a Cenozoic Era (66mya to present day) sedimentary geology that is comprised mainly of blue clays and fine sands called the Yorktown Formation. This formation is known for being highly fossiliferous (mainly oceanic invertebrates but also ancient fishes, birds, and whales). It is derived from recent seabeds.

The site is comprised of three major soil orders with varying features resulting in iterations therein. Eleven (11) of the recognized 13 soil types are Ultisols. Ultisols are old soils that have been weathered in situ, oxidizing their iron and leaching out most plant-available chemical nutrients (nutrient-poor soils). Interestingly, 8 of these Ultisols are Paleaquults and Paleaudults, meaning they highly weathered, acidic, and very old. Variations in proximity to the water table appear to be the primary defining characteristic of these Ultisols, with about 178 acres in a well-drained but clayey soils (Norfolk, Goldsboro, Walkulla, Duplin, and Pocalla Series) and 164 acres being poorly drained, sometimes hydric, soils (Rains, Dunbar, Coxville, Pantego, Lynchburg, and McColl Series) (Figure 1). All of these soils typically require significant interventions to make them productive for crop growth. They historically supported pine-dominated forests, cypress swamps, and mixed lowland forests. A soils map is displayed as Figure 2.

Figure 1. Mottled/gleyed matrix of a weathered soil ped (Ultisol) with significant clay and oxidized iron in the B horizons. This image is from the main ditch cut east of the access road at Linkhaw Farms, revealing a historically hydric/very poorly drained Coxville Series soil. Image by Michael J. McGraw on September 23, 2023.

There is one Alfisol on site (Meggett Series, a Typic Albaqualf) that comprises 30 acres of onsite woodland in the northern section which is similar to an Ultisol but younger, less acidic, and bears more plant-available nutrients in the argillic (B) horizon. This is a poorly drained soil that can support wetlands, including palustrine forested wetlands.

The last soil type is an Entisol (Bibb Series, a Typic Fluvaquent) that is limited to just 6 acres in the northwestern corner along Ivey branch (indicating a historic floodplain). These are young soils with limited development of soil horizons due to a variety of physical and/or chemical reasons. The onsite Entisol is a water-deposited soil (sandy alluvium) that is disturbed episodically from flooding events. New deposition often carries nutrients (and toxicants) from up-watershed areas so these soils can naturally have variable qualities.



Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
BB	Bibb soils	6.7	1.8%
Co	Coxville loam	74.2	19.6%
Dn	Dunbar sandy loam	26.4	7.0%
DpA	Duplin sandy loam, 0 to 2 percent slopes	17.4	4.6%
GoA	Goldsboro loamy sand, 0 to 2 percent slopes, Southern Coastal Plain	27.8	7.3%
Ly	Lynchburg sandy loam, 0 to 2 percent slopes	8.0	2.1%
Mc	McColl loam	8.8	2.3%
Me	Meggett fine sandy loam	28.9	7.6%
NoA	Norfolk loamy sand, 0 to 2 percent slopes	108.9	28.7%
NoB	Norfolk loamy sand, 2 to 6 percent slopes	10.6	2.8%
Pg	Pantego fine sandy loam	23.7	6.3%
PoB	Pocalla loamy sand, 0 to 3 percent slopes	5.9	1.5%
Ra	Rains sandy loam, 0 to 2 percent slopes	23.1	6.1%
Ud	Udorthents, loamy	3.0	0.8%
WkB	Wakulla sand, 0 to 6 percent slopes	6.3	1.7%
Totals for Area of Interest		**379.7**	**100.0%**

Figure 2. USDA Web Soil Survey map of the site and associated legend.

Historic Ecology

As mentioned above, the site is underlain by old, nutrient-poor soils with varying hydrology (from very well drained uplands to hydric wetland soils). Amazingly, many of the Atlantic Coastal Plains ecosystem components thrive in these conditions, with millions of years of adaptation to subtle changes in elevation, hydrology, and nutrient availability (Noss et al. 2015). The conditions within the forested patches that historic maps suggest were not ever farmed reveal oak-pine forest, pine-oak forest, mixed pine/hardwood forest, and maple swamp. Wetland relicts are small and disjunct so inferences regarding these historically present habitat types are less evident, but a variety of forested and open-canopied swamps, floodplain lowlands, and emergent marshes likely occurred. Below are some speculations regarding these habitat types.

Carolina Bays

Upon review of the soil patterns on the landscape it is evident that the site most likely supported a Carolina Bay (oval-shaped McColl Series footprint) prior to any large-scale timbering or agricultural development. Carolina Bays are essentially large, coastal plains vernal pools with a complex mosaic of open water, wetland shrubs, trees, and herbaceous plants. These are highly productive wetland habitat features which supported a wide range of breeding amphibians, snakes, turtles, a host of birds, and myriad insects. A good example of one of the last remaining intact Carolina Bays in the region is Warwick Mill Bay, albeit much larger than the historically present 8-10 acre Carolina Bay on site.

Floodplain Forest

The entirety of the southwestern corner and much of the northern border have floodplain-derived soils (alluvium) and, despite active drain tiles, show evidence of frequent annual flooding. These locations very likely supported any range of palustrine forested wetland (PFO), palustrine scrub-shrub wetland (PSS), and palustrine emergent wetland (PEM) habitat types known to the region. Exact composition would depend largely on the fire regime (entire area has been fire suppressed for approximately 100+ years). The section of the coastal plains is believed to have been on a 1-3 year fire regime prior to settlement, with wetland habitat types likely being more suppressed (up to 25 year cycles). Possible results could have been bald cypress, black gum, green ash, water oak, and willow oak forests with dense understories and/or standing water interspersed with pocosin (mostly ericaceous evergreens) and open-canopied grass and wildflower dominated emergent marsh. These floodplain swamps boasted large, buttressed trees with many breeding birds such as wading bird colonies, prothonotary warbler, pileated woodpeckers, and brown creepers. Many iconic reptile and amphibian species thrived in this environment as well.

Pine Flatwoods and Longleaf Savanna

Longleaf pine savannas were the pinnacle of the frequent fire regime in the southeastern US coastal plains. The structure was bilayered, with mature longleaf pine trees in the canopy shading a bluestem and wiregrass-dominated herb layer with virtually no shrubs or other brushy understory. As early as 1764 there were dozens of water-powered sawmills along Cape Fear River which ramped up processing and cleared native pine stands of longleaf pine in the region. Most of the longleaf pine was cut by 1840 (Frost 2000). Remaining pockets have been fire suppressed and are now invaded by loblolly pine and non-pyrophytic species, such as maples, hickories, and other hardwoods, boasting dense woody understories.

The most common condition of flatwoods in the region now include fire suppressed conditions and, subsequent succession after longleaf pine loss. These typically have a loblolly pine or slash pine dominated canopies with a wide range of hardwood trees and shrubs sharing the canopy, sub-canopy, and understory layers. Groundstory can have varying densities of herbaceous plants, such as giant cane, depending on the duration of fire suppression and hydrology.

FIRE FREQUENCY

DEPTH	1-3 YEARS	4-6 YRS	7-12 YRS	13-25 YRS	26-50 YRS	51-100 YRS	100-300 YRS	NEVER BURNED
Seasonally wet mineral soils	Species-rich wet prairie with graminoids and grass-leaved forbs	Species-rich wet prairie, with dwarf shrubs	ANGL, ARGI, CLJA, ILGL, CYRA, CLMO, tree saplings	Small ACRU, NYBI, LIST, PISE, PITA, PIEL, TAAS	Dense ACRU, NYBI, TAAS, LIST, PISE, PITA, PIEL/ ARGI, Shrubs	PITA, PIEL, TAAS, QUMI, PISE, ACRU, LIST/ sparse ARGI, ferns	TADI, FRPE, LIST, ACRU, NYBI, QUMI other bottomland oaks/mesophytic herbs	TADI, NYBI, FRPE, LIST, ACRU, bottom-land oaks
ROW 1	CELL 1	CELL 2	CELL 3	CELL 4	CELL 5	CELL 6	CELL 7	CELL 8

SPECIES ACRONYMS: ACRU: Acer rubrum (Red Maple), ANGL: Andropogon glomeratus, ARGI: Arundinaria gigantea (Cane), CHTH: Chamaecyparis thyoides (Atlantic White Cedar), CLJA: Cladium jamaicense (Sawgrass), CLMO Cliftonia monophylla (Black Titi), CYRA: Cyrilla racemiflora (Titi), FRCA: Fraxinus caroliniana (Water Ash), FRPE: Fraxinus pennsylvanica Red Ash), GOLA: Gordonia lasianthus (Loblolly Bay), ILGL: Ilex glabra (Gallberry), LIST: Liquidambar styraciflua (Sweet Gum), MAVI: Magnolia virginiana (Sweet Bay), MYCE: Myrica cerifera (Wax Myrtle), NYAQ: Nyssa aquatica (Tupelo or Water Gum), NYBI: Nyssa biflora (Swamp Black Gum), PEPA: Persea palustris (Red Bay), PIEL: Pinus elliottii (Slash Pine), PITA: Pinus taeda (Loblolly Pine), TAAS: Taxodium ascendens (Pond Cypress), TADI: Taxodium distichum (Baldcypress).

Figure 3. A snip from Frost's succession after fire table in mineral soils.

If previously present on site, longleaf pine savannas would likely have been present in the well-drained Ultisols. This habitat supports rare plant and animal species, such as the red-cockaded woodpecker and Bachman's sparrow. Other flatwoods habitats could have been present in the seasonally wet mineral soils on site (ex. Rains, Dunbar, Pantego, Lynchburg, and McColl Series)

Frost's work on this species and the resultant changes in ecology post-settlement and post-fire suppression are a valuable tool for not only assessing potential restoration goals, but also interpreting timelines for the genesis of extant communities and interpreting their futures if left unmanaged.

Methods

In order to rapidly assess the site a combination of methods was enacted simultaneously to best gather snapshots of various biotic elements in a relatively short time. Below are descriptions of methods that were used to document plants and a subset of animals. No areas or taxa were comprehensively assessed, but rather a snapshot of each group was documented.

Flora

Timed meanders were used to document plant species within each natural area on site. An average of 70 minutes was spent in each of the 7 identified areas where the primary focus was plant ID. Lists by species and relative abundance were noted where possible.

Proposed methods for a systematic baseline data collection of vascular plants are detailed in the recommendations section.

Fauna

Random Opportunistic Sampling was the primary method for faunal observations. Birds were documented via sight and sound by following bird activity and pausing to identify individual birds to species where and when observed. This was a blend of both transect and point count methodologies and relies on surveyor experience to be effective. During the two-day survey one day was cold with intermittent rain, making surface observations of ectotherms (vertebrates and insects) difficult. On this day habitat suitability was documented but limited individual observations were made. The following day was warmer and allowed for more observations of surface-active ectotherms.

Proposed methods for a systematic baseline data collection of various taxa are detailed in the recommendations section.

General Ecological Investigations

Prior to visiting the site, a subset of areas of interest were identified using historic and current aerial imagery and the secondary data provided (ex. wetland delineation). These were locations that likely have features that affect the ecological integrity of the site, such as ditches, paths, building ruins, and other modifications to the landscape that may have resulted in impacts to biotic and/or abiotic elements of the natural system. Additionally, any locations that appeared from the desktop review to have possible ecological assets, such as intact sparsely vegetated communities, critical habitat for wildlife, hydric soil peds in natural areas, and other elements were visited/groundtruthed.

Results

Below are summary data from the rapid assessment. These are snapshots and do not comprehensively capture information for any one element of the site. The intention was to develop a cursory understanding of the ecological components to enable thoughtful and data-driven decisions about conceptual design and ecological restoration possibilities. This cursory data gathering event will also likely aid in strategy for permitting purposes and other regulatory-driven decisions in support of the site's development.

Flora

A total of 104 vascular plant species were observed at Linkhaw Farms on September 23rd and 24th, 2023 (Table 1). Please refer to Appendix I for the full species list and relative distribution by species.

Table 1. Summary of Vascular Plants Observed at Linkhaw Farms September 23-24, 2023.

Vegetation Type	Native	Non-Native/Invasive	State or Federally Listed	North Carolina SGCN
Ferns	3	0	0	0
Forbs	20	4	0	0
Graminoid	11	4	0	0
Shrubs	11	5	0	0
Trees	24	2	0	0
Vines	10	10	0	0
Total	79	25	0	0

Native tree diversity on the site is impressive, with this being the highest diversity of all vegetation types observed. The most common species on the site is likely loblolly pine (*Pinus taedus*), with pine-oak and oak-pine woodlands being the most common habitat types observed after annual cropland. No longleaf pines (*P. palustris*) were observed but a concerted effort was not undergone (full botanical inventory not yet completed for the site). Multiple clearings reveal dense pine regeneration amongst (Figure Eight (8) oak species are present, with willow oak (*Quercus phellos*), southern red oak (*Quercus falcata*), water oak (*Quercus nigra*), and white oak (*Quercus alba*) showing the highest relative abundance. Sweet gum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*) are co-dominant canopy trees in a few of the hardwood dominated sections. The most common native shrubs on site are elderberry (*Sambucus nigra*) and winged sumac (*Rhus coppalina*). Native understory forb and graminoid diversity is likely underrepresented due to time of year (plant phenology), difficulty of access in some areas, and lower detection probabilities than other vegetation types. The most commonly observed native forbs include mostly disturbance-dependent plants found on margins, such as evening primrose (*Oenothera biennis*), American pokeweed (*Phytolacca americana*), Canada goldenrod (*Solidago canadensis/altissima*), and hairy white oldfield aster (*Symphyotrichum pilosum*).

Invasive species are present throughout the site but are most concentrated along the margins of the wooded areas and within woodlands where disturbance was most prevalent (ex. near old tobacco house ruins). Vines pose the biggest threat regarding negative effects from invasive plants on the site. Kudzu (*Pueraria montana*) is only present in one centralized location (within "the boot" centered around the homestead ruin). This must be controlled ASAP to prevent it from simplifying this entire wooded parcel ("the boot" and, eventually, others on site (see recommendations section). Japanese honeysuckle (*Lonicera japonica*) and a variety of native and non-native grape vines (*Vitis* spp.) are shading out native vegetation and resulting in tangles of simplified natural areas (lowering botanical and faunal diversity) throughout much of the site. Native muscadine (Vitis rotundifolia) is abundant and does provide a critical food source for a wide range of wildlife (ex. birds and mammals) on site. Native catbriers (*Smilax* spp.) are present throughout the site (and are an important part of the regional ecology) but are behaving somewhat invasively due to a lack of fire/increased nutrients within the forested systems on site. Ragweeds (2 species) and garden asparagus (need to confirm) (Figure 5) are the primary non-native forbs on the site. These can be controlled relatively easily through an ecological restoration plan. Invasive trees, such as tree-of-heaven (*Ailanthus altissima*) and callery pear (*Pyrus calleryana*) are not abundant on site but should be proactively eradicated to prevent future simplification of the currently diverse tree community on site. Privet (2 species) and shrub honeysuckle are problematic in disturbed areas (central woodlands) but less present in the interior of the "boot" and "triangle" woodlots and altogether less present in the "rectangle" parcel in the northeast.

Figure 4. Image of section within the interior of the "triangle" at Linkhaw Farms revealing dense pine (suspected loblolly) regeneration. Image by Michael J. McGraw on September 23, 2023.

Figure 5. Small clearing in Ivey Branch floodplain between "triangle" and "rectangle" parcels at Linkhaw Farms. Notably sloping towards the impaired stream (one of the largest potentially natural topographic changes on site). Image by Michael J. McGraw on September 23, 2023.

Fauna

Birds

A total of 59 bird species were observed on site during this rapid assessment (Table 2). Please refer to Appendix II for the full species list and relative distribution by species. Large flocks of blue grosbeaks, indigo buntings, mourning doves, and brown headed cowbirds were observed foraging the leftover corn in the fields (buntings and grosbeaks on margins/close to the tree line and cowbirds/doves out in the open fields and near power lines). Mixed migrant flocks of neotropical passerine were observed in all wooded sections (Figures 6 and 7) and even foraging in the corn (Figure 8). The survey was conducted after the breeding season so speculation on breeding status of observed species is retained for future analysis.

Table 2. Summary of Bird Species Observed at Linkhaw Farms September 23-24, 2023.

Avifaunal Type	Species Richness	State or Federally Listed	North Carolina SGCN
Passerine	40	0	5
Columbids and Corvids	4	0	0
Woodpeckers	5	0	1
Raptors	7	1*	2
Shorebirds	1	0	0
Wading Birds	0	0	0
Waterfowl	1	0	0
Other	1	1**	1
Total	59	2	9
*peregrine falcon (*Falco peregrinus*), **loggerhead shrike (*Lanius ludovicianus*)			

Figure 6. An adult male summer tanager (*Piranga rubra*) molting into basic/non-breeding plumage while foraging for insects and muscadine in a water oak (*Quercus nigra*) within the interior of the "triangle woods" at Linkhaw Farms. Image captured by Michael J. McGraw on September 24, 2023.

Figure 7. An adult male common yellowthroat (*Geothlypis trichas*) molting into basic/non-breeding plumage while foraging at Linkhaw Farms. Image captured by Michael J. McGraw on September 23, 2023.

Figure 8. A migrant palm warbler (Setophaga palmarum) resting on a corn stalk after capturing and consuming a flying insect in the corn (about 20 meters from woodland edge). Image captured by Michael J. McGraw at Linkhaw Farms on September 23, 2023.

Mammals

A total of 5 mammal species were observed on site. Primary methods were tracks, scat, and direct visual observations. White-tailed deer (*Odocoileus virginianus*), eastern gray squirrel (*Sciurus carolinensis*), short-tailed shrew (*Blarina brevicauda*), raccoon (*Procyon lotor*), and red fox (*Vulpes vulpes*). Mammal diversity is definitely greater than what was observed during this brief visit and likely includes up to 20 other species.

Herpetofauna

Many herpetofauna have a bimodal activity cycle, with spring and fall being the peak times for increased detection probability. Early fall can be a productive time for observing surface active herpetofauna, but spring is preferred for a few important reasons. Neither the timing of the site visit nor the weather conditions were ideal for documenting on site reptile and amphibian activity. However, 4 amphibians and 2 reptiles were observed (Table 3). Observed amphibians were all anurans and included calling little grass frogs (*Pseudacris ocularis*), southern gray treefrog (*Hyla chrysocelis*), southern toad (*Anaxyrus terrestris*) under cover on the surface (Figure 9), and a green frog (*Lithobates clamitans melanota*) in the primary ditch. One adult male 5-lined skink (*Plestiodon fasciatus*) and one juvenile rough green snake (*Opheodrys aestivus*). Historically, this region (southeastern North Carolina) boasted a very high diversity of herpetofauna and, in some locations, still does. Due to low detection probability and the need for specialized surveys during specific seasons and weather conditions, an added column for potentially present species was added for this faunal group. These speculations are based on the biogeographic ranges by species, extant habitat type/condition, and regional context.

Table 3. Summary of Reptile and Amphibian Species Observed at Linkhaw Farms September 23-24, 2023.

Animal Type	Observed Species Richness	Observed State or Federally Listed	Observed North Carolina SGCN	Potential Species Richness*
Salamanders	0	0	0	14(8)
Frogs and Toads (Anuran)	4	0	0	22(12)
Crocodilians	0	0	0	1(0)
Turtles	0	0	0	11(5)
Lizards	1	0	0	9(6)
Snakes	1	0	0	34(14)
Total	6	0	0	91(45)
* First number is within range and second (in parentheses) is possibly occurring within extant site conditions				

Figure 9. A southern toad (*Anaxyrus terrestris*) that was concealed in the collapsed roof material of an abandoned shed at Linkhaw Farms. Image by Michael J. McGraw on September 24, 2023.

Threatened and Endangered Species

As detailed in a previous Natural History Report (Terracon 2023), there is suitable habitat to support the recently Federally-listed tricolored bat (*Perimyotis subflavus*) within most wooded portions of the site. Numerous oak and pine species that harbor the leaf clusters often selected for maternity sites by this species are present. Four (4) additional species were identified as potentially present from the NC landscape project/natural heritage database inquiry. Of these, two species (wood stork and American alligator) do not have any suitable habitat present on the site due to a paucity of surface open waters and connectivity to nearest open water habitat types. Possible habitat is present for two other species (monarch butterfly and red-cockaded woodpecker), albeit degraded/poor conditions. Associate species were documented for red-cockaded woodpecker habitat and, while it may behoove us to provided adequate absence data now, post-construction habitat visioning could include stewardship of this amazing species by virtue of holistic ecological stewardship since the structure is already largely present.

A loggerhead shrike (*Lanius ludovicianus*) was observed within suitable habitat on site (Figure 10). This is a North Carolina Species of Special Concern. Although post-breeding season, this is suitable habitat for this species and it should therefore be considered when monitoring in the future (breeds earlier than songbirds). The peregrine falcon observed was in migration hunting blackbird flocks on open corn fields. No suitable critical habitat is present on site for this species in the breeding season.

Figure 10. Image of adult loggerhead shrike (*Lanius ludovicianus*) observed in the northern section of Linkhaw Farms. Image captured by Michael J. McGraw on September 24, 2023.

General Ecological Conditions

Overall, the site represents a typical agricultural setting of the region, with the majority of the land converted to active annual row crop production (Figure 11). Pre-farming farming habitats likely included logged out pine flatwoods and savannas as well as a mosaic of floodplain forest/swampland and regionally significant wetland types (ex. pocosin and Carolina Bays). Pre-logging conditions (150+ years ago) very possibly supported longleaf pine savanna habitat.

Figure 11. Image of central field (looking south-southwest) at Linkhaw Farms. Image captured by Michael J. McGraw on September 23, 2023.

Currently, remaining wooded tracts/natural areas are limited to locations that weren't farmed due to access, wetness, or proximity to human dwellings/infrastructure (Figure 12). Naturalization along ditches provides narrow, linear habitat features (Figure 13). The site's hydrology has been dramatically altered to dewater hydric and poorly drained soils to maximize crop yield/field productivity. Primary ecological stressors are the drain tile and ditch infrastructure, active conventional agricultural inputs (ex. nutrients, pesticides, herbicides, tilling, etc.), many decades of fire suppression, and invasive plant colonization. Plant communities in the northern tract ("the rectangle") indicate at least 50-100 year fire suppression on mineral soils.

Figure 12. Image of cane brake (*Arundinaria gigantea*) in a mature hardwood lowland woodlot at Linkhaw Farms (the "rectangle"). This area dos does not appear to have been farmed in the past 100+ years if ever and boasts patches of dense wetland and wet-mesic vegetation. Image by Michael J. McGraw on September 23, 2023.

Figure 13. Image of central ditch on site (looking east) revealing a 7' drop and an exposed drain tile outfall. Image by Michael J. McGraw at Linkhaw Farms on September 23, 2023.

Relict natural areas, despite significant ecological stressors, are supporting a relatively diverse and functional ecosystem, with an observed diverse tree community and resilient habitat types expected of a coastal plains woodland on old, weathered, nutrient depauperate soils. The presence of mature tree structure and subsurface soil peds within a matrix of disturbance offers ecological enhancement and restoration potential. Further, the manipulation of the hydrology of the site (currently exhibiting a lowered water table condition throughout most of the site) will be critical for ensuring future site development works for wildlife/natural areas and the built landscape alike.

The onsite homestead was burned at one point (charred joists still present). Sandstone and concrete bricks from the home are weathering in the landscape and altering the local soil chemistry. It appears that certain plant species are benefitting from this effect, especially kudzu (Figure 14), English ivy (*Hedera helix*), and Christmas fern (*Polystichtum acrostichoides*). Within the primary building ruin stands a chimney and fire hearth. Just adjacent to this is a square depression (similar to large tub) (Figure 15) that is filled with rainwater and a duckweed species (Lemna sp.). The margins are all masoned brick so it is functionally serving a pitfall (no escape). Sticks were added to promote a means of safe exit but this should be modified ASAP (ex. add a stabilized ramp) to prevent unintended death of turtles, frogs, small mammals, and other wildlife.

Figure 14. Kudzu vines blanketing the homestead ruin and immediately adjacent woodland at Linkhaw Farms. Image by Michael J. McGraw on September 24, 2023.

Figure 15. Pitfall within homestead ruin in the "boot" at Linkhaw Farms. Image by Michael J. McGraw on September 24, 2023.

Discussion and Recommendations

Below are recommendations related to ecology and habitat restoration. These are independent of the proposed site development to ensure all conceptual and ecological potential are realized prior to including these elements within the master plan for the site. A refined version of the recommendations that is more spatially congruent with the proposed development plan will be developed in support of a subset of prioritized ecological restoration actions.

General Habitat Recommendations

- Implement fire as a critical management tool both in short-term and long-term visioning
  - Set habitat goals such as pine flatwoods oak savanna, and pine-oak savanna as climax ecologies
  - Develop a fire management plan for the entire site and manage all natural areas with prescribed fire prior to any site development
    - Clean up trash and establish fire breaks in Winter 23-24
    - Burn at least 50% of the site's natural areas in Spring 24
    - Highest priority locations for fire are the "toe", "boot" and "triangle"
  - Establish fire breaks to partition woodlots into burn management units
    - The N-S road in the center of the "boot" can be cleared and used to break the boot into two management subunits.
    - Coordinate with local fire and police for ordinances and communication protocols
    - Plan for implementing fire in early spring each year (with possible second burn window in late fall)
    - Coordinate fire regime with chemical treatments for resprouting kudzu and other invasive species that are not negatively impacted by fire
- Identify the best locations to enact hydrological restoration.
  - Install control boxes on drain tiles can result in field backfilling for a low-cost flooding of certain areas (or break them… more costly but effective)
  - Consider a full stream and wetland restoration that includes;
    - Breaking drain tiles and filling the existing ditches (entirely if clean fill is available or via a series of ditch plugs
    - Using the soils footprint to re-meander shallow, low grade stream reaches (tributaries to Ivey Branch) with adequate floodplain benches and relevant habitat restoration
    - Re-meander Ivey Branch to include increased linear feet, a functional floodplain, and significant habitat improvements
      - Will need to pull stream "into" the site more to mitigate flood risk to neighboring properties
    - Remove 48" culvert pipes beneath railroad tracks to eliminate impediment to watershed connectivity
      - Multiple options for final result
  - Restore historic floodplain forest system
    - Cypress/gum swampland would have greatest biodiversity uplift

        - Consider soil removal to increase stormwater/flood water capacity (do not puncture fragipan and/or thick kandic clay layers) and reuse of this soils on site.

- If at all possible, aim for a net zero cut/fill (no soil export or import). If needed/beneficial, import only local, nutrient depauperate, "clean" sands and loams
- Consider innovative methods for funding and tracking ecological metrics for stormwater work
    - Review NC DEQ MS4 model/program
        - Develop plan for site that has farther reaching benefits!
        - Quantify tons of sediment and specific nutrients being removed from the watershed.
        - Collaborate with county and towns for collated results (buy in and resource support from stakeholders)
        - Collaborate with local utilities and other industries that have stormwater compliance and, potentially, wetland mitigation needs.
    - Allow for adaptive management to be a primary tool for stewardship and ensure regular monitoring plays a key role in prioritization of natural areas stewardship goals
    - Create clear and adequate space for integration with Lumbee Tribe cultural aspects for food production and
    - Strategically blend agriculture/permaculture (SC), floodplain forest (SW), and other natural areas as working lands within the southern portion of the site
    - Incorporate monitoring and educational opportunities into programmatic elements of the monitoring and interpretation of the site
        - School programming
        - Citizen science
        - Community working groups
        - Lumbee tribe
        - Overlap with professionals

Woodlands

- Burn all wooded units (with the possible exception of the "rectangle")
- Re-assess all wooded units post-burn to determine invasive species prevalence
- Cut and stump treat surviving invasive trees, shrubs and vines
- Spot spray resprouts of Lonicera spp., Ligustrum spp., kudzu, etc.
- Manage two prominent pine-oak woodlands for red-cockaded woodpecker
    - This rare species can serve as an umbrella species for myriad vertebrates and invertebrates
- Determine extent of wetlands within the "rectangle" and further assess fire relationship in this community before burning (may be candidate for a more protracted fire regime)
- Clear invasives and clean up trash around the stunning oak and sweetgum allee in the "toe" woodlot. These open form trees are a marvel and can become a centralized location (literally and figuratively) for demonstrating, educating, and inspiring people about the natural world in this region.
    - Restore this to a savanna setting by
        - Cleaning up all debris

            - Salvage corrugated metal for coverboard deployment (future faunal monitoring)
        - Back burning around large trees then head fire through the rest,
        - Cut and stump treat and/or spot treat resprouts,
        - Sow native savanna seed mix,
        - Locate planting cluster for adding young trees and shrubs for added spatial complexity and aesthetics, and
        - Design ADA pathway, interpretive signage, and outdoor classroom in compliment (not detriment) to this system!
        - Establish citizen science fixed monitoring point(s)

Corn Fields

- Cease all conventional annual row cropping activity
- Locate a subset of the active farmland for continued agricultural activities
    - Impose restrictions on agricultural activities that
        - promote regenerative practices (i.e., no till, no/low chemicals, live roots all year, residue diversity, polycultures, mechanical termination, etc.)
        - do not use any invasive plant species (regardless of legality)
        - include some element of permaculture
        - prohibits the use of any pesticides
        - encourages organic production (no herbicides)
        - promotes polycultures to diversify soil stressors over time/replenish various nutrients
        - may incorporate some animals IF suitable space for rotational grazing (including natural areas grazing as a weed control mechanism)
            - this will require a champion farmer/leader and should not be enacted without a program that has a STRONG understanding of and capability move sheep/goats/cattle at least once daily to prevent ecological degradation
- Expand woodlots via afforestation to create connectivity between onsite patches
-

Monitoring-related Recommendations

- Develop and implement a comprehensive baseline assessment prior to site development to include:
    - Fixed, permanent plots (or transects) for systematic bird monitoring
        - Follow Ralph et al. 1984 with distance and detectability modifiers
            - Do not add points in locations that will be inaccessible post-construction (ex. private lots) if at all possible. Limit points to natural areas, public parks, and agricultural areas.
        - Repeat surveys no less than 3 times in the breeding season (May 10-June 30), 5 times in the fall migration (August – November), 3 times in spring migration (March 15 – May 09), and 2 times in the winter (December – March 14).
            - Space survey events by at least 7 days

- Conduct amphibian monitoring studies
    - Document calling anurans via the NAAMP protocol
    - Trap for amphiumas and other fully aquatic salamanders
    - Deploy coverboards in select locations (assess need after fire)
- Conduct lizard and snake surveys following ROS and TCS methods
    - Focus on spring and fall bimodal activity seasons
    - Deploy coverboard transects in select locations (assess locations after fire)
- Conduct basking turtle surveys
- Deploy camera traps for documenting site use by mammals
    - Can do baited (ex. pheromone) or non-baited
- Conduct passive acoustic monitoring to document bat population dynamics
    - Focus on summer but capture spring and fall if possible as well
    - May be required for permitting process anyway
- Conduct systematic insect surveys
    - See Dr. Duran's recommendations for survey methods, effort level, target representative taxa, etc.
- Conduct a more comprehensive botanical inventory
    - Develop fixed, permanent plots to conduct nested belt transects
    - Invest in certain target-specific surveys as well such as
        - Check for *Rhus michauxii*
            - Will likely be required for permitting process
        - Check for *Dichanthelium* spp.
        - Check for longleaf pine (*Pinus palustris*)
        - Check onsite *Baccharis halimifolia* populations for *B. glomerulifolia*
        - Conduct sedge inventory

Referenced Literature

To be added in final version

APPENDICES

Appendix I – Vascular Plant Observation List

Appendix II – Avifaunal Observation List