

Figure 1. Distribution of *Spiranthes parksii* populations.

BIOLOGY, ECOLOGY, AND CONSERVATION OF

Navasota ladies' tresses

(*Spiranthes parksii* Correll)

AN ENDANGERED TERRESTRIAL ORCHID OF TEXAS

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ABSTRACT

Navasota ladies' tresses (*Spiranthes parksii* Correll [Orchidaceae]) is a federally and state-listed endangered orchid of east-central Texas. Habitat loss and degradation related to urban and industrial development are major threats to *S. parksii* populations. To ensure recovery, a complete understanding of the population dynamics, ecology, and biology of an endangered species is necessary to foster effective conservation that is compatible with human population growth and continued development. Here we provide an overview of the known aspects of *Spiranthes parksii* ecology and biology and highlight factors with implications for species conservation. Our intention is to provide a framework for development of future *S. parksii* related studies and background for those interested in *S. parksii* conservation and management.

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CONVERSIONS

1 mm = 0.04 in

1 cm = 0.4 in

1 m = 3.3 ft

(°C * 1.8) + 32 = °F

KEY WORDS

Orchidaceae, natural history, habitat management

NOMENCLATURE

USDA NRCS (2012)

Navasota ladies' tresses (*Spiranthes parksii* Correll [Orchidaceae]) is a federally listed endangered species endemic to east-central Texas (USFWS 1996). It occurs in 13 Texas counties (Figure 1) with 93% of known population sites in Brazos and Grimes counties in the Brazos River Valley of east-central Texas (TMPA 1991). This percentage is considered to be inflated due to the high concentration of survey efforts in this area. Oil, natural gas, lignite, and other developments, as well as urban expansion and exurban development pose significant threats to *S. parksii* populations (USFWS 1996).

Our purpose is to 1) provide an overview of the biology and ecology of *S. parksii*; 2) highlight factors with implications for species conservation; 3) provide a framework for development of future scientific study of *S. parksii*; and 4) create a background for subsequent management and conservation of the species.

SPIRANTHES PARKSII BIOLOGY

Description

Spiranthes parksii has a leafless flowering stem 15 to 30 cm in height terminated by a 3 to 7 cm flowering spike composed of up to 4 ranked coils of flowers spiraling counterclockwise around the stalk (Figure 2). Bracts with whitish tips subtend the flowers, which have obovate petals and dentate lip margins (Luer 1975; Poole and others 2007). The flowers extend horizontally from the rachis and the dorsal sepal extends beyond the petals and curls upward at the apex. The lateral sepals hug the corolla and extend slightly beyond the dorsal sepal, curved up at the ends like horns (Sheviak 1991; Pelchat 2000). The creamy-colored inner petals between the dorsal and lateral sepals might have a green stripe. The basal rosette has 1 to 5 lance-like to elliptical leaves and does not usually occur simultaneously with a flowering spike, but can emerge as the flower senesces (Figure 3).



Figure 2. *Spiranthes parksii* flowering stalk. Photo by JR Hammons

Spiranthes parksii is sympatric with several other species in the genus *Spiranthes* throughout its range, including *cernua* (L.) Rich., *lacera* (Raf.) Raf. var. *gracilis* (Bigelow) Luer, *sylvatica* Brown, *vernalis* Engelm. & A. Gray, and *praecox* (Walter) S. Watson. These species are distinct from *S. parksii* with the exception of *S. cernua* which has undulate lip margins, white petal color, dorsal sepals similar in length to the petals, flowers that often droop from the rachis, and bracts often lacking white tips. Vegetatively, *S. parksii* and *S. cernua* appear identical, which poses difficulties for distinguishing the endangered orchid from its more abundant congener when only rosettes are present.

Life History

Spiranthes parksii is perennial. It produces basal rosettes between September and May with maximum leaf size generally occurring from late February to early March. Rosettes usually disappear by mid-May, but in wet, cool years, they may persist well into the summer months. Flowers may emerge as early as September, but generally emergence peaks in October with anthesis and fruiting in October or November and seed dispersal generally occurring in December (USFWS 1984; Hammons 2008) (Figure 3). The plants survive underground from about April or May until September as fleshy tuberous roots with no above-ground leaves, stems, or flowers (Figure 4). Leaf production and flowering are variable for *S. parksii* individuals. Hammons and others (2010) found 20% of permanently marked unknown *Spiranthes* rosettes (both *cernua* and *parksii*) flowering in 2007, only 5% in 2008, and even fewer in 2009. Similarly 63% of the same marked individuals produced basal rosettes in 2008 and only 35% in 2009. Current observations and data suggest radical population fluctuations (USFWS 1984; TMPA 1991). This may, however, reflect the variability of leaf and flower production of individuals and not actual fluctuations in numbers of *S. parksii* present, since belowground structures of individual plants can persist for several years without producing flowering stems or rosettes.

Reproduction

Spiranthes parksii can reproduce sexually and asexually (Catling and McIntosh 1979; Sheviak 1982). Glucose-rich secretions near the lip of the flower may attract pollinators (Catling and McIntosh 1979), and observations of visits to *S. parksii* flowers by honeybees and bumblebees suggest that pollen dissemination by insects occurs; however, detailed examinations of potential pollinators have yet to be conducted. Long-tongued bumblebees are important pollinators of other *Spiranthes* species (Larson and Larson 1990), and *S. parksii* shares a similar morphology with these bee-pollinated species, such as protandrous flowers and easily detachable pollinia, which adhere to viscid stigmata (Catling 1982b). The widely spaced, patchy distribution of *S. parksii* likely limits cross-pollination among isolated populations.

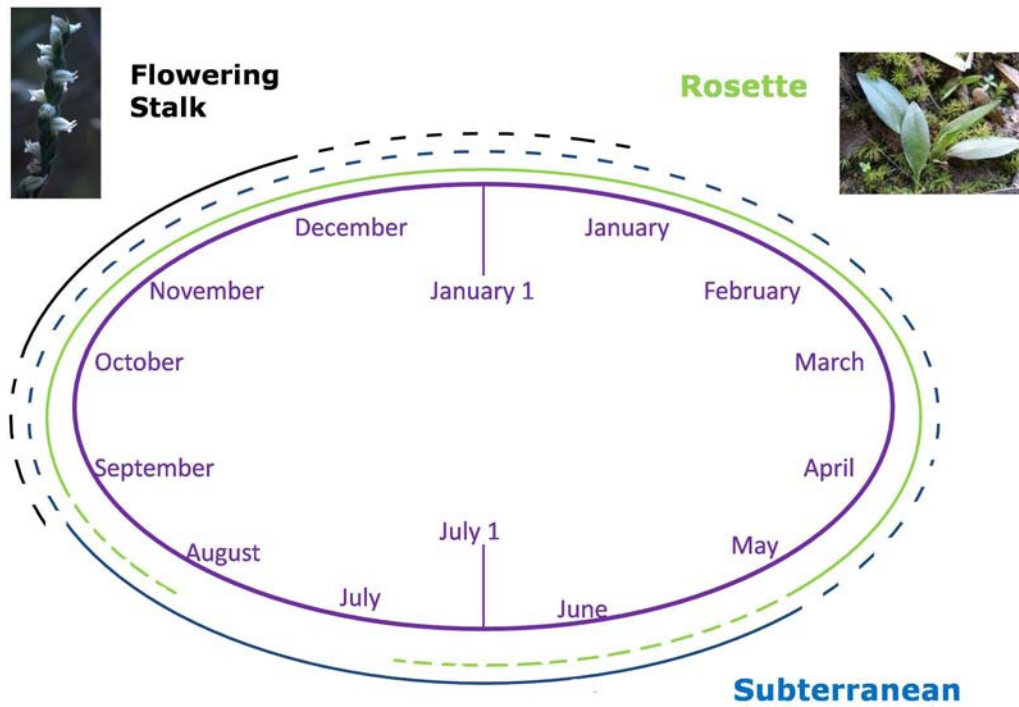


Figure 3. Timing of *S. parksii* life cycle (Solid lines depict the average timing. Dashed lines depict the range of timing possible.)

A high percentage of polyembryonic seeds (80–90%) in *S. parksii* suggests that apomixis (asexual seed production) may be the primary mode of reproduction (Sheviak 1976; Catling and McIntosh 1979; Catling 1982a). *Spiranthes cernua*, the potentially close relative of *S. parksii*, exhibits high levels of apomixis (Sheviak 1982). Both species can reproduce primarily through adventitious embryony (Schmidt and Antlfinger 1992) in which a sporophyte is proliferated from the parent ovular tissue (Sipes and Tepedino 1995). High levels of apomixis have been found to correspond to low occurrence of pollinators (Manning 1981; Lloyd 1988). *Spiranthes* generally have fewer pollinators than other orchids have (Tremblay 1992), and Schmidt and Antlfinger (1992) found pollinator limitation to occur for *S. cernua* at the edges of its range. The high level of apomixis in *S. parksii* might also be an adaptation to low abundance of pollinators throughout its limited range.

Seed Dispersal and Recruitment

Orchid seeds are primarily dispersed by wind, water, and animal contact (Arditti 1967). Seeds are small with thin seed-coats and impermeable testae that contain air bubbles. These features make air and water dispersal particularly effective (Arditti and Ghani 2000). Little is known about *S. parksii* dispersal, but their patchy distribution suggests a limited dispersal shadow. The tiny size of *S. parksii* seeds suggests dispersal by wind and water, and given the proximity of many populations to game trails, dispersal through epizoochory is possible al-

though unlikely. While herbivory of *S. parksii* flowering stalks by deer, rabbit, feral hog, and livestock appears to be significant, much of the observed herbivory occurs before anthesis, suggesting that substantial dispersal by herbivores is not likely. Understanding dispersal in *S. parksii* is crucial to its conservation because the survival of local populations in extremely fragmented landscapes may depend on long-distance dispersal of seeds (Ozinga and others 2004).

Seeds of *S. parksii* lack endosperm. Therefore, protocorn development can occur only after penetration of the seed by mycorrhizae (Wells 1981). This symbiotic relationship between the plant and the mycorrhizal fungus continues throughout its life. *Spiranthes* generally have multiple symbionts but all are saprophytic. Some seasonal variation in the amount of infection occurs as the fungi move in sequestration of resources. While *S. cernua* within the range of *S. parksii* have been discovered to have associations with 3 anamorphic genera of fungi, *Ceratorhiza*, *Monilopsis* and *Epulorhiza*, we have observed that *S. parksii* appear to associate with only one, *Epulorhiza* (Ariza 2010). The degree of specificity between *S. parksii* and mycorrhizal fungi warrants further investigation as fungal distribution is likely an important factor determining its distribution and recruitment (Rasmussen and Rasmussen 2007).

Flowering *S. parksii* show high fungal infection in the middle of the root and decreasing infection along the periphery (Ariza 2010). Isolation and identification of mycorrhizae associated with *S. parksii* throughout its life cycle as well as determination



Figure 4. *Spiranthes parksii* tuberous root. Photo by MC Ariza

of seasonal variation could aid in understanding *S. parksii* distribution. Dynamics of litter decomposition could potentially drive such distribution. Because *S. parksii* impacts the fungal substrate, they may then influence the distribution of the symbiont required for *S. parksii* seedling development and resource acquisition (Batty and others 2002).

While germination has been observed *in situ* after 8 wk (Hammons 2010), the amount of time the *S. parksii* seedling remains underground as a mycorrhizome is unknown. This stage has been determined to last 2 to 4 y on average for orchids in general and about 2 y for the closely related *S. cernua* (Rasmussen 1995). The length of time before first rosette formation is variable among orchids and is related to the amount of carbon storage in root tubers. The number of root tubers on an individual *S. parksii* that has produced a rosette generally varies between 2 and 8 (Hammons and others 2010) (Figure 4). Hammons and others (2010) also found a positive correlation between total leaf length and total root tuber length for *Spiranthes* (both *parksii* and *cernua*) rosettes, suggesting a strong relationship between belowground carbon stores and the production of aboveground structures.

ECOLOGY

The climate throughout the range of *S. parksii* is mild with a mean annual temperature of 19 to 20 °C with mean annual precipitation between 914 and 1016 mm (Bomar 1983). Summers are hot and humid and winters are cool with infrequent freezing temperatures. Elevations range from 60 to 110 m with flat to gently sloping terrain and deep acidic, sandy, or loam soils from parent material of recent alluvial deposits or Tertiary sandstone (Soil Conservation Service 1979).

Flowering appears linked to rainfall. Parker (2001) found that rainfall 8 to 10 wk before flowering in August and Septem-

ber increased numbers of *S. parksii* that flower during a given year. Wilson (2002) also found that increased spring and fall rainfall led to greater numbers of flowering *S. parksii*. Hammons (2008) found August rainfall to positively correlate with number of flowering *S. parksii*.

The habitat of *S. parksii* is upland post oak woodland and savanna with grassland patches, often along the streambanks of upland tributaries of the Navasota and Brazos river drainages (USFWS 1996). They are most often found in lightly forested post oak savanna at the edge of upland drainages or along drip lines at the interface between wooded and adjacent grassland patches, although individual plants may be found in more open, grassland areas. When found in large grass patches, the plant might have established prior to clearing of woody vegetation and persisted for long periods. Although previously thought to be rare in frequently disturbed areas, *S. parksii* seems to be abundant along game and cattle trails, and is found along fencerows and powerline rights-of-way (Wilson 2002), which suggests the importance of either periodic disturbance or relatively high levels of light. Hammons (2008) found that *S. parksii* is likely to occur with some leaf litter but is more often found in thin rather than thick litter cover. Generally, *S. parksii* occurs in areas with moderate to high (41–100%) shade. It is possible, however, that establishment in areas of high shade occurred prior to canopy closure and subsequent reductions in light levels.

Bai and Smeins (2007) categorized 800 soil-mapped and GPS-located plants from the USFWS/TPWD (Texas Parks and Wildlife) files by geologic formation and soil series. They found *S. parksii* occurring on 15 geologic formations (primarily Manning and Wellborn) and 29 soil series (primarily Burlewash, Elimina, Singleton, Shiro, Arol, and Burlewash-gullied). These data may be biased, however, by search efforts concentrated in the areas of documented occurrence. Also, neither plant locations nor soil and geology locations were field-checked. Nonetheless, when surveying in the vicinity of mapped Manning or Wellborn geologic formations on Burlewash, Elimina, Singleton, Shiro, Arol, and Burlewash-gullied soils there is increased likelihood of *S. parksii* occurrence.

GENETICS

The species status of *S. parksii* has recently been questioned. Both Walters (2005) and Dueck and Cameron (2007) found little genetic difference between *S. cernua* and *S. parksii* upon examination of DNA sequencing and AFLP microsatellite marker data. *Spiranthes cernua* is a compilospecies that exhibits considerable morphological variability. Manhart and Pepper (2007) state, however, that a lack of genetic variation between *S. parksii* and *S. cernua* AFLP markers is not proof that *S. parksii* is not a unique species. They view clear morphological and ecological differentiation to be evidence of genetic differences that they failed to detect due to the limited sample of loci explored. Re-

cent re-evaluation by the US Fish and Wildlife Service of *S. parksii* status and recovery has declared that *S. parksii* will continue to retain species status until conclusive evidence establishes synonymy of *S. parksii* and *S. cernua* (USFWS 2009).

CONSERVATION

Formal consultation under Section 7 of the Endangered Species Act has resulted in the creation of 24 protected reserves for *S. parksii*; however, 5 areas are not yet permanently protected and all are relatively small isolated tracts of land (USFWS 2009). The potential impact of fragmentation on *S. parksii* is unknown. Given the potential for fragmentation to modify environmental conditions (Saunders and others 1991; Murcia 1995), and the likelihood that species occurring within limited ranges are more likely to be extirpated by extensive habitat destruction (Rabinowitz 1981), evaluating the effectiveness of this system of small reserves in maintaining adequate populations of *S. parksii* becomes even more important.

Formal consultation has occurred in conjunction with all state or municipal development projects. In addition to preserve creation, Section 7 requires scientific study as well as the monitoring of populations in the preserves (USFWS 2009). Land management in most permanent preserves is also required; however, proper land management activities must first be determined through scientific study. Because most of the land in east-central Texas is privately owned, and the ESA confers little protection to species on private land, developing a system for protection of *S. parksii* on non-public land is essential.

Successful transplant methods, such as those proposed by Hammons and others (2010), may reduce losses of *S. parksii* populations to continued urban and industrial development. They have shown post-transplant production using a soil-intact relocation method to be comparable to production of undisturbed plants. They suggest the possibility of improving production in transplanted individuals by relocation of individuals from degraded habitats where they exist as remnant populations to protected areas where the environmental conditions are more favorable. The improvement of greenhouse propagation methods could also decrease losses to disruptive development in the environment. These techniques could prove invaluable as conservation tools as urban development continues in *S. parksii* habitat, especially as the constituents of favorable habitat become more fully identified.

Continued exploration of the environmental factors important to *S. parksii* persistence is crucial in order to develop management strategies, especially in preserves. The post oak savannas of east Texas have become increasingly “thicketized,” that is, colonized by encroaching understory brush. Oak savannas were historically maintained through a combination of factors including drought, animal browsing, and understory fires (Scholes and Archer 1997). The thicketization is hypothesized

to be caused by an interaction of climate change, fire suppression, and altered grazing regimes (Archer and others 1988; Abrams 1992). This is important to *S. parksii* conservation because the increases in woody plant abundance may influence important ecosystem processes (Van Auken 2000; Breshears 2006), alter the composition and structure of the understory (Bowles and McBride 1998), and change the dynamics of understory competition for resources (Nielsen and others 2003). An understanding of *S. parksii* response to encroachment is necessary to implement effective management. Woody brush removal and maintenance through fire and grazing might be necessary to restore an understory competition dynamic more favorable to *S. parksii*. Currently, however, the response of *S. parksii* to fire and grazing is poorly understood. Timing of fires may be crucial because burning during flowering or rosette production might reduce *S. parksii* viability. Additionally, given the alteration of the structural components of the ecosystem due to woody encroachment, a re-establishment of the historical fire return interval of 1 to 6 y may be ineffective due to substantially reduced understory fuel and the resulting altered fire behavior (Van Auken 2000).

Feral pig disturbance might also have an impact on *S. parksii* abundance and distribution. Feral pigs are abundant in east-central Texas, and they have the potential to directly alter disturbance regimes and the resulting dynamics of the plant community (Mack and D’Antonio 1998; Siemann and others 2009). Pigs have been reported to cause root destruction (Singer and others 1984) and plant death (Kotani 1995). Mack and D’Antonio (1998) also report an alteration in arthropod numbers resulting from pig disturbance, which could substantially modify nutrient fluxes within the disturbed community. Siemann and others (2009) report increased nitrogen availability in areas disturbed by feral pigs. Unfortunately, little is known regarding *S. parksii* nutrient requirements and soil disturbance response. Soil disturbance might facilitate recruitment by offering safe areas of low competition for *S. parksii* establishment, but this positive disturbance effect might be offset by tuber loss to pig consumption. Understanding *S. parksii* population dynamics in relation to disturbance is necessary to effectively manage *S. parksii* habitat.

CONCLUSION

Loss of preferential *S. parksii* habitat is proceeding rapidly. An understanding of the ecology of the species with an emphasis on factors important to establishment, recruitment, and maintenance is essential for the conservation of *S. parksii*. Limiting resources and responses to disturbance have been increasingly seen as crucial to species conservation (Soule and Kohm 1989; Nilsson and Ericson 1997).

Unfortunately, this species has been viewed as an opponent of progress given the overlap of its range with one of the fastest

growing areas of urban and industrial development in Texas. A more complete understanding of *S. parksii* population dynamics informed by continued study of the ecology and biology of *S. parksii* will foster effective conservation that is compatible with human population growth and continued development. This complete understanding must include knowledge of *S. parksii* genetic properties, insight regarding the biotic and abiotic factors regulating *S. parksii* distribution and abundance, the relationship of those factors to disturbance, and the impact of habitat fragmentation on those relationships.

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