Rangewide Status Review of

Ute Ladies'-Tresses

(*Spiranthes diluvialis*)

Prepared for the
US Fish and Wildlife Service

And
Central Utah Water Conservancy District

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INTRODUCTION

Ute ladies'-tresses (*Spiranthes diluvialis*) was listed as Threatened under the US Endangered Species Act on 17 January 1992. At that time, the species was known from fewer than 6,000 individuals in 10 extant and 7 historical (and presumed extirpated) populations in Colorado, Nevada, and Utah and was considered extremely vulnerable to extinction from habitat loss/modification, small population size, and low reproductive rate (US Fish and Wildlife Service 1992). Since 1992, the number of extant populations of *S. diluvialis* has increased to over 50 and its known range has expanded to Idaho, Montana, Nebraska, Washington, and Wyoming. Survey work and monitoring studies suggest that the global population may be over 83,000 individuals. New discoveries have also shed light on the plant's complex life history, dependence on natural and human-induced disturbance, and response to existing and newly identified threats.

In May 1996, the Central Utah Water Conservancy District petitioned the US Fish and Wildlife Service (USFWS) to delist Ute ladies'-tresses on the grounds that it was sufficiently widespread and secure enough to no longer warrant protection under the Endangered Species Act (Woodward-Clyde 1996). On 12 October 2004, USFWS announced a 90-day finding that the petition presented sufficient information to initiate a status review to determine whether delisting was warranted (US Fish and Wildlife Service 2004). The purpose of this rangewide status report is to compile new data (especially since 1996) on the known distribution, population ecology, protection status, and threats of *Spiranthes diluvialis* in order to help USFWS ascertain whether a change in listing status is appropriate.

METHODS

Baseline data on the taxonomy, distribution, abundance, life history, threats, and management needs of *Spiranthes diluvialis* were derived from the original US Fish and Wildlife Service listing package, state natural heritage program element occurrence records, and other pertinent references dating from 1984-1995. This information was augmented with published and unpublished data on population trend, new distribution records, recent taxonomic and cytogenetic studies, habitat modeling, and other research conducted rangewide on *S. diluvialis* since 1996.

SPECIES INFORMATION

Classification:

Scientific Name: *Spiranthes diluvialis* Sheviak.

Bibliographic Citation**:** Sheviak, C.J. 1984. *Spiranthes diluvialis* (Orchidaceae), a new species from the western United States. *Brittonia* 36(1): 8–14.

Type Specimen**:** U.S.A. Colorado. Jefferson Co.: mesic to wet alluvial meadows along Clear Creek just west of junction of routes 6 & 58, Golden, 17 July 1982, *C.J.*

Sheviak, J.K. Sheviak, W. Jennings, L. Long, & S. Smookler 2257 (Holotype: NYS; Isotype: NY).

Etymology: *Spiranthes* from Greek *speira* "coil" and *anthos* "flower" (Cronquist et al. 1977); *diluvialis* from Latin *diluvium* "of the flood" (Sheviak 1984).

Common Name: Ute ladies'-tresses (US Fish and Wildlife Service 1992), Ute lady's tresses (Atwood et al. 1991), Intermountain ladies-tresses (Welsh 1993), Flood ladies-tresses (Welsh et al. 2003), Diluvim ladies'-tresses (Kartesz 2003), Plateau lady's tresses (US Fish and Wildlife Service 1990).

Synonyms: *Spiranthes romanzoffiana* Cham. var. *diluvialis* (Sheviak) Welsh (Welsh 1993).

Family: Orchidaceae (Orchid family).

Size of Genus: Sheviak and Brown (2002) recognize 45 species of *Spiranthes* worldwide, of which 23 occur in North America.

Phylogenetic Relationships: Ute ladies'-tresses was first collected by Henry Engelmann along the South Fork of the Platte River in Weld or Morgan County, Colorado in September 1856 (Jennings 1989), but remained unrecognized as a new species for nearly 125 years. At least 12 additional collections were made from 1880-1979 in Utah and Nevada, but were variously identified as *Spiranthes romanzoffiana, S. porrifolia, S. magnicamporum,* or *S. cernua* (Cronquist et al. 1977, Kaul 1986, Luer 1975, Sheviak 1984). While conducting a revision of the *Spiranthes cernua* complex in the early 1980s, Charles Sheviak recognized that some specimens ascribed to *S. cernua* from northern Utah probably represented a new, undescribed taxon with affinities towards *S. magnicamporum* and *S. romanzoffiana*. Additional discoveries of *S. cernua*-like plants near Golden, Colorado in 1980-81 prompted Sheviak to critically examine other western *Spiranthes* collections and to conduct cytological and morphological studies on fresh material. Sheviak's research demonstrated that low elevation *Spiranthes* populations from the Colorado Front Range, Utah's Wasatch Front and Colorado Plateau, and eastern Nevada were indeed a new species, which he named *Spiranthes diluvialis* (Sheviak 1984).

Based on morphology and genetics, Sheviak (1984) postulated that *Spiranthes diluvialis* was an allopolyploid (2n = 74) derived from hybridization between *S. romanzoffiana* (2n = 44) and *S. magnicamporum* (2n = 30). Allopolyploids are derived from hybridization between two genetically distinct diploid species, followed by chromosome doubling which allows the hybrids to be fertile but no longer cross-compatible with their progenitor species (Grant 1971). Detailed isozyme studies by Arft (1995) and Arft and Ranker (1998) confirmed Sheviak's hypothesis. In addition, Arft and Ranker found an unexpectedly high degree of genetic variability within populations of *S. diluvialis* from Colorado and Utah,

suggesting that the species may have evolved from at least two separate hybridization events. Little genetic differentiation was found between populations, however, a finding confirmed by Szalanski et al. (2001) for samples from Idaho, Montana, Nebraska, and Wyoming. The ranges of *S. romanzoffiana* and *S. magnicamporum* do not currently overlap, suggesting that hybridization may have occurred during the Pleistocene when their ranges shifted in response to glacial advances (Sheviak 1984).

Legal Status:

National: Ute ladies'-tresses is endemic to the United States and was listed as Threatened under the US Endangered Species Act on 17 January 1992 (US Fish and Wildlife Service 1992). In addition, *S. diluvialis* is listed on Appendix II of the Convention of the International Trade in Endangered Species (CITES) which protects species from international trade and export.

States: Of the eight states in which *S. diluvialis* is known to occur, only Nebraska and Nevada have state endangered species laws that specifically address vascular plants (George et al. 1998). The 1971 Nebraska act prohibits the export, possession, and sale of listed plant species and includes provisions regarding critical habitat and consultation. Nevada's 1969 law protects listed plants from removal or destruction. Colorado, Idaho, Montana, and Washington have state endangered species legislation that applies only to listed vertebrate species. These states, along with Utah and Wyoming (which have no state endangered species laws) abide by federal Endangered Species regulations for listed plants.

Natural Heritage Rank:

Global: NatureServe (formerly The Nature Conservancy's network of state natural heritage programs) gives Ute ladies'-tresses a global rank of G2 (on a scale from 1 to 5, with 1 being rarest), indicating that the species is "imperiled because of extreme rarity" (www://NatureServe.org, October 2004). Species ranked G2 are typically known from 20 or fewer extant "occurrences" (discrete population clusters) or have small populations subject to high threat. Moseley (1998a) recommended that this rank be changed to G3 ("rare or uncommon, but not imperiled", and typically with 21-100 extant population clusters) based on the increase in the known range, abundance, and number of extant populations of *Spiranthes diluvialis* in the mid to late 1990s. As of 2004, this change has not been adopted.

States: Ute ladies'-tresses is ranked S2 in Colorado and Montana, indicating that it is "imperiled because of extreme rarity" in each of these states. Idaho, Nebraska, Utah, Washington, and Wyoming each score *S. diluvialis* as S1, indicating that the species is "critically imperiled" and known from 5 or fewer extant population clusters with a small population size. *S. diluvialis* is currently ranked SH

(historical) in Nevada, although this rating is likely to change to S1 in light of the rediscovery of the state's only known population in July 2005.

Description: Ute ladies'-tresses is a perennial herb with erect, glandular-pubescent stems 12-60 cm tall arising from tuberous-thickened roots (Figures 1, 2). Basal leaves are narrowly linear, up to 1 cm wide and 28 cm long, and persist at the time of flowering. Leaves become progressively smaller up the stem and are alternate. The inflorescence is a sparsely pubescent 3-15 cm long spike of numerous small white or ivory-colored flowers arranged in a gradual spiral. Individual flowers are 7.5-15 mm long and faintly fragrant (with a vanilla-like scent). The lip petal is oval to lance-shaped, narrowed at the middle, and has crispy-wavy margins. Sepals are separate or fused only at the base (not fused into a hood-like structure) and are often spreading at their tips. Fruits are cylindric capsules with numerous seeds (Sheviak 1984, Sheviak and Brown 2002, US Fish and Wildlife Service 1992).

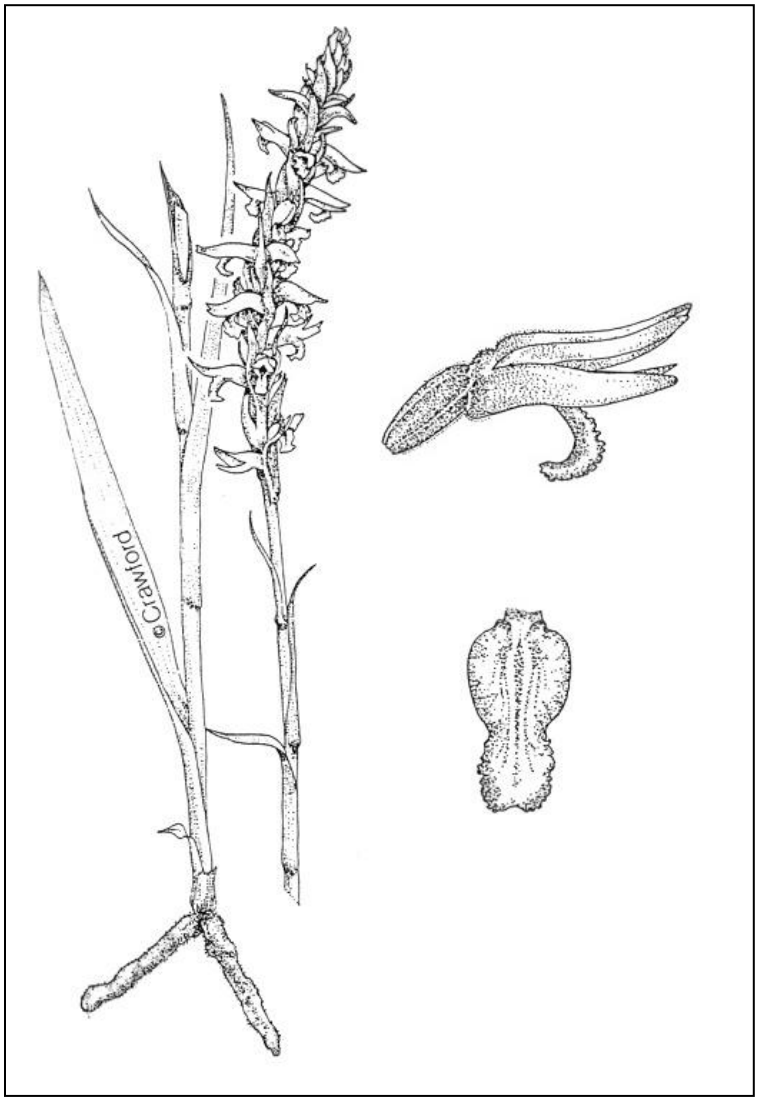

Figure 1. Line drawing of Spiranthes diluvialis *by Carolyn Crawford. Left: growth habit. Upper right: side view of flower. Lower right: lip petal.*

Figure 2 (above). Photo of Spiranthes diluvialis *from Deer Creek, Utah, by Elaine Kneller.*

Similar Species: *Spiranthes romanzoffiana* has deeply constricted, fiddle-shaped lip petals, sepals fused for at least ½ their length into a hood-like tube, pubescence of short hairs along the stem and inflorescence, and typically occurs in montane wetlands (up to 3400 meters in elevation) throughout the Rocky Mountains. *S. magnicamporum* and *S. cernua* have strap-shaped, wavy-margined lip petals, lack leaves at flowering time, and occur in low-elevation (to 1900 meters) wetlands of the Great Plains east of the current known range of *S. diluvialis* (except in Nebraska). *S. porrifolia* has pale yellow flowers with sepals fused for about ½ their length (but not forming a hood), strap-shaped lip petals with peg-like hairs on the upper surface, and glabrous stems. It occurs primarily along the Pacific Coast inland to Idaho and western Nevada in wetlands from 100-2600 m. *S. infernalis* has yellowish-white flowers with a green lip that is widest near the middle before tapering to the base and is endemic to the Ash Meadows of southern Nevada (Sheviak 1989, 1990, Sheviak and Brown 2002).

Geographic Range: When it was first listed under the Endangered Species Act in 1992, *Spiranthes diluvialis* was known only from north-central Colorado, northern and south-central Utah, and southeastern Nevada (Figure 3). Since 1993, Ute ladies'-tresses has been discovered in southeastern Wyoming (Hartman and Nelson 1994), southwestern Montana (Heidel 1996), western Nebraska (Hazlett 1996), eastern Idaho (Moseley 1997), and north-central Washington (Bjork 1997) and new populations have been documented in northwestern Colorado (Ward and Naumann 1998) and northern Utah (Franklin 1993, Stone 1993) (Figure 4). In this same time period, the number of TNC ecoregions* inhabited by Ute ladies'-tresses has increased from six (Central Shortgrass Prairie, Colorado Plateau, Great Basin, Southern Rocky Mountains, Utah-Wyoming Rocky Mountains, and Wyoming Basins) to ten with the addition of the Columbia Plateau, Middle Rockies-Blue Mountains, Northern Great Plains, and Okanogan ecoregions (Figure 5). The number of occupied watersheds has also increased from 15 in 1991 to 38 today.

The location of extant and historical Ute ladies'-tresses populations by state, county, ecoregion, and watershed is summarized in Table 1 and by state below:

Colorado: Prior to 1992, extant populations of Ute ladies'-tresses were known only from Jefferson and Boulder counties along Clear, Boulder, and South Boulder creeks within the Clear and St. Vrain watersheds (Figure 3, Table 1). Historical (and presumed extirpated) occurrences were also known from Weld and El Paso counties (Jennings 1989) in the Middle South Platte-Cherry Creek and Fountain watersheds. Since 1992, additional populations (Figure 4) have been recorded from St. Vrain and Left Hand creeks in Boulder County (St. Vrain

*Ecoregions are biologically-defined geographic units that share comparable climate, topography, and vegetation. Several ecoregional classifications have been proposed for North America, most of which differ in minor details. For this report, we have adopted the classification of The Nature Conservancy (Stein et al. 2000).

Figure 3. Known distribution of Spiranthes diluvialis *in western North America circa January 1992. Populations that were extant at this time are depicted as black circles, while populations that were considered extirpated are marked with an "x". Locations are derived from natural heritage program data and based on standardized element occurrence criteria of NatureServe (2004) (see page 33 for discussion).*

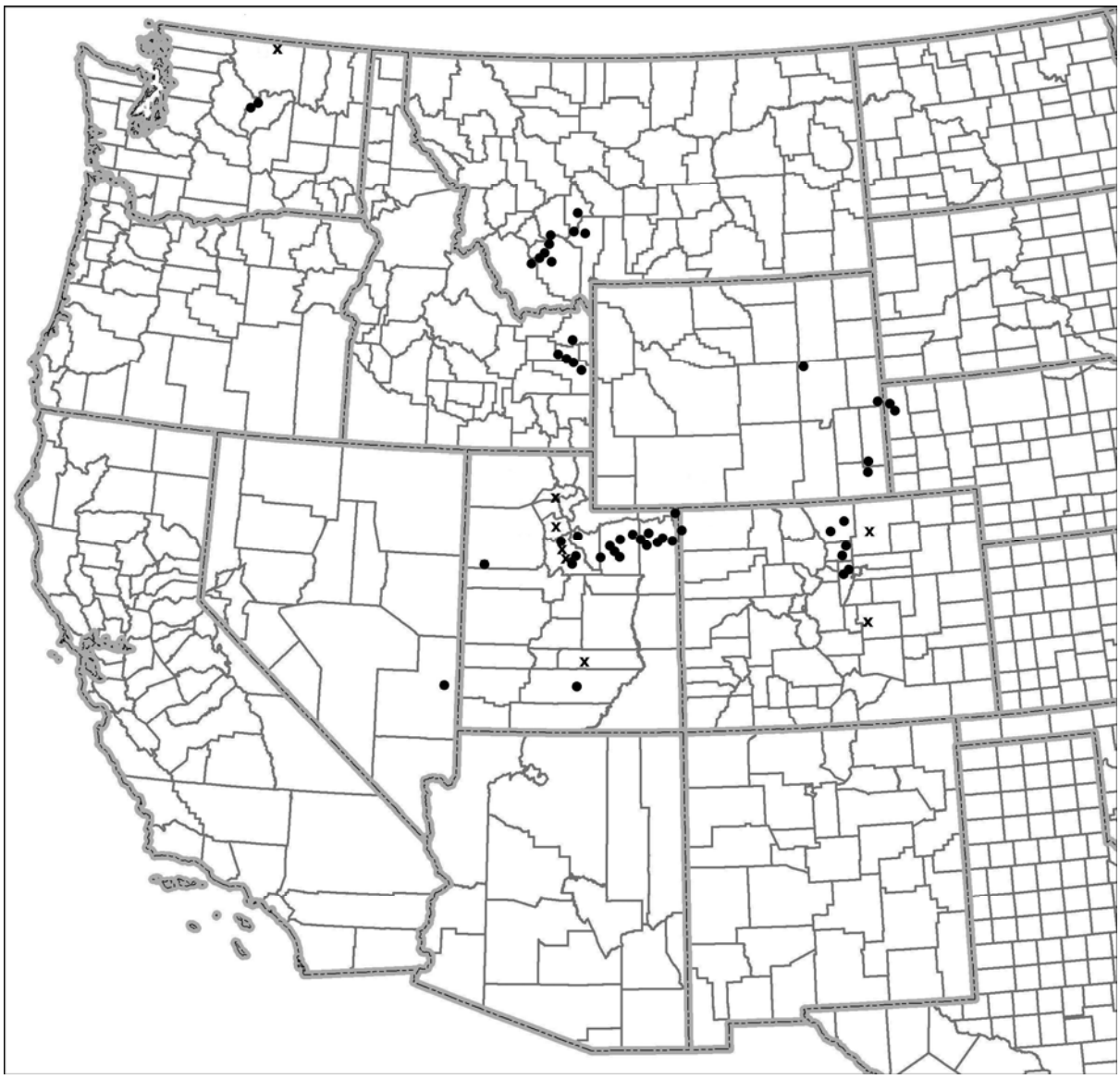

Figure 4. Known distribution of Spiranthes diluvialis *in western North America circa July 2005. Extant populations are indicated by black circles, while extirpated populations are marked by an "x". Locations are derived from natural heritage program data and based on standardized element occurrence criteria of NatureServe (2004) (see page 33 for discussion).*

Figure 5. Known distribution of Spiranthes diluvialis *in western North America by TNC ecoregion (adapted from Stein et al. 2000), circa July 2005. Only those ecoregions containing* S. diluvialis *populations are mapped and labeled. UT-WY RM stands for Utah-Wyoming Rocky Mountains. Locations are derived from natural heritage program data and based on standardized element occurrence criteria of NatureServe (2004) (see page 33 for discussion).*

watershed), Claymore Lake near Fort Collins in Larimer County (Cache La Poudre watershed), and along the Green River from Browns Park through Lodore Canyon in Moffatt County (Upper Green-Flaming Gorge Reservoir watershed) (Colorado Natural Heritage Program EOR data, Ward and Naumann 1998). Extant Colorado populations occur within the Southern Rocky Mountains and Wyoming Basins (Figure 5), and one extirpated site is from the Central Shortgrass Prairie ecoregion.

Idaho: Ute ladies'- tresses was first discovered in Idaho by Mabel Jones in 1996 along the South Fork of the Snake River (Moseley 1997). The species is now known from Bonneville, Fremont, Jefferson, and Madison counties along the Snake River and from wetland sites along the Henry's Fork River (Mancuso 2004, Moseley 1998a, 1998b, 1999a, Murphy 2001a). Idaho populations occur in the Idaho Falls, Palisades, and Lower Henrys watersheds within the Columbia Plateau and Utah-Wyoming Rocky Mountains ecoregions (Table 1, Figures 4, 5).

Montana: No populations of Ute ladies'-tresses were known in Montana until 1994 (Heidel 1996). From 1994-2000, populations were documented in Beaverhead, Broadwater, Gallatin, Jefferson, and Madison counties in the Beaverhead, Gallatin, Jefferson, Madison, Ruby, and Upper Missouri watersheds (Figure 4) (Heidel 1998, Montana Natural Heritage Program records). All known Montana sites occur within the Middle Rockies-Blue Mountains ecoregion (Figure 5).

Nebraska: *Spiranthes diluvialis* was discovered in Nebraska in 1996 (Hazlett 1996). It is presently known only from the Niobrara River in Sioux County (Niobrara headwaters watershed) within the Northern Great Plains ecoregion (Hildebrand 1998) (Table 1, Figures 4, 5).

Nevada: The only known occurrence of Ute ladies'-tresses in Nevada was discovered at "Panaca Spring" in 1936. This site, located within the Meadow Valley Wash watershed in Lincoln County, was not relocated during surveys in 1989 (Coyner 1990) and 1992 (Morefield 1994), and the species was presumed extirpated in the state (US Fish and Wildlife Service 1992). In July 2005, Jim Coyner successfully relocated the Panaca population, demonstrating that *S. diluvialis* is still extant in Nevada (Figure 4)

Utah: Before 1992, extant populations of Ute ladies'-tresses were found in Daggett, Duchesne, Garfield, Uintah, Utah, and Wayne counties and historical occurrences were known from Salt Lake, Tooele, and Weber counties (Coyner 1990, Jennings 1989, US Fish and Wildlife Service 1992) (Figure 3, Table 1). These populations were dispersed across four TNC ecoregions (Colorado Plateau, Great Basin, Utah-Wyoming Rocky Mountains, and Wyoming Basins) (Figure 5) and 10 watersheds (Duchesne, Escalante, Fremont, Jordan, Lower Green, Lower Weber, Southern Great Salt Lake Desert, Spanish Fork, Upper Green-Flaming Gorge Reservoir, and Utah Lake). Since 1992, one **(continued on page 21)**

Table 1. Distribution of Spiranthes diluvialis *populations by state, TNC ecoregion, and watershed. Location and habitat data are derived from state natural heritage program element occurrence records and literature reports (as cited). Each row in the table represents a separate element occurrence or literature report, but some records from the same general vicinity have been aggregated into larger metapopulations following the revised element occurrence standards of NatureServe (2004) (discussed on page 33).*

Location/ Heritage Program Occurrence #		**TNC Ecoregion**	**Watershed**	**Habitat Description/Elevation**	**Yr. First Observed**	**Yr. Last Observed**
Colorado: Weld Co.: Crow Creek, East of Greeley (CO-006, 014)		Central Shortgrass Prairie	Middle South Platte-Cherry Creek	"Abundance of grass, wood, and water" (probably along perennial stream), ca 4560 ft	1856	1856
Colorado: Jefferson Co.: Clear Creek, Wheat Ridge (CO-001)		Southern Rocky Mountains	Clear	Wet meadow along perennial stream, 5400 ft.	1978	2004
Colorado: Jefferson Co.: Clear Creek Canyon	Golden (CO-002)	Southern Rocky Mountains	Clear	Cottonwood-willow-birch riparian graminoid community on floodplain island along perennial stream, 5700 ft.	1980	2004
	Indian Gulch (CO-012)	Southern Rocky Mountains	Clear	Narrowleaf cottonwood/Box-elder community with grassy understory in gulch associated with perennial stream, 6240 ft.	1992	1992
	Clear Creek Canyon (CO-016)	Southern Rocky Mountains	Clear	Wet meadow on terrace of perennial stream, 6200 ft.	1993	1994
	Clear Creek (CO-023)	Southern Rocky Mountains	Clear	Coyote willow-birch community on floodplain island and banks of perennial stream, 5700 ft.	1994	1994
Colorado: Boulder Co.: Boulder Creek	Foothills Parkway (CO-007)	Southern Rocky Mountains	St. Vrain	Wet riparian area in urban setting, 5230 ft.	1988	1990
	CO-018	Southern Rocky Mountains	St. Vrain	Wetland west of gravel pits, 5160 ft.	1993	1993
	CO-028	Southern Rocky Mountains	St. Vrain	Wet meadow on gravelly floodplain of perennial stream, 5150 ft.	1993	2001
	Railroad tracks, Boulder (CO-027)	Southern Rocky Mountains	St. Vrain	Wet meadow on floodplain and old sloughs of perennial stream, 5110 ft.	1992	2000
	CO – Ertl site (Riedel 2005)	Southern Rocky Mountains	St. Vrain	Floodplain meadow.	2001	2004
Colorado: Boulder Co.: South Boulder Creek	CO-005	Southern Rocky Mountains	St. Vrain	Wet meadow on low swales, terraces, and floodplain of perennial stream and irrigated fields, 5280-5460 ft.	1941	2004
	Doudy Draw (CO-017)	Southern Rocky Mountains	St. Vrain	Wet meadow maintained by leaking irrigation ditch, 5740 ft.	1993	2004
Colorado: Boulder Co.: St. Vrain Creek (CO-015)		Southern Rocky Mountains	St. Vrain	Mixed *Populus*, *Salix exigua*, & wet meadows on floodplain of perennial stream, 5050 ft.	1992	1993

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Colorado: Boulder Co.: Left Hand Creek	CO-024	Southern Rocky Mountains	St. Vrain	Wet area being invaded by cottonwood on bench bordering perennial stream, 5480 ft.	1994	1994
	CO-026	Southern Rocky Mountains	St. Vrain	Wet area being invaded by cottonwood on bench bordering perennial stream, 5480 ft.	1994	1994
Colorado: El Paso Co.: Bear or Cheyenne Creek, Colorado Springs ("Camp Harding") (CO-009)		Southern Rocky Mountains	Fountain	Wetland area, 6260 ft (probably along a perennial stream).	1896	1896
Colorado: Larimer Co.: Claymore Lake South, Ft Collins (CO-013)		Southern Rocky Mountains	Cache La Poudre	Subirrigated wet meadow at base of man-made berm, 5130 ft.	1993	1996
Colorado: Moffatt Co.: Browns Park/ Lodore Canyon	Lodore Canyon from Lodore Campground downstream to confluence of Yampa River (CO-025, Ward & Naumann 1998) Wyoming Basins	Wyoming Basins	Upper Green-Flaming Gorge Reservoir	Riparian shrub and meadow communities on post-Flaming Gorge Dam alluvial surfaces along river, 5700-6000 ft.	1995	2004
	South end of Browns Park NWR above Gates of the Lodore (Ward & Naumann 1998)	Wyoming Basins	Upper Green-Flaming Gorge Reservoir	Post-Flaming Gorge Dam banks of river with communities of *Agrostis stolonifera-Equisetum laevigatum*, 6000 ft.	1998	1999
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River	Annis Island (ID-006)	Columbia Plateau	Idaho Falls	*Elaeagnus commutata/Agrostis stolonifera & Equisetum variegatum* community types on island in river floodplain, 4820 ft.	1997	2004
	Lorenzo Levee (ID-008)	Columbia Plateau	Idaho Falls	Moist *Agrostis stolonifera-Carex* meadow along river floodplain, 4840 ft.	1997	1997
	S of Archer (ID-015)	Columbia Plateau	Idaho Falls	*Agrostis stolonifera/Carex* community in openings in *Populus angustifolia* riparian forest along river floodplain, 4920 ft.	1997	1997
	Twin Bridges Island (ID-007)	Columbia Plateau	Idaho Falls	*Elaeagnus commutata/Agrostis stolonifera & Equisetum laevigatum* community types in swales in cottonwood forest along river floodplain, 4945 ft.	1997	2003
	Railroad Island (ID-005)	Columbia Plateau	Idaho Falls	*Equisetum laevigatum & Agrostis stolonifera* community along river floodplain, 4950 ft.	1997	2000
	Kelly's Island (ID-001)	Columbia Plateau	Idaho Falls	Subirrigated *Eleocharis rostellata* meadow on island and river floodplain, 5015 ft.	1996	2004

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Idaho: Bonneville Co.: Upper South Fork Snake River	Island at mouth of Mud Creek (ID-009)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community on gentle slope above river channel, 5100 ft.	1997	2004
	TNC Island, (ID-010)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community on island and river channel, 5095 ft.	1997	2003
	Rattlesnake Point (ID-002)	UT-WY Rocky Mountains	Palisades	Seasonally flooded *Elaeagnus commutata* and *Salix exigua*/mesic graminoid vegetation on island and river floodplain, 5100 ft.	1996	2004
	Warm Springs Bottom (ID-003)	UT-WY Rocky Mountains	Palisades	Mesic *Elaeagnus commutata/ Agrostis stolonifera* community with patches of *Salix exigua & Equisetum laevigatum* communities along river floodplain, 5120 ft.	1996	2004
	Black Canyon (ID-022)	UT-WY Rocky Mountains	Palisades	*Equisetum hyemale, Agrostis stolonifera, & Trifolium repens* wet meadow on post dam cobble & gravel deposits along river floodplain, 5130 ft.	1999	2004
	Lufkin Bottom (ID-011)	UT-WY Rocky Mountains	Palisades	*Equisetum laevigatum & Elaeagnus commutata/Agrostis stolonifera* communities on low terraces & swales on island & river floodplain, 5150 ft.	1997	2004
	Gormer Canyon Camping Area (ID-012)	UT-WY Rocky Mountains	Palisades	*Agrostis stolonifera* meadow in opening in willow thickets along river floodplain, 5150 ft.	1997	1999
	Gormer Canyon Camping Area (ID-013)	UT-WY Rocky Mountains	Palisades	*Agrostis stolonifera* meadow on low terrace bordering dense *Salix exigua/Poa pratensis* community along river floodplain, 5140 ft.	1997	2004
	Gormer Canyon camping area (ID-021)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community in narrow riparian zone of island & side channel of river floodplain, 5200 ft.	1998	2004
	Upstream of Dry Canyon (ID-014)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community along river flooded in 1997 (followed by deep sand deposition), 5200 ft.	1997	2004
continued next page	N of Pine Creek (ID-016)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community along interior channel of river, 5200 ft.	1997	2004
	Across from mouth of Granite Creek (ID-017)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community in old river channel, 5220 ft.	1997	2004

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Idaho: Bonneville Co.: Upper South Fork Snake River	Upper Conant Valley (ID-018)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community along river floodplain, 5240 ft.	1997	2003
	Lower Swan Valley (ID-019)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera* community on island in river, 5270 ft.	1997	2004
	Falls Campground (ID-004)	UT-WY Rocky Mountains	Palisades	Mesic *Elaeagnus commutata/Agrostis stolonifera* community bordering inner channel of river, 5270 ft.	1996	2004
	Squaw Creek islands, Swan Valley (ID-020)	UT-WY Rocky Mountains	Palisades	*Elaeagnus commutata/Agrostis stolonifera & Salix exigua/Poa pratensis* communities in river floodplain, 5315 ft.	1997	1998
Idaho: Fremont Co.: Chester wetlands, Henry's Fork Basin (ID-023)		UT-WY Rocky Mountains	Lower Henrys	*Muhlenbergia richardsonis/Juncus ensifolius/Carex nebrascensis* meadows associated with irrigation ditches, 5030 ft.	2002	2003
Idaho: Madison Co.: Texas Slough – near Thornton (ID-024)		UT-WY Rocky Mountains	Lower Henrys	Irrigated *Elaeagnus commutata* meadow community on seasonally moist banks & swales of slough, 4850 ft.	2003	2003
Montana: Madison Co.: Central Beaverhead River Valley (MT-002)		Middle Rockies-Blue Mtns	Beaverhead	Marl flats along spring-fed subirrigated *Eleocharis pauciflora* meadow, 4785 ft.	1996	1996
Montana: Madison Co.: California Slough (MT-004)		Middle Rockies-Blue Mtns	Beaverhead	Irrigated and spring-fed marl flats along slough and wet meadow dominated by *Carex simulata & Eleocharis pauciflora,* 4700 ft.	1996	1997
Montana: Beaverhead Co.: Albers Slough (MT-011)		Middle Rockies-Blue Mtns	Beaverhead	Wet meadows associated with groundwater-fed swales in river valley, 4950 ft.	1997	1997
Montana: Madison Co.: Ruby River Valley west of Virginia City (MT-006)		Middle Rockies-Blue Mtns	Ruby	Seasonally flooded and subirrigated ditch slopes in highway right-of-way, 5080 ft.	1997	1997
Montana: Jefferson Co.: Piedmont Swamp (MT-001)		Middle Rockies-Blue Mtns	Jefferson	Seasonally flooded and subirrigated alkaline wet meadow in valley bottom, 4350 ft.	1994	2000
Montana: Jefferson Co.: Fish Creek (MT-005)		Middle Rockies-Blue Mtns	Jefferson	Marl peatlands and seep-fed meadows at edge of river valley, 4395 ft.	1996	1997
Montana: Madison Co.: Central Jefferson River Valley (MT-007)		Middle Rockies-Blue Mtns	Jefferson	Subirrigated alkaline meadows, 4460 ft.	1997	1997
Montana: Gallatin Co.: Vicinity of Three Forks	MT-009	Middle Rockies-Blue Mtns	Jefferson	Subirrigated wetland in side channel of river floodplain, 4080 ft.	1997	1997
	MT-012	Middle Rockies-Blue Mtns		Subirrigated borrow pit in valley bottom with meandering wetlands, 4075 ft.	1998	1998
Montana: Gallatin Co.: NE of Three Forks (MT-010)		Middle Rockies-Blue Mtns	Madison	Subirrigated wet meadow in seepage zone above blackwater slough of river, 4050 ft.	1997	1997

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Montana: Broadwater Co.: Missouri River, south of Townsend (MT-003)		Middle Rockies-Blue Mtns	Upper Missouri	Subirrigated wet meadow and borrow pit between highway and railroad in old river oxbow, 3860 ft.	2000	2000
Montana: Gallatin Co.: Gallatin River Valley (MT-008)		Middle Rockies-Blue Mtns	Gallatin	Subirrigated wet meadow, 4220 ft.	1997	1997
Nebraska: Sioux Co.: Niobrara River, SW of Harrison	NE-001	Northern Great Plains	Niobrara headwaters	Subirrigated wet alkaline meadow on alluvial terrace, 4590 ft.	1996	1997
	NE-002	Northern Great Plains	Niobrara headwaters	Subirrigated wet alkaline meadow on alluvial terrace, 4600 ft.	1997	1997
Nevada: Lincoln Co.: Panaca Spring (NV-001)		Great Basin	Meadow Valley Wash	Seep-fed wet meadows in valley bottom, 4750 ft.	1936	2005
Utah: Daggett Co.: Browns Park, vicinity of Jarvie Ranch	UT-005	Wyoming Basins	Upper Green-Flaming Gorge Reservoir	Moist alluvial meadow along abandoned river channel, 5450 ft.	1978	1998
	UT-058	Wyoming Basins	Upper Green-Flaming Gorge Reservoir	Shoreline of seasonally flooded island in river channel, 5455 ft.	1994	1998
	UT-059	Wyoming Basins	Upper Green-Flaming Gorge Reservoir	Boggy wetland bordering river shore, 5425 ft.	1994	1998
Utah: Uintah Co.: Green River, Island Park (UT-044)		Wyoming Basins	Lower Green - Diamond	River floodplain channel and oxbow, 4920 ft.	1993	2004
Utah: Uintah Co.: Lower Hog Canyon/Cub Creek (UT-003)		Wyoming Basins	Lower Green - Diamond	Wet meadow in wash bed, 5400 ft.	1989	1991
Utah: Uintah Co.: Green River below Split Mountain Canyon	Green River Campground (UT-029)	Wyoming Basins	Lower Green - Diamond	Seasonally flooded river bank community, 4800 ft.	1992	1998
	Tributary wash at base of Split Mountain (UT-031)	Wyoming Basins	Lower Green - Diamond	Moist wash bank associated with river tributary, 4850 ft.	1992	1998
	Near Split Mountain Gorge Campground (UT-033)	Wyoming Basins	Lower Green - Diamond	River bank and flood channel, 4800 ft.	1993	1993
Utah: Uintah Co.: “Orchid Draw” WNW of Dinosaur Quarry (UT-030)		Wyoming Basins	Lower Green - Diamond	Moist banks of intermittent stream, 4950 ft.	1991	1991
Utah: Uintah Co.: Steinaker Reservoir, N of Vernal (UT-026)		Wyoming Basins	Ashley-Brush	Irrigated or spring-fed man-made wetland associated with borrow pits, 5470 ft.	1992	1999
Utah: Uintah Co.: Ashley Creek, Vernal (UT-027)		Wyoming Basins	Ashley-Brush	Wetland community along old high-flow channel of perennial stream, 5185 ft.	1992	2002

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Utah: Uintah Co.: Big Brush Creek (UT-028)		Wyoming Basins	Ashley-Brush	Wetland community on moist, sandy soil on banks of perennial stream, 5625 ft.	1992	1994
Utah: Duchesne & Uintah Cos.: Uinta River	Near Whiterocks (UT-006)	Wyoming Basins	Duchesne	Riparian forest/wet meadow on braided channels, point bars, abandoned meanders, and islands of perennial stream, 5550-6320 ft.	1979	2003
	Vicinity of Pole Creek (UT-009)	Wyoming Basins	Duchesne	Mix of riparian shrub & wet meadow veg on alluvial bottomlands and high flow channels of perennial stream, 6640-7000 ft.	1983	1994
	LaPoint Bridge to Daniels Canal (UT-024)	Wyoming Basins	Duchesne	Wetland floodplain of perennial stream, 5300-5500 ft.	1992	1993
	Military Canal diversion (UT-037)	Wyoming Basins	Duchesne	Wetland floodplain of perennial stream, 5150 ft.	1993	1993
	Downstream of Fort Duchesne (UT-060)	Wyoming Basins	Duchesne	Wetland community on channel scar of perennial stream, 4940 ft.	1994	1994
	Upstream of Dry Gulch Creek confluence (UT-061)	Wyoming Basins	Duchesne	Wet meadow on vegetated point bar of perennial stream, 4865 ft.	1994	1994
Utah: Duchesne Co.: Duchesne River	Duchesne River bridge (UT-010)	Wyoming Basins	Duchesne	Riparian community on intermittently flooded stream bank, 5720 ft.	1991	1991
	NNE of Duchesne (UT-011)	Wyoming Basins	Duchesne	Riparian streambank, 5540 ft.	1991	1991
	7.7 miles NNW of Duchesne (UT-017)	Wyoming Basins	Duchesne	Riparian point bars, low floodplains, and high flow channels of perennial stream, 5840 ft.	1992	1992
	Rock Creek Bridge, N of confluence of Rock Creek and Duchesne River (UT-018)	Wyoming Basins	Duchesne	Riparian community along high flow channels of perennial stream, 5145 ft.	1992	1992
	Duchesne (UT-019)	Wyoming Basins	Duchesne	Riparian community on point bar and low floodplain of perennial stream, 5490 ft.	1992	1992
	Duchesne River upstream of Rock Creek (Glisson 2002a)	Wyoming Basins	Duchesne	Early to mid-seral willow or cottonwood communities on oxbows, secondary channels, low floodplains, point bars, and moist banks of perennial stream, 6120-6180 ft.	2002	2002
Utah: Uintah Co.: Whiterocks River (UT-025)		Wyoming Basins	Duchesne	Riparian shrub/wet meadow mosaic on channel banks, floodplains, and islands of perennial stream, 5750-6820 ft.	1992	1994

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Utah: Duchesne Co.: Lake Fork River	Yellowstone/Lake Fork confluence downstream to near Upalco (UT-042)	Wyoming Basins	Duchesne	Mix of riparian forest/shrub/wet meadow veg on alluvial bottomland, channel banks, & side channels of perennial stream, 5500-6920 ft.	1992	1994
	Downstream from Upalco (UT-043)	Wyoming Basins	Duchesne	Wetland community on moist soils along perennial stream, 5200-5500 ft.	1994	1994
Utah: Wasatch & Duchesne Cos.: Currant Creek (UT-034)		UT-WY Rocky Mountains	Strawberry	Wetland community along perennial stream, 6640 ft.	1993	2002
Utah: Weber Co.: Ogden (UT-053)		UT-WY Rocky Mountains	Lower Weber	Wetland, 4400 ft.	1887	1887
Utah: Salt Lake Co.: South Salt Lake (UT-001) [includes Red Butte Canyon?]		UT-WY Rocky Mountains	Jordan	Wet grass meadow, 4300 ft.	1880	1953 (1966?)
Utah: Utah Co.: Utah Lake, "Powell Slough" (UT-004)		UT-WY Rocky Mountains	Utah Lake	Irrigated wet meadow at edge of hay field, 4490 ft.	1925	1994
Utah: Utah Co.: Utah Lake Vineyard (UT-055)		UT-WY Rocky Mountains	Utah Lake	Subirrigated wetland associated with formerly mined peatland, 4510 ft.	1998	2000
Utah: Utah Co.: Utah Lake, American Fork Mill Pond (UT-056)		UT-WY Rocky Mountains	Utah Lake	Spring-fed and irrigated canal banks & marsh adjacent to two-track, 4548 ft.	1998	1998
Utah: Utah Co.: Utah Lake, Lehi wetlands (UT-057)		UT-WY Rocky Mountains	Utah Lake	Subirrigated wet meadow near hummocky fen, 4495 ft.	1998	2000
Utah: Utah Co.: American Fork horse pasture (UT-012)		UT-WY Rocky Mountains	Utah Lake	Subirrigated wet meadow, 4550 ft.	1991	2000
Utah: Utah Co.: Hobble Creek, Springville (Ron Kass, Intermountain Ecosystems, pers. commun., 2005)		UT-WY Rocky Mountains	Utah Lake	Subirrigated *Carex nebrascensis-Juncus balticus* meadow, 4500 ft.	2004	2004
Utah: Utah Co.: Diamond Fork/Spanish Fork	Lower reaches Diamond Fork (UT-013)	UT-WY Rocky Mountains	Spanish Fork	Wet meadows on low floodplains of perennial stream, 5080 ft.	1992	2004
	Mid reaches Diamond Fork	UT-WY Rocky Mountains	Spanish Fork	Wet meadows in floodplain of perennial stream	1992	2004
	Upper reaches Diamond Fork (UT-016)	UT-WY Rocky Mountains	Spanish Fork	Floodplain wetlands along perennial stream, 5460 ft.	1992	2004
	Lower Spanish Fork (UT-014)	UT-WY Rocky Mountains	Spanish Fork	Wet meadows on low floodplains, 4875 ft.	1992	2001
	Upper Spanish Fork (UT-015)	UT-WY Rocky Mountains	Spanish Fork	Wet meadows on low floodplains, 4925 ft.	1992	2001
Utah: Utah Co.: Soldier Creek (SWCA 2002)		UT-WY Rocky Mountains	Spanish Fork	Moist, early seral *Salix lutea/Populus angustifolia* habitat type at edge of small secondary perennial stream channel, 5300 ft.	2001	2001

Location/ Heritage Program Occurrence #		TNC Ecoregion	Watershed	Habitat Description	Yr. First Observed	Yr. Last Observed
Utah: Utah Co.: "Spring Lake" near Payson (UT-051)		UT-WY Rocky Mountains	Spanish Fork	Wetland (probably a subirrigated wet meadow), 4720 ft.	1875	1875
Utah: Wasatch Co.: Middle Provo River	"Reach 8" (UT-032)	UT-WY Rocky Mountains	Provo	Riparian scrub and openings in young *Populus angustifolia* stands on abandoned meanders of managed river system, 5720-5760 ft.	1993	2004
	"Reach 5" (UT-054)	UT-WY Rocky Mountains	Provo	Wetland along managed river system, 5580 ft.	1997	2004
Utah: Tooele Co.: Willow Springs Station, near Callao (UT-002)		Great Basin	Southern Great Salt Lake Desert	Wet meadow irrigated by freshwater springs, 4325 ft.	1956	1994
Utah: Garfield Co.: Deer Creek, SE of Boulder (UT-007)		Colorado Plateau	Escalante	Moist meadow on sandy terrace bordering perennial stream, 5680 ft.	1977	2004
Utah: Wayne Co.: Fremont River oxbow, Capitol Reef NP (UT-008)		Colorado Plateau	Fremont	Abandoned ox-bow of perennial stream, 5100 ft.	1977	1995
Washington: Okanogan Co.: Wannacut Lake (WA-001)		Okanogan	Okanogan	Periodically flooded, moist meadow on alkaline flat bordering lake, 1830 ft.	1997	1998
Washington: Chelan Co.: Columbia River	Gallagher Flats (WA-002).	Columbia Plateau	Chief Joseph	Seasonally flooded, moist meadow on gravel bar bordering reservoir, 720 ft.	2000	2004
	Rocky Reach- mile 505.5 and Chelan Pond (WA-003)	Columbia Plateau	Chief Joseph	Moist meadow bordering small pond and partially wooded riparian community above high water line on reservoir bank, 720 ft.	2000	2004
	Howard Flats (WA-004)	Columbia Plateau	Chief Joseph	Seasonally flooded moist meadow near shore of reservoir, 720 ft.	2000	2004
Wyoming: Goshen Co.: Bear Creek SE of Chugwater (WY-001)		Central Shortgrass Prairie	Horse	Wet, spring-fed alkaline meadows and terraces bordering perennial stream, 5160 - 5180 ft.	1993	2004
Wyoming: Laramie Co.: vicinity of Midway & Meriden (WY-004)		Central Shortgrass Prairie	Horse	Wet, alkaline meadow on bank of perennial stream at edge of hay field, 5420 ft.	1997	1998
Wyoming: Converse Co.: Antelope Creek SW of Ross (WY-002)		Northern Great Plains	Antelope	Wet meadow on perennial stream bank on non-alkaline sandy soil, 5100 ft.	1994	2004
Wyoming: Niobrara Co.: Between Lusk and Van Tassell (WY-003)		Northern Great Plains	Niobrara headwaters	Wet, alkaline meadow on terrace and old ox-bows of perennial stream, 4750 ft.	1996	1998

historical location has been relocated (Tooele County) and one dozen new sites have been documented along the Wasatch Front and the Uinta Basin (Coyner and Hreha 1995, Franklin 1993, Riedel 1992, Stone 1993, SWCA 2002). These new discoveries extend the known range of *Spiranthes diluvialis* into Wasatch County and the Ashley-Brush, Provo, and Strawberry watersheds (Table 1).

Washington: *Spiranthes diluvialis* was first discovered in Washington at Wannacut Lake in Okanogan County (also in the Okanogan watershed and ecoregion) in 1997 (Bjork 1997). In 2000, the species was also found along a reservoir bordering the Columbia River near Chelan in Chelan County (Chief Joseph watershed) within the Columbia Plateau ecoregion (Figures 4, 5).

Wyoming: B. Ernie Nelson located the first population of Ute ladies'-tresses in Wyoming along Bear Creek (Goshen County, Horse watershed) in 1993 (Hartman and Nelson 1994). In subsequent years, additional colonies were located in Converse, Laramie, and Niobrara counties in the Antelope and Niobrara Headwaters watersheds (Fertig 2000) (Figure 4, Table 1). Wyoming populations are divided between the Northern Great Plains and Central Shortgrass Prairie ecoregions (Figure 5).

Habitat: When Ute ladies'-tresses was listed in 1992 it was known primarily from moist meadows associated with perennial stream terraces, floodplains, and oxbows at elevations between 4300-6850 feet (1310-2090 meters) (Coyner 1990, Jennings 1989, US Fish and Wildlife Service 1992). Most sites were reported from openings where vegetation cover was not overly dense or heavily grazed (US Fish and Wildlife Service 1992), although at least one Colorado population was known from Narrowleaf cottonwood-River birch-Box-elder riparian woodlands with a grassy understory. Two historical occurrences from the Great Basin of Nevada and Utah were reported from spring-fed desert wetlands (Coyner 1990). All populations occurred within agricultural or urban settings and those that were still extant were presumed to be relictual in nature, persisting only where moist conditions prevailed and in sites that had not been greatly altered by human activity (Jennings 1989, US Fish and Wildlife Service 1992).

Surveys since 1992 have expanded the number of vegetation and hydrology types occupied by Ute ladies'-tresses to include seasonally flooded river terraces, subirrigated or spring-fed abandoned stream channels and valleys, and lakeshores. In addition, 26 populations have been discovered along irrigation canals, berms, levees, irrigated meadows, excavated gravel pits, roadside barrow pits, reservoirs, and other human-modified wetlands. New surveys have also expanded the elevational range of the species from 720-1830 feet (220-558 meters) in Washington to 7000 feet (2134 meters) in northern Utah.

The following is a summary of each of the major hydrology and habitat types (Tables 2 and 3) occupied by *Spiranthes diluvialis* across its range:

Perennial Streams: Over one-third of all known Ute ladies'-tresses populations are found on alluvial banks, point bars, floodplains, or ox-bows associated with perennial streams (Jennings 1989, Riedel 2002) (Table 2). These habitats occur most frequently in the foothills of the southern Rocky Mountains and Wasatch Front, Colorado Plateau, and the western Great Plains in Colorado, Utah, Nebraska, and Wyoming (Tables 2 and 3). Ward and Naumann (1998) note that many streamside sites occupied by *S. diluvialis* are found at the base of mountain ranges in wide valleys where formerly confined stream reaches become unconfined and free to meander. Periodic flood events rework alluvial bars and terraces within these stream systems to create early successional conditions conducive to the establishment or persistence of Ute ladies'-tresses colonies. Nearly all streambank, floodplain, and abandoned ox-bow sites have a high water table (usually within 12.5- 45 cm of the surface) augmented by seasonal flooding, snowmelt, runoff, and often irrigation (Arft 1995, Black et al. 1999, Jennings 1989, Riedel 2002). In mountain streams, depth to water table is strongly correlated with rates of stream flow (Black et al. 1999, Woodward-Clyde 1996).

Streamside populations of Ute ladies'-tresses typically occur on shallow sandy loam, silty-loam, or clayey-silt alluvial soils overlying more permeable cobbles, gravels, and sediments (Coyner & Hreha 1995, Jennings 1989, Riedel 2002). Soil pH ranges from slightly acidic (pH 6.6) along Clear Creek in Colorado (Arft 1995) to slightly alkaline (pH over 8.1) in sites in Nebraska and Utah (Coyner & Hreha 1995, Hildebrand 1998). Jennings (1990) and Arft (1995) report that growth and reproduction of *Spiranthes diluvialis* may be inhibited by increased alkalinity. Coyner and Hreha (1995) found electrical conductivity to range from 0.3-3.5 mmhos/cm for all but two populations sampled in Utah, indicating that these soils are not saline. The amount of organic matter in soils is variable, ranging from 1.2-2.9% in less fertile sites to 10-26% in wetter areas (Arft 1995, Coyner & Hreha 1995, Hildebrand 1998). Relative to agricultural soils, many sampled sites tend to be higher in soil nutrients (zinc, manganese, iron, copper and often potassium) but lower in nitrates (Hildebrand 1998).

Most streamside populations are dominated by perennial graminoids and forbs, particularly *Agrostis stolonifera, Elymus repens, Juncus balticus,* and *Equisetum laevigatum* (see Table 4 for complete list of species commonly associated with *S. diluvialis* across its range). These habitats typically have short vegetative cover maintained by grazing, periodic flooding, or mowing. In the absence of disturbance or as sites become drier, streamside wet meadow habitats may become encroached by riparian shrub or woodland vegetation dominated by *Salix exigua, Populus angustifolia,* or *Betula occidentalis*. Ute ladies'-tresses populations may persist for a short time in the grassy understory of woody riparian shrublands, but do not appear to thrive under these conditions (Ward and Naumann 1998).

Table 2. Hydrology and management status of known Spiranthes diluvialis *populations. Location, hydrology, and management data are derived from state natural heritage program element occurrence records and literature reports (as cited). Each row in the table represents a population based on the revised element occurrence criteria of NatureServe (2004) (see text on page 33 for discussion).*

Location/ Heritage Program Occurrence #	Hydrology	Management
Colorado: Weld Co.: Crow Creek, East of Greeley (CO-006, 014)	Perennial stream	Unknown
Colorado: Jefferson Co.: Clear Creek, Wheat Ridge (CO-001)	Perennial stream	Managed- dams or reservoirs
Colorado: Jefferson Co.: Clear Creek Canyon (CO-002, 012, 016, 023)	Perennial stream	Unmanaged
Colorado: Boulder Co.: Boulder Creek (CO-007, 018, 028, 027, Ertl site)	Perennial stream	Supplemental irrigation
Colorado: Boulder Co.: South Boulder Creek (CO-005, 017)	Perennial stream	Supplemental irrigation
Colorado: Boulder Co.: St. Vrain Creek (CO-015)	Perennial stream	Managed- dams or reservoirs
Colorado: Boulder Co.: Left Hand Creek (CO-024, 026)	Perennial stream	Managed- dams or reservoirs
Colorado: El Paso Co.: Bear or Cheyenne Creek, Colorado Springs ("Camp Harding") (CO-009)	Perennial stream	Unknown
Colorado: Larimer Co.: Claymore Lake South, Ft Collins (CO-013)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Colorado: Moffatt Co.: Browns Park/ Lodore Canyon (CO-025, Ward & Naumann 1998)	River	Managed- dams or reservoirs
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River (ID-006, 008, 015, 007, 005, 001)	River	Managed- dams or reservoirs
Idaho: Bonneville Co.: Upper South Fork Snake River (ID-009, 010, 002, 003, 022, 011, 012, 013, 021, 014, 016, 017, 018, 019, 004, 020)	River	Managed- dams or reservoirs
Idaho: Fremont Co.: Chester wetlands, Henry's Fork Basin (ID-023)	Groundwater-fed spring or subirrigated meadow	Supplemental irrigation
Idaho: Madison Co.: Texas Slough – near Thornton (ID-024)	River	Supplemental irrigation
Montana: Madison Co.: Central Beaverhead River Valley (MT-002)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Madison Co.: California Slough (MT-004)	Groundwater-fed spring or subirrigated meadow	Supplemental irrigation
Montana: Beaverhead Co.: Albers Slough (MT-011)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Madison Co.: Ruby River Valley west of Virginia City (MT-006)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Jefferson Co.: Piedmont Swamp (MT-001)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Jefferson Co.: Fish Creek (MT-005)	Groundwater-fed spring or subirrigated meadow	Unmanaged

Location/ Heritage Program Occurrence #	Hydrology	Management
Montana: Madison Co.: Central Jefferson River Valley (MT-007)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Gallatin Co.: Vicinity of Three Forks (MT-009, 012)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Gallatin Co.: NE of Three Forks (MT-010)	River	Unmanaged
Montana: Broadwater Co.: Missouri River, south of Townsend (MT-003)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Montana: Gallatin Co.: Gallatin River Valley (MT-008)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Nebraska: Sioux Co.: Niobrara River, SW of Harrison (NE-001, 002)	Perennial stream	Supplemental irrigation
Nevada: Lincoln Co.: "Panaca Spring" – Upper Meadow Valley Wash (NV-001)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Utah: Daggett Co.: Browns Park, vicinity of Jarvie Ranch (UT-005, 058, 059)	River	Managed- dams or reservoirs
Utah: Uintah Co.: Green River, Island Park (UT-044)	River	Managed- dams or reservoirs
Utah: Uintah Co.: Lower Hog Canyon/Cub Creek (UT-003)	Perennial stream	Unmanaged
Utah: Uintah Co.: Green River below Split Mountain Canyon (UT-029, 031, 033)	River	Managed- dams or reservoirs
Utah: Uintah Co.: "Orchid Draw" WNW of Dinosaur Quarry (UT-030)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Utah: Uintah Co.: Steinaker Reservoir, N of Vernal (UT-026)	Groundwater-fed spring or subirrigated meadow	Supplemental irrigation
Utah: Uintah Co.: Ashley Creek, Vernal (UT-027)	Perennial stream	Managed- dams or reservoirs
Utah: Uintah Co.: Big Brush Creek (UT-028)	Perennial stream	Managed- dams or reservoirs
Utah: Duchesne & Uintah Cos.: Uinta River (UT-006, 009, 024, 037, 060, 061)	River	Managed- dams or reservoirs
Utah: Duchesne Co.: Duchesne River (UT-010, 011, 017, 018, 019, Glisson 2002a)	River	Managed- dams or reservoirs
Utah: Uintah Co.: Whiterocks River (UT-025)	River	Managed- dams or reservoirs
Utah: Duchesne Co.: Lake Fork River (UT-042, 043)	River	Managed- dams or reservoirs
Utah: Wasatch & Duchesne Cos.: Currant Creek (UT-034)	Perennial stream	Managed- dams or reservoirs
Utah: Weber Co.: Ogden (UT-053)	Groundwater-fed spring or subirrigated meadow	Unknown
Utah: Salt Lake Co.: South Salt Lake (UT-001) [includes Red Butte Canyon?]	Groundwater-fed spring or subirrigated meadow	Unknown
Utah: Utah Co.: Utah Lake, "Powell Slough" (UT-004)	Groundwater-fed spring or subirrigated meadow	Supplemental irrigation
Utah: Utah Co.: Utah Lake Vineyard (UT-055)	Groundwater-fed spring or subirrigated meadow	Supplemental irrigation
Utah: Utah Co.: Utah Lake, American Fork Mill Pond (UT-056)	Groundwater-fed spring or subirrigated meadow	Unmanaged

Location/ Heritage Program Occurrence #	Hydrology	Management
Utah: Utah Co.: Utah Lake, Lehi wetlands (UT-057)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Utah: Utah Co.: American Fork horse pasture (UT-012)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Utah: Utah Co.: Hobble Creek, Springville (Ron Kass, Intermountain Ecosystems, pers. commun., 2005)	Perennial stream	Supplemental irrigation
Utah: Utah Co.: Diamond Fork/Spanish Fork (UT-013, 016, 014, 015, Black & Gruwell 2004)	Perennial stream	Managed- dams or reservoirs
Utah: Utah Co.: Soldier Creek (SWCA 2002)	Perennial stream	Unmanaged
Utah: Utah Co.: "Spring Lake" near Payson (UT-051)	Groundwater-fed spring or subirrigated meadow	Unknown
Utah: Wasatch Co.: Middle Provo River (UT-032, 054)	River	Managed- dams or reservoirs
Utah: Tooele Co.: Willow Springs Station, near Callao (UT-002)	Groundwater-fed spring or subirrigated meadow	Unmanaged
Utah: Garfield Co.: Deer Creek, SE of Boulder (UT-007)	Perennial stream	Unmanaged
Utah: Wayne Co.: Fremont River oxbow, Capitol Reef NP (UT-008)	Perennial stream	Managed- dams or reservoirs
Washington: Okanogan Co.: Wannacut Lake (WA-001)	Lakeshore	Managed- dams or reservoirs
Washington: Chelan Co.: Columbia River (WA-002, 003, 004)	Lakeshore	Managed- dams or reservoirs
Wyoming: Goshen Co.: Bear Creek SE of Chugwater (WY-001)	Perennial stream	Managed- dams or reservoirs
Wyoming: Laramie Co.: vicinity of Midway & Meriden (WY-004)	Perennial stream	Unmanaged
Wyoming: Converse Co.: Antelope Creek SW of Ross (WY-002)	Perennial stream	Unmanaged
Wyoming: Niobrara Co.: Between Lusk and Van Tassell (WY-003)	Perennial stream	Managed- dams or reservoirs

Rivers: River floodplain habitats resemble those associated with perennial streams but experience regular spring flooding and frequent large scale floods that both create new sandbars and terraces and bury or eliminate existing surfaces. This habitat type occurs along the Green River and its tributaries in Colorado and Utah, the South Fork and Henrys Fork of the Snake River in Idaho, and the Missouri River system in southwest Montana (Franklin 1993, Heidel 1998, Moseley 1997, 1999a, Stone 1993, Ward and Naumann 1998). Nearly all (92%) of these sites are now regulated by dams which have altered their historic flooding dynamics (Moseley 2000). Along the Green River, *Spiranthes diluvialis* populations occur primarily along unconfined and meandering reaches where flow rates are slow enough to allow deposition of sediments (Ward and Naumann 1998). Historically, these conditions existed primarily in Browns Park and Island Park, while Lodore Canyon itself probably had few areas of suitable *S. diluvialis* habitat due to high flows that prevented alluvial terraces from being formed or

Table 3. Summary of Ute ladies'-tresses populations by state and general hydrology/ management types. The number of populations is based on revised element occurrence criteria of NatureServe (2004). Hydrology data derived from state natural heritage program element occurrence records. Unmanaged sites have their natural hydrology intact. Managed sites have had their natural hydrology altered by dams, reservoirs, or supplemental irrigation. Unknown sites are typically historic populations in which the hydrologic state is not known.

Hydrology & Management Type		State								Total
		CO	ID	MT	NE	NV	UT	WA	WY	
Perennial Stream	**Unmanaged**	2	0	0	0	0	3	0	2	7
	Managed	5	0	0	1	0	6	0	2	14
	Unknown	1	0	0	0	0	0	0	0	1
River	**Unmanaged**	0	0	1	0	0	0	0	0	1
	Managed	1	3	0	0	0	8	0	0	12
Lakeshore	**Unmanaged**	0	0	0	0	0	0	0	0	0
	Managed	0	0	0	0	0	0	2	0	2
Groundwater-fed spring or subirrigated meadow	**Unmanaged**	1	0	9	0	1	5	0	0	16
	Managed	0	1	1	0	0	3	0	0	5
	Unknown	0	0	0	0	0	3	0	0	3
Total		10	4	11	1	1	28	2	4	61

maintained for a sufficient time to allow vegetation to become established (Ward and Naumann 1998). With the construction of Flaming Gorge Dam in 1962, the former meanders of Browns Park have become more channelized and the subsequent drop in water table has made adjacent wet meadow communities too dry to support extensive Ute ladies'-tresses populations. In contrast, reduced flows in Lodore Canyon since 1962 have allowed new alluvial terraces to develop (especially in less confined reaches associated with large tributary washes) which over time have become colonized by Ute ladies'-tresses and other riparian species (Ward and Naumann 1998). Today, *S. diluvialis* populations occur on level, post-dam floodplains that average 0.8 meters above baseflow water levels (and which are flooded each spring) as well as slightly higher sandy benches up to 1.9 meters above base flow that flood only in infrequent high-water events (such as the 1983 flood) (Ward and Naumann 1998). Small, relictual orchid populations may still occur on older, pre-dam surfaces in Lodore Canyon, but current flood levels are probably insufficient to maintain early to mid seral conditions favorable for new *S. diluvialis* establishment (Ward and Naumann 1998).

Based on historic photos, inferred successional sequences, and lead isotope dating, researchers believe that most Ute ladies'-tresses populations in Idaho are found on alluvial surfaces that formed before Palisades Dam was completed in 1956 (Moseley 2000, Murphy 2001b). Populations **text continued on page 31**

Table 4. Vascular plant species commonly associated with Spiranthes diluvialis *by state. Non-native species are indicated by *. Data derived from Heritage Program element occurrence records and Arft (1995), Fertig (2000), Heidel (1998), Hildebrand (1998), Murphy (2001a), Pierson and Tepedino (2000), Riedel (2002), and Ward and Naumann (1998). Pertinent synonyms are included in [ ].*

Species	**CO**	**ID**	**MT**	**NE**	**NV**	**UT**	**WA**	**WY**
Acer negundo	X							
Achillea millefolium				X		X		
Agalinis tenuifolia var. *parviflora*	X			X				X
**Agrostis stolonifera* [*A. alba, A. gigantea*]	X	X	X	X		X	X	X
Alisma triviale								X
Alnus incana	X					X		
Alopecurus aequalis	X							
Ambrosia psilostachya						X		
Ambrosia trifida								X
Andropogon gerardii	X							
Apocynum cannabinum	X					X		
**Arctium minus*						X		
Artemisia ludoviciana							X	
Asclepias incarnata	X							
Asclepias speciosa	X	X				X		
Aster ascendens [*Symphyotrichum ascendens*]		X						
Aster ericoides var. *pansus [A. pansus, Symphyotrichum ericoides* var. *pansum*]				X				X
Aster falcatus [*Symphyotrichum falcatum*]			X					X
Aster frondosus [*S. frondosum*]						X		
Aster lanceolatus [*Aster hesperius, Symphyotrichum lanceolatum*]	X	X	X	X		X		X
Aster occidentalis [*Aster spathulatus, Symphyotrichum spathulatum*]		X	X				X	
**Astragalus cicer*						X		
Astragalus robbinsii			X					
Atriplex subspicata				X				X
Betula occidentalis	X	X				X		
Bidens comosa								X
Bidens frondosa				X		X		X
**Bromus inermis* var. *inermis*				X				X
Calamagrostis canadensis						X		
Calamagrostis inexpansa		X	X					X
Calamagrostis stricta [*C. neglecta*]		X		X				
**Carduus nutans*		X				X		
Carex aquatilis						X		
Carex aurea	X			X		X		
Carex douglasii	X							
Carex emoryi	X							
Carex pellita [*C. lanuginosa*]	X	X		X		X	X	X
Carex nebrascensis	X	X		X		X		X
Carex parryana			X					
Carex praegracilis			X	X				

Species	CO	ID	MT	NE	NV	UT	WA	WY
Carex rostrata [*C. utriculata*]						X		
Carex scirpoidea			X					
Carex simulata	X		X					
Carex viridula							X	
Carex vulpinoidea	X							
Castilleja exilis	X	X	X		X	X		
**Centaurea diffusa*		X						
**Centaurea maculosa*		X	X					
** Centaurea repens*			X					
**Chenopodium album*				X				
Chenopodium rubrum var. *rubrum*								X
**Cichorium intybus*	X							
Cicuta maculata						X		
**Cirsium arvense* [*Breea arvensis*]	X	X	X			X		
Cirsium canescens								X
**Cirsium vulgare*						X		
Conyza canadensis	X							
Coreopsis atkinsoniana							X	
Cornus sericea [*C. stolonifera*]		X				X		
Crepis runcinata				X				
Cuscuta indecora								X
**Dactylis glomerata*	X					X		
Deschampsia cespitosa			X			X		X
**Descurainia sophia*				X		X		
**Dianthus armeria*	X							
Dichanthelium acuminatum [*Panicum acuminatum, P. occidentale*]				X			X	
**Dipsacus fullonum*	X							
Distichlis spicata var. *stricta* [*D. stricta*]				X				
Echinochloa muricata								X
**Elaeagnus angustifolia*	X	X				X		
Elaeagnus commutata		X						
Eleocharis acicularis	X							
Eleocharis palustris [*E. erythropoda*]	X			X		X		
Eleocharis pauciflora		X	X					X
Eleocharis rostellata		X				X	X	
Elymus canadensis						X		X
**Elymus elongatus*				X				
Elymus lanceolatus								X
**Elymus repens*						X		X
Elymus smithii	X							
Elymus trachycaulus var. *trachycaulus* [*Agropyron caninum*]			X	X				
Epilobium ciliatum		X				X		
Epilobium palustre var. gracile [*E. leptophyllum*]				X				X
Equisetum arvense	X	X		X		X		
Equisetum [*Hippochaete*] *hyemale*	X	X				X		
Equisetum [*Hippochaete*] *laevigatum*	X	X	X	X		X		X
Equisetum variegatum		X						
Erigeron lonchophyllus						X		X

Species	CO	ID	MT	NE	NV	UT	WA	WY
**Erodium cicutarium*						X		
Eustoma grandiflorum	X							
**Festuca pratensis* [*F. elatior*]	X	X	X					
Galium trifidum								X
Geum macrophyllum						X		
Glaux maritima	X		X			X		
Gentianella amarella			X					X
Glyceria grandis						X		
Glycyrrhiza lepidota	X	X	X	X		X		X
Gnaphalium chilense						X		
Helenium autumnale	X							
Helianthus annuus						X		
Helianthus nuttallii	X			X		X		X
Hordeum jubatum	X					X		X
**Hypericum perforatum*							X	
Juncus balticus [*J. arcticus*]	X	X	X	X		X		X
Juncus confusus	X							
Juncus ensifolius [*J. saximontanus*]	X	X				X		
Juncus longistylis	X	X	X	X				X
Juncus nevadensis		X						
Juncus nodosus			X					X
Juncus tenuis var. *dudleyi* [*J. dudleyi*]	X	X		X				
Juncus torreyi	X					X	X	X
**Lepidium latifolium*						X		
Lobelia siphilitica	X							
Lonicera involucrata						X		
**Lotus corniculatus* [*L. tenuis*]	X						X	
Lycopus americanus	X			X		X		X
Lycopus asper				X				X
**Lythrum salicaria*	X							
Machaeranthera canescens	X							
**Malva neglecta*						X		
**Medicago lupulina*		X				X		X
**Medicago sativa*						X		
**Melilotus alba*	X	X		X		X	X	X
**Melilotus officinalis*				X		X		X
Mentha arvensis	X	X				X		
**Mentha spicata*						X		
Mimulus glabratus	X							
Muhlenbergia asperifolia	X	X	X	X		X	X	X
Muhlenbergia filiformis			X					
Muhlenbergia richardsonis		X	X					
**Myosotis scorpioides*		X						
Oenothera elata	X					X		
Orthocarpus luteus								X
Panicum capillare							X	
Panicum virgatum	X			X				X
Parnassia palustris						X		X
Pedicularis crenulata								X
Phalaris arundinacea	X	X		X		X	X	
**Phleum pratense*	X	X		X		X		X

Species	**CO**	**ID**	**MT**	**NE**	**NV**	**UT**	**WA**	**WY**
Phlox kelseyi			X					
Phragmites australis	X					X		
Plantago eriopoda	X			X				
**Plantago lanceolata*	X						X	
**Plantago major*		X						X
Platanthera [*Habenaria*] *dilatata*		X						X
Platanthera [*Habenaria, Limnorchis*] *hyperborea*	X		X			X		
Platanthera [*Habenaria, Limnorchis*] *stricta*	X							
Poa arida				X				
**Poa compressa*	X						X	
Poa juncifolia				X				
**Poa pratensis*	X	X	X	X		X		
Polygonum amphibium [*P. coccineum*]	X							
**Polygonum lapathifolium*		X						
Polygonum ramosissimum								X
**Polypogon monspeliensis*				X				
Populus angustifolia	X	X				X		
Populus deltoides	X							
Populus fremontii						X		
Potentilla anserina	X	X	X				X	
Primula incana			X					
Prunella vulgaris	X	X				X		
Ranunculus cymbalaria				X		X		X
Rhus aromatica [*R. trilobata*]						X		
Rosa woodsii	X	X				X		
**Rumex crispus*	X							
Salix bebbiana		X						
Salix boothii		X				X		
Salix exigua	X	X				X		
Salix lucida [*S. lasiandra*]						X		
Salix lutea [*S. eriocephala* var. *watsonii*]		X				X		
Schizachyrium [*Andropogon*] *scoparium*	X							
Scirpus [*Schoenoplectus*] *acutus*	X					X		
Scirpus [*Schoenoplectus*] *pungens*	X			X				X
Scirpus validus [*Schoenoplectus tabernaemontani*]				X				X
Shepherdia argentea						X		
Sisyrinchium angustifolium								X
Sisyrinchium demissum						X		
Sisyrinchium montanum	X			X				X
Sium suave								X
Smilacina [*Maianthemum*] *stellata*						X		
Solidago canadensis	X					X	X	X
Solidago missouriensis		X						
Solidago [*Euthamia*] *occidentalis*	X	X				X		
**Sonchus arvensis*		X				X		
**Sonchus uliginosus*	X			X				X
Sorghastrum nutans [*S. avenaceum*]	X							

Species	CO	ID	MT	NE	NV	UT	WA	WY
Sparganium emersum								X
Spartina gracilis				X				X
Spartina pectinata	X					X		
Sphenopholis obtusata			X					
Spiranthes romanzoffiana		X				X		
Stachys palustris var. *pilosa*						X		X
Suaeda calceoliformis [*S. depressa*]				X				X
**Tamarix chinensis*	X							
**Taraxacum laevigatum*				X				
**Taraxacum officinale*		X						
Thelypodium integrifolium								X
Toxicodendron rydbergii	X					X		
**Tragopogon dubius*						X		
**Trifolium fragiferum*			X					
**Trifolium pratense*	X	X		X		X		X
**Trifolium repens*	X	X		X		X		
Triglochin maritima var. *elata*	X	X	X	X		X		X
Triglochin palustris			X					
Typha latifolia				X		X		X
**Verbascum thapsus*						X		
Verbena hastata	X							
Viola sp.		X						
Xanthium strumarium						X		

may occur within 0.4-1.2 meters of the baseflow water level within the typical spring flood zone (usually 20,000 cfs) or on higher terraces that are only rarely flooded in extreme high water events (such as the summer 1997 flood with 43,000 cfs) (Moseley 2000). One population at Black Canyon is found on a cobble bar that formed after Palisades Dam was completed. This site is frequently flooded but scouring is reduced due to the presence of willow vegetation (Murphy 2000, 2001b). At least two other colonies along the Snake River are found on levees built in the last 40 years.

Spiranthes diluvialis populations found on seasonally inundated river floodplains typically occur on clayey-sand beds, sandy point bars, or thin alluvium over large cobbles (Ward and Naumann 1998, Western Wetland Systems 1998, Moseley 2000). Soils that are saturated much of the year may develop mottles or gleying (Moseley 2000). Higher benches that are infrequently flooded typically are comprised of cross-bedded sand or deeper loamy sand deposits over cobbles. Moseley (2000) found that depth to water table along the Snake River averaged 60 cm, but ranged from 1-110 cm. Ward and Naumann (1998) found that soils had to be sufficiently stable and moist in the summer flowering season to support *S. diluvialis* occurrences.

Green River populations of Ute ladies-tresses are found primarily in mid-seral moist meadow communities on floodplain terraces dominated by *Agrostis*

stolonifera, Equisetum laevigatum, various forbs, or scattered stands of *Salix exigua*. Higher terraces are often dominated by *Populus angustifolia-Acer negundo* woodlands and riparian shrub vegetation (Ward and Naumann 1998). *S. diluvialis* populations along the Snake River are frequently associated with *Elaeagnus commutata* or *Salix exigua* shrublands intermixed with mesic *Agrostis stolonifera* or *Carex* meadows. Wetter or earlier seral sites may be dominated by *Equisetum laevigatum* (Moseley 1998a, 1998b, 2000). Occasionally, Ute ladies-tresses are also found in moist swales within *Populus angustifolia-Cornus sericea* woodlands, or along the banks of backwater sloughs. Habitat trend monitoring in Idaho has documented short-term increases in woody cover at several *Spiranthes* locations, which if not affected by flood events may lead to loss of suitable orchid habitat (Murphy 2004a).

Lakeshore/Reservoirs: Both Ute ladies'-tresses occurrences in Washington are associated with lakes or reservoirs. The Wannacut Lake population (Okanogan ecoregion) is found on alkaline and moderately salty flats that have been exposed as the lake level fluctuates in response to drought. Associated species at this site include *Eleocharis rostellata, Carex pellita, C. viridula, Muhlenbergia asperifolia, Panicum capillare,* and *Juncus torreyi* (Bjork 1997). The Columbia Plateau population is distributed along the shore of Rocky Reach Reservoir and a small pond adjacent to the Columbia River on seasonally flooded low-lying gravel bars. Soils are moist silty-loams over rounded cobbles and support mesic meadow vegetation dominated by *Agrostis stolonifera, Dichanthelium acuminatum, Phalaris arundinacea,* and *Poa compressa*. Frequent flooding and a high water table maintain the vegetation at this site in an early mid-seral state.

Groundwater-fed springs or subirrigated meadows: Twenty-four populations of Ute ladies'-tresses are associated with spring-fed or subirrigated moist meadow habitats in southwest Montana, eastern Colorado, Idaho, northern Utah, and Nevada. In Montana, groundwater-irrigated wet meadows occur in depressions, valley bottoms, and swampy lowlands characterized by a high water table and silty to loamy calcic soils with surface accumulations of crumbly, limey, marl (Heidel 1998, 2001). These wetlands mostly occur well outside of active river and stream channels and are not directly impacted by seasonal or periodic flooding events. Vegetation associated with marl-rich wet meadows is dominated by *Eleocharis pauciflora, Carex simulata, Muhlenbergia richardsonis, Juncus balticus,* and *Triglochin maritima* and often occurs within somewhat drier *Sporobolus airoides-Distichlis stricta-Sarcobatus vermiculatus* vegetation (Heidel 1998, 2001, Jones 2002). Edaphic characters, in addition to fire and grazing, are sufficient to prevent the invasion of later seral shrub or grassland vegetation into *S. diluvialis* habitat (Heidel 1998).

At least eight spring sites currently or historically supported *S. diluvialis* populations along the Wasatch Front in the Greater Salt Lake City area of northern Utah. These sites may be found in proximity to lake or stream habitats, but apparently their hydrology is driven by groundwater rather than perennial

surface flows. In at least one site, a spring-fed wet meadow with Ute ladies'-tresses has developed in a former peat bog that was abandoned following mining.

In the Great Basin, Ute ladies'-tresses populations are known from two spring-fed desert wetland sites. The Tooele County, Utah, occurrence is found in a subirrigated meadow of *Carex*, *Eleocharis,* and *Cirsium scariosum* that is currently managed as cattle pasture (Utah Conservation Data Center records). The Nevada location was thought to have been converted to an alfalfa pasture (Morefield 1994) before being rediscovered adjacent to a hummocky warm spring in 2005 (Jim Coyner, retired USFWS, pers. commun., 2005). Since many desert spring sites in the Great Basin have been converted to agriculture or developed for livestock watering the original extent of Ute ladies'-tresses in this region will probably never be known.

Human-Influenced Riparian Habitats: Since 1992, at least 26 new populations of Ute ladies'-tresses have been documented from perennial stream, river, lakeshore, and spring sites directly associated with human-developed dams, levees, reservoirs, irrigation ditches, reclaimed gravel quarries, roadside barrow pits, and irrigated meadows (Tables 1, 2, and 3) (Franklin 1993, Heidel 1998, Murphy 2001a, 2004a, 2004b). In all, 33 of 61 documented populations (54%) occur in sites in which natural hydrology has been influenced by dams, reservoirs, or supplemental irrigation (Table 3). Even sites with undisturbed hydrology, however, have been influenced by human agricultural practices, urban development, or road and dam construction. The magnitude, timing, duration, and permanence of these human-induced changes vary widely, and are discussed in greater detail under the section on existing and potential threats.

Population Size and Trends:

Number of Populations: In the January 1992 final listing rule, Ute ladies'-tresses was reported from 10 extant populations and 7 historical localities in Colorado, Utah, and Nevada (US Fish and Wildlife Service 1992). Since then, nearly 100 additional locations have been discovered or relocated in Colorado and Utah as well as Idaho, Montana, Nebraska, Washington, and Wyoming (Bjork 1997, Fertig 2000, Franklin 1993, Hartman and Nelson 1994, Hazlett 1996, Heidel 1996, 1998, Hildebrand 1998, Moseley 1997, 1998a, 2000, Murphy 2001a, Stone 1993). Many of these "element occurrences" (as recognized by state natural heritage programs) fall within the same drainage or are otherwise in close proximity. In 2004, Susan Spackman and Dave Anderson of the Colorado Natural Heritage Program developed standardized criteria for delineating *S. diluvialis* populations for the entire network of natural heritage programs. Under this system (NatureServe 2004), occurrences within 8.05 km (5 miles) in the same river or stream system are considered part of one natural, interbreeding metapopulation, as are upland meadow areas separated by less than 1.61 km (1 mile). Based on these new criteria, there are currently 61 Ute ladies'-tresses populations recognized rangewide, of which 52 are extant* (Figure 6). Tables 1

and 5 depict the aggregation of state natural heritage program element occurrences into metapopulations according to NatureServe (2004) specifications.

Number of Individuals: Based on available survey data through 1991, the US Fish and Wildlife Service (1992) estimated the total number of Ute ladies'-tresses to be less than 6,000 plants in 10 extant populations and about 170 acres of habitat. In 1995 this estimate was increased to 20,500 plants following the discovery or relocation of 21 additional populations from 1992-1994 (Figure 6, Table 5) (US Fish and Wildlife Service 1995). Since 1995, another 24 populations have been discovered, including several large occurrences along the Green, Snake, and Niobrara rivers (Table 5). *Spiranthes diluvialis* is now known to occupy 674-783 acres of habitat. The highest number of plants recorded in any one year was 38,438 in 1998, based on sampling 23 of 55 populations known at that time (Figure 7). Since these populations were not selected randomly, no useful extrapolations can be made to estimate rangewide numbers based on annual counts. **Text continued on page 56**

* Using these new NatureServe criteria and data not available at the time of listing, Ute ladies'-tresses was known from 11 extant and 8 historical populations in January 1992.

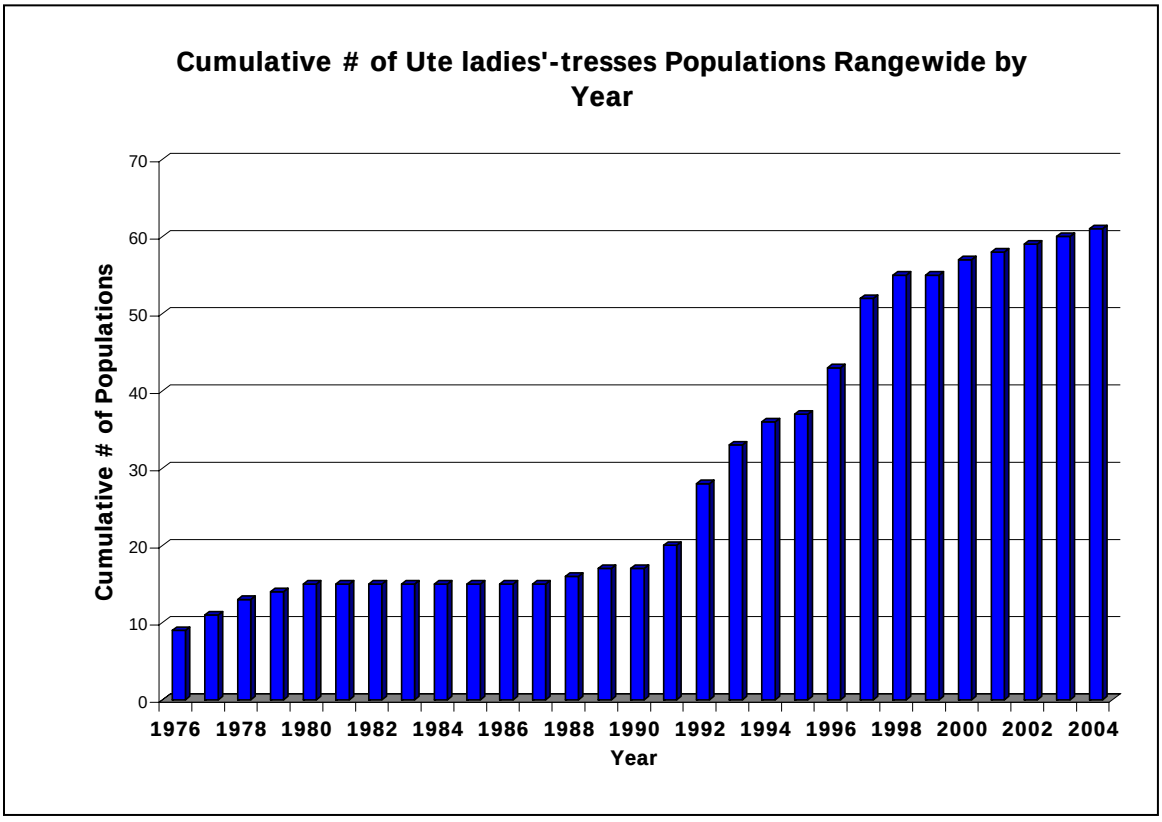

Figure 6. Increase in the number of known Spiranthes diluvialis *populations since 1976. The number of populations is based on criteria used by NatureServe (2004).*

Table 5. Ownership, land use, estimated size, area, and threats of Spiranthes diluvialis *populations. Data derived from state natural heritage program element occurrence records and literature reports as cited. Each row in the table represents a separate element occurrence or literature report, but some records from the same general vicinity have been aggregated into larger metapopulation clusters following the revised element occurrence definitions of NatureServe (2004) (see text on page 33 for discussion).*

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Colorado: Weld Co.: Crow Creek, East of Greeley (CO-006, 014)		Private?	Agriculture?	1856: collected by Engelmann	?	Comments: Population size unknown, possibly extirpated
Colorado: Jefferson Co.: Clear Creek, Wheat Ridge (CO-001)		Prospect Park, city of Wheat Ridge	Recreation (hiking, bike trail, fishing access)	1978: First discovered at site – pop size not est 1984: Collected by Jennings, pop size not est 1985: Collected by Root, pop size not est 1989: 546 plants obs in 4 patches by Jennings (1989) 1990: 598 plants obs by Jennings 1991: 338 fl plants est at 3 sites by Brune 1993: ca 100 plants est by Arft 2000: 1-19 plants est by Anderson 2004: 0 plants obs in search by Native Orchid Survey Project volunteers	1	Current threats: 1. Increased vegetation cover (especially Russian olive and cattails) 2. Trampling from recreation use 3. Some habitat covered by fill and riprap in 1991 Comments: site of demographic monitoring plot by Arft (1995)
Colorado: Jefferson Co.: Clear Creek Canyon	Golden (CO-002)	Private	Recreation (hiking, fishing access)	1980: Collections made by Smookler and Bye– pop size not est 1981: Collections made by Gambill et al. and Anderson – pop size not est 1982: Collections made by Gambill & Jennings and Sheviak – pop size not est 1984: Collections made by Jennings and Callas – pop size not est (Jennings 1990) 1989: 5 plants obs ("in previous years they have numbered in hundreds" Jennings 1990) 1990: 38 plants in fl obs by Jennings 1993: ca 100 plants in fl & fr reported by Arft 1994: 9 fl plants obs by Lederer in 2 sites 2003: 88 fr plants obs by Native Orchid Survey Project 2004: 271 plants obs in fl & fr in newly established monitoring plot by D. Buechler, D. Wilson, and others for Native Orchid Survey Project	1-10	Current threats: Increased vegetation cover Potential threats: Loss of habitat from road construction or maintenance Comments: Type locality (Sheviak 1984). Site of demographic study by Arft (1995)
	Indian Gulch (CO-012)	Private	Recreation?	1992: 6 plants obs by Rondeau	1	
continued next page	Clear Creek Canyon (CO-016)	CO Dept of Transportation	Recreation (fishing access)	1993: 7-8 plants obs by Wostl 1994: 21 plants obs in fl & bud at 2 sites by Lederer	0.1	Potential threats: Disturbance from road construction

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Colorado: Jefferson Co.: Clear Creek Canyon	Clear Creek (CO-023)	Private	Recreation (hiking, fishing access)	1994: 9 fl plants obs in 2 sites by Lederer	1	
Colorado: Boulder Co.: Boulder Creek	Foothills Parkway (CO-007)	Private	Road corridor and open space in urban development	1988: 19 plants est by Jennings 1989: 19 plants obs by Jennings 1990: 19 overwintering rosettes obs in February; 17 plants obs in September by Jennings	2	Current threats: 1. Habitat disturbance and changes in hydrology from additional filling or construction 2. Recreation impacts (two-tracks)
	CO-018	Private	Recreation, vicinity of old gravel pit in urbanized area	1993: 30 fl plants	0.2	Current threats: Competition from non-native plants (*Cirsium arvense*)
	CO-028	City of Boulder Open Space	Former gravel pit, open space/ wildlife management area	1993: 15-20 fl plants est 1997: 0 plants obs 1999: 22 plants obs 2000: 89 plants obs 2001: 3 plants obs (1997-2001 census data from Riedel 2005)	0.2	
	Railroad tracks, Boulder (CO-027)	City of Boulder Open Space	Agriculture, open space natural area	1992: 1-2 plants obs 1993: 1-2 plants obs 1994: 2 plants obs by N. Williams 1996: 0 plants obs 1997: 0 plants obs 1998: 1 plant obs 1999: 0 plants obs 2000: 3 plants obs (Riedel 2005)	1-10	
	Ertl Site	Private	Conservation easement	2001: 36 plants obs 2004: 151 plants obs (Riedel 2005)	1	
Colorado: Boulder Co.: South Boulder Creek continued next page	CO-005	City of Boulder Open Space (South Boulder Creek State Natural Area), private	Recreation (hiking, biking) Agriculture (winter/early spring cattle grazing, haying,	1941: First documented record based on herbarium collection by Ewan (Tulane Univ.) 1985: est in 100s at first of 29 documented subpops discovered by Sharps 1986: 5435 obs at 2 new subpops by Jennings (1989). 1989: 1203 plants obs at same 2 subpops surveyed in 1986 (Jennings 1989)	40	Current threats: (Riedel 2002) 1. Highway expansion and associated disturbance. 2. Changes in hydrology from diversion or increased runoff from construction 3. Competition from non-native plants (especially

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Colorado: Boulder Co.: South Boulder Creek	CO-005		irrigation), prescribed fire, wildlife habitat management	1990: 1922 plants obs at 3 previously documented subpops and 1 additional subpop 1992: 3707 plants obs at 2 largest known subpops and 5 newly documented ones (known from 10 subpops) 1993: 3969 plants obs at 8 known subpops and 11 newly discovered ones (total # of subpops = 21) 1994: 6134 plants obs at 14 known subpops and 1 newly discovered subpop 1995: 2952 plants obs at 12 known subpops and 1 newly discovered one (23 now known) 1996: 5034 plants obs at 22 of 23 known subpops and 1 newly discovered one 1997: 8753 plants obs at all 24 known subpops and 1 newly discovered one (92% of plants in just one subpop) 1998: 1925 plants obs in 24 of 25 known subpops and 1 newly discovered one 1999: 5590 plants obs in 25 subpops (including 2 new ones) 2000: 7949 plants obs in 28 known subpops and one newly discovered one 2001: 987 plants obs at 10 of 29 known subpops 2002: 199 plants obs at 5 of 29 known sites 2003: 228 plants obs at 5 of 29 known sites 2004: 463 plants obs at 10 of 29 known sites (all census data from 1990-2004 from Riedel 2005) Pop est at 4000-8000 by Native Orchid Survey Project team		*Cirsium arvense, Dipsacus fullonum, & Elaeagnus angustifolia*) 4. Ditch cleaning may result in localized mortality 5. Vole herbivory 6. Construction of municipal water line through habitat 7. Conflicting management goals with Preble's meadow jumping mouse, a listed Threatened mammal under the ESA 8. Drought Potential threats: Construction of new flood control structures (earthen berms) to mitigate 500-year flood events Comments: Site of demographic monitoring and genetic and ecological studies by Arft (1995)
	Doudy Draw (CO-017)	City of Boulder Open Space	Agriculture (grazing), recreation, wildlife habitat management	1993: 4 plants in fl & fr obs by Hogan & Tallman 1996: 2 plants obs by Dieter & Neupert 1997: 0 plants found 1999: 0 plants found 2000: 1 plant obs 2004: 1 plant obs	0.5	
Colorado: Boulder Co.: St. Vrain Creek (CO-015)		Boulder County Open Space	Agriculture (grazing), recreation (bike path)	1992: 2 plants obs in fl 1993: 5 plants obs in fl	0.5	Current threats: 1. Changes in hydrology (diversion) 2. Construction of new bike paths

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Colorado: Boulder Co.: Left Hand Creek	CO-024	Private	Agriculture (grazing)	1994: 7 fl plants obs by Brune 1998: 0 obs by Brune	0.3	Current threats: Competition from non-native plants, encroachment of cottonwoods
	CO-026	Private	Agriculture (grazing)	1994: 5 fl & vegetative plants obs by Brune	0.3	Current threats: See above
Colorado: El Paso Co.: Bear or Cheyenne Creek, Colorado Springs ("Camp Harding") (CO-009)		Private	Urban area	1896: collected by A. Butler	?	Comments: presumed extirpated by CO Natural Heritage Program
Colorado: Larimer Co.: Claymore Lake South, Ft Collins (CO-013)		Colorado State University, private	Agriculture (grazing)	1993: 13 plants obs by Wheeling & Jennings 1995: 40-60 plants obs by Wheeling 1996: 75-87 plants obs	6.6	Current threats: 1. Summer grazing (preventing fruit production) 2. Competition from non-native plants (especially *Agrostis stolonifera, Cirsium arvense, & Euphorbia esula*)
Colorado: Moffatt Co.: Browns Park/ Lodore Canyon	Lodore Canyon above confluence of Yampa River (CO-025, Ward & Naumann 1998)	Dinosaur NM	Recreation (boating, fishing access, camping), Agriculture (grazing)	1995: ca 12 plants in limited survey at Hells Half Mile by D. Cooper 1997: 2000 plants est below Trailer Draw by Naumann (cited in Ward & Naumann 1998) 1998: 8108 plants obs along 5 subreaches, total pop est at 14012. 125 of 163 appropriate post-dam floodplain and intermediate bench sites surveyed (77%), of which 78 (62%) had *S. diluvialis* colonies (Ward & Naumann 1998) 2004: Obs in fl July 23-25 by Naumann	115	Current threats: (Ward & Naumann 1998): Competition from non-native plants (*Tamarix chinensis, Lepidium latifolium & Centaurea repens*) Potential threats: Changes in water regulation upstream at Flaming Gorge Dam (water diversion, flooding regimes)
	Browns Park (Ward & Naumann 1998)	Browns Park NWR	Recreation, wildlife management	1998: 50 plants obs at two sites within 1 river mile (pop est at 100) (Ward & Naumann 1998) 1999: 92 plants obs	1-10	Current and Potential threats: see above
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River continued next page	Annis Island (ID-006)	Upper Snake River BLM Snake River ACEC	Agriculture (Spring cattle grazing), Recreation	1997: 35 pl est in cursory survey by Moseley et al. 1998: 2036 fl & fr plants obs in 18 sites by Moseley, Murphy, Murdock, Rice, & Varga 1999: 1917 plants obs in fl & bud by Moseley et al. 2000: 726 plants obs by Rice & Murdock 2001: 2557 plants obs by Murphy (2001a) et al. 2002: 306 plants obs 2003: 2006 plants obs by Rice et al. 2004: 245 plants obs by Velman et al.	40	Current threats: 1. Impacts from OHV recreation 2. Competition from non-native plants (*Centaurea repens & Euphorbia esula*) 3. Trespass summer grazing Comments: Site of habitat trend monitoring study

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River	Lorenzo Levee (ID-008)	Private		1997: 1 plant obs from road in cursory survey by Hemker & Delphey	0.1	Comments: Site apparently fenced from grazing (Murphy 2001a)
	S of Archer (ID-015)	Private	Powerline	1997: 145 plants obs in fl & fr by Delphey & others	2	Current threats: Habitat disturbance from powerline & levee maintenance
	Twin Bridges Island (ID-007)	Upper Snake River BLM Snake River ACEC Madison County Parks Dept	Recreation (camping)	1997: 160 plants obs by Rey-Vizgirdas, Hemker, Jankovsky-Jones, & Lehman 1998: 108 plants obs by Moseley & Rice 1999: 99 plants obs in fl, fr, & bud by Moseley 2000: 43 plants obs by Davis at one site 2001: 36 plants obs by Murphy, Davis, & Duncan (Murphy 2001a) 2002: 14 plants obs 2003: 15 plants obs by Velman & others 2004: 0 plants found in search by Velman, Bowen & Staffel	1.5	Current threats: 1. Trampling from OHVs and hiking 2. Occasional trespass grazing 3. Competition from non-native plants (*Euphorbia esula*) Comments: site of habitat trend monitoring plot
	Railroad Island (ID-005)	Upper Snake River BLM Snake River ACEC	Agriculture (winter grazing)	1997: 9 fl plants obs by Rice & others following large flood 1998: 14 fr plants obs by Rice 1999: 42 fl plants obs by Moseley & others 2000: 17 plants obs by Murphy, Rice, Lehman, & Merigliano 2001: 0 plants obs by Murphy, Davis, & Duncan (Murphy 2001a) 2002: 0 plants obs by Murphy, Velman, & Stevens 2003: 0 plants obs	0.2	Comments: Local population may be extirpated. Site of habitat trend monitoring plot
	Kelly's Island (ID-001)	Upper Snake River BLM Snake River ACEC	Recreation (camping), agriculture (grazing)	1996: 12 plants in fl & fr discovered by Jankovsky-Jones and confirmed by Moseley 1997: 22 fl plants obs by Moseley 1998: 30 plants in fl obs by Rey-Vizgirdas & others 1999: 30 plants obs in fl & bud by Moseley & Mancuso 2000: 15 fl plants obs by Rice & Murdock 2001: 19 plants found by Murphy & Cooke (of which 15 are from a new subpop) (Murphy 2001a) 2002: 15 plants obs 2003: 10 plants obs by Velman, Murphy, & others 2004: 6 plants obs by Murphy	1	Current threats: Competition from non-native plants (*Sonchus arvensis*) Comments: site of habitat trend monitoring plot

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Mud Creek Bar (ID-009)	Upper Snake River BLM Snake River ACEC	Recreation (camping)	1997: 9 fl plants discovered by Moseley 1998: 32 plants obs by Rice 1999: 71 plants obs in fl & bud by Moseley & others 2000: 63 plants obs by Davis 2001: 16 plants obs by Murphy & Cooke and by Rice & others (Murphy 2001a) 2002: 20 plants obs 2003: 25 plants obs by Velman & others 2004: 3 plants obs by Velman & Bowen	0.5	Current threats: Competition from non-native plants (*Cirsium arvense, Carduus nutans, Centaurea maculosa*) Comments: site of habitat trend monitoring plot. Biological control insects being released to contain Canada thistle & knapweed
	TNC island, (ID-010)	Upper Snake River BLM Snake River ACEC	Recreation (camping)	1997: 8 plants obs in fl & fr by Moseley 1998: 9 plants obs in fr by Rice 1999: 118 plants obs in fl & bud by Moseley & others 2000: 21 plants obs by Murphy, Rice, Lehman, & Merigliano 2001: 17 plants obs by Murphy & others (Murphy 2001a) 2002: 13 plants obs 2003: 7 plants recorded by Murphy, Velman, & others 2004: 0 plants found in survey by Zimmerman & others	0.2	Current threats: Trampling by campers Comments: adjacent to lands owned by TNC. Site of habitat trend monitoring plot.
	Rattlesnake Point (ID-002)	Upper Snake River BLM Snake River ACEC	Agriculture (grazing)	1996: 15 fl & fr plants discovered in cursory visit by Moseley 1997: 4 plants in fl & bud found in 2 sites by Moseley 1998: 23 fr plants found in 2 sites by Moseley 1999: 26 plants found in 1 of 2 sites by Lehman 2000: 0 plants found by Murphy & Merigliano 2001: 19 plants found in 2 sites by Davis & others and Murphy & Cooke (Murphy 2001a) 2002: 68 plants obs 2003: 1 plant located by Murphy, Velman, & Stevens 2004: 38 plants found at 2 sites by Lehman, Ciak, & Paige	0.5	Current threats: 1. Competition from non-native plants (*Cirsium arvense*) 2. Impacts from summer or trespass grazing Comments: site of habitat trend monitoring plot.
continued next page	Warm Springs Bottom (ID-003)	Upper Snake River BLM Snake River ACEC	Agriculture (grazing), recreation (camping & ATVs), dam	1996: 173 plants in fl & fr discovered by Moseley in cursory visit 1997: 301 plants obs at 2 sites by Moseley & Lehman 1998: 80 plants in fl & fr obs by Moseley	10	Current threats: Competition from non-native plants (*Cirsium arvense & Sonchus arvensis*) Comments: *Spiranthes* plants

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Warm Springs Bottom (ID-003)			1999: 476 plants obs by Davis & Lehman 2000: 942 plants obs by Davis & others (with 2 *S. romanzoffiana*) 2001: 522 plants obs by Lehman, Duncan, & Rice (Murphy 2001a) 2002: 538 plants obs 2003: 502 plants obs by Lehman, Velman, Winslow, & Bala 2004: 1560 plants obs by Lehman, Ciak, Church, & Colket		growing on old fill. Site of habitat trend monitoring plot.
	Black Canyon (ID-022)	Upper Snake River BLM Snake River ACEC, private	Recreation?	1999: 50 plants in fl & bud obs by Moseley & Williamson 2000: 42 plants obs by Murphy, Lehman, Rice, Murdock, & Merigliano 2001: 507 plants (117 on island, 390 on mainland) by Murphy (2001a) et al. 2002: 236 plants obs 2003: 262 plants obs by Murphy & others 2004: 247 plants obs by Lehman, Ciak, & Paige	0.5	Current threats: Competition from non-native plants (*Cirsium arvense & Sonchus arvensis*) on island portion of population Comments: site of habitat trend monitoring plot
	Lufkin Bottom (ID-011)	Upper Snake River BLM Snake River ACEC	Recreation (camping)	1997: 61 plants obs by Moseley, Rice, Murdock, & Lehman 1998: 96 plants in fl & fr obs by Rice 1999: 224 plants obs by Moseley & others 2000: 494 plants obs by Rice & others after trampling incident. 310+ plants seen 2 weeks later in cursory follow-up visit 2001: 184 plants obs by Lehman & others (Murphy 2001a) 2002: 309 plants obs 2003: 514 plants obs by Velman, Zimmerman, Teel, & DeVoe 2004: 261 plants obs by Velman, Bowen, Paige, Church, & Colket	2.2	Current threats: Disturbance from trampling, high recreation use Comments: site of 2 habitat trend monitoring plots
	Gormer Canyon #5 (ID-012)	Targhee NF	Recreation (camping)	1997: 10 plants obs in fl & fr by Moseley 1998: 0 plants obs by Rice et al. 1999: 1 plant obs by Rice & Wright 2000: 0 plants obs by Moseley et al. 2001: 0 plants obs by Lehman, Rice, & Wright (among others) 2002: 0 plants obs 2003: 0 plants obs by Rice & Zimmerman 2004: 0 plants obs by Lehman, Ciak, & Paige	0.1	Current threats: Competition from non-native plants (*Centaurea maculosa, Cirsium arvense*) Comments: biological control of non-native plants being conducted.

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Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Gormer Canyon #4 (ID-013)	Targhee NF	Recreation (camping)	1997: 10 fl plants obs by Moseley 1998: 11 plants obs by Moseley, Rice, & Lehman 1999: 12 plants obs at 2 sites by Moseley, Mancuso, & others 2000: 7 plants obs by Rice, Murdock, & Zimmerman 2001: 3-7 plants obs by Murphy et al. 2003: 9 plants obs by Murphy 2004: 10 plants obs by Lehman, Ciak, & Paige	0.2	Comments: site of habitat trend monitoring plot
	Gormer Canyon #3 (ID-021)	Upper Snake River BLM Snake River ACEC Targhee NF	Recreation	1998: 8 plants obs. by Lehman & Chu 1999: 59 plants obs (plus 2 *S. romanzoffiana*) by Lehman et al. 2000: 30 plants obs by Rice, Murdock, & Druliner 2001: 31-76 plants obs by Lehman et al. (Murphy 2001a) 2002: 47 plants obs 2003: 50 plants obs by Murphy 2004: 79 plants obs by Lehman, Ciak, & Paige	0.2	Current threats: Competition from non-native plants (*Cirsium arvense*) Comments: site of habitat condition monitoring plot. *S. romanzoffiana* also found at site in 1999.
	Pine Creek #5 (ID-014)	Upper Snake River BLM Snake River ACEC	Recreation (camping), agriculture (winter grazing)	1997: 6 plants obs over 4 areas by Moseley, Lehman, Rice, & Murdock 1998: 14 plants obs by Moseley et al. 1999: 30 plants in fl & bud obs by Moseley et al. 2000: 20-47 plants obs by Rice et al. 2001: 24 plants obs by Murphy, Duncan, & Rice (Murphy 2001a) 2002: 24 plants obs 2003: 74 plants obs by Velman, Zimmerman, Teel, & DeVoe 2004: 120 plants obs by Lehman, Ciak. & Paige	1	Comments: site of habitat trend monitoring plot.
	Pine Creek #3 & 4 (ID-016)	Upper Snake River BLM Snake River ACEC	Recreation (camping), agriculture (winter grazing)	1997: 18 plants in fl & fr obs at 2 sites by Moseley, Rice, Murdock, & Lehman 1998: 113 plants obs by Rice, Murdock, & Lehman 1999: 200 plants obs by Moseley et al. (40-50 *S. romanzoffiana* also present) 2000: 103 plants obs by Rice et al 2001: 118 plants obs at 2 sites by Lehman, Murphy, & others (Murphy 2001a) 2002: 121 plants obs 2003: 353 plants obs by Velman & others 2004: 899 plants obs at two sites by Zimmerman, Velman, & others	5	Current threats: 1. Pollution from adjacent camping areas 2. Competition from non-native plants (*Cirsium arvense*) Comments: site of 2 habitat trend monitoring plots. Population mixed with *S. romanzoffiana.*

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Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Lower Conant Valley (ID-017)	Upper Snake River BLM Snake River ACEC	Recreation (camping)	1997: 127 plants in fl & fr found by Moseley, Rice, Murdock, & Lehman 1998: 0 plants obs by Moseley & others 1999: 10-20 plants obs by Rice, Moseley, & others; at least 190 *S. romanzoffiana* plants also obs 2000: 23 plants obs by Rice & others (1 *S. romanzoffiana*) 2001: 12 plants obs by Murphy, Davis, Rice, & Duncan (0 *S. romanzoffiana*) (Murphy 2001a) 2002: 12 plants obs 2003: 0 plants found by Velman & others 2004: 15 plants obs by Zimmerman, Bowen, Kerbs, & Hose	2	Comments: Site of habitat trend monitoring plot. Population mixed with *S. romanzoffiana.*
	Upper Conant Valley (ID-018)	Upper Snake River BLM Snake River ACEC	Recreation, agriculture? (former cattle trespass, no disturbance since 1997)	1997: 61 plants obs in fr by Moseley, Lehman, & Rice 1998: 13 plants (+ 2 *S. romanzoffiana*) obs by Rice & Lehman 1999: 5 plants obs by Moseley et al. (and 3 *S. romanzoffiana*) 2000: 2-5 plants obs by Rice et al. 2001: 1 plant found by Murphy (2001a) et al. 2002: 0 plants found 2003: 3 plants obs by Velman, Zimmerman, Stevens, & Ciak 2004: 0 plants found by Zimmerman, Bowen, Kerbs, & Hose	0.5	Comments: Site of habitat trend monitoring plot. Population mixed with *S. romanzoffiana.*
	Lower Swan Valley (ID-019)	Upper Snake River BLM Snake River ACEC	Recreation	1997: 1 fr plant found by Lehman 1998: 8 plants obs in new area by Moseley et al. 1999: 4 plants obs by Moseley et al. (+ 1 *S. romanzoffiana*) 2000: 9 plants obs by Rice, Murdock, Druliner, & Zimmerman 2001: 13 plants obs by Murphy & others 2002: 27 plants obs 2003: 25 plants found by Velman, Zimmerman, Stevens, & Ciak 2004: 47 plants obs. by Bowen, Zimmerman, Kerbs, & Hose	3	Comments: Site of habitat trend monitoring plot. Population mixed with *S. romanzoffiana*
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	Falls Campground (ID-004)	Caribou NF (managed by Targhee NF)	Recreation (vicinity of campground), agriculture	1996: 1 plant found in cursory visit by Moseley 1997: 14 plants obs in new site by Moseley et al. 1998: 5 plants found by Lehman & Varga 1999: 13 plants obs at 2 sites (mixed with *S.*	0.2	Comments: Site of habitat trend monitoring plot. Pop mixed with *S. romanzoffiana.* Exclosure established around *S.*

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Falls Campground (ID-004)		(winter grazing)	*romanzoffiana*) by Lehman 2000: 13 plants obs by Lehman 2001: 5 plants found at 2 sites within exclosures (with *S. romanzoffiana*) by Lehman & Murphy 2002: 3 plants obs 2003: 0 plants located by Lehman 2004: 7 plants found by Lehman		*diluvialis* plants.
	Squaw Creek islands (ID-020)	Upper Snake River BLM Snake River ACEC Targhee NF	Agriculture (grazing on mainland) Island is undisturbed, mainland is heavily grazed	1997: 167 plants obs (presumed *S. diluvialis*) at 2 sites by Moseley, Lehman, & Rice 1998: 2 plants obs by Varga (determined as *S. diluvialis*) 1999: 0 *S. diluvialis* plants obs by Moseley et al. (only *S. romanzoffiana* present) 2000: 0 *S. diluvialis* plants obs by Rice et al. (only *S. romanzoffiana* present) 2001: 0 plants obs by Duncan et al. (only *S. romanzoffiana* present) (Murphy 2001a) 2002: 0 plants obs (only *S. romanzoffiana* present) 2003: 0 plants obs by Murphy et al. (only *S. romanzoffiana* present)	1.5	Current threats: Competition from non-native plants Comments: Population mixed with *S. romanzoffiana*
Idaho: Fremont Co.: Chester wetlands, Henry's Fork Basin (ID-023)		Idaho Department of Fish & Game	Waterfowl management, recreation (ATVs), irrigation	2002: 433 plants obs by Murphy 2003: 482 plants found in 4 sites (Murphy 2004b)	1-10	Current threats: Habitat disturbance from recreation Potential threats: Diversion of water
Idaho: Madison Co.: Texas Slough – near Thornton (ID-024)		Private	Irrigation canal	2003: 3 plants obs in 2 sites (Murphy 2004b)	1	Current threats: Competition from non-native plants Potential threats: 1. Diversion of water 2. Road construction proposed
Montana: Madison Co.: Central Beaverhead River Valley (MT-002)		Private	Agriculture (grazing and hay)	1996: 1 fl plant obs by Heidel	1	Current threats: 1. Competition from non-native plants (*Elymus repens*) 2. Summer grazing or haying during fruiting period
Montana: Madison Co.: California Slough (MT-004)		Private, State of Montana	Agriculture (grazing, irrigation)	1996: 58 plants obs by Heidel 1997: 30 plants obs in second site by Heidel, total pop est at 100	10	Potential threats: 1. Changes in hydrology 2. Competition from non-native plants (*Euphorbia esula, Centaurea maculosa*)
Montana: Beaverhead Co.: Albers Slough (MT-011)		Private	Agriculture	1997: 500+ plants est by Heidel	1	

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Montana: Madison Co.: Ruby River Valley west of Virginia City (MT-006)		State of Montana	Highway right-of-way	1997: ca 180 plants obs in fl by Heidel	1	Potential threats: 1. Competition from non-native plants 2. Road construction could affect hydrology
Montana: Jefferson Co.: Piedmont Swamp (MT-001)		Private	Agriculture (grazing)	1994: 71 fl plants obs by Heidel 1995: 29 fl plants obs 1996: 50 plants obs (49 fl/1 vegetative) 1997: 53 plants obs (36 fl/17 vegetative) 1998: 145 plants obs (104 fl/41 vegetative) 1999: 24 plants obs (11 fl/13 vegetative) 2000: 85 plants obs (50 fl/35 vegetative) (Heidel 2001). 1996-2000 monitoring study – pop est at 204 plants	1	Potential threats: 1. Competition from non-native plants (*Centaurea maculosa*) 2. Road construction/ maintenance could affect hydrology Comments: site of long-term pop monitoring plot
Montana: Jefferson Co.: Fish Creek (MT-005)		Private	Agriculture	1996: 500 + plants obs in 4 main areas by Heidel 1997: ca 275 plants est by Heidel	20	Current threats: 1. Changes in hydrology 2. Competition from non-native plants (*Centaurea repens*)
Montana: Madison Co.: Central Jefferson River Valley (MT-007)		Private	Agriculture	1997: 5 fl plants obs from road by Heidel (pop probably larger)	1	
Montana: Gallatin Co.: Vicinity of Three Forks	MT-009	Private	Agriculture	1997: 32 plants obs in late fl by Heidel	1	
	MT-012	Private	Old railroad right-of-way	1998: 15 fl plants obs by Lovell & McCarthy	1	Potential threats: Road construction/ maintenance may impact hydrology
Montana: Gallatin Co.: NE of Three Forks (MT-010)		State of Montana	Agriculture	1997: 15 plants in fl obs by Heidel (1998)	1	Potential threats: Changes in levee management could impact hydrology
Montana: Broadwater Co.: Missouri River, south of Townsend (MT-003)		Private	Roadside borrow pit	2000: 34 plants in fl & fr obs by Schassberger	1	Potential threats: Road construction/ maintenance may impact hydrology
Montana: Gallatin Co.: Gallatin River Valley (MT-008)		Private	Agriculture	1997: 2 fl plants obs by Heidel	1	
Nebraska: Sioux Co.: Niobrara River SW of Harrison	NE-001	Private	Agriculture (hay)	1996: 1000 plants est by Hazlett (1996) 1997: 1000 plants est by Hildebrand (1998)	80	Potential threats: 1. Haying during flowering period (before fruits are ripe) 2. Water diversion 3. Competition from non-native plants
	NE-002	Private	Agriculture (hay)	1997: 1300 plants est by Hildebrand (1998).	60	Potential threats: See above

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Nevada: Lincoln Co.: Panaca Spring (NV-001)		Private	Recreation (swimming hole)	1936: pop first located, no census or estimate made 1989: 0 plants obs by Coyner (1990) 1992: 0 plants obs by Morefield (1994) 2005: at least 75 flowering plants observed by Coyner	0.8	Comments: site was thought to have been converted to alfalfa field and population was considered extirpated before being rediscovered in 2005.
Utah: Daggett Co.: Upper Browns Park, vicinity of Jarvie Ranch	UT-005	Private, Vernal BLM (Browns Park ACEC)	Recreation (camping, boating), Agriculture (grazing)	1978: discovered by E. Neese (Sheviak 1984) 1982: obs in bud by Sheviak (1984) 1989: ca 200 obs in fl (Coyner 1990) 1990: 497 obs by Coyner & Sinclear (Coyner & Hreha 1995) 1991: 32 plants reported (Coyner & Hreha 1995) 1995: 5397 plants est (Sipes et al. 1995) 1998: Entire Upper Browns Park pop (including UT-058 & 059) est at 500 plants by Gecy (Ward & Naumann 1998)	0.5	Current threats: Decline in pollinators (Pierson & Tepedino (2000) Potential threats: River becoming channelized and dewatered (Ward & Naumann 1998)
	UT-058	Vernal BLM (Browns Park ACEC)	Recreation (camping, boating)	1994: 11-50 plants est by Refsdal, Atwood, & Jordan 1998: see comments above	0.1	Current threats: 1. Trampling damage from fishing access 2. Competition from non-native plants
	UT-059	UT Div. of Wildlife Res, (Browns Park Waterfowl Mngmt Area) Ashley NF	Recreation (camping, boating)	1994: discovered by Refsdal, Atwood & Jordan 1998: 5 plants obs	0.5	Current threats: Competition from non-native plants Potential threats: Changes in hydrology (supplemental moisture from leaky irrigation system)
Utah: Uintah Co.: Green River, Island Park (UT-044)		Dinosaur NM	Recreation (boating, camping)	1993: 4 plants obs in 2 sites (Riedel 1992) 1997: Small pop discovered near The Cove. 1998: 96 plants obs, pop est at 198 (Ward and Naumann 1998). 45 of 63 potential post-dam floodplain or intermediate bench surfaces were surveyed, of which 8 (18%) contained *S. diluvialis* 2004: Obs by Naumann	20	Current threats (Ward & Naumann 1998): Competition from non-native plants (*Tamarix chinensis, Lepidium latifolium & Centaurea repens*) Potential threats: Changes in water regulation upstream at Flaming Gorge Dam (water diversion, flooding regimes)
Utah: Uintah Co.: Lower Hog Canyon/Cub Creek (UT-003)		Dinosaur NM	Recreation (boating, camping), Agriculture (winter grazing)	1989: 50 plants est in pop by Naumann & Jennings (Jennings 1989) 1990: 4 plants obs in fl, pop est at 50 (Coyner 1990, Coyner & Hreha 1995) 1991: 104 plants (incl 2 new subpops) reported by Riedel (1992)	1-10	Current threats: Competition from non-native plants Potential threats: Changes in water regulation upstream at Flaming Gorge Dam (water diversion, flooding regimes)

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Uintah Co.: Green River below Split Mountain Canyon	UT-029	Dinosaur NM	Recreation (boating, camping)	1992: 17 dormant plants obs by Franklin (1993) 1993: 5-9 fl plants obs by Riedel 1998: 17 obs, 85 est (Ward & Naumann 1998)	0.25	Current threats: Competition from non-native plants.
	UT-031	Dinosaur NM	Recreation (boating, camping)	1992: 12 plants obs (Riedel 1992) 1998: 13 plants obs, 65 est (Ward & Naumann 1998)	1	
	UT-033	Dinosaur NM	Recreation	1993: 11-13 reported (Ward & Naumann 1998)	5	
Utah: Uintah Co.: "Orchid Draw" WNW of Dinosaur Quarry (UT-030)		Private (within Dinosaur NM)	Recreation (boating, camping)	1991: 30 plants obs (Riedel 1992)	1	
Utah: Uintah Co.: Steinaker Reservoir, N of Vernal (UT-026)		Bureau of Reclamation	Former gravel pit, Agriculture (grazing)	1992: 1071 plants obs in 2 colonies bisected by road (Franklin 1993) 1997: 385 plants obs at 4 sites by Rooks including new areas not previously searched. Monitoring plot established at one site. 1999: Obs in fl and fr (but not censused) (Western Wetland Systems 1999)	30	Current threats: 1. Competition from *Phalaris arundinacea*. 2. Vegetation succession Potential threats: Borrow pit may be reopened.
Utah: Uintah Co.: Ashley Creek, Vernal (UT-027)		Private	Urban area, Agriculture (grazing)	1992: 74 fl and fr plants obs by Franklin (1993) 1999: 43 fl and fr plants obs at 7 sites (Western Wetland Systems 1999) 2002: 236 fl and fr plants obs at 14 of 18 known sites (including 20 at same 7 sites surveyed in 1999) (Western Wetland Systems 2002)	1-10	Potential threats: Changes in hydrology from riparian improvement projects & road construction
Utah: Uintah Co.: Big Brush Creek (UT-028)		Vernal BLM	Agriculture	1992: 72 plants obs in fl, bud & fr (Franklin 1993) 1994: < 50 plants reported by Sinclear (in Coyner & Hreha 1995)	5	Current threats: (Lucy Jordan, USFWS, pers. commun., 2005) 1. Competition from invasive plants 2. Vegetation succession Potential threats: Road impacts (Coyner & Hreha 1995)
Utah: Duchesne & Uintah Cos.: Uinta River continued next page	Near Whiterocks (UT-006)	Private, Uintah & Ouray Indian Reservation, White Rocks Fish Hatchery (UT DWR)	Agriculture (grazing), Irrigation	1979: first documented by E. Neese (Jennings 1989) 1990: 644 plants obs in fl by Coyner & England at site discovered by Neese (Coyner 1990) 1992: 61 plants in fl & fr obs by Franklin (1993) at 3 new sites 1993: 281 plants obs (more est) at Neese's original site & 4 new sites by Mengel and others 1994: Obs by Ecotone and Mt. Nebo Scientific consulting firms at 10 reaches 2003: 3 fl plants obs at fish hatchery (Western Wetland Systems 2003)	10-15	Current threats (Lucy Jordan, USFWS, pers. commun., 2005) 1. Habitat disturbance through channel maintenance 2. Vegetation succession 3. Competition from non-native plants Potential threats: Changes in hydrology (diversion)

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Duchesne & Uintah Cos.: Uinta River	Vicinity of Pole Creek (UT-009)	Uintah & Ouray Indian Reservation	Recreation (near picnic area, fishing), Irrigation, Power plant in vicinity	1983: collected by S. Goodrich (Jennings 1989) 1990: 0 plants found by Coyner (1990) 1992: 11 plants found in fl & fr found at 2 sites by Franklin (1993) 1994: 20 plants obs at 2 new sites	5	Current threats: Trampling from recreation Potential threats: Changes in hydrology (diversion)
	LaPoint Bridge to Daniels Canal (UT-024)	Private	Agriculture (grazing), recreation, irrigation	1992: 323 plants obs in 2 subpops (Franklin 1993) 1993: 57 plants in fl (pop probably larger) obs in 5 subpops	1	Current threats: 1. Habitat disturbance through channel maintenance 2. High grazing (summer use?) Potential threats: Changes in hydrology (diversion)
	Military Canal diversion (UT-037)	Private	Agriculture (grazing), irrigation	1993: 13 plants obs in fl by Mengel and others	0.2	Current and Potential threats: see above.
	Downstream of Fort Duchesne (UT-060)	Uintah & Ouray Indian Reservation	Immediately downstream of Fort Duchesne Sewage Treatment Plant, irrigation	1994: 2 fr plants obs	0.25	Current threats: 1. Polluted discharge 2. Habitat disturbance through channel maintenance Potential threats: Changes in hydrology (diversion)
	Upstream of Dry Gulch Creek confluence (UT-061)	Uintah & Ouray Indian Reservation	Irrigation	1994: 2 plants obs (1 recently dead, 1 in fr)	1	
Utah: Duchesne Co.: Duchesne River continued next page	Duchesne River bridge (UT-010)	Private	Agriculture (hay, grazing), recreation	1991: 24 plants obs in fl/fr by L. Colburn	0.5	Current threats: Habitat disturbance through channel maintenance Potential threats: Changes in hydrology (diversion) and reduction in episodic flood events from flood-control dams (Bruce Glisson, botanical/ecological consultant, pers. commun., 2005)
	NNE of Duchesne (UT-011)	Private	Agriculture (hay, grazing),	1991: 15 plants obs in fl/fr by L. Colburn	0.1	Current threats: See above

			Irrigation			
Location/Heritage Program Occurrence #		**Ownership**	**Land Use**	**Estimated Population Size**	**Area (acres)**	**Current or Potential Threats/Comments**
Utah: Duchesne Co.: Duchesne River	7.7 miles NNW of Duchesne (UT-017)	Private	Ungrazed	1992: 992 plants obs in fl/fr & vegetative condition by Franklin (1993)	40	Current threats: see above
	Rock Creek Bridge, N of confluence of Rock Creek and Duchesne River (UT-018)	Uintah & Ouray Indian Reservation	Agriculture (grazing), recreation	1992: 7 plants obs in fl/fr by Franklin (1993)	1	Current threats: See above
	Duchesne (UT-019)	Private	Vicinity of urban area	1992: 78 plants obs in fl/fr by Franklin (1993)	3	Current threats: Construction in riparian areas
	Duchesne River above Rock Creek (Glisson 2002a)	Private	Agriculture	2002: 1920 fl/fr plants in 42 colonies obs by Glisson (2002a) along 3.2 miles of river	40+	
Utah: Uintah Co.: Whiterocks River (UT-025)		Uintah & Ouray Indian Reservation	Recreation, agriculture (grazing)	1992: 13 plants obs in fl (Franklin 1993) 1994: 700+ plants est by Meyer, Crane, & Grah along at least 9 of 16 surveyed reaches	10-15	
Utah: Duchesne Co.: Lake Fork River	Yellowstone/ Lake Fork confluence downstream to near Upalco (UT-042)	Private, Uintah & Ouray Indian Reservation	Agriculture (grazing), Irrigation	1992: 1 plant discovered by Franklin (1993) 1993: 192 plants obs along 3 reaches by Mengel and others 1994: 2683-2732 obs at 15 different stream reaches by Ecotone and Mt. Nebo Scientific	10-15	Current threats: Habitat disturbance through channel maintenance Potential threats: Changes in hydrology (diversion) Comments: *S. romanzoffiana* also in area
	Downstream from Upalco (UT-043)	Private	Agriculture (grazing), irrigation	1994: 2500+ plants (?) reported by Mt. Nebo Scientific as "… largest population we have seen in this study"	5	Current threats: see above
Utah: Wasatch & Duchesne Cos.: Currant Creek (UT-034)		Private	Agriculture (grazing)	1993: 423 plants obs in fl, bud, and vegetative condition by Franklin 2002: Obs by Glisson (2002b)	1-10	Current threats: Vegetation succession (Lucy Jordan, USFWS, pers. commun., 2005)
Utah: Weber Co.: Ogden (UT-053)		Private	Urban area	1887: Collected by Tracy and Tracy & Evans (Sheviak 1984)	?	Comments: presumed extirpated by UT heritage program
Utah: Salt Lake Co.: South Salt Lake (UT-001)		Private	Urban area	1880: Collected by M.E. Jones (Sheviak 1984) 1953: Collected by L.T. Nielsen (Sheviak 1984) 1966?: Reported by Kim Harper in Red Butte Canyon (US Fish and Wildlife Service 1992) – confirmation needed.	?	Comments: presumed extirpated by UT heritage program.

Location/Heritage Program Occurrence #	Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Utah Co.: Utah Lake, "Powell Slough" (UT-004)	Private	Agriculture (grazing), powerline ROW	1925: Collected by W. Cottam (Jennings 1989) 1963: Collected by Barnett (Jennings 1989) 1978: Collected by Brotherson (Jennings 1989) 1990: 0 plants found in survey by Coyner (1990) 1991: 193 plants obs by England & Coyner (Coyner & Hreha 1995) 1994: < 20 plants obs	0.2	Current threats: Change in hydrology (no longer irrigated) Comments: Hydrology and management have changed in last decade, making site unsuitable for *S. diluvialis.* No plants have been found in the last 4-6 years, and population is presumed extirpated (Lucy Jordan, USFWS, pers. commun., 2005)
Utah: Utah Co.: Utah Lake vineyard (UT-055)	Orem City	Formerly mined for peat, recreation (golf course), urban area	1998: ca 1000 plants est. 2000: 394 plants obs (800 est) by L. England (Population currently estimated at 200 plants by (Lucy Jordan, USFWS, pers. commun., 2005).	1-10	Current threats (Lucy Jordan, USFWS, pers. commun., 2005) 1. Change in hydrology 2. Competition from non-native plants 3. Vegetation succession
Utah: Utah Co.: Utah Lake, American Fork Mill Pond (UT-056)	American Fork City	Urban area	1998: 5 plants obs by Kass	3	Current threats (Lucy Jordan, USFWS, pers. commun., 2005) 1. Competition from non-native plants 2. Vegetation succession
Utah: Utah Co.: Lehi wetlands (UT-057)	Private	Agriculture (grazing), urban area	1998: 12 plants obs by Freeman. Full extent of pop not known 2000: 13 plants obs by England	0.5	Potential threats (Lucy Jordan, USFWS, pers. commun., 2005) 1. Hydrology change 2. Competition from non-native plants 3. Road construction 4. Urbanization/development
Utah: Utah Co.: American Fork horse pasture (UT-012)	Private	Agriculture (grazing), urban area	1991: 1 plant collected in fl & fr by R. Johnson & K. Thorne, pop est at 50 (Coyner & Hreha 1995) 1994: pop est at 50 2000: 8 plants obs by England	1	Current threats (Lucy Jordan, USFWS, pers. commun., 2005) 1. Urbanization and road construction 2. Grazing 3. Competition from non-native plant species 4. Vegetation succession
Utah: Utah Co.: Utah Lake, Hobble Creek, Springville (Ron Kass, Intermountain Ecosystems, pers. commun., 2005)	Private	Agriculture (haying)	2004: 8 plants obs by Kass	1	Potential threats: 1. Urbanization 2. Change in hydrology

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Utah Co.: Diamond Fork/ Spanish Fork	Lower reach Diamond Fork (UT-013)	Uinta NF, UT Reclamation Mitigation & Conservation Commission	Agriculture (grazing), recreation	1992: 276 plants obs in 17 discrete subpops by Stone (1993); these are considered 5 subpops by Black & Gruwell (2004) 1993: 5129 plants obs at 5 known subpops and 9 new subpops 1994: 416 plants obs at 4 of 14 known subpops (1 had 0, 9 could not be censused due to grazing impacts) 1997: 10,858 plants obs at 10 of 14 known subpops (4 had 0 plants) and 7 new subpops 1998: 14,678 plants obs at 12 of 21 known subpops (9 had had 0 plants) and 5 new subpops 1999: 4276 plants obs at 17 of 26 known subpops (9 had 0 plants) and 3 new subpops 2000: 15,282 plants obs at 20 of 29 known subpops (9 had 0 plants) and 4 new subpops 2001: 23,551 plants obs at 28 of 33 known subpops (5 had 0 plants) and 1 new subpop 2002: 15,597 plants obs at 20 of 34 known subpops (14 had 0 plants) and 1 new subpop 2003: 832 plants obs at 17 of 35 known subpops (18 had 0 plants) by Black & Gruwell 2004: 497 plants obs at 16 of 35 known subpops (19 had 0 plants) by Black & Gruwell (2004)	23.4	Current threats: 1. Changes in hydrology (diversion, reduction in supplemental flows) 2. Reduced numbers in some years from summer grazing 3. Decline in pollinators (Pierson & Tepedino (2000) 4. Vole herbivory (Pierson & Tepedino 2000) 5. Competition from non-native plants 6. Vegetation succession
	Mid reach Diamond Fork	Uinta NF	Agriculture (grazing), recreation (campground)	1992: 4 plants found at 1 site by Stone (1993) – initially considered part of UT-013 by Stone. 1993: 723 plants obs in 15 subpops 1994: 359 plants obs in 5 of 15 known subpops (10 had 0 plants) and 1 new subpop 1997: 2603 plants obs at 14 of 16 known subpops (2 had 0 plants) and 5 additional subpops 1998: 1786 plants obs at 19 of 21 known subpops (2 had 0 plants) and 2 new subpops 1999: 1224 plants obs at 19 of 23 known subpops (4 had 0 plants) and 2 new colonies. 2000: 3332 plants obs at 25 of 25 known subpops and 4 new subpops. 2001: 2075 plants obs at 24 of 29 known subpops (4 had 0 plants) and 2 new subpops 2002: 1470 plants obs at 24 of 31 known subpops (7 had 0 plants) and 1 new subpop 2003: 114 plants obs at 18 of 32 known subpops	15.5	Current threats: 1. Changes in hydrology (diversion, reduction in supplemental flows) 2. Reduced numbers in some years from summer grazing

continued next page

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Utah Co.: Diamond Fork/ Spanish Fork	Mid reach Diamond Fork			(14 had 0 plants) 2004: 89 plants obs at 11 of 32 known subpops (21 had 0 plants) by Black & Gruwell (2004)		
	Upper reach Diamond Fork (UT-016)	Uinta NF	Agriculture (grazing)	1992: 23 plants obs in fl & fr at 5 discrete sites by Stone (1993); these are all considered part of 1 subpop by Black & Gruwell (2004) 1993: 197 plants obs in 3 subpops 1994: 29 plants obs in 3 subpops 1997: 20 plants obs in 1 of 3 known subpops (2 had 0 plants) 1998: 428 plants obs 2 of 3 known subpops (1 had 0 plants) and in 2 newly discovered subpops 1999: 503 plants obs 3 of 5 known subpops (2 had 0 plants) and in 2 newly discovered subpops 2000: 1179 plants obs in 6 of 7 known subpops (1 had 0 plants) and in 2 newly discovered subpops 2001: 718 plants obs in 6 of 9 known subpops (3 had 0 plants) 2002: 996 plants obs in 6 of 9 known subpops (3 had 0 plants) and 1 new subpop 2003: 94 plants obs in 8 of 10 known subpops 2004: 111 plants obs in 5 of 10 known subpops by Black & Gruwell (2004)	1.2	Current threats: see above
	Lower Reach Spanish Fork (UT-014)	Private	Agriculture (grazing by cattle & horses), Adjacent to railroad grade	1992: 24 plants in fl & fr obs at 1 main site (Stone 1993) 1993: 397 plants obs at original subpop and 1 additional subpop by Black 1994: 74 plants obs at 2 known subpops and 1 additional subpop 2001: 170 plants obs at 3 known subpops by Glisson (SWCA 2002)	10	Current threats: 1. Changes in hydrology 2. Habitat degradation from road construction
	Upper Reach Spanish Fork (UT-015)	Private	Agriculture	1992: 3 plants in fl & fr obs at 1 main site (Stone 1993) 1993: 108 plants obs at 1 known subpop and 3 additional subpops by Black 1994 13 plants obs at 2 of 4 known subpops and 1 new subpop 2001: 234 plants obs at 2 of 5 known subpop s and an additional 22 at 3 new subpop s (SWCA 2002)	5-10	Current threats: see above

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Utah Co.: Soldier Creek (SWCA report)		Private	Agriculture (grazing), recreation	2001: 132+ plants found in 2 newly discovered colonies (smallest with just 2 individuals) by B. Glisson (SWCA 2002) 2004: 0 plants found in survey by Bruce Glisson, botanical/ecological consultant, pers. commun., 2005	5	Current threats: 1. Changes in hydrology 2. Habitat degradation from road construction
Utah Co.: "Spring Lake" near Payson (UT-051)		Private	Urban area	1875: Collected by Parry 1995: 0 plants found in search by Welsh, though potential habitat remains	?	Comments: presumed extirpated by UT CDC
Utah: Wasatch Co.: Middle Provo River	"Reach 8" (UT-032)	US Bureau of Reclamation, UT Reclamation Mitigation & Conservation Commission	Agriculture (grazing), recreation, watershed management, urban area	1993: 38 plants obs in 1 colony by R. Johnson 1994: 10 plants in fl and fr obs at second subpop (0 at 1993 site) by Johnson, Franklin, & Jordan 1995: 6 plants obs 1996: 13 plants obs 1997: 10 plants obs in 4 subpops 1998: 5 plants obs (includes Reach 5 pop) 1999: 19 plants obs (includes Reach 5 pop) 2000: 44 plants obs (includes Reach 5 pop) 2001: 9 plants obs 2002: 14 plants obs (includes Reach 5 pop) 2002: 14 plants obs (includes Reach 5 pop) 2003: 3 plants obs at 13 survey sites in 11.5 hours. 2004: 17 fl plants obs (census data from 1993-2004 from Weland 2004)	1-10	Current threats: 1. Encroachment of cottonwood & alder 2. Competition from non-native plants
	"Reach 5" (UT-054)	Private	Agriculture (grazing), recreation, urban area	1997: 9 plants in fl obs at 2 subpops 2003: 4 plants obs at 5 sites in 5.75 hours 2004: 5 fl plants obs (census data from 2003-2004 from Weland 2004)	1-10	Current threats: see above
Utah: Tooele Co.: Willow Springs Station, near Callao (UT-002)		Private	Agriculture (grazing)	1956: Collected by W. Cottam (Sheviak 1984) 1990: 0 plants obs in search by Coyner (1990) 1994: 1 plant obs by D. Stone	1	Comments: More potential habitat in vicinity still needs to be surveyed
Utah: Garfield Co.: Deer Creek SE of Boulder (UT-007) continued next page		Grand Staircase-Escalante NM (BLM)	Agriculture (winter grazing), recreation (vicinity of campground)	1977: Collected by Neese & White (Sheviak 1984) 1982: Collected by Sheviak (1984) 1990: 60 plants obs by England & Coyner (1990), pop est at 200 1992: 25 plants obs by Coyner, pop est at 200 (Coyner & Hreha 1995) 1993: 183 plants obs by Franklin 1997: pop est at 150 by Clark & Clark 1998: ca 30 plants obs by Clark & Clark 1999: 2 plants obs following large flood event by Evenden (1999)	10	Current threats: 1. Trampling by high recreation use along creek or unauthorized OHV use (Coyner 1990) 2. Increased shrub cover Potential threats: Change in hydrology (road maintenance or dewatering) Comments: Site of demographic plot established by Arft

Location/Heritage Program Occurrence #		Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Utah: Garfield Co.: Deer Creek SE of Boulder (UT-007)				2001: 25-50 fl plants obs by Fertig, Welp, Miller, and other GSENM staff 2002: 135 plants obs by Kneller & Fertig (Kneller 2002) 2003: 17 plants obs by Hughes (2003) 2004: 37 plants obs by Hughes (2004)		
Utah: Wayne Co.: Fremont River oxbow (UT-008)		Capitol Reef NP	Recreation (hiking)	1977: Collected by Neese & White (Jennings 1989) 1986: Collected by Porter (Jennings 1989) 1987: 25-30 plants obs by Coyner (1990) 1989: 25-30 plants obs by Coyner (1990) 1992: 15 plants obs in poor condition (Coyner & Hreha 1995) 1994: 1 plant obs by England 1995: 1 fl plant obs by Armstrong & Clark 1997-2001: 0, presumed extirpated (Clark 2002)	1	Potential threats: 1. Change in hydrology from road building 2. Competition from non-native plants 3. Vegetation succession Comments: Population is probably extirpated
Washington: Okanogan Co.: Wannacut Lake (WA-001)		Private	Recreation (fishing access), agriculture (grazing)	1997: 27 plants obs by Bjork (1997) 1998: ca 200 plants obs in fl by Rey Vizgirdas et al. 2001: 0 plants found in survey 2004: 0 plants found in survey by Clausnitzer	0.1	Current threats: 1. Drought – reduction in water table & lake level 2. Competition from non-native plants 3. Grazing impacts Comments: May be extirpated
Washington: Chelan Co.: Columbia River	Gallagher Flats (WA-002).	Washington State Dept of Fish & Wildlife	Recreation, hydropower	2000: 7 plants obs 2001: 0 plants found 2002: 1 plant found 2003: 19 plants obs 2004: 15 plants obs (totals reported by K. Beck & F. Caplow)	0.3	Current threats: 1. Fluctuations in water level from drought and dam operations 2. Competition from non-native plants 3. Drought
	Chelan Pond/Rocky Reach (WA-003)	Chelan County	Recreation, hydropower	2000: 185 plants obs (110 pond/75 river) 2001: 71 plants obs (69 pond/2 river) 2002: 128 plants found (51 pond/77 river) 2003: 178 plants found (154 pond/24 river) 2004: 193 plants obs (171 pond/22 river) Totals reported by K. Beck & F. Caplow	0.3	Current threats: see above.
	Howard Flats (WA-004)	Private	Recreation, hydropower	2000: 60 plants obs 2001: 0 plants found 2002: 46 plants obs 2003: 58 plants obs 2004: 172 plants found (results from K. Beck & F. Caplow)	0.3	Current threats: see above.

Location/Heritage Program Occurrence #	Ownership	Land Use	Estimated Population Size	Area (acres)	Current or Potential Threats/Comments
Wyoming: Goshen Co.: Bear Creek SE of Chugwater (WY-001)	State of Wyoming, Private	Agriculture (mostly winter grazing)	1993: Collected by B.E. Nelson 1994: Ca 100 plants obs by Nelson & Chumley (Hartman & Nelson 1994) 1997: 520 plants est by Hildebrand (1998) at two sites 1998: 214 fl & vegetative plants obs by Carroll et al., pop est at 300-500 (Fertig 2000) 1999: 200 fl & vegetative plants obs by Fertig, Jones, Nelson, & Schladweiler, pop est at 500 (Fertig 2000) 2000: 300-500 plants est by Fertig 2002: 426 plants obs by Heidel, Blomquist, Carroll, & Cornelisse 2003: 143 fl plants obs by Carroll et al. 2004: Obs by WY USFWS staff, but no pop estimate made	4	Potential threats: 1. High grazing use in summer some years 2. Competition from non-native plants
Wyoming: Laramie Co.: "vicinity of Midway & Meriden" (WY-004)	Private	Agriculture (hay)	1997: 71 obs by Hazlett (1997) 1998: 454 obs by Carroll et al., ca 400 obs by Fertig (2000)	1	Current threats: Competition from non-native plants
Wyoming: Converse Co.: Antelope Creek SW of Ross (WY-002)	Casper BLM	Agriculture (grazing)	1994: 20-24 plants est by Nelson (Hartman & Nelson 1994) 1995: 11 plants obs by P. Wolken 1997: 35 plants obs by Hildebrand (1998), pop est at 40 1998: 20 fl plants obs by Fertig (2000) 1999: 12-15 vegetative plants obs by Schladweiler 2000: 6-8 plants obs in bud by Schladweiler 2001: 12 fl plants obs by Schweich & Davis of Greystone Environmental Consultants 2002: 0 plants found in survey by Fitzgerald 2004: 7-10 plants obs in two visits by Travsky and Bucklin-Comiskey	0.5	Current threats: 1. Competition from non-native plants 2. Vegetation succession Potential threats: Impacts from Coalbed Methane development in general area
Niobrara Co.: "between Lusk and Van Tassell" (WY-003)	Private	Agriculture (hay)	1996: 57 plants obs by Hazlett (1996) 1997: 12 plants obs by Hildebrand (1998) 1998: 203 plants obs in 3 main colonies by Fertig (2000)	5	Current threats: Competition from non-native plants

Such data gaps, as well as inconsistent monitoring methods, make estimating rangewide population size extremely difficult. In an average year, only 30% of all documented populations and 38% of all occupied acres of habitat are monitored for this species (Figures 7 and 8). Since 2000, only 26 of 61 populations (42.6%) have been revisited or monitored (Table 5). Detailed monitoring studies that map individual plants or conduct repeat visits to the same site for three or more continuous years have been conducted for just 15 populations (24.5%) since 1992. As of 2004, only seven of these populations (11.5%) were still being actively monitored (South Boulder Creek, Lower South Fork Snake River, Upper South Fork Snake River, Diamond Fork, Middle Provo River, Deer Creek, and Columbia River). Relatively few studies have employed standardized survey techniques (such as the rope count method employed at South Boulder Creek) to ensure precise population counts across different years and survey teams (Riedel 2002). Even fewer projects have attempted to estimate

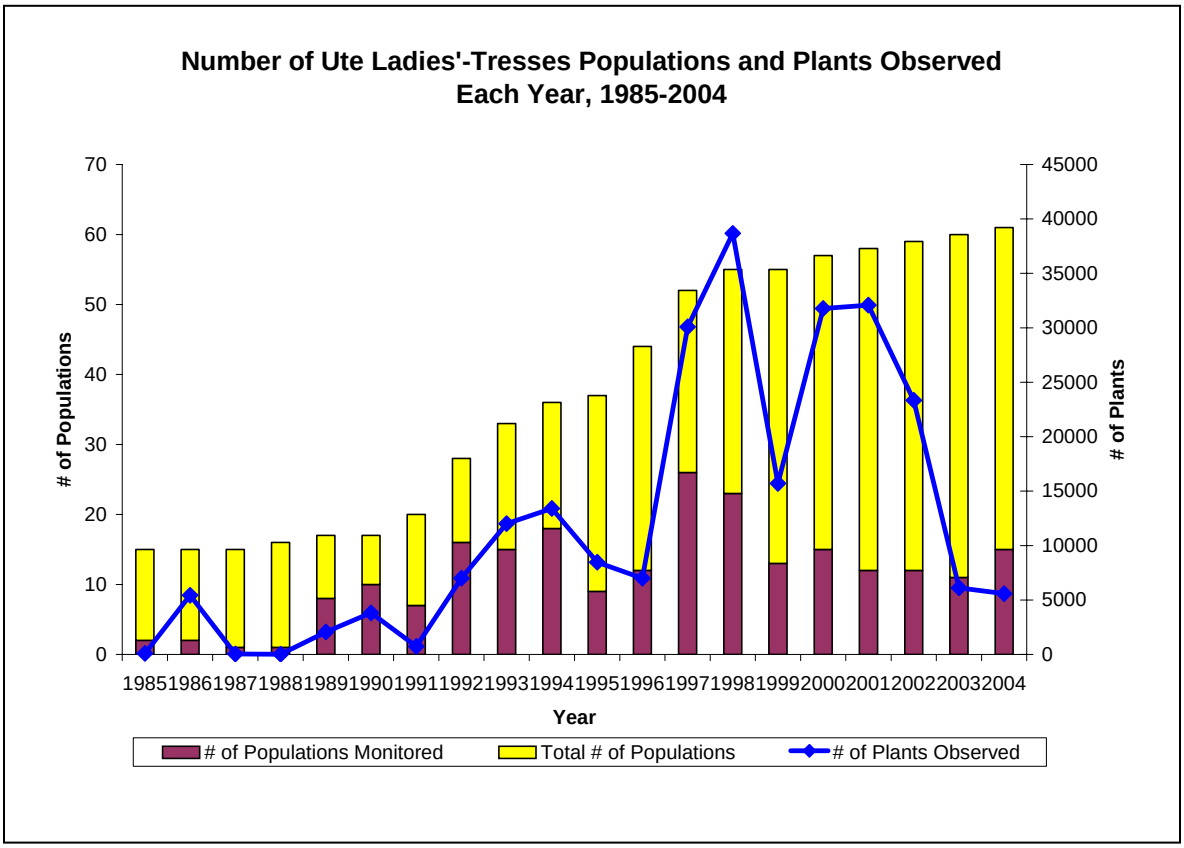

Figure 7. Number of Spiranthes diluvialis *populations and individual plants observed each year since 1985. Since 1991 the number of known populations has more than tripled and the number of observed plants per year has increased. Only 6 to 59% of known populations are monitored in any given year (average is 30% per year).*

survey effort and the proportion of habitat sampled to extrapolate population numbers, as demonstrated by Ward and Naumann (1998) for occurrences along the Green River.

Additionally, there is a strong correlation between the degree of survey effort and documented population size. Ten of the eleven largest known populations (Table 6) have either undergone extensive one-year surveys (Franklin 1993, Glisson 2002a, Hildebrand 1998, Sipes et al. 1995, Ward and Naumann 1998) or been continuously monitored for three or more years (Black and Gruwell 2004, Murphy 2004a, Riedel 2005). With a few notable exceptions (Boulder Creek, Piedmont Swamp, Middle Provo River, Deer Creek, Columbia River), small to medium-sized populations numbering fewer than 1000 individuals typically have not been completely surveyed or monitored for more than two consecutive years (Tables 5 and 6). Thus low population size may be an artifact of incomplete sampling. As a case in point, cursory observations suggested that the Upper

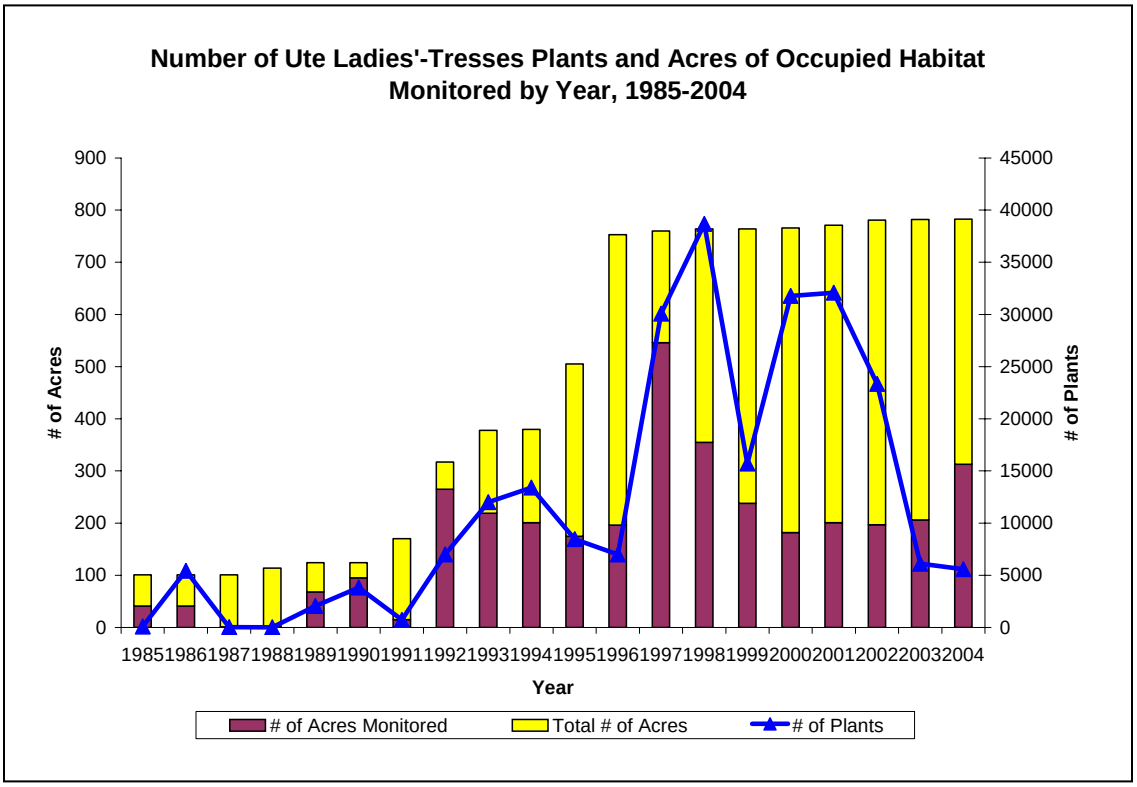

Figure 8. Acres of occupied Spiranthes diluvialis *habitat and number of individual plants monitored per year since 1985. Since 1991 the acreage occupied by this species has more than quadrupled. On average, 38% of all occupied habitat is monitored in any given year.*

Table 6. Estimated size of Spiranthes diluvialis *populations. Location and habitat data are derived from state natural heritage program element occurrence records and literature reports (as cited). Each row in the table represents a population based on the revised element occurrence criteria of NatureServe (2004) (see page 33 for discussion). Population figures are based on the maximum number of plants reported for each location. A "*" following a population estimate indicates that not all known subpopulations at the site were revisited or monitored in the given year or time period. "--- " indicates no data available. "X" indicates the population is extirpated. Under "Population Size Category", populations are considered small if they contain 100 or fewer plants in the period 1856-2004, medium if they have 101-1000 plants, and large if they have more than 1000 individuals.*

Location/ Heritage Program Occurrence #	**Number of Plants in all Subpops from 1856-2004**	**Number of Plants in all Subpops since 1994**	**Number of Plants in 2004**	**Population Size Category 1856-2004**
Colorado: Weld Co.: Crow Creek, East of Greeley (CO-006, 014)	Unknown X	--- X	--- X	Unknown X
Colorado: Jefferson Co.: Clear Creek, Wheat Ridge (CO-001)	0-598	0-19	0	Medium
Colorado: Jefferson Co.: Clear Creek Canyon (CO-002, 012, 016, 023)	28-307	39-301*	271*	Medium
Colorado: Boulder Co.: Boulder Creek (CO-007, 018, 028, 027, Ertl site)	292	243*	151*	Medium
Colorado: Boulder Co.: South Boulder Creek (CO-005, 017)	8753	8753	8000*	Large
Colorado: Boulder Co.: St. Vrain Creek (CO-015)	5	---	---	Small
Colorado: Boulder Co.: Left Hand Creek (CO-024, 026)	12	0*	---	Small
Colorado: El Paso Co.: Bear or Cheyenne Creek, Colorado Springs ("Camp Harding") (CO-009)	Unknown X	--- X	--- X	Unknown X
Colorado: Larimer Co.: Claymore Lake South, Ft Collins (CO-013)	87	87	---	Small
Colorado: Moffatt Co.: Browns Park/Lodore Canyon (CO-025, Ward & Naumann 1998)	14,112	14,112	Unknown*	Large
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River (ID-006, 008, 015, 007, 005, 001)	2949	2949	251*	Large
Idaho: Bonneville Co.: Upper South Fork Snake River (ID-009, 010, 002, 003, 022, 011, 012, 013, 021, 014, 016, 017, 018, 019, 004, 020)	4373	4373	3286	Large
Idaho: Fremont Co.: Chester wetlands, Henry's Fork Basin (ID-023)	482	482	---	Medium

Location/ Heritage Program Occurrence #	Maximum # of Plants in all Subpops from 1856-2004	Maximum # of Plants in all Subpops since 1994	Maximum # of Plants in 2004	Population Size Category 1856-2004
Idaho: Madison Co.: Texas Slough, Henry's Fork Basin – near Thornton (ID-024)	3	3	---	Small
Montana: Madison Co.: Central Beaverhead River Valley (MT-002)	1	1	---	Small
Montana: Madison Co.: California Slough (MT-004)	100	100	---	Small
Montana: Beaverhead Co.: Albers Slough (MT-011)	500	500	---	Medium
Montana: Madison Co.: Ruby River Valley west of Virginia City (MT-006)	180	180	---	Medium
Montana: Jefferson Co.: Piedmont Swamp (MT-001)	204	204	---	Medium
Montana: Jefferson Co.: Fish Creek (MT-005)	500	500	---	Medium
Montana: Madison Co.: Central Jefferson River Valley (MT-007)	5	5	---	Small
Montana: Gallatin Co.: Vicinity of Three Forks (MT-009, 012)	47	47	---	Small
Montana: Gallatin Co.: NE of Three Forks (MT-010)	15	15	---	Small
Montana: Broadwater Co.: Missouri River, south of Townsend (MT-003)	34	34	---	Small
Montana: Gallatin Co.: Gallatin River Valley (MT-008)	2	2	---	Small
Nebraska: Sioux Co.: Niobrara River, SW of Harrison (NE-001, 002)	2300	2300	---	Large
Nevada: Lincoln Co.: "Panaca Spring" – Upper Meadow Valley Wash (NV-001)	Unknown – X	Unknown - X	---	Small* (75 plants discovered in 2005)
Utah: Daggett Co.: Browns Park, vicinity of Jarvie Ranch (UT-005, 058, 059)	5452	5452	---	Large
Utah: Uintah Co.: Green River, Island Park (UT-044)	198	198	Unknown*	Medium
Utah: Uintah Co.: Lower Hog Canyon/Cub Creek (UT-003)	104	0	---	Medium
Utah: Uintah Co.: Green River below Split Mountain Canyon (UT-029, 031, 033)	163	150*	---	Medium
Utah: Uintah Co.: "Orchid Draw" WNW of Dinosaur Quarry (UT-030)	30	---	---	Small
Utah: Uintah Co.: Steinaker Reservoir, N of Vernal (UT-026)	1071	385*	---	Large

Location/ Heritage Program Occurrence #	Maximum # of Plants in all Subpops from 1856-2004	Maximum # of Plants in all Subpops since 1994	Maximum # of Plants in 2004	Population Size Category 1856-2004
Utah: Uintah Co.: Ashley Creek, Vernal (UT-027)	236	236*		Medium
Utah: Uintah Co.: Big Brush Creek (UT-028)	72	50	---	Small
Utah: Duchesne & Uintah Cos.: Uinta River (UT-006, 009, 024, 037, 060, 061)	1004	500 (estimated by L. Jordan)	---	Large
Utah: Duchesne Co.: Duchesne River (UT-010, 011, 017, 018, 019, Glisson 2002a)	3036	1920*	---	Large
Utah: Uintah Co.: Whiterocks River (UT-025)	700	700	---	Medium
Utah: Duchesne Co.: Lake Fork River (UT-042, 043)	5232	5232	---	Large
Utah: Wasatch & Duchesne Cos.: Currant Creek (UT-034)	423	Unknown*	---	Medium
Utah: Weber Co.: Ogden (UT-053)	Unknown X	--- X	--- X	Unknown X
Utah: Salt Lake Co.: South Salt Lake (UT-001) [includes Red Butte Canyon?]	Unknown X	--- X	--- X	Unknown X
Utah: Utah Co.: Utah Lake, "Powell Slough" (UT-004)	193	<20	0	Medium X
Utah: Utah Co.: Utah Lake Vineyard (UT-055)	1000	1000	---	Medium
Utah: Utah Co.: Utah Lake, American Fork Mill Pond (UT-056)	5	5	---	Small
Utah: Utah Co.: Utah Lake, Lehi wetlands (UT-057)	13	13	---	Small
Utah: Utah Co.: American Fork horse pasture (UT-012)	50	50	---	Small
Utah: Utah Co.: Hobble Creek, Springville (Ron Kass, Intermountain Ecosystems, pers. commun., 2005)	8	8	8	Small
Utah: Utah Co.: Diamond Fork/Spanish Fork (UT-013, 016, 014, 015, Black & Gruwell 2004)	28,693	28466	1101*	Large
Utah: Utah Co.: Soldier Creek (SWCA 2002)	132	132	0	Medium
Utah: Utah Co.: "Spring Lake" near Payson (UT-051)	Unknown X	0 X	--- X	Unknown X
Utah: Wasatch Co.: Middle Provo River (UT-032, 054)	53	53	22	Small
Utah: Tooele Co.: Willow Springs Station, near Callao (UT-002)	1	1	---	Small
Utah: Garfield Co.: Deer Creek, SE of Boulder (UT-007)	183	150	37	Medium
Utah: Wayne Co.: Fremont River oxbow, Capitol Reef NP (UT-008)	30	1 (0 from 1997-2001)	--- X	Small X

Location/ Heritage Program Occurrence #	Maximum # of Plants in all Subpops from 1856-2004	Maximum # of Plants in all Subpops since 1994	Maximum # of Plants in 2004	Population Size Category 1856-2004
Washington: Okanogan Co.: Wannacut Lake (WA-001)	200	200	0 X	Medium X
Washington: Chelan Co.: Columbia River (WA-002, 003, 004)	384	384	380	Medium
Wyoming: Goshen Co.: Bear Creek SE of Chugwater (WY-001)	520	520	Unknown*	Medium
Wyoming: Laramie Co.: vicinity of Midway & Meriden (WY-004)	454	454	---	Medium
Wyoming: Converse Co.: Antelope Creek SW of Ross (WY-002)	35	35	10	Small
Wyoming: Niobrara Co.: Between Lusk and Van Tassell (WY-003)	203	203	---	Medium
TOTAL POPULATION SIZE (all populations)	85,739 n = 61	81,728* n = 54	13,592* n = 15 (with data)	Small: n =22 Med: n= 24 Lrg: n = 10 Unk: n = 5
TOTAL POPULATION SIZE (extant populations)	85,316 n = 52	81,507* n = 50	13,592* n = 13	Small: n = 20 Med: n = 22 Lrg: n = 10

Browns Park/Jarvie Ranch population contained only 500 plants (Coyner and Hreha 1995) until detailed plot sampling by Sipes et al. (1995) documented a ten-fold increase in population size (Table 5).

Most *Spiranthes diluvialis* survey and monitoring studies are based on numbers of flowering plants, as these are easiest to detect in dense vegetation. Unfortunately, such counts underestimate the contribution of vegetative, fruiting, and below-ground dormant plants to the total population. Dormant plants are especially difficult to census as they typically persist underground for one to many years and can only be reliably documented after several years of repeated and detailed mapping (Lesica and Steele 1994).

Counts based only on flowering individuals tend to exhibit large annual fluctuations (Arft 1995, Heidel 2001, Moseley 2000, Riedel 1992). Arft (1995) discovered that the number of flowering individuals at South Boulder Creek varied 23-79% between years and among sites, in response to different management activities (such as mowing, grazing, burning, and control treatments), rates of inflorescence herbivory, and localized differences in environmental characteristics. Total population size was relatively stable, however, when fruiting and vegetative plants were also counted. Several long-term monitoring studies have shown that flowering plants from previous years that were presumed to be dead or missing were actually dormant for one to four or more years before reappearing (Allison 2001, Arft 1995, Heidel 2001, Moseley 2000). Heidel (2001) found wide fluctuations in the number of flowering and

vegetative plants at a demographic plot in Montana, but surmised that total population size was comparatively stable if dormant plants were included.

The number of flowering plants reported for a population may also vary depending on the timing of the survey. Individual Ute ladies'-tresses plants bloom at different times over a four to six week period, depending on local site conditions and moisture availability (Arft 1995, Fertig 2000, Murphy 2001b). Kneller (2002) discovered that only 22 of 61 plants in flower on 26 July 2002 in the Deer Creek population were still blooming on 12 August 2002 and that an additional 70 plants were in flower that she had not detected earlier. Relatively few studies (such as Arft 1995 and Riedel 2002) have attempted to assess differences in population size across the entire flowering season.

Recognizing that most annual survey data underestimate the number of dormant, vegetative, and fruiting plants, Black et al. (1999) and Heidel (2001) used the maximum number of flowering plants observed over a multi-year period of monitoring to estimate total population size. This approach assumes that annual variation in plant numbers is more due to missing dormant plants than response to environmental change (Arft 1995). Based on the maximum number of plants reported for each known occurrence since 1985 (Tables 5 and 6), the total rangewide number of Ute ladies'-tresses is currently at least 83,316 plants (Table 6). Utah has the largest number of extant populations (23) of any state as well as the largest occupied area (234-308 acres) and the highest number of reported plants (47,859) (Table 7). Colorado is second with 24,166 plants in eight extant

Table 7. Spiranthes diluvialis *population totals by state through 2004. Population estimates are derived from the sum of the maximum number of plants recorded at each extant population in the state based on data from 1980-2004. Since not all plants in a population are observable each year, these figures are probably conservative.*

State	Total # Populations circa 2004	# of Extant Populations circa 2004	Estimated # of Plants circa 2004	Area (Acres) circa 2004
Colorado	10	8	24,166	173-200
Idaho	4	4	7,807	74-83
Montana	11	11	1,588	40
Nebraska	1	1	2,300	140
Nevada*	1	0	0	1
Utah	28	23	47,859	234-308
Washington	2	1	384	1
Wyoming	4	4	1,212	11
TOTAL	61	52	85,316	674-784

* The Nevada population was rediscovered in July 2005 and contains a minimum of 75 plants in 0.8 acres of habitat.

occurrences and 173-200 acres of occupied habitat. Of the five states added to the range of *S. diluvialis* since 1993, Idaho has the greatest number of plants (7,807 individuals over 74-83 acres), while Montana has the largest number of populations (11). At the ecoregion level (Table 8), the Wyoming Basins of Colorado and Utah has the highest number (13) and extent of populations (268-310 acres), while the Utah-Wyoming Rocky Mountains of Idaho and Utah have the largest number of plants (35,235). Among watersheds (Table 9), the Spanish Fork drainage in Utah has the highest population (28,825 plants) and the Upper Green-Flaming Gorge Reservoir covers the most extensive area (117-126 acres).

Individual Ute ladies'-tresses populations range in size from 1-28,693 plants within 0.1 to 125 acres of occupied habitat (Table 5). Of all extant populations, 38.5% contain fewer than 100 plants and 80.8% have less than 1000 individuals (Table 6, Figure 9). Nearly 66% of all known populations are reported from areas of 0.1-10 acres, while only 4.9% occupy more than 50 acres (Figure 10).

Table 8. Spiranthes diluvialis *population totals by ecoregion through 2004. The number of plants is derived from maximum counts recorded at each extant population in the ecoregion.*

Ecoregion	Total # Populations	# of Extant Populations	# of Plants	Area (Acres)
Central Shortgrass Prairie (CO & WY)	3	2	974	5
Colorado Plateau (UT)	2	1	183	11
Columbia Plateau (ID & WA)	2	2	3333	46
Great Basin (NV & UT)	2	2	1*	2
Middle Rockies-Blue Mountains (MT)	11	11	1588	40
Northern Great Plains (NE & WY)	3	3	2538	146
Okanogan (WA)	1	0	0	0.1
Southern Rocky Mountains (CO)	8	7	10,054	57-75
UT-WY Rocky Mountains (ID & UT)	16	12	35,235	99-149
Wyoming Basins (CO & UT)	13	13	31,410	268-310
TOTAL	61	53	85,316	674-784

* The Nevada population was rediscovered in July 2005 and contains a minimum of 75 plants in 0.8 acres of habitat.

Table 9. Spiranthes diluvialis *population totals by watershed through 2004. The number of plants is derived from maximum counts recorded at each extant population in the watershed.*

Watershed	Total # Populations	# of Extant Populations	# of Plants	Area (Acres)
Antelope (WY)	1	1	35	0.5
Ashley-Brush (UT)	3	3	1379	36-45
Beaverhead (MT)	3	3	601	12
Cache La Poudre (CO)	1	1	87	7
Chief Joseph (WA)	1	1	384	1
Clear (CO)	2	2	905	4-13
Duchesne (UT)	4	4	9972	87-102
Escalante (UT)	1	1	183	10
Fountain (CO)	1	0	0	?
Fremont (UT)	1	0	0	1
Gallatin (MT)	1	1	2	1
Horse (WY)	2	2	974	5
Idaho Falls (ID)	1	1	2949	45
Jefferson (MT)	4	4	756	24
Jordan (UT)	1	0	0	?
Lower Green-Diamond (UT)	4	4	495	28-37
Lower Henrys (ID)	2	2	485	2-11
Lower Weber (UT)	1	0	0	?
Madison (MT)	1	1	15	1
Meadow Valley Wash (NV)	1	1	0*	1
Middle South Platte-Cherry Creek (CO)	1	0	0	?
Niobrara Headwaters (NE & WY)	2	2	2503	145
Okanogon (WA)	1	0	0	0.1
Palisades (ID)	1	1	4373	28
Provo (UT)	1	1	53	2-20
Ruby (MT)	1	1	180	1
St. Vrain (CO)	4	4	9062	46-55
Southern Great Salt Lake Desert (UT)	1	1	1	1
Spanish Fork (UT)	3	2	28,825	60-65
Strawberry (UT)	1	1	423	1-10
Upper Green-Flaming Gorge Reservoir (CO & UT)	2	2	19,564	117-126
Upper Missouri (MT)	1	1	34	1
Utah Lake (UT)	6	5	1076	7-16
TOTAL	61	53	85,316	674-784

* The Nevada population was rediscovered in July 2005 and contains a minimum of 75 plants in 0.8 acres of habitat.

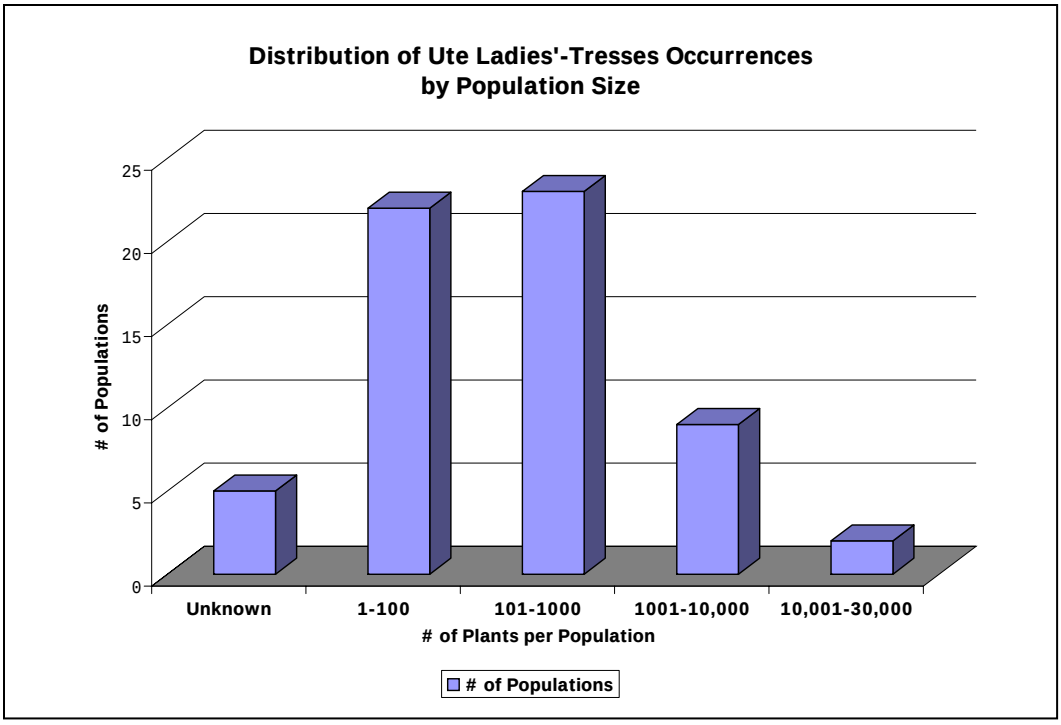

Figure 9. Distribution of Spiranthes diluvialis *occurrences rangewide by population size class.*

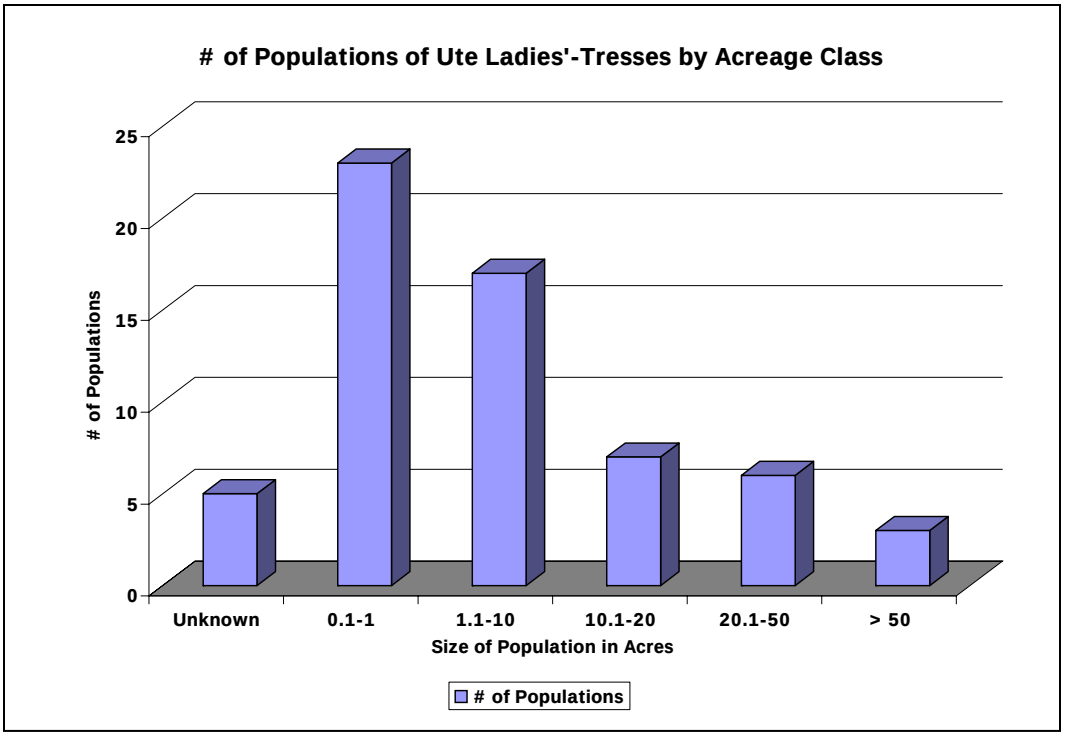

Figure 10. Distribution of Spiranthes diluvialis *occurrences rangewide by acreage class.*

Population Trends: Given the caveats described for estimating population size in the preceding section, rangewide population trends are even more difficult to determine for *Spiranthes diluvialis*. Clearly, the number of populations, geographic range, acreage, and estimated population size of this species has increased significantly since it was listed in 1992. Much of this can be attributed to increased survey and project clearance work over much of the western United States and heightened awareness of the plant due to its protected status. Whether this increase in populations and population size reflects recovery from past impacts will never be known in the absence of baseline distribution and abundance data for these newly discovered populations.

Trend data can be derived for a subset of individual Ute ladies'-tresses populations that have been monitored for three or more consecutive years (about 25% of all known populations). Unfortunately, most of these studies have focused on flowering plants. Arft (1995) found that counts of flowering individuals were more likely to fluctuate than monitoring studies that included more cryptic vegetative, fruiting, and dormant plants. Not surprisingly, most of the multi-year monitoring studies based on flowering plants exhibit an oscillating trend, alternating between periods of increase and decrease around a relatively stable mean (Black and Gruwell 2004, Moseley 2000, Murphy 2001a, Riedel 2005, Washington Natural Heritage Program records, Weland 2004). One interesting discovery of long-term monitoring studies in Idaho has been the detection of local extirpation of subpopulations as habitat condition deteriorates through flooding or vegetative succession (Moseley 2000, Murphy 2001a).

Habitat Monitoring and Distribution Modeling: Population counts alone may be inadequate to identify long-term population trends, especially as environmental conditions change in response to natural or human-influenced causes (Moseley 2000). Habitat condition monitoring for Ute ladies'-tresses populations along the Upper and Lower South Fork of the Snake River in Idaho was initiated in 2001 to quantify changes in habitat suitability that may affect population viability over the long term (Murphy 2001c). This monitoring program utilizes a standardized Index of Habitat Change to rate 19 environmental and management indicators (including hydrologic and fluvial geomorphic characters, competition from invasive weeds, vegetation succession, grazing by livestock and wildlife, recreation impacts, and fire) that directly or indirectly influence *Spiranthes* survival and persistence at local and landscape scales. Scores derived for each attribute (ranging from 0 for "pristine" orchid habitat to 2 for a strong departure from desired condition) are summed to calculate a cumulative score for each sampling unit, which when repeated over time can yield information on overall habitat trend and identify specific factors that may be driving changes in condition (Murphy 2002, 2004a). Other monitoring studies focusing on the response of Ute ladies'-tresses to different management actions (such as grazing, mowing, fire, or control conditions) are being conducted at South Boulder Creek, Colorado (Allison 2001, Riedel 2002).

New strategies are also being developed to identify areas of potential *Spiranthes diluvialis* habitat using modeling. Ward and Naumann (1998) utilized fluvial geomorphology maps and models to identify post-dam terrace surfaces in Lodore Canyon on the Green River to successfully identify and locate orchid habitat in Dinosaur National Monument and Browns Park National Wildlife Refuge. Researchers in Idaho (Moseley 1999b, Jankovsky-Jones and Graham 2001) and Wyoming (Fertig and Thurston 2003, Bonnie Heidel, Wyoming Natural Diversity Database, pers. commun., 2005) have used GIS-based correlational modeling techniques to map watersheds and areas of likely *Spiranthes* habitat. Such studies are useful for locating additional areas for survey, identifying potential conservation or reintroduction sites, or for project clearance (Fertig and Thurston 2003).

Population Biology:

Life History Stages: *Spiranthes diluvialis* is a long-lived perennial forb that probably reproduces exclusively by seed. The occasional presence of clustered plants could be the result of asexual reproduction from a single root mass or broken root segment (Rick Black and Kris Gruwell, HDR Inc., pers. commun. 2004, Heidel 1998). Such clusters could also be from seed caches or germination of seed from an entire buried fruiting capsule. The life cycle of *S. diluvialis* consists of four main stages (Figure 11): seedling, dormant, vegetative, and reproductive (flowering or fruiting) (modified from Arft 1995). Each stage and transition in the life cycle is briefly summarized below, beginning with fruit and seed production.

Fruiting/Seed/Seedling Stages: Fruits are produced in late August or September across most of the plant's range, with seeds shed shortly thereafter (Jennings 1990). As with other orchid species, Ute ladies'-tresses seeds are microscopic, dust-like, and readily dispersed by wind or water. Sipes and Tepedino (1995) estimate that individual *S. diluvialis* fruits may contain several hundred to several thousand seeds apiece and that an entire plant may produce as many as 100,000 seeds per year. Because of their minute size, *Spiranthes* seeds contain little stored food to sustain embryos and are probably short-lived in the soil. Valerie Pence of the Cincinnati Zoo and Botanical Garden recently reported success in germinating *S. diluvialis* seeds in lab culture, but found it took up to 1.5 years for germination to occur (Jennifer Lewinsohn, Red Butte Garden, pers. commun., 2005). It is hypothesized that germinated seedlings must quickly establish a symbiotic relationship with mycorrhizal soil fungi in order to survive. The absence or rarity of appropriate fungal symbionts in the soil may be a major factor limiting the establishment of new Ute ladies'- tresses populations (Hildebrand 1998, McGonigle and Sheridan 2004). Surviving seedlings probably develop slowly into larger, dormant mycorrhizal roots or grow directly into above-ground vegetative shoots, but neither has apparently been confirmed in the wild (Figure 11).

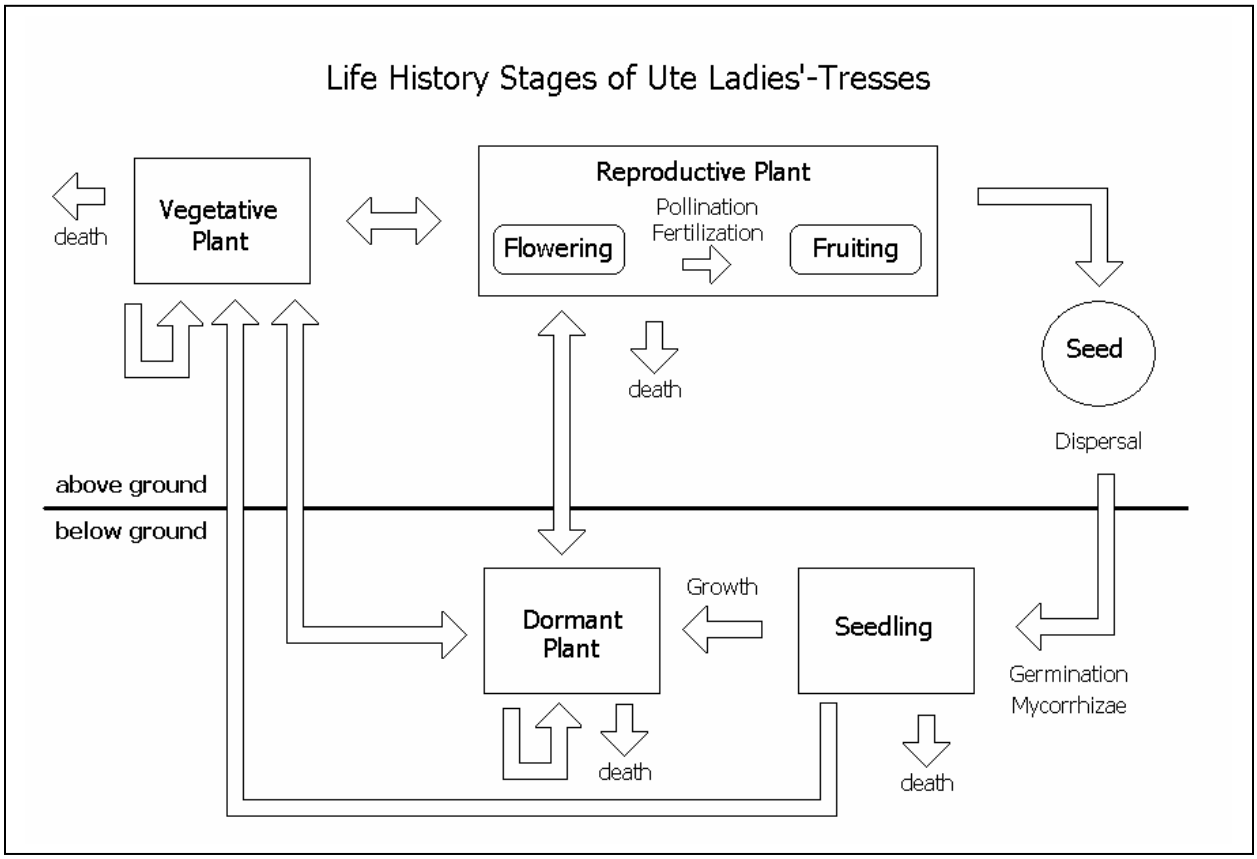

Figure 11. Life history model of Spiranthes diluvialis*. Arrows indicate transitions from one life stage to another. Specific actions (i.e., dissemination, germination, pollination) driving each transition are indicated above the arrow. Reversible transitions are indicated by a double-headed arrow. Several stages can persist in the same form for multiple seasons, as indicated by an arrow circling back on itself. Model developed by Walter Fertig based on an earlier version in Arft (1995).*

Subterranean Dormant Stage: No data are available on the number of years required for subterranean Ute ladies'-tresses roots to reach sufficient size to develop above-ground leafy shoots, though related *Spiranthes* taxa may remain dormant for 8-11 years (Wells 1981). Long-term demographic monitoring studies indicate that vegetative or reproductive *S. diluvialis* plants can revert to a below-ground existence (prolonged dormancy) for one to four or more growing seasons before re-emerging with new above-ground shoots (Arft 1995, Heidel 2001). Although considered dormant, subterranean plants remain metabolically active and derive nourishment from their mycorrhizal partners or food stores laid down when photosynthetic shoots were present.

Above-Ground Vegetative Stage: New vegetative shoots are produced in October and persist through the winter as small rosettes (Arft 1995). These resume growth in the spring and develop into short-stemmed, leafy, photosynthetic plants. Depending on site productivity and conditions, vegetative shoots may remain in this state all summer or develop inflorescences. Vegetative individuals die back in the winter to subterranean roots or persist as winter rosettes. Monitoring studies indicate that plants may remain in the vegetative stage for two or more years, or transform to dormant or reproductive condition in subsequent years (Figure 11).

Reproductive (flowering) Stage: Across its range *Spiranthes diluvialis* blooms from early July to late October. Flowering typically occurs earlier in sites that have an open canopy and later in well-shaded sites (Jennings 1989).

Bees are the primary pollinators of Ute ladies'-tresses, particularly solitary bees in the genus *Anthophora,* bumblebees (genus *Bombus*), and occasionally non-native honeybees (*Apis mellifera*) (Sipes and Tepedino 1995, Sipes et al. 1995, Pierson and Tepedino 2000). Of these species, *Anthophora terminalis* is apparently the most effective pollinator. Studies along the Diamond Fork watershed in Utah indicate that orchids pollinated by *A. terminalis* produce three times as many fruits as plants from Browns Park pollinated only by *Bombus* species (Sipes and Tepedino 1995). Long-term monitoring studies indicate that the relative abundance and composition of the available bee fauna varies from year to year, which may impact overall fruit production rates (Pierson and Tepedino 2000). Other insect taxa (including Syrphid flies, skippers, and other hymenopteran genera) have been observed visiting *S. diluvialis* blooms for nectar but are too small or improperly shaped to function as pollen vectors (Pierson and Tepedino 2000).

Individual Ute ladies'-tresses flowers are arranged in a spiral, with the lowermost blossoms of the inflorescence maturing before those higher up the stalk (Sipes and Tepedino 1995). Although each flower contains both "male" (staminate) and "female" (pistillate) organs, the staminate structures (pollen-bearing anthers fused into sticky pollinia) mature before their female equivalents (stigmatic surface and ovary embedded in a central column). Thus *Spiranthes* flowers are functionally unisexual, passing through a staminate stage before ultimately becoming pistillate. As flowers mature along the inflorescence those higher up the stalk are staminate, while those below become pistillate. Bees attracted to a *Spiranthes* inflorescence by visual cues and a nectar reward visit the lowermost flowers first and then proceed up the spike. When a bee encounters a staminate flower, the viscid pollinarium becomes adhered to the insect's back. Since flowers higher up the same inflorescence are not yet receptive, the bee's pollinia load will remain until it flies to a new inflorescence (on a different *Spiranthes* plant) and repeats its foraging route at the base of the flower stalk. As these lowermost flowers are functionally pistillate, the pollinia can be deposited on the stigmatic surface to cause pollination and the bee is free to pick up another pollinarium higher up the

stem (Sipes and Tepedino 1995). While the asynchronous maturation of flowers within an inflorescence promotes outcrossing in *S. diluvialis*, staminate and pistillate phases may overlap in the same inflorescence and flowers can be pollinated by pollinia produced elsewhere on the same plant (flowers are self-compatible). Sipes and Tepedino (1995) also suggest that Ute ladies'-tresses may be capable of agamospermy (a form of asexual reproduction in which seeds are produced without fertilization), as has been documented in its parental taxon, *S. magnicamporum.*

Population Dynamics: The relative proportion of plants in each of the four life stages can vary widely over time and between different colonies, largely in response to herbivory, pollinator success, climate, disturbance history, and management practices (Allison 2001, Arft 1995, Heidel 2001, Pierson and Tepedino 2000). Based on consecutive years of monitoring in Colorado and Utah, Arft (1995) found that the number of dormant plants in a plot could change from 0 to 20% from one year to the next. The abundance of dormant plants was highest in control (untreated) sites, areas that were manually clipped early in the spring (to simulate winter grazing), or plots subjected to an early burn. In this same study, plants that remained vegetative all year comprised 19-80% of the total sample, with the lowest proportions found in areas that were winter grazed or mowed. On average, plants produced inflorescences in 20-80% of all plots, with the highest flowering rates in sites that were winter grazed and mowed or just winter grazed. Lowest flowering rates occurred in control plots. Arft (1995) found that fruit production was frequently quite low, ranging from 0-18% depending on treatment and herbivory of inflorescences by voles (*Microtus* sp.). Winter grazed sites consistently had the highest fruit production, perhaps because the reduction in cover made the sites less favorable for vole herbivory. Hildebrand (1998) noted that early haying seemed to stimulate flowering and fruiting in Nebraska, but delayed haying during or immediately after the production of inflorescences resulted in significant decline in fruiting production. Sipes and Tepedino (1995) and Pierson and Tepedino (2000) also observed variability in fruit production at sites in Utah in which vole herbivory was high or pollinator success was reduced. Annual fruit production in their sample plots varied from 3.3-75% depending on site characteristics, year, and the abundance, habitat quality, and species of pollinator. Despite the variability in numbers across life stages, Arft (1995) found that overall population trends tended to be relatively stable when counts for all stages were included.

Transition Matrix Modeling: In theory, the long-term persistence of Ute ladies'-tresses populations (and the minimum size necessary for viability) can be predicted by knowing the reproductive output (seed production), number of individuals in each life stage, and the probability that each will survive the transition to the next stage in the plant's life history (Figure 11). In practice, reliably determining the number of plants in each stage can be difficult, especially for subterranean plants (although inferences to the number of dormant plants can be made in long-term demographic studies based on the recurrence of tagged vegetative or reproductive

plants after a one to several year absence) (Arft 1995, Heidel 1998). Survival rates are also difficult to calculate as stochastic events and ever-changing environmental conditions (such as herbivory, competition, shifts in pollinator abundance or fauna, floods, droughts, disturbance, etc.) affect transitions from one stage to another. Arft (1995) developed transition matrix models for plots at South Boulder Creek, Colorado, from three years of data based on a constant environment and on stochastic changes. She found that nearly all colonies were predicted to become extirpated within one century without management intervention or periodic flooding to reduce competing cover or maintain early seral conditions.

Current Land Management and Ownership:

Ownership: *Spiranthes diluvialis* populations occur on a mix of private, federal, tribal, state, county, and city lands. All or portions of 33 populations (54.1%) are on private lands and cover approximately 380 acres (48.7% of occupied habitat) (Tables 10 and 11). Fifteen populations (24.6%) occur on federal lands managed by the Bureau of Land Management, Bureau of Reclamation, National Park Service, US Forest Service, and US Fish and Wildlife Service (Tables 10 and 11). These lands cover about 339 acres (43.3% of all occupied *S. diluvialis* habitat). Four populations (6.6%) covering about 52 acres occur wholly or in part within the Uintah and Ouray Indian Reservation in northeastern Utah. Fourteen other populations (23%) are found partly or completely on state, county, or city-managed lands that cover about 100 acres (12.8% of occupied habitat).

Land Use: Most Ute ladies'-tresses populations occur on lands managed for agriculture, recreation, urban infrastructure, or open space/natural values (Table 12). Typically, more than one of these management activities occurs at any given site. Of the 52 extant populations known in 2004, 7 (14%) are managed for hay production and 34 (65%) are used for cattle or horse grazing (Table 12). Nearly 86% of lands managed for haying and 68% used for grazing are under private or mixed private/public ownership (Table 13). About 14% of all plants occur on lands managed for haying and approximately 53% are found on grazing lands (Table 13). Twenty-four extant orchid populations (46%) are managed for recreational activities, such as hiking, bicycle riding, boating, camping, and OHV use (Table 12). Almost 90% of all known orchid plants occur on lands used for recreation, 83% of which are under full or mixed public ownership (Table 13). Eight mostly publicly-owned populations with 28% of all known *S. diluvialis* plants are found in parks, wildlife refuges, and open space areas managed for natural values (Tables 12 and 13). Six populations (12%) with about 2% of all known plants are managed for a variety of uses, including roads, power plants, dams, sewage plants, mines, and urban infrastructure (Tables 12 and 13).

Table 10. Ownership and protection status of known Spiranthes diluvialis *populations, circa 2004. Location data and acreage estimates are derived from state natural heritage program element occurrence records and literature reports and have been aggregated following the revised element occurrence definitions of NatureServe (2004). Population estimates are based on maximum counts reported at each site.*

Location	Ownership/ Pop. Size	Protection Status	# of Plants Protected	Acres Protected	Comments
Colorado: Weld Co.: Crow Creek, East of Greeley	Private (unknown)	None	0	0	Extirpated
Colorado: Jefferson Co.: Clear Creek, Wheat Ridge	City (598)	Land designation Spdi mgmt plan	598	1	Prospect Park
Colorado: Jefferson Co.: Clear Creek Canyon	Private (307)	None	0	0	
Colorado: Boulder Co.: Boulder Creek	Private (151)	Land designation	151	1	Conservation easement
	Private (49)	None	0	0	
	City (92)	Land designation Spdi mgmt plan	92	1.2-10.2	City of Boulder Open Space
Colorado: Boulder Co.: South Boulder Creek	City (8753)	Land designation Spdi mgmt plan	8753	40.5	City of Boulder Open Space South Boulder Creek State Natural Area
Colorado: Boulder Co.: St. Vrain Creek	County (5)	Land designation Spdi mgmt plan	5	0.5	Boulder County Open Space
Colorado: Boulder Co.: Left Hand Creek	Private (12)	None	0	0	
Colorado: El Paso Co.: Bear or Cheyenne Creek, Colorado Springs	Private (unknown)	None	0	0	Extirpated
Colorado: Larimer Co.: Claymore Lake South, Ft Collins	Private (87)	None	0	0	
	State (included in private total)	None	0	0	Colorado State University
Colorado: Moffatt Co.: Browns Park/ Lodore Canyon	Federal – NPS (14012)	Land designation Spdi mgmt plan	14,012	115	Dinosaur National Monument
	Federal – USFWS (100)	Land designation	100	1-10	Browns Park National Wildlife Refuge
Idaho: Bonneville, Jefferson, & Madison Cos.: Lower South Fork Snake River	Federal – BLM (2803)	Land designation General land mgmt plan	2803	42.7	Snake River ACEC
	Private (146)	None	0	0	
	County (included in BLM total)	Land designation	Included in BLM total	Included in BLM total	Madison County Parks

Location	Ownership/ Pop. Size	Protection Status	# of Plants Protected	Acres Protected	Comments
Idaho: Bonneville Co.: Upper South Fork Snake River	Federal – BLM (4338)	Land designation General land mgmt plan	4338	27.1	Snake River ACEC
	Federal – USFS (35)	General land mgmt plan	35	0.5	Targhee & Caribou National Forests
	Private (included in BLM total)	None	0	0	
Idaho: Fremont Co.: Chester wetlands	State – wildlife area (482)	Land designation Spdi mgmt plan	482	1-10	Idaho Dept. of Fish and Game wetland preserve
Idaho: Madison Co.: Texas Slough	Private (3)	None	0	0	
Montana: Madison Co.: Central Beaver-head River Valley	Private (1)	None	0	0	
Montana: Madison Co.: California Slough	Private (100)	None	0	0	
Montana: Beaverhead Co.: Albers Slough	Private (500)	None	0	0	
Montana: Madison Co.: Ruby River Valley west of Virginia City	State (180)	None	0	0	
Montana: Jefferson Co.: Piedmont Swamp	Private (204)	None	0	0	
Montana: Jefferson Co.: Fish Creek	Private (500)	None	0	0	
Montana: Madison Co.: Central Jefferson River Valley	Private (5)	None	0	0	
Montana: Gallatin Co.: Vicinity of Three Forks	Private (47)	None	0	0	
Montana: Gallatin Co.: NE of Three Forks	State (15)	None	0	0	
Montana: Broadwater Co.: Missouri River, south of Townsend	Private (34)	None	0	0	
Montana: Gallatin Co.: Gallatin River Valley	Private (2)	None	0	0	
Nebraska: Sioux Co.: Niobrara River, SW of Harrison	Private (2300)	None	0	0	

Location	Ownership/ Pop. Size	Protection Status	# of Plants Protected	Acres Protected	Comments
Nevada: Lincoln Co.: Panaca Spring	Private (0) * population relocated in 2005 with 75 plants	None	0	0	Population relocated in July 2005 (previously considered extirpated)
Utah: Daggett Co.: Browns Park, vicinity of Jarvie Ranch	Federal – BLM (5452)	Land designation General land mgmt plan	5452	1.1	Browns Park ACEC
	Federal – USFS (included in BLM total)	General land mgmt plan	Included in BLM total	Included in BLM total	Ashley National Forest
	State – wildlife area (included in BLM total)	Land designation	Included in BLM total	Included in BLM total	Browns Park Waterfowl Management Area
	Private (included in BLM total)	None	0	0	
Utah: Uintah Co.: Green River, Island Park	Federal – NPS (198)	Land designation Spdi mgmt plan	198	20	Dinosaur National Monument
Utah: Uintah Co.: Lower Hog Canyon/Cub Creek	Federal – NPS (104)	Land designation Spdi mgmt plan	104	1-10	Dinosaur National Monument
Utah: Uintah Co.: Green River below Split Mountain Canyon	Federal – NPS (163)	Land designation Spdi mgmt plan	163	6.3	Dinosaur National Monument
Utah: Uintah Co.: "Orchid Draw" WNW of Dinosaur Quarry	Private (30)	None	0	0	
Utah: Uintah Co.: Steinaker Reservoir, N of Vernal	Federal – BuRec (1071)	None	0	0	
Utah: Uintah Co.: Ashley Creek, Vernal	Private (236)	None	0	0	
Utah: Uintah Co.: Big Brush Creek	Federal – BLM (72)	None	0	0	Vernal BLM
Utah: Duchesne & Uintah Cos.: Uinta River	Tribal (668)	None	0	0	Uintah & Ouray Indian Reservation
	Private (336)	None	0	0	
Utah: Duchesne Co.: Duchesne River	Tribal (7)	None	0	0	Uintah & Ouray Indian Reservation
	Private (3029)	None	0	0	
Utah: Uintah Co.: Whiterocks River	Tribal (700)	None	0	0	Uintah & Ouray Indian Reservation
Utah: Duchesne Co.: Lake Fork River	Tribal (2732)	None	0	0	Uintah & Ouray Indian Reservation
	Private (2500)	None	0	0	

Location	Ownership/ Pop. Size	Protection Status	# of Plants Protected	Acres Protected	Comments
Utah: Wasatch & Duchesne Cos.: Currant Creek	Private (423)	None	0	0	
Utah: Weber Co.: Ogden	Private (unknown)	None	0	0	Extirpated
Utah: Salt Lake Co.: South Salt Lake	Private (unknown)	None	0	0	Extirpated
Utah: Utah Co.: Utah Lake, "Powell Slough"	Private (0)	None	0	0	Extirpated
Utah: Utah Co.: Utah Lake Vineyard	City (1000)	Land designation Spdi mgmt plan	1000	1-10	Orem City orchid mitigation under Clean Water Act Section 404
Utah: Utah Co.: Utah Lake, American Fork Mill Pond	City (5)	Land designation Spdi mgmt plan	5	3	American Fork City orchid mitigation under Clean Water Act Section 404
Utah: Utah Co.: Utah Lake, Lehi wetlands	Private (13)	None	0	0	
Utah: Utah Co.: American Fork horse pasture	Private (50)	None	0	0	
Utah: Utah Co.: Hobble Creek, Springville	Private (8)	None	0	0	
Utah: Utah Co.: Diamond Fork/Spanish Fork	Federal – USFS (28,062)	Land designation Spdi mgmt plan	28,062	39.1	Uinta National Forest & UT Reclamation Mitigation and Conservation Commission mitigation for Central Utah Project
	URMCC (included in USFS total)	Land designation Spdi mgmt plan	Included in USFS total	Included in USFS total	Same as above
	Private (631)	None	0	0	
Utah: Utah Co.: Soldier Creek	Private (132)	None	0	0	
Utah: Utah Co.: "Spring Lake" near Payson	Private (unknown)	None	0	0	Extirpated
Utah: Wasatch Co.: Middle Provo River	Federal – BuRec (53)	Land designation Spdi mgmt plan	53	2-20	BuRec & UT Reclamation Mitigation and Conservation Commission mitigation for Provo River Restoration Proj.

Location	Ownership/ Pop. Size	Protection Status	# of Plants Protected	Acres Protected	Comments
Utah: Wasatch Co.: Middle Provo River (continued)	URMCC (included in BuRec total)	Land designation Spdi mgmt plan	Included in BuRec total	Included in BuRec total	Same as above
Utah: Tooele Co.: Willow Springs Station, near Callao	Private (1)	None	0	0	
Utah: Garfield Co.: Deer Creek, SE of Boulder	Federal – BLM (183)	Land designation Spdi mgmt plan	183	10	Grand Staircase-Escalante National Monument
Utah: Wayne Co.: Fremont River oxbow	Federal – NPS (0)	Land designation Spdi mgmt plan	0	0	Capitol Reef National Park Extirpated
Washington: Okanogan Co.: Wannacut Lake	Private (0)	None	0	0	Extirpated
Washington: Chelan Co.: Columbia River	County (193)	None	0	0	
	Private (172)	None	0	0	
	State – wildlife area (19)	Land designation	19	0.3	WA Dept of Fish and Wildlife
Wyoming: Goshen Co.: Bear Creek SE of Chugwater	State (520)	None	0	0	
	Private (included in state total)	None	0	0	
Wyoming: Laramie Co.: vicinity of Midway & Meriden	Private (454)	None	0	0	
Wyoming: Converse Co.: Antelope Creek SW of Ross	Federal – BLM (35)	None	0	0	Casper BLM
Wyoming: Niobrara Co.: Between Lusk and Van Tassell	Private (203)	None	0	0	
TOTAL	85,316		66,608	315.3-378.3	

Table 11. Summary of protection status of extant (circa 2004) Spiranthes diluvialis *populations by ownership type. Populations are considered protected if they occur within designated special management areas or are under binding, legal protective mandates, such as conservation agreements, or management agreements with the Army Corps of Engineers for compliance with the Clean Water Act. The estimated number of individual plants is based on the maximum number reported at each location. Four populations under mixed ownership with protection status divided between protected and unprotected are indicated by *.*

Ownership	# Unprotected Populations/ Individuals	# Protected Populations/ Individuals	Comments
National Park Service	0	3 (465)	Dinosaur NM
National Park Service-US Fish and Wildlife Service	0	1 (14,112)	Browns Park/Lodore population
Bureau of Land Management (including Grand Staircase-Escalante National Monument)	2 (107)	1 (183)	BLM Casper & Vernal populations & GSENM
Bureau of Land Management-Private-County	1* (146)	1* (2803)	Lower South Fork Snake River population
Bureau of Land Management-US Forest Service	0	2 (9825)	Upper South Fork Snake River & Browns Park populations
US Forest Service-UT Reclamation Mitigation and Conservation Commission-Private	1* (631)	1* (28,062)	Diamond Fork population
Bureau of Reclamation	1 (1071)	0	Steinaker Reservoir pop.
Bureau of Reclamation-UT Reclamation Mitigation and Conservation Commission	0	1 (53)	Middle Provo River population
Tribal	1 (700)	0	Uintah & Ouray Indian Reservation
Tribal-Private	3 (9272)	0	Uintah & Ouray Indian Reservation
State Wildlife Management Agency	0	1 (482)	Idaho Department of Fish & Game
State	2 (195)	0	State of Montana
State-Private	2 (607)	0	States of Colorado & Wyoming
City	0	4 (10,356)	Wheat Ridge & Boulder (CO), Orem & American Fork (UT)
City-Private	1* (49)	1* (243)	Boulder Creek pop.
County	0	1 (5)	St. Vrain Creek pop.
County-Private-State Wildlife Management	1* (365)	1* (19)	Columbia River population
Private	24 (5640)	0	
TOTAL	**39 (18,783)**	**18 (66,608)**	

Table 12. Number of Spiranthes diluvialis *populations and estimated number of plants under different land use activities. Figures are based on extant populations (circa 2004) only. Note: numbers add up to more than 100% because many populations have more than one land use.*

Land Uses	# Populations	% Populations	# Plants	% Plants
Haying	7	14	11,809	14
Grazing	34	65	44,972	53
Recreation	24	46	77,307	91
Natural Area	8	15	24,576	29
Other	6	12	1,907	2

Table 13. Number of Spiranthes diluvialis *populations and estimated number of individuals by land use and land ownership category. Figures are based on extant populations (circa 2004) only.*

Land Use	Ownership # of Populations			Ownership # of Plants		
	Private	Mixed	Public	Private	Mixed	Public
Haying	5	1	1	2,764	292	8,753
Grazing	17	6	11	5,465	7,835	31,672
Recreation	4	4	16	3,505	7,228	66,574
Natural Area	0	1	7	0	292	24,284
Other	3	1	2	241	1,004	662

Protection Status: When Ute ladies'-tresses was listed as Threatened in 1992, only six of the 17 known extant or historical populations occurred on public lands. Of these, two were under the jurisdiction of the National Park Service (Capitol Reef National Park and Dinosaur National Monument), two others were in city or county managed parklands (Prospect Park and Boulder Open Space, both in Colorado), and two were located on multiple-use public lands managed by the Bureau of Land Management (BLM). The remaining 11 populations were all found on private or tribal lands that received no formal protection.

Of the 52 extant populations recognized in 2004, 18 (29.5%) receive some form of protection through formal land designation or binding, legal mandates (such as conservation easements or management agreements with the Army Corps of Engineers for compliance with the Clean Water Act) (Tables 10 and 11). These protected sites contain nearly 78% of the total estimated population of Ute ladies'-tresses (Table 11). One extirpated and four extant populations are permanently protected within public lands managed with an emphasis on natural values (Dinosaur National Monument, Capitol Reef National Park, and Browns Park Fish National Wildlife Refuge). Six other populations occur on public lands

managed under a multiple-use mandate, but with policies or agreements in place that recognize conservation of Ute ladies'-tresses as a priority. These sites include Grand Staircase-Escalante National Monument, Snake River and Browns Park ACECs (managed by BLM), and the Diamond Fork and Middle Provo River populations managed under joint agreement of the US Forest Service, Bureau of Reclamation, and the Utah Reclamation Mitigation and Conservation Commission. Eight populations are on state, county, city, or private lands that are managed as wildlife management areas, parks, open space, state natural areas, or conservation easements (Tables 10 and 11).

Among the 18 fully or partially protected Ute ladies'-tresses populations, five are actively managed for orchid conservation through annual monitoring of population size and threats and applied management practices (such as fencing, weed control, supplemental irrigation, or seasonal grazing). These populations (Boulder Creek, South Boulder Creek, Utah Lake Vineyard, American Fork Mill Pond, and Middle Provo River) contain an estimated 10,103 plants, or about 12% of the total population (Table 14). Seven other populations (with about 60% of all known individuals) receive partial management in that some incompatible multiple use activities may be restricted in and near orchid habitat (such as motorized recreation) and populations and habitat are monitored annually. All other *S. diluvialis* populations (including several that are on protected lands) are considered passively managed because monitoring is not regularly occurring and management actions are not being taken specifically to enhance the plant's survival.

Existing and Potential Threats: The US Fish and Wildlife Service (1992) identified habitat loss and modification (through urbanization, water development, and conversion of wetlands to agriculture), overcollection, competition from exotic weeds, and herbicides as the main current and potential threats to the long term survival of Ute ladies'-tresses. These, and additional threats identified since 1992, are summarized below and in Table 15:

1. Habitat Loss (Urbanization): Urban development was probably the primary cause for the extinction of at least four historic *Spiranthes diluvialis* populations in the greater Salt Lake City, Ogden, and Colorado Springs areas (US Fish and Wildlife Service 1992). Today, loss of habitat to urban sprawl and development is considered a current or potential threat to four populations along the Wasatch Front in Utah and near Boulder Colorado. These populations represent approximately 10% of the total estimated Ute ladies'-tresses population (Table 15). Because of their reduced size and increased isolation, surviving populations within urban/suburban environments are more susceptible to other threats, such as increased recreational demands, changes in hydrology from flood control projects and road construction, competition from introduced weeds, and loss of native pollinators (Riedel 2002).

Table 14. Number and size of Spiranthes diluvialis *populations under active, partial or passive management. Active management means that annual monitoring is taking place and management actions are being implemented to promote recovery and survival of* S. diluvialis. *Partial management means that periodic monitoring is occurring and some restrictions may be in place for incompatible multiple uses. Passive management implies that monitoring is not occurring and management is not conducted with the orchid specifically in mind.*

	Active Management	Partial Management	Passive Management
# of Populations	5	7	40
# of Individuals	10,103	51,390	23,823

2. Habitat Loss (Road and Infrastructure Construction): At least 13 (25%) of the 52 extant Ute ladies'-tresses populations and 21% of all known plants are threatened by habitat disturbance associated with construction of roads, highways, water pipelines, dams, and other infrastructure (Table 15). For example, expansion of Highway 36 in Colorado could affect up to 30-40% of the orchid population within 100-200 meters of the road (3000-4000 plants) along South Boulder Creek (Lynn Riedel, City of Boulder Open Space and Mountain Parks Dept., pers. commun., 2005). In addition to direct habitat disturbance, construction activities impact Ute ladies'-tresses populations by contributing to changes in hydrology (flooding or dewatering sites), establishment of competing weeds, additional population fragmentation, and increased pollution runoff.

3. Recreation: Impacts from recreation have been identified as a current or potential threat to 7 extant Ute ladies'- tresses populations and 20% of all plants (Table 15). Increased demand for recreational access and construction of new hiking and bike trails is a threat to several orchid populations near urban areas in Wheat Ridge, Golden, and Boulder, Colorado, including the South Boulder Creek occurrence managed by the City of Boulder Open Space and Mountain Parks Department (Riedel 2002). Trampling from fishing access and boat camping have been reported as potential threats at several sites along the Snake River in Idaho and the Green, Uinta, and Duchesne rivers in Utah (Franklin 1993, Murphy 2001a). In Idaho, several *S. diluvialis* occurrences along the Snake River are threatened from physical disturbance and trail development by unauthorized off-highway vehicle (OHV) recreation (Murphy 2001a). The BLM Upper Snake River Field Office issued a one-year emergency closure to OHV access on Annis Island in 2004 after vehicle trails were located through *Spiranthes* wetland habitat (Wendy Velman, BLM, pers. commun. to Lucy Jordan, 2004).

4. Haying/Mowing: Mowing for hay production occurs at several sites in Colorado, Nebraska, and Wyoming, and has been identified as a potential threat to two extant populations (4%). Mowing, especially in conjunction with winter

Table 15. Potential threats to extant (circa 2004) populations of Spiranthes diluvialis. *Numbers of individuals are based on the maximum count reported for all subpopulations comprising a population. Threats are derived from natural heritage element occurrence records and other pertinent, site-specific literature.*

Threat	Number & Percentage of Populations	Number & Percentage of Individuals
Competition from Invasive Species	32 (62%)	71,306 (84%)
Vegetation Succession	17 (33%)	45,877 (54%)
Road & Other Construction	13 (25%)	17,696 (21%)
Hydrology Change	11 (21%)	44,409 (52%)
Grazing by Livestock	7 (14%)	3,740 (4%)
Recreation	7 (14%)	17,153 (20%)
Urbanization	4 (8%)	8,824 (10%)
Flooding	3 (6%)	23,101 (27%)
Haying/Mowing	2 (4%)	9 (0.01%)
Natural herbivory	2 (4%)	9,045 (11%)
Loss of Pollinators	1 (2%)	5,452 (6%)
Drought	1 (2%)	384 (0.5%)

grazing, can have positive effects on Ute ladies'-tresses by reducing competing vegetative cover and protective cover for voles (Arft 1995, Fertig 2000, Hazlett Hazlett 1996). In addition, irrigation of hay meadows can increase the amount of habitat that would otherwise be unavailable to *S. diluvialis*. However, mowing just before or during the appearance of inflorescences can greatly reduce fruit production (Arft 1995). In Nebraska, the first hay crop is typically mowed in July, allowing abundant flowering to occur in August (Hazlett 1996), but in 1997 a late spring delayed haying until August, resulting in minimal flower or fruit production that year (Hazlett 1997, Hildebrand 1998).

5. Grazing by Livestock: Grazing by cattle or horses occurs at 65% of known *S. diluvialis* populations and has been identified as a potential threat at 7 sites (13.5%) affecting an estimated 4% of all plants (Table 15). Ute ladies'-tresses is edible to livestock and depressed inflorescence and fruit production have been observed at sites that are grazed or trampled in summer (Arft 1995, Fertig 2000, Murphy 2001a). Winter grazing, however, has been shown to be beneficial to *S. diluvialis* populations in Colorado by reducing competing vegetation and escape cover of voles (Allison 2001, Arft 1995, Riedel 2002). Meadow populations that are less directly influenced by seasonal flooding may be dependent on a mix of winter grazing and mowing to maintain habitat conditions needed for long-term persistence (Allison 2001, Arft 1995).

Other potentially adverse impacts of grazing still need to be determined. Grazing disturbance may favor the establishment of competing weedy or non-native plant species such as Redtop (*Agrostis stolonifera*) at sites in Idaho (Moseley 1998a). Impacts of grazing and trampling on the life history of insect pollinators are poorly understood (Sipes and Tepedino 1995).

6. Hydrology Change: Modification of wetland habitats through development, flood control, de-watering, and other changes to hydrology was identified as a significant threat when Ute ladies'-tresses was listed as Threatened. Eleven extant populations (21%) containing an estimated 52% of all orchid plants are considered threatened by further changes in hydrology. The following actions are most likely to impact the hydrology and population dynamics of specific Ute ladies'-tresses populations:

A. Conversion of Irrigation Water to Municipal Use: As human populations expand along the Wasatch Front and Denver metropolitan areas, demand for water to meet culinary and industrial needs will accelerate. Some of this demand may be met by diverting water currently used for irrigating crops and hayfields, including areas occupied by Ute ladies'-tresses. Conversion of irrigation water could reduce the quantity and availability of water (especially during the growing season) and reduce groundwater recharge for seeps and springs, resulting in a net loss in area and quality of wet meadow habitat for this species. Already, loss of irrigation water has negatively impacted three *S. diluvialis* populations in the Utah Lake watershed, including the Powell Slough site which is now thought to be extirpated due to dewatering. Increased demand for water for Las Vegas is a potential threat to the newly rediscovered Panaca Springs population in eastern Nevada.

B. Flood Control: Natural flooding cycles are important for creating new alluvial habitat and for reducing cover of competing plant species for Ute ladies'-tresses populations associated with the Green, Snake, and Columbia rivers in Colorado, Utah, Idaho, and Washington. These rivers are all now regulated by dams, which has resulted in less frequent flooding events and more stabilized river bank terrace features favoring invasion of noxious weeds (such as tamarisk) and succession of later seral plant communities. In Idaho, long-term reduction in new alluvial surfaces and early seral vegetation conditions is likely to prevent establishment of new orchid populations to replace those that will be lost as sites become dominated by riparian shrub and woodland communities (Moseley 2000, Murphy 2001b). Ward and Naumann (1998) hypothesize that the creation of Flaming Gorge Dam has lead to an increase in available *S. diluvialis* habitat in Lodore Canyon in Dinosaur National Monument due to the reduction in large floods, but a decrease in habitat in Browns Park as the Green River has become more channelized and its banks made drier. Proposed changes in flow management to benefit endangered fish species could have potentially negative effects on recently established orchid populations in Lodore Canyon (Tamara Naumann, Dinosaur NM, pers. commun., 2004). Unpredictable flows and water releases associated

with hydroelectric dams is a potential threat to populations along the Columbia River.

C. Water Development or Redevelopment: Water projects that result in diversion of water away from wetland systems or general habitat disruption through construction activities are considered threats to at least 26 *S. diluvialis* occurrences (Table 5) and are the likely cause of extirpation of the Capitol Reef National Park population (Clark 2002). Transfer of water, however, can result in augmented flows that create new areas of orchid habitat, as occurred along the Diamond Fork drainage in the 1980s (Black et al. 1999).

D. Stream and Riparian Restoration: Efforts to restore more natural stream hydrology can have short-term negative consequences for Ute ladies'-tresses populations that have become established along previously altered watercourses. Such efforts are currently underway along the largest known *Spiranthes diluvialis* occurrence in the Diamond Fork drainage of Utah as part of mitigation stipulated by the Central Utah Project (Central Utah Water Conservancy District 1999). Supplemental irrigation water that formerly flowed through Diamond Creek is now being delivered through pipes and tunnels, thus reducing the stream flow of the Creek to pre-settlement levels. With the reduction in water, Diamond Fork is predicted to have 25% less available habitat for Ute ladies'-tresses (Central Utah Water Conservancy District 1999). Some changes in the hydrology of Diamond Fork, however, may result in new areas being colonized by *S. diluvialis* that were previously inundated. Additional stream restoration projects are on-going or planned for Ute ladies'-tresses populations along Ashley Creek and the Provo River.

7. Competition from Invasive Species: Negative impacts from competition by aggressive, non-native weed species is the most frequently cited potential threat to Ute ladies'-tresses, affecting 32 extant populations (62%) and an estimated 84% of all plants (Table 15). *Spiranthes diluvialis* is adapted to early to mid seral conditions where competition for light, space, water, and other resources is normally kept low by periodic or recent disturbance events. Non-native weedy plants are frequently adapted to similar environments and act as highly effective competitors with *S. diluvialis* because they are often under less pressure from herbivores and disease, or spread and reproduce more rapidly. Nearly 50 non-native plant species commonly co-occur with Ute ladies'-tresses (Table 4), of which fourteen are considered especially significant: *Agrostis stolonifera, Carduus nutans*, *Centaurea maculosa, C. repens*, *Cirsium arvense*, *Dipsacus fullonum*, *Elaeagnus angustifolia*, *Elymus repens, Euphorbia esula*, *Lepidium latifolium, Lythrum salicaria*, *Phalaris arundinacea, Sonchus arvensis*, and *Tamarix chinensis* (Moseley 1998a, Murphy 2001a, Ward and Naumann 1998, Riedel 2002). Besides direct competition, non-native species can alter community structure and dynamics (such as nutrient cycling and fire dynamics) and affect the abundance or diversity of pollinators (Moseley 1998a, Sipes and Tepedino 1995). Control of exotic plants with herbicides, however, can have direct impacts on

Spiranthes and its pollinators that are now dependent on exotic plants for supplemental pollen and nectar (Pierson and Tepedino 2000). The state of Idaho has initiated a program to control noxious weeds along the Snake River using biological control insects (Moseley 2000, Murphy 2001b).

8. Vegetation Succession: Change in habitat condition and suitability due to vegetative succession is a current or potential threat to 17 extant Ute ladies'-tresses populations (33%) and 54% of all individuals (Table 15). In the absence of periodic disturbance, such as flooding, fire, or grazing, the composition of riparian and wet meadow vegetation is likely to become more shaded and woody over time, reducing the quality of such sites for the establishment or persistence of Ute ladies'-tresses (Allison 2001, Arft 1995, Moseley 1998a). Several populations in Colorado and Idaho with dense and well-shaded cover of shrub or riparian woodland vegetation have low or declining orchid populations (Coyner 1990, Jennings 1989, Moseley 2000b, Murphy 2001a). Even unshaded meadow sites can have reduced density or inflorescence production of *Spiranthes* in the absence of mowing, clipping, or grazing to keep competing vegetation low (Arft 1995). Densely vegetated sites also correlate with increased herbivory by voles (Arft 1995). Historically, patchy and episodic disturbance events created areas suitable for establishment of new orchid colonies as existing sites became less hospitable over time. In today's fragmented ecosystems, human manipulation may be necessary to augment or direct the creation of early to mid successional habitats for *S. diluvialis* (Allison 2001).

9. Natural Herbivory: Herbivory by native wildlife (particularly voles) has been cited as a threat at two populations with an estimated 11% of all plants (Table 15). Although the foliage of *Spiranthes diluvialis* is edible, it is not typically a desired forage species for livestock or vertebrate species (though it may be consumed by insects). Inflorescences, however, are apparently an important food source for voles in wet meadow sites in Colorado and Utah (Arft 1995, Pierson and Tepedino 2000). Vole herbivory can reduce flower and fruit production by up to 80% in some areas (Arft 1995), though damage is typically greater in grazed meadows than riparian systems. Vole populations naturally fluctuate, but can also be reduced by a combination of mowing and winter grazing (Arft 1995). Incidental herbivory by white-tailed deer, bighorn sheep, and rabbits has also been observed at sites in Idaho, Montana, and Colorado, but has not been reported as a significant threat.

10. Loss of Pollinators: The threat from reduction in the number and diversity of insect pollinators has been well documented at Browns Park (2% of all extant populations and 6% of individuals), but is probably equally significant, though unreported, at many other sites. The abundance and diversity of bee species that pollinate *Spiranthes diluvialis* varies widely between sites and from year to year (Pierson and Tepedino 2000). Because Ute ladies'-tresses does not offer a pollen reward to its pollinators, other pollen-rich wildflowers need to be present in orchid habitat to attract bees. Survival and abundance of bees can also be affected

by the presence of suitable nesting habitat (such as old wood debris and sandy embankments) and the use of pesticides to control weeds or other insects in riparian or adjacent upland areas (Sipes and Tepedino 1995, Sipes et al. 1995, Pierson and Tepedino 2000). Non-native honeybees (*Apis mellifera*) are becoming an important pollinator of Ute ladies'-tresses at some sites (Pierson and Tepedino 2000), but are not as effective pollinators as native bees because they tend to visit a wider variety of flowers and thus waste pollinia on the wrong species. Reduction in the quantity and quality of pollinators lowers overall rates of fruit and seed production in *S. diluvialis* (Sipes and Tepedino 1995) and can lead to greater reliance on self-pollination, with potentially deleterious long-term consequences on genetic variability.

11. Drought: Recent drought has been documented as a threat to orchid survival at one riparian site affecting less than 1% of all orchid plants (Table 15), but has likely impacted populations elsewhere in the species' range. Riedel (2002) noted that several of the larger irrigation ditches providing water to wet meadows occupied by *Spiranthes diluvialis* did not flow after the spring of 2002 for the first time in a century. Without this moisture, flowering and fruiting were reduced and population counts were low. Recent drought may be one of the causes of the drop in population size reported at several locations from 2001-2004 (Figure 7). Continued de-watering of natural flows or loss of irrigation water to municipal use could exacerbate the effects of drought in the future.

12. Other Threats: In addition to the threats identified at specific populations, the following potential adverse impacts have been reported in the literature:

Pesticides: *Spiranthes diluvialis* may be susceptible to broadleaf herbicides applied in hay meadows to control noxious weeds (US Fish and Wildlife Service 1995). The plant's pollinators may also be vulnerable to insecticides used to control grasshoppers and other agricultural pests on rangelands (Sipes and Tepedino 1995). While riparian areas are usually not directly sprayed, wide-ranging bee species can easily contact insecticides that are applied beyond the standard 500-foot buffer zones surrounding watercourses (Pierson and Tepedino 2000).

Pollution: Polluted runoff downstream of a sewage treatment plant along the Uinta River and below a campground along the Snake River in Idaho may have negative impacts on two small Ute ladies'-tresses sites.

Over-collection: The potential for over-collection of *Spiranthes diluvialis* for horticultural use was cited as a potential threat by the US Fish and Wildlife Service (1992) when this species was originally listed. Under the Endangered Species Act, Ute ladies'-tresses is protected from collection of flowers or any other plant parts without a permit. There is relatively little evidence that collection has been a problem for this species, despite the overall popularity of orchids in greenhouse culture. The difficulty in establishing the species in

cultivation from seed or cuttings and its relative drabness compared to more showy tropical species has probably kept interest in the species low. However, the Colorado USFWS reports an "essence of *Spiranthes*" derived from *S. diluvialis* flowers being offered for sale on the internet in the late 1990s.

Fire/Fire Suppression: Arft (1995) experimented with the use of fire at South Boulder Creek to control competing vegetation cover and stimulate growth and reproduction of Ute ladies'-tresses. Sites that were burned in the early 1990s had slightly higher flowering and fruiting rates than untreated plots, but were lower than winter grazed or grazed and mowed sites. Allison (2001) recommends continued experimentation with burning to determine whether fire has a fertilizing effect on *Spiranthes* (through the release of nutrients in ash). Fire suppression may be of little consequence in much of the riparian/wet meadow habitats occupied by *S. diluvialis* (which are probably too moist to typically support frequent fire), but could become an important alternative management tool to abate the conversion of mesic meadows to woody vegetation along the Snake and Green rivers.

Absence of Mycorrhizae: McGonigle and Sheridan (2004) suggest that absence or rarity of mycorrhizal symbionts may restrict the expansion of *Spiranthes diluvialis* into potential new habitat. Hildebrand (1998) reported high levels of phosphorus and potassium in soils in Wyoming and Nebraska that might inhibit mycorrhizal formation with *Spiranthes* seedlings.

Intrinsic Rarity: Although Ute ladies'-tresses is now known to be significantly more widespread and abundant today than when it was listed in 1992, it remains an uncommon plant at the local and regional level. Nearly 78% of all known occurrences contain 1000 or less individuals and more than 60% occupy 10 acres or less of suitable habitat. The complex life history of this species, requiring mycorrhizal infection, frequently disturbed early seral habitat conditions, and specialized pollination biology all combine to make local Ute ladies'-tresses populations more susceptible to stochastic events or human-induced threats than most native plant species. Demographic modeling work by Arft (1995) suggests that colonies in the South Boulder Creek area are all too small at present to persist beyond one century.

Conflicting Management with Other Rare Species: In South Boulder Creek populations of Ute ladies'-tresses co-occur with the federally Threatened Preble's meadow jumping mouse. These species have conflicting habitat requirements, with orchids preferring early to mid seral meadow communities and the jumping mice favoring later seral mixed willow and meadow stands (Fertig 2000). Management actions that benefit one species are likely to be at odds with the other. Managing riparian areas with a mosaic of seral conditions may be the only viable solution to meeting the needs of both taxa. Other rare (though not listed) nesting songbird species in the South Boulder drainage may be negatively affected by early season vegetation treatments that reduce cover and would

otherwise benefit Ute ladies'-tresses (Riedel 2002). Changes in water management for the benefit of salmon could affect populations along the South Fork of the Snake River (Gina Glenne, USFWS, pers. commun., 2005).

Landscape-Level Effects: The long-term survival of Ute ladies'-tresses and its pollinators may increasingly depend on management schemes taking into account landscape or watershed-level ecological processes (Arft 1995, US Fish and Wildlife Service 1995, Moseley 2000, Pierson and Tepedino 2000, Ward and Naumann 1998). The availability, distribution, and quality of water, periodicity of flooding/scouring and sedimentation, maintenance of metapopulations in a mosaic of early, mid, and later seral vegetation types, and other factors contributing to the establishment and persistence of *S. diluvialis* are all dependent on large-scale processes that may be beyond the control of any local land owner or manager. The lack of cooperative and integrated management schemes for *Spiranthes* and overall watershed functioning across land boundaries may be the single greatest impediment to conservation of this species.

Listing/De-Listing Factors: The US Fish and Wildlife Service uses five main factors (present or threatened habitat/range loss, overutilization, disease/predation, inadequacy of protection, and other threats) to determine whether a proposed species warrants listing under the Endangered Species Act. Three other criteria (recovery, extinction, or erroneous information at the time of listing) are used to assess if a listed species can be de-listed. Each of these listing and de-listing factors are summarized below and in Table 16:

Listing Factors

Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range: In 1992, *Spiranthes diluvialis* populations in the greater Denver and Wasatch Front areas of Colorado and Utah were believed to be highly threatened by loss of riparian habitat to urban residential development, stream channelization, and construction projects (US Fish and Wildlife Service 1992). At least seven populations in this area and the Great Basin of Utah and Nevada were thought to be extirpated as a result of such development. These threats are all still present throughout the expanded range of Ute ladies'-tresses, though the most pervasive threats are now considered competition from invasive species, vegetative succession, road and infrastructure construction, and recreation (Table 15).

Overutilization for Commercial, Recreational, Scientific, or Education Purposes: USFWS was concerned in 1992 that collection pressure from orchid enthusiasts and gardeners could threaten Ute ladies'-tresses populations, especially near urban areas. Although not unfounded, this threat has not materialized, and no populations are currently considered highly at risk from over-collection (Table 15). Protection under the ESA prevents legal collection of this species for commercial, scientific, or educational uses without a permit.

Table 16. Summary of changes in status of Spiranthes diluvialis *from 1992 to 2004.*

Attribute	1992	2004
Number of States Present	2 extant (CO and UT), 1 historical/presumed extirpated (NV)	7 extant (CO, ID, MT, NE, UT, WA, WY), 1 historical (NV). (The NV population was rediscovered in 2005, making it 8 states extant.)
Number of Ecoregions Present	5 extant, 1 historical/presumed extirpated	10 extant
Number of Watersheds Present	9 extant, 6 extirpated	26 extant, 7 extirpated (the Meadow Valley Wash, NV, population was rediscovered in 2005, making the total 27 extant, 6 extirpated)
Number of Populations	10 extant, 7 extirpated	52 extant & 9 extirpated (The NV population was rediscovered in 2005, making the total 53 extant and 8 extirpated)
Maximum Estimated Number of Individuals	6000	85,316
Area of Occupied Habitat	129-170 acres	674-784 acres
Preferred Habitat	Undisturbed, relictual sites associated with wet meadows, springs, streambanks, or lakes	Wet meadows, stream or river banks, irrigated hay meadows, and wetlands associated with wet meadows, springs, streams, lakes, irrigation ditches, and reclaimed gravel or peat mines.
Number of Protected Populations	6	All or part of 18 populations, 1 other protected population is probably extirpated (Capitol Reef NP)
Local Population Trends	Based on counts of flowering plants, populations thought to fluctuate widely each season	Based on demographic monitoring data, populations thought to be more stable if fruiting, vegetative, and below-ground dormant plants are included in census.
Taxonomic Status	Questions about whether *S. diluvialis* was a full species or a variety of *S. romanzoffiana* or *S. porrifolia*	Taxonomic studies confirm hybrid origin and taxonomic distinctiveness (Arft & Ranker 1998, Szalanski et al. 2001)
Present or Threatened Destruction or Modification of Habitat/Range	Habitat loss through urbanization, stream channelization, and construction projects considered major threats	Habitat loss or alteration from competition from non-native plants and vegetation succession considered most widespread potential threat rangewide. Urbanization, construction of roads and other infrastructure,

		changes in hydrology, impacts from recreation, late season haying, and pollution considered other potential threats.
Overutilization	Concern that orchid collectors and gardeners could reduce wild populations, especially near urban areas.	Little evidence that over-collection has been a problem (not cited as a threat at any site in species' range)
Disease/Predation	Concern that livestock grazing could have a detrimental impact. Surmised that populations were all relictual and persisted in sites where grazing has been less intense.	Winter grazing found to be beneficial for reducing competing cover in *S. diluvialis* populations. Summer grazing more detrimental, particularly if plants are trampled or inflorescences removed before seed produced. Herbivory of inflorescences by voles much more severe than expected at several sites.
Inadequacy of Protection	No legal protection for individuals or populations prior to listing under the ESA. Four of 17 known populations found in protected areas, (Dinosaur NM, Capitol Reef NP, and city or county parks/open space in Wheat Ridge and Boulder, Colorado).	Legal protection under ESA and CITES protects individual plants from collection or harm on public lands, restricts interstate and international trade, and regulates herbicide use in occupied habitat. Today all or part of 18 populations are protected in special management areas or by binding legal mandate (Dinosaur NM, Capitol Reef NP [extirpated], Browns Park NWR, City of Boulder Open Space and Mountain Parks, Prospect Park [Wheat Ridge], Upper Snake River ACEC, Browns Park ACEC, and Grand Staircase-Escalante NM).
Other	Intrinsic rarity (small population size), competition from non-native plants, and herbicides considered existing or potential threats.	Competition from non-native plants considered the most widespread threat to this species rangewide. Survival of pollinators, vegetation succession, herbicides, intrinsic rarity, and lack of coordinated management across ownership boundaries considered additional threats.

Disease or Predation: Excessive grazing by livestock was considered a threat in 1992, although moderate grazing was acknowledged as beneficial in reducing competing plant cover (US Fish and Wildlife Service 1992). Additional monitoring and research since 1992 has confirmed that winter grazing (often in combination with mowing or haying prior to inflorescence production) can maintain early seral conditions favored by *S. diluvialis* and reduce protective cover and herbivory by voles (Allison 2001, Arft 1995). Summer grazing, however, can result in increased trampling or reduced inflorescence production and make sites more susceptible to invasion by exotic weeds (Moseley 2000, Murphy 2001b). Inflorescence herbivory by voles has been found to be much higher than expected at sites in Colorado and Utah and can lead to diminished pollinator success and reduced fruit and seed production.

Inadequacy of Existing Regulatory Mechanisms: Prior to 1992, Ute ladies'-tresses was not protected under the US Endangered Species Act, but did receive limited protection from international trade under the CITES treaty. Due to its Threatened status, this species is protected from direct physical harm and collection on public lands and from interstate trade and some herbicide application on state, private, and tribal lands. In 1991, only four of 17 known populations were found in protected areas (Dinosaur National Monument, Capitol Reef National Park, and city parks in Boulder and Wheat Ridge, Colorado). Since then, 9 additional populations have been discovered in existing parks (new sites in Dinosaur NM, Browns Park National Wildlife Refuge, City of Boulder Open Space and Mountain Parks), or new protected areas have been designated that contain *S. diluvialis* occurrences (Upper Snake River ACEC, Browns Park ACEC, Grand Staircase-Escalante National Monument). In total, 18 populations with an estimated 66,609 plants (78% of the global population) occur in protected lands or areas under binding legal protective measures (such as conservation easements or management agreements with the Army Corps of Engineers for Clean Water Act compliance). One other protected population in Capitol Reef National Park has not been relocated since 1995 and is now considered extirpated (Clark 2002). At present, 75% of all extant Ute ladies'-tresses populations (representing 22% of all plants) still have no formal protection other than that provided under the ESA (Table 11). Ute ladies'-tresses is minimally protected under state law in Nebraska and Nevada, but receives no state protection elsewhere in its range.

Other Natural or Manmade Factors Affecting Continued Existence: Additional threats identified in 1992 included intrinsic rarity and susceptibility to extinction from stochastic events, competition from non-native plants, and deleterious effects of herbicides. Loss or reduction of pollinators (Pierson and Tepedino 2000, Sipes and Tepedino 1995) and degradation of habitat through vegetation succession (Moseley 2000) are new threats that have been recognized since listing.

Delisting Factors

Recovery Achieved: A draft recovery plan for Ute ladies'-tresses was developed by the US Fish and Wildlife Service (1995), but has not been finalized. This plan had three primary objectives for achieving recovery:

1. Obtaining information on life history, demographics, habitat requirements, and watershed processes that will allow specification of management and population goals and monitoring progress

2. Managing watersheds to perpetuate or enhance viable populations of the orchid

3. Protecting and managing Ute ladies'-tresses populations in wet meadow, seep, and spring habitats.

The draft recovery plan identified several action items needed to achieve these objectives. To date, progress has been made on elucidating the life history, demography, pollination biology, genetic structure, and habitat dynamics of Ute ladies'-tresses (Arft 1995, Arft and Ranker 1998, Moseley 2000, Murphy 2001b, Pierson and Tepedino 2000, Sipes and Tepedino 1995, Szalanski et al. 2001). Data on applied management techniques have been developed for South Boulder Creek (Allison 2001, Arft 1995, Riedel 2002) that may be transferable to similar populations elsewhere in the species' range. Baseline inventories have also been completed for sites in Colorado, Utah, and Wyoming that were not known when the plan was drafted and for new occurrences discovered since 1995 in Idaho, Montana, Nebraska, and Washington. The known habitat of Ute ladies'-tresses has broadened with the discovery of riverine populations in Utah, Idaho, and Washington, as has the need to expand conservation targets in objective 3. Less progress has been made on defining conservation units by watershed, developing watershed-based recovery goals, and informing the public about the merits of the watershed approach. Additionally, trend data and basic monitoring information are not available for nearly 75% of all known occurrences, making it difficult to identify management needs and develop conservation priorities. Active or partially active management actions involving monitoring, habitat manipulation, and other actions specifically intended to promote *Spiranthes diluvialis* recovery have been initiated for 12 of 52 extant populations (23%) (Table 14). Eighteen extant populations (34.6%) are now under some form of protection through special management area designation, conservation easements, or management agreements with the Army Corps of Engineers (Table 11).

Extinction: *Spiranthes diluvialis* has not become extinct since being listed, and so cannot be removed from the Endangered Species list for this reason.

Erroneous Information at the Time of Listing: When Ute ladies'-tresses was listed as Threatened in 1992 it was known from only 10 extant and 7 historic (and

likely extirpated) populations in three states, a total estimated population size of 6000 individuals, and was considered highly vulnerable to habitat loss from development of its riparian habitat. Since then, additional survey work has increased the number of extant populations to 52, the number of states to eight, and the estimated number of plants to over 83,300. General threats present in 1992 continue to exist, but additional research and monitoring have shown that competition from invasive plants, vegetative succession, changes in hydrology (through flood control and dewatering), habitat disturbance associated with road construction, and impacts from recreation are now the most widespread potential threats. New research on management response and threats, however, indicate that *Spiranthes diluvialis* is far more adapted or resilient to human-influenced environments than was suspected in 1992 and relatively few populations are highly at risk. In the original listing rule, the USFWS maintained that "[a]ll known remaining populations are relict in nature, with most in small areas where livestock grazing was less intense than in other riparian communities within the species' range" (US Fish and Wildlife Service 1992). Nearly 80% of all known orchid populations are now known to be associated with agricultural lands managed for grazing, haying, and irrigation, or dam-regulated rivers, recreation areas, or other human-influenced lands (Table 3). The perpetuation of these populations is now known to be favored by management practices that simulate natural disturbance events and maintain adequate soil moisture levels (Allison 2001, Arft 1995).

SUMMARY

Ute ladies'-tresses was first collected in 1856 but not recognized as a distinct species until 1984. Through the 1980s it was known from only 10 extant and 7 historical locations in the Denver and Salt Lake City metropolitan areas and scattered sites along the Green River, Colorado Plateau, and Great Basin in Colorado, Utah, and Nevada. Many of these populations were considered highly threatened by urban sprawl and development of stream and wet meadow habitat, and as many as seven were already considered extirpated. Due to its low estimated population size (6000 individuals), limited range, and high vulnerability to extirpation, Ute ladies'-tresses was listed as Threatened under the US Endangered Species Act in January 1992. In the years following listing, additional field surveys and monitoring greatly increased the number of known populations, total population size, and the global range of this species. Today, Ute ladies'-tresses is known from 52 extant populations, approximately 83,300 individuals, and is found in eight states (including Idaho, Montana, Nebraska, Washington, and Wyoming). New monitoring and demographic research have documented that populations are more stable than originally suspected (especially if subterranean seedling and dormant individuals are counted) and more tolerant of human-induced disturbances. Studies have found that winter grazing and early season mowing can reduce competing vegetation cover and favor orchid survival and reproduction, while grazing or haying after flower production can be detrimental. Many threats to Ute ladies'-tresses remain high, especially flooding and de-watering associated with wetland

development, competition from non-native plants, loss or degradation of habitat associated with urban/residential expansion and development of road and water infrastructure, inappropriately timed agricultural practices, and vegetation succession. This species was originally thought to be limited to relictual, undisturbed riparian habitats, but is now known to occur in agricultural lands and managed riparian systems where frequent human-influence disturbance events simulate natural early to mid seral conditions. Today, about 35% of all known populations are in protected areas or afforded some form of special management attention.

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Appendix A.

Extent of Ute Ladies'-Tresses Surveys

Surveys for Ute ladies'-tresses have increased greatly since the species was listed as Threatened under the Endangered Species Act in 1992, largely to ensure compliance with the Act in areas of potential orchid habitat proposed for development. As a result, the number of known occurrences of *Spiranthes diluvialis* nearly tripled in the decade following listing, and its known range has been expanded from three to eight states. The following is a synopsis of survey effort by state, highlighting areas that have been searched but where no populations have been discovered.

Colorado: Initial surveys in Colorado were conducted by Jennings (1989, 1990), Coyner (1990), and Sheviak (1982) and focused on potential habitat at the base of the Front Range in the greater Boulder and Denver area and along the Green River in Dinosaur National Monument. Since 1992, numerous clearance surveys have been done in north-central Colorado by botanical consultants. Additional surveys along the Green River were conducted by Ward and Naumann (1998) and included an unsuccessful search of the Yampa River (considered by the authors to be mostly unsuited for Ute ladies'-tresses). The US Fish and Wildlife Service (1995) has identified the South Platte River and Fountain Creek as priority areas for re-survey (both contain vague historical records currently presumed to be extirpated), as well as Vermillion Creek, Douglas Draw, and portions of the Yampa, White, and Little Snake River drainages.

Idaho: Following the initial discovery of Ute ladies'-tresses in Idaho in 1996, surveys by the Idaho Conservation Data Center (ID-CDC), BLM, and US Forest Service focused on riparian habitat bordering the South Fork of the Snake River below Palisades Dam (Moseley 1997, 1998a, 2000). In 2001, the ID-CDC completed a study modeling potential *S. diluvialis* habitat in National Forests of Idaho using correlations of selected environmental attributes in GIS (Jankovsky-Jones and Graham 2001, Moseley 1999b). The recent discovery of two small occurrences in the Henry's Fork drainage has shifted survey focus to this area of northeastern Idaho (Mancuso 2004, Murphy 2004b).

Montana: Since being discovered in Montana in 1994, surveys have focused on watersheds in the southwestern corner of the state. Sites were prioritized for survey using aerial photos of riparian habitat, soil maps, and the known distribution of closely associated species (Heidel 1998). The US Fish and Wildlife Service (1995) has recommended surveys in the Northern Great Plains of eastern Montana, as well as the Missouri and Yellowstone rivers.

Nebraska: Hazlett (1996, 1997) and Hildebrand (1997) conducted surveys of potential prairie wetland habitats in Banner, Box Butte, Garden, Kimball, Morrill, Scotts Bluff, Sheridan, and Sioux counties. Since the discovery of populations in extreme western Nebraska in 1996 and 1997, no additional populations have been discovered.

Nevada: Morefield (1994) unsuccessfully searched potential sites in the Meadow Valley Wash and Condor Canyon areas near Panaca in 1993. With the rediscovery of the Panaca population in 2005, other spring and wet meadow sites in southeastern Nevada should be a priority for survey, perhaps at earlier times in the year, such as mid to late July (Jim Coyner, retired USFWS, pers. commun., 2005).

Utah: Numerous Ute ladies'-tresses surveys have been conducted in Utah to comply with the Endangered Species Act and the Clean Water Act, especially in the Uinta Basin (Franklin 1993), Green River (Ward and Naumann 1998), and Wasatch Front (Black and Gruwell 2004, Black et al. 1999, Stone 1993, SWCA 2002). Although the number of known orchid populations has greatly increased since 1992, many of these sites have not been revisited following their initial discovery or during the past decade. Additional historical collections from the Jordan River, Payson, and Ogden areas have not been relocated (though these may be extirpated). While the Tooele County occurrence was relocated in 1994, additional wet meadow areas of the Great Basin in western Utah have been only minimally surveyed. Surveys in the Colorado Plateau by Coyner (1990), Clark (2002), and others have failed to document additional populations.

Washington: Surveys for Ute ladies'-tresses in Washington have focused on riparian habitats along the Columbia River and in Okanogan County. Limited additional surveys have been conducted by the BLM in eastern Washington, but have not located additional populations (Florence Caplow, Washington Natural Heritage Program, pers. commun., 2004).

Wyoming: *S. diluvialis* was discovered in Wyoming in conjunction with a general floristic inventory of public lands in southeastern Wyoming by the University of Wyoming's Rocky Mountain Herbarium (Hartman and Nelson 1994). Additional discoveries were made in eastern Wyoming by Don Hazlett (1996, 1997), a botanical consultant hired by the BLM Wyoming State Office specifically to survey potential riparian habitat for this species. Surveys targeting potential Ute ladies'-tresses habitat on F.E. Warren Air Force Base in Cheyenne, the Snake River and tributaries in Jackson Hole, Powder River Basin, and the Green River have not yielded additional locations, nor have other general floristic surveys of the Laramie, Great Divide, Powder River, and Green River basins by Rocky Mountain Herbarium staff and graduate students (Fertig 2000). Fertig and Thurston (2003) and Heidel (in prep.) have developed models of potential *S. diluvialis* habitat in Wyoming based on intersection of known habitat variables in GIS. Bonnie Heidel (Wyoming Natural Diversity Database, pers. commun., 2005) used these models and photointerpretation of color infrared orthophotos to survey high probability orchid habitat in eastern Wyoming in 2005 and documented 2 new locations and extended the known distribution of 2 others. An additional new report for the state still needs to be verified.