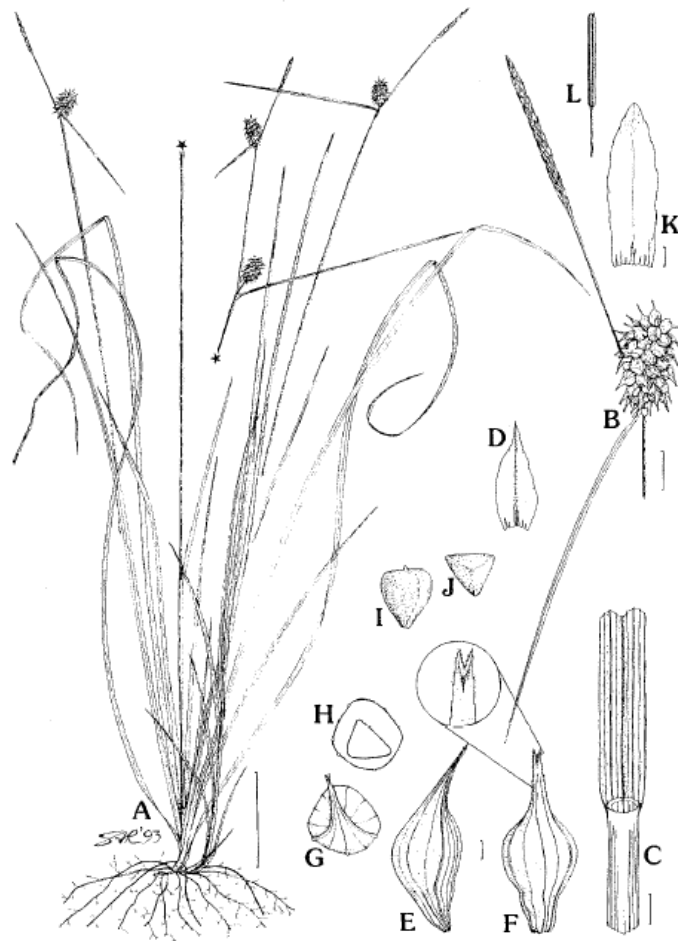


RECOVERY PLAN

FOR

GOLDEN SEDGE

(*Carex lutea*)



Carex lutea A. Habit, B. Portion of inflorescence, C. Sheath and ligule, D. Pistillate scale, E. Perigynium, side view, F. Perigynium, front view, G. Perigynium, top view, H. Perigynium and achene, transverse section, I. Achene, front view, J. Achene, top view, K. Staminate scale, L. Anther. Bar equals 5 cm in A, 5 mm in B, 2 mm in C and 0.5 mm in D. Drawn by Susan A Reznicek from the holotype.



RECOVERY PLAN

for

GOLDEN SEDGE
(Carex lutea)

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Date: _____

3/20/14



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The cover illustration of *Carex lutea* is by Susan A. Reznicek. This illustration was prepared for the species description originally published by LeBlond et al. (1994).

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EXECUTIVE SUMMARY

Status of the Species: *Carex lutea* was described as a distinct species by R. LeBlond in 1994 and was listed as an endangered species under the Endangered Species Act (ESA) on January 23, 2002 (67 FR 3120). It is endemic to the outer coastal plain of North Carolina. *Carex lutea* is also listed as endangered under the North Carolina Plant Conservation Act which is administered by the North Carolina Department of Agriculture and Consumer Services (North Carolina Code Article 19B, § 106-202.12).

Habitat Requirements and Limiting Factors: *Carex lutea* is a perennial (plant with a life span greater than two years) member of the sedge family (Cyperaceae). A small plant, it is generally 1 to 2 feet (0.3-0.6 m) tall but can reach up to 3 feet (1 meter) tall. *Carex lutea* typically occurs in the wet savanna/hardwood ecotones and open wet savannas. This endangered plant is generally found in areas with an open to sparse canopy, a patchy shrub layer, and/or a dense herb cover. It may also occur in fire suppressed closed canopy forests, although plants that occur in low light conditions appear to be less vigorous. All known populations of this plant are in the Northeast Cape Fear River watershed in Pender and Onslow Counties, North Carolina.

Threats to this species include habitat alteration caused by fire suppression, conversion of limited known habitat for residential, commercial, or industrial development, highway and utility expansion, and wetland drainage activities associated with silviculture, agriculture and development projects. In addition, roadside and utility right-of-way populations are vulnerable to extirpation from herbicide application. Invasive species, small population size and drought are other threats to the species.

Recovery Strategy: The recovery strategy for *Carex lutea* involves protection and management of known sites of the species, including addressing immediate threats with fire management and invasive species control as needed. In order to help recover this plant and grow the number of viable populations in the wild, we intend to work closely with partners to reduce threats to known populations, increase understanding of the biology of this plant, and find new strategies for seed collection and banking. With partners like local governments, universities, and State agencies, we will share information with the local community about why *Carex lutea* is a unique plant and should be protected.

Recovery Goal: The ultimate recovery goal is to remove (delist) this species from the *Federal List of Endangered and Threatened Plants* (50 CFR 17.12) by ensuring the long-term viability of the species in the wild. Initially, the recovery goal is to reclassify (downlist) *Carex lutea* from endangered to threatened status based upon its improved status due to the implementation of recovery actions in this plan.

Recovery Criteria:

***Carex lutea* will be considered for reclassification from endangered to threatened status (downlisting) when:**

1. There are 10 protected *Carex lutea* sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a

management agreement and are ranked as an A or B population by the North Carolina Natural Heritage Program (NCNHP). See Appendix C for additional information about the rank specifications for *Carex lutea*.]

2. On each of the 10 *Carex lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *Carex lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume).
3. All 10 *Carex lutea* sites demonstrate stable or increasing population trends for five consecutive years.
4. Habitat management plans are actively being implemented for at least 7 of the protected sites.
5. A prescribed fire regime has been developed and is being conducted at all sites to mimic historical frequency and timing (the frequency will be determined through recovery actions in this plan).

We define “protected” to mean the site has been fee simple acquired and put into long term conservation by a local or State agency or a conservation easement or other binding land agreement has been placed on the site by a landowner that shows a commitment to its conservation in perpetuity and it is represented in a Center for Plant Conservation (CPC) approved seed bank. In addition, each site should have a management agreement/plan developed. Prescribed fire should be part of the agreement/plan and implemented regularly. These plans should include monitoring, according to protocols developed collaboratively by the Service, NCDACS, NCDPR, The Nature Conservancy (TNC) and other interested parties and should occur annually at each protected site. Each site should contain an A or B ranked occurrence (see Appendix C). For downlisting to be considered, at least seven of the 10 protected sites should be “A-ranked” occurrences. The remaining three sites can be either “A or B-ranked” occurrences.

***Carex lutea* will be considered for removal from the List of Endangered and Threatened Species (delisting) when:**

1. There are 15 protected sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a management agreement and are ranked as an A or B population by the NCNHP. See Appendix C for additional information about the rank specifications for *Carex lutea*.]
2. On each of the 15 *Carex lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *Carex lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume).
3. All 15 *Carex lutea* sites demonstrate stable or increasing population trends for ten consecutive years.
4. Habitat management plans are actively being implemented for all protected sites and are showing evidence that actions are proving effective for this plant.
5. A prescribed fire regime is being conducted at all sites to mimic historical frequency and timing (which will be determined through recovery actions in this plan).

We define “protected” to mean the site has been fee simple acquired and put into long term conservation by a local or State agency or a conservation easement or other binding land

agreement has been placed on the site by a landowner that shows a commitment to its conservation in perpetuity and it is represented in a CPC approved seed bank. In addition, each site should have a management agreement/plan developed. Prescribed fire should be part of the agreement/plan and implemented regularly. These plans should include monitoring, according to protocols developed collaboratively by the Service, NCDACS, NCDPR, TNC and other interested parties and should occur annually at each protected site. Each site should contain an A or B ranked occurrence (see Appendix C). For delisting to be considered, at least 10 of the 15 protected sites should be “A-ranked” occurrences. The remaining five sites can be either “A or B-ranked” occurrences.

Recovery Actions Needed:

1. Protect *Carex lutea* sites/occurrences and adjacent buffer habitat.
2. Increase and strengthen *Carex lutea* sites/occurrences through management, augmentation or other techniques.
3. Develop site specific management and prescribed burn plans for each occurrence.
4. Conduct surveys for additional populations and investigate options/avenues for potential reintroductions.
5. Develop and implement a monitoring plan to assess population trends, reproductive success and threats.
6. Conduct research essential to the survival of *Carex lutea*.
7. Develop and implement an education and outreach program to help partners and local landowners.

Estimated Cost of Recovery: The implementation of recovery tasks, from which cost estimates can be made over a three-year period of recovery effort, will total approximately \$231,500.

Year	Action 1	Action 2	Action 3	Action 4	Action 5	Action 6	Action 7	Total Cost
FY 1	30.0	16.0	11.0	6.0	5.0	13.0	2.5	83.5
FY 2	30.0	13.0	7.0	6.0	5.0	13.0	2.5	76.5
FY 3	25.0	13.0	7.0	6.0	5.0	13.0	2.5	71.5
TOTAL	85.0	42.0	25.0	18.0	15.0	39.0	7.5	231.5

Date of Recovery: The estimated date for full recovery is 2025, provided that funds are available to accomplish the required recovery actions and that the recovery criteria are met.

**Golden Sedge (*Carex lutea*)
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PART I. INTRODUCTION

A. Status

Carex lutea was recognized as a distinct species in 1994 (LeBlond et al. 1994). The U.S. Fish and Wildlife Service (Service) listed *Carex lutea* (golden sedge) as an endangered species under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*; hereinafter called the Act) on January 23, 2002 (67 FR 3120; USFWS 2002). *Carex lutea* has a recovery priority number of 8, indicating moderate threats, a high potential for recovery and a taxonomic status of full species (see Appendix A for further detail). The State of North Carolina (North Carolina Department of Agriculture and Consumer Services (NCDACS)) also lists this species as endangered under the North Carolina Plant Conservation and Protection Act (North Carolina Code Article 19B, § 106-202.12)

The North Carolina Natural Heritage Program (NCNHP) currently recognizes eight populations of *Carex lutea*. On March 1, 2011 (76 FR 11086), the Service designated eight critical habitat units (21 subunits) for *Carex lutea*, comprising approximately 202 acres (ac) (82 hectares (ha)) in Pender and Onslow counties in eastern North Carolina. A total of 17 sites/occurrences or more than 80 percent of the designated critical habitat areas are already in conservation ownership by the State of North Carolina (NCDPR), North Carolina Wildlife Resources Commission (NCWRC) and North Carolina Department of Transportation (NCDOT) and The Nature Conservancy (TNC). The remaining 20 percent of the designated critical habitat areas are privately owned (76 FR 11086).

Since this plant was relatively recently discovered, little information is available on biological requirements of this species, the overall status of each site, etc. The only complete status survey for *Carex lutea* was completed in 1996 (LeBlond 1996). In addition, the NCNHP completed natural heritage inventories of Onslow County in 1999 and Pender County in 2000. County-wide surveys have been conducted by NCNHP in both counties of occurrence (Onslow, Pender). In 1993, 1994, and 2000, surveys were also conducted in the Old Dock area of Brunswick and Columbus counties where there are documented occurrences of the rare savanna type in which the sedge occurs; however, no *Carex lutea* was found there. Adjacent counties also have been surveyed, and the Department of Defense (DOD) has conducted surveys at Camp Lejeune Marine Corps Base in Onslow County specifically for the federally listed, endangered *Carex lutea* and *Thalictrum cooleyi* (Cooley's meadowrue); however, neither species has been found there.

The Service and the NC Botanical Garden (NCBG) set up long term monitoring plots at 10 *Carex lutea* sites and began monitoring this species in 2010. This work will continue through 2014; however, additional monitoring will be necessary in the future to determine if those sites are stable, decreasing or increasing.

B. Species Description and Taxonomy

Carex lutea is a perennial member of the sedge family (Cyperaceae). Fertile culms (stems) may reach 39 inches (in) (1 meter; m) or more in height. The yellowish green leaves are grass-like, with those of the culm mostly basal and up to 11 in (28 centimeters; cm) in length, while those of the vegetative shoots reach a length of 25.6 in (65 cm). Fertile culms produce two to four flowering spikes (compact flower clusters), with the terminal spike being male and the one to three (usually two) lateral spikes being female. Lateral spikes are subtended by leaf-like bracts (a much-reduced leaf). The male spike is about 0.8 – 1.6 in (2 - 4 cm) long, 0.06 – 0.1 in (1.5 - 2.5 millimeters; mm) wide, with a peduncle (stalk) about 0.4 – 2.4 in (1 - 6 cm) long. Female spikes are round to elliptic, about 0.4 – 0.6 in (1 - 1.5 cm) long and 0.4 in (1 cm) wide. The upper female spike is sessile (not stalked; sitting), while lower female spikes, if present, have peduncles typically 0.2 – 1.8 in (0.5 - 4.5 cm) long. When two to three female spikes are present, each is separated from the next along the culm by 1.8 – 7.1 in (4.5 to 18 cm). The inflated perigynia (sac which encloses the seed) are bright yellow when seeds mature and about 0.16 – 0.20 in (4 to 5 mm) long. The perigynia are out-curved and spreading, with the lowermost in a spike strongly reflexed (turned downward) (LeBlond et al. 1994).

History of the taxon

Carex lutea was first collected by Richard LeBlond on April 11, 1990, in Pender County, North Carolina. It was collected in an immature state. From analysis of a mature specimen collected on May 22, 1991, it was determined that the taxon belonged to the genus *Carex*, section *Ceratocystis* (= *Extensae*), a circumboreal section not previously known from North Carolina. Sedges of the section *Ceratocystis* occur in temperate regions in North America, Europe, Asia, and Australia. In North America, they are primarily in the northern temperate region. *Carex lutea* is the southern-most species in the section in North America (Ball and Reznicek 2003).

A comparison of the taxon with flora manual descriptions and with specimens of section *Ceratocystis* at the University of North Carolina herbarium at Chapel Hill indicated that the taxon was a new, undescribed species. The May 22, 1991 collection with descriptive analysis was sent to A.A. Reznicek at the University of Michigan, who confirmed that the North Carolina taxon was a new and distinctive member of *Carex* section *Ceratocystis*. Five additional locations, three in Pender County and two in Onslow County, were discovered by Richard LeBlond and Alan Weakley on May 12, 1992. Three of these locations were visited on May 20, 1992, by A.A. Reznicek and others, at which time the holotype and isotypes were collected from The Neck Savanna (formerly known as Lanier Quarry Savanna). Several additional locations have been found in Onslow and Pender counties since that time. The NCNHP currently recognizes eight populations or principal element occurrences consisting of 21 subpopulations. All of the locations occur within a 16 by 5 mile (mi) (25.7 by 8 kilometer; km) area, extending southwest from the Maple Hill area to a location west of Holly Shelter Game Land. There are no known historical populations. The distribution is based solely on currently known populations. *Carex lutea* is considered a narrowly restricted endemic.

According to Derieg et al (2008, 2013), *Carex lutea* maintains the highest levels of genetic diversity observed in North American populations of the section *Ceratocystis* taxa. Its genetic diversity is comparable to levels observed in European representatives of this section.

C. Population Trends and Distribution

Number and geographical spacing of populations

All eight populations of *Carex lutea* occur in the Northeast Cape Fear River watershed in Pender and Onslow counties, North Carolina. The following locations are listed in order of NCNHP Principal Element Occurrence (EO) numbers. Approximate locations are shown in Figure 1. NCNHP site ranks follow the EO numbers. Definitions for site ranks are included in Appendix C.

- *Watkins Savanna, Pender County, North Carolina (Principal EO 5; EO 5.12, 5.13 and 5.19; Rank = B)*. *Carex lutea* occurs in three locations that are under private and state ownership. EO 5.12 is owned by the NCDPR. EO 5.13 is owned by both private entities and NCDPR. EO 5.19 was discovered in 2006 and is also in conservation ownership by NCDPR. NCDPR manages their portion of these lands as part of the Sandy Run Savannas State Natural Area and they are currently negotiating with the NCNHP to designate these sites as Dedicated Nature Preserves. The State owned lands were purchased with the assistance of TNC and the Natural Heritage Trust Fund.
- *Haws Run Mitigation Site, Onslow County, North Carolina (EO 7; Rank = B)*. Haws Run Mitigation Site is located near the Pender County line north of Shelter Swamp Creek. This site is owned by the NCDOT and managed by NCDPR and the N.C. Ecosystem Enhancement Program (NCEEP). It is currently undergoing restoration of natural communities and protection and enhancement of rare species populations. The managers are considering designating this site as a Dedicated Nature Preserve through the NCNHP.
- *Maple Hill School Road Savanna, Pender County, North Carolina (EO 10; Rank = C)*. As of July 2012, it appeared that this privately owned site had been converted into a blueberry farm. The size of the *Carex lutea* population is unknown and it is unclear how much, if any, of the plants were impacted by this land conversion (D. Suiter, pers. observ. 2012).
- *Southwest Ridge Savanna, Pender County, NC (EO 11; Rank = C)*. This site is in a powerline corridor at Ashes Creek, south of Bear Garden Road. The site was added to the state-owned Holly Shelter Game Land (NCWRC) after it was discovered in 2002. The population occurs in two locations separated by Ashes Creek. Both are within a Duke Energy power line right-of-way easement. The utility company entered into a management agreement with the NCNHP and agreed not to use herbicides or mow during the growing season. This population is relatively small in size compared to some of the other populations. Unfortunately, this site was plowed up by the North Carolina Forest Service while trying to contain the Juniper Road wildfire at Holly Shelter Game Lands, in the summer of 2011. Growing season surveys in 2012 indicate that this population has been greatly reduced in size since the last surveys in 2006 (Taggart 2012a).

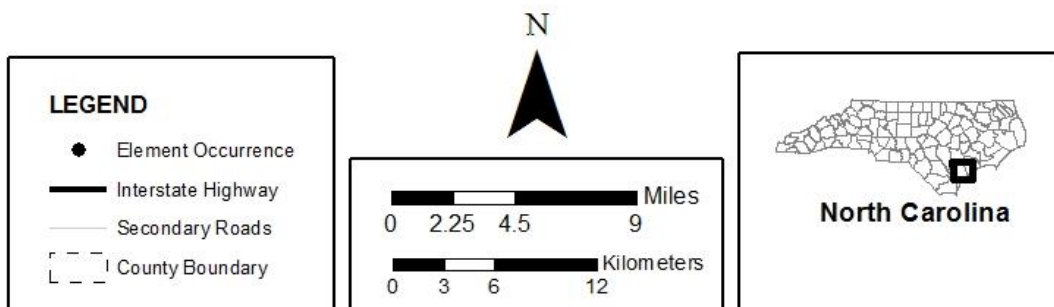
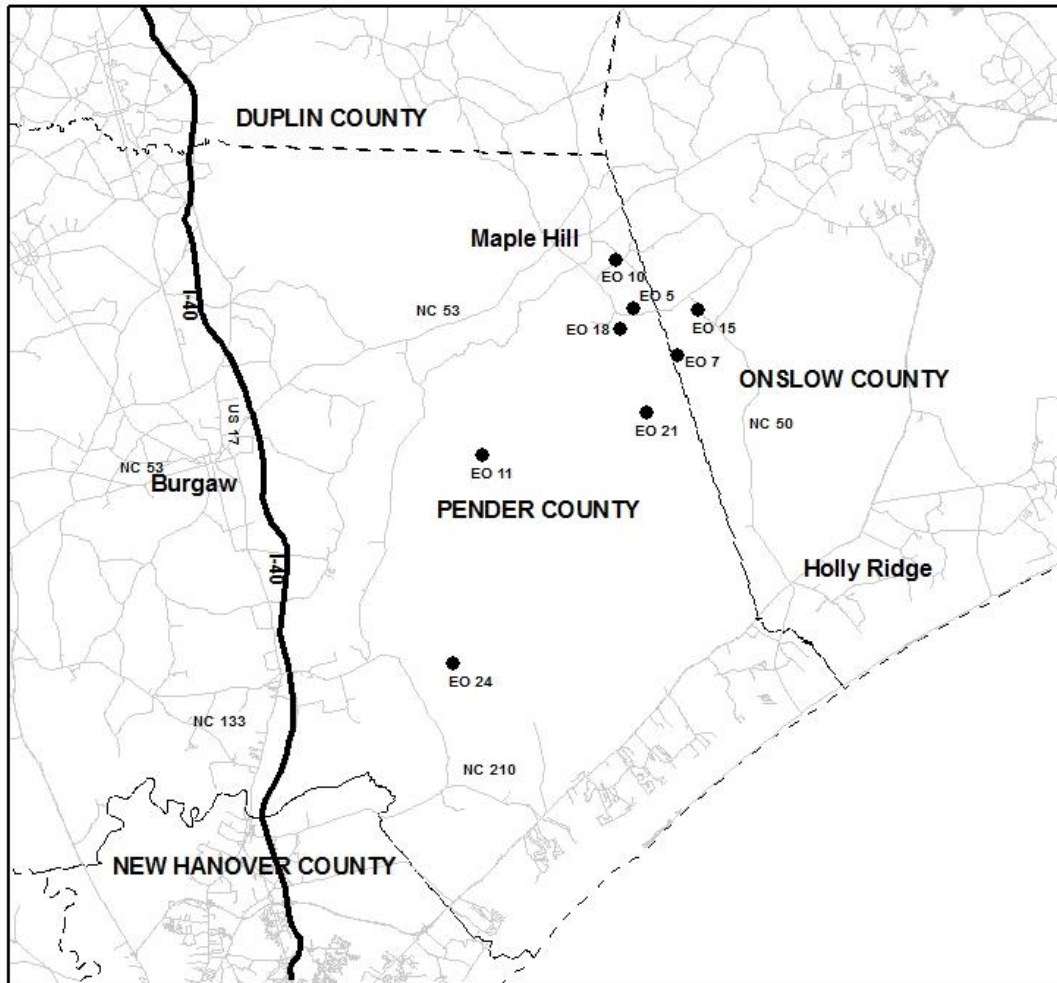


Figure 1. Map of *Carex lutea* populations, Pender and Onslow counties, North Carolina (supported by Service and NCNHP data).

- *Sandy Run Savannas, Onslow County, North Carolina (Principal EO 15; EO 15.3, 15.4 and 15.14; Rank = C)*. The Sandy Run Savannas is owned by NCDPR and managed as part of the Sandy Run Savannas State Natural Area. It consists of five distinct sites that make up three EOs. EO 15.3 occurs in a Duke Energy transmission line right-of-way on the east side of NC Highway 50. Duke Energy has entered into a management agreement with the NCNHP in which they have agreed to not use herbicides or mow during critical *Carex lutea* growth periods. EO 15.4 occurs along the north and south sides of a private sand road through the property and on both sides of and within a small stream swamp. The *Carex lutea* plants are growing in an old, wet road bed, a roadside ditch and along a fire break and in associated low, moist areas. EO 15.14 occurred contiguous to and on the west side of NC 50, however was not located during recent botanical surveys in 2012. Like EO 15.3, this site also occurs in a Duke Energy transmission line right-of-way and is protected by a management agreement with the NCNHP. Despite the management agreement, this site was impacted by the NC Forest Service during the construction of fire plow lines in July 2011 as part of an effort to control the Juniper Road Wild Fire. The impacts to the species are unknown until further surveys can be conducted. These sites have been designated as the Sandy Run Savannas Dedicated Nature Preserve.
- *The Neck Savanna (formerly Lanier Quarry Savanna; Rank = A), Pender County, North Carolina (Principal EO 18; EO 18.1, 18.16 and 18.17)*. *Carex lutea* occurs here at three sites. EO 18.1 is the type locality for *Carex lutea* and is owned by NCDPR. NCDPR manages this land for the protection and enhancement of rare species populations and natural communities. Some of this area will become part of the Sandy Run Savannas State Natural Area. Sub EO 18.1 is designated as a Dedicated Nature Preserve with the NCNHP. Two sites (EO 18.16 and 18.17) are located along the road to Lanier Quarry and in a small power-line corridor along Williams Road near Sandy Run Swamp. These sites are privately owned. The Williams Road site was impacted by herbicides and deposition of woody debris from the trimming of trees along the power line in 2010. No *Carex lutea* plants were observed in 2011; however, due to the woody debris, it was difficult to get to the specific locations where the plants grew. The woody debris was removed in September 2011 after any surviving *Carex lutea* plants would have died back for the season.
- *Shaken Creek Savanna, Pender County, North Carolina (Principal EO 21; EO 21.8, 21.20, 21.26, 21.27, 21.28 and 21.29; Rank = A)*. Shaken Creek Savanna is located north of Shaken Creek and about 1.5 mi (2.4 km) west of the Onslow County line. This savanna complex contains the highest quality natural habitat and the largest population of *Carex lutea* known. The six sites or subpopulations are owned by TNC while the hunting rights are separately owned by private individuals and are tied to a hunt club. With continued fire management, it is believed that these sites should remain stable.
- *McLean Savanna, Pender County, North Carolina (Principal EO 24; EO 24.9, 24.22 and 24.23; Rank = A)*. McLean Savanna is located near Catskin Creek west of Holly Shelter Game Land. This population includes three subpopulations over an extensive area and is the second largest population known. EO 24.9 is owned by TNC. EO 24.22 was discovered in June 2007 and is privately owned but protected by a Clean Water

Management Trust Fund conservation easement. EO 24.23 is owned by TNC. This population was also discovered in June 2007 and the extent of the population was greatly expanded during 2010 surveys. These savannas have been managed by fire for many years to facilitate hunting. Recent prescribed fire greatly increased the known extent of one of the subpopulations.

D. Life History / Ecology

Given that *Carex lutea* is a relatively recently described species and has few known populations, the existing knowledge about the ecology and life history of this species is limited. Recently initiated research should provide additional information about the natural history of this species.

Phenology

The basal leaves of *Carex lutea* overwinter. Culm growth probably begins in mid to late March, with development of flowering spikes beginning in early April. Flowering occurs from mid-April to early May, with perigynia (bottle shaped appendage around the pistil) maturing during May and June. By mid-June, the mature perigynia begin to fall from the spikes, and most perigynia have fallen by the end of June. It is not known how long culms persist after fruit maturation, but senescent culms have been observed as late as September (LeBlond 1994a, 1996 and 1998).

Reproductive biology

The reproductive biology of *Carex lutea* is unknown; however, because ample mature seed production has been observed, we can confidently surmise that *Carex lutea* reproduces both sexually, involving gravity and wind dispersed pollen, as well as vegetatively (L. Bruederle, University of Colorado Denver, pers. comm. 2007). Perigynia are dispersed when rigid fertile culms fall to the ground, thereby depositing the fruits on the substrate adjacent to, but at some distance from the maternal parent (L. Bruederle, pers. comm. 2007). Seeds have been observed in ditches adjacent to colonies, indicating dispersal by precipitation sheet flow. Animals may also be seed dispersers; the perigynia beaks are minutely serrulate, perhaps an adaptation for attachment to fur. According to L. Bruederle (pers. comm. 2014), members in this section of *Carex* may persist in the seed bank. Germination rates as high as 80% were observed in spring after seeds were sown in soil the previous fall (M. Kunz, North Carolina Botanical Garden, pers. comm. 2013). Survival rates and the nature of mortality of individual plants are unknown. Based on observations at Shaken Creek Savanna and McLean Savanna, it appears that *Carex lutea* is a successful colonizer of suitable newly disturbed areas. Preliminary data suggest that populations burned during the reproductive period do not flower again in the same year.

E. Habitat Characteristics

Description of the taxon's general environment, habitat, and physical characteristics

All known and extant *Carex lutea* populations occur in sandy soils overlying coquina limestone deposits. The taxon shows a preference for the ecotone between the pine savanna and adjacent wet hardwood or hardwood-conifer forest, and edges of shrubby depressions within savannas. Most plants occur in the partially tree-shaded savanna/swamp ecotone, with scattered shrubs and a moderate to dense herb layer; however plants have been observed in open sunny savannas and

deeply shaded forests adjacent to these ecotones. The savanna/swamp ecotone is subject to frequent fires which favor an herbaceous ground layer and suppress shrub dominance (LeBlond 1994b). Several sites have been lightly to extensively disturbed by plow lines or surface impacts associated with past clearing, and *Carex lutea* has successfully colonized or re-colonized some of these disturbed areas (R. LeBlond, pers. observ.). *Carex lutea* is a patch dominant at a few sites. Occurrences are densest in areas of partial tree or tall shrub shading with an open ground layer although less vigorous plants may occur in low light conditions. Frequent associates include *Taxodium ascendens* (pond cypress), *Pinus serotina* (pond pine), *Pinus palustris* (longleaf pine), *Liriodendron tulipifera* (tulip poplar), *Acer rubrum* var. *trilobum* (Carolina red maple), *Morella carolinensis* (evergreen bayberry), the federally listed, endangered *Thalictrum cooleyi* (Cooley's meadowrue), *Aletris farinosa* (northern white colic-root), *Rhynchospora pinetorum* (Small's beakrush), and *R. thornei* (Thorne's beakrush) (LeBlond 1996, 1998).

The outer southeastern coastal plain of North Carolina experiences hot and humid subtropical summers and cool temperate winters with subfreezing periods. Persistent snow accumulation is rare. According to National Weather Service data recorded in Wilmington, NC (ca. 30 mi (48.3 km) south-southwest of the center of *Carex lutea* populations), the mean annual temperature in Wilmington is 63.9 °Fahrenheit (F) (17.7 ° Celsius (C)). The average high temperature is 74.0 °F (23.3 °C) and the average low temperature is 53.5 °F (11.9 °C). The mean daily temperature is highest in July (81.1 °F) (27.3 °C) and lowest in January (46.1 °F) (7.8 °C). The annual average precipitation in Wilmington is 57.07 inches (in) [144.96 centimeters (cm)] (National Oceanic and Atmospheric Association (NOAA) 2013a.). The crop growing season averages 244 days (NOAA 2013b).

The area supporting the *Carex lutea* populations is located in the Black River Section of the Northeast Cape Fear River watershed in the Coastal Plain Province. The land surface is characterized by large areas of broad, level flatlands and shallow stream basins. The broad flatlands support longleaf pine forests, pond pine woodlands, shrub swamp pocosins, pine plantations, and cropland. The geology is characterized by unconsolidated sand overlying layers of clayey sand and weakly consolidated marine shell deposits (coquina limestone). These sediments were deposited and reshaped during several cycles of coastal emergence and submergence from the Cretaceous period to the present (LeBlond 1996, 1998).

Carex lutea occurs on fine sandy loam (Grifton, a Typic Ochraqualf) and on loamy fine sands (Foreston, an Aquic Paleudult; Stallings, an Aeric Paleaquult; and Woodington, a Typic Paleaquult). Taggart and Long (2012) collected 96 soil samples (48 topsoil and 48 subsoil) at three *Carex lutea* sites. Mean pH values within sites were very strongly (4.7) to moderately acid (5.7) for topsoils. Mean pH values for subsoils were moderately (5.8) to slightly (6.5) acid.

Carex lutea is found in very wet to saturated to periodically shallowly inundated soils. The largest populations are found in the wet to saturated ecotones of savannas and hardwood forests. At a few sites, the plants are most abundant in wet to saturated soils adjacent to drainage ditches, and in the saturated to shallowly inundated ditches themselves. The occurrence of individuals in ditches is likely due to the wetter soils of the ditches, and/or the washing of seeds into the ditches from adjacent microhabitat. *Carex lutea* occasionally occurs in very wet soil in areas of savanna habitat characterized by an open to absent canopy, suggesting that its abundance in the

savanna/wet hardwood ecotone is strongly influenced by hydrologic conditions as well as by edaphic and/or light conditions. It is probable that drainage ditches have reduced, perhaps greatly, the amount of suitable habitat available for *Carex lutea* and other rare species at these sites. There is also evidence that increased shading and shrub competition from fire suppression has resulted in the reduction of the number of individuals observed (M. Kunz, NC Botanical Garden, pers. comm. 2013).

The savanna habitat where *Carex lutea* is found is ecologically highly unusual and phytogeographically notable. The combination of an open savanna canopy with a near-surface calcareous layer and with a suite of plants of calciphilic affinities is very rare on the Atlantic coastal plain. Many rare plant species are associated with these localities, and several have very restricted distributions, either being endemic to a small area or with a few highly scattered occurrences. The affinities of these taxa are variable, but include connections to the calcareous savannas of the Gulf Coast states; alkaline marshes of the Atlantic tidewater; calcareous glades, barrens, and prairies of the Appalachian region and the ridge-and-valley province of Georgia and Alabama; and pinelands of the Carolinas and southern New Jersey. Most notable are two globally restricted species closely associated with *Carex lutea*: the federally listed, endangered *Thalictrum cooleyi*, and an undescribed species of *Allium* (Savanna onion). As of 2012, *Thalictrum cooleyi* was known from 18 populations globally, all of which are ecotones of savannas with shrubby depressions or adjacent wet hardwoods (including narrow powerline corridors with savanna herbaceous flora) in areas underlain by calcareous deposits (USFWS 2009). *Thalictrum cooleyi* is a microhabitat associate at almost all known *Carex lutea* localities. The undescribed *Allium* (an onion) taxon is known from only nine sites globally, seven of them shared with *Carex lutea*. The undescribed *Scleria* (a nutsedge) taxon is currently known from three sites globally, all shared with *Carex lutea*. Because of their unusual edaphic conditions, these savannas underlain by calcareous deposits have evidently served as a small archipelago of phytogeographic islands for species poorly adapted to present conditions elsewhere on the southeastern coastal plain. The mechanism by which the calcareous substrate influences the occurrence of these plants is unclear. Surface soils in these sites are acidic and not high in calcium, and the influence of the underlying calcareous material has been measured only in the subsoil. Taggart and Long (2012) observed that *Carex lutea* roots and rhizomes extended only to 8 cm deep, confined to the topsoil layer where calcareous influence was not measured. Nevertheless, the strong association of this suite of plants with calcareous subsoils, and their absence from soils that lack calcareous substrate, suggests that this relationship is unlikely to be coincidence. M. Schafale (NC Natural Heritage Program, pers. comm. 2014) suggested two hypotheses for this association: (1.) Transient presence of calcareous water in the topsoil only during periods of seasonal high water table; or (2.) indirect influence through effects on soil microbes. Mycorrhizal hyphae might reach farther than visible plant roots.

Community structure and regional vegetation type

Carex lutea habitat is classified as Very Wet Loamy Pine Savanna according to Schafale (2012). It is the natural community type formerly referred to as the Pine Savanna (Very Wet Clay Variant) by Schafale (1994). Plant community structure is characterized by an open to sparse canopy dominated by *Pinus serotina* (pond pine), and usually with some *P. palustris* (longleaf pine) and *Taxodium ascendens* (pond cypress). The shrub layer typically is sparse to patchy, with *Morella caroliniensis* (evergreen bayberry), *Cyrilla racemiflora* (ti-ti), *Ilex glabra*

(inkberry), *I. myrtifolia* (myrtle holly), and *Vaccinium fuscatum* (hairy highbush blueberry). Juvenile *Acer rubrum* var. *trilobum* (Carolina red maple) and *Nyssa biflora* (swamp black gum) are often present. The herb layer is dense and dominated by combinations of *Ctenium aromaticum*, *Sporobolus pinetorum*, *Muhlenbergia expansa* (savanna hairgrass) and several *Rhynchospora* taxa (e.g., *R. pinetorum* (Small's beakrush)), *R. latifolia* (broadleaf whitetop sedge), and *R. thornei* (Thorne's beakrush). *Carex lutea* also frequently occurs in the ecotone formed by the Pine Savanna community and adjacent Nonriverine Wet Hardwood Forest (LeBlond et al. 1994).

National vegetation type classification places this natural community in the *Pinus palustris* - *Pinus serotina* / *Sporobolus pinetorum* - *Ctenium aromaticum* - *Eriocaulon decangulare* var. *decangulare* Woodland association of the *Pinus palustris* - *Pinus* (*P. elliotii*, *P. serotina*) Saturated Woodland Alliance (NatureServe 2013). This association is equivalent to the Very Wet Loamy Pine Savanna (Schafale 2012), a natural community type with fewer than 10 occurrences globally. The Very Wet Loamy Pine Savanna is known only from the Maple Hill area near the Onslow/Pender county line and north and west of Holly Shelter Game Land, and from the Old Dock area of the Waccamaw River watershed along the Brunswick/Columbus county line. *Carex lutea* has never been found in the Old Dock area.

F. Critical Habitat

Critical habitat was designated for *Carex lutea* on March 1, 2011 (76 FR 11086; USFWS 2011). Based on our current knowledge of the life history, biology, and ecology of the species and the habitat requirements for sustaining the essential life-history functions of the species, we determined that the single primary constituent element (PCE) for *Carex lutea* is Pine Savanna (Very Wet Clay Variant) natural plant community or ecotones that contain:

- (1) moist to completely saturated loamy fine sands, fine sands, fine sandy loams, and loamy sands soils with a pH of 5.5 to 7.2;
- (2) open to relatively open canopy that allows full to partial sunlight to penetrate to the herbaceous layer between savannas and hardwood forests; and
- (3) areas of bare soil immediately adjacent [within 12 in (30 cm)] to mature *Carex lutea* plants where seeds may fall and germinate or existing plants may expand in size.

We have designated critical habitat on lands that have been determined to be essential to the conservation of *Carex lutea*. An area is considered essential if it possesses the PCE described above.

The following eight critical habitat units were designated for *Carex lutea*: Unit 1: Watkins Savanna, Unit 2: Haws Run Mitigation Site, Unit 3: Maple Hill School Road Savanna, Unit 4: Southwest Ridge Savanna, Unit 5: Sandy Run Savannas, Unit 6: The Neck Savanna, Unit 7: Shaken Creek Savanna and Unit 8: McLean Savanna. These units are located in Onslow and Pender counties of North Carolina (Appendix D). The eight units and 21 subunits total 202 ac (82 ha) found on State and local government or private land within Onslow and Pender counties (Table 1).

Table 1. *Carex lutea* site names from critical habitat designation, NCNHP Element Occurrence numbers, designated critical habitat units and approximate sizes of critical habitat units.

Unit	NCNHP EO No.	Unit and Subunit	Land Ownership	Size of Unit Acres (Hectares)
Watkins Savanna	5.12	1-A	NCDPR	1.2 (0.5)
Watkins Savanna	5.13	1-B	Private, NCDPR	2.0 (0.8)
Watkins Savanna	5.19	1-C	NCDPR	0.6 (0.2)
Haws Run Mitigation Site	7	2	NCDOT	27.1 (11.0)
Maple Hill School Road Savanna	10	3	Private	27.7 (11.2)
Southwest Ridge Savanna	11	4-A	NCWRC with Duke Energy, ROW	2.3 (0.9)
Southwest Ridge Savanna	11	4-B	NCWRC with Duke Energy, ROW	1.0 (0.4)
Sandy Run Savannas	15.3	5-A	NCDPR with Duke Energy, ROW	2.6 (1.1)
Sandy Run Savannas	15.4	5-B	NCDPR	4.3 (1.7)
Sandy Run Savannas	15.4	5-C	NCDPR	0.3 (0.1)
Sandy Run Savannas	15.4	5-D	NCDPR	4.9 (2.0)
Sandy Run Savannas	15.14	5-E	NCDPR with Duke Energy, ROW	13.1 (5.3)
The Neck Savanna	18.1	6-A	NCDPR	3.6 (1.5)
The Neck Savanna	18.16	6-B	Private	0.7 (0.3)
The Neck Savanna	18.17	6-C	Private with Powerline ROW	0.1 (0.04)
Shaken Creek Savanna	21.8	7-A	Private (TNC)	6.9 (2.8)
Shaken Creek Savanna	21.8	7-B	Private (TNC)	24.7 (10.0)
Shaken Creek Savanna	21.20	7-C	Private (TNC)	26.1 (10.6)
McLean Savanna	24.9	8-A	Private (TNC)	42.3 (17.1)
McLean Savanna	24.22	8-B	Private	0.5 (0.2)
McLean Savanna	24.23	8-C	Private (TNC), Private	9.8 (4.0)
Total*				201.8 (81.7)

*Note: Area sizes may not sum due to rounding.

G. Reasons for Listing and Ongoing Threats Assessment

The Service listed *Carex lutea* as endangered throughout its range primarily due to threats of habitat loss or alteration posed by development, mining, hydrologic alterations, encroachment of competing vegetation, fire suppression, intensive right-of-way maintenance activities, and trash

dumping. The following analysis details threats to this species as they relate to the five listing factors outlined in section 4(a)(1) of the Act.

Factor A. Present or threatened destruction, modification, or curtailment of habitat or range

According to R. LeBlond (pers. observ. 2006), *Carex lutea* is threatened by fire suppression and the ecological succession (competition and/or shading by woody species) that occurs in areas that are not burned as often as they were historically. *Carex lutea* is also threatened by timber operations such as harvesting, bedding and ditching. Sites located within road and utility rights-of-way are threatened by herbicide use or mowing during critical growth periods. Habitat destruction, resulting from development, also threatens *Carex lutea*, but to a lesser degree than the other factors listed above. Increasing human population growth rates (recorded and predicted) in Pender and Onslow counties will most likely increase habitat fragmentation and decrease suitable habitat for *Carex lutea* (North Carolina Office of State Budget and Management, 2012). See Appendix B for a detailed discussion of threats to specific sites. Progress has been made in protecting *Carex lutea* habitat (see Conservation Efforts section below). For example, over 80 percent of designated critical habitat is in conservation ownership (either State or TNC). There is still much progress to be made with respect to sites/occurrences on private lands.

Factor B. Overutilization for commercial, recreational, scientific or educational purposes

There is currently no evidence to suggest that *Carex lutea* is being overutilized for commercial, recreational, scientific or educational purposes.

Factor C. Disease or predation

Disease and predation are not known to be factors affecting the continued existence of *Carex lutea* at this time, though a small amount of predation is known to occur naturally in the wild. R. LeBlond (pers. observ.) noticed grazing damage to *Carex lutea* plants at The Neck Savanna by unidentified herbivores. The grazed plants subsequently produced flowering culms. The long-term effects of grazing have not been measured but there is no evidence to suggest that it is a threat to this plant. Insects occasionally feed on the developing seeds, but this does not appear to be significant or to be a threat to this species.

Factor D. Inadequacy of existing regulatory mechanisms

Carex lutea is listed as state endangered by North Carolina under the North Carolina Plant Protection and Conservation Act of 1979 (North Carolina Code Article 19B, § 106-202.12). This act provides limited protection from unauthorized collection and trade of plants listed under that statute. However, the statute does not protect the species or its habitat from destruction in conjunction with development projects or otherwise legal activities.

In 2006, the NCDPR (State Parks) was granted permission by the North Carolina Legislature to create the Sandy Run Savannas State Natural Area and the State began acquiring land from TNC and other local landowners soon thereafter. The NCDPR protects a variety of fire-dependent

plant communities including habitat important for the recovery of *Carex lutea* at Sandy Run Savannas State Natural Area, Neck Savanna, Watkins Savanna and the Sandy Run Savannas. The purpose of the State Park system is to protect and preserve unique archaeological, geological, biological, scenic, and recreational resources (North Carolina Code Article 2C § 113-44.8. The Haws Run Mitigation Site is owned by the NCDOT and is managed by (North Carolina Department of Environment and Natural Resources (NCDENR) and NCEEP. The Southwest Ridge Savanna site is owned by the State of North Carolina and managed by the North Carolina Wildlife Resources Commission. Two sites, Shaken Creek Savanna and McLean Savanna, are entirely or partially owned by TNC. Only one population, Maple Hill School Road Savanna, remains threatened due to lack of protection. Observations in 2012 indicate that a large portion of land in the vicinity of this population has been converted into a blueberry farm (D. Suiter, pers. observ. 2012).

Factor E. Other natural or manmade factors affecting the continued existence of a species

Invasive species have the potential to negatively affect the habitats where rare species such as *Carex lutea* are found. Cogon grass (*Imperata cylindrica*) was introduced to the United States in 1912 and is currently known to occur throughout the southeast. A population of cogon grass was found in Pender County in 2012 (C. Glen, NC Cooperative Extension, pers. comm. 2012). Cogon grass is listed as a federal noxious weed by the USDA and a state noxious weed by the NC Department of Agriculture (NC Department of Agriculture and Consumer Services 2008). In other southeastern states, it is found as an invasive species in longleaf pine ecosystems similar to the habitat where *Carex lutea* is found in North Carolina. Given its growth habit and habitat preferences, cogon grass could displace native species such as *Carex lutea*. However, it has not yet been observed at any of the known *Carex lutea* sites.

Small population sizes likely diminish the resiliency of *Carex lutea* occurrences to stochastic disturbances, and the lack of redundancy across the landscape leaves the species at greater risk of extinction due to potential extirpation of these vulnerable occurrences. Other threats to the species include extended drought and habitat fragmentation caused by development projects that result in actions like drainage ditches being implemented.

H. Ongoing Conservation Efforts

A member institution of the Center for Plant Conservation, the NC Botanical Garden (NCBG) has collected *Carex lutea* seeds from several populations and they are working on seed storage and germination protocols for this species. They will continue to seek seed collections from all known populations for long term storage, reintroduction and augmentation work and research.

In addition, NCBG biologists set up long term monitoring plots at 10 *Carex lutea* sites and began monitoring this species in 2010. Initial monitoring will continue through 2014. A management plan has been prepared for six *Carex lutea* subpopulations that occur on NCDPR lands (Taggart 2012b).

The NCDENR has conservation and management agreements with Duke Energy. The intent of these voluntary agreements is to encourage the management of rare species within the rights of ways that they maintain. In general, the utility has agreed to avoid the use of herbicides and to

not mow during critical growth periods for rare species. Specifically, *Carex lutea* occurs within two areas covered by management agreements: Southwest Ridge Savanna (EO 4) and Sandy Run Savannas (EO 15.3 and 15.14) (L. Gadd Robinson, N.C. Natural Heritage Program, pers. comm. 2013).

Other sites are protected as Dedicated Nature Preserves. Dedication agreements are permanently binding documents, endorsed by the Council of State, NCDENR, and the landowner that set aside outstanding natural areas of high biodiversity and conservation value in the state. The intention of dedicating natural areas is to permanently preserve the natural character of the land. Nature preserves may be dedicated by a voluntary act by the owner, but are also often a requirement of funding sources such as the Natural Heritage Trust Fund or Clean Water Management Trust Fund. The articles of the Dedication Agreement often contain restrictions and provisions relating to management, use, development, transfer, and public access of the site (L. Gadd Robinson, pers. comm. 2011) (NC Administrative Code 15A NCAC 12H .0301). NCNHP has designated Sandy Run Savannas, Watkins Savanna and The Neck Savanna as Dedicated Nature Preserves.

TNC is continuing to work with local landowners to protect parcels of land that contain *Carex lutea* and other rare species or parcels that would facilitate management of rare plant sites already in conservation ownership.

PART II. RECOVERY

A. Recovery Strategy

The recovery strategy for *Carex lutea* involves protection and management of known sites/occurrences of the species, including addressing immediate threats with fire management and invasive species control as needed. In order to help recover this plant and increase the number of viable populations in the wild, we intend to work closely with partners to reduce threats to known populations, increase understanding of the biology of this plant, and find new strategies for seed collection and banking. With partners like local governments, universities, and State agencies, we will share information to the local community about why *Carex lutea* is a unique plant and should be protected.

The long-term protection and management of *Carex lutea* populations is critical to the recovery of this species. Known populations should be acquired where appropriate or possible by conservation entities such as federal, state, and local government agencies, TNC, the Coastal Land Trust or other organizations. Fee simple acquisition or permanent conservation easements will ensure that each site is protected in perpetuity. The Service and other partners should also work with private landowners where acquisition is not an option to cooperatively find ways to reduce threats to this plant on private land and find long term agreements where landowners are willing to cooperate in the management of the *Carex lutea* occurrences. All protected sites need to be managed properly. A management plan that considers the long-term management of the habitat where *Carex lutea* occurs and the adjacent habitat should be prepared and implemented for each site. Since it is believed that *Carex lutea* is a fire-dependent species, proper site management will likely include fire management or some other form of habitat disturbance.

Although many of the longleaf pine savanna sites in NC have not been heavily invaded by invasive species, there is potential for this to happen. Cogon grass, an invasive plant, has been found in longleaf pine ecosystems from Texas to North Carolina. If cogon grass spreads into *Carex lutea* habitat in NC, it has potential to displace this species. Therefore, observations of invasive species should be noted at each site and appropriate measures for their eradication or control should be implemented as part of the management of the population.

Threats to this species consist of various forms of habitat alteration, resulting from fire suppression, conversion of limited habitat for residential, commercial or industrial development, highway and utility expansion, and wetland drainage activities associated with silviculture, agriculture and development projects. In addition, roadside and utility right-of-way populations are vulnerable to extirpation from herbicide application.

Long-term monitoring protocols should be developed in order for the USFWS to assess population trends within individual populations as well as for the entire species. The USFWS is working with the NCBG and appropriate landowners to facilitate regular seed collection at each population and seed storage at NCBG using CPC protocols.

B. Recovery Goals

The ultimate recovery goal is to remove (delist) this species from the *Federal List of Endangered and Threatened Plants* (50 CFR 17.12) by ensuring the long term viability of the species in the wild. Initially, the recovery goal is to reclassify (downlist) *Carex lutea* from endangered to threatened status based upon its improved status due to implementation of recovery actions in this plan.

C. Recovery Criteria

The recovery criteria and actions outlined here reflect the information currently available on this species, and identify information needs that are pertinent to the long-term conservation and management of *Carex lutea*. These criteria are based on ranking criteria established by the NCNHP (Appendix C).

***Carex lutea* will be considered for reclassification from endangered to threatened status (downlisting) when:**

1. There are 10 protected *Carex lutea* sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a management agreement and are ranked as an A or B population by the NCNHP. See Appendix C for additional information about the rank specifications for *Carex lutea*.]
2. On each of the 10 *Carex lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *Carex lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume).
3. All 10 *Carex lutea* sites demonstrate stable or increasing population trends for five consecutive years.

4. Habitat management plans are actively being implemented for at least seven of the protected sites.
5. A prescribed fire regime has been developed and is being conducted at all sites to mimic historical frequency and timing (the frequency will be determined through recovery actions in this plan).

We define “protected” to mean the site has been fee simple acquired and put into long term conservation by a local or State agency or a conservation easement or other binding land agreement has been placed on the site by a landowner that shows a commitment to its conservation in perpetuity and it is represented in a CPC approved seed bank. In addition, each site should have a management agreement/plan developed. Prescribed fire should be part of the agreement/plan and implemented regularly. These plans should include monitoring, according to protocols developed collaboratively by the Service, NCDACS, NCDPR, TNC and other interested parties and should occur annually at each protected site. Each site should contain an A or B ranked occurrence (see Appendix C). For downlisting to be considered, at least seven of the 10 protected sites should be “A-ranked” occurrences. The remaining three sites can be either “A or B-ranked” occurrences.

***Carex lutea* will be considered for removal from the List of Endangered and Threatened Species (delisting) when:**

1. There are 15 protected sites in the wild that are distributed across the range of the species. [Note: Recovery sites will be considered permanently protected when they are placed under a conservation easement or other binding land agreement and a management agreement and are ranked as an A or B population by the NCNHP. See Appendix C for additional information about the rank specifications for *Carex lutea*.]
2. On each of the 15 *Carex lutea* sites, for at least 5 years, any non-native plant species that have the potential to displace *Carex lutea* are maintained at or below 10 percent of total number of species and at or below 10 percent cover (volume).
3. All 15 *Carex lutea* sites demonstrate stable or increasing population trends for ten consecutive years.
4. Habitat management plans are actively being implemented for all protected sites and are showing evidence that actions are proving effective for this plant.
5. A prescribed fire regime is being conducted at all sites to mimic historical frequency and timing (which will be determined through recovery actions in this plan).

We define “protected” to mean the site has been fee simple acquired and put into long term conservation by a local or State agency or a conservation easement or other binding land agreement has been placed on the site by a landowner that shows a commitment to its conservation in perpetuity and it is represented in a CPC approved seed bank. In addition, each site should have a management agreement/plan developed. Prescribed fire should be part of the agreement/plan and implemented regularly. These plans should include monitoring, according to protocols developed collaboratively by the Service, NCDACS, NCDPR, TNC and other interested parties and should occur annually at each protected site. Each site should contain an A or B ranked occurrence (see Appendix C). For delisting to be considered, at least 10 of the 15 protected sites should be “A-ranked” occurrences. The remaining five sites can be either “A or B-ranked” occurrences.

Listing/Recovery Factors Addressed by Recovery Actions: Actions listed below with each listing/recovery factor are examples of actions that may reduce or remove the identified threats. These tasks are described in more detail in the Narrative Outline section that follows.

Listing/Recovery Factor A: The Present or Threatened Destruction, Modification, or Curtailment of a Species Habitat or Range. To ensure the long-term recovery needs of *Carex lutea* and provide adequate assurance of population stability, threats to the species' habitat must be removed or minimized (see Reasons for Listing and Ongoing Threats for a discussion of applicable threats). This can be accomplished by the following actions:

- a) establish protection priorities (Action 1.1);
- b) establish priorities of remaining sites/occurrences that require protection (Action 1.2);
- c) collaborate with private landowners to find ways to provide long-term protection to unprotected sites (Action 1.3);
- d) search for opportunities to protect habitat corridors between existing *Carex lutea* sites/occurrences (Action 2.2); and
- e) develop management plans and prescribed burn plans for each population (Action 3.1).

Listing/Recovery Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes. Little or no commercial trade in *Carex lutea* is known to exist at this time, and it is not anticipated that it will become an issue in the future. Likewise, overutilization for recreational, scientific, or educational purposes is not known to be an issue. However, Action 2.4.1 and 2.4.2 calls for maintaining an *ex situ* seed source for this species. These stored seeds could be used for reintroductions to replace extirpated occurrences if suitable habitat remains, for establishing new occurrences as part of recovery efforts, or for augmenting existing occurrences, where necessary.

Listing/Recovery Factor C: Disease or Predation. At this time, there are no data indicating that this is a limiting factor; however, given that herbivory has been observed to varying degrees at *Carex lutea* occurrences, we will monitor the severity of this potential threat through Actions 3.1 and 5.1.

Listing/Recovery Factor D: The Inadequacy of Existing Regulatory Mechanisms. *Carex lutea* is typically found growing on land that has potential for residential or commercial development. Existing regulatory mechanisms do not protect populations on non-Federal lands from conversion to other uses such as residential or commercial development. The following actions can help to overcome these inadequacies and lead to recovery:

- a) Collaborate with private landowners to find ways to protect unprotected sites long term (Action 1.3);

- b) search for opportunities to protect habitat corridors between existing *Carex lutea* sites/occurrences (Action 2.2);
- c) maintain contact with landowners of *Carex lutea* occurrences (Action 3.2);
- d) work with other government agencies to protect the species (Action 7.2).

Listing/Recovery Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence.

Invasive species have the potential to negatively affect the habitats where rare species such as *Carex lutea* are found. Cogon grass negatively affects longleaf pine savannas in other southeastern states and was recently found in North Carolina. Every effort should be made to prevent it from establishing at *Carex lutea* sites.

Small population sizes likely diminish the resiliency of *Carex lutea* occurrences to stochastic disturbances, and the lack of redundancy across the landscape leaves the species at greater risk of extinction due to potential extirpation of these vulnerable occurrences. Management efforts to address this threat are constrained by limited knowledge of ecological and life history characteristics of the species.

Habitat fragmentation has the potential to decrease genetic diversity.

The following recovery actions should protect sites from invasive species, improve resilience of individual occurrences and provide sufficient redundancy to buffer the species against potential losses of individual occurrences:

- a) Develop guidelines for invasive species control at *Carex lutea* sites (Action 3.3.1);
- b) eradicate invasive species from *Carex lutea* sites before they spread and damage the integrity of the habitat (Action 3.3.2);
- c) develop and implement management plans for each population (Action 3.1)
- d) conduct research on habitat requirements (Action 6.1.2);
- e) search for opportunities to protect habitat corridors between existing *Carex lutea* sites/occurrences (Action 2.2).

D. Narrative Outline

1. Protect *Carex lutea* sites/occurrences and adjacent buffer habitat around these sites
Carex lutea is a unique plant in the wet pine savannas of North Carolina. Due to threats, it is now known from a limited number of occurrences in Pender and Onslow Counties that need to be protected to ensure their survival.

- 1.1 Establish protection priorities for all protected *Carex lutea* sites/occurrences.
 With partner’s efforts and help, the Service, State of North Carolina, and TNC have already secured long term protection for 17 occurrences. We need to evaluate all sites for their contribution to recovery due to factors like size, number and extent of plants, habitat quality and acreage, feasibility of protection and management, natural community and percentage of nonnative species and

determine how we want to prioritize sites and focus our resources to protect this plant.

- 1.2 Establish priorities of remaining sites/occurrences that require protection.
Some sites on private land remain unprotected. These will be evaluated with partners based on similar factors like size, health of plants, community structure to help us determine which unprotected sites need protection first. This task will include any new sites that may be discovered that need management/protection.
- 1.3 Collaborate with private landowners to find ways to protect unprotected sites long-term.
We are encouraged by the progress and support growing for this plant's conservation. Current landowners can work together with State agencies and the Service and vice versa to pursue, where feasible, fee simple acquisition by programs like the Service's section 6 Recovery Land Acquisition grant program or TNC's conservation acquisition efforts. Conservation easements or cooperative management agreements can also be investigated where appropriate to secure sites.

2. Increase and strengthen *Carex lutea* sites/occurrences

For this relatively recently described plant, there is much to learn about its biology (see actions under 6.0 for Research) and how it fits as a key piece in the wet pine savanna. As we complete population augmentations and other recovery actions, we will strengthen our largest *Carex lutea* occurrences.

- 2.1 Augment existing *Carex lutea* sites/occurrences.
Introductions, reintroductions, or augmentations should only be conducted in permanently protected sites that are expected to receive long-term management, and these efforts should be carefully coordinated with the appropriate state natural resource agency partners (e.g., NCNHP and NC Plant Conservation Program (NCPCP)) and other stakeholders.
- 2.2 Search for opportunities to protect habitat corridors between existing *Carex lutea* sites/occurrences.
These sites will have habitat attributes that may promote new occurrences and will protect corridors on the landscape for *Carex lutea*.
- 2.3 Identify potential habitat for introductions or reintroductions.
Surveys should also be conducted to identify potential habitat for introduction or reintroductions of *Carex lutea*, should this become necessary in the future. If no suitable sites for reintroduction can be found or protected, areas that appear to be suitable for this species within its current or historical range, but where no plants have ever been found, should be identified as potential future introduction sites. Reintroductions may be appropriate for sites that once contained *Carex lutea*, but where it no longer occurs.

2.4. Ex Situ Conservation

Ex situ conservation is an important element to the long term conservation of any plant species. Seeds of most species can be stored under controlled conditions for many years. Such collections are important for restoring populations decimated by a catastrophic event and they can also be used for basic research, to learn more about the species.

2.4.1 Collect seeds that adequately represent the genetic diversity within the species

Since the entire range of *Carex lutea* occupies a relatively small area in eastern North Carolina and most populations are small and patchy, it is important to maintain an *ex situ* collection of seeds, plants or other genetic material in case a catastrophic event would extirpate one or more populations of this species in the wild. *Ex situ* propagules should represent as much of the existing genetic diversity within the species as possible.

2.4.2 Store seeds in a CPC approved facility

The CPC consists of a network of leading botanical institutions in the U.S. Their National Collection of Endangered Plants (Collection) contains plant material for many of the nation's most imperiled native plants. Seeds, cuttings, spores and other plant material are collected and carefully maintained by CPC's member institutions. These institutions study and hold this material in protective custody. The Collection is an important conservation resource. In the event that a species becomes extinct or no longer reproduces in the wild, seeds from the Collection may be used to start new populations (M. Kunz, pers. comm. 2011).

The NCBG is the designated CPC repository for *Carex lutea* seeds and other plant materials. Botanists at NCBG initiated seed collection from various *Carex lutea* sites in 2006 and they are currently working on seed storage and germination protocols for this species. Periodic testing will be necessary to estimate the rate of viability loss of stored seed. This will help estimate the appropriate interval and adequate quantity of seed to collect for storage. Guidelines for seed collection, storage and germination should be developed in coordination with NCBG staff.

3. Management

Since this plant clearly occurs on limited islands of habitat within pine savanna that have unique habitat characteristics (higher pH, wet soils, limestone), we need to work to manage aspects like invasive plants to ensure *Carex lutea* can thrive.

3.1 Develop and implement management plans and prescribed burn plans for each site/occurrence

The Service and its partners should work with landowners, managers and utility companies to prepare site specific management plans for each *Carex lutea* population. These plans may include one or more types of management regimes that can be accomplished by the landowner or land manager. Site management

should include prescribed fire and routine monitoring. Habitat that is currently managed by mowing should be burned instead. Landowner assistance in this endeavor will be sought. Over time, mowing without fire allows a subtle shift in community structure and composition as non-fire adapted species invade and proliferate R. LeBlond (pers. observ. 2011). Wildlife (e.g., deer) should be managed at levels that are compatible with *Carex lutea* conservation. Should deer browse become an issue, options for protecting *Carex lutea* should be evaluated and implemented. These management plans can be modified as additional information is gathered about needs of the species.

Disturbance (fire, mowing or any other disturbance) should occur at a frequency sufficient to deter succession of competitive plants. It is important to determine the frequency of disturbances necessary to maintain optimum habitat for the species since management on an annual basis may prove to be unnecessary or cost and time prohibitive. This will be further evaluated under Action 6.1.2. The manner in which mowing is implemented as a fire surrogate is important. Mowing should be done carefully as the use of heavy equipment during certain conditions may cause compaction or leave ruts, both of which can be detrimental to *Carex lutea*.

3.2 Maintain contact with landowners of *Carex lutea* occurrences

The Service and State should work together with and reach out to the landowner or land manager of each *Carex lutea* site annually to discuss habitat management practices and find new ways of protecting their respective populations.

3.3 Monitor for invasive species

Invasive species can negatively affect *Carex lutea*. While conducting regular population monitoring, land managers should look for non-native, invasive species.

3.3.1 Develop guidelines for invasive species control at *Carex lutea* sites.

3.3.2 Eradicate invasive species before they spread and damage the integrity of the habitat.

4. Surveys

Extensive surveys that have been conducted for *Carex lutea* have led to the discovery of a few new occurrences. Based on existing knowledge, we do not anticipate finding a lot of additional populations, but it should be a priority to survey any remaining patches of unique wet pine savanna habitat to ensure that we protect this endangered plant. Survey efforts should focus on identifying areas of suitable habitat where *Carex lutea* may occur with the goal of finding additional populations of this species.

4.1 Conduct surveys for additional populations

A status survey for *Carex lutea* was conducted for the Service by NCNHP in 1996 at potential suitable sites along the southern Atlantic and eastern Gulf coasts

(LeBlond 1996). The NCNHP completed natural heritage inventories of Onslow County in 1999 and Pender County in 2000. County-wide surveys have been conducted by NCNHP in both counties of occurrence (Onslow, Pender). In 1993, 1994 and 2000, surveys were also conducted in the Old Dock area of Brunswick and Columbus counties where there are documented occurrences of the rare savanna type in which the sedge occurs; however, no *Carex lutea* was found there. Adjacent counties also have been surveyed, and the DOD has conducted surveys at Camp Lejeune Marine Corps Base in Onslow County specifically for the federally listed, endangered *Carex lutea* and *Thalictrum cooleyi*; however, neither species has been found there. Due to the presence of suitable habitat for *Carex lutea*, additional surveys should focus on the Old Dock area of Brunswick and Columbus counties, and in the area adjacent to Holly Shelter Game Land between Ashes Creek and McLean Savanna in Pender County.

4.2 Share survey data between partners

Survey information is used to assess the size and trends of populations and is also useful when planning future surveys or considering sites for protection or introduction projects. All survey information with positive (i.e., locations where *Carex lutea* is present) or negative (i.e., locations where *Carex lutea* is absent) results should be shared between the USFWS species lead biologist for *Carex lutea* in the Raleigh Field Office and the appropriate state natural resource agency partners (e.g., NCNHP and NCPCP).

5. Monitoring

Range-wide, long-term monitoring is critical to understanding population trends and the overall health of individual sites and populations.

5.1 Develop and implement a range wide monitoring plan and appropriate protocols to assess population trends, reproductive success and threats

Monitoring is an important aspect of the recovery of *Carex lutea*. Long-term monitoring data will provide land managers with information about population trends that can influence site management and ensure that the factors affecting the species are being adequately addressed. Monitoring can also be used to determine reproductive success as well as to identify potential threats to the species and its habitat. Finally, it is essential that an adequate understanding of the species' status and trends be established during the course of recovery efforts, so that post-delisting monitoring data can be meaningfully compared to data collected when the species was still at risk of extinction.

Monitoring for *Carex lutea* is complicated by the physical appearance of the plant and the habitat in which it grows, often with other similar looking species. The Service, in cooperation with the NCNHP, the NCPCP, NCDPR and TNC, should develop a monitoring program for each *Carex lutea* population. Similar monitoring protocols have been developed for other rare species in North Carolina and land managers have agreed to monitor those sites annually. The goal of the *Carex lutea* monitoring program should be to collect long-term data

that can be used to determine population trends and the effects of site management. It is important to record baseline data such as estimates of population size and vigor, existing condition of each site and the nature, timing and spatial extent of past and present management. Monitoring efforts should document the frequency, timing and severity of fire (through prescribed burns or natural fires) and other forms of disturbance in order to guide future management of the populations. Such a monitoring protocol should also balance the need for useful data while considering the potential damage to the population.

The Service should seek to obtain permission from private landowners to annually monitor populations for *Carex lutea* on private lands.

6. Research

Carex lutea is relatively recently described and has a very restricted range. Consequently, little research has been conducted on this species.

6.1 Conduct research essential to the survival of *Carex lutea*

6.1.1 Demographic research

Given that little is known about this species, basic demographic research should be conducted on this species in order to gain additional knowledge about its life history and reproductive biology (e.g., pollination, seed dispersal, seed viability, seed bank, and seedling recruitment). The NCBG is currently conducting some demographic research on this species.

6.1.2 Habitat conditions and requirements

Research should be conducted to better quantify the habitat conditions where *Carex lutea* occurs (including microclimate, soil texture, chemistry, moisture, associated species, woody cover and hydrology, the role of disturbance and disturbance techniques such as fire, floods and wind throws). A better understanding the habitat requirements of *Carex lutea* will be an important step toward identifying appropriate places to survey for new populations and will guide future introduction projects, should they become necessary. Knowledge of the habitat requirements of the species will also guide the management of known populations. This will include getting a better understanding of frequency of disturbance and appropriate management.

6.2 Determine the best techniques to restore *Carex lutea* populations

Experiments should be conducted to develop efficient, effective techniques for establishing *Carex lutea* in cultivation as well as the field, should introduction projects become necessary for the recovery of the species. Methods for seed stratification and germination, site preparation and seedling transplantation should be explored. Population augmentation should be undertaken only with careful planning and coordination among regulatory agencies and stakeholders.

7. Education and Outreach

Education and outreach is important in order to inform the residents and land managers in the vicinity of *Carex lutea* sites about the significance of the species and why long term management of these sites, through prescribed burning and other measures, is necessary for their survival.

7.1 Develop and implement a local outreach program

To date, there has been practically no public outreach related to *Carex lutea* conservation. Because the species is geographically restricted, the recovery of this species will depend largely on the support of local landowners and local government agencies.

The Service, with partners, should develop a coordinated public outreach program to inform local landowners, government agencies, parks, schools, nature centers and the media about *Carex lutea*. Specifically, this program should address threats to the species and offer solutions that may involve the public. A special effort should be made to educate local landowners that this plant occurs on or near their property and the importance of protection and proper management required to perpetuate its continued existence. The Service should work with landowners and developers to highlight alternatives for standard practices that will avoid or minimize project related impacts to the species.

7.2 Work with other government agencies to protect the species

The Service should take measures to educate personnel with the NC Forest Service, both full time and part time, about populations of *Carex lutea* and other rare species that occur in power lines and other places frequently used for fire suppression techniques (i.e., plow lines) and emphasize the importance of protecting these populations while controlling wildfires.

The U.S. Army Corps of Engineers (Corps) issues permits for wetland alterations (Section 404 of the Clean Water Act), and it is their responsibility to address impacts to federally listed species that may be impacted by such permit actions. The Service should work cooperatively with the Corps to educate them about the species' biology and help them identify areas where *Carex lutea* may occur. The Service and Corps should carefully review all projects that occur in such areas. In addition, the Service should offer suggestions that would avoid project related impacts to *Carex lutea* sites. If *Carex lutea* plants cannot be avoided, formal consultation with the Service will ensure that the projected impacts will not jeopardize the continued existence of the species.

7.3 Assess the success of recovery efforts

It is important to review recovery efforts on an annual basis to in order to be updated on new information gained from research and also to determine the overall health of the species as well as individual populations.

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PART III. IMPLEMENTATION SCHEDULE

Recovery plans are intended to assist the Service and other stakeholders in planning and implementing actions to recover and/or protect endangered and threatened species. The following Implementation Schedule indicates action priorities; action numbers; action descriptions; action duration; potential stakeholders and responsible agencies; and, lastly, estimated costs. It is a guide for planning and meeting the goals discussed in Part II of this plan. The Implementation Schedule outlines recovery actions and their estimated costs for the first 3 years of this recovery program. The estimated date of recovery is 2025, provided that funds are available to accomplish the required recovery tasks and that the recovery criteria are met. The costs are broad estimates and identify foreseeable expenditures that could be made to implement the specific recovery tasks during a 3 year period. **Actual expenditures by identified agencies and other partners will be contingent upon appropriations and other budgetary constraints.** Parties with the authority, responsibility, or expressed interest to implement a specific recovery action are identified in the Implementation Schedule. When more than one party has been identified, the proposed lead party is indicated by an asterisk (*). The listing of a party in the implementation Schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

Priorities in column 1 of the following Implementation Schedule are assigned as follows:

Priority 1 – An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2 – An action that must be taken to prevent a significant decline in species population or habitat quality, or some other significant negative impact short of extinction.

Priority 3 – All other actions necessary to meet the recovery goals.

Key to Responsible Parties

CPC	Center for Plant Conservation
NCBG	North Carolina Botanical Garden
NCDPR	North Carolina Division of Parks and Recreation
NCNHP	North Carolina Natural Heritage Program
NCPCP	North Carolina Plant Conservation Program
NCWRC	North Carolina Wildlife Resources Commission
TNC	The Nature Conservancy
USFWS	U.S. Fish and Wildlife Service

GOLDEN SEDGE IMPLEMENTATION SCHEDULE

Priority	Action Number	Action Description	Action Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
1	1.1	Establish protection priorities for all protected <i>Carex lutea</i> sites/occurrences	2 years	R4/ES	NCNHP, NCPCP, TNC	20.0	20.0	20.0	
2	1.2	Establish priorities of remaining sites/occurrences that require protection	5 years	R4/ES	NCNHP, NCPCP, TNC	5.0	5.0	---	
1	1.3	Collaborate with private landowners to find ways to protect unprotected sites long-term	Continual	R4/ES	NCNHP, NCPCP, TNC	5.0	5.0	5.0	
2	2.1	Augment existing <i>Carex lutea</i> sites/occurrences	Ongoing	R4/ES	NCBG, NCPCP, TNC	5.0	5.0	5.0	
2	2.2	Search for opportunities to protect habitat corridors between existing <i>Carex lutea</i> sites/occurrences.	Continual	R4/ES	NCBG, NCNHP, NCPCP, TNC, NCWRC, NCDPR	2.0	2.0	2.0	
2	2.3	Identify potential habitat for introductions or reintroductions	Continual	R4/ES	NCBG, NCNHP, NCDPR, NCPCP, TNC, NCWRC	5.0	2.0	2.0	
1	2.4.1	Collect seeds that adequately represent the genetic diversity within the species	3 years	R4/ES	NCBG, CPC, NCDPR, TNC	3.0	3.0	3.0	
2	2.4.2	Store seeds in a CPC approved	Ongoing	R4/ES	NCBG, CPC,	1.0	1.0	1.0	

GOLDEN SEDGE IMPLEMENTATION SCHEDULE

Priority	Action Number	Action Description	Action Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
		facility			NCNHP				
2	3.1	Develop and implement management plans and prescribed burn plans for each site/occurrence	Continual	R4/ES	TNC, NCNHP, NCDPR, NCPCP	2.0	2.0	2.0	
2	3.2	Maintain contact with landowners of <i>Carex lutea</i> occurrences	Continual	R4/ES	TNC, NCNHP	1.0	1.0	1.0	
2	3.3.1	Develop guidelines for invasive species control at <i>Carex lutea</i> sites	Ongoing	R4/ES	NCBG, NCPCP, TNC	5.0	1.0	1.0	
2	3.3.2	Eradicate invasive species before they spread and damage the integrity of the habitat	Continual	R4/ES	private landowners, NCBG, NCDPR, NCPCP, TNC	3.0	3.0	3.0	
2	4.1	Conduct surveys for additional populations	Ongoing	R4/ES	NCBG, NCPCP, TNC, Universities	5.0	5.0	5.0	
3	4.2	Share survey data between partners	Ongoing	R4/ES	NCNHP, NCBG, NCDPR, NCPCP, TNC	1.0	1.0	1.0	
3	5.1	Develop and implement a range wide monitoring plan and appropriate protocols to assess population trends, reproductive success and threats	Continual	R4/ES	NCNHP, NCBG	5.0	5.0	5.0	
3	6.1.1	Conduct demographic research	5 years	R4/ES	NCBG,	5.0	5.0	5.0	

GOLDEN SEDGE IMPLEMENTATION SCHEDULE

Priority	Action Number	Action Description	Action Duration	Responsible Agency		Cost Estimates (\$000s)			Comments
				FWS	Other	FY1	FY2	FY3	
					Universities				
3	6.1.2	Conduct research on habitat conditions and requirements	4 years	R4/ES	NCBG, Universities	5.0	5.0	5.0	
3	6.2	Determine the best techniques to restore <i>Carex lutea</i> populations	Ongoing	R4/ES	NCBG, Universities	3.0	3.0	3.0	
3	7.1	Develop and implement a local outreach program	Ongoing	R4/ES	NCDPR, TNC, Universities	1.0	1.0	1.0	
3	7.2	Work with other government agencies to protect the species	Ongoing	R4/ES	Universities	0.5	0.5	0.5	
3	7.3	Assess the success of recovery efforts	Ongoing	R4/ES	NCNHP, NCBG, NCPCP	1.0	1.0	1.0	

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Appendix A. Endangered and Threatened Species Recovery Priority Number Guidelines*

Degree of Threat	Recovery Potential	Taxonomy	Conflict?†	Priority
High	High	Monotypic Genus	Yes	1C
			No	1
		Species	Yes	2C
			No	2
		Subspecies	Yes	3C
			No	3
	Low	Monotypic Genus	Yes	4C
			No	4
		Species	Yes	5C
			No	5
		Subspecies	Yes	6C
			No	6
Moderate	High	Monotypic Genus	Yes	7C
			No	7
		Species	Yes	8C
			No	8
		Subspecies	Yes	9C
			No	9
	Low	Monotypic Genus	Yes	10C
			No	10
		Species	Yes	11C
			No	11
		Subspecies	Yes	12C
			No	12
Low	High	Monotypic Genus	Yes	13C
			No	13
		Species	Yes	14C
			No	14
		Subspecies	Yes	15C
			No	15
	Low	Monotypic Genus	Yes	16C
			No	16
		Species	Yes	17C
			No	17
		Subspecies	Yes	18C
			No	18

* adapted from Listing and Recovery Priority Guidelines, Federal Register (48 FR 43098)

† priority is given to those species that are, or may be, in conflict with construction or other development projects or other forms of economic activity, designated by a “C” in the priority ranking system.

Appendix B. Threats to *Carex lutea* populations

Threats to *Carex lutea* populations, listed in order of NCNHP Principal Element numbers, are summarized as follows:

- Watkins Savanna, Pender County, NC (Principal EO 5; EO 5.12, 5.13, and 5.19; Rank = B). This site, in State and private ownership, is fire suppressed and has been altered by timber management. The part in State ownership is being managed but the whole area for these EOs needs to be burned.
- Haws Run Mitigation Site, Onslow County, NC (EO 7; Rank = B). This site is owned by the State of North Carolina (NCDOT) and managed by the NCEEP. The site has been fire suppressed for many years which is causing the site to become overgrown. NCDPR recently started using prescribed fire to restore the natural communities and enhance rare species populations.
- Maple Hill School Road Savanna, Pender County, NC (EO 10; Rank = C). This privately-owned site has not been revisited since *Carex lutea* was discovered there in 1998. Observations of the site in July 2012 from a nearby public road indicated that some of this property has been converted to a blueberry farm. The size of the *Carex lutea* population is unknown and it is unclear how much, if any, of the plants were impacted by this land conversion. This site is vulnerable to further land use changes.
- Southwest Ridge Savanna, Pender County, NC (EO 11; Rank = C). The population occurs within a Duke Energy powerline right-of-way easement, and the utility company entered into a management agreement with the NCNHP, agreeing not to use herbicides or mow during critical *Carex lutea* growth periods. The population is moderately small but appears to be stable. Unfortunately, in an effort to contain the Juniper Road wildfire at Holly Shelter Game Lands, the NC Forest Service plowed this site in the summer of 2011. Growing season surveys in 2012 indicate that this population has been greatly reduced in size since the last surveys in 2006 (Taggart 2012a).
- Sandy Run Savannas, Onslow County, NC (Principal EO 15; EO 15.3, 15.4, and 15.14; Rank = C). The Sandy Run Swamp Powerline Savanna, Cooley's Meadowrue Powerline Site (EO 15.3 and 15.14) is owned by NCDPR with a powerline right-of-way easement by Duke Energy. The habitat was prescribed burned in 1996 and 2007. In a 2005 management agreement with the NCNHP, Progress Energy (now Duke Energy) agreed not to use herbicides or mow during critical *Carex lutea* growth periods. The population is small and subject to extirpation from localized impacts. This site was impacted by the NC Forest Service during the construction of fire plow lines in July 2011 as part of an effort to control the Juniper Road Wild Fire. The impacts to the species are unknown until further surveys can be conducted. The Sandy Run Swamp Powerline Savanna, Pine Plantation Survey Site (EO 15.4) is also owned by NCDPR and has been impacted by previous timber management, including bedding and ditching. NCDPR is currently engaged in habitat restoration in this area, but the *Carex lutea* population is small and vulnerable to localized impacts. These sites have been designated the Sandy Run Savannas Dedicated Nature Preserve by the NCNHP.
- The Neck Savanna (formerly Lanier Quarry Savanna; Rank = A), Pender County, NC (Principal EO 18; EO 18.1, 18.16 and 18.17). Most of this site is privately owned, with portions of the *Carex lutea* population occurring on land owned by NCDPR and managed for protection and enhancement of rare species populations; however, *Carex lutea* plants in this area seem to be

declining because of fire suppression and ecological succession (R. LeBlond, pers. observ.). Sub EO 18.1 is designated as a Dedicated Nature Preserve with the NCNHP. Other portions of the population occur on land subject to timber harvesting and fire suppression. Drainage ditches impact the hydrology of the soils supporting *Carex lutea*. One subpopulation occurs in a small powerline corridor along a roadside and is vulnerable to woody growth and herbicide use. The site was sprayed with an herbicide in the fall of 2010 and then tree branches were trimmed along the edge of the powerline and the woody debris was left on the ground in the area where *Carex lutea* occurred. No plants were observed in 2011 because it was difficult to access the site and look for plants. The woody debris was removed in September 2011 after any surviving *Carex lutea* plants would have died back for the season.

- *Shaken Creek Savanna, Pender County, NC (Principal EO 21; EO 21.8, 21.20, 21.26, 21.27, 21.28 and 21.29; Rank = A)*. The population at this site is the largest known and occurs in the highest quality natural habitat. Owned by TNC, it has been managed with frequent prescribed fires to facilitate hunting for several decades. With continued fire management, this site should remain stable.

- *McLean Savanna, Pender County, NC (Principal EO 24; EO 24. 9, 24.22 and 24.23; Rank = A)*. This privately-owned site has been kept open for hunting by prescribed burns. *Carex lutea* occurs over an extensive area and is second largest population known.

Appendix C. *Carex lutea* Ranking Specifications

These ranking specifications were prepared by Jame Amoroso, NCNHP, December 15, 2004.

The number of clumps used for rank divisions are based on R.J. LeBlond's ranks from 1996 to 2004, which were developed using A.S. Weakley's *Carex* rank scale.

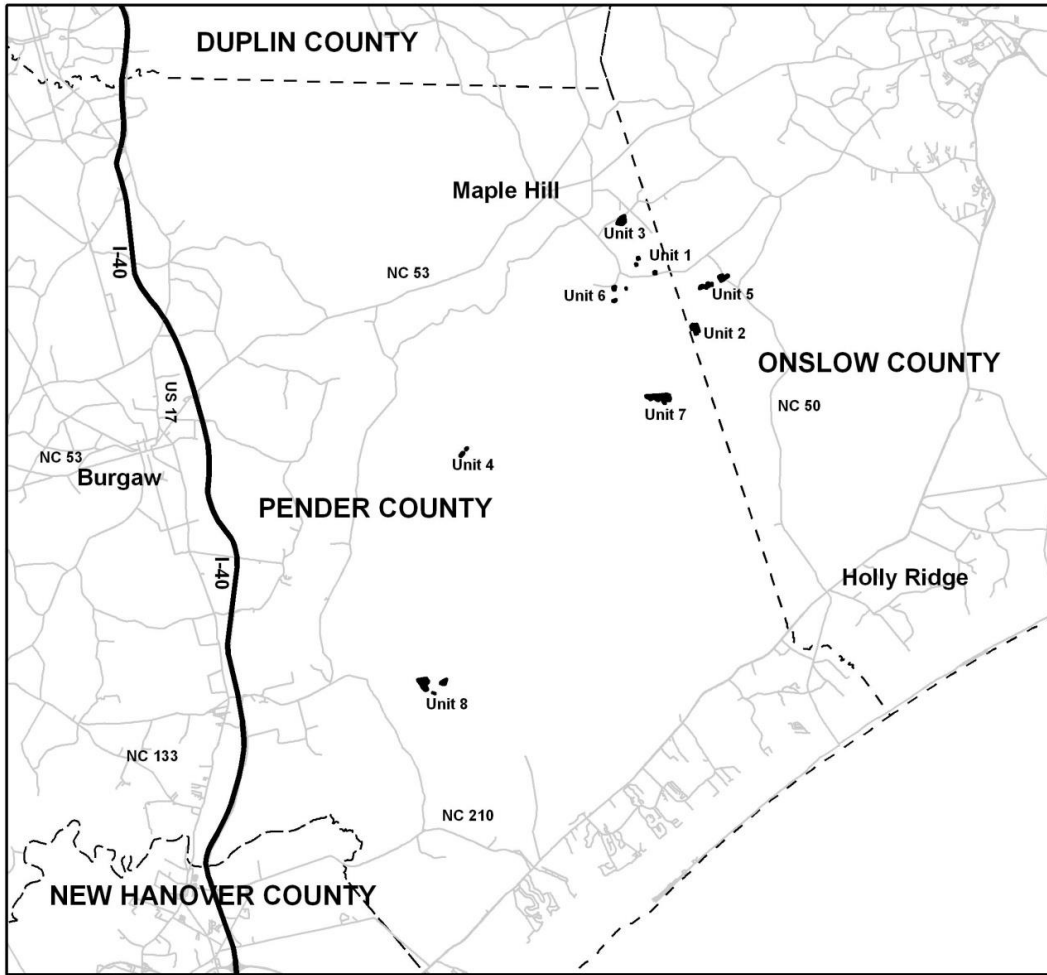
An **A-ranked occurrence** of *Carex lutea* should have more than 100 clumps occurring in high quality wet pine savanna with evidence of frequent fire. A high quality savanna will have no evidence of past ditching or other ground disturbing activities.

A **B-ranked occurrence** of *Carex lutea* should have between 30 and 99 clumps occurring in high to moderate quality wet pine savanna with evidence of frequent fire or more than 100+ clumps occurring in a moderate quality to significantly disturbed habitat. A high quality savanna will have no evidence of past ditching or other ground disturbing activities. A moderate quality savanna will have evidence of some ditching, but will have an intact herbaceous layer. A significantly disturbed habitat will have evidence of ditching and a depauperate (poor, discontinuous) herbaceous layer as well as some evidence of fire suppression.

A **C-ranked occurrence** of *Carex lutea* should have between 10 and 29 clumps occurring in high to moderate quality wet pine savanna with evidence of frequent fire or between 30 and 99 clumps occurring in a significantly disturbed habitat. A high quality savanna will have no evidence of past ditching or other ground disturbing activities. A moderate quality savanna will have evidence of some ditching, but will have an intact herbaceous layer. A significantly disturbed habitat will have evidence of ditching and a depauperate herbaceous layer as well as some evidence of fire suppression.

A **D-ranked occurrence** of *Carex lutea* should have fewer than 10 clumps occurring in any habitat or between 10 and 29 clumps in significantly disturbed habitat. A significantly disturbed habitat will have evidence of ditching and a depauperate herbaceous layer as well as some evidence of fire suppression.

Appendix D. Map of critical habitat units for *Carex lutea* (76 FR 11086; supported by USFWS and NCNHP data).



LEGEND

- Critical Habitat
- Interstate Highway
- Secondary Roads
- County Boundary

N

Miles

0 2 4 8

Kilometers

0 2.5 5 10

North Carolina

Appendix E. Summary of peer review

A. Peer Review Method:

The USFWS announced the availability of the draft recovery plan in the *Federal Register* on June 18, 2013 (78 FR 36566). In addition, a draft copy of the recovery plan was mailed to Laura Gadd Robinson (NC Natural Heritage Program), Michael Kunz (NC Botanical Garden), Dr. Anton Reznicek (University of Michigan) and Dr. John Taggart (University of North Carolina at Wilmington). Since *Carex lutea* only occurs in eastern North Carolina, no other USFWS Ecological Services Field Offices were included in the review of this document. This species does not occur on or near any National Wildlife Refuge so no other Service reviews were solicited, with the exception of regional office staff. Reviewers provided comments by email and / or modifications to the original document in “track changes.” All of the peer reviewers know the species and are familiar with the habitats where the species occurs and the threats to its long term survival.

B. Summary of Peer Review Comments:

Section: Executive Summary

Comment: One reviewer noted the recent discoveries of *Carex lutea* plants at McLean Savanna and Shaken Creek Preserve in deeply shaded sites.

Response: This comment has been noted and addressed. We decided that these forested areas are probably fire suppressed former savannas and addressed this in the Habitat Requirements and Limiting Factors of the Executive Summary section and Habitat Characteristics of the Introduction section.

Comment: One reviewer asked if it was common for Recovery Criteria to require more protected populations for recovery than are known at the time the Recovery Plan is prepared.

Response: Yes, it is common to need more stable, protected recovery populations than are known at the time the Recovery Plan is written in order to meet the recovery criteria. For most of our listed species at the time of listing and at the time of a recovery plan, the species has faced threats that have removed it from important habitat. Therefore, many recovery plans call for restoring some additional populations to return the species to a place where it can sustain itself in the wild. Based on this comment, we did not change the number of stable, protected populations required from the draft Recovery Plan.

Comment: One reviewer suggested that prescribed fire be a part of the species’ management plans.

Response: We agree with this statement and modified the language in the Recovery Criteria and Recovery Actions Needed of the Executive Summary and also in the Recovery Criteria and Narrative Outline of the Recovery section in order to reflect this suggestion.

Comment: One reviewer pointed out that both down-listing and de-listing require at least seven protected sites to be “A-ranked” by the NCNHP and asked if we should require that more sites be A-Ranked for de-listing than down-listing.

Response: We agree with this comment and changed the Recovery Criteria to reflect this comment. We believe that seven “A-ranked” populations are sufficient for down-listing the species, but 10 “A-ranked” populations should be required for de-listing the species.

Comment: One reviewer suggested that the total Estimated Cost of Recovery is low for Action 1 (Site Protection) and Action 5 (Monitoring).

Response: We agree that site protection, even through conservation easement, is more costly than we originally estimated. We adjusted the estimated costs appropriately in the Executive Summary and also in the Implementation Schedule.

Section: Introduction

Comment: Under Population Trends and Distribution, two reviewers provided additional information about specific *Carex lutea* populations.

Response: We appreciate the additional information and incorporated that information into the final Recovery Plan.

Comment: Under Population Trends and Distribution, one reviewer provided additional information about *Carex lutea* populations that are now Dedicated Nature Preserves.

Response: We appreciate the information and updated the final Recovery Plan accordingly.

Comment: In the Life History/Ecology section, one reviewer provided additional information about seed germination rates and the response to fire as it relates to flowering.

Response: We appreciate this information and included it in the final Recovery Plan.

Comment: One reviewer pointed out that the draft Recovery Plan included conflicting statements about asexual reproduction in the genus *Carex*.

Response: We agree with the comment and made the appropriate changes to the Recovery Plan under Reproductive biology.

Comment: One reviewer provided additional information about a recent study of the characteristics of the soils found at *Carex lutea* sites.

Response: We appreciate this information and included it in the Habitat Characteristics section.

Comment: One reviewer included information that insects occasionally feed on developing seeds.

Response: We included this information in the Disease and Predation section under Reasons for Listing and Ongoing Threats Assessments.

Comment: One reviewer suggested that mining and hydrologic alterations should be included in the Reasons for Listing and Ongoing Threats Assessment.

Response: We agree and incorporated this into the final Recovery Plan.

Section: Recovery

Comment: One reviewer suggested that *Carex lutea* reintroduction projects should be considered before introductions site where the species is not historically known.

Response: We agree with this philosophy and incorporated language to reflect this in the Narrative Outline section (Action 2.3).

Comment: One reviewer commented that mowing can cause soil compaction which can be harmful to *Carex lutea* plants.

Response: We agree with this statement and included this information in the Management section of the Narrative Outline.

Section: Implementation Schedule

Comment: One reviewer suggested additional partners to be included in the “Responsible Agency – Partner” column for some of the recovery actions.

Response: We agree with those recommendations and incorporated NCDPR into Actions 2.2, 3.3.2 and 4.2 the Implementation Schedule.

Modification of the proposed Recovery Date

In the draft recovery plan, we proposed that we could reach our recovery goals for this species by 2018. However, since we just started annual monitoring at 10 of these sites in 2010, it will be 2020 before we can demonstrate that those sites are stable or increasing. In addition, we need to begin annual monitoring at an additional five sites, for a total of 15 sites. We need additional funds to continue the current monitoring (10 sites) and initiate monitoring at five additional sites. If we can initiate monitoring at five more sites in 2015 and continue monitoring the initial 10 sites, it will be 2025 before we have 10 years of monitoring data. At that point, if monitoring data indicates stable or increasing populations, we would be able to remove the species from the endangered species list.