

Restoration Plan for the Northwestern Portion of Raven Rock State Park

Harnett County, North Carolina

A project in partial fulfillment of the graduate degree, Master of Forestry
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Fig. 1. Bottomland after Hurricane Florence.

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Executive Summary

The restoration tract, the 630-acre Raven Rock State Park Northwest, is located in the Coastal Plain near the Fall Line. The tract is bordered to the south by the Cape Fear River, to the north by Mill Creek, and to the east by Avents Creek, a tributary to the Cape Fear. It is currently forested with four natural community types: Dry Oak-Hickory Forest, Mesic Mixed Hardwood Forest (Piedmont Subtype), Piedmont/Mountain Bottomland Forest, and Piedmont/Mountain Levee Forest, as well as an old loblolly pine (*Pinus taeda*) plantation. No longleaf pine (*Pinus palustris*) is present. The management objective of Raven Rock State Park is to restore the tract to the pre-colonization landscape as best as can be determined by natural history, soil, topography, hydrology, and succession, and to establish the Piedmont Longleaf Pine Forest on the landscape wherever appropriate. Until 2002, Raven Rock State Park Northwest was under timber management by Bradley Lumber Company, Willamette, and then Weyerhaeuser.

Management units are grouped by natural community evidence, especially species composition, and prior management. The management regime of Unit 1 – Piedmont Longleaf Pine Forest – includes pre-harvest burning, clearcutting, planting containerized longleaf at 7 x 10 spacing, herbicide control of hardwood competition, and burning every 1-4 years after longleaf reaches the canopy in order to restore longleaf to the landscape.

In the Dry Oak-Hickory Forest, the stands of existing oak-hickory overstory or understory include recommendations for prescribed burns to control the hardwood understory in Stand 6 and imazapyr application during the growing season in Stands 2 and 8. All loblolly pine should be girdled over a period of 10 years, except within a 100-foot buffer zone of the equestrian trail where it should be harvested. Shortleaf pine (*Pinus echinata*) should be retained for the red-cockaded woodpecker. In Stands 12 and 14, which have a loblolly-dominated overstory and oak-hickory understory, the loblolly should be girdled and the hardwood treated with triclopyr. Burning is recommended for wherever longleaf volunteers in from Stand 1.

In the Mesic Mixed Hardwood Forest (Piedmont Subtype), the main recommendation in all stands is to girdle all loblolly over a 10-year period because it is not a natural component of this forest type. The 100-foot buffer of the equestrian trail applies here as well.

For Piedmont/Mountain Bottomland Forest, the recommendations include reduction of the loblolly to 8 percent of the total basal area (Braun, 1950), since the species is naturally found in this community but not in its current numbers. Chinese privet (*Ligustrum sinense*) and Japanese stilt grass (*Microstegium vimineum*) exist in both the bottomland and levee forests. The recommendation is to control the invasive vegetation with aquatic glyphosate with surfactant during dry periods to release herbaceous and woody vegetation.

The recommendation for the Piedmont/Mountain Levee Forest is the same as in the Bottomland Forest: control the invasive plants and release the native understory. Hydrilla (*Hydrilla* spp.) should be treated annually with fluridone.

Best Management Practices and protection of Streamside Management Zones should be adhered to conform to North Carolina Forest Practices Guidelines during all forest management operations.

Purpose

This management plan was developed to restore the current vegetation of the northwestern portion of Raven Rock State Park to the vegetation likely present in the year 1491. This plan serves as an information guide and schedule of proposed activities over time for Raven Rock State Park Northwest (RARO Nw).

Management Objectives

North Carolina State Parks manage their lands for conservation of natural resources, land and water protection, ecological and species diversity, aesthetic value, recreation, education, and natural and cultural heritage preservation. The vegetation of the northwestern portion of Raven Rock State Park has been considerably altered over the last several hundred years owing to the introduction of exotic species, fire suppression, and tree planting.

The objective of this project was to develop a management plan as a guide to return this portion of the park to the vegetation likely present before colonization by Europeans. However, the lack of complete historical records, specifically for the longleaf transitional forest that probably once existed here, limits the silvicultural prescriptions. Past land-use practices (including agriculture, foraging by farm animals, timber harvest, and introduction of invasive species) have dramatically changed the landscape over hundreds of years. These events have led to a landscape which is unlikely to return completely to its pre-colonial condition (especially in our lifetime).

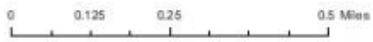
Location of study area

This management plan covers the portion of Raven Rock State Park north of the Cape Fear River and west of Avents Creek, a total of 630 acres accessed from River Road in northern Harnett County, NC, at approximately N 35°29'17" and W 78°55'9" (Fig. 2).

RARO Nw Management Tract



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks



1:15,000



Fig. 2. Location of the RARO Nw management tract.

The site is located just inside the Upper Coastal Plain, approximately five miles southeast of a geologically significant junction of the Piedmont, Upper Coastal Plain and Sandhills (Fig. 3).

Figure 1a. Physical Regions

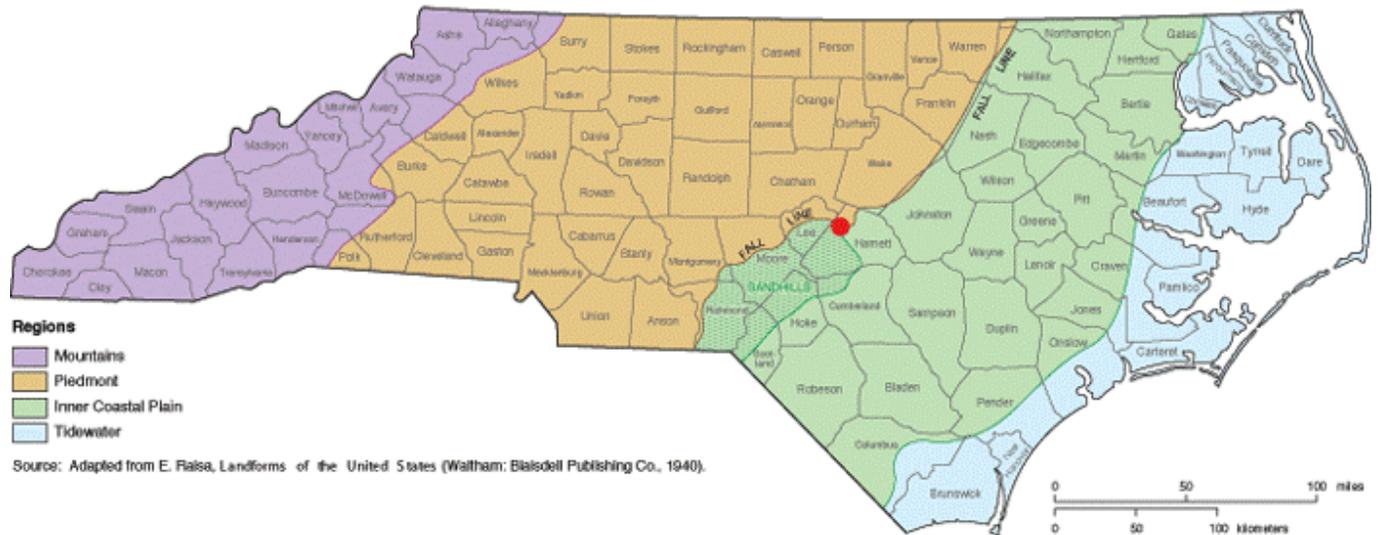


Fig. 3. Raven Rock State Park (red dot) close to the junction of Piedmont, Inner Coastal Plain and Sandhills.

The site occurs along a line of counties where natural remnants of Piedmont Transitional Longleaf Forest have been found (Fig. 4).

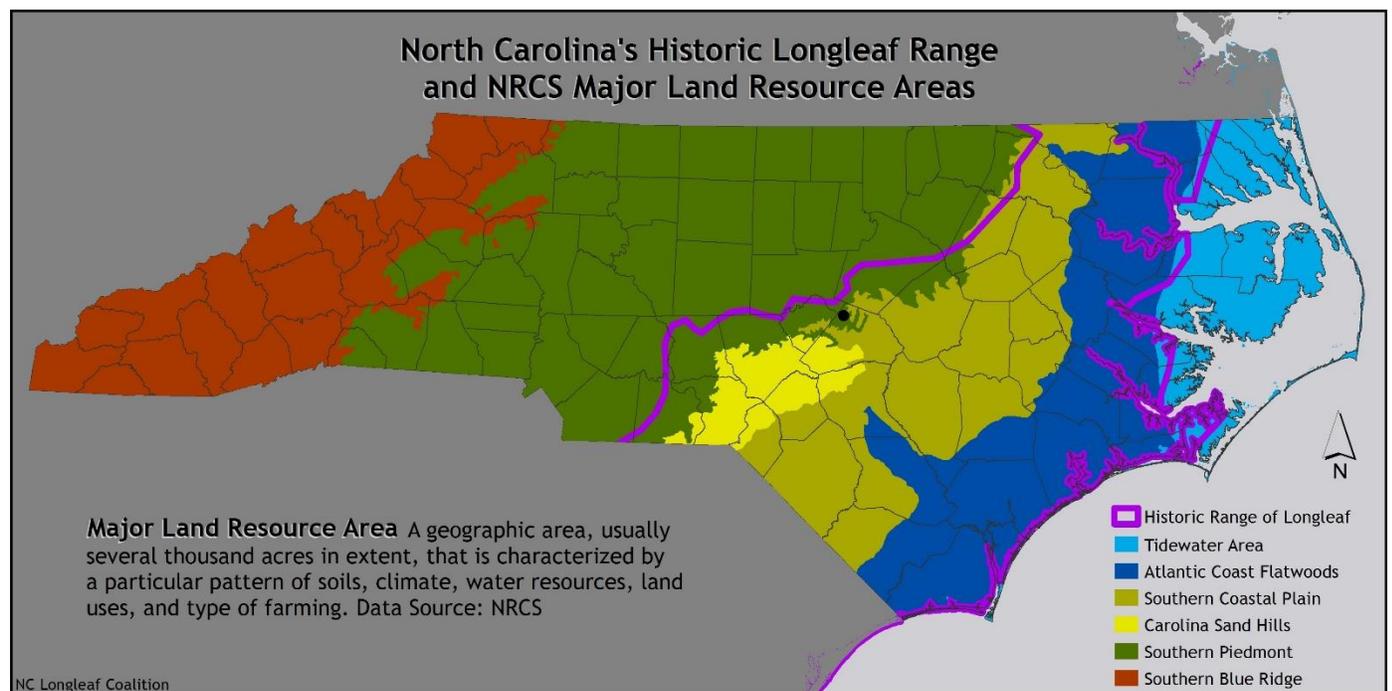
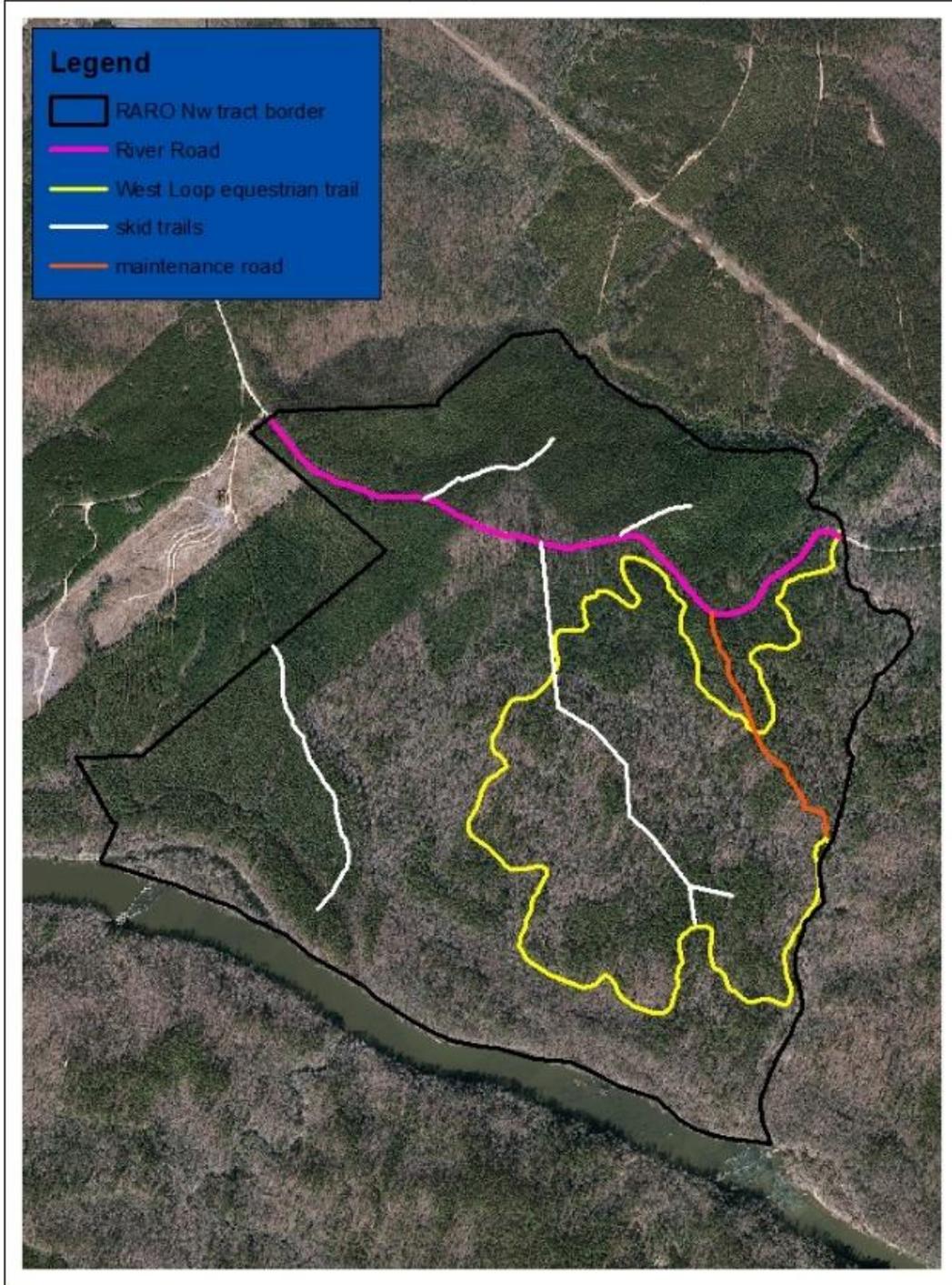


Fig. 4. Longleaf pine was likely once found at Raven Rock State Park (black dot).

Management Constraints

Some recommendations in this plan include prescribed burning. Prescribed fire in small areas may not create an issue with local residents, as RARO Nw is located in a rural area with few residential neighbors (some of whom are managing for timber as well). The tract hosts an equestrian trail (which runs through Stands 4 through 9) (Fig. 5), and the West Loop trail could be closed during and after burning.

RARO Nw - River Road, Equestrian Trail, and Skid Trails



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.125 0.25 0.5 Miles

1:13,575



Fig. 5. Various roads and trails of the tract.

The stand which is the most likely candidate for burning surrounds a short section of River Road, which could create issues, but various old skid roads and a maintenance road provide access for fire equipment and personnel (Fig. 5). Additionally, clearcut harvest close to the road could draw negative feedback from park goers, so public education may be warranted.

Additionally, large quartz and granite rocks are scattered throughout the tract, which may make harvest difficult to impossible in some areas, especially considering that granitic flatrock is a natural community which hosts annual and perennial herbaceous plants (Appendix A - NC Natural Heritage Program – Natural Heritage Element Occurrences, Natural Areas, and Managed Areas Intersecting the Project Area, West side of Raven Rock).

Background

The eastern two-thirds of the tract is a portion of the old Bradley Tract. It was purchased by the State of North Carolina in August 1974 from the Bradley Lumber Company. An additional tract which lies along the west side of the Bradley Tract was purchased from Weyerhaeuser Company in December 2002 (Christopher Brockenfelt, pers. comm., Weyerhaeuser, June 1, 2018). Earlier that same year, Weyerhaeuser acquired Willamette Industries who owned the land for several decades (Fig. 6).

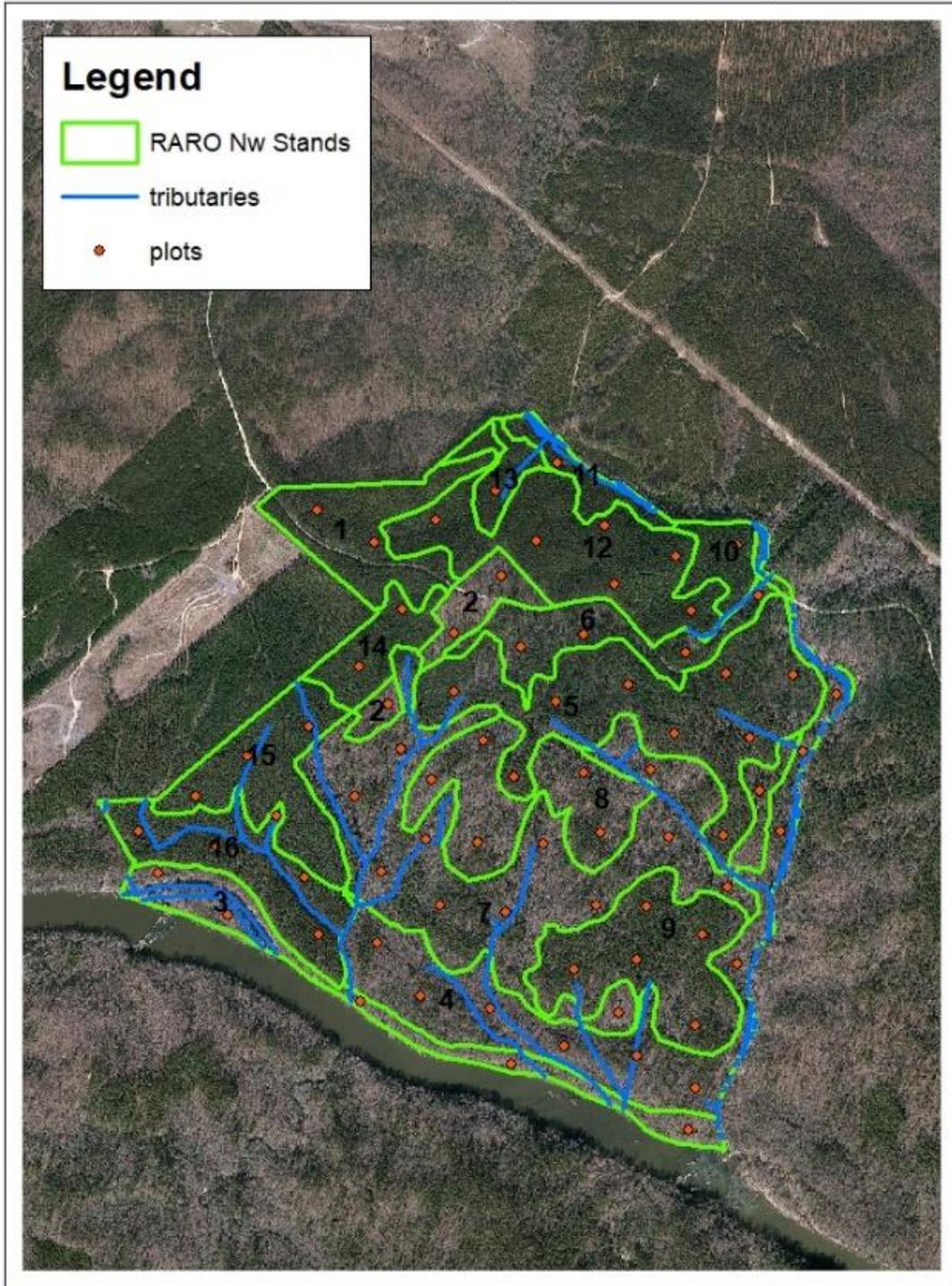


Fig. 6. An old Willamette boundary marker, near the boundary of Stands 15 and 16.

Methods

The current vegetation was mapped using ArcGIS. I used the natural community descriptions of Schafale and Weakley (1990) as a guide for delineating plant communities and guiding restoration. I installed 75 plots on the tract in a stratified random sample using SilvAssist technology, which was 0.12 plots/acre (Fig. 7). Since the main objective is ecologically- rather than economically-based, a low cruising intensity was appropriate.

RARO Nw - Plots (with tributaries)



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.125 0.25 0.5 Miles

1:15,000

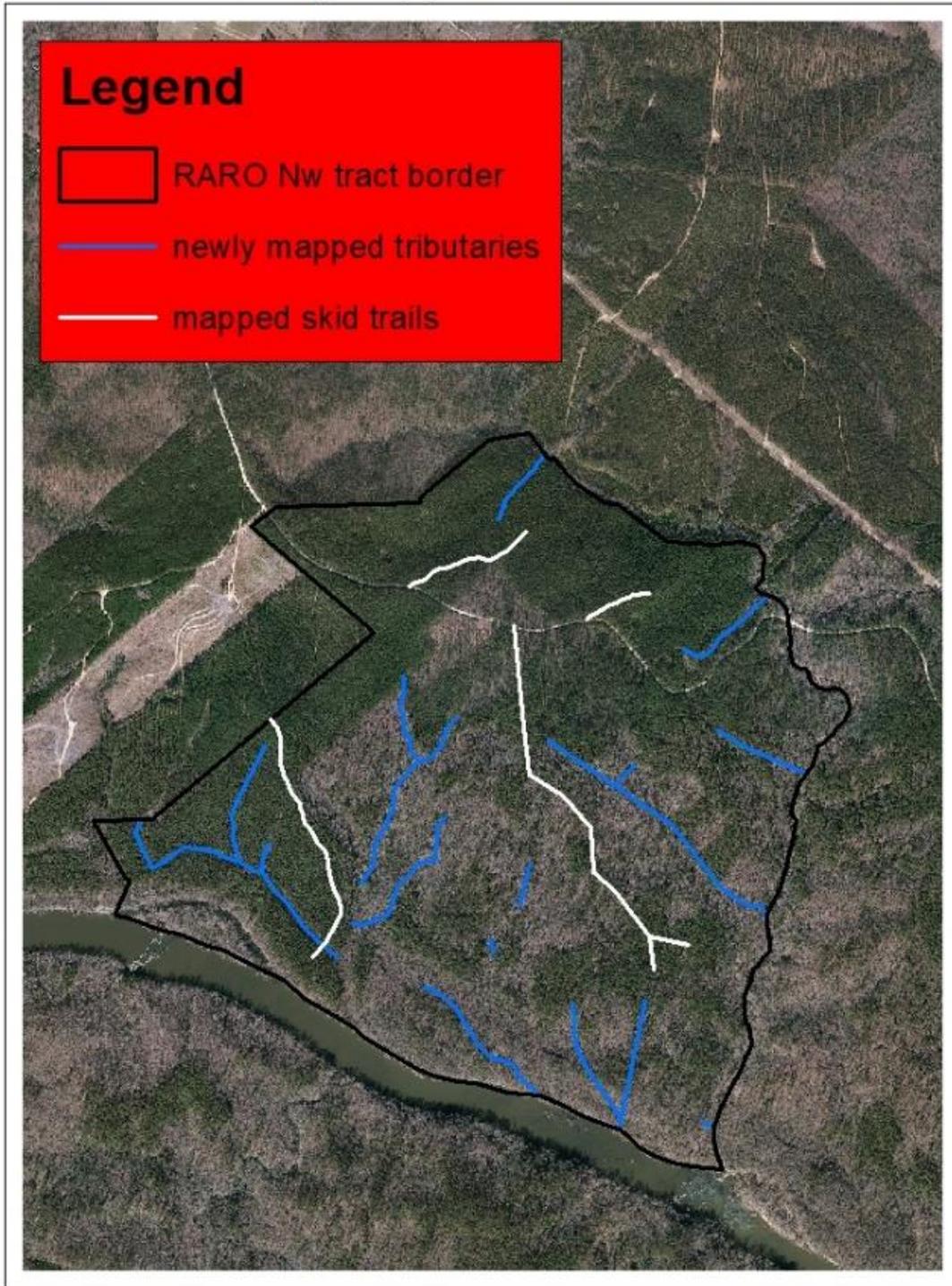


Fig. 7. Location of inventory plots.

At each sample point, I established a variable plot to measure trees over 5 inches dbh (hereafter the “overstory”), and 1/100-acre fixed plot to measure woody species under 5 inches dbh (hereafter the “understory”). Variable plots and fixed plots had the same plot center. In the variable plots, I determined BA by species. In the fixed plots, all woody individuals were counted by species. I compared the species typical of natural communities reported by Schafale and Weakley (1990) or Braun (1950) to my inventory data to guide the restoration effort.

Increment cores were taken from a dominant or co-dominant tree on every other plot in each stand to determine age. Height and diameter were measured for 1-3 dominant or co-dominant trees within each variable plot. Any lianas present were also noted by species. Additionally, for general ecological and fire management information, I measured the depth of the O-horizon, estimated the number of stumps, snags, and downed woody material, and noted the topography, aspect, and general observations in each plot. The identities of many herbaceous species found in each stand were recorded. I took photographs of unknown species for later identification. I mapped streams not shown on the USGS topographic map and mapped existing skid trails (Fig. 8).

RARO Nw - Newly Mapped Tributaries and Skid Trails



Map author: Wren Gershman
Map date: 27 February 2019
Map data source: Harnett County and NC Parks

0 0.125 0.25 0.5 Miles

1:15,000



Fig. 8. Newly mapped tributaries and mapped skid trails.

Results

Using the classification system of Schafale and Weakley (1990), the forest types on the management tract include Dry Oak-Hickory, Mesic Mixed Hardwood Forest (Piedmont Subtype), Piedmont/Mountain Bottomland (with Floodplain Pool), and Piedmont/Mountain Levee. There is also a remnant loblolly pine plantation.

Current Vegetation and Recommendations for Restoration

I identified sixteen stands that comprised the tract. These stands consist of four natural community types and a stand to be restored to longleaf pine, which are the five management units discussed below (Table 1).

Table 1. Management units, natural community types, and stands of RARO Nw.

Management Unit 1	Piedmont Longleaf Pine Forest	Stand 1
Management Unit 2	Dry Oak-Hickory Forest	Stands 2, 6, 8, 12, 14
Management Unit 3	Mesic Mixed Hardwood Forest (Piedmont Subtype) with Floodplain Pool	Stands 5, 7, 9, 10, 13, 15
Management Unit 4	Piedmont/Mountain Bottomland Forest	Stands 4, 11, 16
Management Unit 5	Piedmont/Mountain Levee Forest	Stand 3

Management Unit 1 to Be Restored to Piedmont Longleaf Pine Forest

Current Composition

This unit is comprised of Stand 1, which occupies 30.7 acres. Stand 1 is located near the northwest corner of the management tract, which is part of the loblolly plantation (Fig. 9).

RARO Nw - Stand 1

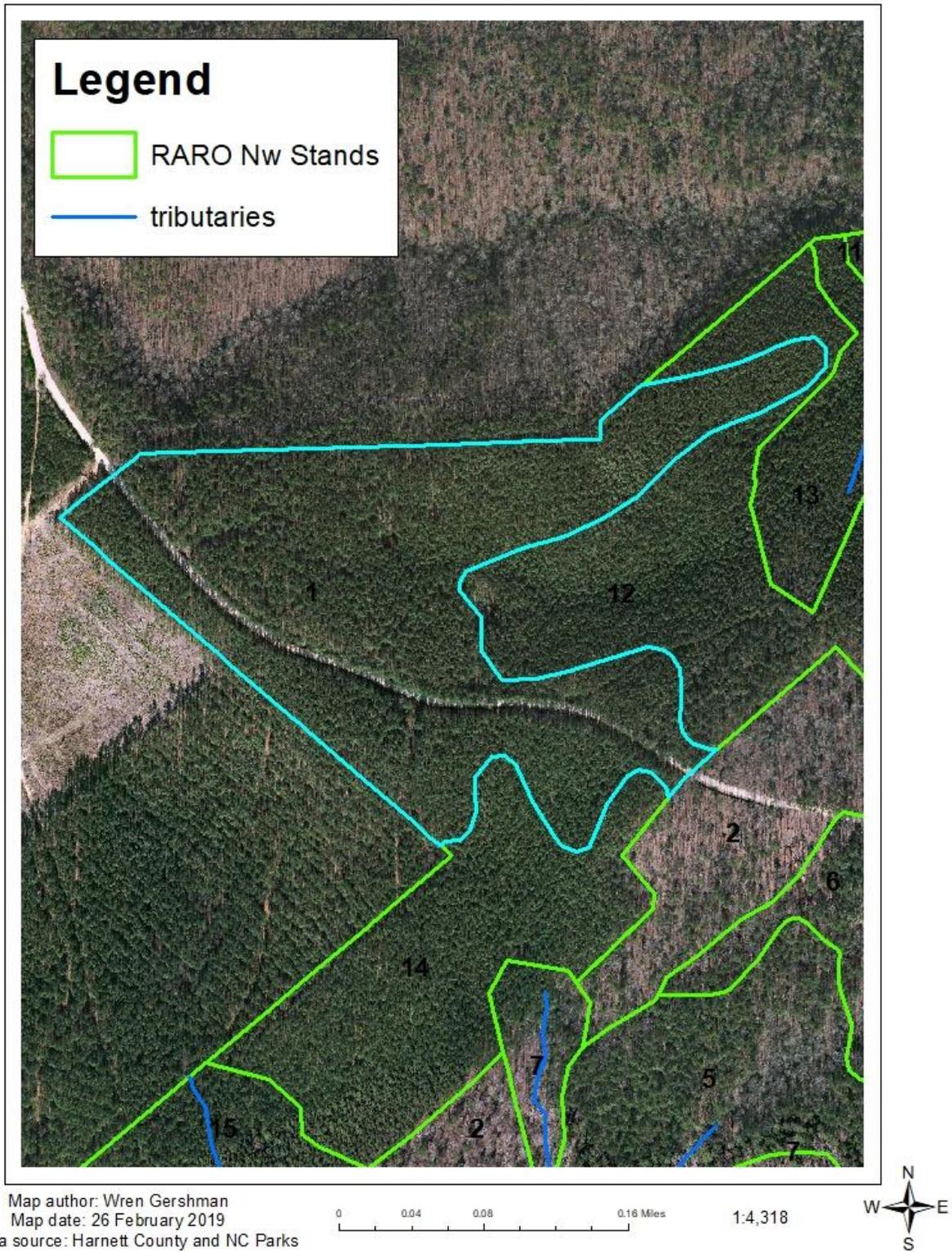
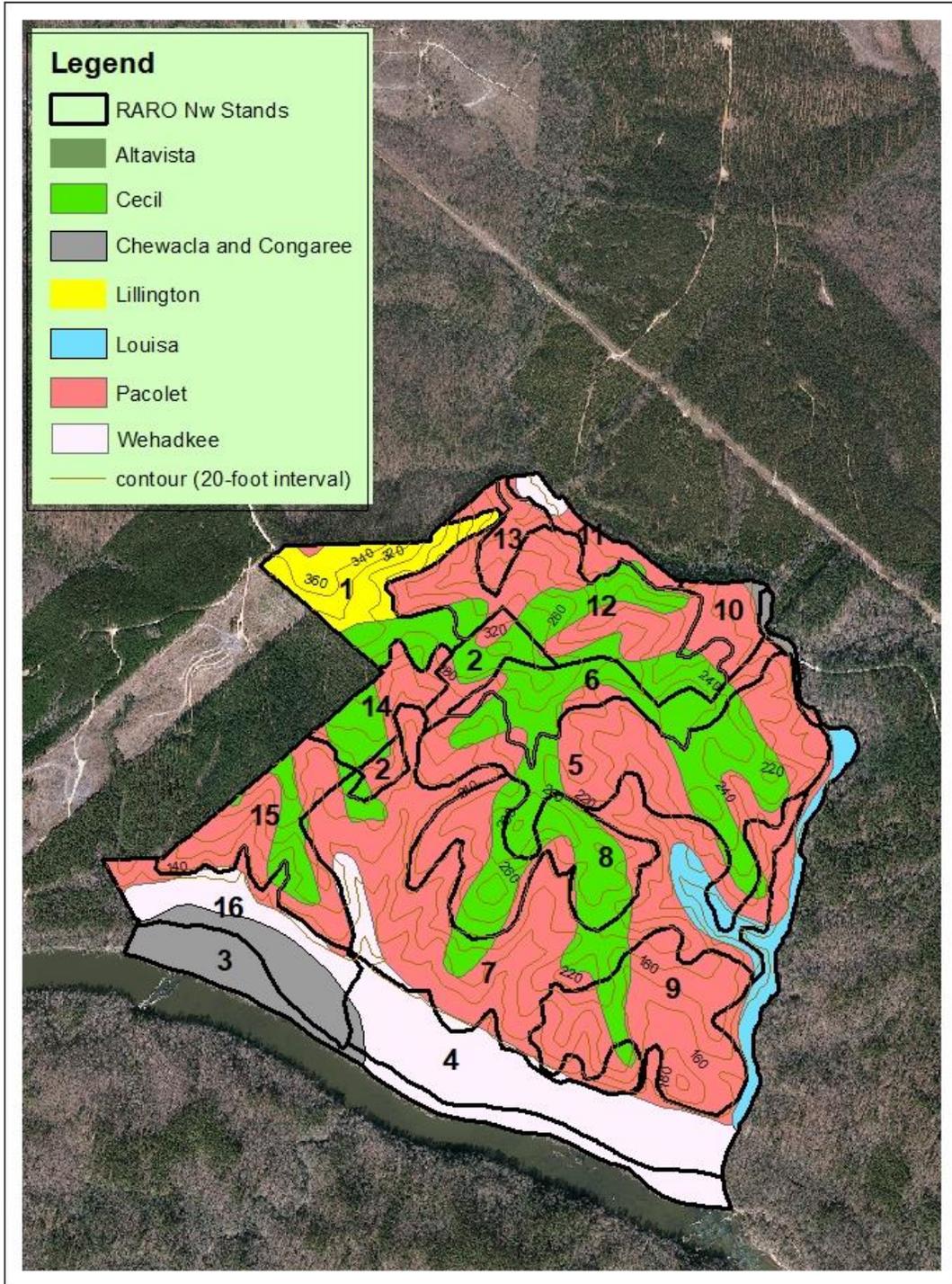


Fig. 9. Stand 1 highlighted in turquoise.

The stand is a topographical high point on the tract, ranging from 220-360 feet above MSL. The aspect of the stand is mainly east and southeast, and most of the stand lies on a ridge. No streams occur. The soil series is mostly Lillington, a well-drained sandy loam (Fig. 10). But Cecil soil also occurs in the stand along River Road (Fig. 10). Cecil is not listed in Schafale and Weakley (1990) as a soil series where longleaf was found, but it is in a similar family to those listed (Typic Hapludult). Cecil soil can support longleaf if it is well-drained (USDA, 2012).

RARO Nw - Soils and Topography



Map author: Wren Gershman
 Map date: 26 February 2019
 Map data source: Harnett County and NC Parks

0 0.125 0.25 0.5 Miles

1:15,000

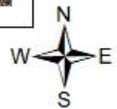
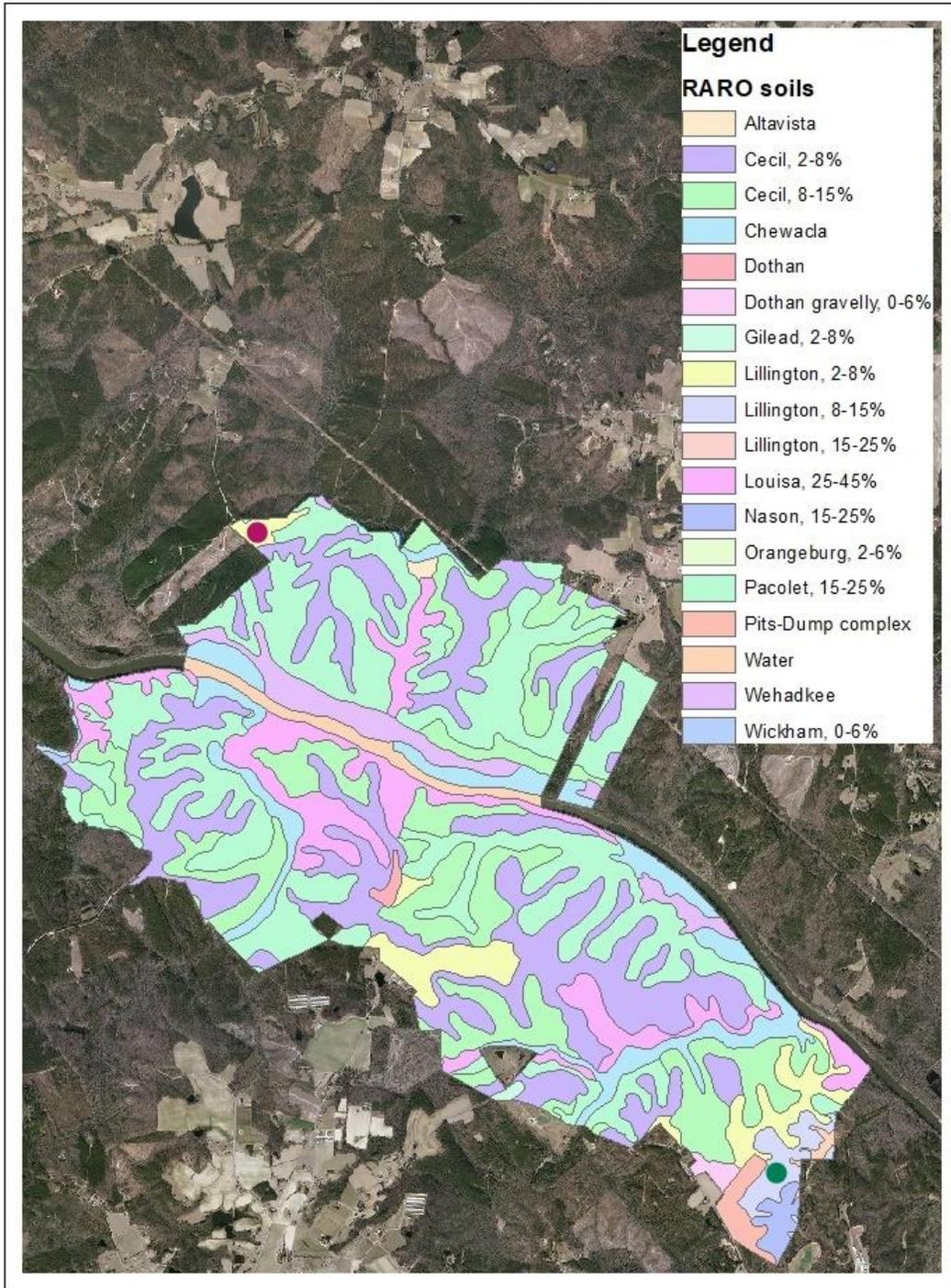


Fig. 10. Soils of RARO Nw.

All overstory trees were loblolly pine (*Pinus taeda*). The average age was 39 years, and basal area averaged 130 ft²/ac. The mean dbh of dominant and co-dominant trees was 13.8 inches, and the mean height was 79.5 feet. Half of the understory was black cherry (*Prunus serotina*), 30 percent was loblolly, and 10 percent of American holly (*Ilex opaca*) and eastern redcedar (*Juniperus virginiana*) each. Numerous smilax (*Smilax* spp.) and muscadine (*Muscadinia rotundifolia*) lianas were found in one plot with a large disturbance opening. Sweetgum (*Liquidambar styraciflua*), blueberry (*Vaccinium* spp.), beautyberry (*Callicarpa americana*), Carolina jessamine (*Gelsemium sempervirens*), and unknown grasses were also noted outside of the plots. The O-horizon was 1-1 ¼ inches thick and composed entirely of pine needles.

Stand 1 is a prime candidate for restoration to longleaf pine (*Pinus palustris*). The stand has soils, aspect and elevation similar to those seen in RARO Southeast where small populations of longleaf pine remain (Fig. 11).

RARO soils



Map author: Wren Gershman
 Map date: 12 March 2019
 Map data source: Harnett County and NC Parks

0 0.425 0.85 1.7 Miles 1:44,948



Fig. 11. Soils of Raven Rock State Park. The Lillington soil series is most prevalent in Stand 1 (purple dot), as it is where remnant longleaf is found in RARO Southeast (green dot).

These longleaf remnants, some with diameters over 20 inches, exist where it was probably too inaccessible to harvest (Jimmy Dodson, pers. comm., NC Parks, June 21, 2018). Raven Rock State Park is on the fringes of the western range of longleaf on the Atlantic seaboard (Fig. 12).

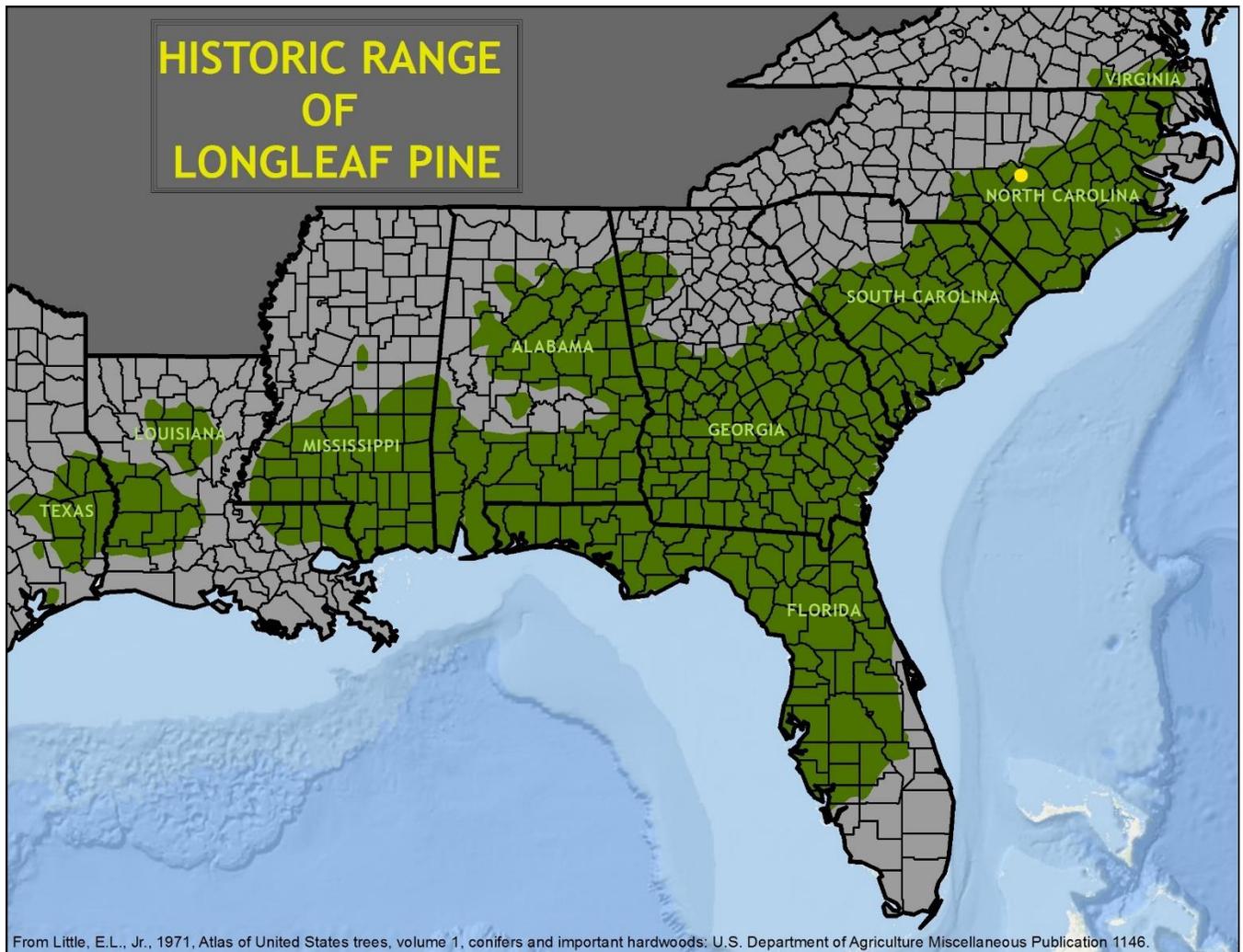


Fig. 12. Raven Rock State Park (yellow dot) is on the western edge of the historic range of longleaf.

Blank (2004) researched the history of longleaf pine on the Shearon Harris Tract, which is approximately 10 miles northwest of Raven Rock State Park, and where natural longleaf has been found. On both sites, longleaf is intermixed with other pines and hardwoods, which was typical of longleaf in the Piedmont. Additionally, Dr. Michael Schafale (pers. comm., NC Natural Heritage Program, Dec. 2018) suggested that longleaf was more likely to occur on drier, flat upland areas where fire would easily spread.

Longleaf may have been dominant on 85 percent of the uplands in its historical range prior to exploitation (Walker, 2000). Exact percentages of longleaf within these forests is unknown.

Oak was likely a notable component in transitional longleaf forests (Schafale and Weakley, 1990). The natural longleaf found on RARO Southeast is associated with black oak (*Quercus velutina*), southern red oak (*Quercus falcata*), post oak (*Quercus stellata*), white oak (*Quercus alba*), some hickories (*Carya* spp.). The understory is open woodlands, with Indian grass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), split beard bluestem (*Andropogon ternarius*), and other *Andropogon* spp. (Jimmy Dodson, pers. comm., NC Parks, June 21, 2018). Where longleaf is not found, shortleaf pine (*Pinus echinata*) occurs with blueberry (*Vaccinium* spp.), including farkleberry (*Vaccinium arboreum*), and huckleberry (*Gaylussacia frondosa*).

Restoration Prescription

Historically found largely in bottomlands, pioneer species such as loblolly and sweetgum now occur in the overstory, understory, and possibly in the seed bank on this site. These species may regenerate the area when the overstory loblolly and sweetgum are harvested. The understory does not contain oak or hickory regeneration but did have generalist species such as black cherry, holly, and red maple. Therefore, the silvicultural prescription is to burn 6-8 years prior to harvest to reduce competition (Hamilton, 2014). The thick O-horizon and grasses will carry the fire. Burning should be followed by clearcut harvest. Containerized longleaf seedlings should be planted in sinuous rows (for a natural appearance) with a spacing of approximately 7 x 10 (622 trees per acre) (Franklin, 2009). After planting, herbicide treatment should be used to control the hardwood competition. At 15-20 years, when the longleaf is established in the overstory and the O-horizon sufficient to carry a fire, prescribed burns should be performed every 1-4 years to control competition. Longleaf burned at this interval prior to colonization (Stanturf et al., 2002).

Oak and hickory likely have not persisted in the seedbank, as evident by both the overstory and understory vegetation. However, oak and hickory regeneration was seen in adjacent stands and seeds may be dispersed by wildlife over time into this stand.

Management Unit 2 to Be Restored to Dry Oak-Hickory Forest

According to Schafale and Weakley (1990), Dry Oak-Hickory Forest is dominated by white oak, southern red oak, and post oak, with a mixture of other dry oak and hickory species (Schafale and Weakley, 1990) (Table 2).

Table 2. Dry-Oak Hickory overstory and understory species and shrubs (Schafale and Weakley, 1990).

Dry-Oak Hickory primary overstory	<i>Quercus alba</i>	white oak
	<i>Quercus falcata</i>	southern red oak
	<i>Quercus stellata</i>	post oak
Dry-Oak Hickory secondary overstory	<i>Quercus montana</i>	chestnut oak
	<i>Quercus marilandica</i>	blackjack oak
	<i>Quercus coccinea</i>	scarlet oak
	<i>Quercus velutina</i>	black oak
	<i>Carya tomentosa</i>	mockernut hickory
	<i>Carya glabra</i>	pignut hickory
	<i>Carya glabra</i> var. <i>odorata</i>	red hickory
	<i>Pinus</i> spp.	pine
Dry-Oak Hickory understory and shrubs	<i>Oxydendrum arboreum</i>	sourwood
	<i>Acer rubrum</i>	red maple
	<i>Nyssa sylvatica</i>	blackgum
	<i>Cornus florida</i>	flowering dogwood
	<i>Vaccinium arboreum</i>	farkleberry
	<i>Vaccinium</i> spp.	blueberry

The data for Stands 2, 6, and 8 were pooled and averaged together. Data for Stands 12 and 14 were pooled and averaged together because the latter have loblolly dominant in the overstory. Excluding the plantations, my inventory showed oak (*Quercus* spp.) (Fig. 13) and pine (*Pinus* spp.) overstory, with pecan (*Carya illinoensis*) the only hickory species within the plots (Table 3).



Fig. 13. Black oak (*Quercus velutina*) with interesting bark on the border of Stands 2 and 14.

Table 3. Inventory data for overstory species in Management Unit 2, Stands 2, 6, and 8.

scientific name	common name
<i>Acer floridanum</i>	southern sugar maple
<i>Acer rubrum</i>	red maple
<i>Carya illinoensis</i>	pecan
<i>Juniperus virginiana</i>	eastern redcedar
<i>Liquidambar styraciflua</i>	sweetgum
<i>Pinus echinata</i>	shortleaf pine
<i>Pinus taeda</i>	loblolly pine
<i>Quercus alba</i>	white oak
<i>Quercus falcata</i>	southern red oak
<i>Quercus velutina</i>	black oak

Dry Oak-Hickory Stands in Management Unit 2

Stands 2, 6, and 8 are forested with the Dry Oak-Hickory Forest, totaling 79.4 acres. The soil series were Cecil and Pacolet (Fig. 10), with elevations ranging from 180-360, and mainly south aspects (Table 4). The average age, dbh and height of dominant trees for all stands was 80.2 years, 19.9 inches and 87 feet, respectively, and average basal area was 123 ft²/ac (Table 4).

Table 4. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stands 2, 6, and 8.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
2	14.9	Cecil, Pacolet	220-320	SE	90.5	19.5	79.5	120
6	22.9	Cecil, Pacolet	180-260	S, SE	93.7	22.0	96.5	145
8	41.6	Cecil, Pacolet	200-280	S, SE, SW	56.5	18.3	84.9	104
TOTAL	79.4			AVERAGE	80.2	19.9	87.0	123

In upland natural communities of the Piedmont of North Carolina, the percentage of white oak (*Quercus alba*) in a stand should be approximately 44 percent (Braun, 1950). White oak, at 41 ft²/ac across the three stands, was well-represented in the overstory (Table 5), but still only averaged 33 percent (although the range was from 6 to 71 percent of the basal area for each stand). Hickory was not seen in the overstory plots. Both oaks and hickories were few in the understory, while holly and red maple (*Acer rubrum*) at 24 percent and 16 percent, respectively, were plentiful (Table 6). The hickory overstory should be 32 percent and understory should be 20 percent, and other (red) oaks should comprise 1-8 percent of the understory according to Braun (1950).

In Stand 6, loblolly represented 64 ft²/ac, which was 44 percent of the basal area of the stand, and an average of 22 ft²/ac across all three stands, 18 percent of the basal area, which is much more than the 1 percent historically seen (Braun, 1950). Shortleaf was 31 ft²/ac of the overstory basal area. Additional tree species seen in the overstory of these stands were blackgum (*Nyssa sylvatica*) and chestnut oak (*Quercus montana*).

Table 5. Overstory basal area (ft²/ac) by species in Stands 2, 6, and 8.

overstory	BA average across stands, ft ² /ac	Stand 2 BA, ft ² /ac	Stand 6 BA, ft ² /ac	Stand 8, BA, ft ² /ac
<i>Quercus alba</i>	41	40	9	74
<i>Pinus echinata</i>	31	40	40	12
<i>Pinus taeda</i>	22	0	64	3
<i>Quercus falcata</i>	9	10	18	0
<i>Liquidambar styraciflua</i>	4	0	4	7
<i>Acer rubrum</i>	3	10	0	0
<i>Carya illinoensis</i>	3	10	0	0
<i>Ulmus americana</i>	3	10	0	0
<i>Ilex opaca</i>	2	0	0	5
<i>Juniperus virginiana</i>	2	0	7	0
<i>Acer floridanum</i>	1	0	0	3
<i>Quercus velutina</i>	1	0	4	0

Dogwood and sourwood, which formerly occurred in the understory in this community at rates of about 31 and 24 percent, respectively (Braun, 1950), are now outcompeted by fire-intolerant species such as red maple and holly (Table 6). Red maple was once only five percent of this forest, sweetgum was 0.2 percent, and holly is not listed as a species (Braun, 1950).

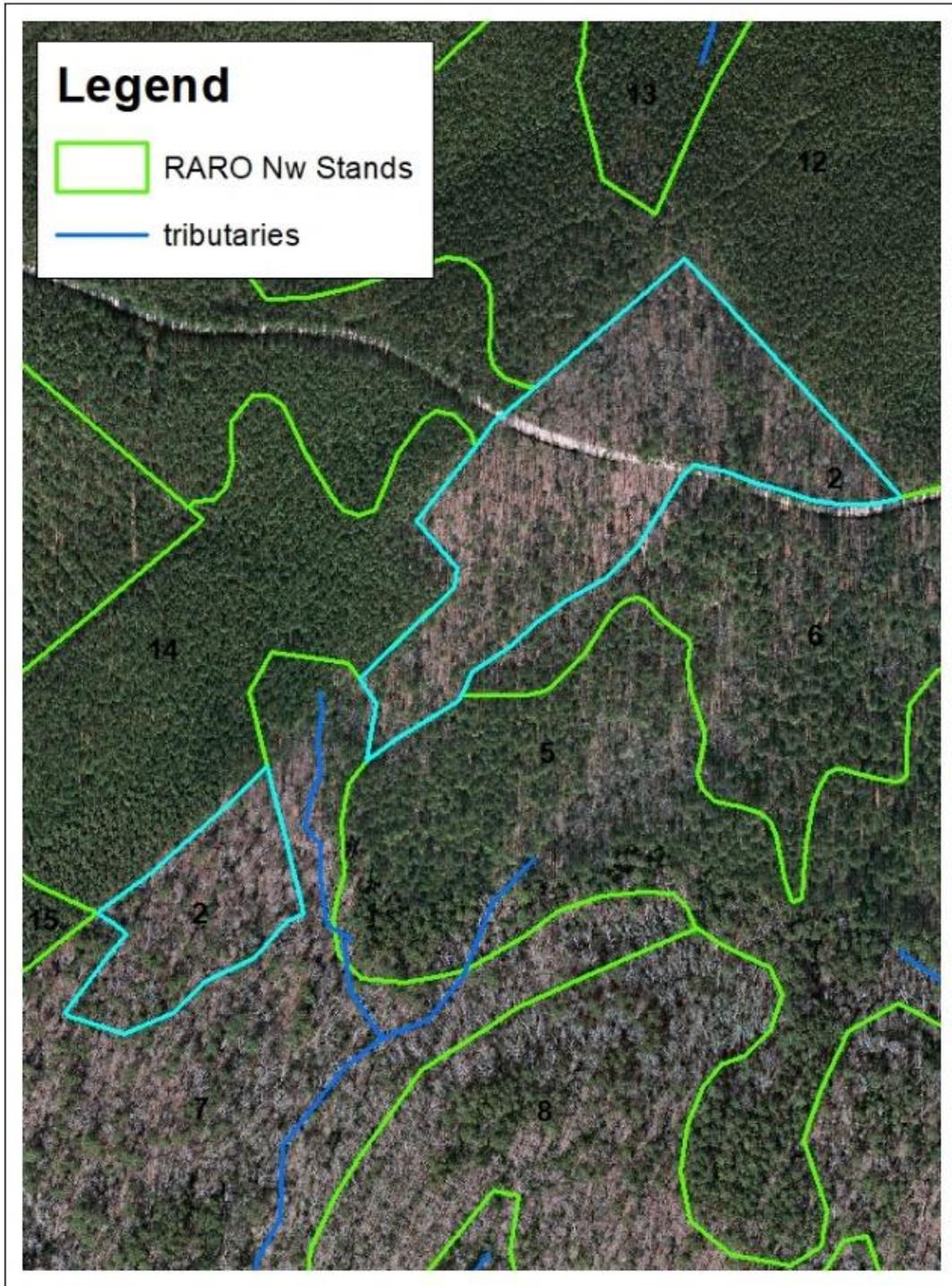
Table 6. Dry Oak-Hickory Forest understory species percentage average for Stands 2, 6, and 8.

understory	percentage average across stands	Stand 2 percentage	Stand 6 percentage	Stand 8 percentage
<i>Acer rubrum</i>	23.8	20.0	28.3	23.2
<i>Ilex opaca</i>	16.0	0	29.2	18.7
<i>Vaccinium</i> spp.	14.4	23.3	0	20.0
<i>Ulmus americana</i>	8.9	26.7	0	0
<i>Nyssa sylvatica</i>	6.1	10.0	8.3	0
<i>Acer floridanum</i>	5.9	0	0	17.7
<i>Oxydendrum arboreum</i>	5.6	0	10.0	6.7
<i>Liquidambar styraciflua</i>	5.0	0	8.3	6.7
<i>Quercus rubra</i>	3.9	3.3	8.3	0
<i>Juniperus virginiana</i>	3.0	0	5.0	4.0
<i>Cornus florida</i>	2.2	6.7	0	0
<i>Quercus velutina</i>	2.2	6.7	0	0
<i>Quercus stellata</i>	1.1	3.3	0	0
<i>Ulmus</i> spp.	0.8	0	2.5	0
<i>Carya</i> spp.	0.5	0	0	1.5
<i>Fraxinus</i> spp.	0.5	0	0	1.5

Current Composition

Stand 2 is intersected by River Road, as well as by a portion of Stand 7 (Fig. 14). The stand is in a late successional stage, although one plot was dominated by shortleaf pine. Besides the species found within overstory plots, I also observed blackgum, sourwood, and chestnut oak (Fig. 15), and lesser amounts of beautyberry, persimmon (*Diospyros virginiana*), sweetgum, and winged elm (*Ulmus alata*). Pawpaw (*Asimina* spp.) was present in all stands. The lianas present were Carolina jessamine, muscadine, Virginia creeper (*Parthenocisscus quinquefolia*), and smilax. Herbaceous species included ebony spleenwort (*Asplenium platyneuron*), other ferns, wild ginger (*Hexastylis* spp.), Indian pipe (*Monotropa uniflora*), wingstem (*Verbesina* spp.), and unknown grasses. The O-horizon was 1 ½ inches thick pine in one plot only, the middle portion of the stand, just south of River Road.

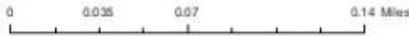
RARO Nw - Stand 2



Legend

-  RARO Nw Stands
-  tributaries

Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks



1:3,750



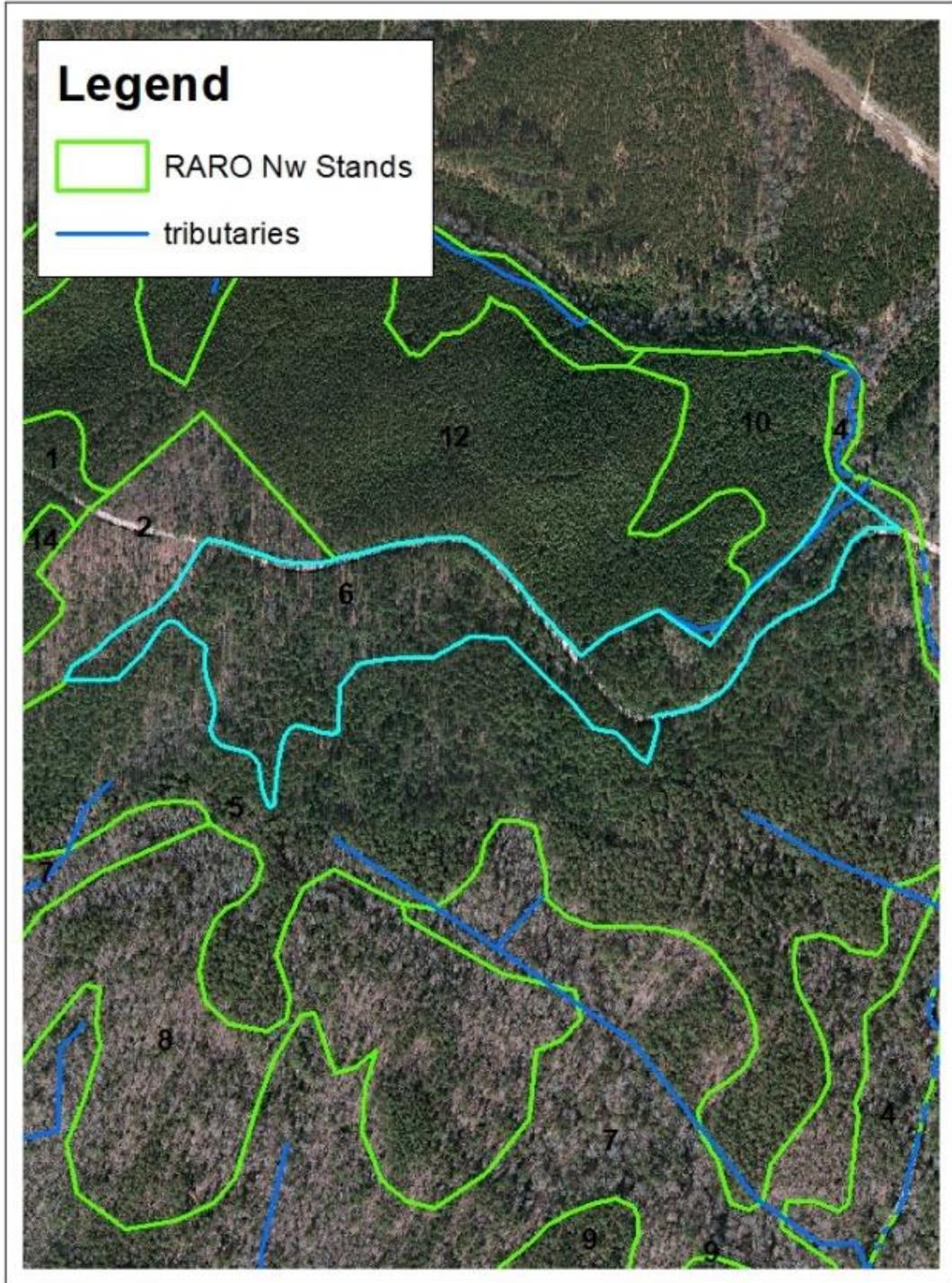
Fig. 14. Stand 2 highlighted in turquoise.



Fig. 15. Chestnut oak in Stand 2.

Stand 6 is partially both bordered and divided by River Road (Fig. 16). The stand is in a late successional stage, with senescing loblolly and shortleaf pine. In addition to the understory vegetation, southern red oak was present. The stand included Carolina jessamine, muscadine, smilax, Christmas fern (*Polystichum acrostichoides*), and wild ginger. The O-horizon was ½-2 inches thick with pine and hardwood litter.

RARO Nw - Stand 6



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.05 0.1 0.2 Miles

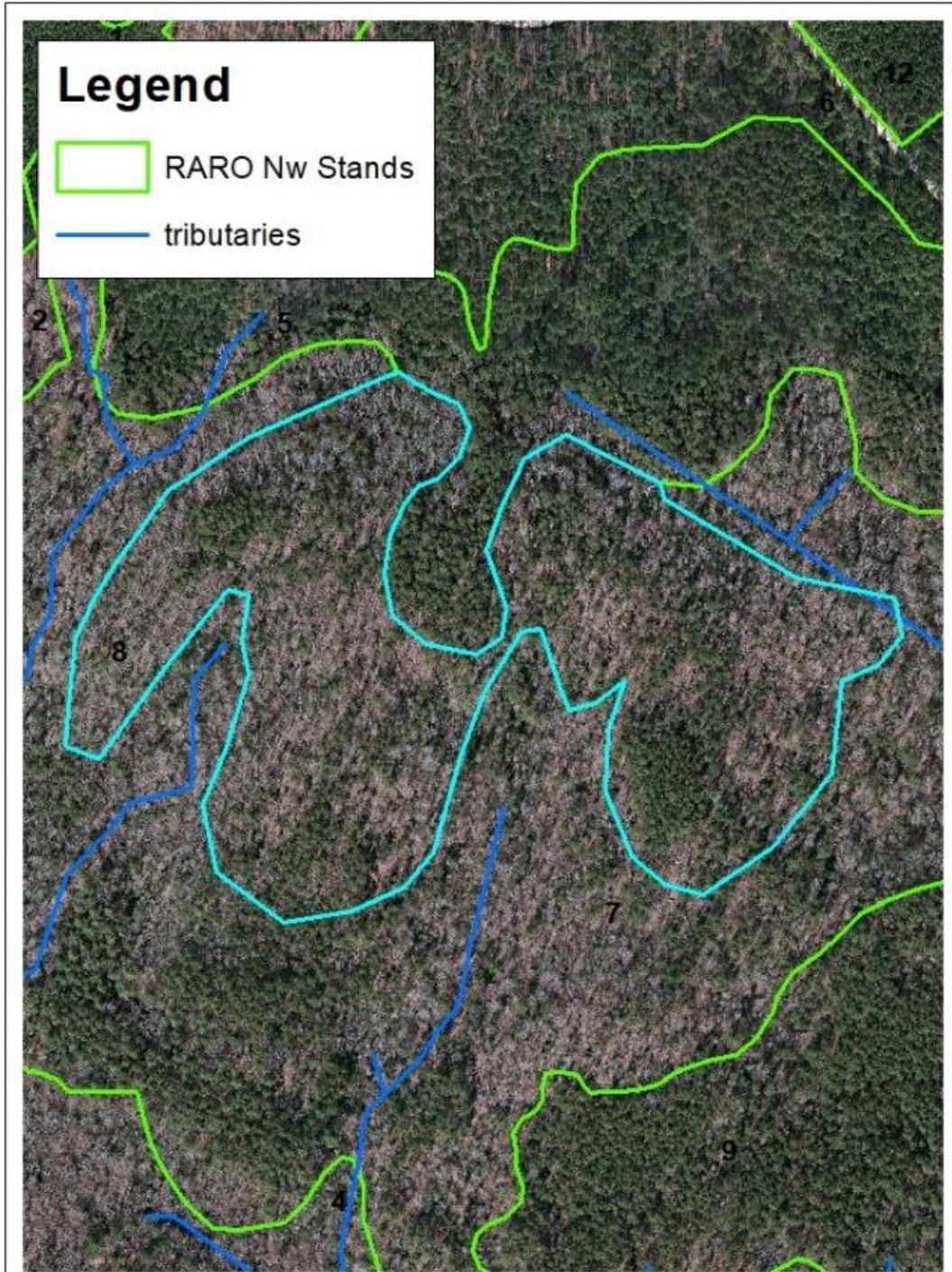
1:6,102



Fig. 16. Stand 6 highlighted in turquoise.

Stand 8 is 41.6 acres, and located in the center of the tract (Fig. 17). The stand is in a mid-successional stage, transitioning from pine to hardwood dominance. There are 3 acres of remnant loblolly-dominated overstory on the eastern side of the stand. In addition to the species that fell in the plots, I observed blackgum, scarlet oak (*Quercus coccinea*), chestnut oak, farkleberry, and blueberry. Muscadine, smilax (*Smilax glauca*), poison-ivy (*Toxicodendron radicans*), and wild ginger were also seen. The O-horizon was ¼-1 inch and mostly hardwood. More than half of the plots were located on ridgetops.

RARO Nw - Stand 8



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.0425 0.085 0.17 Miles

1:4,503



Fig. 17. Stand 8 highlighted in turquoise.

Restoration Prescription

Although red maple is naturally found in the understory of this community, it was never dominant at 5 percent (Braun, 1950). The lack of burning has led to an increased abundance of red maple and holly. Therefore, I recommend that prior to other management, Stand 6 should be burned to reduce the red maple and holly understory. Stands 2 and 8 do not have enough (pine) O-horizon to carry a fire, so hack-and-squirt of red maple, holly, and sweetgum with imazapyr is recommended during the growing season (Lambert et al., 2016). All holly and sweetgum should be killed, and all red maple should be killed in the overstory. In Stand 2, treat three of four red maple; and in Stand 8, treat four of five in the understory to reduce the understory to 5 percent (Braun, 1950).

Additionally, the shortleaf pine overstory should be untouched in Stands 2, 6, and 8 for shortleaf restoration and for cavity trees for the federally-endangered red-cockaded woodpecker (*Leuconotopicus borealis*) (USFS). Stand 2 should be otherwise left to natural succession.

Although the ecological conditions in the northwestern part of Stand 6 are similar to those found on RARO Southeast where longleaf occurs (Cecil and Pacolet soil series, 200 feet above MSL, southeastern aspect), the recommendation is to girdle all of the loblolly. Loblolly should be girdled at a rate of 10 percent of the loblolly basal area of each stand per year each year for ten years. The reason to stagger girdling is to have snags for wildlife habitat for a longer period of time, and to not open up the canopy to light all at once, which would stress the understory or release undesirable, intolerant species. Smaller amounts of light would better facilitate the release of the oak and hickory, species which are more tolerant of shade than loblolly is (USFS). Girdling at the rate recommended would ultimately create an effect similar to femelschlag, which favors the succession of mid-tolerant species. The exception to girdling loblolly would occur within a 100-foot buffer of the West Loop equestrian trail. In that location, the loblolly should be felled for the safety of the public traveling the trail. Otherwise, harvesting loblolly pine to plant longleaf would likely disturb the O-horizon and damage the understory oaks and other hardwoods. Additionally, while clearcutting the stand might allow the coppiced hardwood to grow into the next stand, as well as profit NC State Parks financially, it would likely invite criticism from the public. As Stand 6 is adjacent to the east of Stands 1 and 14, where longleaf restoration is recommended, longleaf is likely to volunteer in Stand 6 over time. Longleaf is shade-intolerant and fire-tolerant. Therefore, if longleaf volunteers into Stand 6, the recommendation is to burn to favor longleaf.

For Stand 8, the recommendation is to leave the stand alone, allowing succession to continue. As with Stand 6, longleaf is likely to volunteer in Stand 8 in a gradient across the tract over time, but only if fire is used. Again, longleaf is intolerant of shade and thrives in a frequent fire regime that reduces competition, so the stand should be burned if longleaf volunteers in.

Stands of Loblolly with Oak-Hickory Understory in Management Unit 2

Stands 12 and 14 are loblolly plantations with an oak-hickory understory, totaling 67.2 acres. The soil series are Cecil and Pacolet (Fig. 10), with elevations ranging from 200-300, and both northeasterly and southeasterly aspects (Table 7). The average age, dbh and height of

dominant trees for all stands were 36.7 years, 11 inches and 82.2 feet, respectively (Table 7), and average basal area was 244 ft²/ac.

Table 7. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stands 12 and 14.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
12	52.5	Cecil, Pacolet	200-300	NE	35.3	10.8	79.8	207
14	14.7	Cecil, Pacolet	220-300	SE	38.0	11.1	84.5	280
TOTAL	67.2			AVERAGE	36.7	11.0	82.2	244

Loblolly and sweetgum were the overstory species present (Table 8).

Table 8. Overstory basal area (ft²/ac) by species in Stands 12 and 14.

overstory (loblolly-dominated)	BA average across stands, ft ² /ac	Stand 12 BA, ft ² /ac	Stand 14 BA, ft ² /ac
<i>Pinus taeda</i>	224	207	240
<i>Liquidambar styraciflua</i>	20	0	40

The prevailing understory species were black cherry at 33.1 percent (mostly in Stand 14) and red maple at 32 percent (Table 9). However, white oak, black oak, and assorted other oak species and hickory were present. Additional (outside of plots) understory species had included hickory and oak.

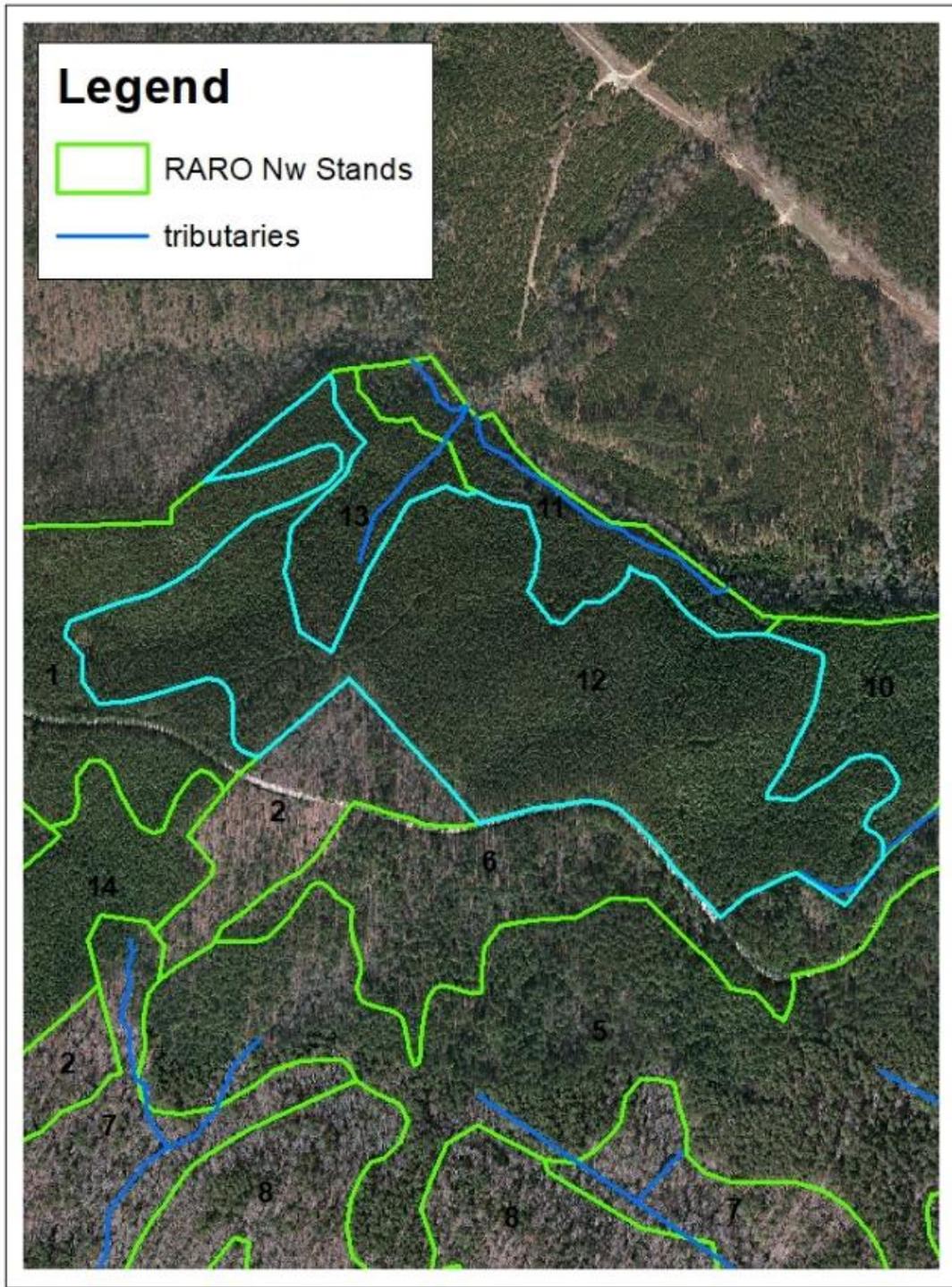
Table 9. Dry Oak-Hickory Forest understory species percentage average for Stands 12 and 14.

understory (with loblolly-dominated overstory)	percentage average across stands	Stand 12 percentage	Stand 14 percentage
<i>Prunus serotina</i>	33.1	3.7	62.5
<i>Acer rubrum</i>	32.0	32.6	31.3
<i>Carya</i> spp.	8.4	16.7	0
<i>Liquidambar styraciflua</i>	6.7	13.4	0
<i>Quercus</i> spp.	4.1	1.9	6.3
<i>Cornus florida</i>	3.2	6.3	0
<i>Quercus alba</i>	1.0	1.9	0
<i>Quercus velutina</i>	1.0	1.9	0
<i>Pinus taeda</i>	0.9	1.8	0
<i>Vaccinium</i> spp.	0.9	1.7	0
<i>Ilex opaca</i>	0.5	0.9	0
<i>Nyssa sylvatica</i>	0.5	0.9	0

Current Composition

Stand 12 is in the north-central portion of the tract (Fig. 18). Winterberry (*Ilex decidua*), cane (*Arundinaria* spp.), wild ginger, and jack-in-the-pulpit (*Arisaema triphyllum*) were noticed near the eastern border of the stand (adjacent to more mesic areas). The lianas in the stand were Carolina jessamine, muscadine, Virginia creeper, and smilax. The O-horizon was generally 1 ¼-2 inches thick pine.

RARO Nw - Stand 12



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.05 0.1 0.2 Miles

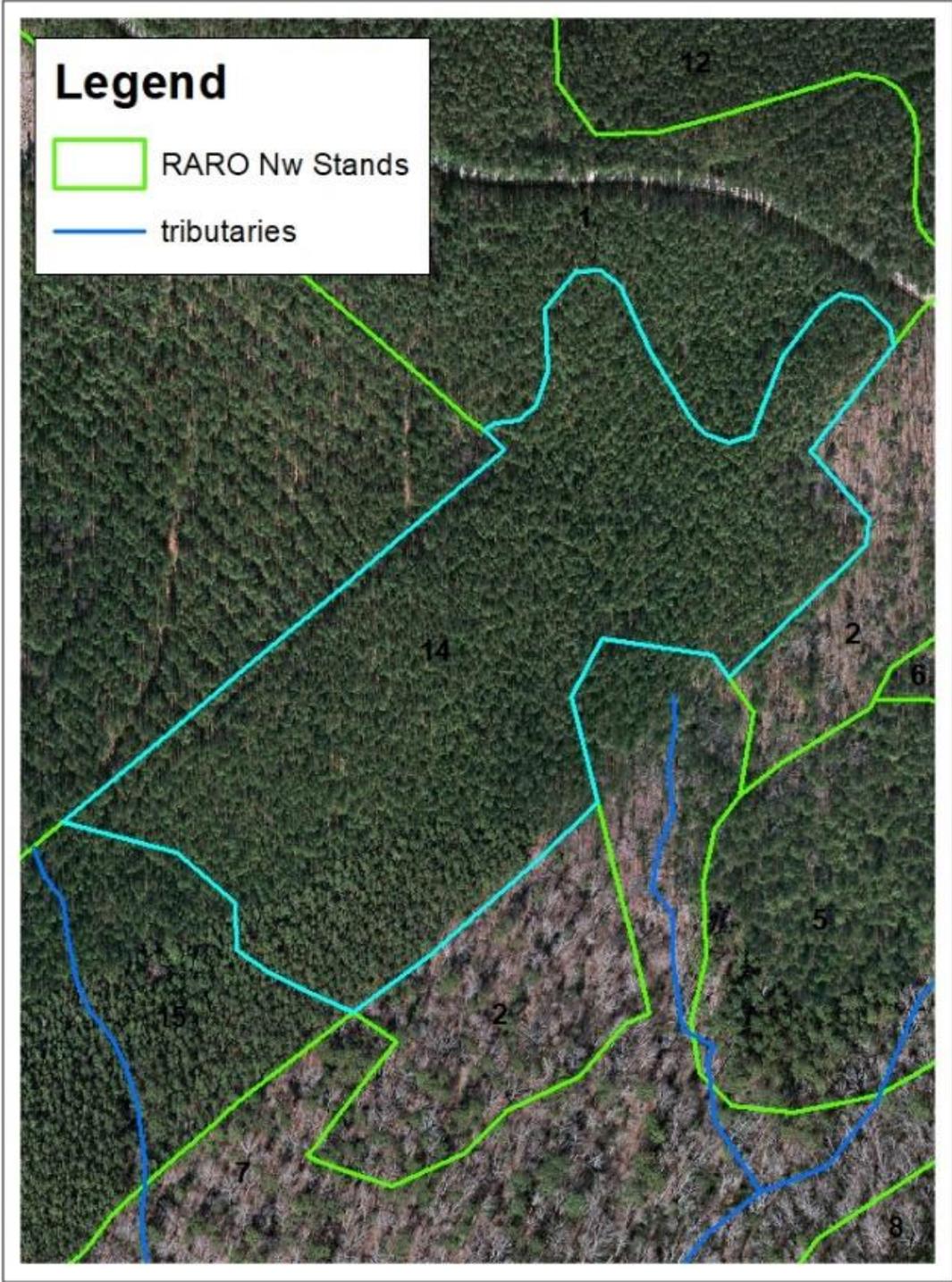
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Fig. 18. Stand 12 highlighted in turquoise.

Stand 14 is located in the west-central portion of the tract (Fig. 19). Beautyberry was prevalent in the stand but outside of the plots. The only liana seen in the stand was trumpet creeper (*Campsis radicans*). The herbaceous vegetation included wild ginger and unknown grasses. The O-horizon was about ½ inch thick pine.

RARO Nw - Stand 14



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.025 0.05 0.1 Miles

1:2,610



Fig. 19. Stand 14 highlighted in turquoise.

Restoration Prescription

In Stand 12, the recommendation to release the oak and hickory understory is to remove the overstory loblolly and sweetgum, as well as the understory red maple and sweetgum, with triclopyr during the active growing season with the hack-and-squirt method. All sweetgum and six of seven red maple should be killed to reduce the red maple understory to 5 percent (Braun, 1950). Burning is not recommended because the O-horizon was mostly 1 ¼-2 inches thick, and fire would stress or kill too many of the desirable understory species.

I recommend the northern portion of Stand 14 be reserved for longleaf restoration based on similar abiotic ecological factors to where longleaf is found on RARO Southeast (Cecil soil series about 280 feet above MSL; and south to southeast aspect). This is also where the oak and hickory understory was found. In order to preserve the next overstory, the loblolly should be girdled at a rate of ten percent of the total loblolly basal area per stand annually for ten years. As in Stand 6, loblolly should not be clearcut due to public disapproval for such practices on state land. Girdling would still release the understory. Stand 14 is adjacent and south of Stand 1, so longleaf may natural regenerate over time. The canopy is closed now, but after the loblolly snags fall and decay, control of the weedy hardwood competition should occur as prescribed in Stand 12. However, imazapyr should be used instead of triclopyr to protect hickory understory (Lambert et al., 2016). As in Stands 6 and 8, Stand 12 should be burned after longleaf volunteers in.

The southern portion of the stand's overstory should also be controlled with herbicides, as prescribed in Stand 12. The red maple and sweetgum understory should also be chemically controlled with imazapyr as in the northern portion of this stand. This should release the oak and hickory understory. All sweetgum and five of six red maple should be killed to reduce the red maple understory to 5 percent (Braun, 1950).

Management Unit 3 to Be Restored to Mesic Mixed Hardwood Forest (Piedmont Subtype)

American beech (beech) (*Fagus grandifolia*), yellow-poplar (*Liriodendron tulipifera*), and northern red oak (*Quercus rubra*), among other species, dominate the overstory of the Mesic Mixed Hardwood Forest (Piedmont Subtype) (Schafale and Weakley, 1990) (Table 10).

Table 10. Mesic Mixed Hardwood (Piedmont Subtype) overstory and understory species and shrubs (Schafale and Weakley, 1990).

Mesic Mixed Hardwood (Piedmont Subtype) dominant overstory	<i>Fagus grandifolia</i>	American beech
	<i>Quercus rubra</i>	northern red oak
	<i>Liriodendron tulipifera</i>	yellow-poplar
	<i>Acer rubrum</i>	red maple
	<i>Acer floridanum</i>	southern sugar maple
Mesic Mixed Hardwood (Piedmont Subtype) understory and shrubs	<i>Cornus florida</i>	flowering dogwood
	<i>Ostrya virginiana</i>	hophornbeam
	<i>Acer rubrum</i>	red maple
	<i>Ilex opaca</i>	American holly
	<i>Vaccinium</i> spp.	blueberry
	<i>Viburnum rafinesquianum</i>	downy arrowwood
	<i>Euonymus americanus</i>	strawberry bush
	<i>Kalmia latifolia</i>	mountain laurel

In RARO Nw, this forest type included Stands 5, 7, 9, 10, 13, and 15. The data for Stands 5, 7, and 9 were pooled because they are natural Mesic Mixed Hardwood Forest (Piedmont Subtype), and 10, 13, and 15 were pooled because they have loblolly-dominated overstory with Mesic Mixed Hardwood (Piedmont Subtype) understory. These stands hosted a wide range of overstory species (Table 11).

Table 11. Inventory data for overstory species in Management Unit 3, Stands 5, 7, and 9.

scientific name	common name
<i>Acer floridanum</i>	southern sugar maple
<i>Acer rubrum</i>	red maple
<i>Carya</i> spp.	hickory
<i>Carya tomentosa</i>	mockernut hickory
<i>Fagus grandifolia</i>	American beech
<i>Ilex opaca</i>	American holly
<i>Juniperus virginiana</i>	eastern redcedar
<i>Liquidambar styraciflua</i>	sweetgum
<i>Liriodendron tulipifera</i>	yellow-poplar
<i>Oxydendrum arboreum</i>	sourwood
<i>Pinus echinata</i>	shortleaf pine
<i>Pinus taeda</i>	loblolly pine
<i>Quercus alba</i>	white oak
<i>Quercus coccinea</i>	scarlet oak
<i>Quercus falcata</i>	southern red oak
<i>Quercus rubra</i>	northern red oak
<i>Quercus</i> spp.	oak
<i>Quercus stellata</i>	post oak
<i>Ulmus alata</i>	winged elm
<i>Ulmus</i> spp.	elm

Mesic Mixed Hardwood Stands in Management Unit 3

Stands 5, 7, and 9 are forested with the Mesic Mixed Hardwood Forest, with a total of about 250 acres. The soil series are Cecil, Pacolet, Louisa, and Wehadkee (Fig. 10), with elevations ranging from 140-220 feet above MSL, and mainly southern aspects (Table 12). The average age, and dbh and height of dominant trees for all stands was 63.1 years, 20.2 inches and 95 feet, respectively, and average basal area was 165 ft²/ac (Table 12).

Table 12. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stands 5, 7, and 9.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
5	82.0	Cecil, Pacolet (Louisa)*	140-200	S, SE, E	59.0	21.9	100.9	171
7	121.8	Pacolet, Cecil, Louisa, Wehadkee	140-220	S, SE, E	66.6	21.4	88.8	131
9	46.1	Pacolet, Cecil (Wehadkee)*	160-200	S, E	63.7	17.2	95.2	192
TOTAL	249.9			AVERAGE	63.1	20.2	95.0	165

* parentheses for minimal occurrence.

Additional tree species observed in these stands included pawpaw (*Asimina triloba*), beautyberry, musclewood (*Carpinus caroliniana*), flowering dogwood (*Cornus florida*), persimmon, white ash (*Fraxinus americana*), mountain laurel (*Kalmia latifolia*) (Fig. 20), blackgum, and hophornbeam (*Ostrya virginiana*).



Fig. 20. Mountain laurel in Stand 7.

Beech is a notable component of this forest type, and beech aphid (*Grylloprociphilus imbricator*) was observed on multiple beech trees. However, this aphid is not a serious threat to beech.

The species with the largest overstory basal area was loblolly with 73 ft²/ac, followed by shortleaf with 25 ft²/ac, white oak with 16 ft²/ac, and sweetgum with 14 ft²/ac (Table 13). Braun (1950) provided percentages for a very similar community called “mesophytic mixed hardwoods of ravine slopes.” She writes that beech is 37 percent of the overstory while yellow-poplar is 6 percent, while in Schafale and Weakley (1990) report yellow-poplar is the dominant species of this community. Therefore, Braun’s percentages were not used here.

Table 13. Overstory basal area (ft²/ac) by species in Stands 5, 7, and 9.

overstory	BA average across stands, ft ² /ac	Stand 5 BA, ft ² /ac	Stand 7 BA, ft ² /ac	Stand 9, BA, ft ² /ac
<i>Pinus taeda</i>	73	96	20	103
<i>Pinus echinata</i>	25	14	11	50
<i>Quercus alba</i>	16	11	33	4
<i>Liquidambar styraciflua</i>	14	14	5	23
<i>Acer rubrum</i>	8	10	9	4
<i>Liriodendron tulipifera</i>	8	13	13	0
<i>Ilex opaca</i>	3	0	9	0
<i>Acer floridanum</i>	2	0	5	0
<i>Fagus grandifolia</i>	2	0	5	0
<i>Oxydendrum arboreum</i>	2	4	2	0
<i>Quercus falcata</i>	2	4	1	0
<i>Quercus stellata</i>	2	0	5	0
<i>Carya</i> spp.	1	0	3	0
<i>Juniperus virginiana</i>	1	0	1	3
<i>Quercus coccinea</i>	1	0	2	0
<i>Quercus rubra</i>	1	0	2	0
<i>Quercus</i> spp.	1	2	0	0
<i>Quercus velutina</i>	1	0	0	4
<i>Ulmus alata</i>	1	0	2	0
<i>Ulmus</i> spp.	1	2	0	0

Holly had the greatest representation in the understory at 23.2 percent, followed by red maple at 13.8 percent (Table 14). Beech was about 10 percent of the understory.

Table 14. Mesic Mixed Hardwood Forest (Piedmont Subtype) understory species percentage average for Stands 5, 7, and 9.

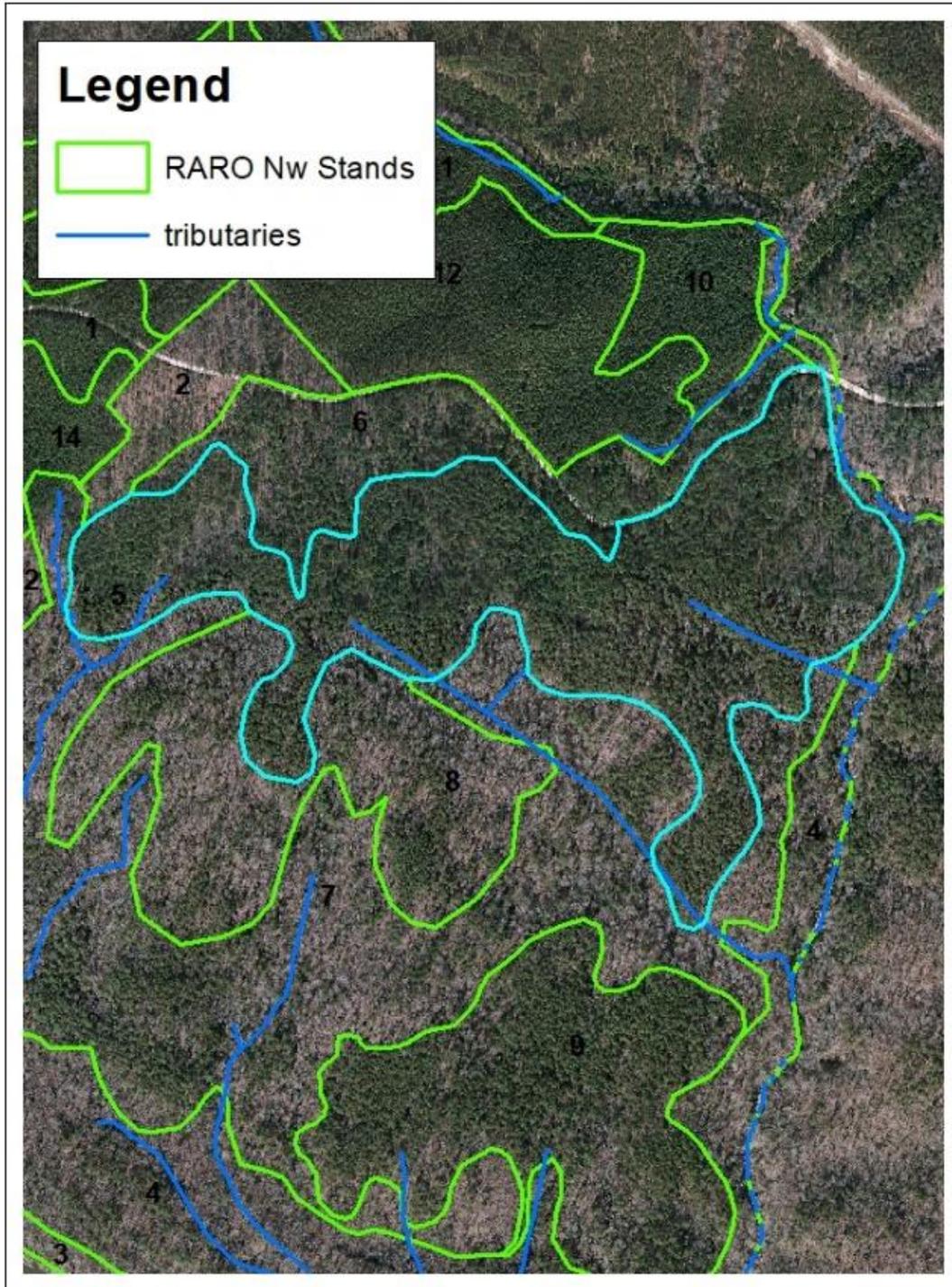
understory	percentage average across stands	Stand 5 percentage	Stand 7 percentage	Stand 9 percentage
<i>Ilex opaca</i>	23.2	25.3	29.8	14.6
<i>Acer rubrum</i>	13.8	21.4	8.5	11.4
<i>Juniperus virginiana</i>	12.4	3.9	0.7	32.7
<i>Vaccinium</i> spp.	11.4	14.3	12.0	8.0
<i>Fagus grandifolia</i>	9.9	0.8	20.8	8.0
<i>Liquidambar styraciflua</i>	6.7	13.7	5.1	1.4
<i>Nyssa sylvatica</i>	6.1	4.0	1.3	12.9
<i>Carpinus caroliniana</i>	4.9	1.6	13.1	0
<i>Oxydendrum arboreum</i>	4.9	5.4	1.7	7.7
<i>Cornus florida</i>	1.9	4.5	1.3	0
<i>Kalmia latifolia</i>	1.9	2.4	3.1	0
<i>Callicarpa americana</i>	1.1	0	0	3.3
<i>Ostrya virginiana</i>	0.9	0	2.6	0
<i>Carya</i> spp.	0.5	1.4	0	0
<i>Ilex decidua</i>	0.2	0.7	0	0
<i>Quercus nigra</i>	0.2	0.7	0	0

Places in this unit with Pacolet soil at 200 feet above MSL and an east/southeast aspect are candidates for the introduction of longleaf pine based on abiotic conditions of longleaf found on RARO Southeast.

Current Composition

Stand 5 is a mixed pine-hardwood stand in the center of the tract near River Road (Fig. 21). Understory woody species found outside the plots were cane (*Arundinaria* spp.), running-cedar (*Diphasiastrum digitatum*), strawberry bush (*Euonymus americanus*), Carolina jessamine, muscadine, Virginia creeper, and smilax. Herbaceous species in the stand included slender oats (*Chasmanthium laxum*), wintergreen (*Chimaphila maculata*), rattlesnake plantain (*Goodyera pubescens*), partridgeberry (*Mitchella repens*), and various ferns and grasses. Schafale and Weakley (1990) report that panicgrass (*Dichanthelium* spp.), beechdrops (*Epifagus virginiana*), oneflower bedstraw (*Galium uniflorum*) (Fig. 22), wild ginger, and Christmas fern should also occur, and these species were found in the stand. The O-horizon was ½-2 inches mixed pine and hardwood litter.

RARO Nw - Stand 5



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.05 0.1 0.2 Miles

1:7,437



Fig. 21. Stand 5 highlighted in turquoise.



Fig. 22. Oneflower bedstraw (*Galium uniflorum*), listed as rare in this community in Schafale and Weakley (1990), was seen repeatedly in both the Mesic Mixed Hardwood (Piedmont Subtype) and Piedmont/Mountain Bottomland Forests on the tract.

Stand 7, extending across most of the middle of the tract, is the largest stand on the tract at 121.8 acres (Fig. 23). The stand has more hardwoods and less pine than Stands 5 and 9, although roughly 12 acres of pine occur in the south-central portion. The extension of Stand 7 that divides Stand 2 is a stream head surrounded by 0.8-acre of loblolly-dominated overstory. A few large beech trees in the southwestern portion of the stand had fire scars on their northern or western sides (Fig. 24).

RARO Nw - Stand 7

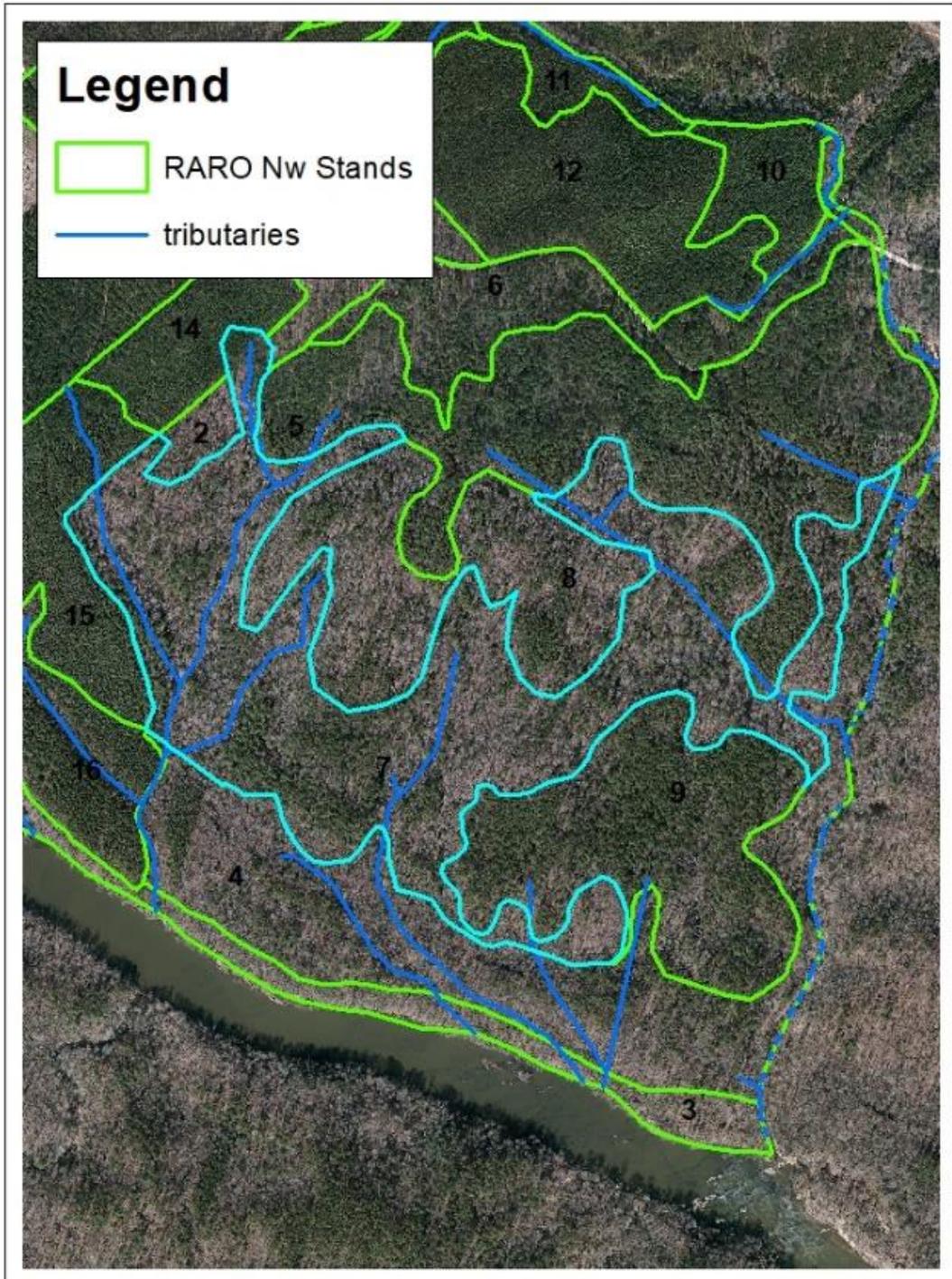


Fig. 23. Stand 7 highlighted in turquoise.



Fig. 24. Fire scar in beech in Stand 7.

The additional understory woody species found outside of plots were cane, trumpet creeper, running-cedar, strawberry bush, Carolina jessamine, muscadine, Virginia creeper, and smilax. The herbaceous vegetation is the same as that found in Stand 5, with the addition of Jack-in-the-pulpit (*Arisaema triphyllum*). Japanese stilt grass (*Microstegium vimineum*) was also present in one plot. The O-horizon was trace amounts to ¼ inch, mostly hardwood litter.

Near the border of Stand 7 and Stand 4 was a vernal pool, similar to the Floodplain Pool (Schafale and Weakley, 1990) in Stand 4 (Piedmont/Mountain Bottomland Forest) which should be protected (Fig. 25).



Fig. 25. Vernal pool in Stand 7 near the border of the Piedmont/Mountain Bottomland Forest (Stand 4).

Stand 9 is a mixed pine-hardwood stand located in the southeastern portion of the tract (Fig. 26). Understory woody species found outside of plots included cane, running-cedar, muscadine, and Virginia creeper. The same herbs were seen in this stand but at lower numbers than in Stands 5 and 7. The O-horizon was trace amounts to $\frac{1}{4}$ inch, mostly pine.

RARO Nw - Stand 9

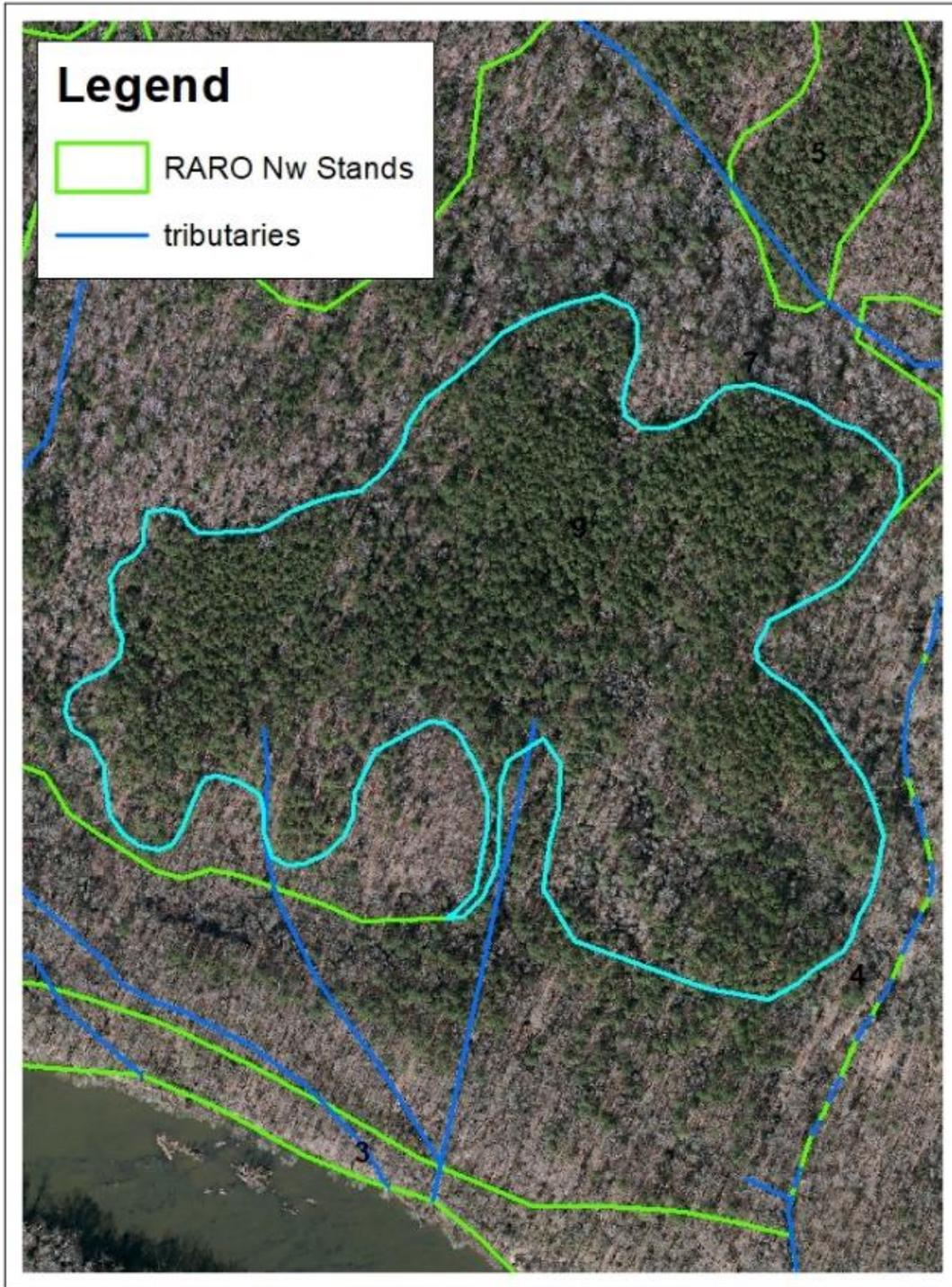


Fig. 26. Stand 9 highlighted in turquoise.

Restoration Prescription

Schafale and Weakley (1990) do not list pine as a component of Mesic Mixed Hardwood Forest (Piedmont Subtype). Therefore, all loblolly should be girdled (for snags for wildlife) at a rate of 10 percent of the loblolly basal area in each stand annually for ten years, to eradicate the species and release the hardwood understory. As in Stands 2, 6, and 8, loblolly within a 100-foot buffer of the equestrian trail should be felled for the safety of the public, though clearcut harvest of the stands is not recommended for the same reasons discussed previously. The highest percentage of loblolly pine basal area is found in Stand 5 with 56 percent, followed by Stand 9 with 54 percent, then Stand 7 with 15 percent. The shortleaf pine should be retained for restoration efforts and potential red-cockaded woodpecker habitat as discussed for Stands 2, 6, and 8 in the Dry-Oak Hickory Forest. Stand 7 had the most shortleaf pine.

The stands should not be burned because beech, red maple, sugar maple, and holly, which are not fire-resistant, are integral species of this forest type. Red maple and holly occur in greater numbers than other species in the stand, perhaps due to lack of burning and the generalist nature of those species. Since Braun (1950) does not provide percentages for this community type, no specific recommendation can be made for control.

Although invasive vegetation is much less than that found in the Piedmont/Mountain Bottomland and Levee Forests, I recommend that the control methods described for Stand 4 should be used wherever Japanese stilt grass is found.

Stands of Loblolly with Mesic Mixed Hardwood Understory in Management Unit 3

Stands 10, 13, and 15 are loblolly plantations with a mesic mixed hardwood understory, totaling 54 acres. The soil series were mostly Pacolet and Cecil with some Wehadkee and Chewacla (Fig. 10), with elevations ranging from 140-260 feet above MSL, and both north and south aspects (Table 15). The average age, dbh and height of dominant trees for all stands was 36 years, 12.2 inches and 81.2 feet, respectively, and average basal area was 264 ft²/ac (Table 15).

Table 15. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stands 10, 13, and 15.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
10	13.6	Pacolet (Chewacla, Cecil)*	140-200	NE	34.0	13.3	80.0	280
13	7.0	Pacolet (Wehadkee)*	200-260	N	40.0	10.7	80.3	240
15	33.4	Pacolet, Cecil (Wehadkee)*	160-220	S, SE	34.0	12.7	83.2	273
TOTAL	54.0			AVERAGE	36.0	12.2	81.2	264

* parentheses for minimal occurrence.

Loblolly dominated the overstory with small amounts of sweetgum (Table 16).

Table 16. Overstory basal area (ft²/ac) by species in Stands 10, 13, and 15.

overstory (loblolly-dominated)	BA average across stands, ft ² /ac	Stand 10 BA, ft ² /ac	Stand 13 BA, ft ² /ac	Stand 15, BA, ft ² /ac
<i>Pinus taeda</i>	258	280	220	273
<i>Liquidambar styraciflua</i>	7	0	20	0

The understory was 26.7 percent holly and 16.2 percent red maple, followed by sweetgum and sourwood with 14.1 percent each (Table 17).

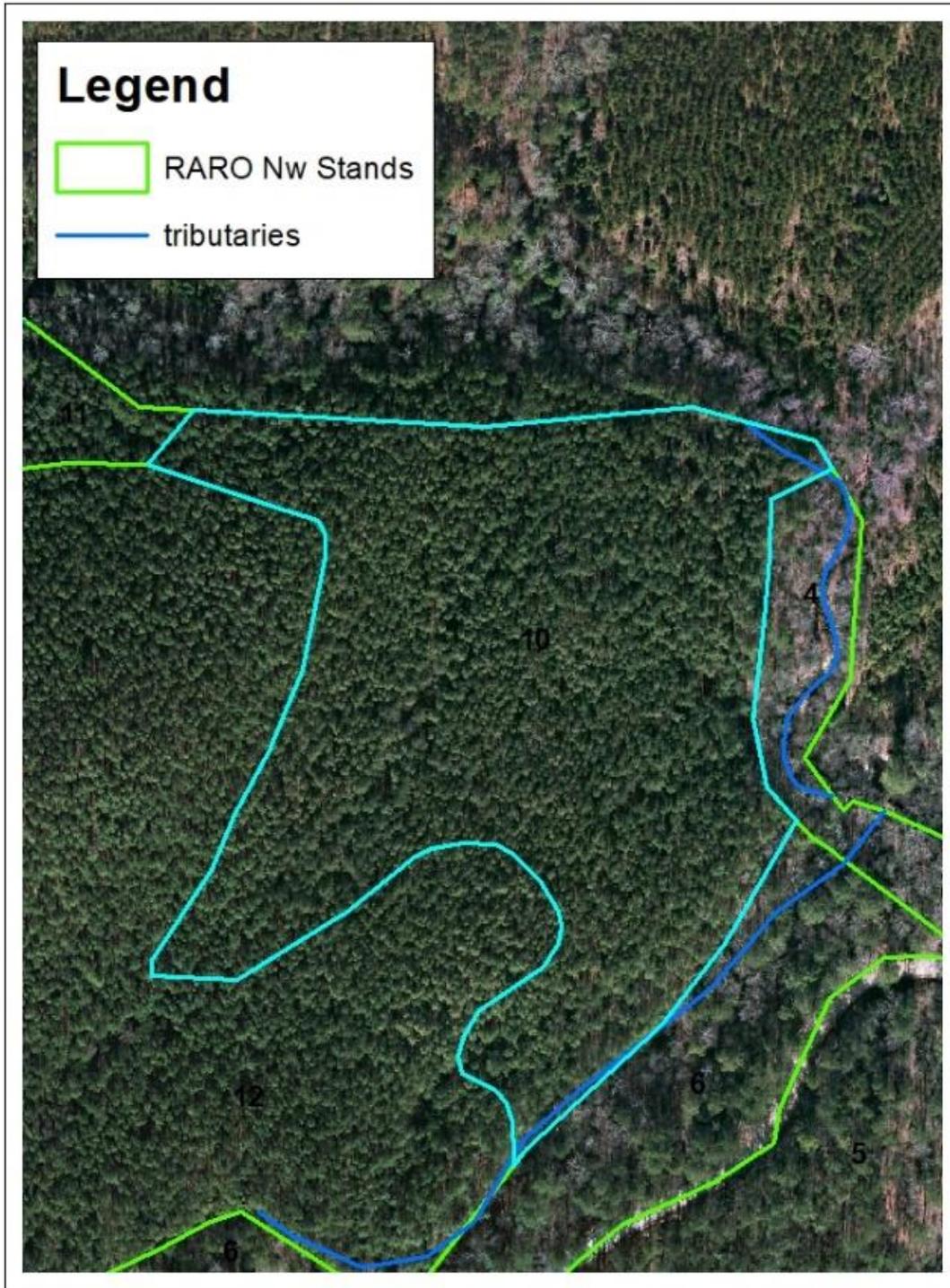
Table 17. Mesic Mixed Hardwood Forest (Piedmont Subtype) understory species percentage average for Stands 10, 13, and 15.

understory (with loblolly-dominated overstory)	percentage average across stands	Stand 10 percentage	Stand 13 percentage	Stand 15 percentage
<i>Ilex opaca</i>	26.7	37.5	0	42.6
<i>Acer rubrum</i>	16.2	0	37.5	11.1
<i>Liquidambar styraciflua</i>	14.1	31.2	0	11.1
<i>Oxydendrum arboreum</i>	14.1	6.3	25.0	11.1
<i>Vaccinium spp.</i>	6.0	12.5	0	5.6
<i>Amelanchier arborea</i>	4.2	0	12.5	0
<i>Prunus serotina</i>	4.2	0	12.5	0
<i>Quercus falcata</i>	4.2	0	12.5	0
<i>Liriodendron tulipifera</i>	2.5	0	0	7.4
<i>Carpinus caroliniana</i>	2.1	6.3	0	0
<i>Nyssa sylvatica</i>	2.1	6.3	0	0
<i>Cornus florida</i>	1.9	0	0	5.6
<i>Juniperus virginiana</i>	1.9	0	0	5.6

Current Composition

Stand 10 is located at the northeastern-most corner of the management tract (Fig. 27). Mill Creek runs through a small part on the stand's northeastern corner. The additional understory woody species found outside of plots included trumpet creeper, muscadine, poison-ivy, and smilax. Jack-in-the-pulpit and various ferns were also in the stand. The O-horizon was 1 inch pine.

RARO Nw - Stand 10



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.0175 0.035 0.07 Miles

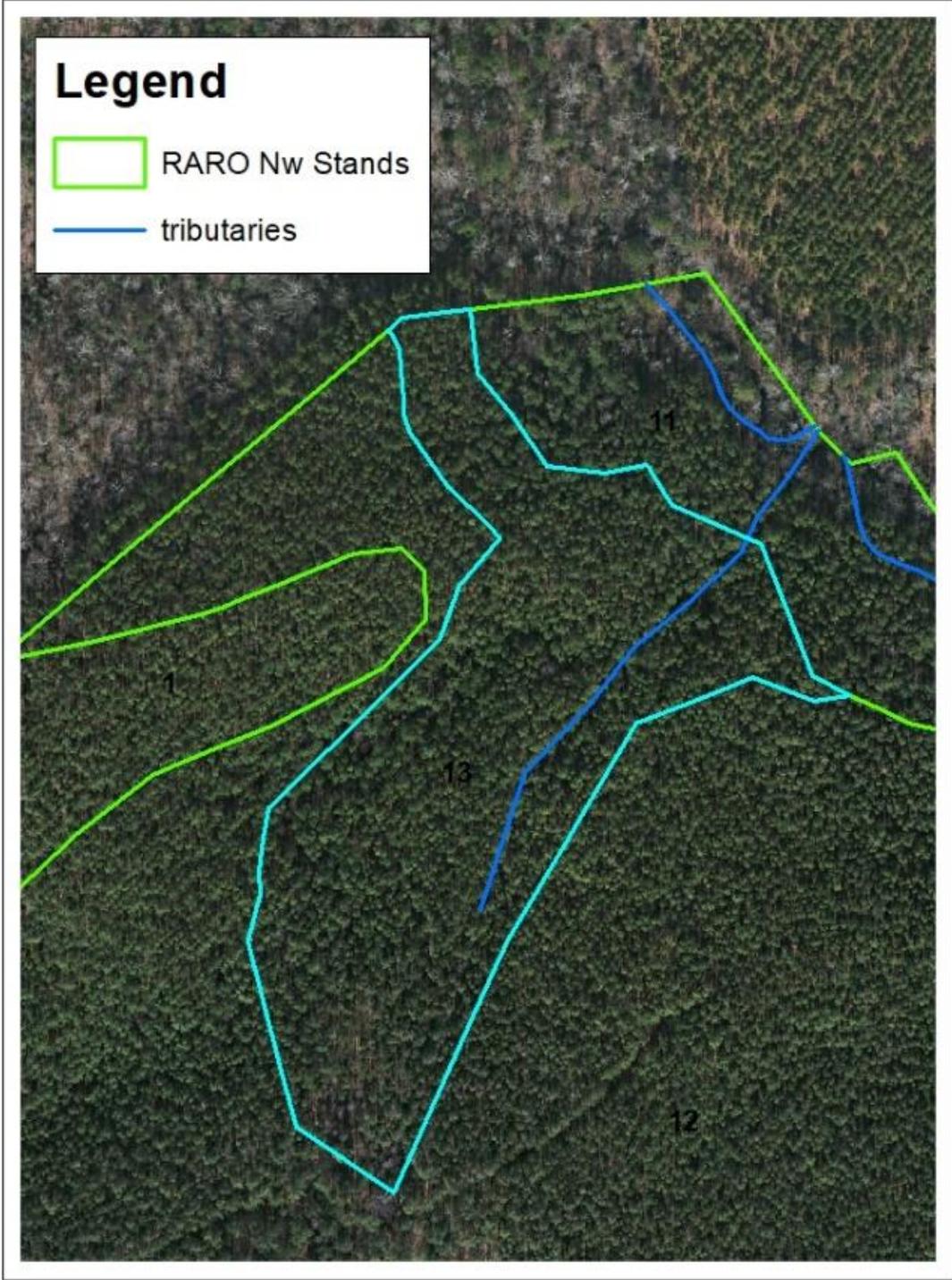
1:2,000



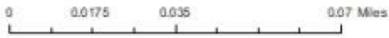
Fig. 27. Stand 10 highlighted in turquoise.

Stand 13 is the smallest stand in the tract at just 7 acres, located in the northwestern portion of the stand (Fig. 28). It contains an unnamed tributary that feeds into Mill Creek. Even though beech and yellow-poplar did not fall within the plot, both species were present in the overstory along with cane, various ferns, and wild ginger in the understory. The O-horizon was $\frac{1}{4}$ inch pine.

RARO Nw - Stand 13



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks



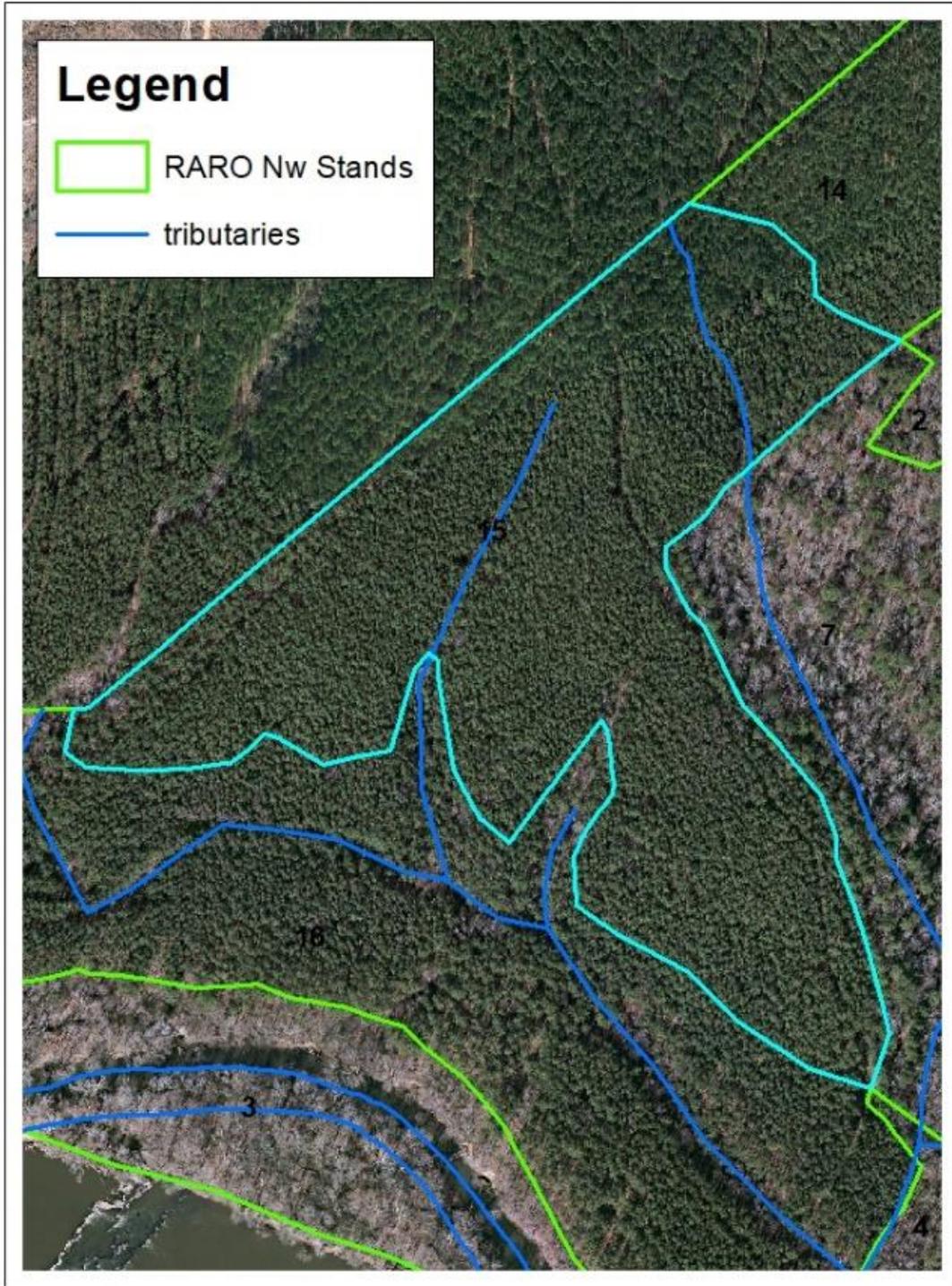
1:2,000



Fig. 28. Stand 13 highlighted in turquoise.

Stand 15 is in the central-western portion of the stand (Fig. 29). The understory was mostly oak and hickory, especially near the skid road. Beech increased in number on the lower slopes. Additional understory woody vegetation included cane and pawpaw. Herbaceous species present included wild oats (*Chasmanthium* spp.), wintergreen, oneflower bedstraw, partridgeberry, and various ferns and grasses. The O-horizon was ½-2 inches pine litter.

RARO Nw - Stand 15



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.0325 0.065 0.13 Miles

1:3,602



Fig. 29. Stand 15 highlighted in turquoise.

Restoration Prescription

I recommend girdling the loblolly in Stands 10, 13, and 15 for wildlife habitat and eventual release of the hardwood understory, because loblolly is not a member of this community. The recommendation to girdle at a rate of 10 percent of the total loblolly basal area annually over a period of ten years applies to these stands as well. However, the current hardwood understory is largely a mix of red maple, holly, and sweetgum, as seen on most other areas of the management tract. Red maple is an overstory species of the Mesic Mixed Hardwood community type, but it may be too abundant in this stand. Since Braun (1950) does not provide percentages for this community type, no specific recommendation can be made for control.

Yellow-poplar is lacking from the understory in Stands 10 and 13, but as Stand 10 is adjacent to Mill Creek with yellow-poplar, and Stand 13 is adjacent to Stand 11 which also has yellow-poplar (shade-intolerant), the species may seed into Stands 10 and 13 in canopy gaps. Similarly, northern red oak (mid-tolerant) in canopy gaps, and sugar maple and beech (both tolerant) may seed in over time.

Management Unit 4 to Be Restored to Piedmont/Mountain Bottomland Forest

Some of the dominant overstory species of the Piedmont/Mountain Bottomland Forest are yellow-poplar, sweetgum, swamp chestnut oak (*Quercus michauxii*), bitternut hickory (*Carya cordiformis*), and loblolly (Schafale and Weakley, 1990) (Table 18).

Table 18. Piedmont/Mountain Bottomland overstory and understory species and shrubs (Schafale and Weakley, 1990).

Piedmont/Mountain Bottomland dominant overstory	<i>Liriodendron tulipifera</i>	yellow-poplar
	<i>Liquidambar styraciflua</i>	sweetgum
	<i>Quercus pagoda</i>	cherrybark oak
	<i>Quercus michauxii</i>	swamp chestnut oak
	<i>Ulmus americana</i>	American elm
	<i>Celtis laevigata</i>	southern hackberry
	<i>Fraxinus pennsylvanica</i>	green ash
	<i>Pinus taeda</i>	loblolly pine
	<i>Carya ovata</i>	shagbark hickory
	<i>Carya cordiformis</i>	bitternut hickory
Piedmont/Mountain Bottomland understory and shrubs	<i>Carpinus caroliniana</i>	musclewood
	<i>Acer floridanum</i>	southern sugar maple
	<i>Acer rubrum</i>	red maple
	<i>Cornus florida</i>	flowering dogwood
	<i>Ilex opaca</i>	American holly
	<i>Asimina triloba</i>	pawpaw
	<i>Aesculus sylvatica</i>	painted buckeye
	<i>Euonymus americanus</i>	strawberry bush
	<i>Arundinaria gigantea</i>	river cane

This management unit consists of Stands 4, 11, and 16. Stands 11 and 16 data are pooled because they have a loblolly-dominated overstory. The overstory of Stand 4 was dominated by species typical of Piedmont bottomland sites (Table 19).

Table 19. Inventory data for overstory species in Management Unit 4, Stand 4.

scientific name	common name
<i>Acer floridanum</i>	southern sugar maple
<i>Acer rubrum</i>	red maple
<i>Fagus grandifolia</i>	American beech
<i>Ilex opaca</i>	American holly
<i>Juniperus virginiana</i>	eastern redcedar
<i>Liquidambar styraciflua</i>	sweetgum
<i>Liriodendron tulipifera</i>	yellow-poplar
<i>Morus rubra</i>	red mulberry
<i>Ostrya virginiana</i>	hophornbeam
<i>Pinus taeda</i>	loblolly pine
<i>Prunus serotina</i>	black cherry
<i>Quercus alba</i>	white oak
<i>Quercus nigra</i>	water oak
<i>Quercus pagoda</i>	cherrybark oak
<i>Quercus phellos</i>	willow oak
<i>Quercus velutina</i>	black oak
<i>Ulmus alata</i>	winged elm
<i>Ulmus americana</i>	American elm

Additional overstory species observed in these stands outside the plots were river birch (*Betula nigra*), musclewood, flowering dogwood, ash (*Fraxinus* spp.), sycamore (*Platanus occidentalis*), and swamp chestnut oak.

Bottomlands are prone to flooding. Stands 4 and 16 were flooded to a depth of several feet during and for a time after Hurricane Florence in September 2018 (Fig. 30).



Fig. 30. Flooding along the Cape Fear River four days after Hurricane Florence (at the border of Stands 7 and 4).

Piedmont/Mountain Stands in Management Unit 4

Current Composition

Stand 4 is forested with the Piedmont/Mountain Bottomland Forest, a mostly flat landscape with poorly drained soils (Table 20). The average basal area was 160 ft²/ac (Table 20).

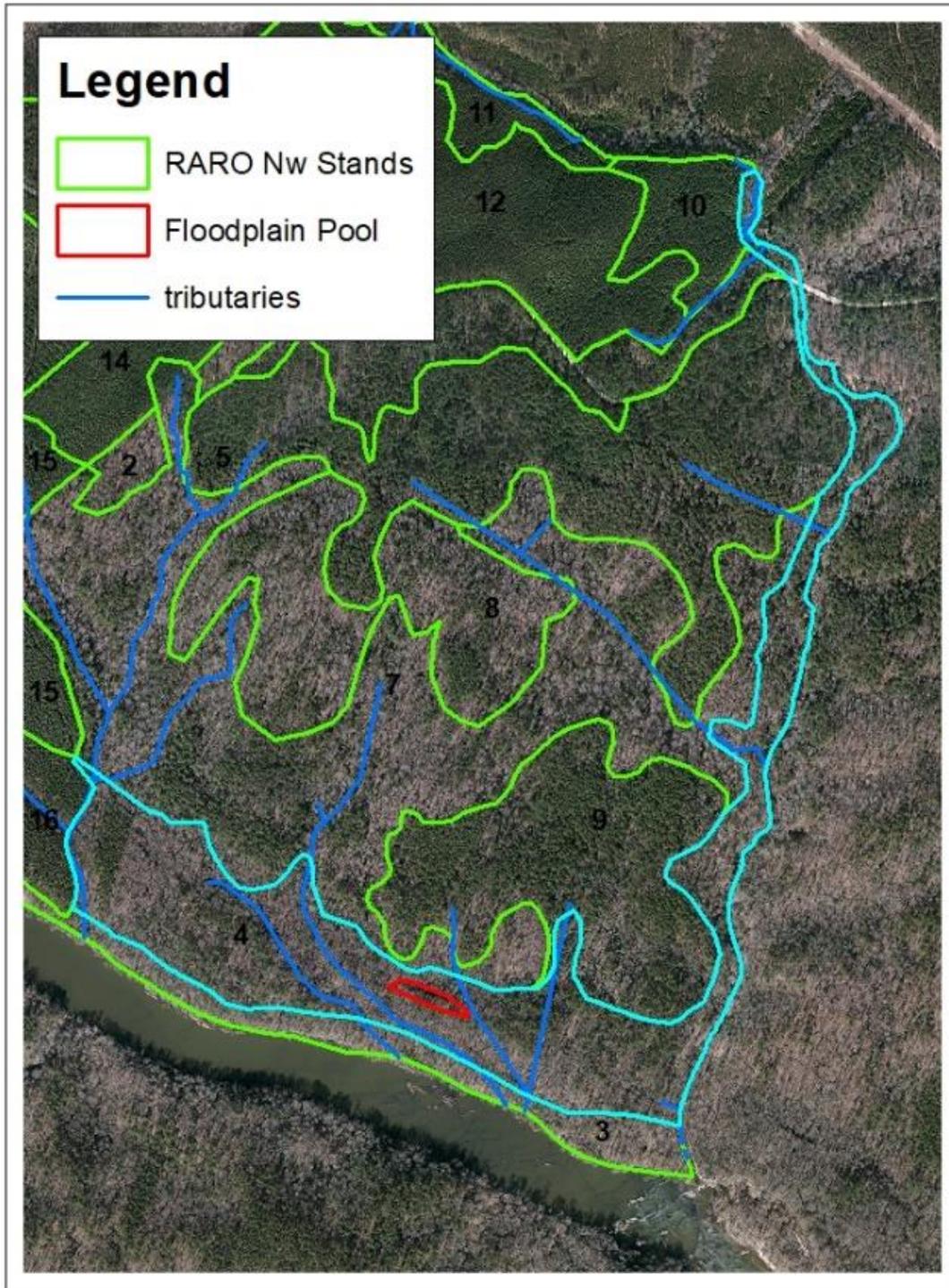
Table 20. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stand 4.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
4	75.0	Wehadkee, Louisa, Pacolet, Chewacla (Altavista)*	120-160	flat, S, E	60 (range 28-98)	23.9	106.8	160

* parentheses for minimal occurrence.

Stand 4 extends across the southern end of the tract, through north of the levee, and north along the eastern edge along Avents Creek. It contains a 0.78-acre Floodplain Pool (Schafale and Weakley, 1990) which should be protected (Fig. 31).

RARO Nw - Stand 4



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.075 0.15 0.3 Miles

1:9,238



Fig. 31. Stand 4 highlighted in turquoise with Floodplain Pool highlighted in red.

The confluence of Mill Creek and Avents Creek occurs in the northern portion of the stand. This is also the only occurrence of the Altavista soil series on the tract (Fig. 10). Several unnamed tributaries flow through the stand. The Floodplain Pool is covered in duckweed (*Lemna* spp.) (Fig. 32). A 2-acre pine plantation occurs in the southwestern part of the stand. Open, park-like loblolly pine stands exist in the south-central and southeastern portion, about 9 and 10 acres in size, respectively.



Fig. 32. Floodplain Pool within the Piedmont/Mountain Bottomland Forest (Stand 4).

The majority of species in the overstory were loblolly with 53 ft²/ac, yellow-poplar with 34 ft²/ac, and sweetgum with 18 ft²/ac (Table 21), which represent 33 percent, 21 percent, and 11 percent of the total overstory basal area, respectively. Braun (1950) noted percentages for these species were 8.4 percent for loblolly and 18.3 percent for sweetgum. No figures were given for

yellow-poplar, only that it was a “common species of the bottomland forest” (Braun, 1950). Loblolly is a bottomland species, but it has been favored in adjacent natural communities due to fire suppression and planting, likely leading to the greater presence than natural even in the bottomland. Historically, cherrybark oak (*Quercus pagoda*) would have had a much greater presence in the overstory at 15.5 percent (Braun, 1950).

Table 21. Overstory basal area (ft²/ac) by species in Stand 4.

overstory	Stand 4 BA, ft ² /ac
<i>Pinus taeda</i>	53
<i>Liriodendron tulipifera</i>	34
<i>Liquidambar styraciflua</i>	18
<i>Quercus velutina</i>	6
<i>Ilex opaca</i>	5
<i>Morus rubra</i>	5
<i>Quercus nigra</i>	5
<i>Quercus pagoda</i>	5
<i>Acer rubrum</i>	4
<i>Juniperus virginiana</i>	4
<i>Ulmus alata</i>	4
<i>Ulmus americana</i>	4
<i>Ostrya virginiana</i>	3
<i>Quercus alba</i>	3
<i>Quercus phellos</i>	3
<i>Acer floridanum</i>	2
<i>Quercus spp.</i>	1

The most prevalent understory species were holly at 22.1 percent, winged elm at 21.5 percent, and pawpaw at 16.7 percent (Table 22). Historically, the understory percentage of these species were 6.7 and 6.3 for holly and winged elm, respectively, with no mention of pawpaw (Braun, 1950). The increase in percentage of holly is probably due to fire suppression. Historically there was more southern sugar maple in the understory, up to 23.5 percent, and more dogwood, about 16 percent (Braun, 1950).

Table 22. Average percent of Piedmont/Mountain Bottomland Forest understory species in Stand 4.

understory	Stand 4 percentage
<i>Ilex opaca</i>	22.1
<i>Ulmus alata</i>	21.5
<i>Asimina triloba</i>	16.7
<i>Acer floridanum</i>	6.3
<i>Ligustrum sinense</i>	6.2
<i>Liquidambar styraciflua</i>	5.6
<i>Carpinus caroliniana</i>	5.2
<i>Fraxinus</i> spp.	3.7
<i>Ostrya virginiana</i>	3.7
<i>Carya</i> spp.	2.8
<i>Ilex decidua</i>	2.8
<i>Acer rubrum</i>	1.6
<i>Quercus nigra</i>	1.2
<i>Aesculus sylvatica</i>	0.6

Overstory trees in the stand, but not within the variable plots, included river birch, musclewood, flowering dogwood, sycamore, and swamp chestnut oak. The understory was populated with abundant cane, pawpaw (Fig. 33), red mulberry (*Morus rubra*), running-cedar, and various fern species. Hickory occurred in one place.



Fig. 33. Pawpaw over a carpet of running-cedar.

The native lianas present were crossvine (*Bignonia capreolata*), muscadine, and poison-ivy. Herbaceous species listed in this community by Schafale and Weakley (1990) and also found in Stand 4 included Jack-in-the-pulpit, false nettle (*Boehmeria cylindrica*), sedges (*Carex* spp.), slender woodoats, jumpseed (*Polygonum virginianum*), and Christmas fern. Additional herbaceous species not noted in Schafale and Weakley (1990) included partridgeberry, wingstem, and unknown grasses. The O-horizon was 1 inch or less throughout the stand, mostly hardwood, with the exception of one plot with 2 inches. The invasive plant species in Stand 4 were Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), and Japanese stilt grass (*Microstegium vimineum*). These invasive species are considered a severe threat to natural areas in North Carolina (Buchanan, 2017).

Restoration Prescription

Since loblolly is a bottomland species, the silvicultural prescription for Stand 4 is to reduce the loblolly basal area to about 8 percent of the total basal area (about 13 ft²/ac) from its current level of 33 percent (53 ft²/ac) (Braun, 1950). Girdling (at the same rate suggested in previous stands) will create snags for wildlife and facilitate eventual release of the hardwood understory.

I recommend using herbicide to control excess or invasive vegetation, including winged elm (no numbers are given for holly, which may also be in excess) and exotic plants. Treat every two of three winged elms. Before herbicide application, cut the large honeysuckle lianas. Then apply the aquatic form of glyphosate without surfactant to all invasive plants, when the site is dry and preferably not during the growing season (Mark Megalos, Extension Forestry Specialist, pers. comm., Feb. 27, 2019; Colby Lambert, Area Specialized Agent - Forestry, pers. comm., Feb 28, 2019). Apply aquatic glyphosate without surfactant to Japanese stilt grass in summer for several years to reduce seed production. Then mow in early fall to further slow seeding (Miller, 2003). Seeds will still be in the seed bank; Japanese stilt grass seed is viable for up to seven years (Neal and Judge, 2013). Seeds may also be deposited by flood waters.

Stands of Loblolly with Bottomland Understory in Management Unit 4

Stands 11 and 16 are loblolly plantations with a bottomland understory, totaling 44.1 acres. The overstory was largely composed of loblolly, sweetgum, beech, and cherry. The soil series were mostly Wehadkee, Pacolet, and Chewacla with some Cecil (Fig. 10). Elevations ranged from 120-200 feet above MSL with a mainly flat topography. The toeslope in Stand 11 had a north-facing aspect, while the toeslope north of Stand 16 was south-facing (Table 23). The average age, and dbh and height of dominant trees for the stands was 35 years, 15 inches and 97.4 feet, respectively (Table 23). Average basal area was 210 ft²/ac (Table 23).

Table 23. Stand acreage, soil series, elevation, aspect, dominant average age, dominant mean dbh, dominant mean height, and basal area for Stands 11 and 16.

Stand	acres	soil type	elevation, feet MSL	aspect	dominant average age, years	dominant mean dbh, inches	dominant mean height, feet	overstory BA (ft ² /ac)
11	9.5	Pacolet, Wehadkee (Cecil)*	160-200	flat, N	35.0	14.7	100.7	220
16	34.6	Wehadkee, Chewacla, Pacolet (Cecil)*	120-160	flat, S	35.0**	15.3	94.1	200
TOTAL	44.1			AVERAGE	35.0	15.0	97.4	210

* parentheses for minimal occurrence.

** average age excluding 100-year-old beech.

The overstory was dominated by loblolly, with smaller amounts of sweetgum, beech, and cherry (Table 24).

Table 24. Overstory basal area (ft²/ac) by species in Stands 11 and 16.

overstory (loblolly-dominated)	BA average across stands, ft ² /ac	Stand 11 BA, ft ² /ac	Stand 16 BA, ft ² /ac
<i>Pinus taeda</i>	186	200	173
<i>Liquidambar styraciflua</i>	19	20	17
<i>Fagus grandifolia</i>	3	0	5
<i>Prunus serotina</i>	3	0	5

In Stand 11, red maple and cherry with 33 percent each were the most prevalent understory species. Holly with 16.8 percent and sweetgum with 37.3 percent were most prevalent in Stand 16. Overall, red maple, sweetgum, and cherry were the majority of the understory, with 21.1 percent, 18.7 percent, and 16.7 percent, respectively (Table 25).

Table 25. Percent of understory species in Piedmont/Mountain Bottomland Forest in Stands 11 and 16.

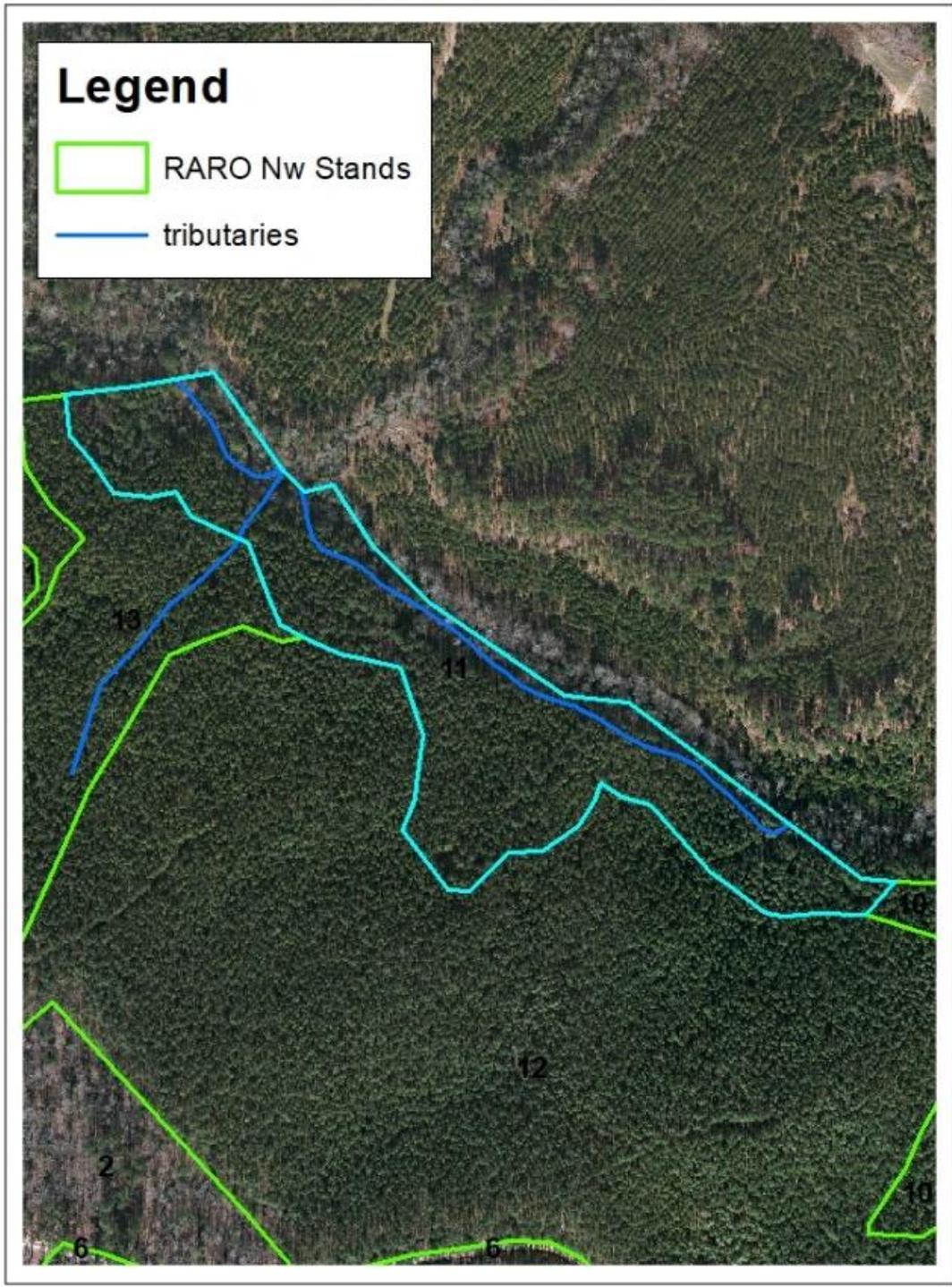
understory (with loblolly-dominated overstory)	percentage average across stands	Stand 11 percentage	Stand 16 percentage
<i>Acer rubrum</i>	21.1	33.3	8.8
<i>Liquidambar styraciflua</i>	18.7	0	37.3
<i>Prunus serotina</i>	16.7	33.3	0
<i>Vaccinium</i> spp.	16.7	33.3	0
<i>Ilex opaca</i>	8.4	0	16.8
<i>Fagus grandifolia</i>	4.6	0	9.1
<i>Cornus florida</i>	4.0	0	8.0
<i>Juniperus virginiana</i>	4.0	0	8.0
<i>Acer negundo</i>	2.5	0	5.0
<i>Acer floridanum</i>	1.8	0	3.6
<i>Liriodendron tulipifera</i>	1.7	0	3.3

Current Composition

Stand 11 is the northern-most on the tract, bordered almost entirely to its north by Mill Creek (Fig. 34). The ground of the western-most portion of the stand was saturated. An unnamed tributary, that begins in Stand 13 and empties into Mill Creek, flows through this part of Stand 11. River birch, sycamore and water oak (*Quercus nigra*) were also present. Yellow-poplar dominated the overstory. Musclewood and mountain laurel were found in the understory,

along with cane (Fig. 35), various ferns, lianas and herbaceous species associated with bottomland forests, such as crossvine, smilax (*Smilax glauca*), Jack-in-the-pulpit, and partridgeberry. The O-horizon was ¼ inch of pine litter.

RARO Nw - Stand 11



Legend

- RARO Nw Stands
- tributaries

Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks



1:3,180



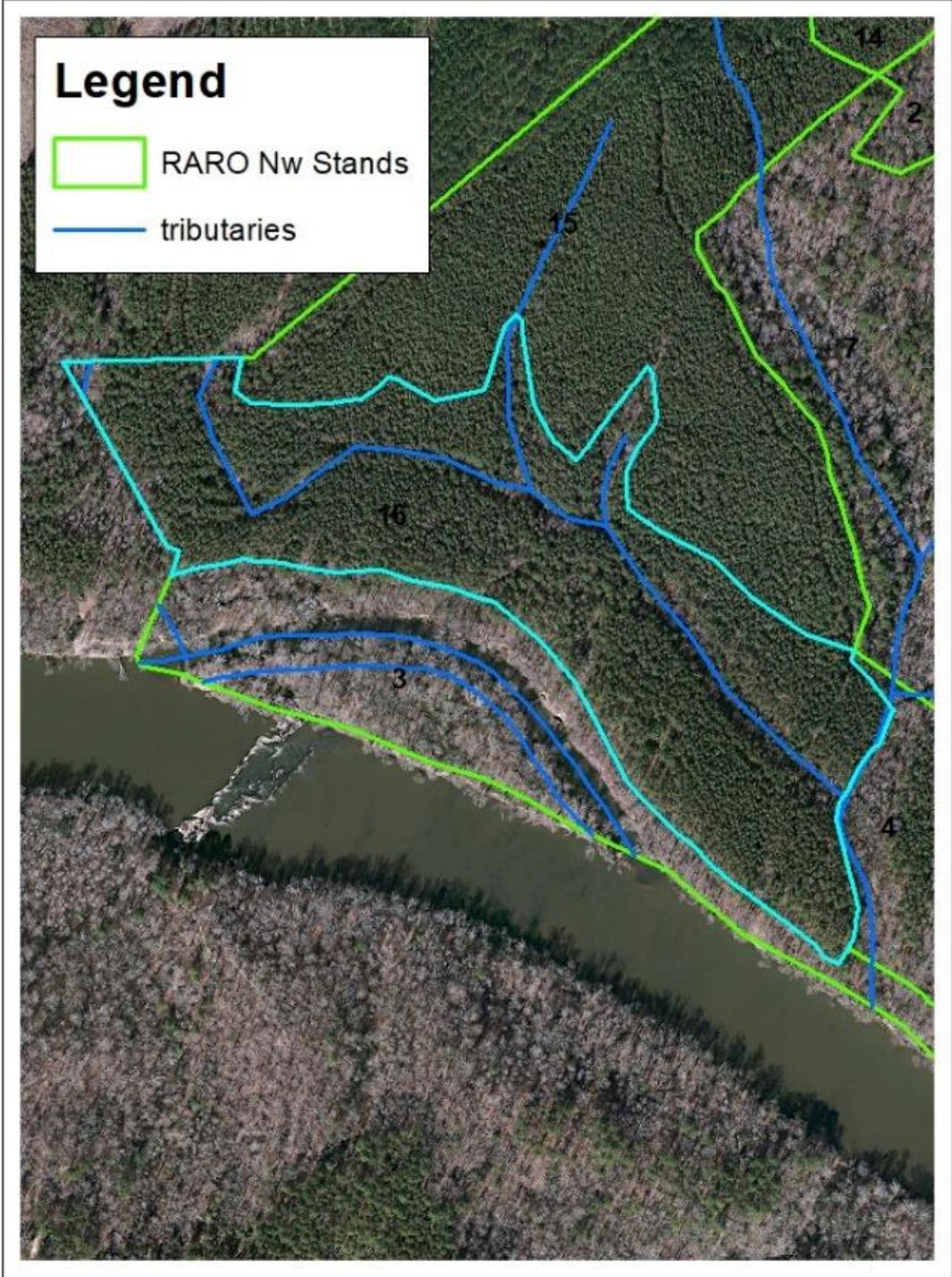
Fig. 34. Stand 11 highlighted in turquoise.



Fig. 35. Abundant cane in Stand 11.

Stand 16 is the southern-most portion of the old loblolly plantation (Fig. 36). Several unnamed tributaries flowed through the stand, on through the levee and to the Cape Fear River. There was a ravine on the eastern side of the stand, as well as large granite rock outcrops covered with vegetation (Fig. 37).

RARO Nw - Stand 16



Map author: Wren Gershman
Map date: 26 February 2019
Map data source: Harnett County and NC Parks

0 0.045 0.09 0.18 Miles

1:4,656



Fig. 36. Stand 16 highlighted in turquoise.



Fig. 37. Granitic flatrock in Stand 16.

Some of the loblolly showed sweep at the base, probably from flooding. Some of the beeches had fire scars as seen in the adjacent Mesic Mixed Hardwood Stand 7. Ash (*Fraxinus* spp.) and American elm (*Ulmus americana*) were seen outside of the plots, as well as redbud (*Cercis canadensis*), winterberry, pawpaw and cane. Considerable Virginia creeper was entwined in the overstory trees, along with trumpet creeper and poison-ivy. Ferns, unknown grasses, and Gray's sedge (*Carex grayi*) were also seen. Invasive vegetation included abundant Chinese privet and Japanese stilt grass on the forest floor (Fig. 38). The O-horizon was ¼-1 ¼ inches pine in plots where Chinese privet was not pervasive.

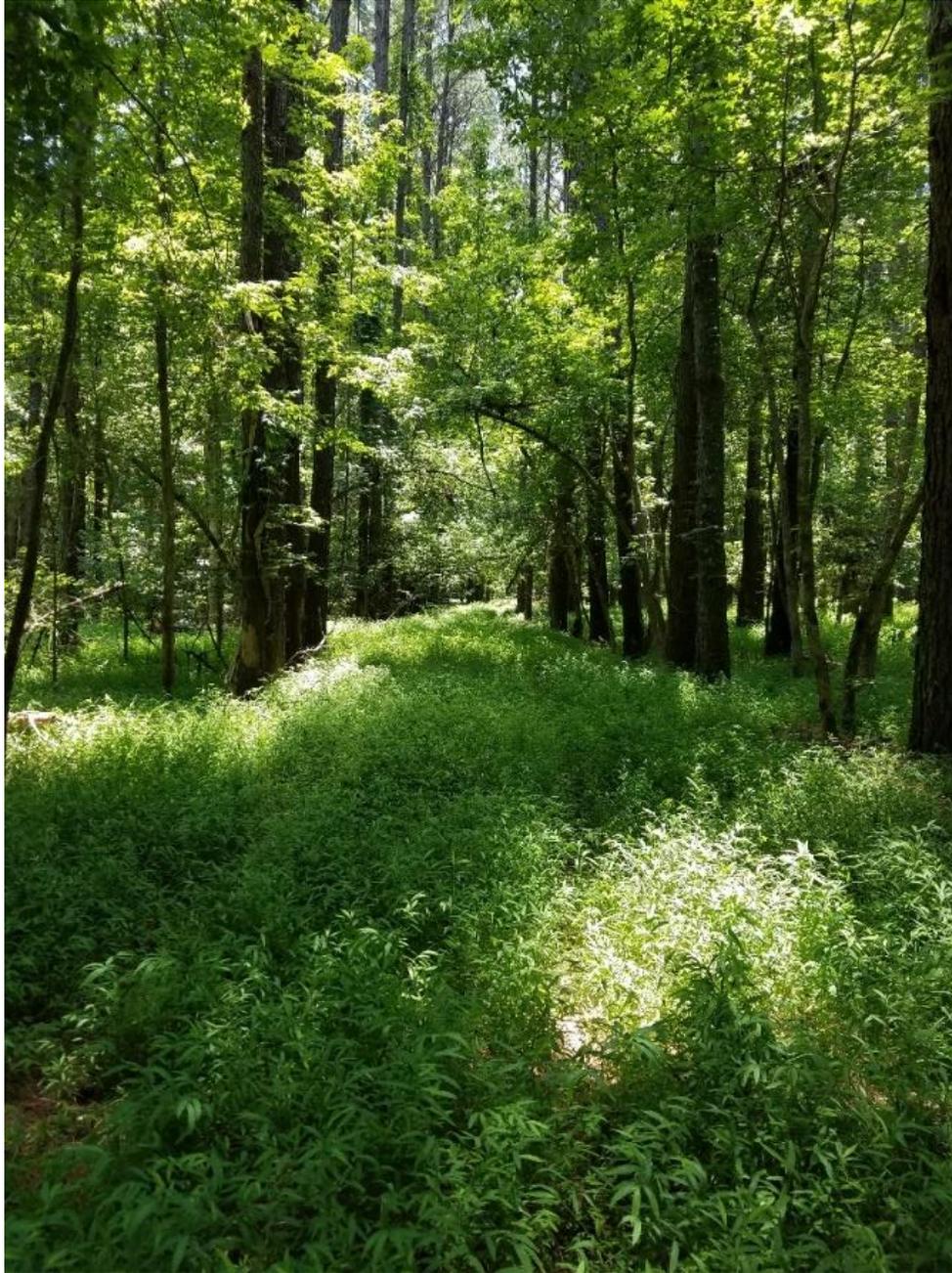


Fig. 38. Japanese stilt grass carpets old skid road and between old loblolly plantation rows in Stand 16.

Restoration Prescription

Following results reported by Braun (1950) as in Stand 4, the loblolly should be girdled to 8 percent of the total stand basal area (at the same rate as recommended in the previous stands): 18 ft²/ac in Stand 11, and 16 ft²/ac in Stand 16. The recommendation for control of Chinese privet and Japanese stilt grass is the same as in Stand 4.

Management Unit 5 to Be Restored to Piedmont/Mountain Levee Forest

In the Piedmont/Mountain Levee Forest, the overstory is dominated by species such as sycamore, river birch, southern hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), and boxelder (*Acer negundo*) according to Schafale and Weakley (1990) (Table 26).

Table 26. Piedmont/Mountain Levee overstory and understory species and shrubs (Schafale and Weakley, 1990).

Piedmont/Mountain Levee dominant overstory	<i>Platanus occidentalis</i>	sycamore
	<i>Betula nigra</i>	river birch
	<i>Celtis laevigata</i>	southern hackberry
	<i>Acer negundo</i>	boxelder
	<i>Liquidambar styraciflua</i>	sweetgum
	<i>Quercus pagoda</i>	cherrybark oak
	<i>Quercus michauxii</i>	swamp chestnut oak
	<i>Liriodendron tulipifera</i>	yellow-poplar
	<i>Fraxinus pennsylvanica</i>	green ash
	<i>Ulmus americana</i>	American elm
	<i>Carya cordiformis</i>	bitternut hickory
	<i>Juglans nigra</i>	black walnut
	<i>Carya ovata</i>	shagbark hickory
Piedmont/Mountain Levee understory and shrubs	<i>Acer negundo</i>	boxelder
	<i>Asimina triloba</i>	pawpaw
	<i>Carpinus caroliniana</i>	musclewood
	<i>Ilex opaca</i>	American holly
	<i>Lindera benzoin</i>	spicebush
	<i>Aesculus sylvatica</i>	painted buckeye
	<i>Xanthorhiza simplicissima</i>	yellowroot
	<i>Arundinaria gigantea</i>	river cane

Current Composition

This unit consisted of Stand 3 only, which was 29.8 acres. The topography was flat, and is the lowest of the tract at 140 feet above MSL. The stand is a narrow band adjacent to the Cape Fear River to its south (Fig. 39).

RARO Nw - Stand 3

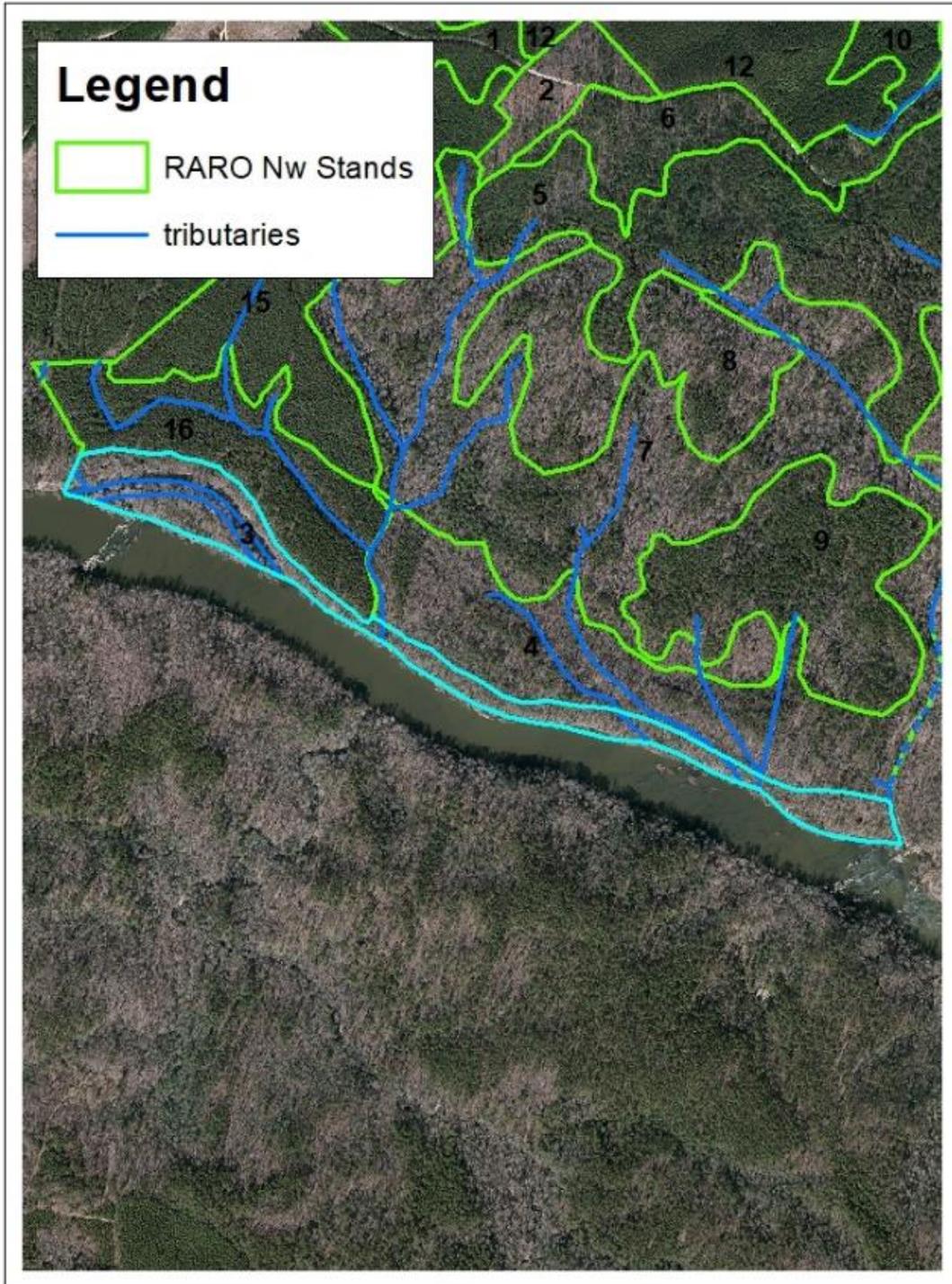


Fig. 39. Stand 3 highlighted in turquoise.

The soils are the Wehadkee soil series in the eastern part of the stand, and the Chewacla soil series in the western part (Fig. 10). Several of the unnamed tributaries drain to the river through this stand. Near the western border of the stand are the remains of what may have been a mill bridge (Fig. 40), and the river seems to be diverted artificially here at a section perpendicular to Lanier Falls (rapids) (Fig. 41). Along the stand's eastern border are the remains of the Northington Lock and Dam (NC Parks) (Fig. 41).

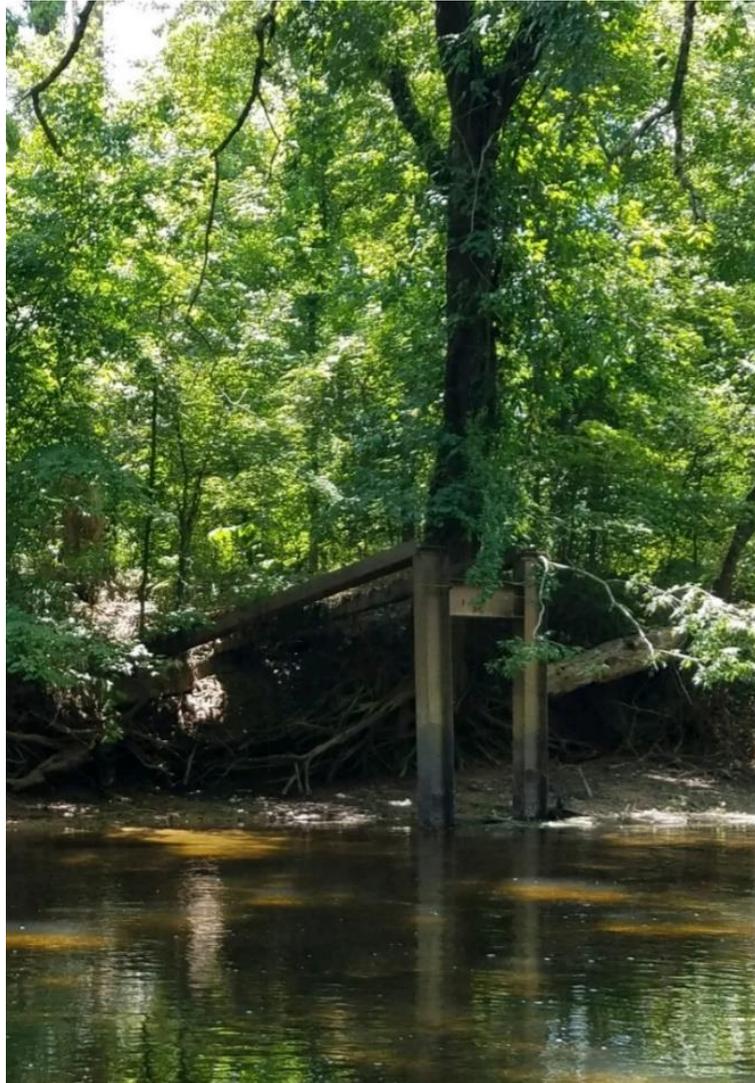


Fig. 40. Remnants of what may have been a mill bridge.

Lanier Falls and Northington Lock & Dam

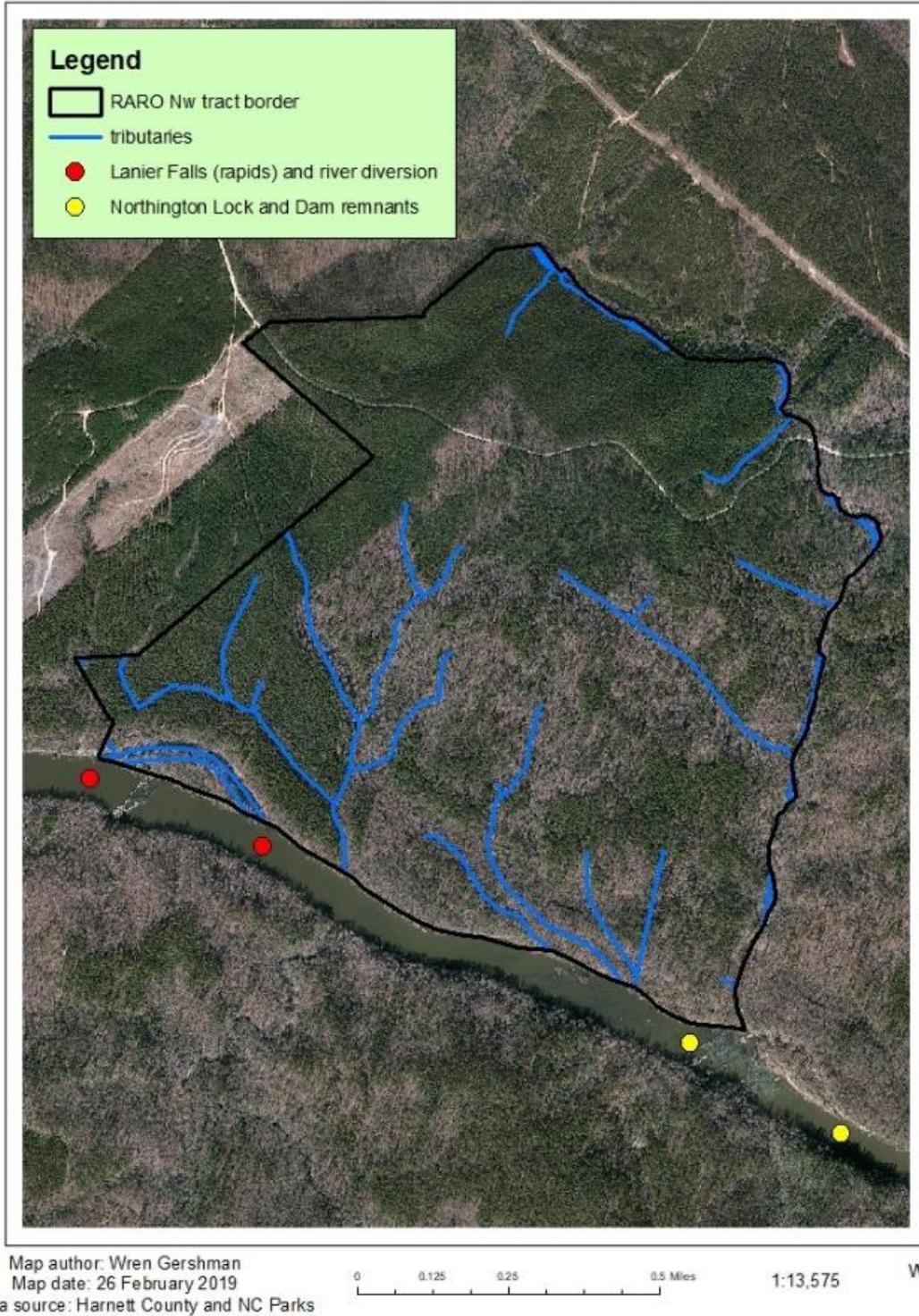


Fig. 41. Lanier Falls (rapids) and the river diversion between the red dots, and the remains of the Northington Lock and Dam between the yellow dots.

The overstory trees I inventoried are similar to the list from Schafale and Weakley (1990) (Table 27).

Table 27. Inventory data for overstory species in Management Unit 5, Stand 3.

scientific name	common name
<i>Acer floridanum</i>	southern sugar maple
<i>Acer negundo</i>	boxelder
<i>Aesculus sylvatica</i>	painted buckeye
<i>Betula nigra</i>	river birch
<i>Carya cordiformis</i>	bitternut hickory
<i>Celtis laevigata</i>	southern hackberry
<i>Fraxinus pennsylvanica</i>	green ash
<i>Liriodendron tulipifera</i>	yellow-poplar
<i>Morus rubra</i>	red mulberry
<i>Platanus occidentalis</i>	sycamore
<i>Ulmus alata</i>	winged elm
<i>Ulmus americana</i>	American elm

The average age was 76.7 years. The basal area averaged 152 ft²/ac. The mean dbh of dominant and co-dominant trees was 23.4 inches (with a range from 16.2 to 37.1 inches), and the mean height was 99.8 feet. Southern hackberry, boxelder, sycamore, and green ash, in that order, were the majority of the overstory (Table 28). Pawpaw (*Asimina triloba*) at 50.4 percent and painted buckeye (*Aesculus sylvatica*) at 29.6 percent were the majority of the understory (Table 29). Braun (1950) did not provide percentages for this community type.

Table 28. Overstory basal area (ft²/ac) by species in Stand 3.

overstory	Stand 3 BA, ft²/ac
<i>Celtis laevigata</i>	35
<i>Acer negundo</i>	28
<i>Platanus occidentalis</i>	27
<i>Fraxinus pennsylvanica</i>	20
<i>Liriodendron tulipifera</i>	8
<i>Carya cordiformis</i>	7
<i>Morus rubra</i>	6
<i>Ulmus alata</i>	6
<i>Acer floridanum</i>	4
<i>Aesculus sylvatica</i>	4
<i>Betula nigra</i>	4
<i>Ulmus Americana</i>	4

Table 29. Average percentage of understory species in fixed plots in Piedmont/Mountain Levee Forest.

understory	Stand 3 percentage
<i>Asimina triloba</i>	50.4
<i>Aesculus sylvatica</i>	29.6
<i>Ligustrum sinense</i>	6.6
<i>Lindera benzoin</i>	6.6
<i>Ilex decidua</i>	2.8
<i>Carya</i> spp.	1.8
<i>Quercus velutina</i>	1.8

Cherrybark oak (*Quercus pagoda*) was the only tree species observed that was not found in the overstory plots. The painted buckeye in the stand are mature and sizeable (Fig. 42).



Fig. 42. Species of Piedmont/Mountain Levee Forest: (left) Cherrybark oak adjacent to the Cape Fear River; (right) large painted buckeye.

Sugar maple (*Acer floridanum*) was regenerating in the understory. Muscadine, Virginia creeper, and poison-ivy were large and frequent. There were also cane, crossvine, false nettle (Fig. 43), Virginia wildrye (*Elymus virginicus*), smilax, wingstem, and unknown grasses. Even

more so than in the bottomland forest of the tract, the O-horizon was mostly trace amounts of hardwood litter. Chinese privet and Japanese stilt grass were abundant. Additionally, the invasive aquatic plant hydrilla (*Hydrilla* spp.) was found in the channel diversion between the mainland and the Cape Fear.



Fig. 43. False nettle, smilax, crossvine, ferns and grasses on the bank of a channel in levee forest.

Restoration Prescription

The hardwood overstory was typical for this natural community, and nothing needs to be removed. However, the potential for herbaceous and woody vegetation is obstructed by the abundance of Chinese privet and Japanese stilt grass. The recommendation for the control of these invasive species would be the same as mentioned in Stand 4, Piedmont/Mountain Bottomland Forest. Additionally, for several years, the river diversion adjacent to Lanier Falls should be closed off to control hydrilla with an annual treatment of fluridone released into the

channel at a constant rate (Rob Richardson, pers. comm., Aquatic and Noncropland Weed Science Professor and Extension Specialist, Mar. 7, 2019).

Summary

- Management Unit 1
 - Stand 1: Perform pre-harvest burn, clearcut harvest, plant longleaf, control the hardwood competition with herbicide, burn when longleaf has reached canopy.
- Management Unit 2
 - Stands 2, 6, and 8: Girdle all loblolly except for those within a 100-foot buffer of the equestrian trail, where the trees should be felled instead. Girdle 10 percent of the loblolly basal area in each stand annually for ten years until all of the loblolly is gone. Leave shortleaf for red-cockaded woodpecker.
 - In Stand 6, burn to reduce the red maple and holly understory.
 - In Stands 2 and 8, use imazapyr to control the hardwood understory.
 - Stands 12 and 14:
 - Girdle 10 percent of the loblolly basal area in each stand annually for ten years until all of the loblolly is gone.
 - In Stand 12, remove all of the loblolly and sweetgum, and most of the red maple with triclopyr.
 - Northern portion of Stand 14: Girdle loblolly, and eventually treat hardwood competition with imazapyr. Longleaf may volunteer from Stand 1, but only if fire is used.
 - Southern portion of Stand 14: Treat all of the sweetgum and most of the red maple with imazapyr.
- Management Unit 3
 - Stands 5, 7, 9, 10, 13, and 15: Girdle all loblolly in these stands; 10 percent of the loblolly basal area in each stand annually over a period of ten years until the species is gone. In Stands 5, 7, and 9, leave a 100-foot buffer of felled loblolly surrounding the equestrian trail instead of girdling.
 - No species percentages given in Braun (1950) for this forest type, so there is no recommendation for control.
 - In Stands 5, 7, and 9, retain shortleaf for red-cockaded woodpecker, and use herbicide control of Japanese stilt grass as recommended in Stand 4.

- In Stands 10, 13, and 15, yellow-poplar and northern red oak may seed into canopy gaps; southern sugar maple and beech may also seed in.
- Management Unit 4
 - Stands 4, 11, and 16: Girdle loblolly to 8% of the total stand basal area (at the same rate as recommended in previous stands); apply aquatic glyphosate without surfactant to control the excess winged elm and exotic invasive vegetation.
- Management Unit 5
 - Stand 3: Apply aquatic glyphosate without surfactant to control the Japanese stilt grass and Chinese privet; use a steady fluridone drip to control hydrilla.

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Appendix A –

NC Natural Heritage Program – Natural
Heritage Element Occurrences, Natural
Areas, and Managed Areas Intersecting the
Project Area, West side of Raven Rock