Navasota Ladies'-Tresses
(*Spiranthes parksii*)

5-Year Review:
Summary and Evaluation

U.S. Fish and Wildlife Service
Austin Ecological Services Field Office
Austin, Texas

5-YEAR REVIEW
Navasota Ladies'-Tresses/*Spiranthes parksii* Correll

1.0 GENERAL INFORMATION

1.1 Reviewers

Lead Regional Office: U.S. Fish and Wildlife Service - Southwest (Region 2)
Susan Jacobsen, Chief, Threatened and Endangered Species
505-248-6641

Wendy Brown, Recovery Coordinator, 505-248-6664;
Brady McGee, Regional Recovery Biologist, 505-248-6657;
Julie McIntyre, Recovery Biologist, 505-248-6657.

Lead Field Office: Austin Ecological Services Field Office
Chris Best, Texas Botanist, 512-490-0057 x 225.

1.2 Methodology used to complete the review:

The public notice for this review was published in the Federal Register on September 21, 2007 (72 FR 54059 - 54060). This review considers both new and previously existing information from Federal and State agencies, non-governmental organizations, academia, and the general public. Information used in the preparation of the review include the recovery plan, section 7 consultations, the Texas Parks and Wildlife Department (TPWD) Natural Diversity Database (NDD), final reports of Section 6-funded projects, monitoring reports, scientific publications, unpublished documents, personal communications from botanists familiar with the species, and Internet web sites. The 5-year review document was prepared by personnel of Austin Ecological Services Field Office, without peer review.

1.2 Background:

Navasota ladies'-tresses was first collected by H.B. Parks in Brazos County in 1945, and described by D. S. Correll in 1947 (Correll 1947). This terrestrial orchid was not observed again until 1978, when 20 individuals were observed in post oak savanna in two locations northwest of Navasota, Brazos County, Texas (Catling and McIntosh1979). U.S. Fish and Wildlife Service (USFWS) listed the species as endangered in 1982 (47 FR 19539 – 19542). The following year, Wilson and Ajilvsgi (1983) found a total of 1,816 Navasota ladies'-tresses at 24 sites in Brazos, Grimes, Robertson, and Burleson counties, but botanists still knew little about its biology, ecology, or range. Today the species is found in 13 Texan counties and is protected in 24 small reserves, 21 of which resulted from Section 7 consultation with USFWS. Five of these reserves may be sold after 2015,

and as such, are not permanently protected. The most recent surveys indicate that the plant has a potential population of 3,207 individuals.
The species is an edaphic endemic dependent on ephemeral seeps with sandy soils, and found mainly in small clearings within post oak savanna in central east Texas. As a member of the orchid family, the ecology of Navasota ladies'-tresses is intertwined with its mycorrhizae, which complicates the understanding of the flower's breeding system and genetics, as described below. The primary threats to the continued existence of Navasota ladies'-tresses are habitat loss and modification, primarily from mines, a landfill, pipelines, highway construction, and various private development projects that have not required Section 7 consultation with USFWS. Even where the species' habitat remains secure, habitat quality is declining as a result of a dense woody understory replacing the herbaceous component of the post oak savanna. This "thicketization" has occurred throughout the post oak savanna region, and elsewhere, and is attributed to a greatly reduced frequency of wildfire and to poor rangeland management techniques.

For the purposes of this review, a "site" is a fairly precise geographic location where one or more individuals of the species have been found. Although pollination occurs regularly, due to the unusual biology of this orchid, sexual reproduction is rare and most individuals at a site are clonal. Thus, even if many plants are found, the effective genetic population size often is one individual. A "population" may consist of one or many sites among which gene flow, such as pollination or seed dispersal, may occur. Geographic clusters of interacting populations may be considered "meta-populations," and the geographic area of a meta-population is a "macro-site." Large expanses of unsuitable habitat, cropland, or urban and residential development may serve as barriers to gene flow. Therefore, while individual sites may have too few individuals to meet the criterion of minimally sustainable populations, a group of sites may function as components of a larger, more viable population if their proximity and the continuity of habitat allow for gene flow from site to site.

13.1 FR Notice citation announcing initiation of this review:

72 Federal Register 54059-54060, September 21, 2007.

1.3.2 Listing history:

Original Listing

FR notice: 47 Federal Register, 19539 - 19542.
Date listed: May 6, 1982
Entity listed: *Spiranthes parksii* (Navasota ladies'-tresses)
Classification: Endangered without Critical Habitat.

1.3.3 Associated rulemakings: None

1.3.4. Review History:

No previous 5-year review has been conducted for this species. Other review documents include:
Status Report, 1980 (Mahler 1980)
Status Report, 1983 (Wilson and Ajilvsgi 1983)
Final Recovery Plan, 1984

1.3.5 Species' Recovery Priority Number at start of 5-year review:

The species' Recovery Priority Number is 2, meaning there is a high degree of threat, the recovery potential is high, and the listed entity is a species.

1.3.6 Recovery Plan or Outline:

Name of plan or outline: Navasota Ladies'-Tresses (*Spiranthes parksii*) Recovery Plan
Date issued: September 21, 1984
Dates of previous revisions, if applicable: N/A

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment (DPS) policy:

The Distinct Population Segment policy does not apply to Navasota ladies'-tresses because it is not a vertebrate animal.

2.2 Recovery Criteria:

2.2.1 Does the species have a final, approved recovery plan?

Yes.

2.2.1.1 Does the recovery plan contain objective, measurable criteria?

Yes (but not for all objectives).

2.2.2 Adequacy of recovery criteria:

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat?

No.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

Navasota Ladies'-Tresses (*Spiranthes parksii*) Recovery Plan (USFWS 1984) gives the following criteria for downlisting the species:

"The criteria for initiation of downlisting procedures are the establishment and securing of two safe sites containing portions of the existing *S. parksii* population, through cooperative agreements, purchases, easements or other means of obtaining management rights, and through preparation and implementation of management plans."

The plan then presents a step-down outline with the following major headings:

1. Remove immediate threats to *S. parksii* by protecting the major population systems from threats posed by human modification of the habitat and impact from collecting.
2. Minimize long-term threats to *S. parksii* through development of a base of information that is relevant to recovery.
3. Develop public awareness, appreciation, and support for protection and recovery of *S. parksii*.

This outline and the following narrative function as a list of recovery objectives, although they are not specifically identified as such. The stated recovery criterion is further elaborated under the first heading:

111. Protect land north of Texas International Speedway (sic) in Brazos County, Texas.

First priority with regard to selection of a safe site is clearly land immediately north of the Texas International Speedway. An area about one mile square with State Highway 6 as the western boundary and Texas International Speedway as the southern boundary would provide maximum protection for the largest number of individuals. Land north of Alum Creek supports scattered individuals in relatively isolated, widely separated populations.

112. Protect land near Carlos in Grimes County, Texas.

Land just west of Carlos, Texas, represents the secondary center of plant density, 400 individuals within a 2.02-hectare (ha) (5-acre (ac)) area. This population is in an area underlain with lignite deposits and is in close proximity to a lignite-burning power plant, operated by Texas Municipal Power Authority.

The recovery plan does not articulate measurable criteria for the second and third objectives, although the criteria might be inferred from the narrative descriptions. Note that USFWS documents have often incorrectly cited the name of the Texas World Speedway (referred to in paragraph 111, above), which was completed in 1968 (Texas World Speedway 2009).

Recovery team and recovery plan revisions. Organizations and individuals concerned with the recovery of Navasota ladies'-tresses met in College Station on July 5, 2001. The participants included USFWS, TPWD, the City of College Station, professors from Texas A&M University (TAMU), Texas Department of Transportation (TxDOT), the Texas Agricultural Extension Service, environmental consultants, and private individuals. This group, which then was called the Navasota ladies'-tresses conservation group, met again on January 23, 2002, April 10, 2002, April 23, 2002, and October 22, 2002. At a meeting in College Station on August 13, 2003, the Recovery Team was formed and held its first meeting. The team appointed Flo Oxley, Director of Education for Lady Bird Johnson Wildflower Center (LBJWC), to be the team leader; Ms. Oxley continues to serve in this capacity. As originally formed, the team consisted of a technical sub-team, with 12 members who accepted invitations from USFWS to serve on the team, and an implementation team, with 7 invited members. Additionally, two individuals accepted invitations to serve as consultants to the team. A few members of the original team have moved out of the area, or have changed jobs, while several new individuals have asked to serve on the team.

The Recovery Team has met 11 times as of June, 2009. Detailed notes from each team meeting have been provided to all team members, and are archived in the files of LBJWC and USFWS. Table 1 summarizes the dates, participation, and major topics discussed.

The Recovery Team has frequently discussed the need to revise the recovery plan. The original recovery plan's primary author, Dr. Hugh Wilson of TAMU, prepared a draft revised plan in 1993 (Wilson 1993); this draft was never finalized. The draft plan and related comments and recommendations may be downloaded from Dr. Wilson's website (Wilson 2009). This draft revised plan articulates the recovery criteria as follows:

> "Recovery Criteria: Areas currently designated as protected sites in Grimes and Brazos Counties include populations that represent genetic diversity from the two 'core' areas of *S. parksii* distribution. *Spiranthes parksii* should be considered for downlisting when:
>
> - Extant protected sites, or other areas of comparable size, and *S. parksii* population density on both sides of the Navasota Valley, are set aside - in perpetuity - as *S. parksii* preserves.

- Procedures are established and in place to monitor, on an annual basis, *S. parksii* populations inhabiting the preserves.…The species should be down listed when both of these criteria are attained."

The known range of *S. parksii* is now much more extensive than when the original and revised recovery plans were written. The recovery team concurs that the species will not recover solely through the establishment of two protected populations. The team intends to establish a completely new recovery plan that addresses updated information on the range, habitat, ecology, genetics, propagation, and management of the species. Additionally, the new recovery plan should incorporate the revised guidance on recovery planning now required by USFWS and National Marine Fisheries Service (NMFS) (NMFS 2007). In particular, the recovery plan must have criteria for each recovery objective that address the threats in terms of the five listing factors (see section 2.3.2). Recovery criteria must be "SMART": Specific, Measurable, Achievable, Realistic, and Time-referenced. The recovery team is currently seeking support for a contract to prepare a new recovery plan. One possible source of support is the conservation fund managed by LBJWC (discussed below), subject to the limitations on the use of the fund contributions. USFWS personnel provided a draft Recovery Outline to the recovery team in June, 2007, for the purpose of guiding recovery efforts until a new recovery plan is finalized; this outline remains in draft form.

Table 1. Summary of Navasota Ladies'-Tresses Recovery Team Meetings.
Shaded blocks indicate topics covered.

	13-Aug-03	13-Jul-04	08-Nov-04	30-Mar-05	17-Jun-05	28-Sep-05	22-Mar-07	14-Jun-07	26-Sep-07	27-Feb-08	12-Jun-08
Number of Participants	19	17	18	18	16	n/a	19	20	13	14	13
Meeting Topics:											
BVSWMA Consultation							■				
Ecological research	■						■			■	
Field identification										■	
Five-year review							■	■		■	■
Genetic research	■	■	■	■	■		■			■	■
Indian Lakes surveys		■							■		
Jeopardy/cumulative impact determination							■				
Minimum Viable Population estimates					■	■			■		
New population in Bastrop Co.			■								
New population in Limestone Co.			■			■					
NFWF/LBJWC SPIPAR Conservation Fund		■	■	■			■		■		
Outreach										■	
Population buffer zones									■		
Recovery Outline revision				■	■		■	■	■		■
Recovery plan revision	■	■	■	■			■	■		■	■
Recovery team membership	■							■	■	■	
Regional Park: Proposed acquisition of TMPA sites		■		■							
Reserves - proposed, new, and status	■	■	■		■		■				
Review/mapping of known populations		■			■				■		
S6 grant to City of College Station		■					■				
S6 grant to support genetics research		■									
TMPA survey results		■		■							
TPWD NDD revisions								■	■	■	

Section 7 Consultations. Formal consultations under Section 7 of the Endangered Species Act have lead to significant progress toward meeting the recovery criteria, as stated or implied in the original recovery plan (see Table 2 for a summary of formal consultations related to Navasota ladies'-tresses). These accomplishments were described variously as reasonable and prudent alternatives, conservation measures, conservation compensation, or conservation recommendations in USFWS Biological Opinions.

The first formal consultation (2-11-83-F-10) on *S. parksii* was requested by U.S. Federal Highways Administration (USFHA) on March 4, 1983, concerning the planned expansion of State Highway 6 (SH 6) by TxDOT. The expansion of the 15.9-mile (mi) segment of SH 6 from Navasota to College Station included acquisition of 269-ac of new ROW, and three interchanges were to be constructed. Surveys conducted from 1983 – 1985 discovered up to 150 *S. parksii* in a dense post oak forest near the project area (about 80 percent of the total *S. parksii* population known at that time), north of Texas World Speedway (TMPA 2001). The Biological Opinion (July 5, 1983) states that from five to nine orchids would be lost by the project; this would constitute jeopardy to the continued existence of the species, since continued development of the habitat would lead to a cumulative population decline. However, this loss of five to nine orchids would be considered non-jeopardy if either of two reasonable and prudent alternatives were adopted: 1) Utilize an alternative alignment for the proposed highway expansion that would not affect the orchid; or 2) Protect the main population to avoid a cumulative impact. TxDOT agreed to purchase an eight-ac tract as a permanent reserve for the densest portion of the *S. parksii* population. Sixteen additional orchids found within the proposed construction site were transplanted into this tract (TMPA 2001). Unfortunately, the landowner bulldozed the tract just before the acquisition was complete (Nations 1987). Surprisingly, surveyors detected 1,000 *S. parksii* at this site in 1993. However, Dr. Fred Smeins of TAMU found no orchids there in 2000. A very dense growth of scrub forest dominated the site in 2001 (TMPA 2001). Approximately 13 *S. parksii* were identified and mapped at this site in 2008 (Linda Langlitz, pers. com. 2009; see figure 1).

One of the most intricate *S. parksii* consultations (2-12-1985-F-0111) was initiated at the request of U.S. Environmental Protection Agency (USEPA) on June 11, 1985. This involved the re-issue of a National Pollutant Discharge Elimination System permit, under Section 402 of the Clean Water Act, for mining operations from 1986 – 1991 at the Gibbons Creek Lignite Mine (GCLM). This mine, near Carlos in Grimes County, is operated by the Texas Municipal Power Authority (TMPA). The initial wastewater permit had been issued prior to the listing of Navasota ladies'-tresses. In 1984, TMPA contracted Dr. Hugh Wilson, a biology professor at TAMU and co-author of the recovery plan, to survey about half of the 30,000-ac GCLM project area (the permit area and surrounding affected areas). The 30-year permit area was projected to include 11,000 ac to be surface mined, and 4,500 ac to be disturbed by support facilities, such as wastewater ponds, haul roads, lignite loading and hauling, and topsoil storage; 3,080 ac would remain as woodland. Wilson found 844 *S. parksii* plants at 64 of 97 sites surveyed in October and November, 1984. Of 618 *S. parksii* found on 39 sites within the permit area, 119 individuals on 25 sites would be lost to mining and related activities. The Biological Opinion, dated December 3, 1985, found that this take of 119 individuals, representing 5 percent of the total population then known, would jeopardize the continued existence of the species. The reasonable and prudent alternatives called for the protection from development of 9 survey sites, transplantation of orchids from the 25 sites to be developed, and the development of a monitoring plan "to determine the success of transplanting activities and status of plants within the protected locations." The 9 protected survey sites contained 484 *S. parksii*, representing 20 percent of the total population then known, and 78 percent of the population found within the 10-year project area. Two of the protected sites, owned fee-title by TMPA, were to be protected through long-term conservation easements or title transfer to an appropriate natural resource agency. Buffer zones were to be established to protect the remaining seven leased sites throughout the duration of the mine permit. For practical purposes, the nine protected survey sites were later combined into four protected areas.

USFWS initiated a second formal consultation (2-12-91-F-246) on the GCLM at the request of USEPA on June 18, 1991. This consultation covered "…the remaining life-of-mine area which was not previously considered in the 1985 Biological Opinion due to the lack of plant survey data and sufficient long-range mine plans." The 1992 – 1997 permit area (Area IV) consisted of about 6,950 acres. In 1985, 1988, and 1989, surveys of potential orchid habitat in Area IV detected a total of 174 *S. parksii* at 26 of 130 sites. The Biological Opinion (October 16, 1991) noted that *S. parksii* by that time had been reported from nine Texas counties, and was more abundant and widespread than previously thought. Up to 1,187 individual orchids had been observed at the GCLM project area. TMPA had by then established four protected areas, transplanted orchids from impact areas into the protected areas, conducted annual monitoring and reporting, and implemented a long-term conservation agreement and management plan for conservation of the endangered orchid in the project area. USFWS determined that the continued mining operations were not likely to jeopardize the existence of the species. The Biological Opinion presented five non-binding conservation recommendations: 1) A fifth orchid protection site of 75 to 125 ac, which had been designated by TMPA, should be added to the Navasota Ladies' Tresses Management Plan; 2) TMPA should continue to transplant orchids from areas subject to mining impacts into protected sites, in accordance with the management plan; 3) TMPA should continue to monitor the impacts of their activities on the orchid and the success of transplanting, make corrections as needed, and coordinate activities with USFWS and other regulatory agencies; 4) the mine plan should avoid four sites in the southeast portion of the mine, where 40 orchids had been found; and 5) TMPA should submit annual reports of all monitoring to USFWS.

The original management plan (TMPA 1987?) defined four protected areas, totaling about 163 ac. Two of these areas were owned by TMPA, one was privately owned, and ownership of the fourth was uncertain at that time. USFWS and TMPA, but not USEPA, signed a conservation agreement (TMPA, USFWS and USEPA 1988). The management plan was revised in 1991 to include the fifth protected site (81 ac), owned by TMPA (TMPA 1991). A revised conservation agreement (USFWS, USEPA and TMPA 1992), signed by all parties, stipulated that TMPA would monitor and manage these 5 protected sites until the cessation of mining and reclamation, expected to occur at least 20 years after the effective date of the agreement. TMPA agreed to sell the protected sites under their ownership to USFWS and/or USEPA when mining and restoration are complete (2012 or later); however, these Federal agencies are not required to purchase the properties. Mining operations ceased and the GCLM was permanently closed in 1996; reclamation of the 8,744 ac that were disturbed was projected to be compete by 2001 (Horbaczewski 2000).

TMPA continues to implement the reasonable and prudent alternatives and conservation recommendations listed under these biological opinions. The annual monitoring reports, transplant efforts, and other conservation efforts (discussed in Section 2.3, below) have generated valuable new information on the biology and management of the species. Figures 4 – 8 show the locations of the five TMPA reserve sites.

U.S. Federal Highways Administration (USFHA) requested formal consultation with USFWS in 1996 regarding a plan by TxDOT to construct State Highway 40 (SH 40), near College Station in Brazos County (Consultation no. 2-15-96-F-117). TxDOT contracted a private consultant, Tejas Ecological Services, to survey the 3.5-mi ROW from FM 2154 to SH 6. *Spiranthes parksii* was documented on privately-owned land that would be affected by the project. TxDOT proposed acquiring a 38-ac conservation easement from the private landowner. The Biological Opinion (March 22, 2000) concluded that 26 *S. parksii* plants would be protected on the easement, while 11 individuals occurring within the construction zone would be damaged or destroyed. The project will alter drainage, which could indirectly impact from 5 to 40 more *S. parksii*. The non-jeopardy conclusion was based on the following conservation measures: 1) Acquisition of the 38-ac easement dedicated to conservation of *S. parksii*; 2) development and implementation of a management plan for the conservation easement; 3) monitoring of *S. parksii* during the flowering season; and 4) future modification of the management plan if monitoring determines that the conservation goals are not met. A survey conducted at this site in the fall of 2008 detected 117 *S. parksii* (John Moravec, pers. com. 2009).

U.S. Army Corps of Engineers (USACOE) entered into formal consultation (2-15-1996-F-290), through its authority over Section 404 of the Clean Water Act, regarding Delhi Gas Pipeline Corporation's application to construct a 39-mi gas pipeline in Freestone and Leon counties. The project determination was "may affect" for both *S. parksii* and the listed endangered Houston toad. Surveys for *S. parksii* during the previous 14 years revealed that this orchid can be reliably identified only during a brief flowering period, usually in October or November, and only during years when ample rain falls in just the right pattern to stimulate flowering. In consideration of the potentially lengthy delays, Delhi agreed to an alternative consultation process; in lieu of field surveys for identifiable *S. parksii* plants, they would provide conservation compensation for all *potential* habitat of *S. parksii* impacted by the project. According to the Biological Opinion (March 7, 1997), this was the first project to employ this alternative process. Analysis of soils and vegetation determined that 5.52 ac of potential *S. parksii* habitat would be impacted by the main pipeline. Compensation consisted of a payment of $850 per acre (the estimated cost of land acquisition), plus transaction expenses of 15 percent, for a total compensation of $5,520. These funds were to be transferred in a grant for a *S. parksii* habitat conservation initiative. Delhi would also compensate for additional loss of potential *S. parksii* habitat, estimated at 28.5 ac, prior to constructing tie-ins to future gas wells; however, the locations, timing, and exact amount of habitat along these secondary pipelines was not then known (see consultation 2-15-1998-F-0762). The Biological Opinion included these non-binding conservation recommendations for *S. parksii*: 1) Maintain as much cover of woody vegetation as possible; 2) Avoid the use of herbicides and pesticides within *S. parksii* habitat; 3) Report any occurrences of *S. parksii* to USACE and USFWS; and 4) Conduct *S. parksii* surveys during the flowering season.

This alternative method of project review and consultation has since been employed in 10 additional formal consultations which was likely to adversely affect *S. parksii* (see Table 2). An additional formal consultation (2-15-1998-F-0762) was determined to have no affect on *S. parksii*. By 2006, the compensation for these projects and accumulated interest had generated $251,749 for conservation of *S. parksii* (see Table 3). These funds are currently managed as a Navasota Ladies'-Tresses Conservation Fund, administered by LBJWC. This fund, originally administered by the National Fish and Wildlife Foundation (NFWF), is described in more detail under "Cooperative agreements," below. However, the compensation funds from five consultations related to TxDOT projects, totaling more than $244,000, have apparently not yet been provided to the conservation fund.

Consultation 2-15-00-F-413 was requested by USEPA and the U.S. Department of Transportation (USDOT) on February 10 and 17, 2000, (respectively) for Phase I of an application by Longhorn Pipeline Partners, L.P. The two phases of this Longhorn Pipeline project consist of maintenance and minimal construction on a 723-mile pipeline from Houston to El Paso, TX (Phase I), and subsequent operation of the pipeline (Phase II). The pipeline and 50-ft wide cleared ROW have been used and maintained for more than 50 years to transport crude oil from west Texas to Houston. The Longhorn project modifies the pipeline to allow refined petroleum products to be transported from Houston to West Texas and beyond. Six federally-listed species, including *S. parksii*, were adversely affected by the project. The Biological Opinion (February 17, 2000) established reasonable and prudent measures that required USEPA and USDOT to ensure that Longhorn fully implement its proposed plan to minimize and offset impacts to these listed species. With regard to *S. parksii*, this consisted of a monetary contribution to the Navasota Ladies'-Tresses Conservation Fund for impacts to an estimated 5.2 ac of the species' habitat.

The Brazos Valley Solid Waste Management Agency (BVSWMA) permit application to USACE under Section 404 of the Clean Water Act for a proposed landfill required formal consultation with USFWS (2-15-2001-F-0531). The landfill, in Grimes County, has a 239-ac footprint within a permit boundary of about 610 ac. The Biological Opinion established conservation measures for four cells to be developed during Phase I of the project; new measures are to be proposed for the remaining cells of the landfill, which has a 35-year life expectancy. The landfill development will destroy 110 ac of *S. parksii* habitat, representing less than 5 percent of the total known population, and 20 percent of the population within the permit boundary. These conservation measures (summarized in Table 2) included the permanent deed restriction of 12 areas, totaling 140.5 ac, surrounding the landfill footprint, to protect 361 *S. parksii* plants and 112 ac of potential habitat. BVSWMA would also purchase and preserve 22 ac of additional *S. parksii* habitat, containing about 200 endangered orchids, adjacent to the TMPA site in Grimes County. BVSWMA will transplant up to 360 orchids from landfill cells to other protected sites, and will monitor the transplant sites for 5 years. BVSWMA will fund a graduate assistant in the TAMU Department of Rangeland Ecology and Management to investigate *S. parksii* ecology, and will support genetic research on *S. parksii* to be conducted by Drs. Allen Pepper and James Manhart at TAMU. BVSWMA will provide funding to the City of College Station Parks and Recreation Department for management of Lick Creek Park (discussed below).

Formal consultation with USACE (2-15-2003-F-0239) resulted from a joint Section 401 and Section 404 (Clean Water Act) permit application by Smiling Mallard Development, Ltd., for the Indian Lakes housing development in Brazos County. The plan for this 1,500-ac site near College Station included 120 lots, ranging from 1.2 to 13 ac. Surveys in 2000 found populations with 48 individual *S. parksii* plants. A 1983 survey found three populations with 100, 26, and 1 *S. parksii* within the project site. The Biological Opinion (September 8, 2003) described a series of conservation buffers that the developer agreed to establish along watercourses at the site. These include 75-ft buffers along both sides of 6,587 ft of intermittent streams and 11,260 ft of ephemeral streams, and 150-ft buffers along both sides of 19,199 ft of intermittent channels and 2,236 ft of ephemeral channels. The developer established a conservation agreement to protect in perpetuity a 32-ac *S. parksii* preservation area where 43 *S. parksii* were found on 6 ac of occupied habitat. The developer also agreed to place permanent monitoring transects within the site and to implement an adaptive management plan. Additional conservation recommendations included the continuation of annual surveys, determination of the number of *S. parksii* that flower each year, and documentation of the life span of the orchids and damages that might occur to plants and habitat. The development will cause the loss of 5 *S. parksii* and 22 ac of habitat. USFWS concluded that the project was not likely to jeopardize the continued existence of the species.

Consultation 2-15-2004-F-0155 with USACE under Section 404 of the Clean Water Act regarded a plan by TxDOT to realign Green Prairie Road and construct an interchange in College Station. The project area covered about 9 ac, including 2,300 ft of road relocation to the south. The Biological Opinion (May 23, 2005) stated that *S. parksii* was found in 3 areas, as well as 4 individuals within the ROW but outside the action area. The project would affect 6 plants on 0.21 ac. The City of College Station will transfer funds for acquisition of SPIPAR habitat in College Station; this was assumed to be at Lick Creek Park. The Biological Opinion states "The amount transferred will be somewhat commensurate with the amount of habitat and the number of plants affected." Conservation recommendations included avoiding use of herbicides within *S. parksii* habitat, and continued support for research and recovery of the species. At this time, we cannot confirm whether the City of College Station did indeed transfer funds for acquisition of *S. parksii* habitat.

In summary, seventeen projects that required formal Section 7 consultations resulted in the loss of 520 individual *S. parksii* plants and 375 ac of habitat. These losses were compensated by: 1) Creation of 21 protected sites with 425.1 ac of habitat; 2) establishment of 5 long-term monitoring and management plans; 3) $235,450 to support land acquisition and conservation (an additional amount of over $244,000 has not yet been collected); and 4) support for research on the ecology, management, propagation, and (pending) genetics of the species.

Table 2. Summary of Biological Opinions involving Navasota ladies'-tresses.

Consult. No.	Date Concluded	Action Agency / Nexus	Non-Federal Entity / Project	Counties	Reasonable and Prudent Alternatives, Measures, and Conservation Recommendations
2-11-83-F-10	4 Mar, 1983	USFHA	TxDOT Construct SH6	Brazos	• 269 ac of new ROW for 16.9-mile SH6. • 150 *S. parksii* on private land near project (80% of population known at that time). • 5 – 9 *S. parksii* lost to project; additional 16 to be transplanted from project into protected area. • TxDOT to acquire 8-ac site for *S. parksii* preserve.
2-12-85-F-111	3 Dec, 1985	USEPA S.402 CWA	TMPA Gibbons Creek Lignite Mine	Grimes	• Protect 9 sites that contain 484 *S. parksii* plants (78% of population in permit area, 20% of known population). Two sites owned fee title by TMPA to have long-term conservation easement or title transfer to "an appropriate natural resource agency." 7 leased sites "protected from surface disturbances…" • 119 *S. parksii* plants (5% of known population) at 25 sites will be lost to mining activities. • Transplant *S. parksii* plants into safe area prior to mining. • Develop monitoring plan "to determine the success of transplanting activities and status of plants within the protected location."
2-15-96-F-117	22 Mar, 2000	USFHA	TxDOT Construct SH40	Brazos	• TxDOT to acquire 38-ac easement for conservation of *S. parksii*. • Develop and implement a management plan. • Monitor *S. parksii* during flowering season. • Modify the management plan if monitoring shows goals not met.
2-15-96-F-290	7 Mar, 1997	USACOE S. 404 CWA Nationwide Permit 12.	Delhi Gas Pipeline Corp. 39-mile long natural gas pipeline	Freestone Leon	• Applicant (Delhi) agreed to alternative consultation process: in lieu of surveys, applicant will compensate for 5.52 ac of potential *S. parksii* habitat @ $1000/ac. • Funds to be transferred as a grant to an appropriate organization for a regional *S. parksii* habitat conservation initiative. • 28.5 ac of habitat may be impacted by future activities.
2-12-96-F-291	30 Nov, 1997	USACOE	Rockland Pipeline Co. 25-mile natural gas pipeline	Freestone Leon	• Applicant will compensate for 1.44 ac of potential *S. parksii* habitat @ $920/ac. • Funds to be transferred as a grant to an appropriate organization for a regional *S. parksii* habitat conservation initiative.

Consult. No.	Date Concluded	Action Agency / Nexus	Non-Federal Entity / Project	Counties	Reasonable and Prudent Alternatives, Measures, and Conservation Recommendations
2-15-97-F-98	28 Mar, 1997	USACOE S.404 CWA Nationwide Permit 12	Pinnacle Gas Treating, Inc. 61.1-mile natural gas pipeline	Anderson Freestone Leon Robertson	• Applicant will compensate for 1.96 ac of potential *S. parksii* habitat @ $2,904/ac. • Funds to be transferred as a grant to an appropriate organization for a regional *S. parksii* habitat conservation initiative. • An estimated 57.0 ac (combined Houston toad and *S. parksii*) potential habitat may be impacted by future activities…Pinnacle will compensate on an annual basis. • Pinnacle will make annual report to ACOE & USFWS for 10 years.
2-15-97-F-396	11 May, 2004	USACOE S. 404 CWA Nationwide Permit 21 – Surface Mining	Northwestern Resources Co. Jewett Mine	Freestone Leon Limestone	• Surveys detected up to 28 *S. parksii* at mine. 12 of 50 sites are suitable for *S. parksii*, 5 already destroyed. • Applicant will compensate at a rate of 2 ac for every 1 ac of occupied *S. parksii* habitat lost, 1 ac per 1 ac of supporting habitat lost, and 0.75 ac per 1 ac of potential habitat lost. • Applicant will compensate for a total of 69.61 ac at all sites.
2-15-98-F-762	27 Mar, 1998	USACOE S. 404 CWA Nationwide Permit	Koch Midstream Services (formerly Delhi), 4.7-mile natural gas pipeline	Leon	• $38,739.36 compensation for impacts to 23.95 ac of Houston toad habitat. Additional 20 ac may be impacted for tie-ins over 20-year period. • No effect for Navasota ladies'-tresses.
2-15-99-F-55	6 Jan, 2006	USFHA.	TxDOT. Widening of US Hwy 79.	Leon	• 170 ac of new ROW, including 12 ac of post oak woodland. • Compensation rate of 1 ac known habitat acquired per 1 ac of optimal habitat destroyed, or 0.5 ac known habitat acquired per 1 ac of marginal habitat destroyed; + 20% for edge impacts. • 8.48 ac optimal + 6.7 ac marginal habitat destroyed, + 20% = 15.18 ac compensation.
2-15-00-F-413	17 Feb, 2000	USEPA and USDOT	Longhorn Pipeline Partners, L.P. Maintenance and minor construction of 723-mile pipeline from Houston to El Paso.	Numerous	• 5.2 ac of *S. parksii* habitat x 1.2 multiplier + 10% for land value inflation = $6,864 to contribute to Navasota Ladies'-Tresses Conservation Fund. • Survey ROW for *S. parksii*, schedule mowing to avoid Oct-Nov flowering period. • USEPA and USDOT must ensure proposed plan is implemented.

Consult. No.	Date Concluded	Action Agency / Nexus	Non-Federal Entity / Project	Counties	Reasonable and Prudent Alternatives, Measures, and Conservation Recommendations
2-15-00-F-1264	9 Jan, 2002	USFHA.	TxDOT Construction of 9.6 miles of SH6.	Brazos	• 359 ac to be acquired for ROW • Negative surveys not accepted due to drought conditions. • Alternative compensation rate of 1 ac known habitat acquired per 1 ac of good potential habitat destroyed, or 0.5 ac known habitat acquired per 1 ac of low potential habitat destroyed; + 20% for edge impacts. • 17.33 ac good potential + 6.61 ac low potential habitat destroyed, + 20% = 24.77 ac compensation ($161,655.21 contributed to *S. parksii* fund managed by NFWF).
2-15-01-F-531	8 May, 2001	USACOE S. 404 CWA	Brazos Valley Solid Waste Management Agency (BVSWMA) landfill.	Grimes	• 610-ac permit boundary, 239-ac project footprint, 35-year expected lifespan. Conservation measures apply to first 10-year Phase I in cells 1, 2a, 2b, & 3a. New measures will be needed for Phase II in cells 3b, 4, 5a-d, and 6a-b. • Landfill, rerouted gas pipelines, wells, and other construction will avoid largest *S. parksii* populations; drainage will be restored to pre-construction conditions. • BVSWMA will permanently deed-restrict 140.5 ac in 12 areas surrounding landfill footprint, containing 361 *S. parksii* plants on 112 ac of suitable habitat. Deed restriction will be lifted if *S. parksii* is delisted. BVSMA purchased and preserved 22 ac of *S. parksii* habitat adjacent to TMPA site C3 with about 200 *S. parksii* plants. • BVSWMA will survey cell C1, transplant up to 360 *S. parksii* to protected site and monitor for 5 years. Other methods may be adopted if transplanting is unsuccessful. • BVSWMA will provide funding to support a) graduate assistant at TAMU to study *S. parksii* ecology; b) *S. parksii* management at the landfill site and at Lick Creek Park in College Station; c) seed collection and propagation; and d) genetic research by Drs. Manhart and Pepper. Must provide annual report to USFWS. • Project will destroy 110.5 ac of *S. parksii* habitat; <20% *S. parksii* habitat in 9 locations will be permanently protected and managed.

Consult. No.	Date Concluded	Action Agency / Nexus	Non-Federal Entity / Project	Counties	Reasonable and Prudent Alternatives, Measures, and Conservation Recommendations
2-15-01-F-557	13 Sep, 2001	USACOE S.404 CWA	XTO Energy. 20-mile natural gas pipeline.	Freestone Leon Limestone Robertson	• Project will compensate for direct impacts to 2.03 ac of *S. parksii* habitat, + 20% for edge impacts, through land acquisition @$1000/ac + 15% for transaction costs. Total compensation of $2,794 to be paid to NFWF fund for NLT conservation. • Compensation to be used specifically for land acquisition for preserves, conservation easements, or other binding agreements for *S. parksii* conservation, including "…indirect costs related to habitat preservation/conservation, such as appraisals, legal fees, landowner contact expenses, and expenses of preserve design."
2-15-02-F-589	27 Jan, 2003	USFHA	TxDOT. Widening of 15.8 miles of SH21 and US Hwy 190.	Brazos Madison	• Project acquires 301 ac of new ROW, including 13.91 ac of potential *S. parksii* habitat. • Compensation of 1 ac acquired per 1 ac of high potential habitat destroyed, or 0.5 ac acquired per 1 ac of low potential habitat. Included additional 20% for edge impacts and 15% for land acquisition costs. • Total contribution to NFWF *S. parksii* fund of $82,449.49.
2-15-03-F-10	24 Sep, 2004	USFHA	TxDOT, New 8.3-mile 4-lane US Hwy 79.	Milam	• Compensation rate of 1 ac: 1 ac for optimal and 1 ac: 0.5 ac for marginal habitat, + 20% for edge impacts. • Compensation of (9.57 ac optimal habitat + 0.5(93.96 ac marginal habitat) x 1.20 = 67.86 ac.
2-15-03-F-239	05 Sep, 2003	USACOE Joint S.401 and S. 404 CWA	Smiling Mallard Development, Ltd. Indian Lakes Development. 120 homes to be built on 1500 ac near College Station on lots ranging from 1.2 to 13 ac.	Brazos	• 150-ft conservation buffers (75 ft each side) along 6,587 ft of intermittent streams and 11,260 ft of ephemeral streams. • 300-ft conservation buffers along 19,199 ft of intermittent and 2,236 ft of ephemeral channels. • 32-ac *S. parksii* preservation area (including 6 ac of occupied habitat), containing 43 *S. parksii* plants, will be protected in perpetuity with conservation easement. • Permanent monitoring transects and management plan. • Project will cause the loss of 5 *S. parksii* plants and 22 ac of potential habitat.
21450-04-F-155	23 May, 2005	USACOE S. 404 CWA.	TxDOT. Realignment of 2300-ft portion of Green Prairie Rd, interchange construction.	Brazos	• *S. parksii* found on 0.31 ac of 9-ac project; 6 individuals on 0.21 ac will be affected by project. • City of College Station will transfer funds (to be determined later) to acquire *S. parksii* habitat (assumed to be Lick Creek Park).

Consult. No.	Date Concluded	Action Agency / Nexus	Non-Federal Entity / Project	Counties	Reasonable and Prudent Alternatives, Measures, and Conservation Recommendations
21450-06-F-126	12 July, 2006	USFHA	TxDOT. Widening of US 290.	Bastrop	• No effect to *S. parksii*.
2006-F-0160	25 Aug, 2006	USFHA	TxDOT. Improvements to FM 1441.	Bastrop	• No effect to *S. parksii*
21450-07-F-22	12 Jan, 2006	USFHA	TxDOT. Improvements to CR169 (road approaches to two new bridges on Mathis Creek).	Brazos	• Project includes 0.3 miles of road and 2.93 ac of ROW. • 0.15 ac of *S. parksii* habitat (0.13 ac optimal and 0.02 marginal) will be destroyed by project; no *S. parksii* plants were found. • Fee in lieu compensation for (0.13 ac + 0.5(0.02 ac)) + 20% = 0.168 ac + 15% for indirect costs. • Funds will be based on average assessed land values/ac, to be contributed to *S. parksii* habitat conservation fund.

Figure 1. TxDOT SH 6 Reserve.

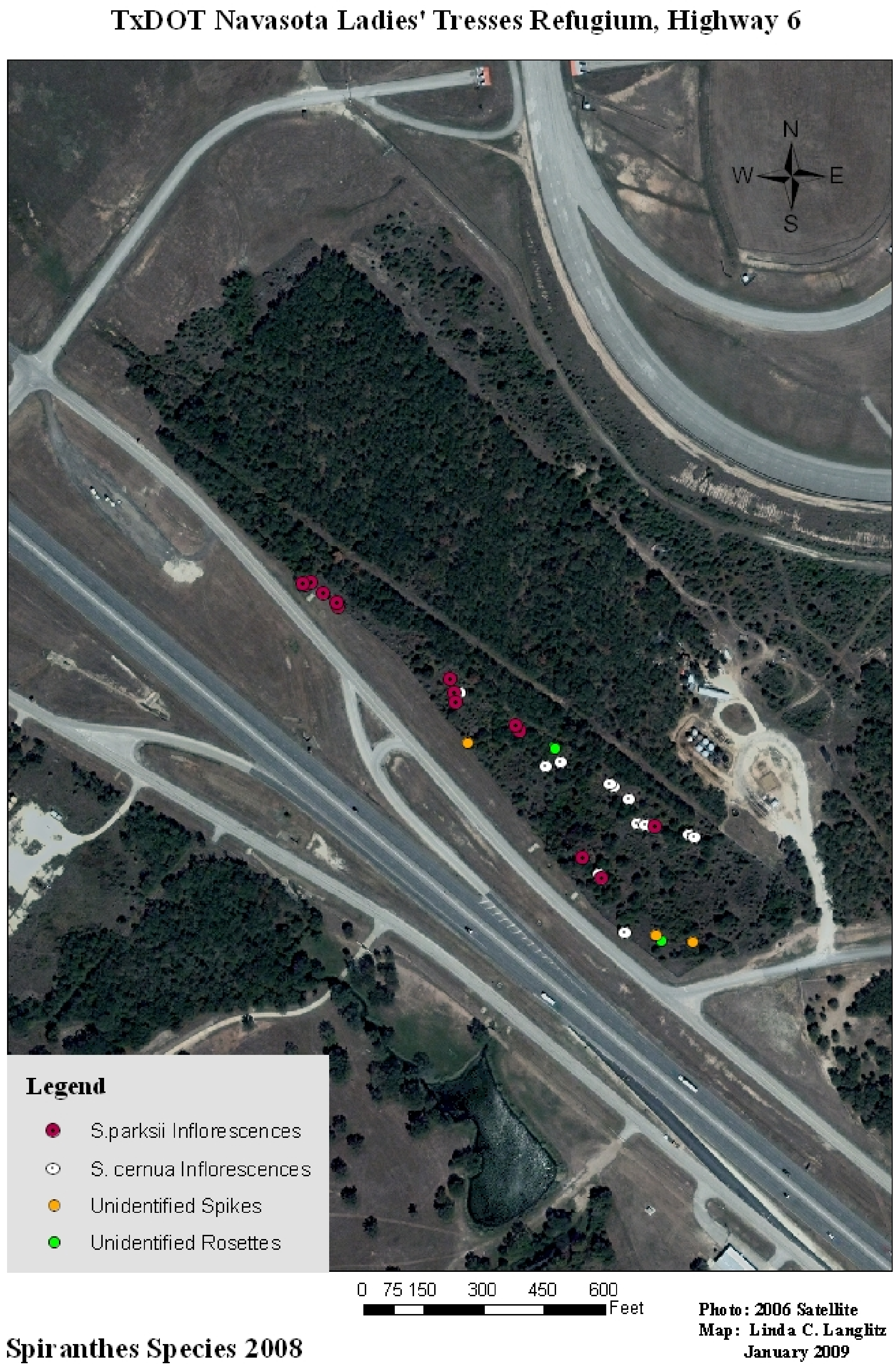


Figure 2. TxDOT SH 40 Reserve.

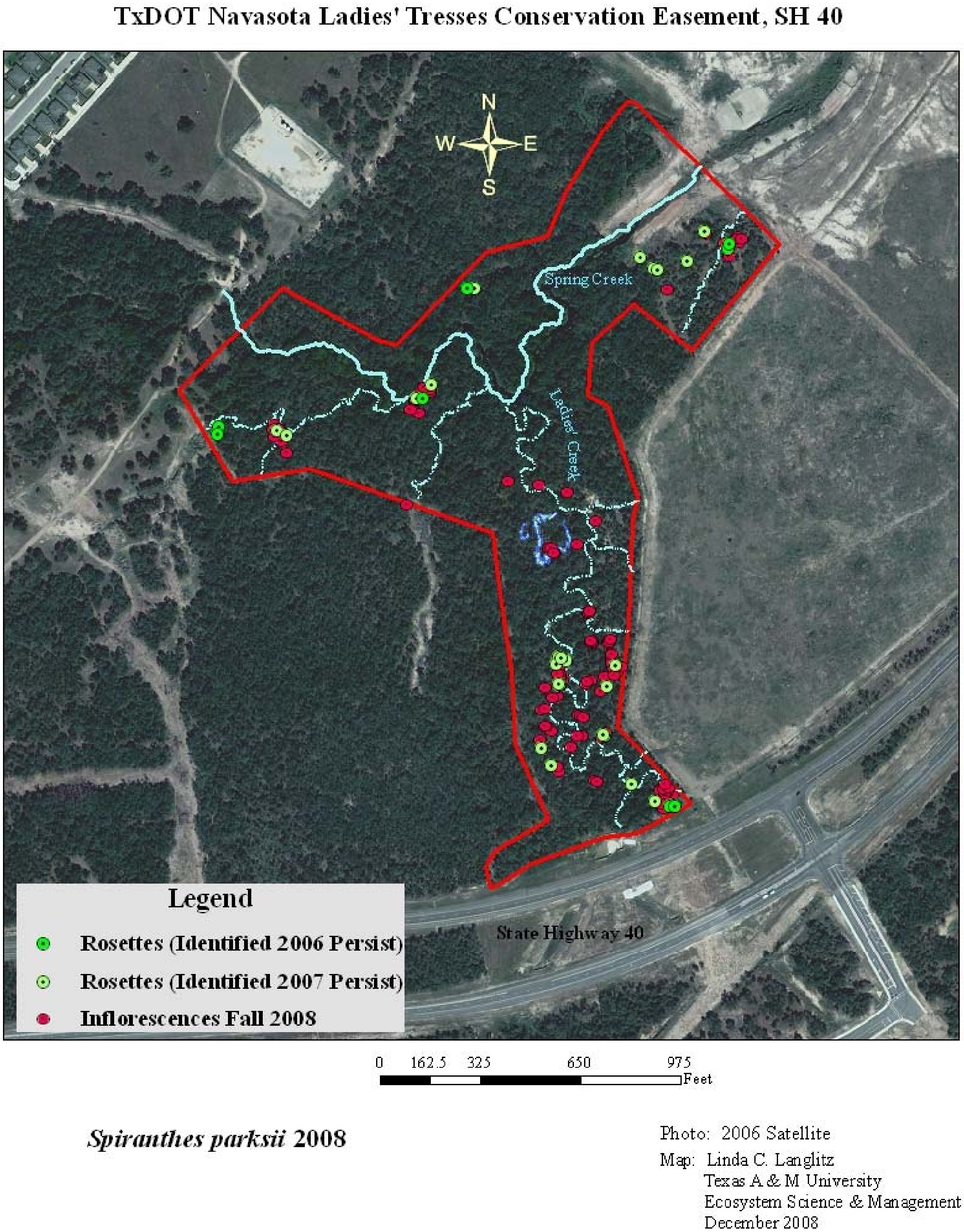
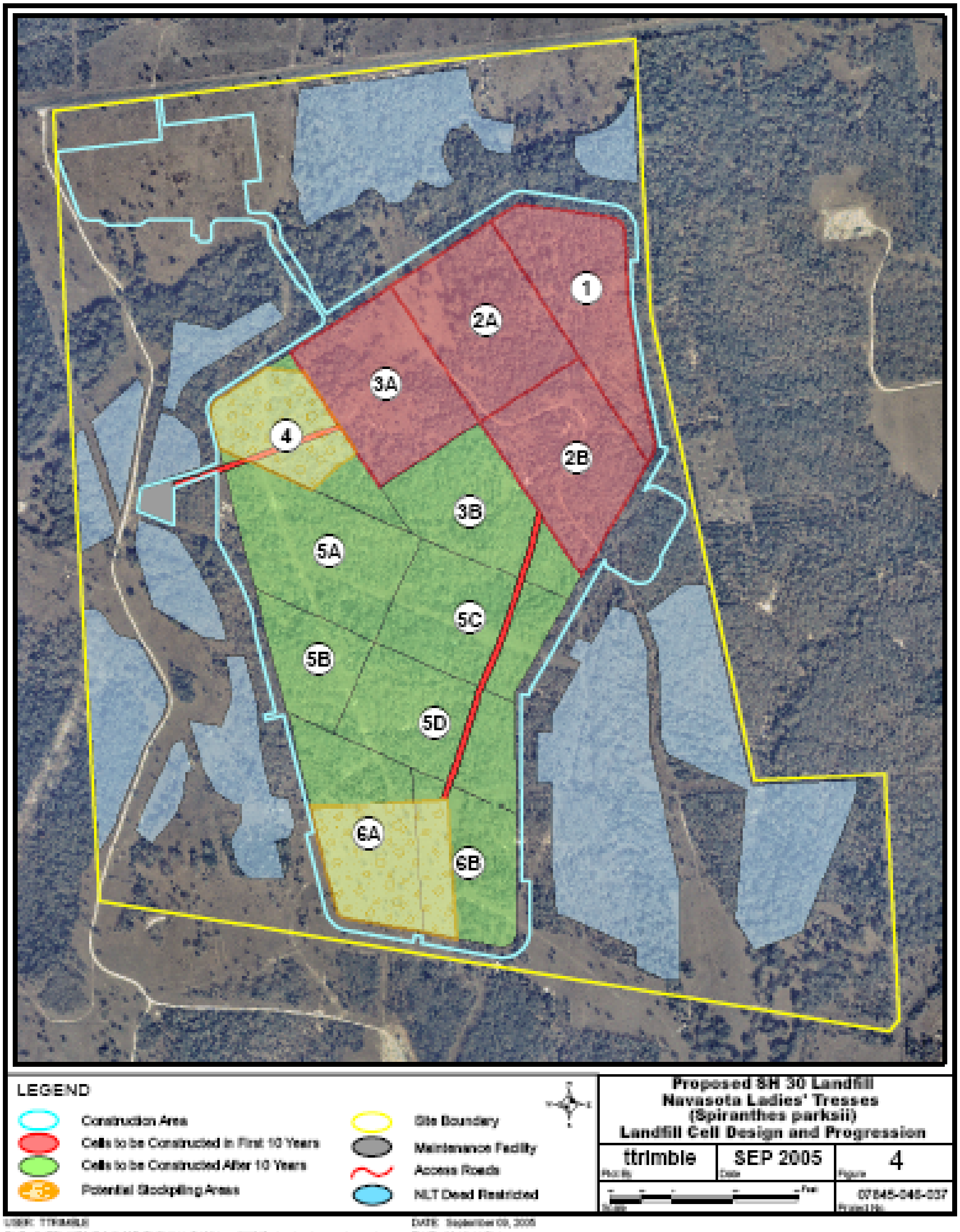


Figure 3. BVSWMA Reserves.



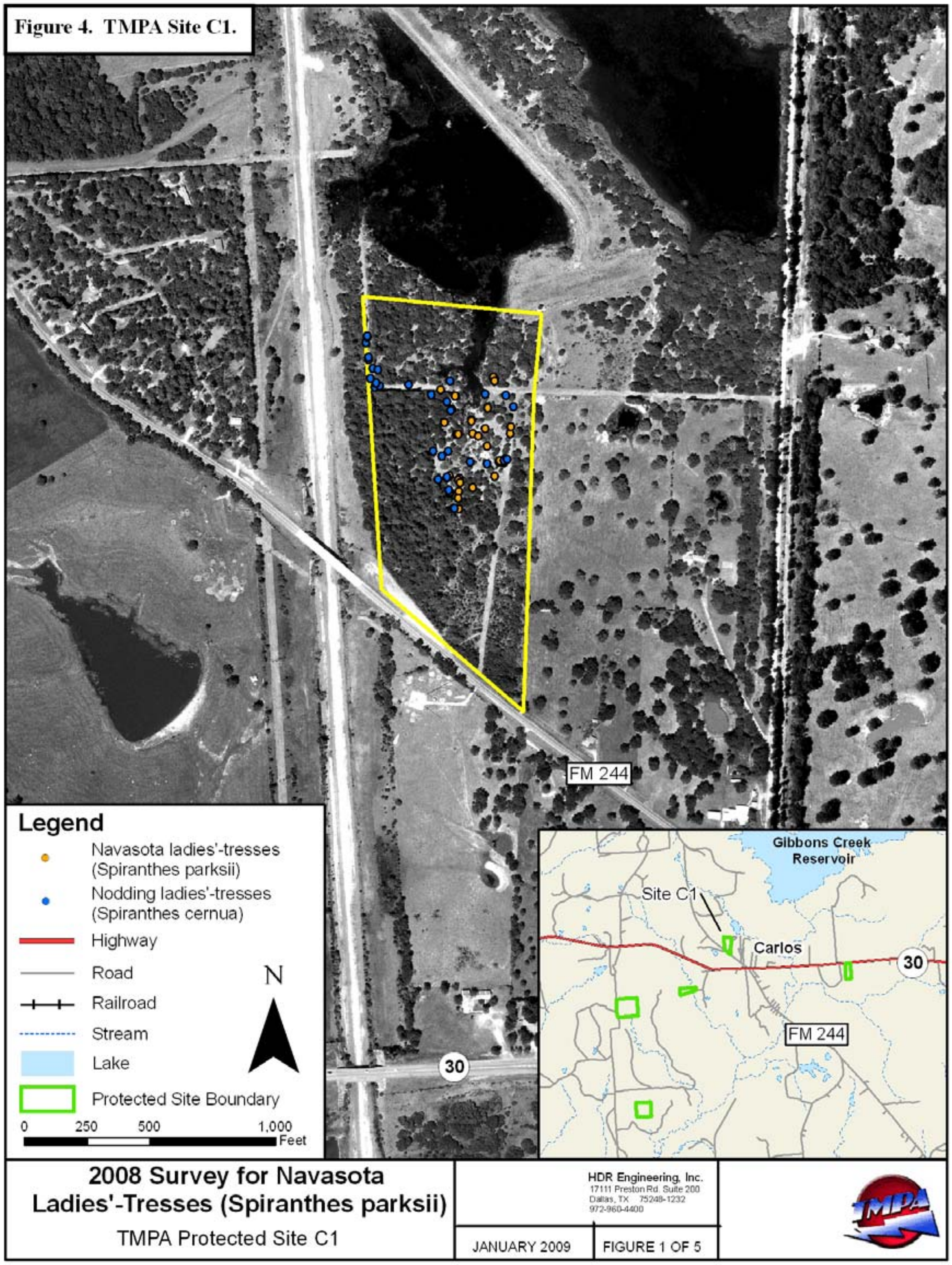
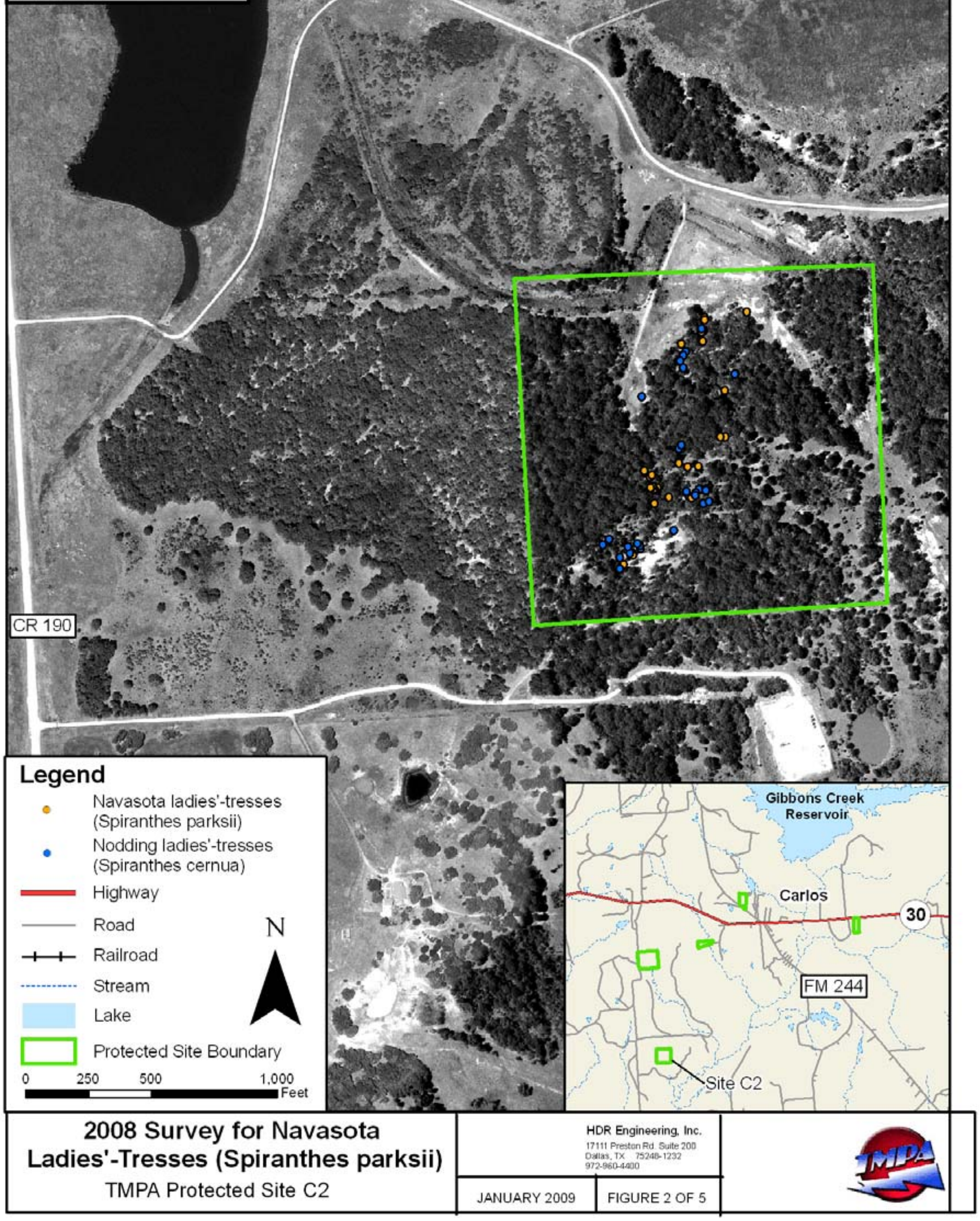


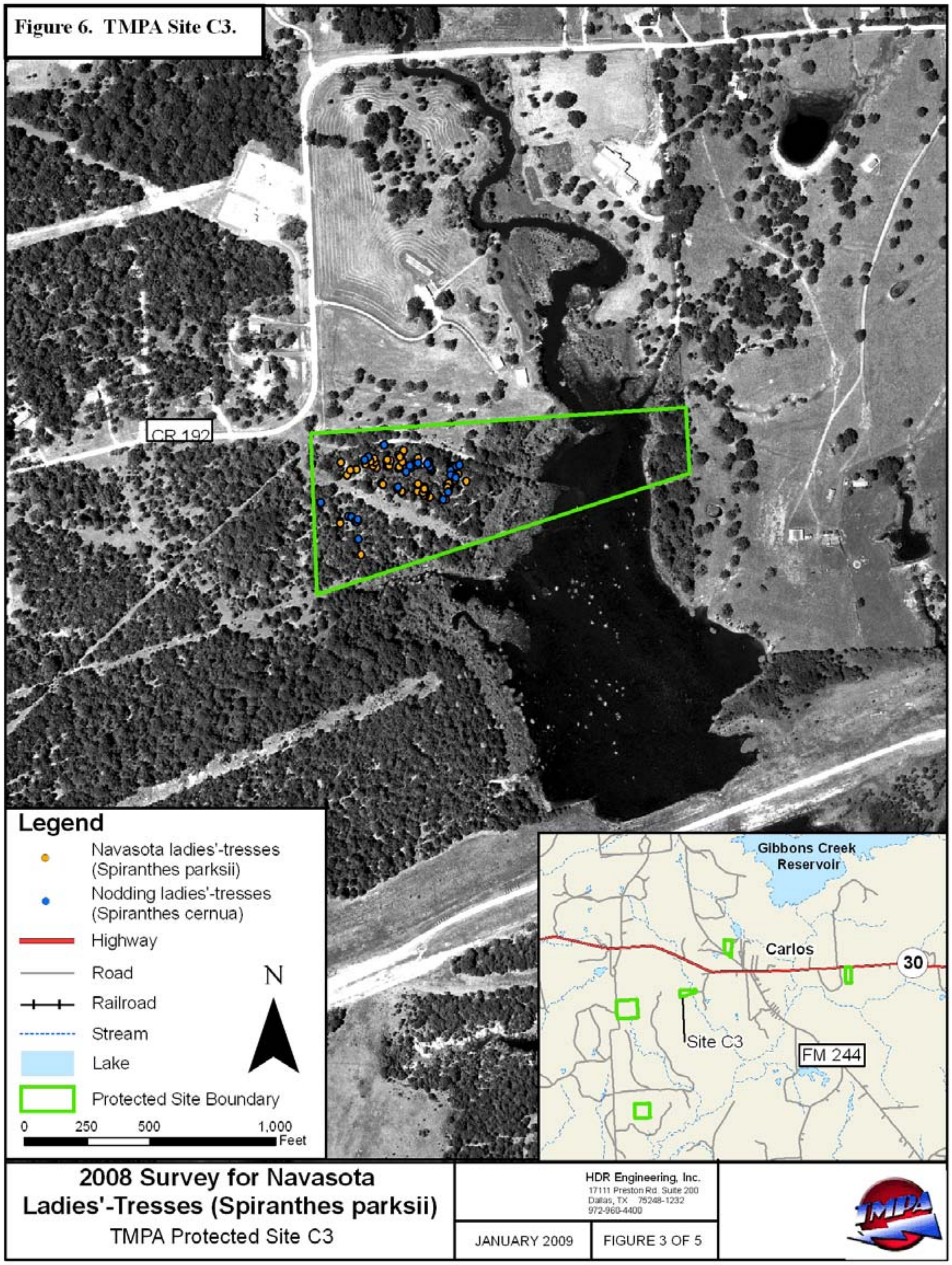
Figure 4. TMPA Site C1.

FILE: O:\Dept037_DallasEngineering\EnvSciences\96104_TMPA_2008_NLT_Survey\MapDocs\arcmap\TMPA_NLT_Survey_C1_8x11_v1.mxd

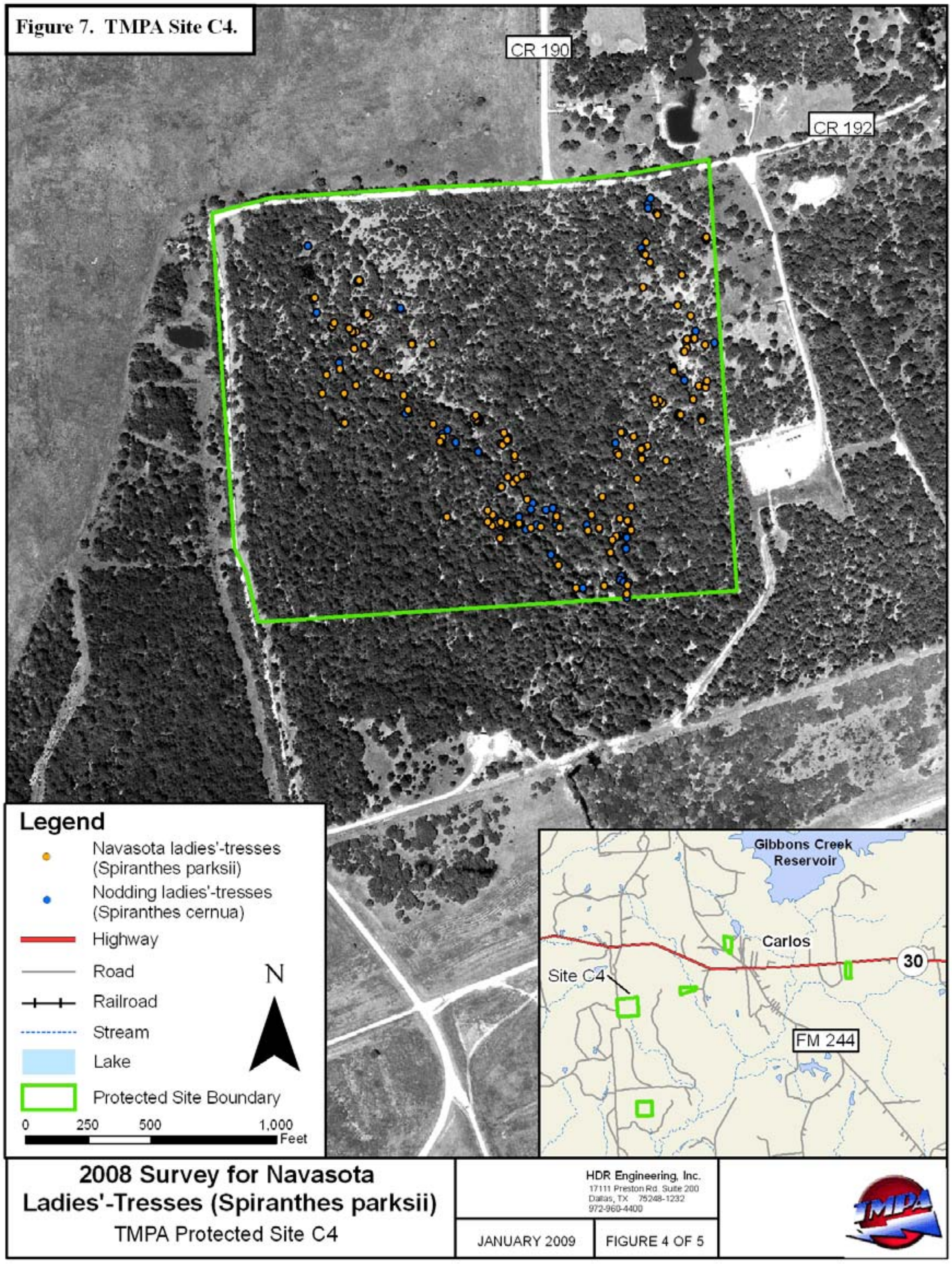
Figure 5. TMPA Site C2.



FILE: O:\Dept037_DallasEngineering\EnvSciences\96104_TMPA_2008_NLT_Survey\MapDocs\arcmap\TMPA_NLT_Survey_C2_8x11_v1.mxd



FILE: O:\Dept037_DallasEngineering\EnvSciences\96104_TMPA_2008_NLT_Survey\MapDocs\arcmap\TMPA_NLT_Survey_C3_8x11_v1.mxd



FILE: O:\Dept037_DallasEngineering\EnvSciences\96104_TMPA_2008_NLT_Survey\MapDocs\arcmap\TMPA_NLT_Survey_C4_8x11_v1.mxd

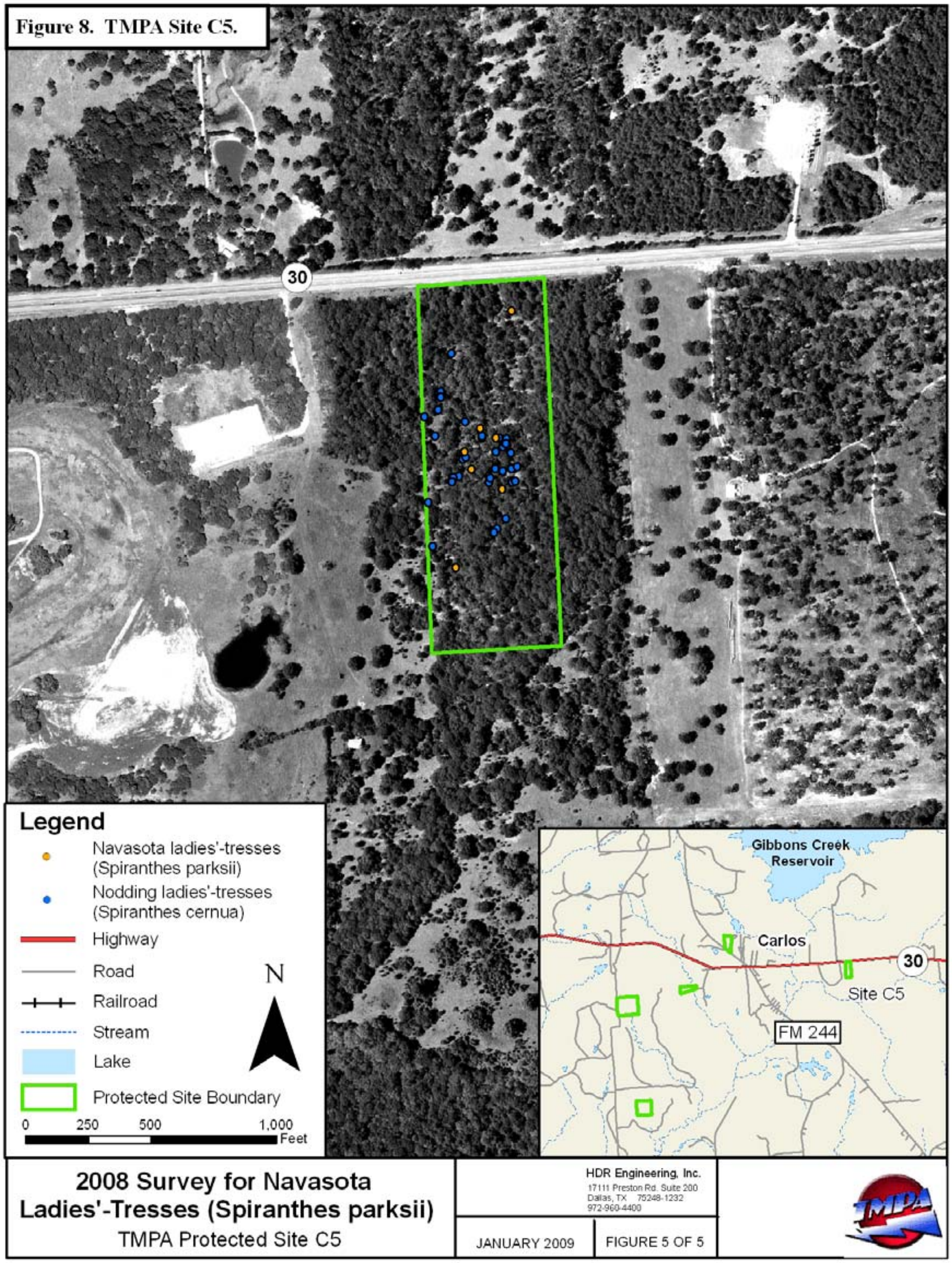


Figure 8. TMPA Site C5.

FILE: O:\Dept037_DallasEngineering\EnvSciences\96104_TMPA_2008_NLT_Survey\MapDocs\arcmap\TMPA_NLT_Survey_C5_8x11_v1.mxd

Cooperative agreements. Central and South West Services, Inc., through a cooperative agreement with USFWS (No. 14-16-0002-86-903), provided $30,000 in 1985 to support a contract with Dr. Hugh Wilson of TAMU to conduct surveys for new populations, describe habitats, and monitor populations changes.

In 1999, USFWS established a cooperative agreement (no. 1448-20181-99-J829) with investigators from the Missouri Resource Assessment Partnership, who used remote sensing to assess habitat for the Houston toad and Navasota ladies'-tresses (Diamond and True 2000). The results of this project are described in section 2.3.1.1.

A letter of agreement was signed in 1998 by USFWS and NFWF, establishing a Navasota Ladies'-Tresses Conservation Fund, to be administered by NFWF, to receive and distribute appropriately the compensation funds generated by the USFWS Biological Opinions described above (USFWS and NFWF 1998). This agreement was amended to extend the agreement from 2003 to 2005 (USFWS and NFWF 2005). The purpose of the fund is "to be used exclusively for conservation and recovery of the Navasota ladies'-tresses and the habitats on which it depends." This fund is not a substitute for continued federal or state support; however, it may be used to provide matching funds as requested by USFWS to leverage donations. NFWF received an initial administrative overhead reimbursement of five percent at the time of fund contribution. In 2005, the Navasota Ladies'-Tresses Conservation Fund was transferred to LBJWC, which continues to administer it under essentially the same provisions, including the initial reimbursement of five percent of fund contributions for overhead costs (USFWS and LBJWC 2005). The specific use of each compensation contribution is stipulated in the Biological Opinions. On May 16, 2007, the fund contained $212,496.88 to be used solely for land acquisition, $24,332.84 reserved for purposes related to a regional habitat conservation initiative, and $5,520 for general conservation of *S. parksii* (Paige Najvar, pers. com. 2007). However, the interest earned on the fund contributions is presumably subject only to the general purpose of the fund, as stated above. Currently, only one expenditure has been made, to fund a predictive model developed by Dr. Fred Smeins and Edith Bai of TAMU. The current amount and designated uses of the conservation fund are summarized in Table 3.

Table 3. NFWF-LBJWC Navasota Ladies'-Tresses Conservation Fund.

Update:	19 June, 2009						
Date	**Fund Contributor**	**Fund Manager**	**Credits**	**Less 5% Fee**	**Other Debits**	**Net Activity**	**Account Balance**
3-Jun-1999	Northwestern Resources Co.; 2-15-97-F-396 (Jewett Mine)	NFWF	$88,057.00	$4,402.85	$0.00	$83,654.15	$83,654.15
3-Aug-1999	Pinnacle Gas, Inc.; 2-15-97-F-98	NFWF	$11,090.60	$554.53	$0.00	$10,536.07	$94,190.22
20-Oct-1999	Koch Industries (Formerly Delhi); 2-15-96-F-290	NFWF	$5,520.00	$276.00	$0.00	$5,244.00	$99,434.22
11-May-2000	Northwestern Resources Co.; 2-15-97-F-396 (Jewett Mine)	NFWF	$12,144.00	$607.20	$0.00	$11,536.80	$110,971.02
19-Jul-2000	TXU; Limestone-Watermill Transmission Line	NFWF	$30,038.00	$1,501.90	$0.00	$28,536.10	$139,507.12
12-Mar-2001	T.A.C. Realty, Inc.; Miramont project	NFWF	$13,352.00	$667.60	$0.00	$12,684.40	$152,191.52
2-May-2001	Anadarko Petroleum Corp (Pinnacle Gas); 2-15-97-F-98	NFWF	$2,933.04	$146.65	$0.00	$2,786.39	$154,977.91
31-Oct-2001	Longhorn Partners Pipeline; 2-15-00-F-413	NFWF	$2,484.90	$124.25	$0.00	$2,360.66	$157,338.56
30-Jan-2002	XTO Energy, Inc.; 2-15-2001-F-557	NFWF	$2,794.00	$139.70	$0.00	$2,654.30	$159,992.86
10-Jul-2002	Northwestern Resources Co.; 2-15-97-F-396 (Jewett Mine)	NFWF	$6,641.25	$332.06	$0.00	$6,309.19	$166,302.05
9-Oct-2002	Longhorn Partners Pipeline; 2-15-00-F-413	NFWF	$2,484.90	$124.25	$0.00	$2,360.66	$168,662.71
9-May-2003	Northwestern Resources Co.; 2-15-97-F-396 (Jewett Mine)	NFWF	$41,366.50	$2,068.33	$0.00	$39,298.18	$207,960.88
26-Nov-2003	Longhorn Partners Pipeline; 2-15-00-F-413	NFWF	$2,484.90	$124.25	$0.00	$2,360.66	$210,321.54
18-Jun-2004	Northwestern Resources Co.; 2-15-2002-F-0214	NFWF	$1,265.00	$63.25	$0.00	$1,201.75	$211,523.29
30-Jul-2004	Anadarko Petroleum Corp (Pinnacle Gas); 2-15-97-F-98	NFWF	$10,309.20	$515.46	$0.00	$9,793.74	$221,317.03
9-Nov-2004	Longhorn Partners Pipeline; 2-15-00-F-413	NFWF	$2,484.90	$124.25	$0.00	$2,360.66	$223,677.68
31-Dec-2004	Interest accrued by date:	NFWF	$22,294.51	$0.00	$0.00	$22,294.51	$245,972.19
31-Dec-2005	Interest earned 2005	NFWF	$5,583.85	$0.00	$0.00	$5,583.85	$251,556.04
31-Dec-2006	Interest earned 2006	NFWF	$725.20	$0.00	$0.00	$725.20	$252,281.24
31-Dec-04	Bank Fee	NFWF	$0.00	$0.00	$420.28	-$420.28	$251,860.96
31-Dec-05	Bank Fee	NFWF	$0.00	$0.00	$295.72	-$295.72	$251,565.24
30-Sep-06	Administrative costs	NFWF	$0.00	$0.00	$50.76	-$50.76	*$251,514.48*
8-Nov-05	Transfer to LBJWC	LBJWC	*$251,749.42*	$12,587.47	$0.00	$239,161.95	$239,161.95
1-Sep-07	Accumulated interest (presumed)	LBJWC	$5,361.85	$0.00	$0.00	$5,361.85	$244,523.80
2-Nov-08	Expenditure: Dr. Fred Smeins, TAMU, Predictive GIS Modeling	LBJWC	-$5,000.00	$0.00	$0.00	-$5,000.00	$239,523.80

Note: The amount transferred to LBJWC is slightly greater than the final balance calculated here for the NFWF fund (numbers in italics). We believe this discrepancy of $234.94 is due to errors in the way accumulated interest was reported to us, probably due to the asynchrony between the federal fiscal year (Oct 1 - Sep 30) and the bank fiscal year (Jan 1 - Dec 31).

Section 6-funded grants. "The Cooperative Endangered Species Conservation Fund (section 6 of the ESA) provides grants to States and Territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to States and Territories for species and habitat conservation actions on non-Federal lands (USFWS 2009). USFWS has awarded two Section 6 grants in Texas that support *S. parksii* conservation. The first grant, in 1997, supported monitoring and management of endangered plants on highway rights-of-way in Texas (Poole and Janssen 1997).

The second Section 6-funded project was a genetic analysis using AFLP markers and microsatellite loci, with three major objectives: 1) define the breeding system and identify the pattern and distribution of genetic diversity in *S. parksii* populations; 2) grow *S. parksii* from seed to determine extent of sexual reproduction and develop protocols for future reintroductions; and 3) determine levels of gene flow between *Spiranthes parksii* and *S. cernua* (Walters 2005; Manhart and Pepper 2007). The results of this project are discussed in sections 2.3.1.3. and 2.3.1.4.

Other existing and proposed reserves. In 1981 the City of College Station acquired 1,265 ac of land along Sundew Creek, Brazos County, for future development as an industrial park. A 500-ac portion of this land was set aside as a natural park, now known as Lick Creek Park (Stephen Beachy *in. litt*. 1991). When a bicycle race was held at the park that passed through the *S. parksii* habitat, Dr. Hugh Wilson, who had investigated that population (Wilson 1988), recommended that the park board establish a formal advisory group to provide input to the board on the planning, development, maintenance, and protection of the site (Hugh Wilson, *in. litt*. 1991). The City of College Station adopted a master plan in 1998 for the park, which now officially contains 515.5 ac of land (City of College Station 2009). Reed (2009) provides a detailed description of the vegetation of the park.

TMPA continues to protect and manage five sites containing *S. parksii* populations at the now inactive GCLM. However, the long-term fate of these sites remains unresolved; when the Texas Railroad Commission issues the final bond release for GCLM, TMPA will have no further obligation to protect the sites. Some 10,692 ac of reclaimed mine and related areas may be sold and developed. In 2003, the Brazos Valley Council of Governments (BVCOG) adopted resolutions approving recommendations to develop a Regional Park Proposal to create a multi-use, nature-based park on TMPA lands in Grimes County (BVCOG 2003a and 2003b). BVCOG established an advisory board, which produced a vision study titled "Preserving Today for Tomorrow." The Grimes County Commission also approved the Regional Park concept (Grimes County 2004), and the Mayor of Navasota wrote a letter of support for this plan (Patricia Gruner 2004). The proposed Grimes County Regional Park has yet to materialize. If implemented, the long-term protection of the TMPA *S. parksii* sites may be very compatible with the management and purposes of the regional park. Alternatively, TMPA may be interested in retaining ownership of the land for its potential use as a Carbon sequestration site, which would also be compatible with conservation of *S. parksii* habitat (Jan Horbaczewski, pers. com. 2009).

Animate Habitat Home Owners Association (AHHOA) submitted a grant proposal to NFWF on September 30, 2004, to acquire and manage a 9-ac parcel of land with over 400 *S. parksii* plants inhabiting ideal habitat. This property, adjacent to Lick Creek Park, along Alum Creek, in Brazos County, is part of the Thousand Oaks development, owned by Animate Habitat, Ltd. The proposal requested $160,952 to acquire 8.16 ac of land, plus $28,047 for management and miscellaneous costs. AHHOA would donate an additional 0.84 ac of land to the project. However, the proposal was not approved.

Dr. Fred Smeins has provided information on numerous tracts of land containing *S. parksii* populations that might be acquired through the Navasota Ladies'-Tresses Conservation Fund (Fred Smeins, pers. com. 2003 and 2004). These include a number of sites near Lick Creek Park, Greens Prairie Road, Indian Lakes, Mentor's Spring, and Welburn Road.

Summary of accomplishments toward meeting the recovery criteria.

- A recovery team formed in 2003, and has met 11 times.
- 502.1 ac of habitat at 24 sites have been protected (see table 4); the total high count at these sites is 3,207 individual *S. parksii*.
- Seventeen formal Section 7 consultations have: 1) created 21 protected sites with 425.1 ac of habitat; 2) established 5 long-term monitoring and management plans; 3) raised $235,450 to support land acquisition and conservation (an additional amount of over $244,000 has not yet been collected); 4) supported research on the ecology, management, propagation, and (pending) genetics of the species; and 5) minimized impacts to the species from a variety of development projects.
- Cooperative agreements have: 1) raised $30,000 for population and habitat research; 2) created a Navasota Ladies'-Tresses Conservation Fund, now managed by LBJWC, to support land acquisition and conservation; and 3) produced a habitat assessment GIS using remote sensing.
- Section 6 grants have generated an inventory and monitoring of State Highway ROWs, and supported a genetic analysis to determine the breeding system, genetic diversity, extent of sexual reproduction, and degree of gene flow between *Spiranthes parksii* and *S. cernua*.

Therefore, the recovery criteria, as written in the original recovery plan, have been met and exceeded. Nevertheless, the recovery team has determined that the objectives of the existing plan are insufficient to recover the species. This plan does not meet the revised guidance (NMFS 2007), and should be re-written.

Despite this uncertainty, it is clear that significant progress has been made to recover Navasota ladies'-tresses in the 27 years since the species was listed.

Table 4. Summary of Navasota ladies'-tresses protected reserves.

Owner	**Ownership**	**County**	**Site Name**	**Acres[1]**	**Highest *S. parksii* Count**
BVSWMA	Fee title	Grimes	1 – 12	140.5	774
BVSWMA	Fee title	Grimes	C3 (private)[3]	22.5	200
City of College Station	Fee title	Brazos	Lick Creek Park	75.0[4]	70
Smiling Mallard Development, Ltd.	Permanent Deed Restriction	Brazos	Indian Lakes	32.0	200
TMPA	Fee Title	Grimes	C1	21.1	216
TMPA	Fee title[2]	Grimes	C2	47.0	229
TMPA	Fee title	Grimes	C3	16.5	130
TMPA	Leased	Grimes	C4	81.2	227
TMPA	Fee title	Grimes	C5	18.3	33
TxDOT	Conservation Easement	Brazos	SH 40 Preserve	38.0	117
TxDOT	Fee title	Brazos	SH 6 Preserve	8.0	1000
U.S. Forest Service	Fee title	Jasper	Angelina National Forest	1.0	10
University of Texas	Fee title	Bastrop	Stengl Lost Pines	1.0	1
TOTAL:			**24 sites**	**502.1**	**3207**

1. Acreage Source of TMPA sites is TMPA 2009.
2. Site includes 4-ac cemetery owned by Grimes County.
3. Part of the original C3 site.
4. Estimated population area of 515.5-ac park (Thomas 2005).

2.3 Updated Information and Current Species Status

Note: The glossary on page 64-65 defines many of the technical terms in sections 2.3.1 and 2.3.2.

2.3.1 Biology and Habitat

2.3.1.1 New information on the species' biology and life history:

More than 240 SPIPAR surveys have been reported to the TPWD NDD (discussed in 2.3.1.2) since the species was listed in 1982. Populations at Gibbons Creek Lignite Mine (Grimes County), TxDOT's SH 6 and SH 40 reserves (Brazos County), Lick Creek Park (Brazos County), and the BVSWMA landfill (Grimes County) have been surveyed multiple times in multiple years. From these combined experiences, it is abundantly clear that *S. parksii*, though perennial, is an ephemeral species. The appearance of observable portions of the plant, that is, the sterile leaf rosettes and flowering stalks, fluctuates widely from year to year. The perennial tubers develop leaf rosettes that are most often observed from January to June, although rosettes have been observed in every month of the year (Hammon et. al. 2009). In any given year, some proportion of tubers produce rosettes, while others remain dormant. Leaf rosettes usually senesce during the hot, dry summer months; however, rosettes were observed as late as September in 2007, when summer rainfall was unusually frequent. Flowering occurs mostly from October 15 to November 7, when the basal rosette of leaves is no longer present; flower stalks have been observed as early as mid-September, or as late as early December (Fred Smeins, pers. com. 2009). Hammons et al. (2009) report preliminary analyses indicating that rainfall during the month of August (versus other time frames) has the greatest correlation with the numbers of flowering *S. parksii* plants at their study sites. In most years, only a small percentage of the total population flowers.

Spiranthes parksii and *S. cernua* are similar in general appearance. The latter species is often present in habitat of the former (though the inverse is not true). The ability to distinguish these closely-related species on the basis of their leaf morphology has been the holy grail long sought by ladies'-tresses surveyors, but no reliable method has been documented to date. The distinguishing features are based on floral morphology, when rosettes are no longer present. For these reasons, it has been impossible to determine total population sizes. For any given site, the highest count of positively-identified *S. parksii*, during a series of annual fall surveys, is assumed to represent the total population size. Nevertheless, it is unlikely that 100 percent of the viable plants flower even in ideal years. Hammon et al. (2009) have determined that individual plants that flower have a low probability of flowering again during the following year. Therefore, the total size of populations is likely to be greater than their "high counts"; how much greater we cannot say.

The Orchidaceae is one of the largest and most diverse plant families, with at least 20,000 species. The minute, dust-like seeds of orchids contain only a tiny embryo without endosperm, and so contain no stored energy reserves. Although many orchids may be grown in synthetic media without fungal associations, all orchid species, in order to establish in the wild, must be infected by specific soil fungi soon after germination (University of Wisconsin 2002). During this mycoparasitic phase, the orchid obtains energy and minerals from the fungus, which acquires these nutrients through saprophytic decomposition of organic matter, parasitic infection of other plants, or ectomycorrhizal association with other plants. The germinated seed and fungal symbiont form a non-photosynthetic protocorm, which may persist for years before finally generating a shoot with roots and photosynthetic leaves that develops into a mature plant. The plant may terminate or continue its association with this fungus, or form mycorrhizal associations with one or more other fungal species. Therefore, the ecology of orchids is intricately intertwined with their mycorrhizae. The mycorrhizae of *Spiranthes parksii* and *S. cernua* have not been reported, but are currently being investigated by Dr. Fred Smeins' research group at TAMU, with support from BVSWMA (Fred Smeins, pers. comm. 2009).

Spiranthes parksii flowers are visited by bumblebees and other insects, but produce polyembryonic seeds even when the flowers have not been pollinated (Catling and McIntosh 1979). Charles Sheviak (*in. litt*. 1986) reported that all polyploid species within the *Spiranthes cernua* complex (including *S. parksii*) are facultatively agamospermic, through adventitious embryony; but the rare occurrence of apparent hybrids between *S. parksii* and *S. cernua* indicate that *parksii* is capable of sexual reproduction. The genetic analyses of Walters (2005), Manhart and Pepper (2007), and Dueck and Cameron (2008), discussed in 2.3.1.3., confirm that agamospermy, with rare instances of sexual reproduction, is the predominant means of reproduction in the species. Therefore, the millions of tiny seeds produced by *S. parksii* plants are almost always clones of the parent plant. This has important implications for the management of populations and calculations of minimum viable population size; a clonal population may have hundreds of individual plants, but the effective genetic population size is one individual.

From 1986 – 1995, a total of 526 *S. parksii* plants were removed from portions of the Gibbons Creek Lignite Mine prior to surface mining. Most of the salvaged plants were transplanted into protected site C2, while others were transplanted at two sites in Somerville Lake State Park (Tejas Ecological Surveys 2001). The sites were monitored annually at least until 1999 and occasionally since then. The transplants have met a range of fates, none of them good, including feral hog and armadillo rooting, inundation, deer and rabbit browsing, or gradual decline in flowering and rosette production. However, these transplanted individuals may simply be dormant. The "wild" population at the same site had increased more than 300 percent by 2001; at least some portion of this increase could be progeny of the transplanted individuals. Additionally, 50 seedlings were transplanted into site C2 that had been propagated from seed at Marie Selby Gardens and Atlanta Botanical Gardens (in cooperation with San Antonio Botanical Gardens). The relatively rapid demise of these propagated individuals is attributed to insufficient "hardening off" (adaptation of nursery-grown plants to ambient field conditions). Dr. Fred Smeins' research group at TAMU is currently conducting trails with bare-root and intact-soil transplants of individuals salvaged from the BVSWMA landfill site (Hammons et al. 2009). This team has also successfully germinated SPIPAR seeds in sterile culture, and is currently initiating studies on mycorrhizae (Fred Smeins, pers. com. 2009).

2.3.1.2 Abundance, population trends (e.g. increasing, decreasing, stable), demographic features (e.g., age structure, sex ratio, family size, birth rate, age at mortality, mortality rate, etc.), or demographic trends:

TPWD manages the State's Natural Diversity Database (NDD), which compiles data on tracked plant and animal species that is submitted by a vast consortium of Federal, State, academic, NGO and private researchers, and consultants. The NDD tracks 232 rare, threatened, and endangered plant species in Texas, including all 33 federally-listed endangered (24), threatened (6), and candidate (3) plant species. The geographic, population, and other relevant data for each species are tracked as Element Occurrences. "An Element Occurrence (EO) is an area of land and/or water in which a species or natural community is, or was, present." (NatureServe 2002). Element Occurrences may consist of one or many "sites" as reported by surveyors. In the GIS component of the NDD, EOs are displayed as points and polygons buffered by their estimated geographic precision. For this reason, historic reports that do not contain precise geographic coordinates are shown as relatively large polygons, while more recent survey data collected with GPS instruments are represented by smaller polygons. Therefore, it must be understood that the tracked species occur within but not necessary throughout the polygons displayed in the GIS. The NDD is an essential tool for the long-term conservation and management of species at risk. USFWS makes frequent use of the NDD in listing actions, for planning and tracking recovery of listed species, and to streamline Section 7 consultations.

Figures 10 and 11 display the global range and core populations of Navasota ladies'-tresses, respectively. Previously, the NDD recorded 141 EOs for the species. Currently, TPWD is revising its EOs to conform to the standard published by NatureServe (2002); the revisions relate specifically to the separation distances between EOs. Consequently, many of the 141 EOs for Navasota ladies'-tresses have been recombined into a smaller number of geographically-larger EOs. However, this revision of EOs for this species is not yet complete. The summary below is our analysis of the most recent update of the NDD, which was provided to USFWS in April 2009. While the re-grouping of data into EOs may continue to change in subsequent updates, the total populations they represent will remain the same. We understand that survey data from recent years may not yet be included in this update.

Table 5. Summary of NDD Element Occurrences for Navasota ladies'-tresses.

Total Number of EOs recorded	64
Number of surveys reported 1945 – 2008	241
Total *S. parksii* individuals observed	11,537
Total of all "high counts"	3,651
Average "high count" per EO	48
Maximum *S. parksii* observed in one year (1983)	1,880
Number of EOs destroyed	3
Number of *S. parksii* individuals lost	510
Potential surviving population	3,141
Number of EOs surveyed last 5 years	10
Extant EOs observed last 5 years	10
Individual *S. parksii* observed last 5 years	1,043
EOs surveyed last 10 years	16
Extant EOs observed last 10 years	16
Individual *S. parksii* observed last 10 years	1,856
EOs surveyed last 20 years	37
Extant EOs observed last 20 years	38
Individual *S. parksii* observed last 20 years	6,921

The total of 11,537 *S. parksii* individuals observed includes plants counted multiple times at EOs surveyed more than once. The total "high count" of 3,651 for all EOs represents the total population size. From this number, 510 individuals have been lost in three large EOs, leaving a potential surviving known population of 3,141. As discussed in Section 2.3.1.1, the actual population sizes, as well as the number of individuals lost, must be greater – to some unknown degree – than the "high counts" for each EO. It is interesting to note that the potential population of the 24 protected sites is 3,207; this figure includes some recent surveys that probably were not included in the April, 2009, update of the NDD. Nevertheless, it is safe to say that a large proportion of the surviving known population occurs on the protected sites. It should be noted that the number of EOs surveyed in the last 5 years must be greater than 10, as the most recent surveys reported to the NDD were probably not included in this update.

Dr. Norma Fowler (University of Texas – Austin) has described methods to determine the minimum viable population size and minimum numbers of populations necessary to ensure that *S. parksii* does not become extinct (Fowler 2005). The calculations of minimum viable population depend on good demographic data, which has been difficult to obtain, due to the ephemeral nature of the species. In a sample calculation based on typical values, if the annual rate of population loss is 6.7 percent, 4,731 initial populations are needed to ensure that at least one population survives 100 years. The importance of this exercise is to emphasize that continued survival of the species may depend on our ability to propagate and reintroduce populations lost to catastrophic events.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation (e.g., loss of genetic variation, genetic drift, inbreeding, etc.):

Wilson and Walters (1982) investigated the taxonomic relationship of *Spiranthes parksii* with its closest relatives through isozyme electrophoresis of floral tissue. They found that *S. parksii* was phenotypically distinct from *S. lacera* var. *gracilis* and a grassland form of *S. cernua*. A sympatric woodland form of *S. cernua* was electrophoretically identical to *S. parksii*.

Charles Sheviak (*in. litt*. 1986) analyzed the cytology of the *Spiranthes cernua* complex. He found that *S. cernua* is a tetraploid (2n = 60) compilospecies that "acquires genes from related diploids and then utilizes these genes adaptively under conditions that would otherwise be unsuitable for it." The species is highly variable morphologically; individual populations consist of a variety of forms. He found evidence of gene flow between *S. cernua* and *S. magnicamporum* in the southern prairies. Sheviak reported that *S. parksii* is also tetraploid (2n = 60), polyembrionic, and facultatively agamospermic. Meiosis is regular, usually bivalent, and sometimes quadrivalent; the species may be capable of sexual reproduction.

A Section 6 grant (contract no. 147331) supported a genetic analysis of *Spiranthes parksii* and its close relatives. This work became the Master's Thesis of Catherine Walters (2005), working under the direction of Dr. James Manhart at TAMU; Manhart and Pepper (2007) submitted the final project report to USFWS. These authors examined chloroplast sequence DNA, 4 AFLPs (amplified fragment length polymorphisms), and 7 microsatellite loci of *S. parksii*, the open-flower (of) and closed-flower (cf) forms of *S. cernua* from Texas, *S. cernua* from the eastern U.S., *S. magnicamporum* and *S. vernalis*. *Spiranthes cernua* (of), also known as the woodland form, is sympatric with *S. parksii*. *Spiranthes cernua* (cf), known as the southern prairie form, was predicted to reproduce through agamospermy, since the flowers do not normally open (so are not fertilized by pollinators). *Spiranthes vernalis*, though not closely related, was chosen because it is believed to be an obligate outcrosser. *Spiranthes magnicamporum* is a diploid species related to *S. cernua*. Their samples included 216 *S. cernua* individuals and 318 *S. parksii* individuals collected from 12 populations in Grimes, Brazos, Limestone, and Bastrop counties. The TAMU team found no variation in chloroplast sequence DNA between *S. parksii* and *S. cernua*, which they attribute to lower mutation rates in chloroplasts. Both the AFLPs and microsatellites revealed that *S. cernua* (cf) segregated from *S. cernua* (of) and *S. parksii*, but the latter two could not be distinguished. Eastern *S. cernua* also separated from Texas *S. cernua* and *S. parksii*. Three individual *S. parksii* from Limestone County had one unique microsatellite allele. Surprisingly, they found greater genetic variation in *S. cernua* (cf), indicating that sexual reproduction does occur in this population; the authors note that this "closed form" does indeed open some of its flowers. The limited genetic variation of both *S. cernua* (of) and *S. parksii* are probably due to a high level of asexual reproduction. Fixed heterozygotes at several loci support the hypothesis of apomixis, rather than allopolyploidy or inbreeding. The authors conclude that *S. cernua* (of) and *S. parksii* recently diverged from a common ancestor within the *cernua* complex. Both have a predominantly asexual mode of reproduction, with rare occasions of sexual reproduction. They reject the founder hypothesis for *S. parksii*, because both *parksii* and *cernua* (of) lack genetic diversity. They neither confirm nor reject the hypothesis that *S. parksii* and *S. cernua* are not genetically differentiated, or that the morphological differences could be due to environment or development factors.

Dueck and Cameron (2007) did not detect genetic differentiation between *S. parksii* and *S. cernua* in an analysis of the North American species of *Spiranthes*. Subsequently (Dueck and Cameron 2008), they used parsimony analysis of 4 DNA sequences from 61 samples of 10 *Spiranthes* taxa, including 11 each of *S. parksii*, Texas *S. cernua* (of) and Texas *S. cernua* (cf). These consisted of 2 chloroplast, 1 mitochondrial, and 1 nuclear ribosomal sequences, totaling 3,191 base pairs. The other species investigated were *S. lacera* var. *gracilis*, *S. longilabris*, *S. magnicamporum*, *S. odorata*, *S. praecox*, *S. vernalis*, *S. sylvatica* and *Sacoila lanceolata* var. *lanceolata* (an out-group used to root the phylogenetic analysis). They found no nucleotide differences among all *S. parksii* and *S. cernua* (of), and one base pair insertion in a chloroplast sequence of *S. cernua* (cf). The authors state, "…despite the fact that we have employed some of the most rapidly evolving DNA loci used routinely by plant systematists, we could find no genetic differences between *S. parksii* and the majority of *S. cernua* individuals in our study. Specifically, sequences from all individuals of *S. parksii* sampled were found to be identical to those obtained from the open-flowered phenotype of *S. cernua* from Texas."

2.3.1.4 Taxonomic classification or changes in nomenclature:

Spiranthes parksii was described as a new species by Correll (1947). The Flora of North America treatment (Sheviak and Brown 2002) continues to recognize the species, on this basis:

> "The tetraploid chromosome number and apomictic development of polyembryonic seeds indicate that *Spiranthes parksii* is a member of the *S. cernua* complex. The broad petals with central green stripe, several veins (instead of the three typical of the group), and erose-emarginate apical margin furthermore evidently represent partial peloria. Peloria is common in *S. cernua*, especially in the prairies, although in most cases it involves the suppression of the lip rather than the elaboration of the petals to a condition approximating the lip, as is the case in *S. parksii*. With a very limited distribution in east-central Texas, *S. parksii* might therefore represent merely a local, minor form of *S. cernua*. Other characteristics, however, including the small flower size and often upturned lateral sepal apices, lie outside the

> normal range of variation in *S. cernua* and suggest that the plants represent a distinct species."

Charles Sheviak has frequently communicated with members of the recovery team, USFWS personnel, and others concerned with the systematics of the genus. In a recent communication with Linda Langlitz (Charles Sheviak, *in. litt*. 2008), he states:

> "My thinking in including it as a species in my FNA treatment was this: The plant exhibits characteristics that are outside the range seen elsewhere in *S. cernua*…What is unusual is the disproportionately short dorsal sepal. That, combined with the open spiral, small size, and, finally peloria, is indeed a unique combination that lies well outside the range of variation of *S. cernua*, however great…
>
> "…The one thing that has most strongly influenced my thinking on the matter is the status of *S. casei*. This species is in many respects entirely analogous to *S. parksii*: It is a facultative apomict clearly derived from *S. cernua*, but with smaller, peculiarly curved flowers with short dorsal sepals and disposed in an open spiral. This species, however, clearly demonstrates species status with an extensive geographic range that reflects post-Pleistocene migration. It furthermore has even developed a local variety in response to extreme conditions in one part of its range. It clearly is functioning in isolation from *S. cernua*, despite a nearly complete overlap in range. I don't think there is much doubt that it is most appropriately treated as a distinct species.
>
> "What is the difference, then, between *S. parksii* and *S. casei*? As near as I can tell, the status of these two entities is analogous, and *S. parksii* differs from *S. casei* only in having a much more restricted range without the clear migrational pattern. Perhaps it is merely younger. At what point, then does a novel population become a distinct species? I haven't got a clue.

With regard to the absence of genetic variation in the AFLP markers and microsatellite loci examined, Manhart and Pepper (2007) assert:

> "It should be clearly stated that in our studies, we found no positive evidence to conclude that *S. parksii* should be combined with *S. cernua*, or reclassified in any way. However, it was surprising that we did not observe differences in the molecular genetic markers between *S. parksii* and *S. cernua*, given their clear morphological and habitat preference differences. It should be pointed out that microsatellite markers are generally considered to be neutral markers and represent only a tiny fraction of the whole genome…most, if not all of these

> differences undoubtedly have a genetic basis. Further, there is clear ecological and habitat differentiation, or more specifically habitat specialization in the case of *S. parksii*, which also undoubtedly has a genetic basis. Unfortunately, locating and characterizing the responsible genes is not possible using currently affordable technologies, particularly given the breeding system of *S. parksii*."

Dueck and Cameron (2008), however, disagree:

> "Our DNA sequence data and phylogenetic analyses demonstrate that *S. parksii* does not deserve species status, but rather represents one of several local phenotypes of the widespread, polyploid, and highly variable *S. cernua*. There is no evidence to suggest that it represents an interspecific hybrid. Based on the phylogenetic species concept, we feel it best to treat *S. parksii* as a synonym of *S. cernua sensu lato*.
>
> "Evidence other than molecular also justifies synonymy of these taxa. For example, the two taxa are sympatric and share a suite of characteristics including apomixis, polyembryony, the same chromosome number, identical vegetative morphology, and a common phenology. Furthermore, *Spiranthes parksii* probably represents a peloric mutant phenotype of *S. cernua* as suggested by Sheviak and Brown (2002). Their flowers are mostly unopen with a nearly actinomorphic perianth, and the lateral petals are unusual in their morphology—they are obovate in outline, with erose margins, a central green stripe, and exhibit multiple veins instead of the three typical of *Spiranthes*.

Nevertheless, members of the recovery team have expressed unanimous dissent with Dueck and Cameron's conclusions. In a letter to USFWS from the recovery team (*Spiranthes parksii* Recovery Team 2009), they state, "We have discussed the evidence relevant to the species status of *Spiranthes parksii*, and read the document prepared by Dr. Alan Pepper (*in litt*. 2009). We concur with the conclusions and recommendations presented by Alan Pepper. We disagree with the conclusions of Lucy Dueck. At this time there is insufficient evidence to conclude that *Spiranthes parksii* is not a valid species, and indeed quite a bit of evidence to the contrary." Several team members, as well as an outside reviewer, submitted written rebuttals, which are included as an attachment to this review (Langlitz *in litt*. 2008, Clary *in litt*. 2008, Pepper *in litt*. 2009 and Robertson *in litt*. 2008). In synthesis, some of the main arguments of these rebuttals are as follows:

- "The phylogenetic topographies presented by Dueck and Cameron (2008) are, simply stated, poorly resolved, and are based on an extremely limited number of variable nucleotide sites within the focal taxa (*S. parksii* and *S. cernua*). Each of the consensus gene trees presented represents from several hundred to more than 10,000 equally parsimonious trees. Even the strict consensus trees for each gene have large topological segments with only marginal statistical support…Using poorly resolved trees, based on a limited number of informative nucleotide characters, to lump species together is untenable… For example, in our study of the molecular phylogeny of the Streptanthoid complex (Brassicaceae) using the *trn*L chloroplast sequence, we saw no variation among six highly ecologically divergent and morphologically distinct species, in three genera (*Streptanthus*, *Caulanthus*, *Guillenia*), spread across western North American (Pepper and Norwood, 2001). However, if we had relied solely on these DNA sequences, and used the phylogenetic species concept as applied by Dueck and Cameron (2008), we would have been compelled to lump these together into a single species with infraspecific entities. Recent sequencing has expanded the clade that is lacking any *trnL* sequence variation to nearly 30 distinct species in the Streptanthoid complex, including some that, based on independent evidence, diverged as long as 5-6 million years ago (Burrell and Pepper, in preparation)…It is one of the basic tenants of western science that "absence of evidence is not evidence of absence." (Pepper, *in litt*. 2008).

- "Parsimony analysis was utilized by Dueck and Cameron to infer phylogenetic reconstruction of *S. parksii* as compared to other *Spiranthes* species. A cursory literature review of recent studies indicates dissatisfaction on the part of some researchers with the accuracy of the phylogenetic reconstruction method maximum parsimony (MP). The method minimizes the number of convergences inferred in a parsimony tree. Of late, researchers are doing MP analysis in conjunction with other methods such as the Bayesian…Hartmann and Vision (2009) compared three phylogenetic reconstruction methods, Neighbor Joining, Maximum Parsimony and Maximum Likelihood, using partial gene sequences derived from expressed sequence tags. Their objective was to discern the accuracy with which each method (Langlitz *in litt*. 2008).
- "My understanding of the article and data at hand comes from phylogenetic work that I did on my doctoral dissertation on yuccas (University of Texas, Austin, 1997). I used the same ITS marker that the authors used in their investigation of nrDNA, ITS 1 & 2 and the 5.8 S region in 50 species of *Yucca*…I do not see how the data can support the authors' conclusion… The molecular data presented in the article are simply not sufficient enough in their scope, breadth, or rigor to support that conclusion.…The ITS marker is useful in delineating the branching pattern of species in a phylogenetic framework. However, this analysis is limited in its scope because of the low resolution at the tips of the phylogenetic tree… The inability of the DNA methods to find genetic differences between *S. parksii* and *S. cernua* is not evidence that they are not different species, especially if *S. parksii* is young…Based on the data at hand, *S. cernua* is polyphyletic and not a good species…The morphological differences between *S. parksii* and *S. cernua* are obvious as well as the recognized ecological niche that *S. parksii* occupies relative to *S. cernua*…the DNA data do not fail to support a hypothesis that *S.*

parksii is on its own evolutionary path separate from any other species. DNA markers with low resolution at this evolutionary level have a low probability of capturing such events…" (Clary *in litt*. 2008).

- "At this point in time, our best evidence on the species status of *S. parksii* comes from the morphological species or 'morphospecies' concept (which is the only species concept used for the overwhelming majority of organisms on the planet) and from the ecological species concept…in east-central Texas, *S. cernua* is extremely common and has a remarkably wide range of habitats, including a variety of woodlands, pastures, and disturbed areas… In stark contrast, *S. parksii* is a rare endemic that shows a high fidelity to sandy loam soils perched over low-permeability clay, at the margins of the upper reaches of shallow drainages, in openings in the Post Oak Savanna community. Recent quantitative studies by Edith Bai and Fred Smeins at Texas A&M University (Bai and Fred Smeins, unpublished) have shown a remarkably high fidelity of *S. parksii* for soils of the Burlewash soil series, occurring on the Manning and Wellborn geological formations. This level of geological restriction qualifies *S. parksii* as a geological or edaphic specialist (Kruckeberg 2004)…" (Pepper *in litt*. 2009).
- "Sample size too small to detect rare mutations: only 11 *S. parksii* and 17 *S. cernua* were used, at most. Of the 17 *S. cernua*, only 11 were from Texas and only 5 were closed form. For the ITS analysis, the most informative of the 4 loci examined, 3 *S. cernua* (one of which was a closed form) and 4 *S. parksii* failed to sequence. Thus, the results of the study are based on 10 Texas *S. cernua* samples (2 closed and 8 open) and 7 *S. parksii* samples. This sample size is more appropriate for a pilot study rather than basis for making policy/conservation decisions." (Roberston *in litt*. 2008).
- MtDNA NAD7 gene sequences were completely uninformative, but the trees were included in the combined analysis. This would dilute any signal that may have been present. This is particularly notable since the paper claims to analyze 3,191 bp, but the mtDNA NAD7 accounted for nearly 1/3 of all bases (1,012 bp) (Robertson *in litt*. 2008)."

Dueck and Cameron have not had the opportunity to respond to these reviews of their work on *Spiranthes*. However, Lucy Dueck *(in litt*. 2009) suggested a compelling recommendation for future investigations which might help resolve the taxonomic status of *S. parksii*:

> "Although it was beyond the scope of our paper, my literature search suggested that differential gene expression may be responsible for initiating the separate floral phenotype of *Spiranthes parksii*. Many factors can alter gene expression, including polyploidy, epigenetic mechanisms, and even infection by different symbionts. Dust-sized orchid seeds are dependent upon mycorrhizal fungi to survive after germination in nature. One orchid study (Watkinson 2002) found that some genes were differentially regulated in the presence or absence of a specific fungus. Separate studies on two orchid species found that

> distinct floral variants growing sympatrically were infected by different fungi (Taylor & Bruns 1999, Taylor et al. 2003). Their morphological differences could be attributed either to plant specificity for a particular fungus, or perhaps to gene expression changes generating different phenotypes by different fungi. Further studies have opened new doors on gene expression involving helper bacteria in multitrophic complexes (reviewed in Frey-Klett & Garbaye 2005).
>
> "An exploration of reasons for phenotypic differences between the *parksii* form and the open-flower form of *Spiranthes cernua* may wish to investigate differential gene expression, particularly whether different phenotypes are (or were) infected by and induced by different mycobionts.

In summary, it should be emphasized that USFWS listed *Spiranthes parksii* in 1982 on the basis of the best scientific information available at that time. More recent advances in genetic analyses have added a new realm of data on the systematics of the taxonomically difficult *Spiranthes* genus. Nevertheless, it is clear from the preceding discussion that the leading scientific authorities on this group do not all agree on the meaning of this data. Considering the obligate nature of orchid mycorrhizae, if the morphological characters that define *S. parksii* are shown to be induced by different mycorrhizal symbionts, as Dueck hypothesizes, this edaphic endemic entity would be analagous to lichen species, which are composite organisms composed of specific fungus and alga or cyanobacteria species living symbiotically in a single thallus. Currently, two lichen species, the Florida perforate cladonia (*Cladonia perforata*) and the rock gnome lichen (*Gymnoderma lineara*) are federally listed as endangered in the U.S. As Charles Sheviak himself stated (*in litt*. 2008), "You ask if *Spiranthes parksii* is a distinct species. That's somewhat akin to asking the meaning of life. There probably isn't a definitive answer."

Figure 9. Comparison of *Spiranthes* species.

Spiranthes lacera **(Raf.) Raf. var. *gracilis* (Bigelow) Luer**

Spiranthes cernua (L.) Rich.

Spiranthes parksii **Correll**

2.3.1.5 Spatial distribution, trends in spatial distribution (e.g. increasingly fragmented, increased numbers of corridors, etc.), or historic range (e.g. corrections to the historical range, change in distribution of the species' within its historic range, etc.):

When Navasota ladies'-tresses was listed in 1982, it was known only from Brazos County. It has now been confirmed in 13 Texas counties (see figure 10). This includes one apparently disjunct population at Angelina National Forest, in Jasper County, 114 miles east of the nearest population in Madison County. The known range of the species extends 210 miles east to west and 110 miles north to south.

While the known range of *S. parksii* is larger than once thought, and more Element Occurrences have been found within this range, the rapid pace of urban and residential development continues to destroy and fragment this orchid's potential habitat. The most rapid development is occurring in Brazos and Grimes counties, precisely where the greatest density of *S. parksii* Element Occurrences have been found. Diamond and True (2000) analyzed satellite images to determine that forest and woodland covered 28 percent of the land area within the post oak savanna region. They found that there had been a 5.8 percent loss of forest canopy within the post oak savanna from 1987 – 1997. They also documented an increase in urban land within the areas of highest *S. parksii* density.

However, the high density of known *S. parksii* EOs in the vicinity of Bryan and College Station may simply be due to the disproportionate number of surveys that have been conducted there. Most of the surveys for this species resulted from Section 7 consultations with USFWS over development projects. Hence, more development engendered more surveys that found more *S. parksii*. James Thomas (pers. comm. 2009) of HDR, Inc., a private consultant firm, stated that the pace of new *S. parksii* discoveries continues unabated.

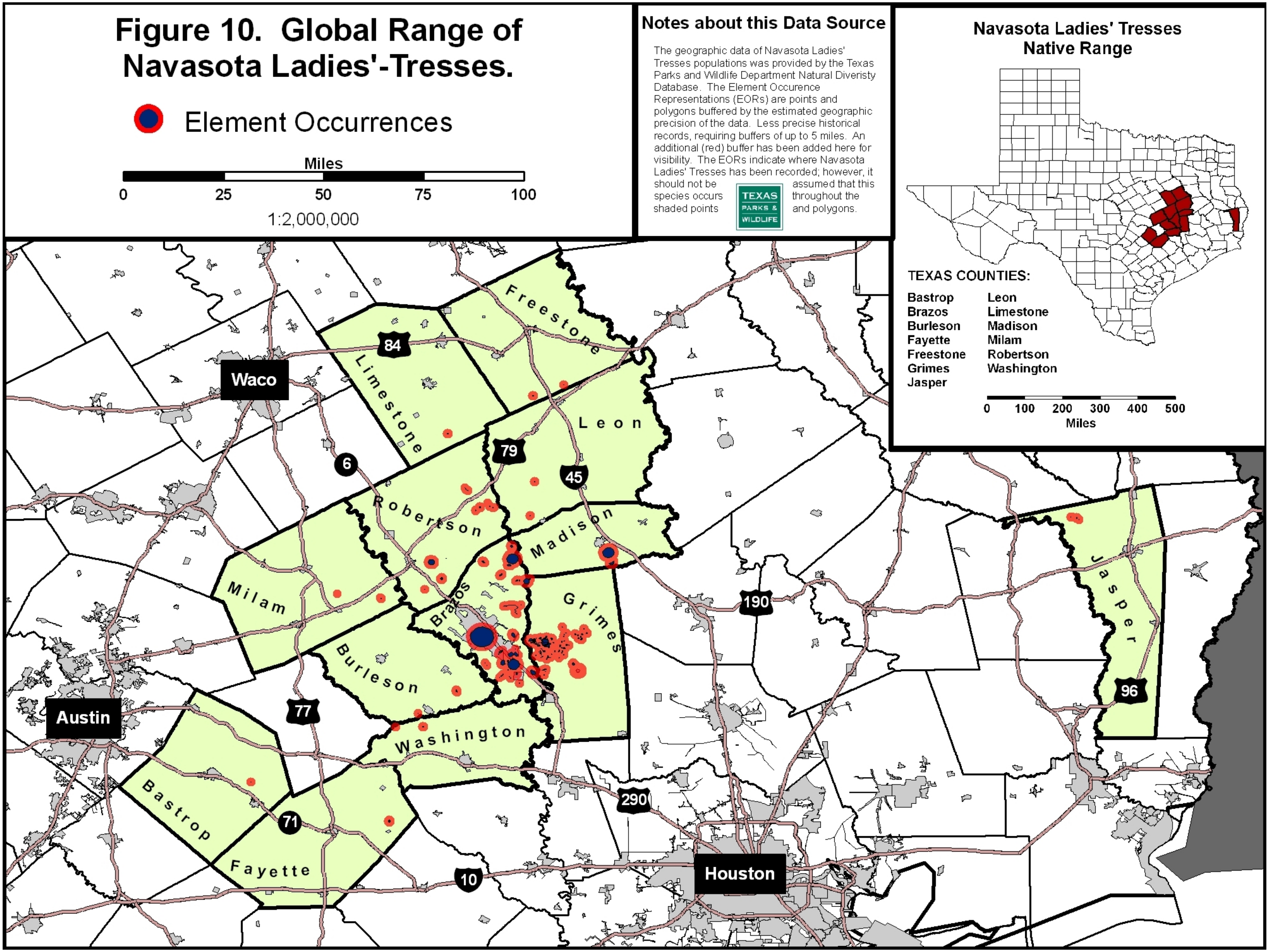


Figure 10. Global Range of Navasota Ladies'-Tresses.

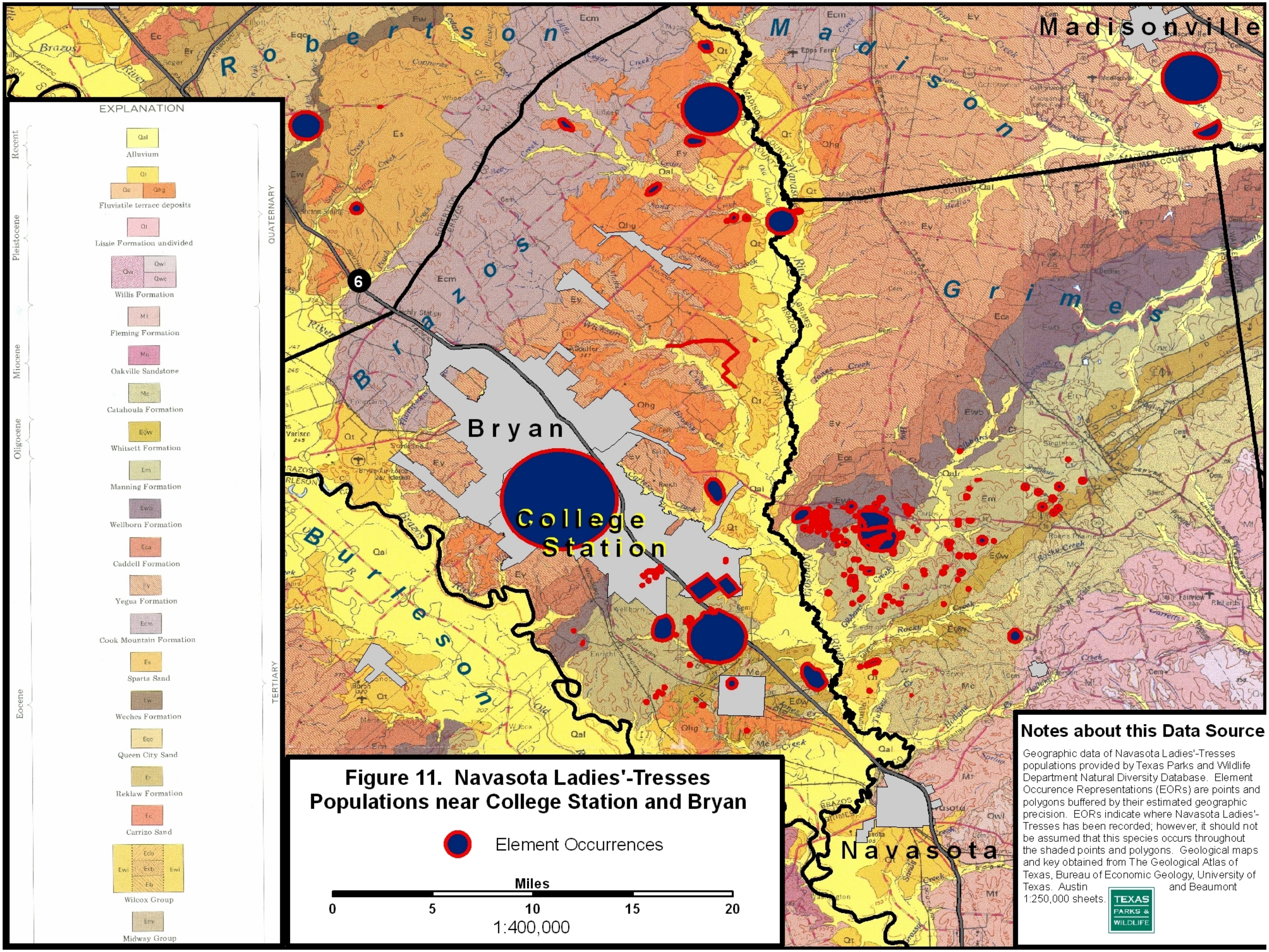


Figure 11. Navasota Ladies'-Tresses Populations near College Station and Bryan

Notes about this Data Source

Geographic data of Navasota Ladies'-Tresses populations provided by Texas Parks and Wildlife Department Natural Diversity Database. Element Occurence Representations (EORs) are points and polygons buffered by their estimated geographic precision. EORs indicate where Navasota Ladies'-Tresses has been recorded; however, it should not be assumed that this species occurs throughout the shaded points and polygons. Geological maps and key obtained from The Geological Atlas of Texas, Bureau of Economic Geology, University of Texas. Austin and Beaumont 1:250,000 sheets.

2.3.1.6 Habitat or ecosystem conditions (e.g., amount, distribution, and suitability of the habitat or ecosystem):

Wilson (1988, 2009), Tejas Ecological Surveys (2001), Poole et al. (2007), and Hammons et al. (2009) describe the habitat of Navasota ladies'-tresses. This terrestrial orchid is found in sandy soil in the post oak savanna of central-east Texas, often along the naturally eroded slopes of the upper reaches of drainages and ephemeral streams, or occasionally near the margins of seeps and swales. Post oak savanna, which extends in a narrow band from northeast Texas to southeast of San Antonio, forms an ecotone along the western fringe of the more mesic eastern deciduous forest and the blackland prairies to the west (Gould 1975, Poole et. al. 2007). Within the post oak savanna, *S. parksii* typically occurs in a specific topographic position where permeable fine sand or sandy loam shallowly overlies less permeable clay. Along these narrow contours of shallow topsoil, where there may be less competition from more robust herbaceous and woody plants, available moisture may be sustained by seepage along the upper surface of the clay stratum. Micro-habitats occupied by *S. parksii* are often described as seeps; the common association with other wet-soil plants, such as sundews (*Drosera spp.*) and grass-pink (*Calopogon tuberosus*), lend credence to this hypothesis. Dr. Fred Smeins, Dr. Bill Rogers, and Dr. Edith Bai at TAMU are currently developing a predictive model for *S. parksii* distribution, using a GIS based on precise locations of known populations, geological formations, soil types, hydrology, topography, and vegetation. Although the authors have not completed or published their investigation, they have provided some preliminary results to the recovery team (Bai 2008). When complete, this model will be extremely useful for conservation, management, and recovery of the species, and will streamline the Section 7 consultation process. This research is being supported primarily by BVSWMA, as well as the Navasota Ladies'-Tresses Conservation Fund.

Spiranthes parksii plants are most often found under canopy gaps, where both the woody and herbaceous vegetation are less dense than in surrounding areas. Herbaceous plants often associated with *S. parksii* include little bluestem (*Schizachyrium scoparium*), split-beard bluestem (*Andropogon ternarius*), broomsedge bluestem (*Andropogon virginicus*), gay-feather (*Liatris elegans*), nodding ladies'-tresses (*Spiranthes cernua*), and Sundews. Trees and shrubs include post oak (*Quercus stellata*), black jack oak (*Q. marilandica*), yaupon (*Ilex vomitoria*), farkleberry (*Vaccinium arboreum*), and American beauty berry (*Callicarpa americana*) (see Table 6). Known *S. parksii* populations tend to decline when the herbaceous understory is replaced by shrubs and trees, as process commonly called "thicketization" (Tejas 2001). This increased density of woody plants has been attributed to decreased fire frequency and poor range-land management. Pre-settlement fire frequency in the post oak savanna may have occurred at a rate of once per 1 to 6 years (Frost 1998, quoted in Hammon et. al. 2009), far more often than during recent decades. Hammon et al. (2009) are currently investigating the effects of prescribed burning, shrub clearing, and percent cover of woody vegetation on vegetative growth and flowering of *S. parksii* plants in wild populations. Preliminary results suggest that reducing shrub density does stimulate rosette emergence and flowering, and that *S. parksii* -occupied microhabitats have significantly lower percent cover of woody vegetation above 2 m; however, the authors caution that they are still collecting and analyzing the data.

A disjunct population, consisting of a few plants in two small sites, occurs on the Angelina National Forest in Jasper County (Bridges and Orzell 1989). This is the only *S. parksii* population on federally-owned land. While most of the vegetation in that area is dominated by longleaf and loblolly pine (*Pinus palustris* and *taeda*, respectively), one *S. parksii* population was observed in 1996 and 1997 at Black Branch barrens in association with little bluestem and Nuttall's rayless goldenrod (*Bigelowia nuttallii*) (MacRoberts and MacRoberts 1998). *Spiranthes parksii* was first observed nearby in 1986, in association with post oak, black hickory (*Carya texana*), farkleberry, and yaupon (Bridges and Orzell 1989), but this population has not been relocated.

Table 6. Plant species associated with Navasota ladies'-tresses[1].

Genus	Species	Wilson 1985	Tejas 2001	Bridges & Orzell 1991	Poole et. al. 2007
I. Herbaceous species.					
Ampelopsis	*arborea*	2			
Andropogon	*ternarius*	6	■		■
Andropogon	*virginicus*		■		
Antennaria	*fallax*	3			
Aristida	*longispica*		■		
Ascyrum	*hypericoides*	21	■		
Aster	*ericoides*	4			
Aster	*patens*	4	■		
Baptisia	*bracteata* var. *leucophaea*				■
Bigelowia	*nuttallii*				■
Bigelowia	*virgata*		■		
Boltonia	*diffusa*	2	■		
Callirhöe	*involucrata*	1			
Chaetopappa	*asteroides*	3			■
Chasmanthium	*sessiliflorum*	5		■	
Croptilon	*divaricatum*	6			
Croton	*capitatus*	9	■		
Croton	*glandulosus*		■		
Croton	*monanthogynus*	1			
Crotonopsis	*elliptica*		■		
Dichanthelium	*lanuginosum*		■		
Dichanthelium	*oligosanthes*	1			
Dichondra	*carolinensis*	1			
Diodia	*teres*		■		
Drosera	*annua*	8	■		
Drosera	*brevifolia*				■
Eryngium	*yuccifolium*	7			
Eupatorium	*capillifolium*	1			
Eupatorium	*compositifolium*		■		
Gelsemium	*sempervirens*			■	
Gratiola	*flava*				■
Hedyotis	*crassifolia*	10			
Helianthemum	*rosmarinifolium*	34			■
Heterotheca	*graminifolia*	8			
Heterotheca	*latifolia*	4			
Heterotheca	*pilosa*		■		
Hieracium	*gronovii*	3			
Houstonia	*pusilla*				■
Hypericum	*hypericoides*				■
Hypoxis	*hirsuta*	4			
Juncus	*effusus*	2			
Juncus	*spp.*		■		
Juncus	*tenuis*	1			
Juncus	*torreyi*	1			
Juniperus	*virginiana*	1			
Lechea	*tenuifolia*		■		

Genus	Species	Wilson 1985	Tejas 2001	Bridges & Orzell 1991	Poole et. al. 2007
Liatris	*elegans*	20			
Linum	*medium*				
Luzula	*multiflora*	1			
Muhlenbergia	*capillaris*				
Nothoscordum	*bivalve*	3			
Oxalis	*violacea*	7			
Oxalis	*dillenii*	1			
Panicum	*virgatum*	1			
Paspalum	*floridanum*	4			
Paspalum	*setaceum*	1			
Pityopsis	*graminifolia*				
Polypremum	*procumbens*				
Ptilmnium	*nuttallii*				
Quercus	*marilandica*	6			
Rhus	*copalina*				
Rhychospora	*globularis*				
Rhychospora	*glomerata*	1			
Rubus	*trivialis*	3			
Rudbeckia	*hirta*	1			
Salvia	*lyrata*	1			
Schizachyrium	*scoparium*	67			
Scutellaria	*parvula*	3			
Smilax	*bona-nox*				
Sorgastrum	*nutans*	1			
Spyranthes	*cernua*				
Spyranthes	*lacera* var. *gracilis*				
Stillingia	*sylvatica*	1			
Stylosanthes	*biflora*				
Tridens	*flavus*	4			
Vernonia	*baldwinii*	3			
Vernonia	*texana*	2			
II. Woody species.					
Callicarpa	*americana*	18			
Carya	*texana*				
Crataegus	*spathulata*	1			
Forestiera	*ligustrina*	3			
Ilex	*vomitoria*	136			
Ilex	*decidua*	2			
Juniperus	*virginiana*				
Pinus	*taeda*				
Quercus	*Stellata*	99			
Quercus	*marilandica*	51			
Quercus	*nigra*	1			
Ulmus	*alata*	18			
Vaccinium	*arboreum*	47			

1. Wilson's data are relative frequencies; the others are presence (shaded blocks) or absence (unshaded blocks).

Figure 12. ***Spiranthes parksii*** **Correll Habitat.**

2.3.2 Five-Factor Analysis (threats, conservation measures, and regulatory mechanisms):

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range:

The primary threats to the continued existence of Navasota ladies'-tresses are habitat loss and modification (Wilson 1993). Approximately 14 percent of the known SPIPAR population has been lost to development of two lignite mines, a landfill, pipelines and highway construction and improvement. An unknown amount of habitat and individuals have undoubtedly been consumed by development projects that did not require Section 7 consultation with USFWS. Diamond and True (2000) documented a loss of 5.8 percent of the forest cover within the post oak savanna region from 1987 to 1997. However, the species is now protected in 24 small reserves, 21 of which resulted from the reasonable and prudent alternatives and measures approved during Section 7 consultation with USFWS. Five of these reserves are owned by TMPA and may be sold after the final release of their bond by the Texas Railroad Commission, scheduled for 2015.

Even where the species' habitat remains secure, habitat quality declines as the herbaceous component of the post oak savanna is replaced by a dense woody understory. This "thicketization" has occurred throughout the post oak savanna region, and elsewhere, and is attributed to a greatly reduced frequency of wildfire, and to poor rangeland management techniques. A team of researchers from TAMU, with support from BVSWMA, is currently creating an adaptive habitat management plan based on their investigations of *S. parksii* ecology.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes:

When USFWS listed this orchid species in 1982, in view of the widespread over-collection and illicit trade in wild orchids, collection was considered a potential threat. However, we have found no evidence of the overutilization of Navasota ladies'-tresses for commercial collections or any other purpose.

2.3.2.3 Disease or predation:

No diseases, pathogens, or parasites have been reported for Navasota ladies'-tresses. However, deer, squirrels, and perhaps other herbivores cause a significant amount of damage to flower stalks. Hammons et al. (2009) reported that 30 percent of the flower stalks in one trial were browsed by herbivores before they could mature. Although these fauna are native throughout the species' range, white tailed deer are now far more abundant than during pre-settlement times. Introduced feral hogs and native armadillo also cause significant damage to *S. parksii* habitat (Hammons et al. 2009).

2.3.2.4 Inadequacy of existing regulatory mechanisms:

Federally-listed plants occurring on private lands have limited protection under the ESA, unless also protected by State laws; the State of Texas also provides very little protection to listed plant species on private lands. Approximately 95 percent of Texas land area is privately owned. It is reasonable to assume that the vast majority of existing Navasota ladies'-tresses habitat, including sites that have not been documented, occurs on private land. Therefore, most of the species' populations and habitats are not subject to federal or state protection unless there is a federal nexus, such as provisions of the Clean Water Act or a federally-funded project.

Chapter 88 of the Texas Parks and Wildlife Code lists plant species as State-threatened or endangered once they are federally-listed with these statuses. Therefore, Navasota ladies'-tresses is listed as endangered by the State of Texas. The State prohibits taking and/or possession for commercial sale of all or any part of an endangered, threatened, or protected plant from public land. TPWD requires commercial permits for the commercial use of listed plants collected from private land. Scientific permits are required for collection of endangered plants or plant parts from public lands for scientific or education purposes. In addition to State endangered species regulations, other State laws may apply. State law prohibits the destruction or removal of any plant species from State lands without a TPWD permit.

The ESA does provide some protection for listed plants on land under Federal jurisdiction, such as the National Forests.

2.3.2.5 Other natural or manmade factors affecting its continued existence:

According to the Intergovernmental Panel on Climate Change (IPCC) (2007, p. 1) "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level." Average Northern Hemisphere temperatures during the second half of the 20th century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1300 years (IPCC 2007, p. 1). It is very likely that over the past 50 years: cold days, cold nights and frosts have become less frequent over most land areas, and hot days and hot nights have become more frequent (IPCC 2007, p. 1). It is likely that: heat waves have become more frequent over most land areas, and the frequency of heavy precipitation events has increased over most areas (IPCC 2007, p. 1).

The IPCC (2007, p. 6) predicts that changes in the global climate system during the 21st century are very likely be larger than those observed during the 20th century. For the next two decades a warming of about 0.2°C (0.4°F) per decade is projected (IPCC 2007, p. 6). Afterwards, temperature projections increasingly depend on specific emission scenarios (IPCC 2007, p. 6). Various emission scenarios suggest that by the end of the 21st century, average global temperatures are expected to increase 0.6°C to 4.0°C (1.1°F to 7.2°F) with the greatest warming expected over land (IPCC 2007, p. 6-8). Localized projections suggest the southwest may experience the greatest temperature increase of any area in the lower 48 States (IPCC 2007, p. 8). The IPCC says it is very likely hot extremes, heat waves, and heavy precipitation will increase in frequency (IPCC 2007, p. 8). There is also high confidence that many semi-arid areas like the western United States will suffer a decrease in water resources due to climate change (IPCC 2007, p. 8). Milly et al. (2005) project a 10–30 percent decrease in precipitation in mid-latitude western North America by the year 2050 based on an ensemble of 12 climate models.

We do not know whether the changes that have already occurred have affected Navasota ladies'-tresses populations or distribution, nor can we predict how the species will be affected by the type and degree of climate changes forecast by a range of models. The known populations of Navasota ladies'-tresses are almost entirely restricted to post oak savanna in central east Texas. Rising temperatures might enable the species to survive further north that at present, but might also reduce the southern limit of the range. However, the discontiguous nature of the populations and potential habitat, and the existence of new, anthropogenic barriers to migration, could impede the spontaneous extension of the range. Some climate change models also predict increased precipitation along the Gulf Coast, largely due to increased tropical storm activity and severity (Twilley et. al. 2001). Since the species is an edaphic endemic dependent on ephemeral seeps, increasing or decreasing rainfall could alter its competitive advantage in the unique micro-habitats it now inhabits. Regardless of how changes in temperature and rainfall amounts and patterns may affect the autecology of Navasota ladies'-tresses, the altered synecology may be far more significant. For example, higher winter temperatures and increased precipitation could augment competition from yaupon, farkleberry, or other understory shrubs. Conversely, the same changes could increase the frequency or intensity of wildfires, which might benefit Navasota ladies'-tresses. The possible effects of climate change on the synecology of Navasota ladies'-tresses habitat are infinitely complex. Therefore, we will continue to monitor the species and its habitat, and will adapt our recovery and management strategies when necessary to address the changing conditions.

2.4 Synthesis

The original and revised (draft) recovery plans list a single recovery criterion, which is the establishment of two permanently-protected reserves for Navasota ladies'-tresses. The existing plan does list additional recovery objectives without criteria. The sole criterion as stated in the plan has been met and exceeded. However, we concur with the recovery team's recommendation that the existing plan is insufficient to recover the species. A completely revised recovery plan should be established as soon as possible that incorporates the revised guidance on recovery planning now required by USFWS and National Marine Fisheries Service (NMFS) (NMFS 2007). This plan must have criteria for each recovery objective that address the threats in terms of the five listing factors; these criteria must be specific, measurable, achievable, realistic, and time-referenced.

Nevertheless, significant progress has been made to recover Navasota ladies'-tresses. This includes the establishment of 24 protected reserves for the species, the formation of an active recovery team, the establishment of a conservation fund for land acquisition of additional reserves, extensive surveys and monitoring, and a growing body of scientific research on the ecology, management, life history, threats, propagation, and genetics of the species. Much of this progress has been achieved through the reasonable and prudent alternatives and measures of formal Section 7 consultations. Other sources of support have come from cooperative agreements and Section 6 grants. On the basis of these accomplishments and valuable knowledge gained, we have changed the Recovery Priority Number from 2 to 8C, as described in Section 3.2

The taxonomic status of *Spiranthes parksii* as a unique species is questioned by some systematists. However, most of the systematists familiar with this taxon who responded to our request for information concurred that there is currently insufficient evidence to justify synonymy of *S. parksii* with its close relative, *S. cernua*. This valid scientific debate is likely to continue, and may never reach a definitive resolution. We concur with the recovery team's recommendation that *S. parksii* continue to be treated as a valid species.

If the current pace of recovery efforts continues, it is likely that the species could warrant a change in status to threatened, or to be removed from the Endangered Species list, in the near future. This underscores the need to establish a new recovery plan that is sufficient to achieve full recovery, and by which a change in the species' status can be clearly justified through the fulfillment of its criteria.

Finally, we must consider the mandate of the ESA to conserve not just species, but the ecosystems upon which they depend. Much of the public concern over Navasota ladies'-tresses stems from an interest in conserving the post oak savanna ecosystem. Several other rare plant species occur there, including Texas meadow rue (*Thalictrum texanum*), branched gay-feather (*Liatris cymosa*), and Navasota false foxglove (*Agalinis navasotensis*), that are not protected, but may benefit from the efforts to conserve this rare endemic orchid. Dr. James Manhart (pers. com. 2009) calls attention to the near-extirpation of big bluestem (*Andropogon gerardii*) from the post oak savanna. This palatable old-growth grass once was a keystone species of this ecosystem, upon which many other plants and animals depended. In a recent floristic study, graduate student Amanda Neal did not find a single big bluestem plant in all of Madison County. The continued conservation of Navasota ladies'-tresses should be considered as an integral component of an ecosystem-scale effort to conserve the post oak savanna of east Texas.

3.0 RESULTS

3.1 Recommended Classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist (*Indicate reasons for delisting per 50 CFR 424.11):*
  ____ *Extinction*
  ____ *Recovery*
  ____ *Original data for classification in error*
_X_ **No change is needed**

3.2 New Recovery Priority Number: 8C.

Brief Rationale:

Navasota ladies'-tresses was listed with a recovery priority number of 2. The discovery of many new sites over a much broader range reduces the degree of threat from imminent extinction. However, almost all potential habitat for the species is privately-owned, and faces significant threats from rapid urban and residential development. Twenty-four small reserves have been established for the species, but five of these are not yet permanently protected. These reserves protect a known population of 3,207 individuals of the species. However, since the species' reproduction is primarily asexual, the populations have little genetic diversity and a very small effective size. All populations are subject to gradual decline in habitat quality due to competition from increased shrub density; this might be ameliorated by periodic cutting of the shrub understory, or by prescribed burning. In the aggregate, the degree of threat is moderate. The increased knowledge of the species' range, habitat, life history, and propagation contribute to justify a high potential for recovery. Although the taxonomic status of Navasota ladies'-tresses as a unique species is controversial, there is currently insufficient evidence to justify synonymy; we continue to recognize it as valid species. This edaphic endemic is found primarily in close association with ephemeral seeps in the post oak savanna of east central Texas. Conservation of the species and its habitat may conflict with urban and residential development, construction of new highways and pipelines, lignite surface mining, and oil and gas exploration. Therefore, the "C" designation indicates potential conflict with economic activity.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS

The Navasota ladies'-tresses recovery plan should be revised to include criteria that incorporate the five-factor analysis (2.3.2), incorporate the revised recovery planning guidance (NMFS 2007), and take into account new information regarding the species' range, edaphic endemism, habitat, life history, genetics, and threats. The revised objectives and their criteria should be SMART (specific, measurable, achievable, realistic and time-referenced).

The most important recovery actions during the next five years include, but are not limited to, the following:

- Continue monitoring and surveying within the 24 established protected reserves.
- Conduct surveys of high-potential habitat within the known range of the species, focusing on sites that have not previously been surveyed.
- Continue to investigate ecology and management, with special emphasis on woody plant control and prescribed burning.
- Apply sound management, as needed, to protected sites.
- Seek permanent protection for existing reserves; establish new reserves, using LBJWC conservation fund and other resources.
- Investigate mycorrhizal symbionts.
- Obtain peer review and seek consensus on taxonomic status.
- Collect seeds of representative populations for propagation and seed banking, establish germ-plasm (live plant) refugia, and develop techniques for successful propagation and reintroduction.
- Establish cooperative efforts to promote the conservation of the post oak savanna ecosystem.
- Conduct public outreach efforts to encourage conservation of the species and its habitat on private lands.

5.0 REFERENCES

PUBLICATIONS, REPORTS AND INTERNAL DOCUMENTS

Bai, E. 2008. Assessment of the Habitat Suitability and Potential Occurrence of *Spiranthes parksii* in Brazos and Grimes counties, TX. A report to the Navasota ladies'-tresses recovery team. 12 pp.

Brazos Valley Council of Governments. 2003a. Resolution approving recommendations related to a regional park in Grimes County. Passed July 9, 2003.

Brazos Valley Council of Governments. 2003b. Resolution of support regarding recommendations related to a regional park in Grimes County. Passed December 9, 2003.

Bridges, E.L. and S.L. Orzell. 1989. Additions and noteworthy vascular plant collections from Texas and Louisiana with historical, ecological, and geographical notes. Phytologia 66:12-69.

Bureau of Economic Geology. 1975-1976. The Geological Atlas of Texas: McAllen – Brownsville (1976), Corpus Christi (1975) and Laredo (1976) 1:250,000 maps. University of Texas. Austin.

Catling, P.M. and K.L. McIntosh. 1979. Rediscovery of *Spiranthes parksii* Correll. Sida 8:188-193.

Correll, D.S. 1947. A new *Spiranthes* from Texas. American Orchid Society Bulletin 16:400-401.

Correll, D.S. and M.C. Johnston. 1970. Manual of the Vascular Plants of Texas. University of Texas. Dallas, Texas. 1881 pp.

Diamond, D.D. and C.D. True. 2000. Houston toad and Navasota ladies'-tresses habitat assessment via use of remotely sensed satellite data and geographic information system analysis. Final Report for Cooperative Agreement no. 1448-20181-99-J829. Submitted to U.S. Fish and Wildlife Service, Austin, TX. 11 pp + GIS.

Dueck, L.A. and K.M. Cameron. 2007. Sequencing re-defines *Spiranthes* relationships, with implications for rare and endangered taxa. Lankesteriana 7:190-195.

Dueck, L.A. and K.M. Cameron. 2008. Molecular evidence on the species status and phylogenetic relationships of *Spiranthes parksii*, an endangered orchid from Texas. Conservation Genetics 9:1617-1631.

Fowler, N. 2005. Preliminary comments on determining minimum viable population size and minimum number of populations to ensure that NLT does not go extinct. Report to the Navasota ladies'-tresses recovery team. 4 pp.

Frost, C.C. 1998. Presettlement fire frequency regimes of the Unites States: a first approximation. *In* Proceedings of the 20th Tall Timbers fire ecology conference – fire in ecosystem management: shifting the paradigm from suppression to prescription. *Edited by* Pruden, T.L. and L.A. Brennan. Tall Timbers Research Station, Tallahassee, FL. Pp 70-81.

Gould, F.W. 1975. The Grasses of Texas. With drawings by Valloo Kapadia and others. Texas A&M University Press. College Station. 653 pp.

Grimes County Commission. 2004. Resolution approving the concept of a regional park in Grimes County and ownership of the land with conditions. Approved March 22, 2004.

Hammons, R., F.E. Smeins, W.E. Rogers, J.A. Thomas and M. Oden. 2009. Progress report on habitat management and life history research for Navasota ladies'-tresses (*Spiranthes parksii* Correll) in support of the adaptive management plan. Twin Oaks Landfill, Grimes County, Texas. Prepared for Brazos Valley Solid Waste Management Agency.

MacRoberts, M.H. and B.R. MacRoberts. 1998. Rare plants in east Texas. Phytologia 84:1-27.

MacRoberts, M.H., B.R. MacRoberts, and R.E. Evans. 1997. Notes on *Spiranthes parksii* Correll (Orchidaceae) in deep east Texas. Phytologia 83:133-137.

Mahler, W.F. 1980. Status Report. *Spiranthes parksii* Correll. U.S. Fish and Wildlife Service.

Manhart, J.R. and A.E. Pepper. 2007. A genetic study of the rare and endangered orchid *Spiranthes parksii* Correll in a comparative context. Final report. Contract no. 147331.

Milly, P.C.D., K.A. Dunne and A.V. Vecchia. Global pattern of trends in streamflow and water availability in a changing climate. Nature. The Nature Publishing group. Vol. 438. November 17, 2005. pp. 347-350.

Nations, H. 1987. Site for endangered orchids is wiped clean by bulldozer. Bryan – College Station Eagle. November 19. 1987. Pp 1a and 10a.

Poole, J., W. Carr, D. Price, and J. Singhurst. 2007. The rare plants of Texas. Texas A&M University Press. College Station, Texas. 640 pp.

Tejas Ecological Surveys. 2001. A compendium on *Spiranthes parksii* Correll (Navasota ladies'-tresses). Prepared for Texas Municipal Power Agency, Bryan Texas. 23 pp + 4 appendices.

Texas Municipal Power Agency. 1987? (Undated). Gibbons Creek Project Area Navasota Ladies' Tresses Management Plan. 33 pp.

Texas Municipal Power Agency. 1991. Amended Navasota ladies'-tresses management plan. 22 pp, 6 appendices and 6 exhibits.

Texas Municipal Power Agency. 2009. Report on 2008 survey for Navasota ladies'-tresses (*Spiranthes parksii*) within five TMPA protected sites. Prepared by HDR Engineering, Inc. Dallas, Texas. 7 pp + 5 maps.

Texas Municipal Power Agency, U.S. Fish and Wildlife Service, and U.S. Environmental Protection Agency. 1988. Conservation agreement for conservation of Navasota ladies' tresses (draft). 7 pp plus 7 exhibits.

Texas Natural Diversity Database. 2009. Element occurrence printouts for *Spiranthes parksii*. Wildlife Diversity Program of Texas Parks and Wildlife Department. April 13, 2009.

Thomas, J. 2005. Update of population status and occurrence information for Navasota Ladies' Tresses (*Spiranthes parksii*). Report submitted to the Recovery Team, June 2005.

Twilley, R.R., E.J. Barron, H.L. Gholz, M.A. Harwell, R.L. Miller, D.J. Reed, J.B. Rose, E.H. Siemann, R.G. Wetzel and R.J. Zimmerman (2001). Confronting Climate Change in the Gulf Coast Region: Prospects for Sustaining Our Ecological Heritage. Union of Concerned Scientists, Cambridge, Massachusetts, and Ecological Society of America, Washington, D.C.

U.S. Fish and Wildlife Service. 1984. Navasota Ladies'-Tresses Recovery Plan. U.S. Fish and Wildlife Service. Albuquerque, New Mexico. iii + 61 pp.

U.S. Fish and Wildlife Service, U.S. Environmental Protection Agency and Texas Municipal Power Agency. 1992. Conservation agreement for protection of Navasota ladies' tresses. 9 pp plus exhibits A – F.

U.S. Fish and Wildlife Service and Lady Bird Johnson Wildflower Center. 2005. Memorandum of Agreement between U.S. Fish and Wildlife Service, Region 2, P.O. Box 1306, Albuquerque, New Mexico 87103-1306 and the Lady Bird Johnson Wildflower Center. FWS no. 21450-6-K-0001. September 14, 2005. 8 pp.

U.S. Fish and Wildlife Service and National Fish and Wildlife Foundation. 1998. Letter of Agreement: Navasota Ladies'-Tresses (*Spiranthes parksii*) Conservation Fund. National Fish and Wildlife Foundation project number 98-246. Signed May 26, 1998.

U.S. Fish and Wildlife Service and National Fish and Wildlife Foundation. 2005. Letter of agreement between U.S. Fish and Wildlife Service and National Fish and Wildlife Foundation establishing the Navasota Ladies Tresses Habitat Conservation Fund. National Fish and Wildlife Project Number 1998-0246-000. Signed March 16, 2005.

Walters, C. 2005. Genetic relationships among *Spiranthes parksii* and congeneric species. Master's Thesis. Texas A&M University, College Station, Texas. 56 pp.

Walters, T. and H.D. Wilson. 1982. Electrophoretic variation and taxonomic relationships of *Spiranthes parksii*. Botanical Society of America Miscellaneous Publication No. 162.

Wilson, H.D. 1993. Navasota Ladies'-Tresses *Spiranthes parksii* Recovery Plan (draft). 32 pp.

Wilson, H.D. and G. Ajilvsgi. 1983. Status Report for Navasota ladies'-tresses (*Spiranthes parksii* Correll). Prepared for U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

PERSONAL COMMUNICATIONS

Beachy, Stephen. 1991. Letter from Stephen Beachy, Director, Parks and Recreation, City of College Station, to Andrew Sansom, Executive Director, Texas Parks and Wildlife Department. March 8, 1991.

Horbaczewski, Jan. 2009. Telephone conversation with Chris Best, June 17, 2009.

Langlitz, Linda. 2009. Telephone conversation with Chris Best, USFWS, on June 19, 2009.

Manhart, James. 2009. Telephone conversation with Chris Best, USFWS, on June 23, 2009.

Moravec, John. 2009. Email to Chris Best, USFWS. Subject: Navasota Ladies Tresses Surveys. June 17, 2009.

Najvar, Paige. 2007. Email to Florence M. Oxley, Chris Best and Alisa Shull. Recap of Our Meeting. May 16, 2007.

Sheviak, Charles. 1986. Letter to Hugh D. Wilson, Department of Biology, Texas Agriculture & Military University, College Station, Texas. November 13, 1986.

Sheviak, Charles. 2008. Emailed letter to Linda Langlitz, Texas A&M University. January 8 or 9, 2008.

Smeins, Fred. 2003. Telephone conversation with Charmaine Delmatier, USFWS. May 9, 2003.

Smeins, Fred. 2004. Telephone conversation with Charmaine Delmatier, USFWS. January 29, 2004.

Smeins, Fred. 2009. Telephone conversation with Chris Best, U.S. Fish and Wildlife Service. June 24, 2009.

Spiranthes parksii Recovery Team. 2009. Letter to USFWS. May 15, 2009.

Thomas, James. 2009. Telephone conversation with Chris Best, USFWS. June 22, 2009.

Wilson, Hugh. 1991. Letter to Stephen Beachy, Director, Parks and Recreation Department, College Station. January 18, 1991.

INTERNET SOURCES

City of College Station. 2009. Lick Creek Park. http://www.cstx.gov/index.aspx?page=1510. Accessed: June 21, 2009.

Intergovernmental Panel on Climate Change. 2007. Fourth Assessment Report Climate Change 2007: Synthesis Report Summary for Policymakers. Released on 17 November 2007. Available at: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf

National Marine Fisheries Service. 2007. Interim endangered and threatened species recovery planning guidance. Version 1.2. Silver Springs, MD. 121 pp. http://www.nmfs.noaa.gov/pr/pdfs/recovery/guidance.pdf. Accessed June 21, 2009.

NatureServe. 2002. NatureServe Element Occurrence Standard. http://www.natureserve.org/prodServices/eodata.jsp. Accessed: June 26, 2009.

Reed, M. 2009. Lick Creek Park. Herbarium, Department of Botany, Texas A&M University. Photographs by J. R. Manhart and H. D. Wilson. http://botany.csdl.tamu.edu/FLORA/LCP/LCPINTRO.HTML. Accessed: June 21, 2009.

Sheviak, C.J. and P.M. Brown. 2002. Spiranthes. Flora of North America 26. http://www.efloras.org/florataxon.aspx?flora_id=1&taxon_id=242101962. Accessed: June 25, 2009.

Texas State Data Center and Office of the State Demographer. 2006 Population Projections – Texas Counties. http://txsdc.utsa.edu/tpepp/2006projections/2006_txpopprj_cntytotnum.php. San Antonio, Texas. Texas State Data Center and Office of the State Demographer, Institute for Demographic and Socioeconomic Research. The University of Texas at San Antonio. Accessed December 3, 2008.

Texas World Speedway. 2009. http://www.texasworldspeedway.com/. Accessed June 10, 2009.

University of Wisconsin. 2002. Orchidoid mycorrhizae. Department of Botany Instructional Technology. Madison, Wisconsin. http://botit.botany.wisc.edu/courses/mpp/OrchidMyco116.html. Accessed June 24, 2009.

U.S. Fish and Wildlife Service. 2009. Cooperative Endangered Species Conservation Fund (Section 6 of the Endangered Species Act). http://www.fws.gov/endangered/factsheets/Sec6_Factsheet_2009.pdf. Accessed June 20, 2009.

Wikipedia. 2009. http://www.wikipedia.org. Accessed June 30, 2009.

Wilson, H.D. 2009. *Spiranthes parksii* – Endangered Orchid of the Texas Post Oak Savannah. http://botany.cs.tamu.edu/FLORA/hdwsp/sp_contents.htm. Accessed June 20, 2009.

PHOTOGRAPHIC AND MAP CREDITS

Brazos Valley Solid Waste Management Agency: Map of BVSWMA landfill and protected sites (figure 3).
Lucy Dueck: Photograph of *Spiranthes parksii* on the cover page.
Linda Langlitz: Photographs of *Spiranthes lacera* var. *gracilis*, *S. cernua* and *S. parksii* (Figure 9); photographs of *S. parksii* habitat (figure 12). Maps of SH 6 and SH 40 protected sites (figures 1 and 2).
Texas Municipal Power Agency: Maps of protected sites C1 – C5 (figures 4 – 8).

GLOSSARY OF TECHNICAL TERMS

Agamospermy	Reproduction with seeds produced without sexual fertilization.
Allopolyploid	Polyploid whose chromosomes derive from different species. (Wikipedia 2009).
Apomixis	Replacement of normal sexual reproduction by asexual reproduction. (Wikipedia 2009).
Autecology	Ecology of individual species.
Bivalent	Having two poles.
Chloroplast	A double-membrane organelle found in higher plants in which photosynthesis takes place.
Compilospecies	An artificial grouping of organisms that do not share the same phylogeny.
Cytology	Study of cellular biology.
Diploid	Organism possessing two replicate sets of chromosomes.
Edaphic	Adjective referring to soil.
Electophoresis	Technique for separating organic compounds through exposure to an electric field.
Emarginate	Possessing a minute indentation at the apex of the leaf margin. (Correll and Johnston 1970).
Endosperm	A nutritious, often polyploid tissue surrounding the embryo of most plant seeds.
Ephemeral	Of short duration.
Erose	Leaf or petal margin with irregular teeth. (Correll and Johnston 1970).

Isozyme	Enzymes that differ in amino acid sequence but catalyze the same chemical reaction. (Wikipedia 2009).
Meiosis	The division of spore mother cells into gametes with half the original chromosome number.
Mesic	Habitat in which soil moisture is normally sufficient for plant growth.
Mitochondria	A double-membrane organelle found in all eukaryote organisms in which the Krebs Cycle (respiration) takes place.
Mycorrhiza	A symbiotic or mutualistic association of specialized soil fungi with the roots of higher plants.
Nucleotide	Molecules that form the basic structure of DNA, composed of a 5-carbon sugar (ribose or deoxyribose), a nitrogenous base and phosphate groups. (Wikipedia 2009).
Outcross	In plants, sexual fertilization involving a different individual.
Parsimony analysis	A mathematical technique for resolving genetic trees into the simplest possible clades.
Peloria	Occurrence of similar perianth (sepal or petal) morphology in taxa where these are normally dissimilar.
Phenotype	The physical characteristics of an organism.
Polyembryony	Asexual proliferation of embryos within the seed coat of a plant.
Protocorm	Plant tissue that will give rise to a corm.
Quadrivalent	Having four poles.
Ribosome	Complex of nucleic acid and protein, found in all organisms, that catalyzes the translation of DNA sequences into proteins. (Wikipedia 2009).
Saprophyte	Organism deriving its nutrition from the remains of dead organisms.
Symbiont	Member of a symbiotic relationship between two or more organisms.
Sympatry	Occurring together in the same habitat.
Synecology	Ecology of groups of organisms.
Tetrapoid	Organism possessing four replicate sets of chromosomes.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW OF NAVASOTA LADIES'-TRESSES (*Spiranthes parksii*)

Current Classification: Endangered

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change needed

Appropriate Listing/Reclassification Priority Number, if applicable: N/A

Review Conducted By: Chris Best, Austin Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve ______________________ Date 6-29-09

REGIONAL OFFICE APPROVAL:

for **Assistant Regional Director, Ecological Services, U.S. Fish and Wildlife Service**

Approve ______________________ Date 8/26/09