# Compensatory Mitigation Plan
# for
# Haws Run Mitigation Site

Prepared for:
North Carolina Department of Transportation
Planning and Environmental Branch
Raleigh, North Carolina

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Land Management Group, Inc.
Wilmington, North Carolina
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# 1.0 INTRODUCTION

## 1.1 Mitigation Site Description

The Haws Run mitigation site is located approximately 28 miles northeast of the city of Wilmington, North Carolina, and straddles the Pender-Onslow County line (Figure 1). The site is 595 acres in size, approximately rectangular in shape, and is geographically positioned between Sandy Run Swamp Creek to the north and Shelter Swamp Creek to the south (Figure 2).

The site is located in the Lower Coastal Plain, an area of wide, level interstream divides separated by small streams. Topographic relief of the region is low, and elevations at the site range from about 40 ft above mean sea level (MSL) in the middle to about 25 ft near the creeks at the northern and southern ends. Because of the low topographic relief of the of the region, stream velocities are low and water seasonally floods into adjacent wooded areas.

Sandy Run Creek originates in western Onslow County approximately five miles north of the Haws Run Mitigation Site. It flows southward, then turns westward, and forms the northern boundary of the site. The creek then flows southwestward until it drains into Holly Shelter Creek, which then flows into the Northeast Cape Fear River.

The headwaters of Shelter Swamp Creek are in Great Sandy Run Pocosin, approximately six miles east of the Haws Run Mitigation Site. The creek flows westward, forming the southern boundary of the site, and ends at its confluence with Sandy Run Creek, approximately two miles west of the site.

The north and south portions of the site consist of approximately 200 acres of swamp forest associated with the two creeks. The average width of Sandy Run Swamp is approximately 1,600 feet and that of Shelter Swamp is 1,700 feet. Two earthen causeways and associated canals extend into both swamp forests at each end of the site, terminating at the respective creeks (Figure 2). Also, an approximately 2,300 foot-long logging access road extends through the Sandy Run Swamp connecting the property with NC Highway 50.

Approximately 390 acres of the site was cleared and sub-soiled between the early 1960's and 1983 for silvicultural harvest and creation of pasture land. That area currently supports a dense stand of herbaceous vegetation (mostly grasses, sedges, and rushes) and scattered patches of broadleaf trees and shrubs. Aerial photographs dating back to 1949 indicate that the interior portion of the site historically consisted of approximately 138 acres of wet savanna, approximately 40 acres of dry savanna, approximately 169 acres of pine flatwoods, and approximately 44 acres of cleared swamp forest (Figure 3).

The Haws Run Mitigation Site was purchased in 1995 by the North Carolina Department of Transportation (NCDOT) to provide compensatory mitigation for unavoidable impacts to wetlands resulting from highway construction in the region.

## 1.2 Site History

Silvicultural activities appear to have been initiated prior to 1966, based on NRCS aerial photographs (Figure 4). Logging concentrated on selective harvest of long leaf pine (*Pinus palustris*) from the interstream divide portion of the tract and much of the larger cypress (*Taxodium distichum*) from the swamp forests where large remnant stumps are still visible.

During the early 1970's, an effort was undertaken to convert the interior (mostly non-swamp forest) portions of the site into pasture land with the intent of raising American Bison. Site preparation included removal of all remaining trees and excavation of an extensive ditch and canal system with canals and causeways extending through the swamp forests to both creeks. The canal system was also used to make the potential pasture area more symmetrical. The wet nature of the property made drainage difficult; approximately one foot of water reportedly stood over 60% of the interior portion during the conversion effort. Once the canal system was complete, the entire interior portion was sub-soiled and approximately 900 tons of lime were applied to increase soil pH. Several remnant lime piles remain on the site.

## 1.3 Plant Community Types

The swamp forests at each end of the site are classified as Coastal Plain Small Stream Swamp (Blackwater Subtype) (Schafale and Weakley, 1990). Dominant tree species are swamp tupelo (*Nyssa biflora*), bald cypress, pond cypress (*Taxodium ascendens*), sweet-gum (*Liquidambar styraciflua*), yellow poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), willow oak (*Quercus phellos*), loblolly pine (*Pinus taeda*), and pond pine (*P. serotina*). One causeway at the north end of the site is continuous to NC 50, with the exception of an opening approximately 25 feet wide. The entire flow of water through the swamp is restricted to this narrow opening.

At present, the cleared, interior area supports a diverse herbaceous community dominated by grasses, sedges, and rushes. Scattered patches of woody shrubs and small trees occur throughout, with most concentrated in the northern half of this area. The most common species present are sweet-gum, black gum (*Nyssa sylvatica* var. *biflora*), wax myrtle (*Myrica cerifera*), sweetbay (*Magnolia virginiana*), ti-ti (*Cyrilla racemiflora*), and red maple.

## 1.4 Soils

The soils of the swamp forests are mapped as Muckalee. Soils of the interior portions include Woodington, Torhunta, Foreston, Stallings, and Grifton (USDA 1990, 1992). Muckalee soil is generally found along flood plains and is frequently flooded for brief periods. The other soils of the site are generally found on uplands, interstream divides, or near drainage ways. The distribution of the soils of the site is shown in Figure 5 and a summary of their pertinent characteristics is found in Table 1.

# 2.0 PRELIMINARY STUDIES

## 2.1 Jurisdictional Wetlands

National Wetland Inventory (NWI) maps identified the majority of the interior portion of the site as upland (Figure 6), although the USDA mapping indicates the presence of hydric soils throughout the site (Figure 5 and Table 1). A soil survey conducted in 1994 concluded that 92% of the cleared portion of the site consisted of hydric soils (Figure 7) (DEHNR 1994). The majority of the non-hydric soils identified in that survey generally correspond to the distribution of the Foreston series mapped by the Soil Conservation Service (USDA 1990, 1992). The wetland areas mapped by NWI generally coincide with the swamp forests. These wetland types are mostly identified as PFO1C (Palustrine, Forested, Broadleaf Deciduous, Seasonally Flooded) (Cowardin *et al.* 1979).

Ten Remote Data System WL-40 groundwater monitoring wells (WL-40s) were installed on the site prior to the 1995 growing season by Land Management Group, Inc. Six additional wells were installed in December 1995. The locations of these wells are shown in Figure 8. A wetland delineation map was developed (Figure 8) in consultation with the Regulatory Branch of the USACOE, Wilmington District, based on daily groundwater levels at these wells, and the mapping of hydric soils by DEHNR (1994) (Figure 7). One hundred and ten acres of the interior cleared portion of the tract were determined to be jurisdictional wetlands, based on this delineation. The majority of the wetlands occur in two irregularly shaped areas near the center of the tract. A drained area separates the two jurisdictional wetland areas. This drained area is approximately 200 feet wide and is centered on the large canal extending from the north end of the site to the south end. The length of that area is approximately 4,500 feet. One smaller area of jurisdictional wetlands was also identified near the southern end of the site.

## 2.2 Soil Sampling

Soil sampling was conducted in June 1996. Samples were collected at eight

locations throughout the interior portion of the site. Sample locations generally correspond to the locations of the groundwater monitoring wells (Figure 8). At each location, three sub-samples were collected from an area of approximately 100 $ft^2$, mixed, and a composite sample taken. One set of samples was collected from the surface to a depth of 6 inches. Another set of samples was collected from a depth of 12 to 18 inches. The samples were then analyzed by the Agronomic Division of the NC Department of Agriculture (NCDA). A copy of the results is attached and summarized in Table 2. The analyses indicated that the soils of the site are acidic to circumneutral, with an arithmetic mean pH of 5.1.

Samples from suspected remnant lime piles were taken in January 1997. Analyses of the samples for calcium carbonates are shown in Table 3. Results of the analyses support previous statements that lime was applied to interior portion of the site in an effort to convert it to pasture land.

## 2.3 Vegetation Surveys

On June 13 and June 18, 1996, personnel of the North Carolina Natural Heritage Program visited the Haws Run Mitigation Site in the process of conducting an inventory of rare plants and vegetative communities in Onslow County. During the surveys of the site, eight species of rare plants were found. These included Cooley's Meadowrue (*Thalictrum cooleyi*), a federally listed as Endangered species. Supplementary plant surveys were conducted throughout the remainder of the year. A total of seventeen rare species, including four C2 Federal Candidate species, were confirmed to occur on the site (Memorandum from Mr. Richard LeBlond, North Carolina Natural Heritage Program [NCNHP], attached). Summary information on the species found is given in Table 4.

During the surveys, efforts to determine the distribution of Cooley's Meadowrue were conducted by NCDOT personnel in coordination with Mr. LeBlond. The distribution and estimated numbers of plants found is shown in Figure 9. In addition to the listed species, remnants of Pine Savanna Very Wet Clay Variant were identified at the southern end of the site between the cleared area and the swamp forest.

Pine Savanna Very Wet Clay Variant is a very rare community type that Schafale (1994) has identified as one of five savanna types. The dominant tree canopy is composed of a mixture of pond pine, long leaf pine, and pond cypress. This variant occurs on clayey soils usually underlain by marl. Only five other examples of this ecosystem are known. The nearest example is the Lanier Quarry Savanna, approximately two miles west of the Haws Run Mitigation Site. That site is partially owned by The Nature Conservancy; however, various inholdings result in a patchwork of ownership.

## 2.4 Consultation With Resource Agencies

Because of the occurrence of a federally listed as Endangered species (Cooley's Meadowrue) on the mitigation site, NCDOT contacted the US Fish and Wildlife Service (USFWS) to discuss the status of this occurrence and how it may affect the implementation of hydrologic and vegetative restoration of the site. Discussions between NCDOT and USFWS are ongoing to ensure that implementation of the mitigation plan will not adversely affect populations of Cooley's Meadowrue on the mitigation site. Comments from Mr. Richard LeBlond (NCNHP) and Dr. John Taggart, Coastal Reserve Coordinator of the North Carolina Division of Coastal Management, were also included in the development of the plan.

## 2.5 Cooley's Meadowrue Recovery Plan

After implementation, the Haws Run Mitigation Site will be a valuable component in fulfilling many of the tasks that have been outlined in the Recovery Plan for the species (USFWS, 1994). The site will provide for the protection of a large, newly discovered population of the species. Also, the site will provide a location for research related to the reestablishment of the species in areas that have been disturbed. Specific tasks noted in the recovery plan that will be supported by the Haws Run Mitigation Site are given in Table 6.

# 3.0 MITIGATION PLAN

A total of 415 acres of Haws Run Mitigation Site is proposed for wetland mitigation. This will consist of restoration, enhancement, and preservation of both wet savanna and swamp forest as shown in Table 5. An additional 113 acres of dry savanna will be enhanced. A total of 67 acres of the site will not be manipulated.

## 3.1 Swamp Forest Mitigation

A total of 28 acres of swamp forest will be restored (Table 5). For descriptive purposes, swamp forest restoration will be divided into five areas. Restoration will consist of one area in the interior portion of the site that has been cleared and filled, and four areas within in the swamp forests where previously constructed causeways will be removed (Figures 10 and 11). In addition, the canals adjacent to the causeway at the north end of the site (Restoration Area 3) will be filled. These activities will lower the elevations of the causeways and raise the elevations of the canals to those of the adjacent swamp. Swamp and bottomland hardwood tree species will be planted in all five restoration areas.

The swamp forest areas of Shelter Creek Swamp and Sandy Run Swamp

provide important hydrologic, biogeochemical and habitat functions for the Cape Fear River watershed. The areas provide water storage, both at the surface and subsurface levels. This aids in decreasing extreme flood energy by attenuating a portion of flood flow volume. As low order riverine streams, the swamp forests are effective in removing non-point source pollution, nutrient cycling, and maintenance of characteristic vegetative conditions. The swamp forests also provide habitat for a variety of invertebrate and invertebrate species.

### 3.1.1 Swamp Forest Restoration

#### 3.1.1.1 Hydrological Restoration

Restoration Area 1 (Figure 10) consists of the removal of one half acre of filled causeway extending into Shelter Creek Swamp. Approximately 1,200 cubic yards of fill material will be removed and placed into the central canal. This will lower the elevation of the causeway approximately 1.5 feet to the elevation of the adjoining swamp forest. Since microtopography has been shown to be important in tree establishment and distribution (Beatty 1984; Huenneke and Sharitz 1986), small hummocks will be left undisturbed or created to serve as microsites for seedling establishment.

Restoration Area 2 (Figure 10) consists of approximately 22 acres which was cleared and filled during past conversion activities. Examination of existing ground elevations, soil profiles (by hand auger), and historical aerial photography indicate that this area was filled during the conversion of the interior portion of the site to pasture. Approximately 53,000 cubic yards of fill will be excavated from this area and used to fill the central canal. This will lower the elevation of the area approximately 1.5 feet and will result in the area being similar in elevation to that of the adjacent swamp forest.

Restoration Area 3 (Figure 10) consists of approximately 4 acres of canal and causeways created to give site access during the previous conversion area. The causeway will be used to fill the adjacent canals.

Restoration Area 4 (Figure 11) consists of approximately one half acre of causeway extending into Shelter Creek Swamp. The causeway fill material (approximately 1,210 cubic yards) will be removed and used as fill in the central canal. Small hummocks will be left for planting.

Restoration Area 5 (Figure 11) consists of approximately one acre of an improved logging path created during past silvicultural activities. Approximately 2,420 cubic yards will be removed as with Areas 1 and 4. This will bring the area to a similar grade of the adjacent swamp forest.

3.1.1.2 Plant Community Restoration

As described in Restoration Area 1, small hummocks will be left or created for tree seedling establishment in all swamp forest restoration areas. Trees will be planted systematically on these hummocks on approximately eight foot centers. This will establish a planting density of 680 trees per acre.

A total of nine species of wetland trees, in two mixtures, will be planted in Restoration Areas 1-5. Species included in the two mixtures are based upon on-site observations, Schafale and Weakley (1990), and regulatory agency guidelines (DOA, 1993).

Mixture # 1 generally corresponds with the composition of Coastal Plain Small Stream Swamp (Blackwater Subtype). Species include swamp tupelo, bald cypress, pond cypress, laurel oak (*Quercus laurifolia*), overcup oak (*Q. lyrata*), and swamp chestnut oak(*Q. michauxii*). This mixture will be planted in the half of each restoration area nearest the creek; that is, those areas subject to a greater frequency of flooding. Mixture # 2 more closely corresponds with Coastal Plain Bottomland Hardwoods and includes swamp chestnut oak, laurel oak, overcup oak, pond cypress, yellow poplar, and cherrybark oak (*Q. pagodaefolia*). This mixture will be planted in the remaining portions of the restoration areas further from the creeks which are subject to less flooding.

3.1.2 Swamp Forest Enhancement

Shelter Creek swamp forest enhancement will be created by the removal of the logging road (Restoration Area 5) which currently isolates 25 acres of Shelter Creek Swamp (Figure 11) from the creek. The removal of this road will restore the hydrologic connection between the enhancement area and adjacent swamp forest.

The removal of the causeways, particularly the large causeway in Restoration Area 3 is expected to enhance Sandy Run Swamp both upstream and downstream of the site. These enhancement effects will be addressed through a functional assessment which will be conducted at a later time. If approved by appropriate agencies, this assessment will yield additional enhancement mitigation credits. However, no additional enhancement mitigation is proposed at this time.

3.1.3 Swamp Forest Preservation

Approximately 171 acres of the remaining swamp forest will be preserved. These wetlands are divided approximately equally between Sandy Run and Shelter Creek Swamps. Appropriate deed restrictions will ensure that the area will be preserved in perpetuity.

## 3.2 Savanna Mitigation

Based on the historical mosaic of pine-dominated ecosystems in the interior portions of the mitigation site, savanna will be the primary target ecosystem of all non-swamp forest areas. This mitigation plan proposes restoring 81 acres of wet savanna, enhancing 99 acres of wet savanna, and enhancing 113 acres of dry savanna (Figure 13 and Table 5).

The term savanna has been used by many to describe grass-dominated communities that contain scattered trees. Originally covering millions of acres in the southeastern United States, this ecosystem has been reduced to a series of small and scattered islands within a highly managed and manipulated landscape by silvicultural practices, alternate land use, suppression of naturally occurring fires, and drainage activities. The remaining, unprotected savannas are few in number and small in area and are subject to further loss from growth and development in the region.

A specific, agreed-upon definition for savanna has not been developed; however, for the purpose of this project, the definition used by Taggart (1994) in a study of southeastern savannas will be used. That definition is as follows:

> ". . . a naturally occurring, bi-layered (tree and herb), fire-maintained ecosystem of the southeastern United States coastal plain that exhibits greater that 50% cover by a herbaceous, graminoid-dominated undergrowth, shrub (woody plants less than 2 m in height) cover less than 10% and scattered pines (less than 50% canopy cover) as the overstory dominant".

The functions and values of savannas are numerous. Noted for their beauty, they provide habitat for many species of rare flora and fauna. Among the most biologically diverse ecosystems in the world, savannas support more species per unit area than any ecosystem in temperate North America. They provide habitat diversity within the landscape and ecotones favorable to certain wildlife species. Savannas also are of special importance for education and research purposes due to high biological diversity.

### 3.2.1 Wet Savanna Restoration

#### 3.2.1.1 Hydrological Restoration

The canal through the central portion of the site will be filled from a point near the electric transmission line (approximately 1,800 feet north of the northern occurrence of Cooley's Meadowrue) to the northern end of the canal. The length of the proposed fill is approximately 4,600 feet. In addition, all smaller interior ditches and canals (total

length of approximately 5,500 feet) will be filled. Fill material will consist of soil originally excavated from the ditches which currently form berms adjacent to these ditches and material excavated from the swamp forest restoration areas. Ditches to be filled are shown in Figure 12. The eastern and western boundary canals will not be filled to prevent flooding adjacent properties which are not owned by NCDOT. These activities will restore wetland hydrology to approximately 81 acres (Figure 13) which are currently drained.

3.2.1.2 Plant Community Restoration

Because the herbaceous and shrub layers of the savanna community are largely in place, planting activities will concentrate on the reestablishment of the canopy tree species. An equal mixture of pond pine, long leaf pine, and pond cypress will be planted at a total density of 40 trees per acre.

Reestablishment of wet savanna grasses will be attempted. Species proposed for planting include wiregrass (*Aristida stricta*), Carolina dropseed (*Sporobolus* sp. 1), toothache grass (*Ctenium aromaticum*), and savanna muhly (*Muhlenbergia expansa*). Depending on availability, these species will be established in plots at scattered locations throughout the interior portion of the site and allowed to naturally repopulate suitable areas.

3.2.2 Wet Savanna Enhancement

The goal of savanna enhancement will be the restoration of a typical plant community over 99 acres of remnant wet savanna area that has maintained jurisdictional wetland status (Figure 13). The planting strategy will be identical to that of the wet savanna restoration area.

3.2.3 Wet Savanna Preservation

Approximately eleven acres of wet savanna will be preserved (Figure 13). This area is a remnant pine savanna very wet clay variant described by LeBlond. Since Cooley's Meadowrue is found in this area, no manipulation is proposed for this area.

3.2.4 Dry Savanna Enhancement

Dry savanna plant community species will be reestablished over 113 acres in the remnant dry savanna areas of the site (Figure 13). Long leaf pine seedlings will be planted at a ratio of 40 seedlings per acre in these areas. Wiregrass will be established in plots at scattered locations throughout dry savanna areas of the site and allowed to naturally repopulate these areas.

## 4.0 MITIGATION PLAN IMPLEMENTATION SCHEDULE

Grading and shaping of the restoration areas and filling all ditches and canals will take place during the summer and fall of 1998. Planting will occur during the dormant season of 1998-1999.

## 5.0 MONITORING PLAN

### 5.1 Swamp Forest Monitoring

#### 5.1.1 Hydrological Monitoring

Three groundwater monitoring wells will be established in Restoration Area 2 (Figure 14). Data will be collected by these wells on a daily basis during the growing season. No wells are proposed for installation in other swamp forest restoration areas because of their small size. These other areas will be assumed to meet hydrology criterion due to the high water tables of adjacent areas.

In addition to the wells installed in Restoration Area 2, three groundwater monitoring wells will be installed in adjacent areas of Sandy Run Swamp. Data collected by these wells will provide a reference for determining the hydrologic success of Restoration Area 2.

Success criteria for Restoration Area 2 will be the restoration of the water table similar to that of the reference wells. Groundwater levels will be monitored for five years or until success criteria are met.

#### 5.1.2 Plant Community Monitoring

One 50' x 50' vegetation plot will be established adjacently to each groundwater monitoring well In Restoration Area 2. One plot will be established in each of the other restoration areas (Figures 14 and 15). Sampling will be conducted annually. Success criteria will be the survival of 320 trees per acre at the end of the fifth growing season, including acceptable volunteer species. Non-acceptable volunteer species are red maple, sweet gum or any pine species.

### 5.2 Savanna Monitoring

#### 5.2.1 Hydrologic Monitoring

Six groundwater monitoring wells will be installed in the wet savanna restoration area as shown in Figure 16. Data will be collected from these wells on a daily basis. In

addition, three groundwater monitoring wells will be installed in the Lanier Quarry Savanna, approximately two miles east of the Haws Run Mitigation Site (Figure 17). Data collected by these wells will provide a reference for determining the hydrologic success of wet savanna restoration.

Success criteria for wet savanna restoration will be the establishment of the water table similar to that of the reference wells. Groundwater levels will be monitored until success criteria are met.

### 5.2.2 Plant Community Monitoring

Due to the low density of planted species in the savanna area, large sample areas will be required. Three 500' x 500' (5.7 acres) sample plots will be established (Figure 16): one in the wet savanna restoration area, one in the wet savanna enhancement area, and one in the dry savanna enhancement area. Each plot will be sampled annually. To facilitate locating each tree within the low densities of these large plots, the position of each tree planted in the monitoring plots will be marked by either permanent stakes or Global Positioning System. Success criteria will be the survival of 20 trees per acre of the species planted at the end of the fifth growing season after planting.

## 6.0 AS-BUILT REPORT AND DRAWINGS

As-built drawings, photographs, plans, and specifications will be provided to the appropriate regulatory agencies within 90 days after the Haws Run Mitigation Site is completed. Annual monitoring reports, including data, photographs, and locations of any identified problem areas, will be submitted by the end of January each year until the site is deemed successful.

## 7.0 CONTINGENCY

Should vegetation success criteria not be met within the specified period, replanting and extended monitoring will be implemented. Should hydrological success not be achieved, consultation with appropriate resource agencies will be held to outline specific measures, including regrading, to be undertaken.

## 8.0 DISPENSATION OF PROPERTY

NCDOT will maintain ownership of the property until all mitigation activities are completed and the site is determined to be successful. Although no plan for

dispensation of the Haws Run Mitigation Site has been developed, NCDOT will deed the property to a resource agency (public or private) acceptable to the appropriate regulatory agencies. Covenants and/or restrictions on the deed will be included that will ensure adequate management and protection of the site in perpetuity.

## 9.0 LITERATURE CITED

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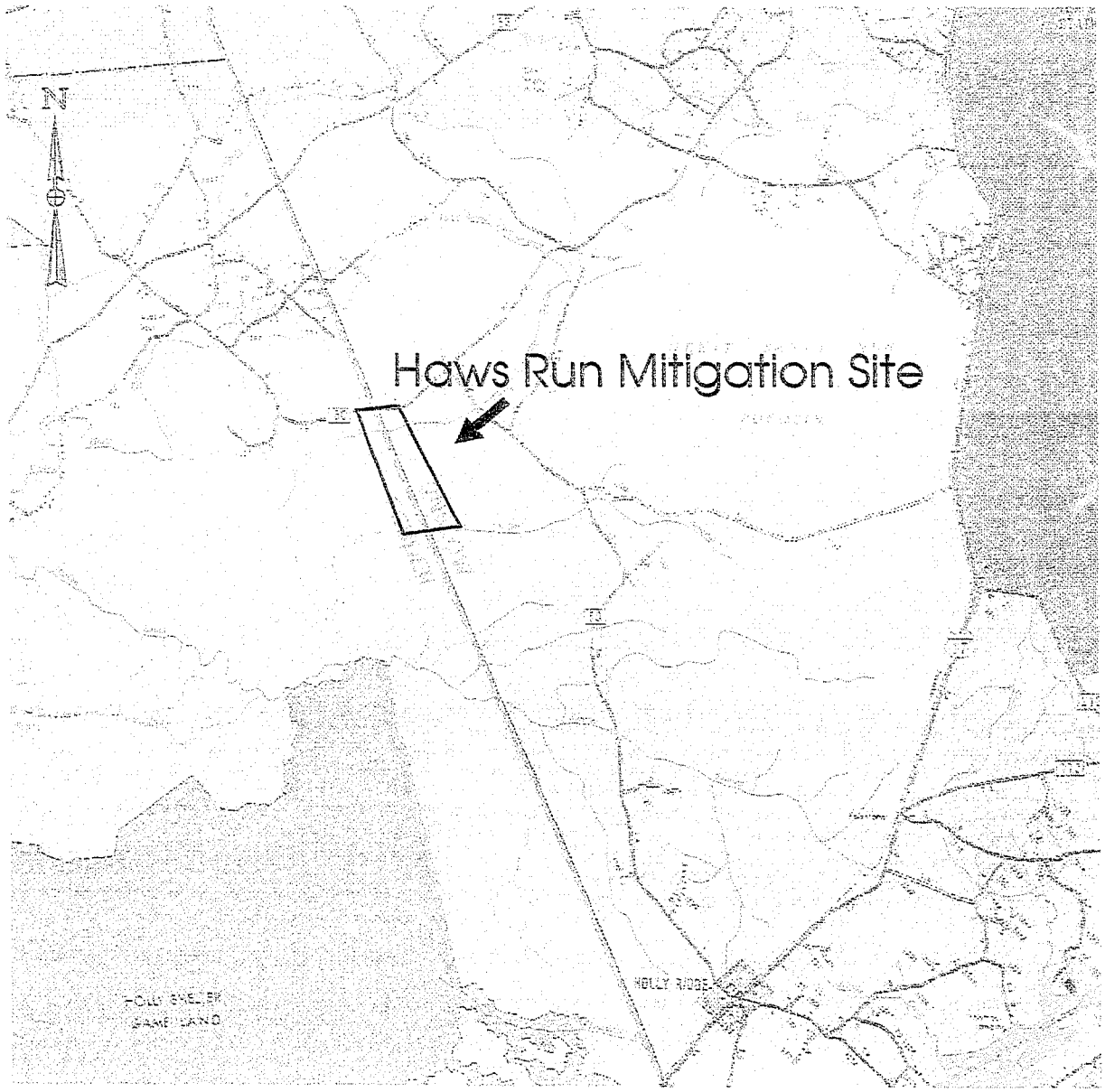
## 10.0 FIGURES, TABLES, AND APPENDICES




1" = ~ 2.5 miles

Figure 1. Vicinity map of Haws Run Mitigation Site.

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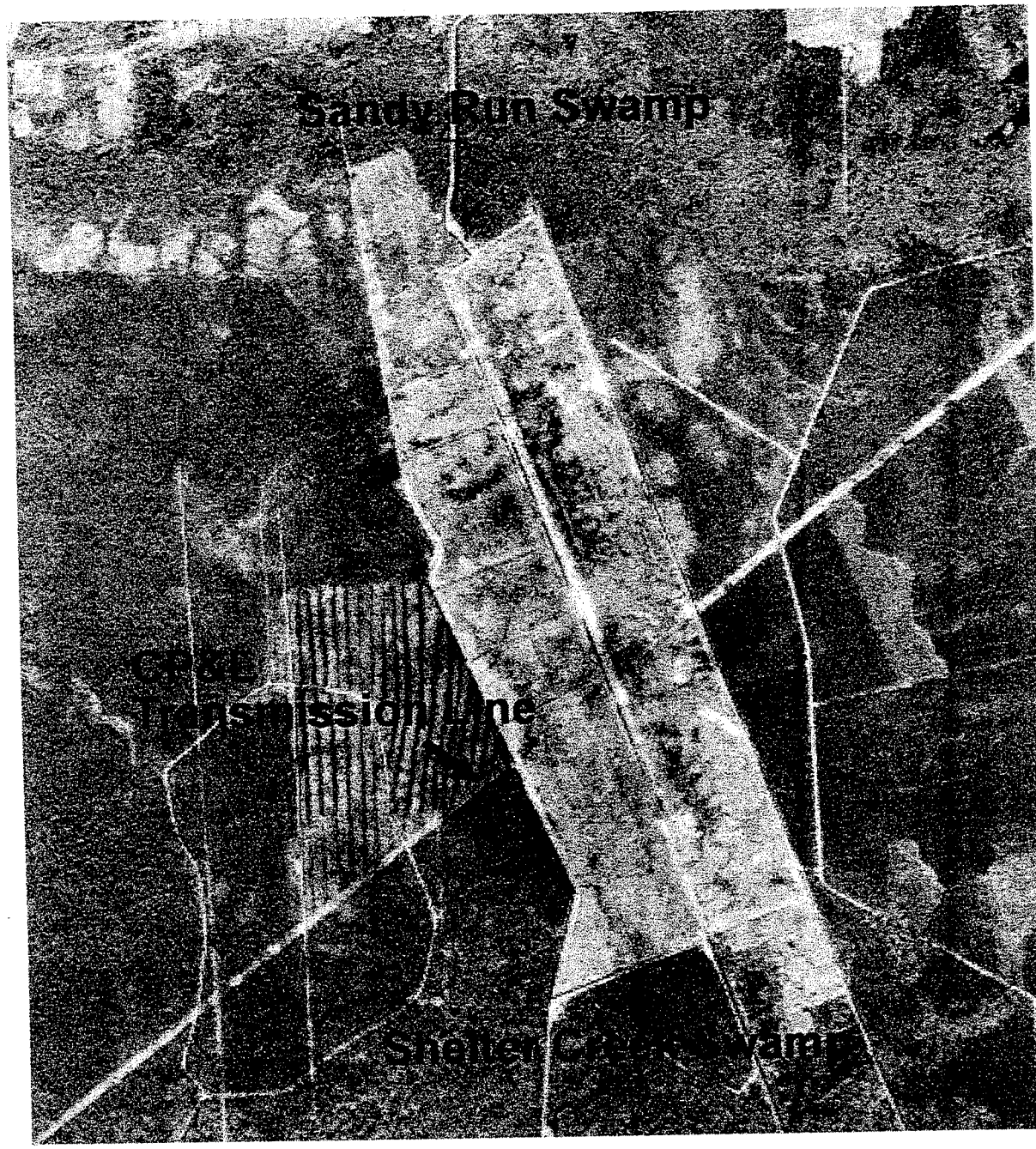
**NC DOT**
**Haws Run Mitigation Site**
**Pender/Onslow Counties**

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| Figure 2. Haws Run Mitigation Site. | **LAND MANAGEMENT GROUP, INC**<br>April, 1997 | **NCDOT**<br>**Haws Run Mitigation Site**<br>**Pender/Onslow Counties, NC** |

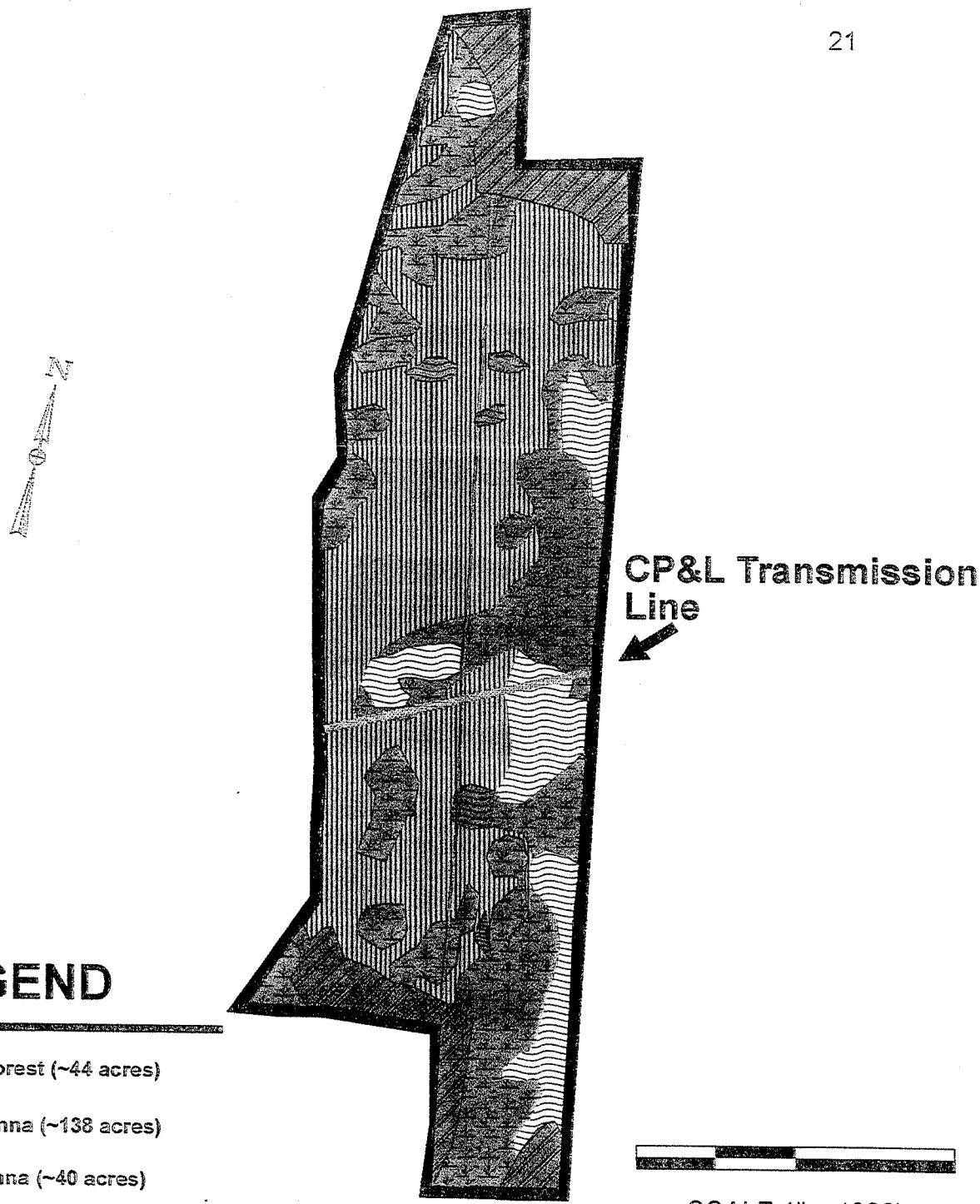


Figure 3. Historical patterns of ecosystems identified in the interior portion of the site.

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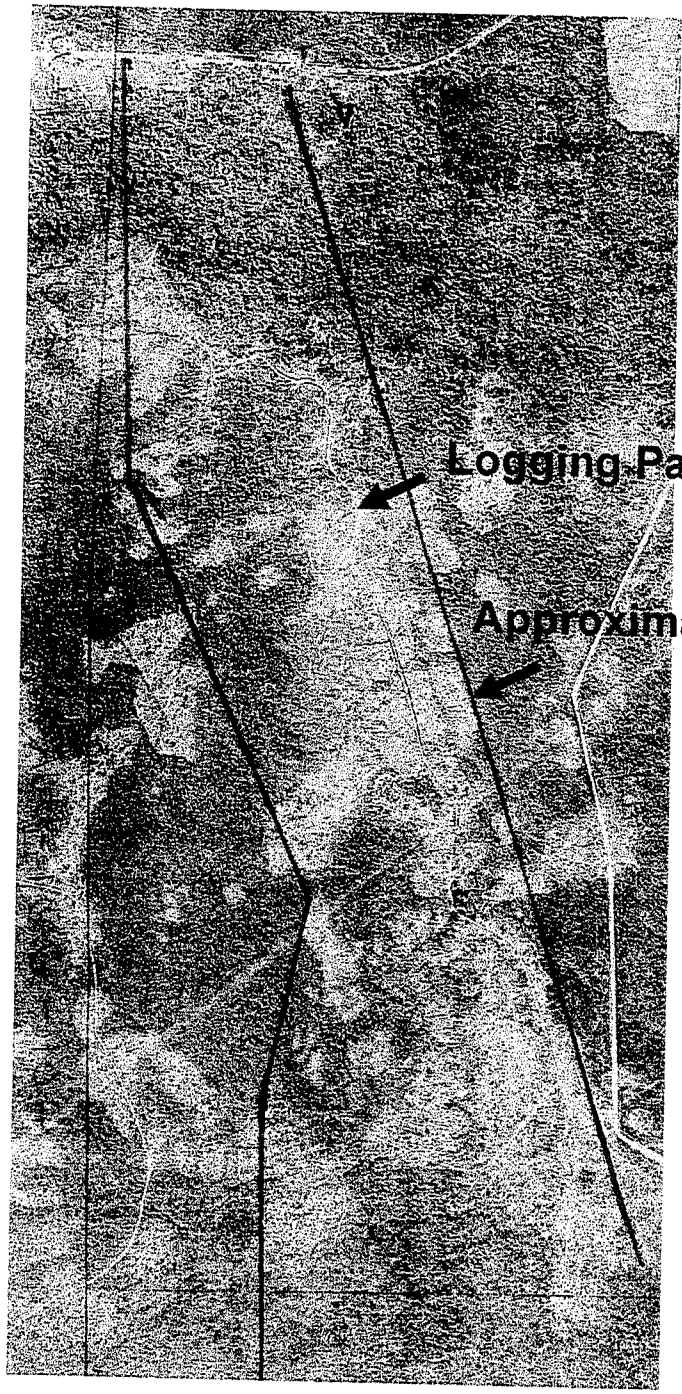


Figure 4. 1966 NRCS aerial photo showing logging path.

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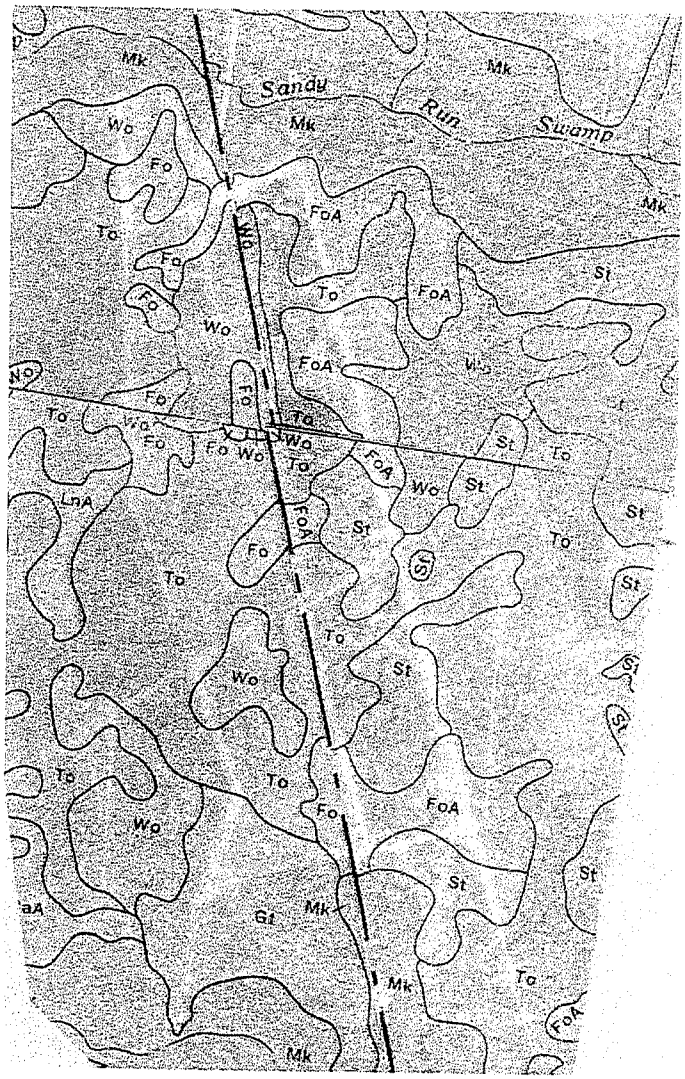


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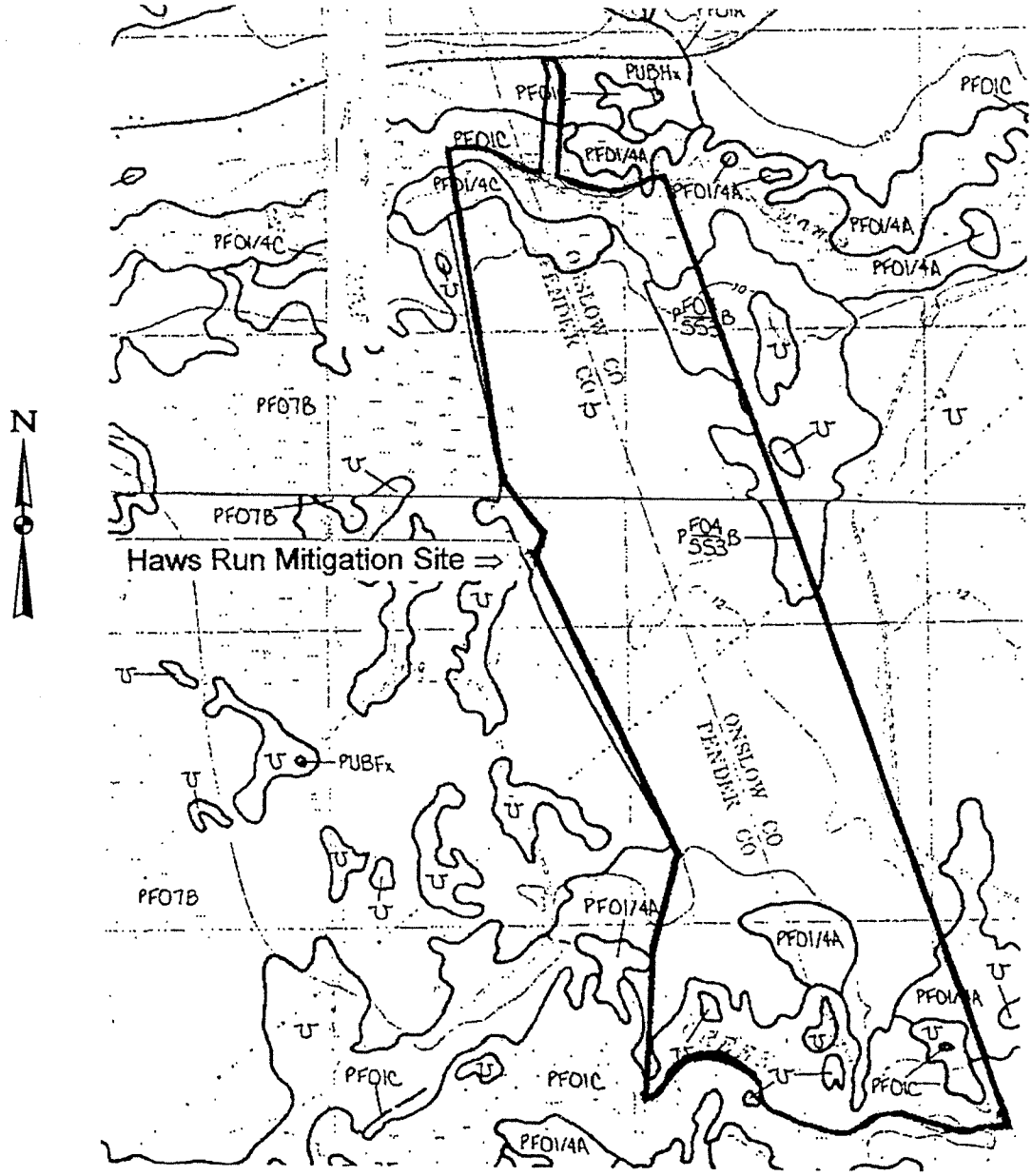
| Figure 5. NRCS soil map. | **LAND MANAGEMENT GROUP, INC**<br>April, 1997 | NCDOT<br>Haws Run Mitigation Site<br>Pender/Onslow Counties, NC |

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| Figure 6. NWI map of site. | **LAND MANAGEMENT GROUP, INC**<br>April, 1997 | NCDOT<br>Haws Run Mitigation Site<br>Pender/Onslow Counties, NC |

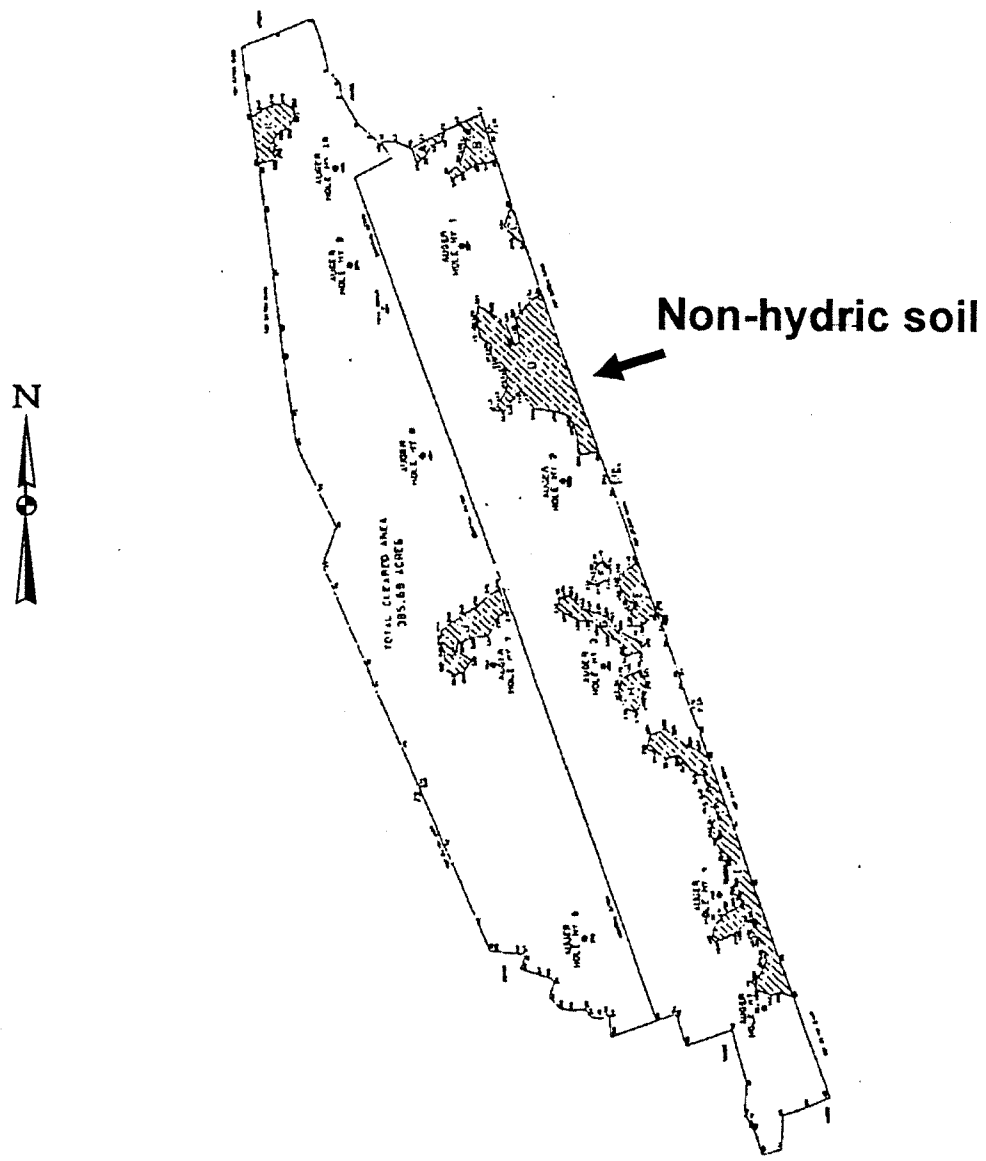


Figure 7. NCDSWC hydric soil delineation of the interior portion of the site.

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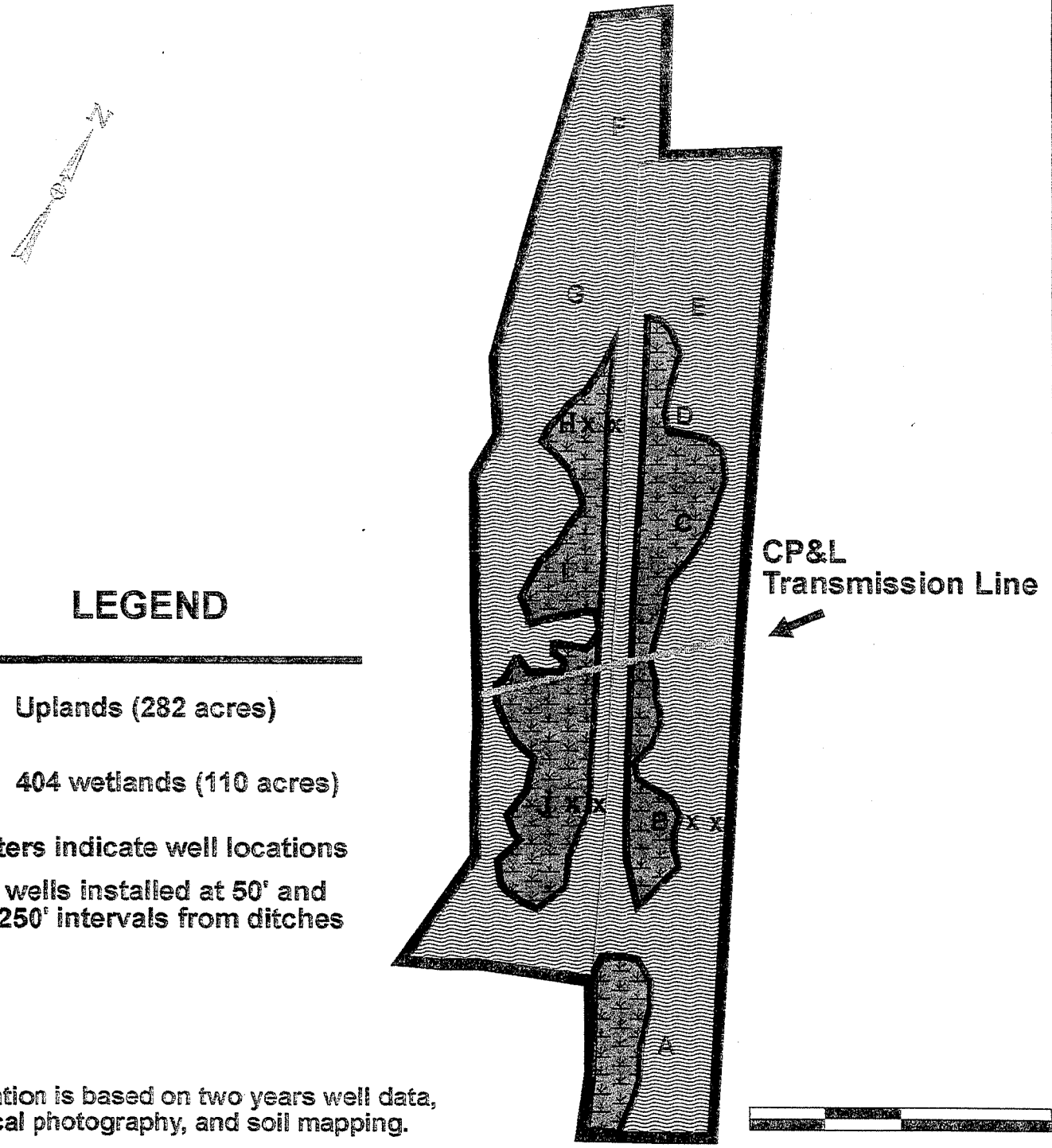


Figure 8. Well location and wetland delineation of interior portion of tract.

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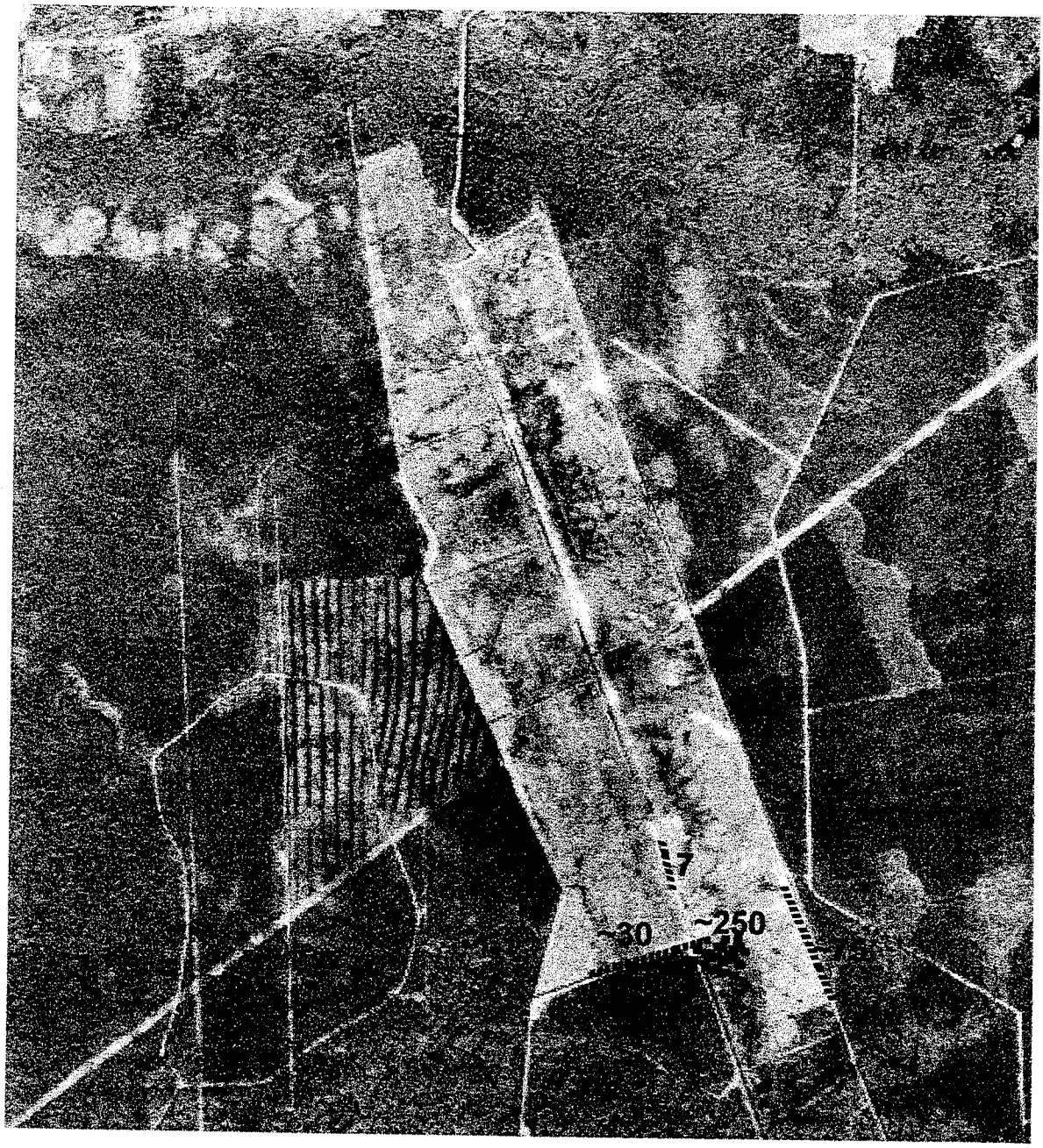
Haws Run Mitigation Site
Pender/Onslow Counties, NC

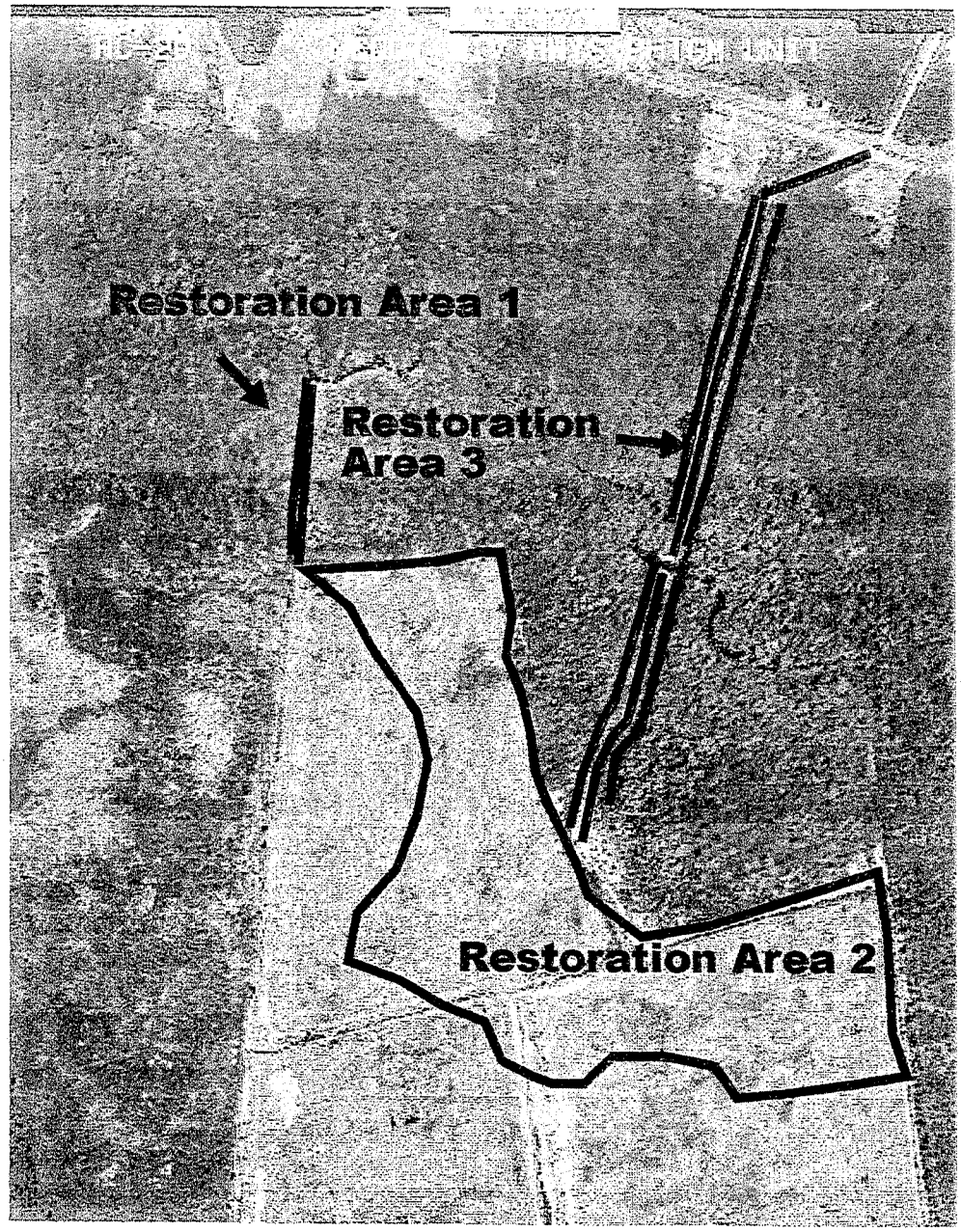



**Dots indicate plants**
**Numbers indicate # of plants present**

860 1720 3440

**Scale: 1" = 1720'**

| | | |
|---|---|---|
| Figure 9. Observed distribution of *Thalictrum cooleyi.* | **LAND MANAGEMENT GROUP, INC**<br>April, 1997 | NCDOT<br>Haws Run Mitigation Site<br>Pender/Onslow Counties, NC |




SCALE 1" = 500'

Figure 10. Restoration Areas of Sandy Run Swamp

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April, 1997

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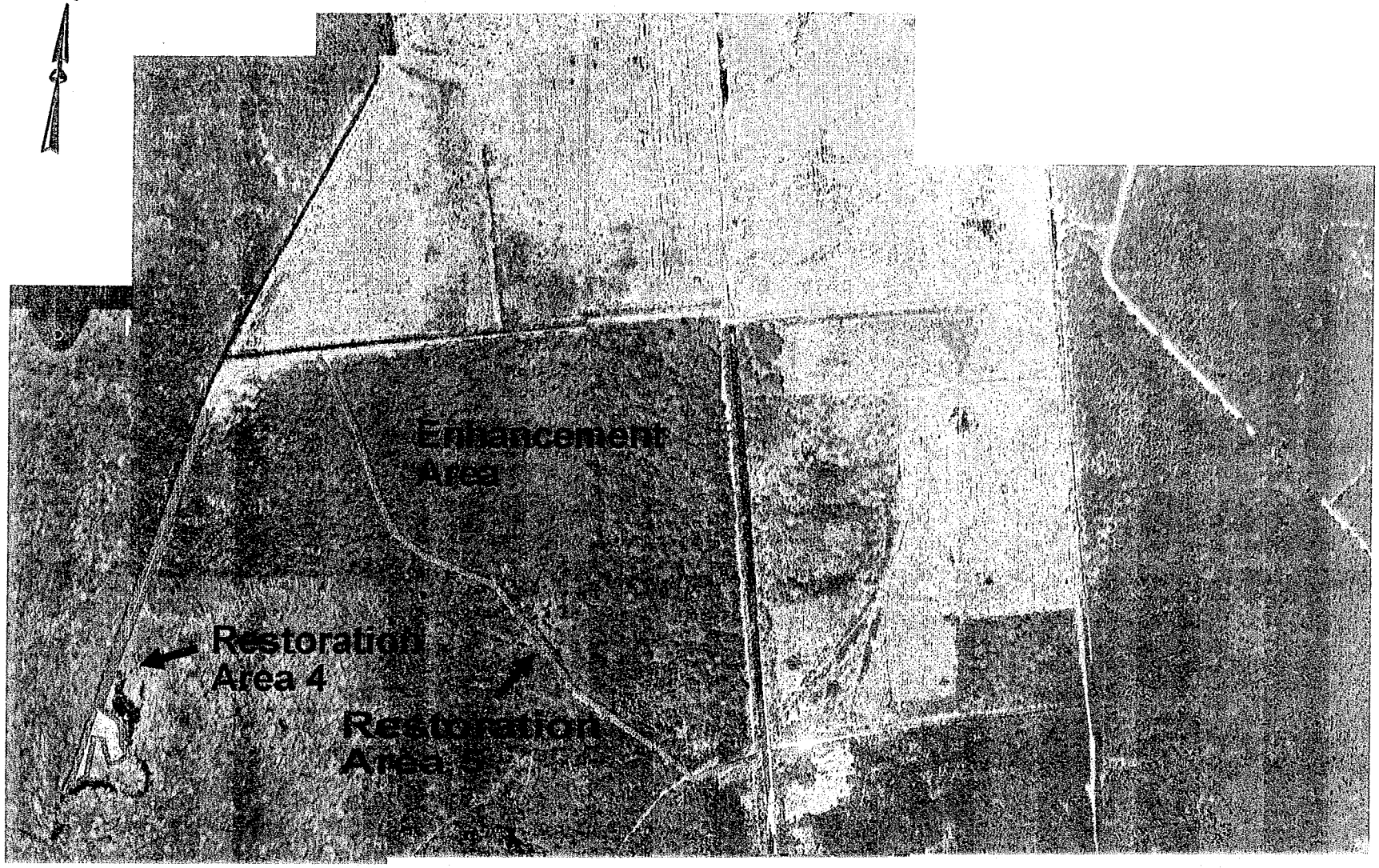
Haws Run Mitigation Site
Pender/Onslow Counties, NC




SCALE 1" = 500'

Figure 11. Proposed restoration and enhancement areas of Shelter Creek Swamp Forest

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April, 1997

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Haws Run Mitigation Site
Pender/Onslow Counties

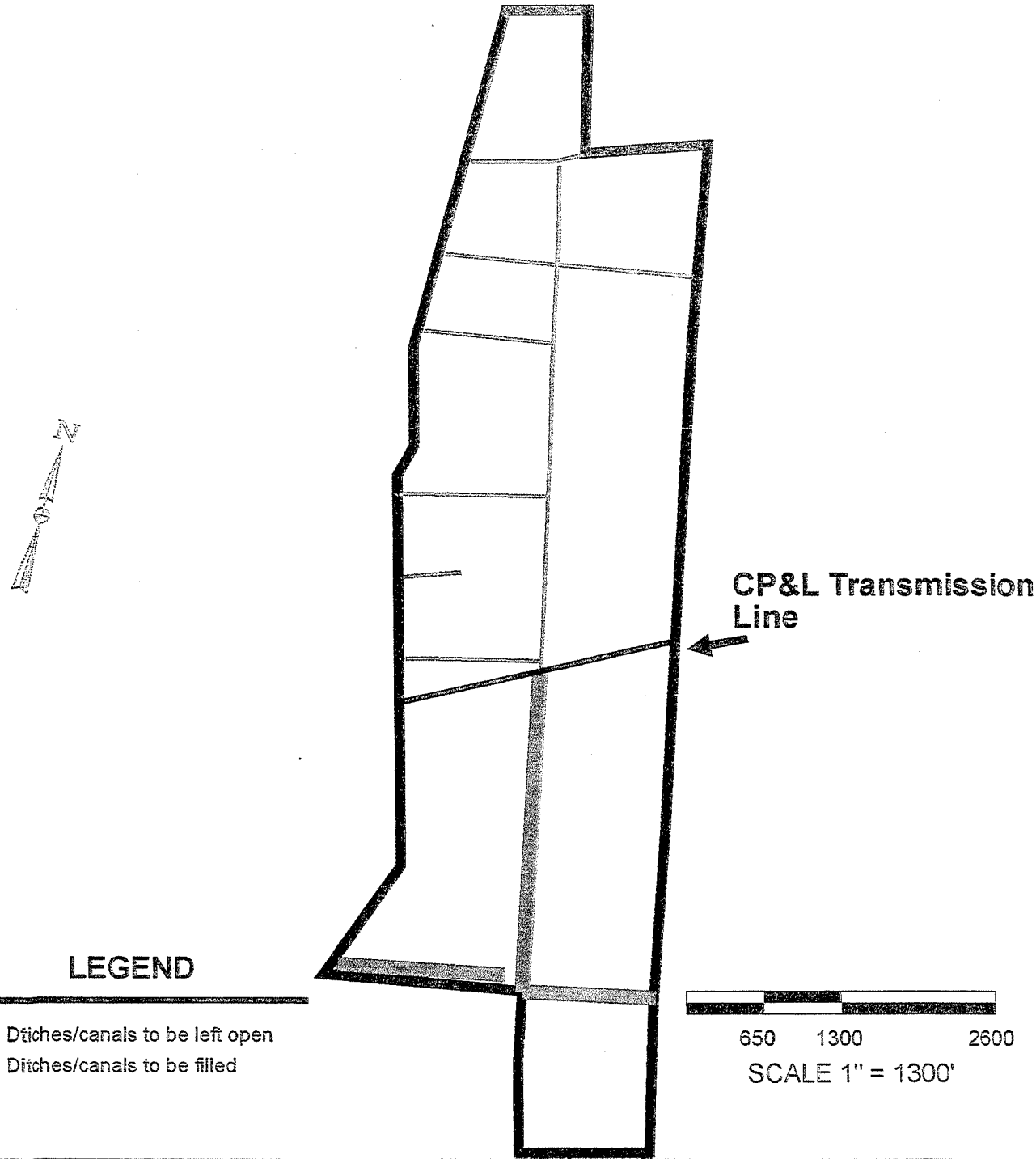


Figure 12. Ditches to be filled in the savanna mitigation area.

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Pender/Onslow Counties, NC

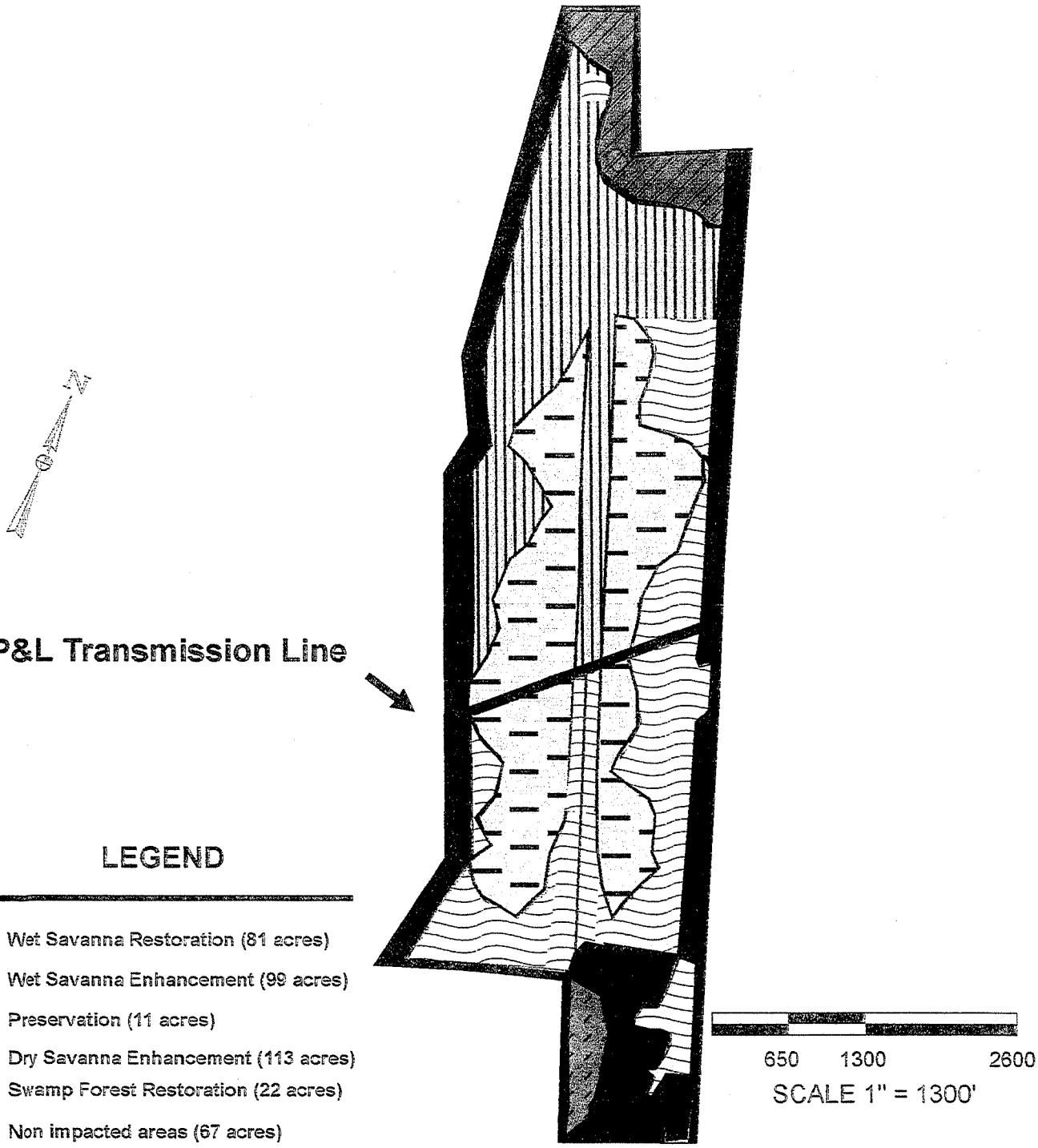


Figure 13. Savanna mitigation areas.

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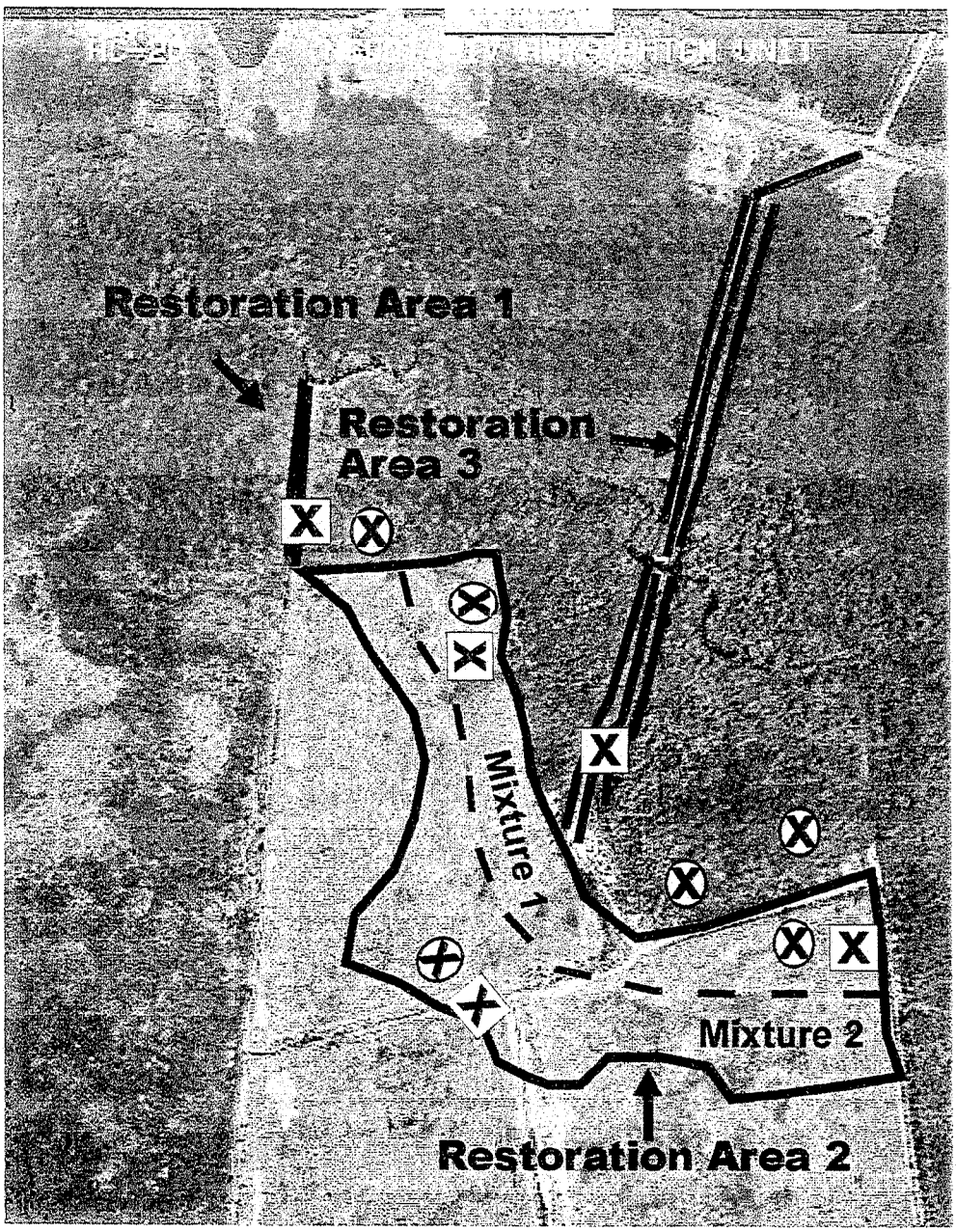
Pender/Onslow Counties, NC




## LEGEND

⊗ = Monitoring wells

X = Vegetation plots

SCALE 1" = 500'

Figure 14. Well locations, vegetation plots, and planting mixtures for Restoration Areas 1-3.

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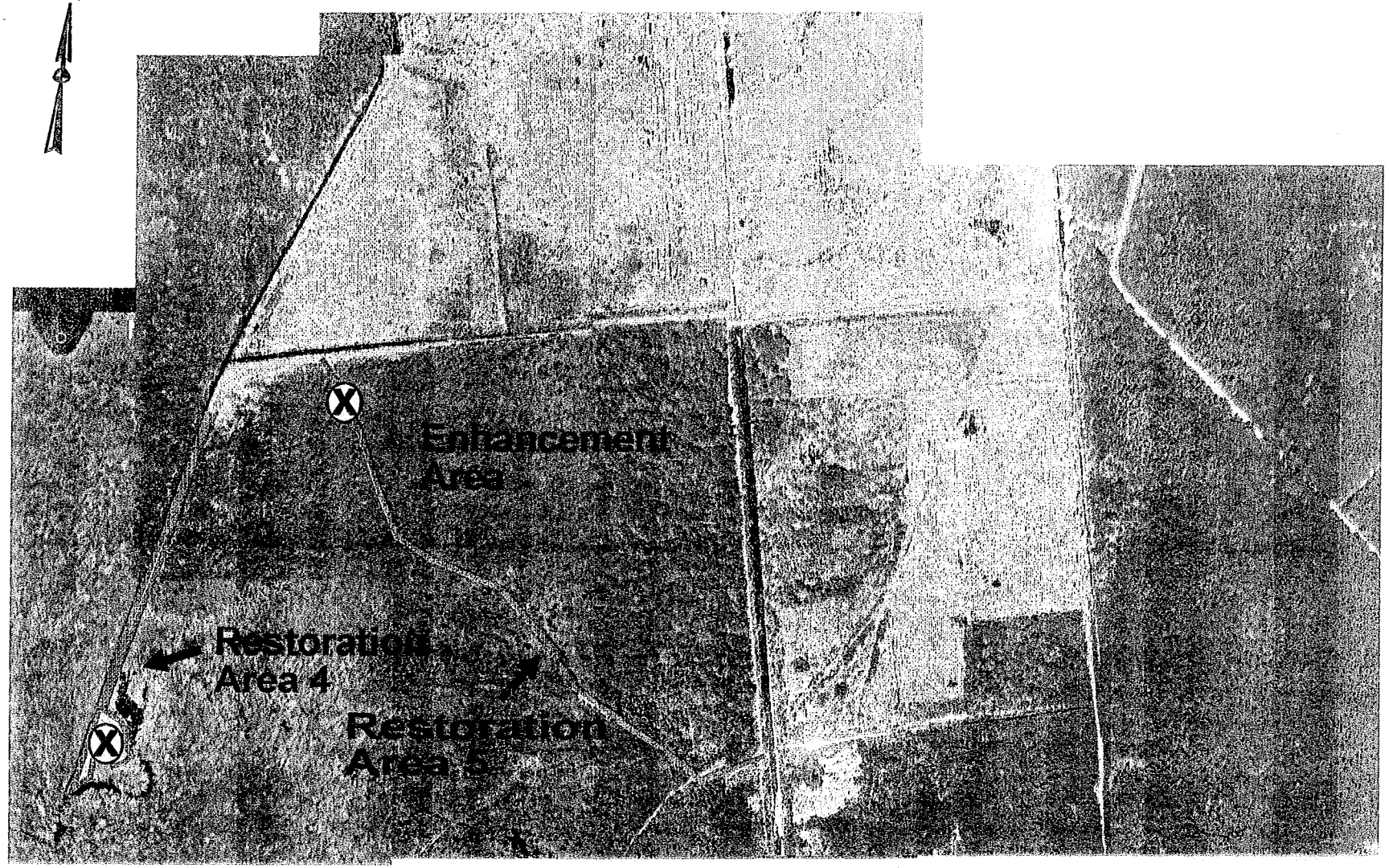


⊗ Vegetation plot

SCALE 1" = 500'

Figure 15. Vegetation plot locations in Restoration Areas 4 and 5.

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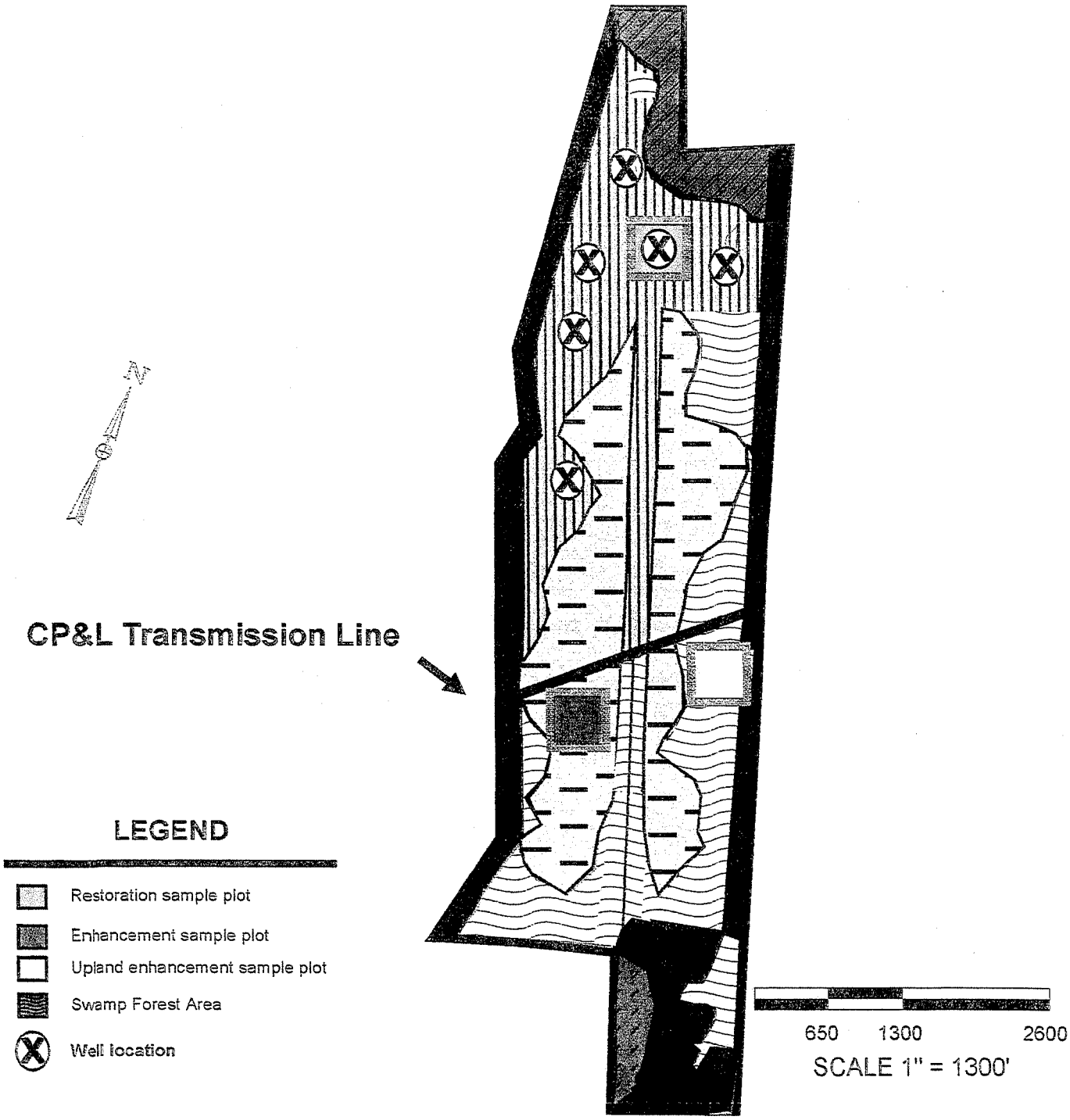


Figure 16. Savanna well locations and vegetation plots.

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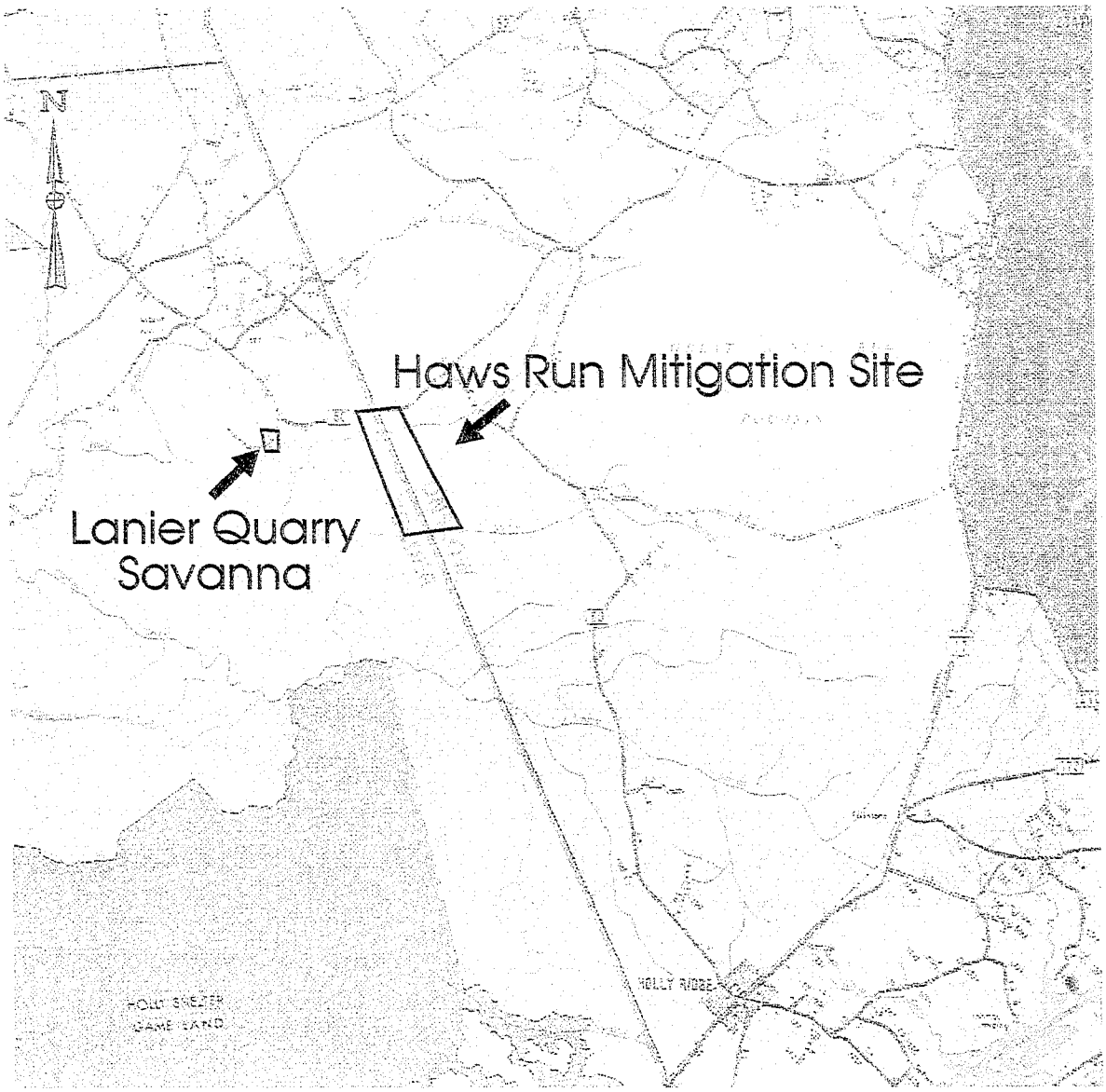
Pender/Onslow Counties, NC




1" = ~ 2.5 miles

Figure 17. Location of Lanier Quarry Savanna.

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Table 1. Characteristics of soils of the Haws Run Mitigation Site.

| Soil Series | Drainage | Location | Hydric (Y/N) | Community Type |
|---|---|---|---|---|
| Foreston | Moderately well | Interstream divides | N | Various Pine/HW |
| Grifton | Poor | Shallow depressions | Y | Various Pine/HW |
| Muckalee | Poor | Flood Plains | Y | Swamp Forest |
| Stallings | Somewhat poor | Interstream divides | Inclusions | Various Pine/HW |
| Torhunta | Very poor | Interstream divides | Y | Various Pine/HW |
| Woodington | Poor | Interstream divides | Y | Various Pine/HW |

Table 2. Summary of chemical and physical characteristics of soils from Haws Run Mitigation Site.

| Location | Wetland (Y/N) | Depth | Class | HM (%) | W/V | CEC | BS (%) | pH |
|---|---|---|---|---|---|---|---|---|
| A | N | 0-6" | Mineral | 1.55 | 1.20 | 3.4 | 59 | 5.4 |
| A | N | 12-18" | Mineral | 1.31 | 1.12 | 2.5 | 40 | 5.0 |
| B | Y | 0-6" | Mineral | 1.94 | 0.91 | 10.6 | 92 | 6.2 |
| B | Y | 12-18" | Mineral | 1.25 | 1.13 | 6.4 | 97 | 6.4 |
| D | Y | 0-6" | Organic | 5.53 | 0.82 | 6.1 | 31 | 4.4 |
| D | Y | 12-18" | Organic | 5.85 | 0.92 | 5.0 | 22 | 4.3 |
| E | N | 0-6" | Min/Org | 4.69 | 0.97 | 8.3 | 70 | 5.4 |
| E | N | 12-18" | Min/Org | 4.69 | 1.14 | 4.9 | 43 | 5.0 |
| F | N | 0-6" | Mineral | 2.76 | 1.07 | 7.2 | 82 | 5.8 |
| F | N | 12-18" | Mineral | 1.67 | 1.22 | 5.2 | 92 | 6.4 |
| H | Y | 0-6" | Organic | 10.00 | 0.88 | 6.3 | 14 | 4.3 |
| H | Y | 12-18" | Organic | 7.96 | 0.71 | 17.1 | 78 | 5.3 |
| J | Y | 0-6" | Mineral | 1.31 | 1.03 | 5.2 | 54 | 4.7 |
| J | Y | 12-18" | Mineral | 0.92 | 1.23 | 3.0 | 60 | 5.2 |
| K | N | 0-6" | Min/Org | 4.95 | 0.78 | 6.8 | 21 | 4.2 |
| K | N | 12-18" | Organic | 7.96 | 0.79 | 7.7 | 13 | 4.1 |

Notes:
Wetland (Y/N) - Denotes whether sample was collected in an area designated as wetland
Depth = Depth from which sample was collected
Class = Soil type
HM (%) = Humic matter content
W/V = Weight per volume (g/cc), Soil density
CEC = Cation exchange capacity
BS (%) = Percent base saturation
pH = Acidity

Table 3. Information on samples taken from lime piles at Haws Run Mitigation Site.

| Sample # | Depth Extracted From | % CACO3 |
|---|---|---|
| A6 | 6" | 40.9 |
| A24 | 24" | 3.8 |
| B6 | 6" | 42.3 |
| B24 | 24" | 35.3 |

Table 4. Information on rare plants found at Haws Run Mitigation Site

| Species | Global Rank | Federal Status | State Status | Comment |
|---|---|---|---|---|
| *Agalinis aphylla* | G3G4 | | C | |
| *Allium sp. 1* | G1 | | C | One of 6 known populations worldwide |
| *Arnoglossum ovatum* | G4G5 | | SR | Largest know population in NC |
| *Carex lutea* | G1 | C2 | PE | One of 6 known populations worldwide |
| *Cladium mariscoides* | G5 | | SR | |
| *Plantago sparsisiflora* | G2 | C2 | E | One of 5 known populations worldwide |
| *Rhynchospora breviseta* | G3G4 | | C | |
| *R. decurrens* | G2 | C2 | C | Largest known population in NC |
| *R. divergins* | | | SR | |
| *R. globularis var. pinetorum* | | | SR | Largest known population in NC |
| *R. thornei* | G1 | C2 | PE | Largest known population worldwide |
| *Scleria georgiana* | G4 | | SR | |
| *S. verticillata* | G5 | | C | |
| *Solidago pulchra* | G3 | C2 | E | |
| *Thalictrum cooleyi* | G1 | E | E | One of 12 known populations worldwide |
| *Xyris deformis* var. *floridana* | G4 | | C | |
| *X. flabelliformis* | G5/T3 | | C | |

Global Status Codes:
G1: Critically imperiled globally
G2: Imperiled globally
G3: Either rare or restricted
G4: Apparently globally secure
G5: Demonstrably secure globally
T3: Either very rare or restricted

Federal Status Codes:
E: Endangered
PC: Proposed candidate for endangered
C: Candidate for endangered

State Status Codes:
SR: Reported in NC without persuasive documentation
E: Endangered
C: Candidate for endangered
PE: Proposed for endangered

Table 5. Description of mitigation areas of Haws Run Mitigation Site.

| Ecosystem Type | Mitigation Type | Area (acres) |
|---|---|---|
| Swamp Forest | Restoration | 28 |
| Swamp Forest | Enhancement | 25 |
| Swamp Forest | Preservation | 171 |
| Wet Savanna | Restoration | 81 |
| Wet Savanna | Enhancement | 99 |
| Wet Savanna | Preservation | 11 |
| Dry Savanna | Enhancement | 113 |
| TOTAL MITIGATION | | **528** |
| Ditch and canal affected areas | Not mitigated | ***67 |
| TOTAL SITE AREA | | **595** |

***Area not counted towards mitigation. Total mitigation area equals 528 acres of restoration, enhancement, and preservation.

Table 6. Summary of Cooley's Meadowrue Recovery Plan

| Priority | Task Number | Task Description | Potential Role of Haws Run Mitigation Site |
|---|---|---|---|
| 1 | 1.1 | Research & management plan with landowners | Habitat maintenance and improvement |
| 1 | 1.3 | Rank populations for focus of protection efforts | Site owned by cooperating agency |
| 1 | 1.4 | Evaluate habitat protection alternatives | Research in hydrological requirements |
| 1 | 4 | Enforce protection of species and habitat | Site is protected by federal funding |
| 2 | 1.2 | Search for additional populations | Site may support additional plants |
| 2 | 2.1 | Determine population makeup | Large population on site for studies |
| 2 | 2.2 | Study abiotic and biotic features of the species | Large population on site for studies |
| 2 | 2.3 | Conduct long-term demographic studies | Habitat protection |
| 2 | 2.4 | Determine effects of habitat disturbance | Documented past disturbance of site |
| 2 | 2.5 | Criteria for self-sustaining populations | Habitat protection |
| 2 | 2.6 | Implement appropriate management techniques | Perpetual site protection |
| 3 | 2.7 | Population re-establishment research | Large population exists for research |
| 3 | 3 | Cultivation of the species | Large population exists for research |
| 3 | 5.1 | News releases and informational brochures | NCDOT Public Affairs cooperation |
| 3 | 5.2 | Articles for popular and scientific publications | Site owned by cooperating agency |
| 3 | 6 | Assess success of recovery efforts | Annual monitoring of site |

NCDA Agronomic Division, 4300 Reedy Creek Road, Raleigh, NC 27607-6465 (919) 733-2655

# Soil Test Report

SERVING N.C. CITIZENS FOR OVER 50 YEARS

## How To Interpret Your Soil Test Report:

## FORESTRY, TREES/SEED

A critical part of your soil test report is the pH and the amount of lime and fertilizer required for optimum tree and seed production. The target pH for crops in this category is 5.5, except for hardwood seed where the target pH is 6.0. The amount of lime recommended is based the target pH, amount of acidity in the soil, soil class and the target pH of the crop. Lime and fertilizer rates are given in tons and lbs/acre, respectively. Maximum benefit from lime and phosphorus application is obtained when they are incorporated into the soil prior to planting. Surface application on established sites is appropriate when recommended. Under extremely acid conditions, lime is just as important and may have just as much benefit as applying the proper amounts of fertilizer.

The amounts of phosphorus and potassium recommended decreases as the soil test level increases. Guidelines for evaluating soil test index and crop response are shown in the table below.

Local agricultural advisors can assist you in selecting a fertilizer grade that fits the recommendations. Additional information regarding lime and fertilizer is contained in Note 11 that accompanies this report.

| Soil Test Index | | Crop Response to Nutrient Application | | | | |
|---|---|---|---|---|---|---|
| Range | Rating | Phosphorus | Potassium | Manganese | Zinc | Copper |
| 0-10 | Very Low | Very High | Very High | Very High | Very High | Very High |
| 11-25 | Low | High | High | High | High | High |
| 26-50 | Medium | Medium* | Medium* | None | None | None |
| 51-100 | High | None | Low-None | None | None | None |
| 100+ | Very High | None | None | None | None | None |

* Response decreases as soil test index increases

HM% = percent humic matter | Mn-I = manganese index
WV = weight/volume of soil | NRAI = nitrogen release availability index
CEC = cation exchange capacity | Zn-I = zinc index
BS% = percent of CEC occupied by bases | Cu-I = copper index
AC = acidity (decreases as pH increases) | S-I = sulfur index
P-I = phosphorus index | SS-I = soluble salt index
KI = potassium index | NO3-N = nitrate nitrogen (ppm)
Ca = calcium, Mg = magnesium | NH4-N = ammonium nitrogen (ppm)
Na = sodium | Soil Classes: MIN = mineral, M-O = mineral-organic, ORG = organic

NCDA Agronomic Division 4300 Reedy Creek Road Raleigh, NC 27607-6465 (919) 733-2655 **Report No: 34626**

# Soil Test Report

6/25/96 SERVING N.C. CITIZENS FOR OVER 50 YEARS

*Grower:* NCDOT - REU
Attn:Randy Wise
PO Box 25201
Raleigh, NC 27611

*Farm:* Onslow County

*Copies to:* County Extension Director
NCDOT - P&E

NCDOT - P&E
Attn:Dave Schiller
PO Box 25201
Raleigh, NC 27611

**Agronomist Comments:**

Most areas have low levels of phosphorus and potassium. Soil pH of most of the mineral soil sites should be adequate for pine or related species. In these areas application of phosphorus and potassium should be adequate for tree growth. The organic areas are quite acidic and have low levels of phosphorus and potassium. In areas where the pH is approaching 5.0, I would not see any need to apply lime. However in areas where the pH is below 4.0, lime application should benefit. I would think a maximum of two tons lime /acre should be adequate. In most cases application of 60-80 lbs of phosphate and potash should be adequate for establishment. M. Ray Tucker, Agronomist.

| Field Information | | Applied Lime | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Last Crop* | *Mo* | *Yr* | *T/A* | *Crop or Year* | *Lime* | *N* | *P2O5* | *K2O* | *Mg* | *Cu* | *Zn* | *B* | *Mn* | *See Note* |
| 06HRA | | | | | 1st Crop: Pine,E | 0 | 0.0 | 60-80 | 50-70 | 0 | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| *Soil Class* | *HM%* | *W/V* | *CEC* | *BS%* | *Ac* | *pH* | *P-I* | *K-I* | *Ca%* | *Mg%* | *Mn-I* | *Mn-AI (1)* | *Mn-AI (2)* | *Zn-I* | *Zn-AI* | *Cu-I* | *S-I* | *SS-I* | *NO3-N* | *NH4-N* | *Na* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 1.55 | 1.20 | 3.4 | 59.0 | 1.4 | 5.4 | 6 | 7 | 43.0 | 15.0 | 10 | | | 35 | 35 | 16 | 30 | 9 | | | 0.1 |

| Field Information | | Applied Lime | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Last Crop* | *Mo* | *Yr* | *T/A* | *Crop or Year* | *Lime* | *N* | *P2O5* | *K2O* | *Mg* | *Cu* | *Zn* | *B* | *Mn* | *See Note* |
| 28HRA | | | | | 1st Crop: Pine,E | .5T | 0.0 | 70-90 | 60-80 | $ | $ | $ | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| *Soil Class* | *HM%* | *W/V* | *CEC* | *BS%* | *Ac* | *pH* | *P-I* | *K-I* | *Ca%* | *Mg%* | *Mn-I* | *Mn-AI (1)* | *Mn-AI (2)* | *Zn-I* | *Zn-AI* | *Cu-I* | *S-I* | *SS-I* | *NO3-N* | *NH4-N* | *Na* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 1.31 | 1.12 | 2.5 | 40.0 | 1.5 | 5.0 | 0 | 5 | 28.0 | 10.0 | 4 | | | 25 | 25 | 6 | 31 | 8 | | | 0.1 |

| Field Information | | Applied Lime | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Last Crop* | *Mo* | *Yr* | *T/A* | *Crop or Year* | *Lime* | *N* | *P2O5* | *K2O* | *Mg* | *Cu* | *Zn* | *B* | *Mn* | *See Note* |
| 06HRB | | | | | 1st Crop: Pine,E | 0 | 0.0 | 60-80 | 50-70 | 0 | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| *Soil Class* | *HM%* | *W/V* | *CEC* | *BS%* | *Ac* | *pH* | *P-I* | *K-I* | *Ca%* | *Mg%* | *Mn-I* | *Mn-AI (1)* | *Mn-AI (2)* | *Zn-I* | *Zn-AI* | *Cu-I* | *S-I* | *SS-I* | *NO3-N* | *NH4-N* | *Na* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 1.94 | 0.91 | 10.6 | 92.0 | 0.8 | 6.2 | 5 | 10 | 86.0 | 7.0 | 62 | | | 46 | 46 | 13 | 25 | 11 | | | 0.1 |

| Field Information | | Applied Lime | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Last Crop* | *Mo* | *Yr* | *T/A* | *Crop or Year* | *Lime* | *N* | *P2O5* | *K2O* | *Mg* | *Cu* | *Zn* | *B* | *Mn* | *See Note* |
| 28HRB | | | | | 1st Crop: Pine,E | 0 | 0.0 | 70-90 | 60-80 | $ | $ | $ | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| *Soil Class* | *HM%* | *W/V* | *CEC* | *BS%* | *Ac* | *pH* | *P-I* | *K-I* | *Ca%* | *Mg%* | *Mn-I* | *Mn-AI (1)* | *Mn-AI (2)* | *Zn-I* | *Zn-AI* | *Cu-I* | *S-I* | *SS-I* | *NO3-N* | *NH4-N* | *Na* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 1.25 | 1.13 | 6.4 | 97.0 | 0.2 | 6.4 | 1 | 4 | 92.0 | 4.0 | 27 | | | 21 | 21 | 8 | 16 | 9 | | | 0.0 |

| Field Information | | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRD | | | | | | 1st Crop: Pine,E | 1.1T | 0.0 | 40-60 | 40-60 | 0 | $ | 0 | | | 11 |
| | | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORG | 5.53 | 0.82 | 6.1 | 31.0 | 4.2 | 4.4 | 12 | 12 | 22.0 | 9.0 | 8 | | | 43 | 71 | 9 | 25 | 9 | | | 0.1 |

| Field Information | | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRD | | | | | | 1st Crop: Pine,E | 1.2T | 0.0 | 40-60 | 50-70 | $ | $ | 0 | | | 11 |
| | | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ORG | 5.85 | 0.92 | 5.0 | 22.0 | 3.9 | 4.3 | 14 | 11 | 14.0 | 7.0 | 6 | | | 56 | 93 | 10 | 26 | 9 | | | 0.0 |

| Field Information | | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRE | | | | | | 1st Crop: Pine,E | 0 | 0.0 | 40-60 | 50-70 | 0 | $ | 0 | | | 11 |
| | | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-O | 4.69 | 0.97 | 8.3 | 70.0 | 2.5 | 5.4 | 12 | 7 | 63.0 | 7.0 | 18 | | | 44 | 55 | 11 | 20 | 8 | | | 0.0 |

| Field Information | | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRE | | | | | | 1st Crop: Pine,E | .9T | 0.0 | 60-80 | 60-80 | $ | $ | 0 | | | 11 |
| | | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-O | 4.69 | 1.14 | 4.9 | 43.0 | 2.8 | 5.0 | 6 | 3 | 37.0 | 5.0 | 5 | | | 28 | 35 | 7 | 23 | 7 | | | 0.0 |

| Field Information | | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRF | | | | | | 1st Crop: Pine,E | 0 | 0.0 | 50-70 | 50-70 | $ | $ | 0 | | | 11 |
| | | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIN | 2.76 | 1.07 | 7.2 | 82.0 | 1.3 | 5.8 | 9 | 8 | 78.0 | 4.0 | 15 | | | 49 | 49 | 11 | 24 | 9 | | | 0.1 |

| Field Information | Applied Lime | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. / Last Crop | Mo Yr T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRF | | 1st Crop: Pine,E | 0 | 0.0 | 70-90 | 60-80 | $ | $ | 0 | | | 11 |
| | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| MIN | 1.67 | 1.22 | 5.2 | 92.0 | 0.4 | 6.4 | 2 | 3 | 89.0 | 3.0 | 6 | | | 35 | 35 | 9 | 41 | 12 | | | 0.0 |

| Field Information | Applied Lime | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. / Last Crop | Mo Yr T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRH | | 1st Crop: Pine,E | 1.6T | 0.0 | 50-70 | 50-70 | $ | $ | 0 | | | 11 |
| | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| ORG | 10+ | 0.88 | 6.3 | 14.0 | 5.4 | 4.3 | 9 | 9 | 11.0 | 3.0 | 9 | | | 95 | 158 | 10 | 19 | 4 | | | 0.1 |

| Field Information | Applied Lime | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. / Last Crop | Mo Yr T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRH | | 1st Crop: Pine,E | 0 | 0.0 | 30-50 | 30-50 | 0 | $ | 0 | | | 11 |
| | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| ORG | 7.96 | 0.71 | 17.1 | 78.0 | 3.8 | 5.3 | 20 | 19 | 73.0 | 4.0 | 29 | | | 103 | 171 | 8 | 24 | 12 | | | 0.1 |

| Field Information | Applied Lime | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. / Last Crop | Mo Yr T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRJ | | 1st Crop: Pine,E | 1T | 0.0 | 60-80 | 50-70 | $ | $ | 0 | | | 11 |
| | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| MIN | 1.31 | 1.03 | 5.2 | 54.0 | 2.4 | 4.7 | 4 | 9 | 48.0 | 6.0 | 10 | | | 47 | 47 | 11 | 26 | 9 | | | 0.1 |

| Field Information | Applied Lime | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. / Last Crop | Mo Yr T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRJ | | 1st Crop: Pine,E | .3T | 0.0 | 70-90 | 60-80 | $ | $ | 0 | | | 11 |
| | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| MIN | 0.92 | 1.23 | 3.0 | 60.0 | 1.2 | 5.2 | 2 | 4 | 54.0 | 5.0 | 3 | | | 45 | 45 | 8 | 21 | 8 | | | 0.0 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRK | | | | | 1st Crop: Pine,E | 2.9T | 0.0 | 50-70 | 20-40 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| M-O | 4.95 | 0.78 | 6.8 | 21.0 | 5.4 | 4.2 | 11 | 22 | 14.0 | 4.0 | 12 | | | 51 | 64 | 11 | 28 | 2 | | | 0.1 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRK | | | | | 1st Crop: Pine,E | 2.4T | 0.0 | 50-70 | 40-60 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| ORG | 7.96 | 0.79 | 7.7 | 13.0 | 6.7 | 4.1 | 11 | 15 | 8.0 | 4.0 | 6 | | | 63 | 105 | 7 | 26 | 2 | | | 0.1 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRP | Pine,E | | | | 1st Crop: Pine,E | 2.2T | 0.0 | 40-60 | 40-60 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| ORG | 5.53 | 0.90 | 6.2 | 13.0 | 5.4 | 3.9 | 12 | 12 | 8.0 | 4.0 | 4 | | | 38 | 63 | 9 | 15 | 3 | | | 0.1 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 28HRP | Pine,E | | | | 1st Crop: Pine,E | 2.7T | 0.0 | 50-70 | 50-70 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| M-O | 4.44 | 1.12 | 5.1 | 10.0 | 4.6 | 3.9 | 9 | 7 | 5.0 | 4.0 | 2 | | | 55 | 69 | 8 | 16 | 11 | | | 0.1 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample No. | Last Crop | Mo | Yr | T/A | Crop or Year | Lime | N | $P_2O_5$ | $K_2O$ | Mg | Cu | Zn | B | Mn | See Note |
| 06HRS | Pine,E | | | | 1st Crop: Pine,E | 1.4T | 0.0 | 40-60 | 30-50 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

| Test Results | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Soil Class | HM% | W/V | CEC | BS% | Ac | pH | P-I | K-I | Ca% | Mg% | Mn-I | Mn-AI (1) | Mn-AI (2) | Zn-I | Zn-AI | Cu-I | S-I | SS-I | $NO_3$-N | $NH_4$-N | Na |
| MIN | 1.94 | 1.00 | 3.7 | 24.0 | 2.8 | 4.4 | 12 | 19 | 16.0 | 5.0 | 3 | | | 35 | 35 | 9 | 37 | 2 | | | 0.1 |

| Field Information | | Applied Lime | | | Recommendations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Sample No.* | *Last Crop* | *Mo* | *Yr* | *T/A* | *Crop or Year* | *Lime* | *N* | *$P_2O_5$* | *$K_2O$* | *Mg* | *Cu* | *Zn* | *B* | *Mn* | *See Note* |
| 28 | Pine,E | | | | 1st Crop: Pine,E | 0 | 0.0 | 30-50 | 40-60 | $ | $ | 0 | | | 11 |
| | | | | | 2nd Crop: | | | | | | | | | | |

**Test Results**

| *Soil Class* | *HM%* | *W/V* | *CEC* | *BS%* | *Ac* | *pH* | *P-I* | *K-I* | *Ca%* | *Mg%* | *Mn-I* | *Mn-AI (1)* | *Mn-AI (2)* | *Zn-I* | *Zn-AI* | *Cu-I* | *S-I* | *SS-I* | *$NO_3$-N* | *$NH_4$-N* | *Na* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M-O | 3.98 | 1.04 | 4.8 | 65.0 | 1.7 | 5.6 | 16 | 12 | 58.0 | 5.0 | 4 | | | 41 | 51 | 8 | 33 | 11 | | | 0.1 |

PRELIMINARY REPORT
FOR
HAWS RUN MITIGATION SITE, ONSLOW COUNTY
10/3/96

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N.C. DEPARTMENT OF ENVIRONMENT, HEALTH, AND NATURAL RESOURCES

## INTRODUCTION

Haws Run Mitigation Site is located in western Onslow County along the boundary with Pender County southeast of Maple Hill. The site is comprised of two parcels totaling 593 acres, and it is owned by the N.C. Department of Transportation (NC DOT). NC DOT acquired the site "to provide compensatory mitigation to offset unavoidable impacts to wetlands as a result of [roadway] construction" (NC DOT 1996). The site is located on an interstream terrace and is bounded on the north by Sandy Run Swamp and on the south by Shelter Swamp Creek. About 400 acres of the site were clear-cut and apparently grubbed in the early 1980's, and the canopy still has not recovered. Herb vegetation indicates that the cleared area once supported the very rare Pine Savanna Very Wet Clay community variant (Schafale 1994). Remnants of Pine Savanna habitat persist at the site, and several rare plant species associated with the Very Wet Clay variant occur at the site, including a few globally rare endemics restricted to this variant. Thalictrum cooleyi (Cooley's meadowrue), federally listed as Endangered, is among the globally rare endemics. Many problems are posed by the protection of rare species populations, restoration of natural community habitat and processes, and restoration of the site's natural hydrologic and edaphic conditions. But the site also presents an excellent opportunity to study the dynamics of the Pine Savanna Very Wet Clay community variant, to learn the survival requirements of the globally rare endemic plant species, to develop successful restoration techniques, and to ultimately protect a site that, in spite of the degradation, is nationally significant.

## PHYSICAL DESCRIPTION

Haws Run Mitigation Site lies along the Onslow/Pender county line approximately four miles southeast of Maple Hill and 10 miles northwest of Holly Ridge. According to the U.S.G.S. Maple Hill and Maple Hill SW topographic quads, the site is bisected from northwest to southeast by the county line. However, the Onslow County Assessor's property map shows the boundary as coinciding with the west side of the NC DOT property; thus, all of the site is located within Onslow County, at least for tax purposes. The county line in this area is described as an "indefinite boundary" on the U.S.G.S. topographic quads.

The NC DOT property is composed of two parcels: 708-1 (540.20 acres) and 707-33 (53.08 acres). As of June 17, 1996, the Onslow County Tax Office computer records showed parcel 708-1 as owned by NC DOT, but parcel 707-33 as owned by Nationsbank Financial Services. NC DOT claims ownership of both parcels (Schiller 1996). Parcel 707-33 is located at the extreme northwest end of the site, along the south side of Sandy Run Swamp.

The site is located on a low terrace about 2 miles broad between Sandy Run Swamp to the north and Shelter Swamp Creek to the south. Both creeks drain into Holly Shelter Creek, a tributary of Northeast Cape Fear River. The topography is essentially flat, with the highest elevation (about 43 feet) near the middle, and grading downslope to about 27 feet elevation in the stream floodplains to the northwest and southeast. Some portions of the site within or adjacent to the stream floodplains are wooded, and total about 200 acres, most of which are located at the southeast end adjacent to Shelter Swamp Creek. Floodplain forest supports the Coastal Plain Small Stream Swamp (Blackwater Subtype) community (NC DOT 1996). Wooded areas between the Shelter Swamp Creek floodplain and the cleared area to the northwest support pine plantation and remnant Pine Savanna Very Wet Clay Variant habitat. The cleared area totals about 400 acres and is dominated by herbs associated with the Pine Savanna variant, and with shrubs and low trees occurring in scattered patches.

Several soils have been documented at the site. The cleared area is dominated by Stallings, Foreston, Woodington, and Torhunta soils. Muckalee is the dominant floodplain soil, and Grifton occurs in a wooded area between the Shelter Swamp Creek floodplain and the cleared area. According to soil sampling conducted in June 1996, "soils of the site are acidic to circumneutral, with an arithmetic mean pH of 5.1" (NC DOT 1996). Although the 1996 NC DOT report (ibid.) states that the soils "are reasonably normal and have not been significantly altered," sample soil probes made during the June 25 site visit indicated a uniform light gray fine silt or clayey soil to a depth of three or more feet without characteristic layering, lacking a dark surface layer, and with buried undecomposed vegetation. These sample probes were made in the southeast portion of the site, and may not be characteristic of the entire site. But they suggest that at least in the southeastern portion of the cleared area, the soil was turned over to a considerable depth subsequent to clearing.

All of the Pine Savanna Very Wet Clay Variant habitat and most of the rare plant species populations identified to date are located in the southeastern portion of the site. The most significant area is bounded along the northwest by the access road from the adjacent Hancock property; along the northeast by the parcel boundary ditch; along the southeast by an abandoned roadbed parallel to and about 1200 feet southeast of the access road from the Hancock property; and along the southwest by a flooded canal that centrally bisects the site from northwest to southeast.

## MITIGATION

In its July 1996 report, NC DOT recommends the following mitigation projects at the site:

(1) filling of the central NW/SE canal in the cleared interior of the site;
(2) causeway removal, ditch filling, and swamp forest re-establishment in the creek floodplains;
(3) Pine Savanna Very Wet Clay Variant canopy and dominant ground-cover grass re-establishment in the cleared interior; and
(4) hydrologic and vegetation monitoring.

**Filling of the central canal.** Towards the goal of hydrologic restoration, NC DOT proposes to fill this canal southward from its northern terminus to a point "200 feet north of the northern occurrence of Cooley's Meadowrue," a distance of about 5,200 feet. In addition, another 7,400 feet of axillary ditches in this area are also proposed for filling. It has been proposed (Schiller 1996) that original spoil paralleling the ditches and canal be used for the fill.

Prevention of runoff and erosion associated with these ditches and the canal is highly desirable. However, due to erosion, the amount of spoil paralleling the proposed fill areas has decreased, and fill will have to be transferred from elsewhere on-site or imported from off-site. To avoid undesirable impacts from these options, consideration should be given to damming rather than filling the canal and ditches, or to a combination of filling and damming.

**Creek floodplain causeway removal, ditch filling, and swamp forest re-establishment.** Towards the goals of hydrologic and vegetation restoration, NC DOT proposes to remove to original elevation about 8,200 linear feet of causeways in the Sandy Run Swamp and Shelter Swamp Creek floodplains, and to fill to original elevation about 5,400 linear feet of canals parallel to the causeways. These areas will then be planted with swamp hardwood and cypress trees, with a species composition that "will approximate those of nearby areas." "Trees will be established at a density of 680 trees/acre (8'x8' spacing)."

**Pine Savanna canopy and dominant grasses re-establishment.** Towards the goal of plant community restoration, NC DOT proposes to plant pond pine, longleaf pine, and pond cypress trees throughout most of the interior area with a density and pattern based on the proposed reference system, Lanier Quarry Savanna. Re-establishment of wiregrass (Aristida stricta) and Carolina dropseed (Sporobolus sp. 1) will also be attempted at scattered locations.

The goal is highly desirable, but it is recommended that canopy and dominant grass re-establishment first be conducted on study plots to determine which soil types and/or hydrologic conditions are most favorable for active restoration efforts. It is also recommended that fire

management be introduced into the area of remnant Pine Savanna Very Wet Clay Variant in the southeastern portion of the property; woody vegetation is naturally recovering in the remnant habitat in this area

**Hydrologic and vegetation monitoring.** NC DOT proposes to establish wells to monitor hydrologic restoration, and to establish vegetation sampling plots to monitor plant community restoration. NC DOT is seeking to establish reference system plots at Lanier Quarry Savanna "to determine the species composition and densities of canopy trees to be planted in the interior areas of the mitigation site." However, if such data already exist, they can be used in place of the plots. Sampling plots will be established in both the cleared interior and in swamp forest "to monitor the success of tree planting."

It is recommended that wiregrass and Carolina dropseed densities also be studied in the mitigation site plots, and in the Lanier Quarry Savanna plots if such data are not already available.

## SIGNIFICANCE OF RARE PLANT POPULATIONS

As of September 19, 1996, the following rare plant taxa have been documented as occurring at the Haws Run Mitigation Site:

| TAXON | STATUS US | STATUS NC |
|---|---|---|
| Agalinis aphylla | | C |
| Allium sp. 1 | | C |
| Arnoglossum ovatum | | SR |
| Carex lutea | PC2 | PE |
| Cladium mariscoides | | SR |
| Plantago sparsiflora | C2 | E |
| Rhynchospora breviseta | | C |
| R. decurrens | C2 | C |
| R. divergens | | SR |
| R. globularis var. pinetorum | | SR |
| R. thornei | C2 | PE |
| Scleria georgiana | | SR |
| S. verticillata | | C |
| Solidago pulchra | C2 | E |
| Thalictrum cooleyi | E | E |
| Xyris flabelliformis | | C |
| X. deformis var. Floridana | | C (State Historical) |

("C2" taxa are currently treated as "Species of Concern" by the U.S. Fish and Wildlife Service.)

The site contains the 12th currently known global population of US Endangered Thalictrum cooleyi, the 6th globally known populations of Carex lutea and Allium sp. 1, one of few currently known global populations of the little-known Rhynchospora decurrens, and the world's largest known population of Rhynchospora thornei. In addition, the Pine Savanna Very Wet Clay Variant is a very rare natural community type restricted to the Maple Hill and Old Dock areas of eastern North Carolina. Based on these critical populations for globally rare plant species, and the presence of a remnant of a very rare natural community type, the site has been determined to be nationally significant by N.C. Natural Heritage Program.

## REFERENCES CITED

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