Survey of ***Spiranthes diluvialis*** (Ute ladies'-tresses) in Eastern Wyoming (Campbell, Converse, Goshen, Laramie, Niobrara and Platte counties) 2005-2006

Prepared for Bureau of Land Management -
Buffalo, Casper, and Rawlins Field Offices and the Wyoming State Office;
and the Medicine Bow/Routt National Forest/Thunder Basin National Grassland

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BLM Agreement No. KAA041037
FS Agreement No. 02-CS-11020600-033 M4

April 2007

Citation: Heidel, B. 2007. Survey of *Spiranthes diluvialis* (Ute ladies'-tresses) in eastern Wyoming, 2005-06. Prepared for Bureau of Land Management and the Medicine Bow/Routt National Forest/Thunder Basin National Grassland. Wyoming Natural Diversity Database, Laramie, WY.

Cover photograph: *Spiranthes diluvialis* by Kristi DuBois, used with permission

ABSTRACT

Systematic survey of Ute ladies'-tresses (*Spiranthes diluvialis*) was conducted on public lands in six counties of eastern Wyoming using two systematic survey techniques for the first time in the state, including potential distribution models and photointerpretation involving digital color infrared imagery.

At the start of this survey project, four occurrences of *Spiranthes diluvialis* were known from four counties of Wyoming (Converse, Goshen, Laramie and Niobrara counties). As a result of survey, four new occurrences were documented on public lands including both Bureau of Land Management (BLM) parcels and state parcels; and a fifth new occurrence was reported from private land. The new occurrences do not appreciably expand species' distribution, though all but one are on creeks where the species had not been found before. All but one of the new occurrences are in areas predicted by the primary potential distribution model and photointerpretation. The exception was immediate upstream less than 0.2 miles from an area identified as potential habitat. The survey is presented as covering all federal lands with potential habitat for *S. diluvialis* in the six-county area.

At present, *Spiranthes diluvialis* is known from three geographic centers of distribution in eastern Wyoming: a portion of the Antelope Creek watershed, a portion of the Niobrara River watershed, and a portion of the Horse Creek watershed. They represent discrete areas containing 1-several suitable riparian corridor segments. These areas are not set off by any single landform, surface geology, or elevation characteristic but have a consistent suite of environmental conditions. Soils were collected at occupied and unoccupied sites for analysis to help differentiate suitable from unsuitable habitat, and it was determined that occupied *S. diluvialis* sites had generally lower electrical conductivity, sodium absorption ratios and clay content than unoccupied habitats that were sampled, while they had higher lime concentrations. Provisional guidelines are presented for using remote sensing (potential distribution models and photointerpretation) and field data (including soils) in addressing *S. diluvialis* survey across the six-county area of Wyoming.

A tabulation of peak census and population size estimates at *Spiranthes diluvialis* occurrences indicates that there are at least 3800 plants in the state, highly concentrated among a few of the nine known occurrences. Areas that were mowed at the time of past surveys were not mowed in 2005-06 and account for much of the increased numbers of plants relative to past surveys.

The new data revise *Spiranthes diluvialis* numbers and circumscription of habitat requirements in Wyoming. The methods provide a basis for refining survey standards and process across the six-county area of Wyoming.

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INTRODUCTION

Ute ladies'-tresses (*Spiranthes diluvialis*) was listed as a Threatened species under the Endangered Species Act on 17 January 1992 when it was only known from extant populations in Colorado and Utah. *Spiranthes diluvialis* was first discovered in Wyoming in 1993 by B. E. Nelson (Fertig 1994). Since the time of listing, it has been documented in Idaho, Montana, Nebraska, Washington, and Wyoming; and was relocated in the historic collection record area of Nevada (Fertig et al. 2005).

Discovery of *Spiranthes diluvialis* in Wyoming spurred a flurry of survey efforts in the state by academic researchers, agencies, consultants, and Wyoming Natural Diversity Database (WYNDD) staff. To date, over 30 sets of surveys have been conducted in Wyoming for *S. diluvalis,* and they are presented in this report to document the extent of past surveys and as context for the 2005-06 surveys. The previous status summary of *S. diluvialis* for Wyoming (Fertig 2000a), as highlighted in a state species abstract (Fertig 2001), is updated by this study.

Spiranthes diluvialis is a species that typically occupies riparian corridors. The original Section 7 consultation guidelines were developed for *S. diluvialis* by the U.S. Fish and Wildlife Service using watershed criteria (U.S. Fish and Wildlife Service 1995). In Wyoming, it is present in portions of the Horse Creek (North Platte River tributary), Antelope Creek (Cheyenne River tributary) and Niobrara River watersheds. Later discoveries of *S. diluvialis* in neighboring states included watersheds that have their headwaters in Wyoming, including the Green River and Snake River. It was also discovered at the headwaters of the Missouri River, with tributaries originating in Wyoming (including the Big Horn and Powder River watersheds). For want of more information, the scope of current Section 7 guidelines for *S. diluvialis* addresses 22 of 23 counties in Wyoming, generally below 7000 feet in elevation (excluding Teton County, where there have been extensive *S. diluvialis* surveys).

By 2003, a potential distribution model was completed for *Spiranthes diluvialis* and for 43 other plant species in Wyoming based on known distribution and the strongest environmental correlations from among 20 characteristics and many categories within them (Fertig and Thurston 2003). It resulted in the identification of over 70 small polygons of potential habitat for *S. diluvialis*, in six counties of eastern Wyoming. In 2004, a potential distribution model was prepared for *S. diluvialis* and for animal species in Wyoming in a different analysis (Beauvais and Smith 2004).

This new *Spiranthes diluvialis* survey project originated from the perceived need for testing the potential distribution models and alternate approaches like photointerpretation for extrapolating from known distribution on public lands in Wyoming. It represents allocations from challenge cost-share funding by the BLM and WYNDD, and by the Medicine Bow-Routt NF and WYNDD. This final report replaces the progress report that was prepared before the 2006 fieldwork (Heidel 2006) and represents an update to the status report for *S. diluvialis* (Fertig 2000). While this work is limited to eastern Wyoming, its methods have application in other parts of the state.

Wyoming and Nebraska populations of *Spiranthes diluvialis* are the only populations in Great Plains landscapes, and represent the northeastern extent of species' distribution. A rangewide status review of *S. diluvialis* under the Endangered Species Act is underway, with updated information compiled from throughout its range (Fertig et al. 2005).

METHODS

Systematic surveys of *Spiranthes diluvialis* were initiated on public lands in six counties of eastern Wyoming using two techniques that had not been employed before in the state, including potential distribution models and photointerpretation. Potential distribution models were developed for all Threatened and Endangered plant species in Wyoming in addition to BLM sensitive species (total of 44 species) by Fertig and Thurston (2003) and the following information comes from their report. Predictive modeling of plant distributions rests on the assumption that correlations exist between the presence/absence of a species and selected climate, topographic, substrate, and land cover variable. Once the correlations are determined, maps can be created in GIS that identify all areas that meet the specific conditions for a given species. Fertig and Thurston (2003) tried to use classification tree analysis and 20 environmental variables against existing presence/absence data for *S. diluvialis* for model-building and validation data sets. Species like *S. diluvialis* with fewer than 16 known locations were also modeled using the range/intersection method in which the range of environmental values at all present sites of a species were intersected in GIS to identify areas with similar attributes across the state using the same 20 sets of environmental variables. Wetland species like *S. diluvialis* require an additional step of overlaying a riparian/aquatic model to highlight potentially suitable wetland areas within the species' predicted range. The complete methods in the Fertig and Thurston (2003) report are posted (www.uwyp.edu/wyndd/). The classification tree results were rejected for *S. diluvialis* by the authors and the range/intersection analysis was employed to develop a potential distribution model based on four primary categories of characteristics and specific components that had the best correlation (below):

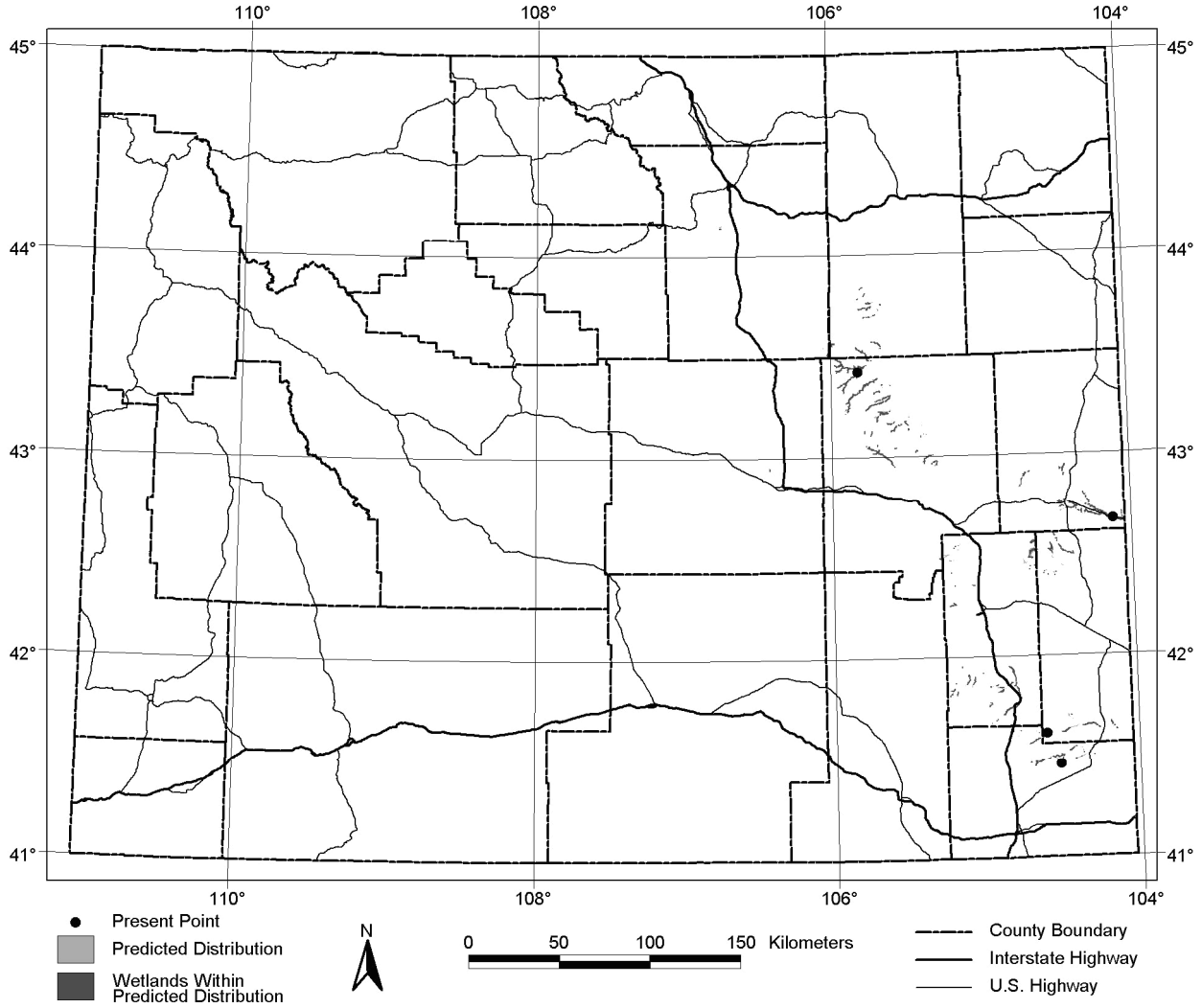
1. Bedrock geology, including Early Eocene, Miocene/Pliocene and Quaternary alluvium.
2. Land cover, including Graminoid-dominated wetland, Forest-dominated wetland, Mixed Grass prairie and Shrub-dominated riparian.
3. Soil, including Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frig; and Ustic Haplargid and Ustic or Typic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic.
4. Surface geology, containing old alluvial plain.

The resulting distribution model for *S. diluvialis* is reproduced in Figure 1.

In a separate approach, a second potential distribution model for *Spiranthes diluvialis* was developed by Beauvais and Smith using a domain model (described in Beauvais and Smith 2004). Environmental variables were selected from among 20 classes of variables using Principal Components Analysis against plant and animal distribution data collectively. The four variables that were selected, in addition to elevation, included: annual mean precipitation, coefficient of variation of monthly precipitation, mean temperature during the driest quarter of

the year, and the mean number of frost-free days. This model effort had the benefit of incorporating distribution data for *S. diluvialis* from adjoining states within 1° latitude/longitude of Wyoming. However, the environmental data that was used to incorporate climate data from the five-state area represented coarser themes than the Fertig and Thurston (2003) model, and it represented environmental attributes picked as fitting multiple plant and animal species distributions collectively rather than *S. diluvialis* in particular. A buffered riparian layer was added as a screen to highlight potentially suitable riparian areas. By this second model, nearly all streams in the eastern third of the state were identified as potential habitat, encompassing the areas predicted by the first model plus most of the rest of the riparian habitat of the six-county area. Thus, the two models might be compared directly as having magnitude differences in the scope of potential habitat predicted across the six-county study area.

Figure 1. Potential distribution of *Spiranthes diluvialis* in Wyoming
(from Fertig and Thurston 2003)



Photointerpretation of aerial photographs is a widely-employed technique for locating vegetation features on the ground. The four original populations of *Spiranthes diluvialis* served as references in initial photointerpretation, and they were also ground-truthed in the first field season to link microhabitat features with aerial photo signatures. They had all previously been visited by the same botanist, Walter Fertig, in 1998-99, so this study had the benefit of previous consistency in habitat description and survey effort. These re-visits served to link aerial photo patterns to ground features and refine the habitat description, while also determining population sizes, and identifying prospective changes since the prior visits.

Digital color infrared aerial orthophotographs were viewed in ArcView 3.0 across the entire six-county area, generally at 1:10,000 scale, but zooming in for closer inspection of potential *on Spiranthes diluvialis* habitat along riparian corridors. The theme with polygons of potential habitat was superimposed, as identified by potential distribution modeling (Fertig and Thurston 2003). Photointerpretation was not limited to the areas within these polygons but covered the six-county area. Each polygon of potential habitat was accepted or rejected as having wet meadow habitat. Each other stream segment containing potentially suitable wet meadow habitat was identified. The three key characteristics that were sought included: standing or flowing water at the time of aerial photography (late Aug, early Sept), dark tones with red coloration in valleybottom flats indicating photosynthetic activity associated with wet meadows, and presence of meanders or oxbows indicating alluvial processes. Sites were not ruled out unless it was evident that the wet meadow zone had been plowed. An example of a public tract meeting the three screening criteria is presented and discussed under the section *on S. diluvialis* habitat.

Photointerpretation results were transcribed as potential habitat boundaries onto DRGs printed out as quarter-quads (1:24,000). Each polygon was also represented as an entry on a master excel spreadsheet that included the shapefile identifier numbers for each area of potential habitat. Added to this were the names of the topographic maps, topo quarter-quad, and surface management maps on which they appeared, the public land management, the legal description, county, and a cross-reference to whether they had been previously surveyed or not. These same values were determined for areas of potentially suitable wet meadow habitat.

The areas initially identified as potential *Spiranthes diluvialis* habitat included ones identified by the Fertig and Thurston (2003) model and screened through photointerpretation, as well as ones that fell outside potential habitat model boundaries. The potential habitat boundaries were cross-referenced with public lands boundaries by visual inspection from printed BLM surface management maps (1:100,000). In 2006, this cross-reference between potential habitat and public lands was done using GIS analysis to identify all theme intersections to ensure that all suitable habitat on public lands was identified. The end result in both years was a target list of photointerpretation site priorities, cross-referenced and with capacity to sort by maps, legal descriptions, public land management, notation whether they had prior surveys, and whether they were identified in the potential distribution model and/or photointerpretation.

Revisits to occurrences of *Spiranthes diluvialis* on private land were made with the permission of landowners. All federal tracts identified for survey were routed to the respective federal agency. All state tracts identified for survey were sent to the Wyoming Office of State

Lands and Investments to request contact information for lease holders. State lease holders were contacted prior to visit for coordination purposes if there was public access, or for access permission if there was not public access.

The two-year timeframe was particularly useful in this study. Not only did it accommodate refinement in GIS techniques but it also extended the time available for contacting landowners to access isolated public tracts and state lease holders to provide for notification and coordination. Finally, the expanded timeframe provided opportunities to visit a few of the same sites under different climate conditions and associated differences in phenology.

In addition to models and photointerpretation, agency and academic botanist expertise was consulted, and coordination was sought with consultants doing survey for *Spiranthes diluvialis* in 2005-06.

The use of digital orthophotographs made it possible to link the potential distribution models for *Spiranthes diluvialis* and the photointerpretation methods. It also made it possible to produce geo-referenced copies of aerial photographs for fieldwork with section lines superimposed, and printed at the same scale as topographic maps. Each digital orthophotograph containing potential habitat on public land was printed in black and white on 8 ½ x 11" paper to cover a quarter-quad of the topographic map (DOQQ), and labeled by topographic map and quarter-quad. These quarter-quad printouts of aerial photographs were also used to determine access, determine the extent and orientation of potential habitat along meandered systems, and traverse potential habitat. About 90 quarter-quads were printed out, and each area of potential *S. diluvialis* habitat on public land was circled using a blue highlighter directly on the printed DOQQs.

Initial survey priority was placed on the largest areas of *Spiranthes diluvialis* potential habitat, areas with access, and areas fitting into travel itineraries. Negative survey data also fed into the system to par down targets. The winnowed target list had 40 sites (varying in size from one to few sections). In addition to the four known populations and the new populations, 23 sites were visited in 2005, and 17 additional sites were visited in 2006 where it was sought but not found. They have been added to the compiled spreadsheet of negative survey results for *S. diluvialis*. Essentially, all public tracts identified for survey were visited (N=40) except for four areas of state lands in Converse and Laramie counties without access.

One site adjoining Thunder Basin National Grassland was visited as recommended by Ernie Gipson, U.S. Forest Service. Four other drainages identified by Clarke McClung, U.S. Forest Service, were visited separate from this study, including two stream surveys incidental to a spring survey for Barr's milkvetch (*Astragalus barrii*; Spring Creek and Little Powder River; Heidel 2003), and subsequent surveys by U.S. Forest Service biologists.

To promote understanding and communication about *Spiranthes diluvialis*, including its field identification and habitat requirements, field training events were scheduled in both years: July 27, 2005 at the only occurrence on federal land known at that time (in Converse County on the Antelope Creek watershed), and August 10, 2006 at a population on state land (in Goshen County in the Horse Creek watershed). The field events provided training in recognizing

distinguishing characteristics and in the process for conducting surveys using the known population site as an example. The effectiveness of the training event was limited in 2005 because all *S. diluvialis* plants were in bud. Apart from the field training events, all field surveys took place over nine days between August 18-September 1 in 2005, and over six days between August 5- September 4 in 2006.

Surveys for *Spiranthes diluvialis* were conducted on both sides of the stream if both sides had distinct wet meadow habitat. Outlying wet meadows in oxbows or other settings isolated from the river were also surveyed, as identified from aerial photographs, topographic maps, and on-the-ground inspections. A working set of habitat cues were developed over the course of the study that included stream morphology, topographic features, and vegetation features. The latter included vegetation stature, canopy cover, species' composition and diversity, as discussed further in the habitat description section of this report.

Prior to the start of 2005 surveys, the four known *Spiranthes diluvialis* population sites were re-surveyed. GPS points were taken, species lists compiled, added information on the settings and habitats were recorded, and running tallies of *S. diluvialis* were also recorded. In areas of high species' density, the occupied habitat was paced in lanes, but without the benefit of demarcating ropes or tapes; or with extra field assistance. The gps points served to delimit the occupied stream reach and cross-reference high density areas. The gps point data was used to map occupied habitat as a narrow polygon encompassing the stream bed, even though the species does not grow in the channel, and is not distributed continuously along both sides of the streams where it occurs.

At one known occurrence, a running tally of *Spiranthes diluvialis* plants took place in 2005 in the same week as a 6-person survey crew thoroughly censused the same population. The running tally of 143 plants was the basis for estimating that over 200 plants are present; much less than the complete census of 241 plants determined by the 6-person team. The vegetation conditions at the particular site and the unevenness of *S. diluvialis* distribution there may have affected the difference, but provide the basis for inferring that the running tallies made by one person without measures to ensure exhaustive counts can be missing 20-40% of total numbers.

As part of 2006 surveys for *Spiranthes diluvialis*, soil samples were collected from all previously-surveyed population sites. Censuses and population estimates were not repeated in 2006 except that the 2006 field training site in Goshen County as censused by a 6-person crew in 2005 was completely re-censused, the largest population of *S. diluvialis* in Wyoming had a rigorous census of its largest subpopulation by subdividing it into lanes, and a "new" subpopulation as previously reported by a private landowner was verified and censused.

All sites where it was found have occurrence records that have been entered in the Wyoming Natural Diversity Database. A voucher specimen was collected on the one new population large enough to be unaffected (*Bucklin-Comiskey and Fifield 113*). The results of complete or partial censuses were recorded in field notes, and survey notes including census results were transcribed on sensitive species survey forms. Survey results are presented in this report. A call to standardize field data for risk assessment purposes was issued by the U.S. Fish and Wildlife Service, representing a reconstituted framework for the data presented in this report.

Extent of Surveys Conducted in Wyoming in the Past

New systematic survey for *Spiranthes diluvialis* was initiated despite numerous, extensive surveys in the past for the species by consultants, academic researchers, agency personnel and staff of Wyoming Natural Diversity Database. This study sought to compare the new techniques of photointerpretation and potential distribution modeling to locate *S. diluvialis* with other techniques and with project-driven surveys.

A bibliography of all surveys for *S. diluvialis* in Wyoming was initiated (Table 1; Appendix A). The conventions for reporting past surveys varied, and the accompanying documentation. All survey efforts were compiled in an excel spreadsheet, and converted to a shapefile. The following information was recorded, as available.

- Study - abbreviated citation or any available information to indicate the source of the survey information, e.g., the name of a company, the name of the surveyors recorded in agency files, etc.
- County - the county of survey
- Administrative unit scope - any cross-reference to the survey extent (e.g., the public land name if all surveys were on public land, or the project name if all surveys were clearance)
- Survey timing - the date of the survey or any indication of when it was conducted
- Survey map- notation is made if a map was produced to indicate the streams and stream reaches that were surveyed
- Stream or river name
- TRS enummerated- note whether the township, range, and sections were recorded in survey documents
- Township and Range and Section columns - interpretation was made from all available survey information of which township, range, and sections were included in the survey at any level.
- Additional location text - all narrative describing the survey location is recorded. Notation - any context for the survey is recorded. This is the place to note if the survey was a 2 mile traverse on both sides of the stream or only a peering-over-the-fence survey to see if appropriate habitat parameters were present.

The *Spiranthes diluvialis* surveys as represented by township-range-section values in the excel spreadsheet were converted in a TRS theme and used to produce a shapefile (Figure 2). A total of 1593 sections in 13 of the 23 counties in Wyoming have some level of *S. diluvialis* survey to date (including 58 sections surveyed in this study). The information in this spreadsheet is generally inadequate to determine the precise location and suitability of survey, but it provides a cross-reference to the original source, a record of survey distribution, and a springboard for improvements in compiling such survey information. Included in this compilation are surveys conducted from roadsides, and surveys conducted outside of the flowering period for *S. diluvialis* in which presence/absence of suitable habitat was addressed by U.S. Fish and Wildlife Service guidelines (1995). The negative results of this project in 2005-06 have been incorporated in the spreadsheet and shapefiles, and the list of references cited at the end of this report includes all studies with negative survey results.

Figure 2. Sections in Wyoming where *Spiranthes diluvialis* has been surveyed but not found

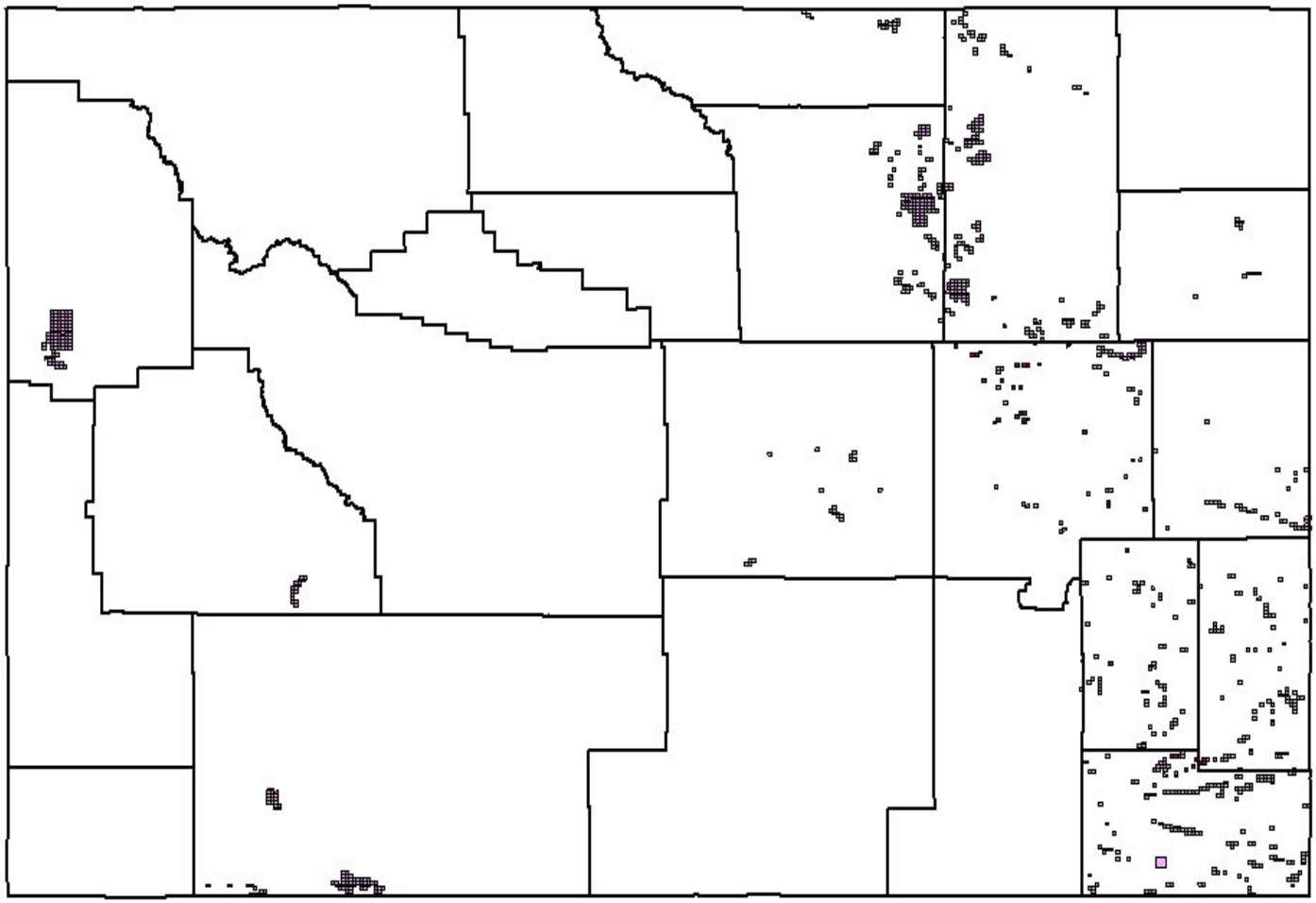


Table 1. Compilation of *Spiranthes diluvialis* surveys in Wyoming where it was not found

Study	**Year of survey**	**County**	**Administration**
ARCADIS	2006	Campbell, Johnson	Pvt
Bighorn Environmental Consulting	2006	Campbell, Johnson	Pvt
BKS	2004	Campbell	FS
CRD	2000	Sublette	BLM, State, Pvt
Fertig	1995a	Campbell, Converse	Antelope Coal Mine site
Fertig	1995b	Laramie	Warren AFB
Fertig	1998	Teton	Natl Elk Refuge
Fertig	1999	Sweetwater	Blacks Fork of Green R.
Fertig	2000	Natrona	Pathfinder NWR
Fertig	2001	Teton	Pvt
FS personnel	2004	Campbell, Converse, Weston	FS-TBNG
Hartman and Nelson	1994	Converse, Goshen, Laramie, Natrona, Platte	Public
Hayden-Wing Associates	2003	Campbell	Pvt
Hayden-Wing Associates	2004	Campbell, Johnson	Pvt
Hayden-Wing Associates	2005	Campbell, Johnson	Pvt
Hayden-Wing Associates	2006	Johnson	Pvt
Hazlett	1995	Goshen, Laramie, Platte,	Public, pvt lands
Hazlett	1996	Laramie, Niobrara	Public, pvt lands
Hazlett	1997	Laramie, Niobrara, Platte	FS
Hazlett, Bartosiak, Bradshaw, Zimmerman	1998	Campbell, Converse, Weston	FS-TBNG
Heidel	2005, 2006	Campbell, Converse, Goshen, Laramie, Niobrara, Platte	BLM, FS, state
Heidel	2003	Campbell	FS-Spring Creek
Heidel	2003	Goshen	NPS-Ft Laramie NHS
Intermountain Resources	2006	Converse	Pvt, State
Jones	2000	Teton	BLM-Snake R.
Jones	2001	Sweetwater	BLM-Henry's Fork
Lance Co.	ND	Campbell	BLM
Markow	2000	Teton	Pvt
Moseley	1997	Teton	Public
Nelson and Hartman	1995	Converse, Goshen, Laramie, Niobrara, Platte	Public
Pvt consultants	2004	Campbell	FS-TBNG
Thunderbird-Jones & Stokes	2006	Campbell, Johnson, Sheridan	Pvt
Williams Co.	ND	Converse	BLM

The compilation of *Spiranthes diluvialis* negative surveys is intended as a reference only. It is not linked to the database used by Wyoming Natural Diversity Database in producing data

distribution exports, and is one of few survey compilations generated as context for understanding complex distribution patterns and increasingly complex survey efforts for a federally listed species for which surveys are currently required in 22 of 23 Wyoming counties below 7000 feet.

SPECIES INFORMATION

This document summarizes current *Spiranthes diluvialis* status information in Wyoming. Information as presented in the previous *S. diluvialis* status report for Wyoming (Fertig 2000a) is cited in the following sections in cases where the information is unchanged. In addition, a species status assessment of *S. diluvialis* throughout its range (Fertig et al. 2005) provides the most complete information on rangewide status and most other aspects of species' biology, including updated information from adjoining states. All other report information draws from 2005-06 surveys in Wyoming unless otherwise stated.

Classification

Spiranthes diluvialis Sheviak (Ute ladies'-tresses) is in the *Spiranthes* genus, a temperate genus of the Northern Hemisphere in the Orchid family. It was described as a new species by Charles Sheviak (1984) based on cytological and morphological studies of material from the Colorado Front Range, as well as specimens from the Colorado Plateau, Utah's Wasatch Front and western Nevada. It was first collected in northeastern Colorado by Harold Engelmann in 1856, but was not recognized as distinct for nearly 125 years (Jennings 1989, in Fertig et al. 2005).

Legal Status

Spiranthes diluvialis was listed as a Threatened species under the Endangered Species Act on 17 January 1992 (USDI FWS 1992), when it was only known from extant populations in Colorado and Utah, and considered extremely vulnerable to habitat loss and modification in much of its range. *Spiranthes diluvialis* is also listed on Appendix II of the Convention on the International Trade in Endangered Species (CITES) and is protected from illegal export (USDI FWS 1995).

Spiranthes diluvialis was first discovered in Wyoming in 1993 by B. E. Nelson, after it was listed (Fertig 1994). This species receives no formal protection under Wyoming state law. It was subsequently discovered in Idaho, Montana, Nebraska, and Washington, and was relocated in the area where the historic collection was made in northern Nevada (Fertig et al. 2005).

In 1996, the Central Utah Water Conservancy District petitioned the U.S. Fish and Wildlife Service (FWS) to delist *Spiranthes diluvialis* as being sufficiently widespread and secure enough to no longer warrant protection under the Endangered Species Act (Woodward-Clyde 1996). A 90-day finding was announced by FWS in October, 2004 that the petition presented sufficient information to initiate a status review (USDI FWS 2004). A rangewide status report was compiled and released the following year in order to ascertain whether a change in listing status is warranted (Fertig et al. 2005); a determination that has yet to be made.

Natural Heritage Rank

NatureServe (formerly The Nature Conservancy's network of state natural heritage programs) reports a global rank of G2 for *Spiranthes diluvialis* (imperiled because of extreme rarity; NatureService 2007). Species ranked G2 are typically known from 20 or fewer extant occurrences or have small populations subject to high threat. It has been recommended that this rank be changed to G3 (rare or uncommon, but not imperiled; Moseley 1998) but this change has not been adopted as of 2006.

In Wyoming, *Spiranthes diluvialis* is assigned a subnational rank of S1 (critically imperiled because of extreme rarity). Species ranked S1 are typically known from five or fewer extant occurrences or else have small populations or high threats. Four of the nine known occurrences in Wyoming have population numbers below 50 plants, and additional threats have been identified for the majority of occurrences that were not known at the time of the previous state rank review (represented by Fertig 2000). Therefore, the S1 rank is retained (Heidel 2007).

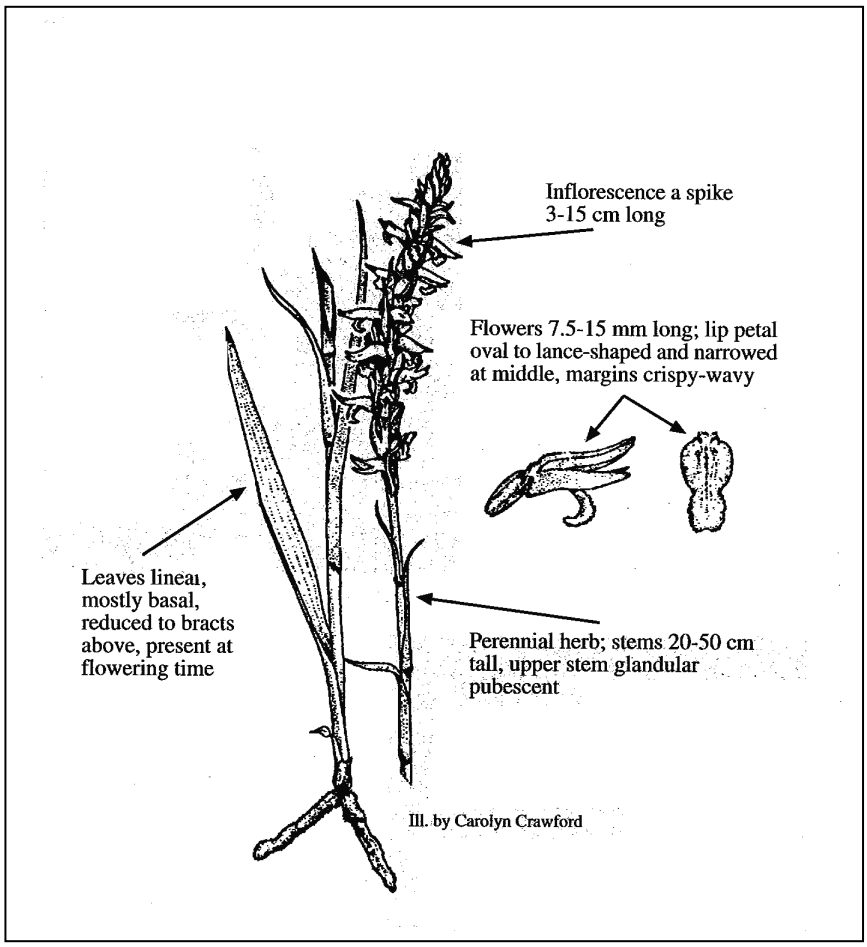
Description

Spiranthes diluvialis is a perennial herb with erect, glandular-pubescent stems 12-50 cm tall arising from tuberous-thickened roots (Figure 3). Basal leaves are linear, up to 1 cm wide and 28 cm long, and persist at flowering time. Leaves become progressively reduced higher up the stem. The inflorescence is a loose or dense spike 3-15 cm long of numerous, small white to ivory flowers arranged in 3-ranked spirals. The lip petal is oval to lance-shaped, narrowed at the middle, and has crispy-wavy margins. Sepals are linear-lanceolate, separate or fused only at the base (not forming a hood-like structure), typically oriented perpendicular to the stem, and are often spreading at their tips (Sheviak 1984; Atwood et al. 1991; Fertig et al. 1994; US Fish and Wildlife Service 1995; Heidel 1998, Fertig 2000, 2001).

Similar Species

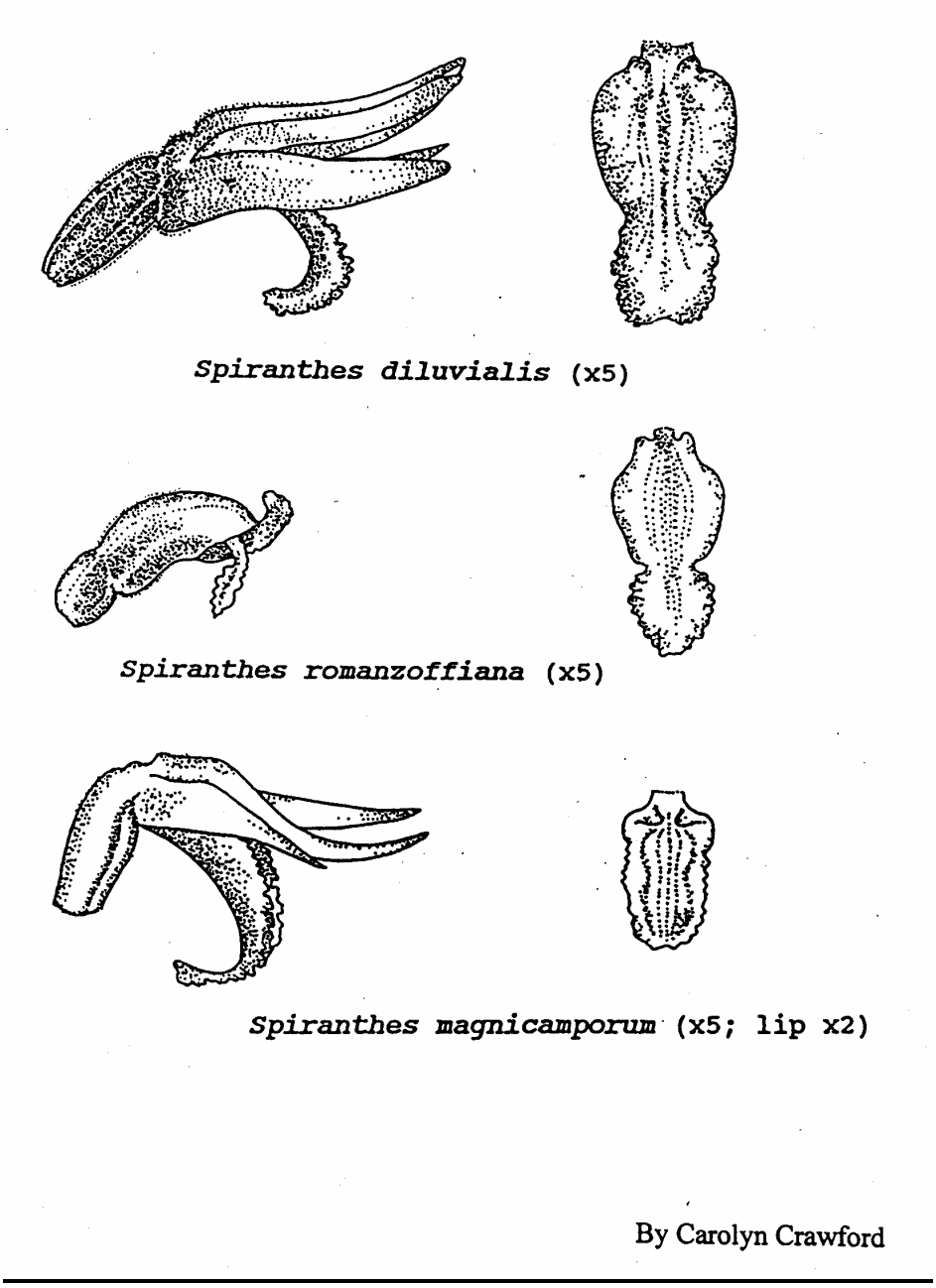
Spiranthes romanzoffiana has deeply constricted lip petals, sepals often fused for at least 1/2 their length into a hood-like tube, and a densely congested inflorescence. It typically occurs in montane wetlands. *Spiranthes magnicamporum* is a prairie species not currently known from Wyoming, has strap-shaped, wavy- margined lip petals and lacks leaves at flowering time. *S. porrifolia* is also not known from Wyoming, has yellowish flowers with sepals fused for about 1/2 their length (but not forming a hood), and strap-shaped lip petals with peg-like projections near their tip (Moseley 1998). The differences between these species were first characterized in a FWS report as prepared by Lucy Jordan, and illustrated by Carolyn Crawford (USDI FWS 1995; Figure, Table 2 and distributed as part of Ute ladies'-tresses field survey guidelines (USDI Fish and Wildlife Service 1995, 2007). Close-up photographs that show free sepal petals and flower orientation generally serve in making positive determination, but only the sharpest close-up photographs show the crispy-wavy margins and narrowed shape of the lip petal (cover photograph).

Figure 3. *Spiranthes diluvialis* whole plant, by Carolyn Crawford, used with permission (reprinted from Fertig et al. 1994)



At higher elevations, *Spiranthes diluvialis* is replaced by *S. romanzoffiana*, which is found in 14 of 23 counties in Wyoming, including one collection from the Laramie Range of southeastern Wyoming in Platte Co. (Dorn 2001, Rocky Mountain Herbarium). In most states, the elevation range of the two species does not overlap. The highest know elevation of *S. diluvialis* in Wyoming is 5420 ft whereas the lowest known elevation of *S. romanoffiana* in the state is 4500 ft based on a specimen of Erwin Evert in the Black Hills. The two different species also tend to occupy contrasting habitats in Wyoming: open plains settings on one hand as compared to forested montane settings for the latter. Rangewide, the highest known elevation *of S. diluvialis* is in Utah, at about 7000 feet. *Spiranthes diluvialis* is an alloploid species that is thought to have originated when the ranges of its putative mountain and plains parent species, *S. romanzoffiana* and *S. magnicamporum*, overlapped (Sheviak 1984; discussed in Fertig 2000). The latter species is not known from Wyoming, but occurs in the North Platte drainage of Nebraska close to the state line (Hildebrand 1998). The ranges of *S. romanzoffiana* and *S. magnicamporum* do not currently overlap, suggesting that alloploidy may have occurred during the Pleistocene when

Figure 4. Comparative illustration of the flowers of *Spiranthes diuvialis, S. romanzoffiana,* and *S. magnicamporum* [omitted *S. porrifolia*]; by Carolyn Crawford, used with permission



their ranges shifted in response to glacial advances (Sheviak 1984). Genetics research involving Colorado and Utah populations suggested that *S. diluvialis* had arisen at least two separate times (Arft 1995a,b; Arft and Ranker 1998).

Species of *Habenaria* [syn. *Platanthera*] have an elongated, cylindrical spur on the back of the lip petal.

Table 2. Comparison of diagnostic features of *Spiranthes diluvialis* with *S. romanzoffiana*, *S. magnicamporum and S. porrifolia*.

Table 1. Comparison of diagnostic features of *Spiranthes diluvialis* with *S. porrifolia*, *S. romanzoffiana*, and *S. magnicamporum*. (Data are from Luer 1975; Sheviak 1984, 1990; U.S. Fish and Wildlife Service 1992a.)

Character	*Spiranthes diluvialis*	*Spiranthes porrifolia*	*Spiranthes romanzoffiana*	*Spiranthes magnicamporum*
Leaves	Several, mostly at base of stem, persistent	As in *S. romanzoffiana*	Often numerous, sometimes extending up the lower stem, persistent	Few, strictly basal, typically withering before anthesis
Rachis	As in *S. magnicamporum*	As in *S. romanzoffiana*	Glabrous or sparsely pubescent, the the longest hairs < 0.18 mm long (usually much less), the glands often sessile or subsessile	Sparsely to densely pubescent, the longest hairs ≥ 0.19 mm (often much longer), the glands obviously stalked
Flowers	Ascending, rather long and slender, whitish to ivory-colored, ringent (gaping at mouth); lip exposed in lateral view	Ventrally curved, slender, yellowish, open only at the apex (not ringent); lip hidden in lateral view except for the reflexed tip	Strongly ascending, short, broad at base, white to cream, with a well-developed hood open only at the apex (not ringent); lip hidden in lateral view except for the reflexed tip	Abruptly nodding, long and slender; lip exposed in lateral view for its entire length
Sepals	Often connate at base for a short distance, sometimes free; variably appressed, spreading, or ascending; hood rarely evident	Fused for some length and joined with the petals, appressed for most of their length but widely spreading toward the apices	Fused for some length and united with the petals to form a prominent hood above the lip	Free at base, the lateral sepals spreading, often ascending above the rest of the flower

Prepared by Lucy Jordan as part of U.S. Fish and Wildlife Service (1995a)

Table 1 (cont'd). Comparison of diagnostic features of *Spiranthes diluvialis* with *S. porrifolia*, *S. romanzoffiana*, and *S. magnicamporum*.

Character	*Spiranthes diluvialis*	*Spiranthes porrifolia*	*Spiranthes romanzoffiana*	*Spiranthes magnicamporum*
Lip	Ovate to lanceolate or oblong in outline, with a marked median constriction, the base usually dilated; lacking a dense cushion of short hairs on upper surface near apex; membranous when moist; venation mostly parallel, typically with some branching, divaricating veins in lower half; calli often elongated	Ovate to lanceolate in outline, ± acute, the apex only slightly or not at all dilated; with a dense cushion of peg-shaped hairs on upper surface near apex; membranous when moist	Strongly pandurate (violin-shaped with a marked median constriction), the apex dilated; glabrous on upper surface; membranous when moist; prominently veined below the constriction with laterally diverging, branched veins	Ovate to lanceolate in outline, without a marked subapical constriction; thick and fleshy when moist; venation largely parallel, diverging branched veins if present restricted to the very base; calli short, conical
Chromosome Number	$2n = 74$	$2n = 44, 66, 88$	Commonly $2n = 44$	$2n = 30$
Flowering Period	Late July through August, in some cases through September	May through early July, rarely into early August at high elevations	May to October	Mid-September into November
Geographic Range	Low elevations (mostly below 6,500 feet) in the Colorado River drainage and eastern Great Basin of Utah and (historically) eastern Nevada; disjunct locally along the eastern front of the Rocky Mtns. in Colorado	Widespread in Pacific Northwest, not known from east of the eastern base of the Sierra Nevada in California	Boreal region of North America; high elevations (rarely below 8,500 feet) in Utah and Colorado	Midwestern plains, from Indiana to the Dakotas and south to Texas; disjunct in Ohio, Alabama and Mississippi, and New Mexico

Phenology

In Wyoming, *Spiranthes diluvialis* can sometimes be found in flower from very late July to mid September. However, flowering times differ between sites, between years, and between individuals of the same population (discussed below). This is important to understand because flowering is the phenological stage when the species is most reliably located to determine presence/absence and numbers. In general, all Wyoming populations have peak flowering during a couple weeks of August. Fruits are produced in mid August to September.

Insights into phenology were gleaned by surveying *Spiranthes diluvialis* throughout its Wyoming distribution in contrasting years, and by the repeated visits made by Sarah Bucklin-Comiskey (BLM) to one population (002) over the flowering period. All flowering of *S. diluvialis* appears to begin one week later in the Antelope Creek watershed, representing the northernmost occurrences, compared to plants in other sites, in both 2005-06. For example, in 2006, only 10% of the flowering stems had their first flowers open on 2 Aug (at 002; Bucklin-Comiskey personal communication 2006), whereas over 95% of all flowering stems were in peak flower about the same time in Niobrara County (003) on 5 Aug (personal observation).

Flowering times also differ between years for *Spiranthes diluvialis*. The site that was in peak flowering condition on 5 Aug 2006 (003) had been at or slightly past peak flowering condition two weeks later the previous year (18 Aug 2005; personal observation).

Finally, flowering times can also differ significantly within the same population of *Spiranthes diluvialis*. One of the small Antelope Creek watershed populations (002) has small colonies in two different locations that had phenologies with limited overlap, differing by almost two weeks in their flowering time. These differences may reflect microhabitat differences. The flowering activity overlapped between the two colonies for less than half of their flowering period, an asynchrony in flowering that may be adaptive. This also means that at any given time, one of the two colonies is more likely to be missed in surveys than the other. Without precise location information and delimitation, there can be question whether the repeated surveys represent census of the same colonies over the full extent of the population.

In most populations, and all large ones, there appears to be a single peak in flowering activity, with at least as great a range of phenological conditions present. The plants shown in Figures 5-7 were all photographed on 5 Aug 2006 and range from bud to flowering and fruiting stages. This is the same site in the Niobrara watershed where peak flowering of 17 Aug 1996 was reported by Hazlett (1996).

The earliest flowering on record for *Spiranthes diluvialis* in Wyoming was on 3 Aug 1998 (001 in Goshen County) but the species would be expected to start flowering the last week of July in years with early growing seasons. Peak flowering ranges from the first to third weeks of August, depending on location and annual climate conditions. The latest flowering on record in Wyoming was 19 Sept 2004 (002 in Converse County) for a late-flowering individual plant among fruiting plants, but flowering can be curtailed by September under drought or freezing temperatures.

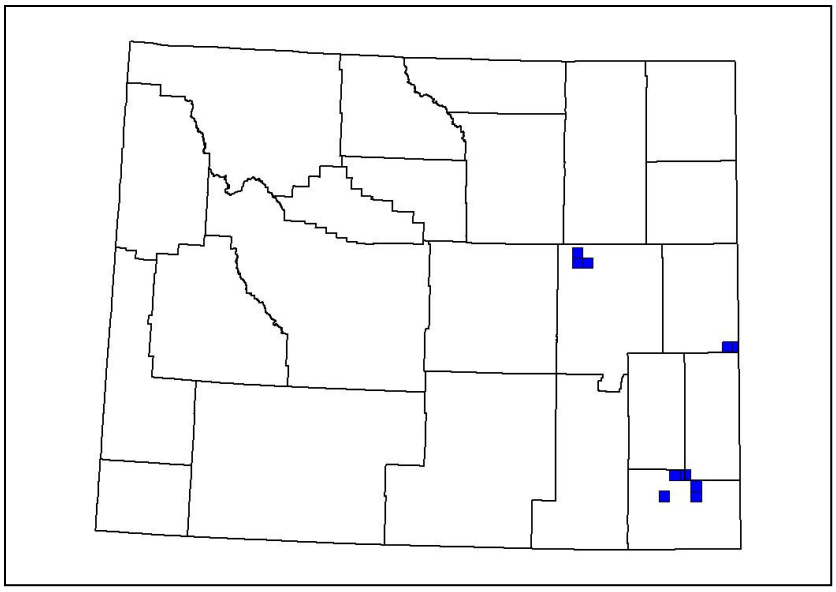
Figures 5-7. Range of phenological conditions simultaneously present for *Spiranthes diluvialis* (bud, flowering, fruiting) (003; 5 Aug 2006). Figure 8. Nonflowering plants are also present at flowering time; photographed in previous monitoring study (Heidel 2001). Photos by B. Heidel

Flowering in the *Spiranthes diluvialis* inflorescence progresses from the base of the inflorescence to the tip, and lasts up to two weeks for individual plants depending on the number of flowers and environmental conditions. Flowering usually spans even longer within populations due to offsets in flowering mentioned above. In 2006, unusual inflorescences were found in one population that had the lower flowers spaced so widely from one another that it looked like lose coils with lower flowers wedged into the flowers above. In this configuration, the lower flowers did not have typical orientation or flared sepals (Figure 6).

Geographic Range

Spiranthes diluvialis is currently known from extant occurrences in western Nebraska, southeastern Wyoming, northwest and north-central Colorado, northeastern and southern Utah, east-central Idaho, southwestern Montana, south-central Nevada, and north-central Washington (Fertig et al. 2005).

Figure 9. Wyoming distribution of *Spiranthes diluvialis* (townships)



In Wyoming, *Spiranthes diluvialis* is currently known from four counties and what we are treating as nine occurrences (Wyoming Natural Diversity Database 2006; Figure 9). The nine Wyoming occurrences represent 14% of the total number of all occurrences (63 occurrences; Fertig et al. 2005 and this report). They represent three watersheds and geographic centers of distribution in eastern Wyoming, including a portion of the Antelope Creek watershed (Converse County), a portion of the Niobrara River watershed (Niobrara County), and a portion of the Horse Creek watershed (Goshen and Laramie counties). The Niobrara River population is immediately upstream from the only two occurrences in Nebraska, comprising a cluster of occurrences that straddles the state line.). Another way to summarize the distribution is that the nine occurrences are known from eight drainages in ten townships and fifteen sections. The Wyoming distribution of *S. diluvialis* is presented in this and in all future status reports at a scale that is consistent with the sensitive nature of species' occurrence data. An additional report from Uinta County was based on a misidentified specimen of *S. romanzoffiana* (Jennings and Fertig

1995). Complete printouts and maps for the eight surveyed occurrences are presented in Appendix B, and the associated update to the state species abstract is presented in Appendix C.

As a result of this project, four new *Spiranthes diluvialis* occurrences were documented and delimited on public lands (BLM, state). Three of the four new occurrences were discovered in Converse County. One of them was discovered by Sarah Bucklin-Comiskey and Charlie Fifield (BLM Casper FO) on a BLM tract in Converse County with limited public access, surveyed by BLM staff as part of this project. Another was discovered by consultants in Converse County who independently surveyed the state tract prior to WYNDD survey later in the same week. The consultant surveys also covered private lands where the population is apparently larger. The third new Converse County occurrence is the smallest of known populations, also on BLM lands. In addition, a new occurrence was discovered in Laramie County in 2005 on state land, about 10 km upstream from a known occurrence. Separate from this project, a new occurrence was reported from private land (Tyler Abbott personal communication 2005). The five occurrences do not appreciably expand species' distribution, though four of the five are on drainages where the species had not been found before. All but one was in habitat predicted by the primary potential distribution model, and the one was immediate upstream less than 0.2 miles from predicted habitat. The known populations are in a total of 10 townships and 15 sections, not including the newly-reported site on private land that does not have precise location information available to the township level but is only known to within a 10-mile radius (Figure 2). In addition, there were four state parcels where access was not granted, and areas that may have potential habitat but have no public lands.

Survey and mapping of known *Spiranthes diluvialis* occurrences also provided significant results. The occupied habitat of *S. diluvialis* was delimited by gps points in the riparian corridors and found to straddle unmarked public-private boundaries at two of the original sites. Private landowner contacts and requests for permission were integral to the project. New colonies were verified at the two other previously-known sites. All occurrences were mapped as polygons that encompass the occupied wet meadow, with or without the adjoining creek bed. They are represented by polygons ranging from 0.1-13.1 ha (0.2-32.3 acres), including the unoccupied stream channel in cases where it is on both sides.

WYNDD uses *Spiranthes diluvialis* element occurrence delimitation guidelines consistent with those employed by Colorado Natural Heritage Program that define separation distance across hydrologically connected suitable habitat as 8 km, and across unsuitable habitat as 1.6 km. One of the new occurrences was ca. 10 km upstream from a known occurrence. It is treated as separate though there is hydrological connectivity and small chance of gene exchange. An intervening tract on public land was surveyed where *S. diluvialis* was not found. Another one of the new occurrences was less than 3.2 km by air from an existing occurrence, though on a tributary with ca 7 km of stream corridor separating them at a confluence that lies downstream from both. Though the intervening habitat downstream may be suitable, they are not hydrologically linked and they are treated as separate with the information at hand. Revisionary data standards for *S. diluvialis* have been proposed by the Idaho Conservation Data Center (Colket 2006) separating occurrences by 3 km if they share linear water-current flows or 1 km if they do not share linear water-current flow. The separation distance may be extend to 10 km if colonies share linear water-current flow if more information is known about habitat suitability

between the occurrence features. The outcome by either standard is similar for Wyoming occurrences, with between seven and ten occurrences depending on separation distances and the criteria applied to surveyed and to unsurveyed intervening habitat.

Also as a result of survey results, *Spiranthese diluvialis* occurrence data is being placed in a category that falls under the Wyoming Natural Diversity sensitive data policy. This is because there is there are no open-access public lands that are also demarcated from adjoining private lands. At the two public land sites with open access, *S. diluvialis* straddles unmarked public/private property lines that may have unknowingly been traversed in the past. This is also because there is potential collecting pressure on showy orchids.

Habitat

The habitat for *Spiranthes diluvialis* in Wyoming has been described as low, flat floodplain terraces or abandoned oxbows within 0.5-15 m of a small stream (Fertig 2000, 2001). The habitat is subirrigated and seasonally flooded wet meadow, remaining moist into the summer. The soils are derived from Quaternary alluvial deposits, on occasionally drab sandstones and claystones of the Eocene Wasatch Formation. Wyoming populations range in elevation from 4650-5420 feet.

All of the above information was substantiated in 2005-06 surveys, with minor revisions. One site has a colony distant from the stream but fed by springs and seeps at the mouth of a side valley. Another has floodplain terraces of occupied habitat that are over 50 m wide at their maximum. The zones of occupied habitat, if not the entire terraces, were consistently narrowest in Converse County than in other counties.

The vegetation in Wyoming habitat occupied by *Spiranthes diluvialis* has been characterized as moist meadow communities dominated by *Agrostis stolonifera, Elymus repens, Juncus balticus, Panicum virgatum*, and *Hordeum jubatum* within a narrow band between emergent aquatic vegetation and adjacent dry upland prairie (Fertig 2000, 2001). Vegetative cover is typically 75-90%, but is usually short (under 45 cm tall). Common associated species include *Equisetum laevigatum, Glycyrrhiza lepidota, Melilotus officinalis, M. albus, Muhlenbergia asperifolia, Juncus nodosus, Triglochin maritima, Pedicularis crenulata, Sisyrinchium angustifolium* and *S. montanum,* and *Schoenoplectus pungens*. The *Agrostis stolonifera* is unrivaled as an exotic species that makes major contributions to total vegetation cover in occupied habitat.

The wet meadow composition information was corroborated in 2005-06 surveys for *Spiranthes diluvialis*. There were no areas of occupied habitat found to be dominated by foxtail barley (*Hordeum jubatum*) or quackgrass (*Elymus repens*) as previously reported, even though it was present and sometimes abundant in other zones. Dominants, co-dominants and indicator species differ slightly between the three geographic areas in Wyoming, but with redtop (*Agrostis stolonifera*) and Baltic rush (*Juncus balticus* var. *montanus*) common in all three areas. The Horse Creek watershed area had an abundance, co-dominance or dominance of switchgrass (*Panicum virgatum*), a warm season grass, along with redtop (*Agrostis stolonifera*), and localized boggy areas dominated by few-flowered spikerush (*Eleocharis quinqueflora*; e.g. at 001 and 004). Though the marl flat vegetation represents localized features along the wet meadow zone,

they may reflect groundwater discharge, an earlier successional state, and possibly travertine deposits. The Niobrara watershed area had prevailing dominance by *Agrostis stolonifera*, and major contributions or co-dominance by relatively robust graminoid species: slender wild-rye (*Elymus trachycaulus* var. *trachycaulus*), clustered field sedge (*Carex praegracilis*) and threesquare (*Scirpus pungens*). While the latter was present in most sites, it usually did not overlap with *S. diluvialis* at other sites but was in lower, wetter zones. Compared to the Horse Creek and Niobrara River areas, the Antelope Creek area had what appeared to be a less diverse composition, dominated by *Agrostis stolonifera*. The less-palatable species that seemed to increase under grazing pressure in all three areas include Baltic rush (*Juncus balticus* var. *montanus*; particularly in Converse County), horsetail (*Equisetum laevigatum*), and seaside arrowgrass (*Triglochin maritima* var. *elata*).

The associated species that are usually present in all three geographic areas of *Spiranthes diluvialis* distribution in Wyoming included blue-eyed grasses (*Sisyrinchium angustifolium* to the south and *S. montanum* to the north), and white prairie aster (*Symphyotrichum falcatum*). These species are not reported as consistently associated species in other states. The prior species composition list (Table2 in Fertig 2000) was cross-referenced to the three geographic areas where *S. diluvialis* occurs in Wyoming, and a few species added (Table 3). In general, the species associates for *S. diluvialis* in Wyoming have the greatest commonality with those nearest in Nebraska and the Front Range of Colorado. The species diversity was higher in the Horse Creek and Niobrara River areas than in Antelope Creek. The Niobrara area had a high forb diversity in some of its meanders that included high numbers of slender false-foxglove (*Agalinis tenuifolia* var. *parviflora*) and purple-flower lousewort (*Pedicularis crenulata*) in a couple meanders. The boggy areas in Laramie County typically had northern grass-of-Parnassus (*Parnassia palustris*) and golden-fruit sedge (*Carex aurea*). For a complete list of species associated with *S. diluvialis* across its range, see Table 2 in Fertig et al. (2005).

Four other current Wyoming plant species of concern were documented incidental to 2005-06 surveys for *Spiranthes diluvialis*: slender false-foxglove (*Agalinis tenuifolia* var. *parviflora*), Sartwell's sedge (*Carex sartwellii* var. *sartwellii*), great blue lobelia (*Lobelia siphilitica*) and rosy palafoxia (*Palafoxia rosea* var. *macrolepis*). They included new county records for two of the four species. In addition, a fifth species, large bur-reed (Sparganium eurycarpum) was already known from one site (003) and pretty dodder (*Cuscuta indecora* var. *neuropetala*) was collected by Don Hazelett (004). Three state records were also documented in 2005-06, including slender burr-reed (*Alisma subcordatum*) in Niobrara County, hairy fimbry (*Fimbristylis parvula* var. *interior*) also in Niobrara County, and nodding leafy bulrush (*Scirpus pendulus*) in Converse County. Only one of the above-mentioned species was found to occasionally occupy the same habitat as *S. diluvialis* (*Agalinis tenuifolia* var. *parviflora*) but some of the others were found on the same meander or in the vicinity.

Descriptions of stream conditions and hydrological conditions of *Spiranthes diluvialis* habitat were expanded. The Antelope Creek and Niobrara River areas have Great Plains headwaters, while the Horse Creek area has its headwaters in the Laramie Range. The Antelope Creek watershed occurrences are on first- and second-order streams in the watershed. Most but not all other Wyoming occurrences are on third order streams. They are almost all perennial streams, with exception of the smallest Converse County occurrence on a seasonal stream that

had beaded pools along the channel that held water in most years (007). The largest drainage (003) had dried out below its impoundment under prolonged drought in 2006, which is likely to reflect the combined influence of the impoundment and climate. The perennial or semi-permanent nature of the stream was evidenced in the presence of robust emergent vegetation bordering, filling or intermittently present in the stream channel at known sites. Broad-leaf cattail (*Typha latifolia*) was present at almost all sites and almost completely filled some adjoining river and stream channels; narrow-leaf cattail (*T. angustifolia*) was also present in unoccupied habitat above the reservoir at one site (003). Soft-stem rush (*Schoenoplectus tabermontanaei*) was the most common or only common emergent at some sites (001) which also have robust streamside grasses not present elsewhere rice cut-grass (*Leersia oryzoides*) and rough barnyard grass (*Echinochloa muricata*). Further evidence of hydrological stability was seen in the submerged vegetation. *Chara* spp. was conspicuous among emerged vegetation at most sites (Figure 11), or at least noted as present, and the water temperatures were cool, suggesting groundwater discharge at or near the occupied stream reach. Pondweeds were sometimes present though secondary, including waterthread (*Potamogeton diversifolius*). Species associated with springs, like watercress (*Nasturtium officinale*), seep monkeyflower (*Mimulus guttatus*) and porcupine sedge (*Carex hystricina*) were sometimes in the landscape though not routinely beside occupied habitat. Water clarity was high and filamentous algal cover on the stream bottom and on emergent plants was low. *Chara* spp. are typically found in waters rich in calcium carbonate.

Table 3. Vascular plant species associated with *Spiranthes diluvialis* in the three areas where it is known in Wyoming (includes Fertig 2000, Hazlett 1996, 1997; and this study)

Scientific Name	**Common name**	**Non-native**	**Tracked**	**Antelope Cr**	**Horse Cr**	**Niobrara R**
Agalinis tenuifolia var. parviflora	slender false-foxglove		Y			X
Agoseris glauca	pale goat-chicory				X	
Agrostis stolonifera	Redtop	Y		X	X	X
Alisma subcordatum	a water-plantain					X
Alisma triviale	northern water-plantain			X	X	X
Alopecurus pratensis	field meadow-foxtail			X		
Ambrosia trifida	giant ragweed				X	
Asclepias speciosa	showy milkweed			X		
Astragalus canadensis	Canadian milkvetch				X	
Atriplex subspicata	saline saltbush					X
Berula erecta	cut-leaf water-parsnip				X	
Bidens comosa	three-lobed beggarticks				X	X
Bidens frondosa	devils'-pitchfork				X	X
Bromus inermis	smooth brome	Y			X	
Calamagrostis inexpansa	slimstem reedgrass			X	X	X
Carex aureg	golden sedge			X	X	
Carex hystricina	porcupine sedge				X	
Carex lanuginosa	woolly sedge			X	X	
Carex nebrascensis	Nebraska sedge			X	X	X
Carex praegracilis	clustered field sedge			X		X

Scientific Name	Common name	Non-native	Tracked	Antelope Cr	Horse Cr	Niobrara R
Chenopodium rubrum var. rubrum	low goosefoot				X	X
Chenopodium simplex	giant seed goosefoot					X
Cirsium arvense	Canada thistle	Y*		X	X	X
Cirsium canescens	prairie thistle					
Cirsium flodmanii	Flodman's thistle				X	
Cirsium vulgaris	bull thistle	Y*			X	
Cuscuta indecora	large seed dodder		Y		X	
Cynoglossum officinale	hound's-tongue	Y*		X		
Deschampsia cespitosa	tufted hairgrass				X	X
Echinochloa muricata var. microstachya	rough barnyard grass				X	X
Elaeagnus angustifolia	Russian olive*	Y		X		
Eleocharis acicularis	needle spike-rush					X
Eleocharis quinqueflora	few-flowered spikerush				X	X
Elymus canadensis	nodding wild rye					X
Elymus lanceolatus	thickspike wheatgrass			X	X	
Elymus repens	quackgrass	Y			X	X
Elymus trachycaulus	slender wild rye			X	X	X
Epilobium palustre var. gracile	bog willowherb				X	X
Equisetum arvense	field horsetail			X		
Equisetum laevigatum	smooth scouring-rush			X	X	X
Erigeron lonchophyllus	short-ray fleabane				X	X
Euphorbia esula	leafy spurge	Y*			X	
Festuca spp.	A fescue	Y		X		
Fimbristylis puberula var. interior	hairy fimbry		Y			X
Galium trifidum	three-petal bedstraw					X
Gentianella amarella	autumn dwarf-gentian				X	X
Glycyrrhiza lepidota	wild licorice			X	X	X
Habenaria [Platanthera] dilatata – no voucher for these counties!	white bog-orchid				X	
Helianthus nuttallii	Nuttall's sunflower				X	
Hordeum jubatum	foxtail barley			X	X	X
Juncus balticus	Baltic rush			X	X	X
Juncus longistylis	long-style rush			X	X	X
Juncus nodosus	knotted rush				X	

Scientific Name	Common name	Non-native	Tracked	Antelope Cr	Horse Cr	Niobrara R
Juncus torreyi	Torrey's rush			X	X	X
Leerzia oryzoides	rice cutgrass				X	
Linaria vulgaris	butter-and-eggs	Y*			X	
Lycopus americanus	cut-leaf water-horehound				X	
Lycopus asper	rough water-horehound			X	X	X
Medicago lupulina	black medic	Y		X	X	
Melilotus alba	white sweetclover	Y		X	X	X
Melilotus officinalis	yellow sweetclover	Y		X		
Mentha arvensis	wild mint			X	X	X
Muhlenbergia asperifolia	alkali muhly			X	X	X
Muhlenbergia richardsonis	matted muhly			X	X	X
Nasturtium officinale	watercress	Y		X	X	
Orthocarpus luteus	owl clover					X
Panicum virgatum	switchgrass				X	X
Parnassia palustris var. montanensis	northern grass-of-Parnassus				X	
Pedicularis crenulata	purple-flower lousewort				X	X
Phleum pratense	timothy	Y		X	X	
Phragmites australis	common reed			X	X	X
Plantago eriopoda	red-wooly plantain					X
Plantago lanceolata	English plantain			X	X	
Plantago major	common plantain	Y			X	X
Platanthera [dilatata]	Bog orchid				Y	
Poa pratensis	Kentucky bluegrass	Y		X		
Polygonum persicaria	lady's-thumb				X	
Polygonum ramosissimum	bushy knotweed				X	X
Potamogeton diversifolius	waterthread				X	
Potentilla diversifolia	mountain-meadow cinquefoil				X	
Ranunculus cymbalaria var. cymbalaria	alkali buttercup					X
Ratibida columnifera	black-eyed susan				X	
Sagittaria cuneata	arum-leaf arrowhead				X	
Salix boothii	Booth's willow				X	
Salix exigua var. exigua	sandbar willow				X	
Schoenoplectus tabernaemonanei Scirpus validus	soft-stem bulrush				X	X

Scientific Name	Common name	Non-native	Tracked	Antelope Cr	Horse Cr	Niobrara R
Scirpus pungens var. polyphyllus	threesquare			X	X	X
Sisyrinchium angustifolium	Pointed blue-eyed grass			?	X	
Sisyrinchium montanum	strict blue-eyed grass			?		X
Sium suave	hemlock water-parsnip					X
Solidago canadensis var. gilvocanescens	Canadian goldenrod			X	X	X
Sonchus uliginosus	marsh sow-thistle	Y				X
Sparganium emersum	simple-stem burr-reed			X	X	rep H
Sparganium eurycarpum	broad-fruit burr-reed		Y			X
Spartina gracilis	alkali cordgrass			X	X	
Sphenopholis obtusata var. obtusata	slender wedgescale					X
Stachys palustris var. pilosa	hairy hedge-nettle					X
Suaeda calceoliformis	seablite					X
Symphoricarpos occidentalis	western snowberry				X	
Symphyotrichum boreale	bog aster				X	
Symphyotrichum ciliatum	alkali aster				X	
Symphyotrichum ericoides var. pansus	white heath aster			X		
Symphyotrichum falcatum var. falcatum	rough white prairie aster			X	X	X
Symphyotrichum lanceolatum var hesperium	white panicled aster				X	X
Taraxacum officinale	common dandelion	Y			X	
Teucrium canadense	American germander					X
Thelypodium integrifolium	entire-leaf thelypody					X
Trifolium frageriferum	strawberry clover	Y		X	X	X
Trifolium pratense	red clover	Y			X	X
Trifolium repens	white clover	Y			X	
Triglochin maritimua var. elatum	seaside arrow-grass				X	X
Typha angustifolia	narrow-leaf cattail					X
Typha latifolia	broad-leaf cattail			X	X	X
Vernica anagallis-aquatica	blue water speedwell				X	

Available habitat information was tested in photointerpretation and in fieldwork. Three key photointerpretation characteristics were sought: standing or flowing water at the time of aerial photography (late Aug, early Sept), dark tones with red coloration in valleybottom flats indicating photosynthetic activity associated with subirrigated wet meadows, and presence of meanders or oxbows indicating alluvial processes. Aerial photographs also provided information needed to rule out areas as suitable, showing cultivation patterns and other sorts of habitat conversions (see Fogires 18, 19).

The four criteria used in modeling potential distribution of *Spiranthes diluvialis* (Fertig and Thurston 2003) were considered in field surveys as they potentially elucidate habitat requirements. The first criterion is bedrock geology, including Early Eocene, Miocene/Pliocene and Quaternary alluvium. These widespread deposits include the Arikaree Formation (lower Miocene and upper Oligocene in the Horse Creek and Niobrara River areas) and the Wasatch Formation (Eocene in the Antelope Creek area). In all occupied habitat sites, there were outcrops on or above the stream channel in the vicinity (see habitat photos; Figures 10-14).

The second criterion is land cover, including graminoid-dominated wetland, forest-dominated wetland, mixed grass prairie and shrub-dominated riparian. These broad categories are not limited by elevation, but encompass the riparian settings across most of eastern Wyoming. In all occupied habitat sites, there were graminoid wet meadow habitats, sometime restricted to narrow bands or interrupted features, that would not necessarily be mapped as graminoid vegetation under the scale of vegetation mapping that was used.

The third criterion is soil classification, including Typic Hapludolls and Typic Hapludalfs, loamy-skeletal, mixed, frig; and Ustic Haplargid and Ustic or Typic Torrifluvents, fine-loamy over sandy or sandy-skeletal, mixed, mesic. Though soils have not been mapped in detail across most of the six county area, the STATSGO level of mapping served to identify intermediate soil textures with well-drained conditions on a plains landscape.

Figure 10. Two *Spiranthes diluvialis* habitat criteria are evident (002):
1) Subirrigated wet meadow habitat dominated by *Agrostis stolonifera*, present in riparian settings (foreground); with
2) Perennial flow or at least persisting standing water at end of growing season (characterized by presence of *Typha latifolia* or *Schoenoplectus tabaernaemontanaei* in the vicinity). Photo by John Proctor, Medicine Bow/Routte National Forest

Figure 11. A third *Spiranthes diluvialis* habitat criterion is evident: presence of *Chara* spp. in the nearby creek, indicating high concentrations of calcium bicarbonate (lime), often with high water clarity (001). Photo by B. Heidel

Figure 12. The three characteristics of *Spiranthes diluvialis* habitat are evident even when the tall emergent vegetation (*Schoenoplectus tabermontanei*) typical for this site (001) and the wet meadow habitat are grazed. Note: Gopher mounds are generally outside occupied habitat. (Compare this habitat view where there is summer grazing with that in Figure 10 where there is winter grazing.) Photo by Patricia Sweanor, U.S. Fish and Wildlife Service.

Figure 13. *Spiranthes diluvialis* also occupies very sparsely-vegetated marl flats dominated by *Eleocharis quinqueflora* (004). These localized features along the wet meadow zone may reflect groundwater discharge, an earlier successional state, or possibly travertine deposits.
Photo by B. Heidel

Figure 14. *Spiranthes diluvialis* is generally a poor competitor, but at any occupied site, the variations in disturbance and microhabitat may result in apparent exceptions where it appears in dense vegetation (001). Photo by B. Heidel

The fourth criterion is surface geology, containing old alluvial plain. This represents reworked riparian habitat with interbedded deposits. This indicates habitat with ongoing or past fluvial processes.

Description of soils information was expanded by collecting soil samples from sites where *Spiranthes diluvialis* is present, and from other surveyed wet meadow sites where it is absent. Soil samples were collected from all eight of the surveyed occurrences, including multiple samples to represent microhabitats (total of 13 samples). Soil samples were collected in wet meadow habitat elsewhere in the six-county area that were surveyed for *S. diluvialis* where it is absent (total of 12 samples). The distribution of soil sample sites by township is presented in Figure15.

Soil samples were dug to a depth of 15 cm, surface vegetation was removed, coarse root material was removed, and then stored in airtight containers under refrigerated conditions for later analysis at the University of Wyoming Soils Testing Laboratory. Each sample was analyzed for ten parameters that included pH, electrical conductivity (DS/M), sodium absorption ratio, texture (% sand, silt, and clay fractions), % organic matter, nitrate (mg/kg) and potassium (ppm); with exception of a few samples having inadequate material for all ten tests. This does not replicate all of the parameters measured in the earlier studies (Hildebrand 1998, Arft 1995) but provides a basis for comparison and drawing generalizations. The analysis performed in the current study was limited to calculation of averages and presenting the range of values. Average values and the range in values were compared between the set of sites where *Spiranthes diluvialis* is present with those where it is absent.

Figure 15. *Spiranthes diluvialis* soil sample areas

Soils correlation analyses were previously run in the Hildebrand study (1998) in an effort to correlate soil characteristics with presence and absence of *Spiranthes diluvialis*. This highlighted significant positive correlation coefficients for phosphorus, iron, conductivity, and nitrate. Significant negative correlation coefficients were found for pH and ammonia.

In this study, the average values for four of the ten characteristics were distinct at sites where *Spiranthes diluvialis* is present vs. absent, though the ranges of values overlapped. The occupied *Spiranthes diluvialis* sites had lower electrical conductivity, sodium absorption ratios and clay content than unoccupied habitats that were sampled, while they had higher lime concentrations (Table 4). The soil characteristics with least overlap between sites where *S. diluvialis* is present vs absent were clay content and sodium absorption ratio (SAR). While occupied and unoccupied sites had some overlaps in values, it is postulated that non-overlapping soils values of the four soil characteristics named above serve to identify unsuitable habitat.

The sites where *Spiranthes diluvialis* was present tended to have coarse textures and ranged from sands and sandy loams to loamy sands, loams and silt loams (Table 4). The sites where *S. diluvialis* was absent had generally overlapping textural classifications except that they

Table 4. Soil characteristics at wet meadow sites where *Spiranthes diluvialis* is absent and present in Wyoming[1]

SOIL SAMPLE SITES - *SPIRANTHES* ABSENT													
Drainage	ID	EO	pH	EC ds/m	NO3N mg/kg	% CaCO3	% Sand	% Silt	% Clay	Textural Class	% Organic Matter (LOI)	SAR	K mg//kg
Antelope Cr	11		7	3.8	3	3.2	50	32	18	sandy loam	9.61	0.88	250
Crow Ck	19		7.7	1.85	37	2	60	27	13	sandy loam	5.42	11.35	360
Crow Ck	20		7.5	0.81	7	0.5	85	12	3	loamy sand	2.17	0.24	160
Crow Ck	18		7.4	2.28	1	2.4	53	30	18	sandy loam	4.66	0.92	210
Horse Cr	5		7.7	1.46	35	1.1	82	13	5	loamy sand	1.56	0.87	350
Horse Cr	14		7.1	2.92	6	2.8	30	32	28	clay loam	10.77	1.16	360
Horse Cr	15		7.4	6.95	4	0.9	70	15	15	sandy loam	3.27	4.56	180
Powder R	21		7.5	5.17	71	3.3	40	40	20	loam	10.88	3.16	560
TBNG	22		8.1	16.49	11	0.4	75	15	10	loamy sand	1.22	17.31	170
TBNG	23		8.1	17.75	9	0.5	40	37	23	loam	1.5	22.83	250
TBNG	24		6.1	4.5	9	0.3	55	25	20	sandy clay loam	1.72	3.61	200
TBNG	25		7.8	NES	2	0.6	50	22	28	sandy clay loam	3.11	NES	220
Average			7.45	**5.82**	16.25	**1.50**	57.50	25.00	**16.75**		4.66	**6.08**	272.50
Range			6.1-8.1	0.81-17.75	1.0-71	0.3-3.3	40-85	12-40.0	3-28.0		1.22-10.88	0.24-22.83	170-560

SOIL SAMPLE SITES - *SPIRANTHES* PRESENT													
Drainage	ID	EO	pH	EC ds/m	NO3N mg/kg	% CaCO3	% Sand	% Silt	% Clay		% Organic Matter (LOI)	SAR	K mg//kg
Antelope Cr	13	002	7.7	NES	25	3.3	93	5	3	sand	22.54	NES	670
Antelope Cr	16	007	7.6	2.05	1	2.2	88	10	3	sand	1.67	0.86	80
Antelope Cr	26	006	7.2	4.24	4	1.4	78	12	10	loamy sand	5.71	2.82	130
Antelope Cr	17	008	7.8	NES	11	3.8	NES	NES	NES	NES	12	NES	360
Horse Cr	6	001	7.6	1.42	45	1	80	17	3	loamy sand	1.96	0.93	390
Horse Cr	7	001	7.7	1.34	5	1	80	17	3	loamy sand	2.23	1.89	480
Horse Cr	4	005	7.9	1.55	25	1.2	67	30	3	sandy loam	4.56	1.32	240
Horse Cr	10	004	7.8	1.1	1	1.7	53	42	5	sandy loam	3.79	1.74	220
Horse Cr	8	004	7.8	1.4	11	2.4	63	25	13	sandy loam	7.52	2	380
Horse Cr	9	004	8.3	NES	5	5.5	63	25	13	sandy loam	16.2	NES	370
Niobrara R	1	003	7.9	2.07	2	9.7	40	47	13	loam	6.77	3.75	500
Niobrara R	2	003	7.8	1.79	17	3.1	52	40	7	sandy loam	13.19	2.8	590
Niobrara R	3	003	7.9	2.42	16	2.3	35	55	10	silt loam	6.71	3.24	620
Average			7.77	**1.94**	12.92	**2.97**	66.00	27.08	**7.17**		8.07	**2.14**	386.92
Range			7.3-8.3	1.1-4.24	1.0-45	1.0-9.7	40-93	5.0-55	3.0-13		1.67-22.54	0.86-3.75	80-620

included clay loams and sandy clay loams. At an occupied site with high habitat diversity (003), there were three soil samples collected that document an accompanying soil texture diversity,

[1] Significant differences of soil characteristics average between sites where *Spiranthes diluvialis* is absent and present are bold-faced.

including sandy loam (near channel), loam (outer margin of occupied habitat away from channel), and silt loam (abandoned oxbow influenced by surface runoff from adjoining slopes).

Two of the eight *Spiranthes diluvialis* occurrences in Wyoming were represented in the previous soil sampling as collected and reported by Hildebrand (1998), so the results provide a basis for directly comparing results of the two investigations. The Hildebrand study (1998) also reported seven soil samples collected from five occurrences in southwestern Montana by B. Heidel about 500 miles away, so the Hildebrand averages for occupied *S. diluvialis* sites represent a geographically and geologically heterogeneous set. A comparison between the results from this test and that of the Hildebrand study (1998) and the Arft study (1995) indicated that electrical conductivity is consistently low but not a differentiating characteristic in the Hildebrand (1998) study, and that nitrate tends to be lower in occupied habitat compared with unoccupied habitat samples but is not a differentiating characteristic (Table 5).

There are only five parameters that are directly comparable between the three different studies (pH, % organic matter, K, nitrate, and organic mater). However, Hildebrand (1998) also provided site-specific measurements of lime content (ppm) and texture classes for each site, data that are not summarized, but still provide a basis for making generalizations.

Table 5. Average soil characteristics at wet meadow sites where *Spiranthes diluvialis* is absent and present (this study and others)

	Wyoming (Heidel 2007)		Nebraska, Montana, Wyoming (Hildebrand 1998)		Colorado and Utah (Arft 1995)
	Spiranthes Present	*Spiranthes* Absent	*Spiranthes* Present	*Spiranthes* Absent	*Spiranthes* Present
pH	7.77 (7.3-8.3)	7.45 (6.1-8.1)	7.88 (7.66-8.25)	8.50 (7.12-8.01)	6.6-8.15
EC ds/m (mmhos/cm)	1.94 (1.1-4.24)	5.82 (0.81-17.75)	0.72 (0.3-1.5)	0.41 (0.31-0.56)	0.37-1.9
NO3N mg/kg (ppm)	12.92 (1.0-45)	16.25 (1.0-71)	3.44 (1.94-5.53)	4.27 (2.44-7.31)	2.0-29
% CaCO3	2.97 (1.0-9.7)	1.5 (0.3-3.3)			
% Sand	66.0 (40-93)	57.5 (40-85)			
% Silt	27.08 (5.0-55)	25.00 (12-40.0)			
% Clay	7.58 (3.0-13)	16.75 (3-28.0)			
SAR	2.13 (0.86-3.75)	6.08 (0.24-22.83)			
% Organic Matter (LOI)	8.06 (1.67-22.54)	4.66 (1.22-10.88)	9.92 (2.24-26.35)	10.66 (2.03-39.21)	7.0-16
K mg/kg (ppm)	386.92(80-620)	272.5 (170-560)	292.53 (102-586)	455.67 (119-951)	65-160
Ammonia ppm			4.26 (2.81-6.4)	4.66 (3.47-8.92)	6.5-12.8
Bray P ppm			1.24 (0-2.61)	0.89 (0-3.14)	1-3.4
ZN			2.66 (0.48-4.03)	3.11 (0.93-10.13)	3.0-270
MN			27.76 (6.3-63)	26/42 (8.5-57.3)	8.0-26
FE			110.35 (40.4-281.3)	167.42 (18.3-915.6)	60-280
CU			1.52 (0.48-5.2)	0.78 (0.43-1.13)	11.0-56.0

Population Size and Trends

A tabulation of peak census and population size estimates at *Spiranthes diluvialis* occurrences indicates that there have been at least 3,800 plants in the state over time, in an area of ca 60 acres. This is a conservative figure because it does not reflect seasonal dormancy phenomena (discussed later), and is based on one-time visits of varying intensity within the flowering period. This peak census represents less than 5% of projected total rangewide numbers of *S. diluvialis* (83,329 plants; discussed in Fertig et al. 2005). The Wyoming plant numbers of *S. diluvialis* are highly concentrated among a few of the nine known occurrences. Previously, Fertig (2000) reported documenting total Wyoming numbers of 800-1200 individuals in a total area of less than 10 acres. The increase in numbers and area is not influenced as much by the discovery of new occurrences, as by the expansion of known population boundaries and repeated census in years and conditions more favorable to flowering, with over 90% of the state numbers found at three of the original occurrences (Table 6).

The largest known occurrence of *Spiranthes diluvialis* had flowering stem numbers estimated at 2000+ plants, representing over half of the numbers in the state, based on a 2005 census of a previously-known occurrence on private lands. Exhaustive census of the single largest colony among the 16 local colonies in 2006 documented 1106 plants, i.e., not including the 15 other colonies that comprise the rest of the occurrence. The major reason for this difference is thought to be that the entire colony had been mown by the time of the 1998 survey, as determined from slides taken in the original survey. This site is on private land. The highest number of flowering plants found on public lands among the new occurrences in 2005-06 was 40 plants. Except for documentation of the largest occurrence, the 2005 and 2006 survey results presented downward trends for all other previously-known occurrences.

Figure 16. Peak census and estimates of *Spiranthes diluvialis* numbers in Wyoming

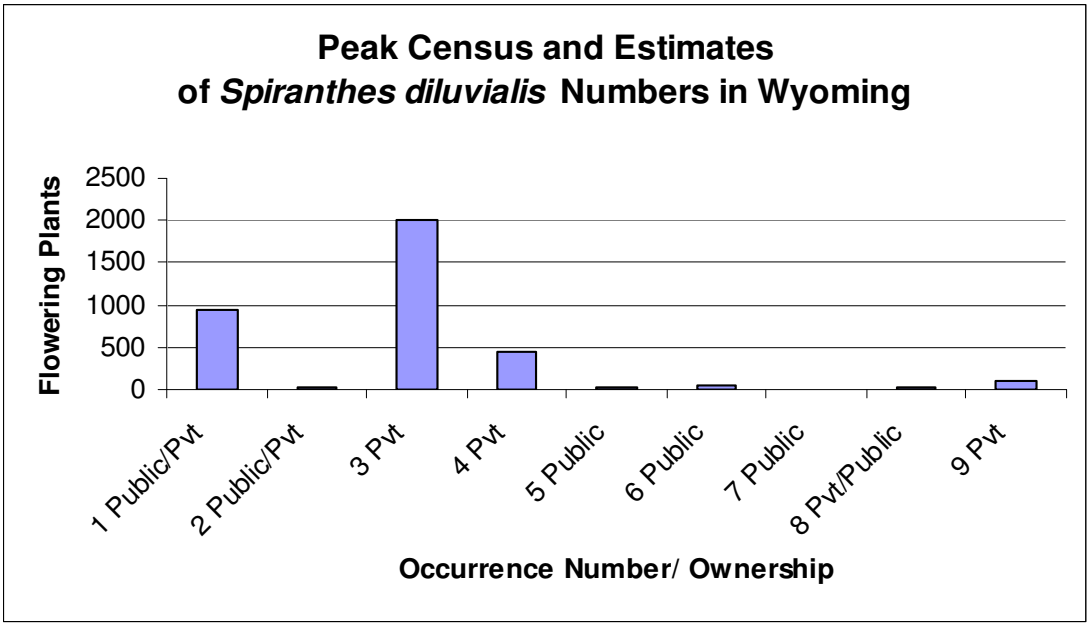


Table 6. *Spiranthes diluvialis* population size, area and trends in Wyoming

Occurrence Number	Ownership*	County	Population Area in ha (acres)	Population Size	Population Trend and Trend Comment	Delimitation comments
WY-001	State and private	Goshen	1.8 (4.6)	Population spans at least 0.5 miles of creek with peak census numbers in Parcel 1 of 426 plants (2002) and a separate meadow at the mouth of a side valley with estimated numbers of 500+ plants (1997). If trends are stable over the long-term, net numbers are estimated at close to 1000 plants. All census numbers prior to 2006 pertain to Parcel 1 except for those in 1997. The 2006 tally represents Parcel 1 and public portion of Parcel 2: 305 plants. 2006-09-01: 11 plants in pvt portion of Parcel 1 by B. Heidel. 2006-08-10: 249 plants on public land of parcel 1 by training team (21 on north side, 228 on south side). 2006-08-10: 45 plants on public portion of Parcel 2 by B. Heidel. 2005-08-18: 241 plants (28 on north side, 213 on south side) by interagency team. 2004-08-31: Observed by USFWS team. 2003-08-15: 143 plants surveyed by BLM team. 2002-08-20: 426 plants (118 on north side, 308 on south side) by B. Heidel, F. Blomquist, J. Carroll and P. Cornelius. 2000-08-20: 300-500 plants est by W. Fertig and biologists from WEST. 1999-08-09: 200 flowering and vegetative plants observed by W. Fertig, G. Jones, B.E. Nelson, and B. Schladweiler. Density of 4-8 plants/sq meter observed at best sites. Total population estimated at 500 along entire stream.	Oscillating, or declining under prolonged drought. The highest counts on the regularly-censused Parcel 1 pasture were in 2002 under drought conditions. The Hildebrand 1997 estimate appears to represent a separate parcel than the other surveys. Only part of that second pasture is on public land and that portion was censused in 2006.	Two main colonies on a creek and side valley; 10 km downstream from 005
				1998-08-17: 70 plants observed at 2 sites by Fertig. Population estimated at 300-500.		
				1998-08-03: 214 flowering and in bud plants observed by J. Carroll, M. Jennings, D. Felley, D. Hazlett, and D. Young.		
				1997-08-30: Estimated at 500 plants by T. Hildebrand.		
				1994-08: Ca 100 plants observed by B.E. Nelson and T. Chumley.		
				1993-08-17: 4 plants observed in brief visit by B.E. Nelson.		

WY-002	BLM and private	Converse	1.1 (2.7)	Population spans less than 0.3 miles of creek, with peak census of 35 plants. Most tallies prior to 2005 correspond with north end or south end but not both. 2006-07-29: 19 plants iat south end n bud, surveyed by S. Bucklin-Comiskey. 2005-08-18: 5 plants at two places at south end by S. Bucklin-Comiskey. 2005-07-26: In bud. 13 plants at north end by B. Heidel and training crew. 2004-08-19: 3 plants (2 in fruit) by A. Travskey. 2004-08-01: 7 plants, including one recently nipped off by browser, by S. Bucklin-Comiskey. 2002-summer: No plants found by W. Fitzgerald. 2001-07-21: 6-8 plants in bud by B. Schladweiler. 1999-07-22: 12-15 plants in bud observed by Brenda Schladweiler.E12	Oscillating, or declining under drought. The highest counts were in the Hildebrand 1997 census.	One diffuse colony within 3.2 km by air from 006 but over 7 km apart on a creek and tributary
				1998-08-19: 20 flowering plants observed by W. Fertig.		
				1997-08-15: 35 plants observed by T. Hildebrand.		
				1995-08-17: 11 plants observed by P. Wolken.		
				1994-08-21: Ca 20-24 flowering and in bud plants observed by B.E. Nelson.		
WY-003	Private	Niobrara	13.1 (32.3)	Population spans ca 1.5 miles of river, with peak estimates of 2000+ plants, discontinuous in 16 meander colonies. 2006-08-05: 1106 plants censused in the meander colony with highest numbers (among 16 colonies), representing ca 50% of population, by B. Heidel. 2005-08-18: 1557 plants censused in complete walk-through (across 16 colonies), est 2000+ plants, by B. Heidel. 1998-08-18: 203 plants counted by W. Fertig in 3 main colonies (surveyed with consent of landowner).	Stable or increasing? Most of the increase in numbers is attributed to an expansion of survey boundaries.	Ca 16 meanders (colonies)
				1996-08-17: 57 plants observed in 5 colonies by D. Hazlett. Reported as “sporadic”.		
WY-004	Private	Laramie	3.7 (9.2)	Population spans almost 0.5 miles of creek, with a remote outlier ca two miles away, and peak census of 454 plants (main colony in 1998) plus 17 plants (outlier colony in 2006). 2006-08-14: Outlier colony mapped and 17 plants censused by B. Heidel. 2005-08-17: 200+ plants estimated by B. Heidel. 1998-08-18: ca 400 plants observed by W. Fertig (with permission of landowner). 1998-08-18: Ca 400 plants estimated by W. Fertig.	Oscillating, or declining under drought. The landowner identified a new colony; which was verified and censused in 2006.	Two colonies ca 3 km apart on the same creek
				1998-08-03: 454 plants observed by J. Carroll and USFWS tour group.		
				1997-09-04: 71 plants observed by D. Hazlett		

WY-005	State	Laramie	0.1 (0.2)	Population occurs in a single band on south side less than 0.1 mile long. 2006-08-09: 10 plants censused by B. Heidel. 2005-08-18: 20 plants censused by B. Heidel.	Oscillating or declining under drought	One small colony 10 km upstream from 001
WY-006	BLM, possibly extending onto private	Converse	0.3 (0.7)	2005-08-22: 40 plants estimated in less than 1 acre suitable habitat by S. Bucklin-Comiskey and C. Fifield.	Unknown	One colony within ca 3 km by air from 002 but over 7 km apart on a creek and tributary
WY-007	BLM	Converse	0.1 (0.2)	Population present at a couple points less than 10 m apart. 2006-08-15: No plants found by B. Heidel under severe drought. 2005-08-22: 5 plants censused by B. Heidel.	Oscillating or declining under drought	One small colony
WY-008	State and private	Converse	4.7 (11.3)?	Population discontinuous along ca 1.5 miles of creek totaling 29 plants in 2006 census. 2006-08-14 or 15: 1 plant found on public land by Orpet et al. (revisited by B. Heidel on 8-16). 2006-08-14 thru 18: 28 plants censused by Orpet et al. on pvt land.	Unknown	Two main colonies and an upstream outlier spanning ca 3 km on the same creek
WY-009	Private	Laramie	Unknown	2006-08: Ca. 100 plants estimated by T. Abbott.	Unknown	Unknown

The running tallies at all new and prior sites occurrences of *Spiranthes diluvialis* were recorded and estimates made accordingly. Results are represented in Figure 16 as a ballpark tally of confirmed numbers. *Spiranthes diluvialis* cannot be censused in nonflowering condition and is one of many orchid species that have seasonal dormancy (no above-ground stage in someyears; see the following section), so the population numbers even in peak years are going to represent an undetermined fraction of actual population size. This report of tallies and trends is hampered by the uncertainty in flowering levels from year to year, and the differences among conventions for making an estimate or a census (discussed in the following section).

The concerted *Spiranthes diluvialis* surveys by Fertig (1998-99) and by Heidel (2005-06) are the only extensive ones by the same investigator at all known sites in Wyoming, but are not certain gauges of trend without knowing that they covered the same area with similar approaches. Only parts of two occurrences (001, 002) have been census in the same segment over time, documenting oscillation.

Population Biology and Ecology:

In any given year, *Spiranthes diluvialis* plants may be in flowering condition, vegetative condition, or remain belowground. The latter stage has been referred to as seasonal dormancy, though the plants are physiologically active with an ectomycorrhizal symbiont. Preliminary data from Montana indicates that the mean length of season-long dormancy exceeds two years (Heidel 2001). The three mature life history stages and the seedling stage are described by Fertig et al. (2005).

Some Wyoming surveys have noted plants as "vegetative" when in fact they were reproductive plants that were in bud. Likewise, surveys have also been done when the plant is in fruit, which still has a flowering stalk though the flowers are less conspicuous when they are dessicated and brown. Vegetative plants are composed of solitary leaves, and some of these can be less than 2 cm, as determined in a monitoring study (Figure 8; from Heidel 2001).

In the previous *Spiranthes diluvialis* status report for Wyoming, there have been statements made that *S. diluvialis* cannot reliably be located in any given year due to the irregularity with which it produced flowers. By this inference, sites that have been "cleared" in the past could still support populations (Fertig 2000). This statement and inference were drawn from conclusions reached in Snake River surveys (Moseley 1998), where flood events, burial and curtailed flows below the Palisades Dam represent volatile habitat conditions. However, long-term monitoring of *S. diluvialis* in other habitats indicated that the species' flowered at levels between 5%-46% of the total population (assuming no mortality over the short time period; Based on Colorado Front Range by Arft 1995a, and Montana monitoring by Heidel 2001). If we take these numbers as rule-of-thumb, and if populations are stable, then the peak flowering plant counts of 3,800 in Wyoming may actually represent total population numbers of 7600 plants.

It is hypothesized that sustained presence of *Spiranthes diluvialis* is reliable in Wyoming except in extremely small populations under climate extremes (prolonged drought or else late-season inundation). The 2005-06 surveys of *S. diluvialis* provided a graphic example. In 2005, a

new occurrence was discovered by the author in Converse County in which only five plants could be found. In 2006, this same site was surveyed and no plants were found. Within 10 m of the occupied habitat, an oxbow pool that held ca 0.2 m of water in 2005 held no water but contained dead animals in 2006. The apparent absence of plants at the surface is hypothesized to represent response to severe, prolonged drought. The suppression may also be associated with the unusually dense cover of Baltic rush (*Juncus balticus*) that forms thick thatch and intercepts water and light. This is the basis for hypothesizing that it is only under prolonged drought where population numbers are extremely low that *S. diluvialis* can be missed in Wyoming surveys conducted during the flowering period.

Pollinators and other insects

In Wyoming, *Spiranthes diluvialis* blooms from early August to early September in most years, with fruits produced in mid August to September. Bumblebee visitors have been noted at two Wyoming sites (003, 004). The following information is taken from Fertig (2000): Sipes and Tepedino (1994) report that large, long-tongued bumblebees in the genus *Bombus* are the primary pollinators in Utah and Colorado. Smaller bees may also visit these flowers but have the incorrect body shape or mass to properly accommodate the flower's large, sticky anther/pollen clusters (pollinaria). Out-crossing in Ute's ladies'- tresses is promoted by the asynchronous maturation of anthers and pistils in individual flowers. *Bombus* typically visit the oldest basal flowers of an inflorescence first (these are by then functionally pistillate) and pick up pollinaria from younger (functionally staminate) flowers at the tip of the inflorescence. These pollinaria are then delivered to the basal pistillate flowers of the next inflorescence they visit (Sipes and Tepedino 1994). Some overlap in the maturation of staminate and pistillate flowers can occur within the same inflorescence, allowing for low rates of self-pollination. *S. diluvialis* may also 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* (Sipes and Tepedino 1994).

When *Spiranthes diluvialis* is found with more than one flowering stem in a clump, it has been suggested that this may correspond with asexual reproduction by broken tuberous root segments (Heidel 1998). However, it is not clear that this is anything more than a response to trampling rather than a vegetative reproduction adaptation.

ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

Management

Spiranthes diluvialis occurrences in Converse, Goshen and Laramie counties are located on state and federal lands (State Trust lands and BLM Casper Field Office-administered lands leased for cattle, horse and sheep grazing, and for haying). A moratorium has been lifted on the sale of state lands, and the draft Resource Management Plan for the Casper Field Office identifies sale of all or most BLM lands in three counties as the preferred alternative. There are also *S. diluvialis* occurrences in all three counties plus Niobrara County that are on private land, similarly used for cattle, horse and sheep grazing and for haying.

It is important to maintain current, compatible land uses on private and leased public lands and minimize or avoid impacts during flowering in order to ensure the continued survival of *Spiranthes diluvialis* in Wyoming: No evidence was seen of impacts during flowering. Continuation of grazing and mowing cycles in early spring, or else late in fall or winter (after fruit have ripened) will help ensure that the low cover conditions favored by *Spiranthes diluvialis* will be maintained. With the exception of West Nile virus, there are no known applications of herbicides and insecticides in occupied Ute ladies tresses habitat at present.

None of the Wyoming *Spiranthes diluvialis* occurrences are currently under formal designation or conservation easement. One of the occurrences (009) is on the same privately-owned tract as Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradoensis*) where a Habitat Conservation Plan is in place between the landowner and the U.S. Fish and Wildlife Service that addresses both species (Tyler Abbott personal communication 2006). Incentive programs may need to be developed to encourage private landowners and leaseholders to continue or modify compatible management techniques for the enhancement of Ute ladies tresses habitat. Financial compensation would help defray costs incurred by private individuals to manage this species and would ensure greater cooperation between landowners, federal agencies, and private conservation groups. Monetary awards could come from existing agricultural support programs (such as those administered by the Natural Resources Conservation Service), new funding sources (such as the proposed Conservation and Reinvestment Act), income or estate tax relief (through conservation easements), or compensation from private conservation organizations. Incentives could also come through county-wide or regional Habitat Conservation Plans or Safe Harbor agreements.

Education has been identified as important in fostering management of *Spiranthes diluvialis* on public lands. Towards this end, a poster of Threatened and Endangered plants has been printed that includes *S. diluvialis*, and an information fact sheet that addresses *S. diluvialis* will also be printed.

It is appropriate to provide copies of this *Spiranthes diluvialis* report to research and agency colleagues in Wyoming and counterparts in adjoining states, particularly in Nebraska. The *S. diluvialis* occurrences on the Niobrara River of Nebraska and Wyoming appear to represent the area with largest populations in the two-state area, and may call for coordination between states.

Existing and Potential Threats

Wyoming occurrences of *Spiranthes diluvialis* are not directly threatened under current management except as mowing or grazing sometimes occur during flowering. However, new threats have been identified. A summary of current land uses and threats for *S. diluvialis* in Wyoming are presented in Table 7. The salient new threat information is highlighted below, and the following pages present a complete list with expanded discussion of potential threats known to date.

1. One of the originally-known populations has an extremely large subdivision underway on adjoining property that has resulted in upslope road construction, will require new wells and

septic systems, is likely to foster spread of non-native species if not noxious weeds, and is also likely to compound the economic hardship effects of drought on local ranching.

2. One new population was located incidental to surveys for uranium mining development. It is possible but not known that there are uranium resources at this site and possibly at the three other Converse County sites in adjoining townships. This area is also experiencing increased development of coalbed methane resources.

3. Two of the four originally-known populations have *Euphorbia esula* (leafy spurge) present adjoining or within 0.1 miles of occupied habitat. Invasion of this species, or indiscrimate herbicide application to eradicate it, pose serious threats.

4. Discontinuation of current agricultural practices is a potential threat on both private and public lands. Two of the three large populations (with census numbers exceeding 400 plants) are entirely on private land. Their persistence hinges on the deliberate stewardship, good graces and circumstances of private landowners. Public lands represent only about 20% of total numbers, and these may also be susceptible to curtailment of current agricultural practices. The moratorium is lifted on sale of state lands. Sale or exchange of BLM lands where *S. diluvialis* occurs is proposed as the preferred alternative of the draft BLM Casper Field Office resource management plan.

Table 7. *Spiranthes diluvialis* site ownership and potential threats in Wyoming

Occurrence	**Ownership**	**Drainage**	**Immediate Threat**	**Long-term Threat**
001	State, Pvt	Horse		Discont of current Ag practices, State sales?
002	BLM, Pvt	Antelope		Discont of current Ag practices , Leafy spurge, CBM runoff? BLM sales?
003	Pvt	Niobrara		Discont of current Ag practices
004	Pvt	Horse	Hydrological alteration from adjoining subdivision, leafy spurge	Discont of current Ag practices
005	State	Horse		Discont of current Ag practices
006	BLM	Antelope		Discont of current Ag practices , CBM runoff? BLM sales?
007	BLM	Antelope		Discont of current Ag practices, CBM runoff? BLM sales?
008	Pvt, State	Antelope	Uranium mining?	Discont of current Ag practices, CBM runoff? State sales?
009	Pvt	Horse	Undetermined	Undetermined

The following text draws from the information presented by Fertig (2000), elaborating on the points above drawing from 2005-06 surveys. It generally follows the discussion of threats presented in the most recent rangewide status review (Fertig et al. 2005).

Subdivision is an immediate threat at one major *Spiranthes diluvialis* occurrence in Wyoming (004). Despite the remoteness of this and all other Wyoming occurrences, and the unlikelihood of high-density urbanization, a large ranch of about 17 sections is being subdivided into about 150 lots directly adjoining the occurrence. This development could impact the spring-fed hydrology of *S. diluvialis* habitat due to new roads (completed) as they accelerate erosion or increase runoff, or to the future development of wells and septic systems (pending). Such developments may also indirectly affect the habitat, e.g., fostering the spread of competitive exotic species; or impacting the landowner.

Outside of Wyoming, occurrences of *Spiranthes diluvialis* in Colorado and Utah have been extirpated due to habitat loss stemming from urban sprawl in the Colorado Front Range and Wasatch Front (Arft 1995a; US Fish and Wildlife Service 1995). Remaining populations in these areas are all small and highly vulnerable to continued habitat loss or degradation that could result from increased recreational use or the spread of competing weeds (US Fish and Wildlife Service 1995).

A moratorium has been lifted on the sale of state lands in Wyoming, and the draft Resource Management Plan for the Casper Field Office identifies sale of all or most BLM lands in three counties (including Converse County) as the preferred alternative. Sales of public or private lands transfer property rights and such transactions are often accompanied by development and land use conversions.

Road construction is not a direct threat for *Spiranthes diluvialis* in Wyoming, but three occurrences lie downstream within 0.2 miles of a developed drainage road crossing (with fill). Only one road crossing is a public county road and the rest are private roads, including impoundments used as crossings.

Oil, gas, mineral exploration and mining have not been identified as potential threats to *Spiranthes diluvialis* in Wyoming in the past. However, the Antelope Creek area is on the edge of the Powder River Basin, where there are major deposits of coal, oil, gas and coalbed methane. Coalbed methane exploration is occurring in the Antelope Creek watershed. Exploration for uranium mining was conducted in 2006 in part of the area, there has been active uranium mining to the south, and there is a resurgence of uranium permitting activity. Contemporary uranium mining does not remove overburden, but involves injecting solutions that bind and are treated at the surface, producing wastewater. These developments may signify limited disturbance to valley floodplain surfaces, but potentially affect the hydrology and water quality of species' habitat. To a lesser exten, they may also involve construction of new roads or other infrastructure that have influence.

Exotics are a relatively small component of the flora of *Spiranthes diluvialis* habitats in Wyoming based on the number of species (Table 1), but can be locally dominant or abundant. Redtop (*Agrostis stolonifera*) is a non-native species in a class by itself in terms of abundance.

White sweetclover (*Melilotus albus*) is sometimes common but does not have the same robust stature as when it grows in disturbed settings. There are at least six Wyoming noxious weeds that are present at or beside *S. diluvialis* occurrences (Table 8). The most ubiquitious is Canada thistle (*Cirsium arvense*). At least one of the occurrences has both herbicide treatment and goats introduced for treatment. There may be but are not known to be other treatments in place designed to eradicate or contain noxious weeds at the *S. diluvialis* occurrences.

Table 8. Noxious weeds present at *Spiranthes diluvialis* in Wyoming

Noxious Weed	**Occurrence**	**Distribution Comments**
Cirsium arvense	001, 002, 003, 004, 006, 007, 008	Widespread, but rarely forming solid swards in or adjoining occupied habitat
Cirsium vulgare	001	Occasional and mostly above the occupied habitat
Cynoglossum vulgare	001	Uncommon and mostly above the occupied habitat
Elaeagnus angustifolia	004, 007	Rare and barely in occupied habitat
Euphorbia esula	002, 004, 006	(002) Controlled at nearby roadside; (004) Present downstream from but very close to occupied habitat
Linaria vulgaris	001, 005	Present in very low numbers in the vicinity, reportedly carried in on water

In Idaho, introduced plant species may contribute 33-109% of the cumulative vegetative cover in some *Spiranthes diluvialis* occurrences (Moseley 1998b). Many of these weeds, such as *Cirsium arvense, Centaurea maculosa,* and *Elaeagnus angustifolia* can be aggressive and ultimately displace native species. Less well-known are the impacts of introduced sod-forming grasses such as *Agrostis stolonifera* and *Poa pratensis* on the structure and species composition of floodplain plant communities (Moseley 1998b).

Spiranthes diluvialis may be susceptible to broadleaf herbicides applied in hay meadows. Both noxious weed encroachment and pesticide control of noxious weeds pose potential threats. In addition, the plant's pollinators may be vulnerable to insecticides used in control of grasshoppers and other pests on range lands (Sipes and Tepedino 1994). At the time of surveying one occurrence (004), aerial pesticide was being sprayed for control of mosquitoes that spread West Nile virus. As previously mentioned, insecticides can lead to mortality of the bumblebee pollinators of Ute ladies tresses and reduced seed production. Other management actions, such as flooding, fire, or mowing, could have potentially negative impacts on pollinators (Sipes and Tepedino 1994). Management plans for *S. diluvialis* should take into account the habitat needs of its pollinators, including adequate availability of other flowering plants for food and sites for nest establishment (Sipes and Tepedino 1994). Information is not available on the identity and life history of these pollinators in Wyoming.

Recreational uses of *Spiranthes diluvialis* sites are generally low. One of the new *S. diluvialis* sites in Converse County is popularly used as a hunting camp, but the wet meadow

habitat has not been affected. The Niobrara County site has a reservoir that had once been open to public access, but has since been closed. In general, present land ownership patterns and the remoteness of the Wyoming sites mean that recreational uses are negligible threats at present. Outside of Wyoming, high recreational use (fishing access, camping, and hiking) have been noted at sites in Idaho and Colorado.

Mowing for hay production occurs annually at one *Spiranthes diluvialis* occurrences in Wyoming regardless of drought, where the species is restricted to a semi-native zone of mown vegetation bordering the creek, below an upland zone planted into alfalfa (005). The mowing apparently occurs by the middle of summer, well before *S. diluvialis* bolts. The largest occurrence has large hay meadows of non-native grasses above occupied wet meadow habitat and portions of occupied habitat are also mown less frequently (003). Previous surveys were conducted in years of extensive mowing, and the biggest new colony was found in an area that was mown, as determined from photographs taken in the original surveys. Two more occurrences are part of winter pasture that is sometimes mown (001, 004). Only 005 and the northern portion of 004 were mown under the prolonged drought of 2006.

Mowing is considered to have the potential for both beneficial and adverse affects on *Spiranthes diluvialis*, as reported at the largest known occurrence on the Great Plains, a mowed site on the Niobrara River in Nebraska (Hazlett 1996, 1997). Mowing can be beneficial to populations by reducing competing vegetation cover, but can be detrimental if done before fruit have ripened, or if the height of cutting is too low (Arft 1995a; Hazlett 1996, 1997). Late season mowing (after fruit have ripened) may be one of the best management tools available for maintaining the habitat of this species.

Grazing is the primary land use at six of the eight surveyed *Spiranthes diluvialis* occurrences, and is likely to have been ongoing since the homesteading era. Grazing occurs only during winter and early spring months at present for at least three of the six sites (002, 004, 007), and possibly others. This timing reduces the level of livestock use in the riparian corridor, and means that the ground is less likely to be trampled if it is frozen most or all of the time. This timing in turn may also have limited benefit in reducing the cover of competing vegetation. One site currently grazed by sheep in the winter had particularly dense wet meadow vegetation with thatch accumulation (007). It had a particularly high component of Baltic rush (*Juncus balticus*), a composition that may itself reflect the grazing history.

Grazing has been shown to be beneficial to *Spiranthes diluvialis* under select conditions in reducing the cover of competing vegetation, especially when it is done in the early summer before *S. diluvialis* produces flowers or fruits (Arft 1995a,b; Heidel 1998, Moseley 1998b). Grazing may mimic the effects of flooding, fire, or other disturbances in maintaining low vegetative cover or reducing weed cover (Moseley 1998b). Atypically high levels of summer grazing and drought in 1994 resulted in few flowering plants of *Spiranthes diluvialis* being observed at the first place where it was discovered (B.E. Nelson, pers. comm.), although the population and range condition has since recovered under more moderate grazing use.Some effects of grazing are still poorly known, particularly the relationship between grazing intensity and the establishment of *Agrostis stolonifera* (a dominant introduced species at many Wyoming sites as well as in Idaho and Montana sites) and the impacts of grazing and trampling on the life

history of insect pollinators (Arft 1995a; Moseley 1998b). Overall, the impacts of grazing on *S. diluvialis* in Wyoming appears to have been low.

A comparison of the influences of horse, cattle and sheep grazing on *Spiranthes diluvialis* and its habitat is not possible in light of different management regimes and site differences. One site (002) was grazed by sheep up until the 1980's, and is currently used as winter pasture for cattle. It is likely from talking with local ranchers that all four of the Converse County sites were grazed by sheep at one time, even though only one is at present (007). In addition, goats graze in the same pasture of at least one occurrence (002), presumably brought in to control leafy spurge.

None of the *Spiranthes diluvialis* sites in Wyoming are in irrigated landscapes. Ditches and canals are relatively uncommon in the valleybottom areas of potential habitat. The three different drainages fall within three different watershed planning frameworks including the North Platte River Basin, the Upper Niobrara River Basin, and the Cheyenne River Basin; the latter has no compacts or decrees. One site of potential habitat was ditched, but the species' absence cannot be linked with certainty to the influence of ditches (Figure 17). Parts or all of two occurrences lie below impoundments that are used mainly to provide water for livestock. The construction of these impoundments may have flooded *S. diluvialis* habitat upstream, and it is possible that they curtail periodic flooding in occupied habitat downstream. The use of impoundments as private road crossings has limited management implication unless such crossings were made public or expanded. There are a few places in the Horse Creek watershed where central pivot irrigation is being installed in the uplands. It is possible but not known that central pivot irrigation in the uplands can reduce groundwater flows in nearby valleys occupied by *S. diluvialis.*

It was previously reported that flood control is not a concern in Wyoming because the populations are on small, mostly unregulated streams (Fertig 2000). However, the larger streams in the Horse Creek watershed have headwaters in the Laramie Range and they do flood, as seen when a July 2006 storm cell rained heavily at the head of a drainage where there are two downstream occurrences of *Spiranthes diluvialis* (001, 005; lease holder personal communication). The banks were breached at the upstream occurrence possibly inundating *S. diluvialis*, but not at the downstream occurrence about 10 km away. While it seems more likely that there would be pressure to impound these streams for livestock than for flood control, water developments of any sort may contribute to vegetation shifts if not interruption of natural processes, and may have particularly serious influence under drought conditions. The presence of coarse alluvial deposits immediately below the loamy soils of occupied habitat, as shallow as 10 cm in one case (008), indicates that flooding and meandering channels are part of the natural disturbance regimes.

Outside of Wyoming, *Spiranthes diluvialis* occurrences on large rivers in Colorado, Idaho and Utah where impoundments have both negative and positive affects on flooding regimes depending on placement and pre-existing conditions (summarized in Fertig et al. 2005). Without a periodic source of disturbance by meandering channels and deposition on these major river systems, the sparsely vegetated *S. diluvialis* habitat may become replaced by dense shrub stands.

Pollution has not been documented at *Spiranthes diluvialis* sites in Wyoming. The only potential sources are nonpoint pollution associated with livestock operations, but known sites have no concentrations of use associated with streamside feed yards or corrals.

Displacement by succession has not been reported before at *Spiranthes diluvialis* sites in Wyoming, but areas of relatively dense vegetation cover or litter accumulation tended to have low numbers or absence of the species. Tall shrubs (Booth's willow; *Salix boothii*) are present in occupied habitat at only one site (001) but do not appear to be encroaching. Robust graminoides are present in almost all sites, but rarely overlap with *S. diluvialis* except in occasional spots (e.g., *Carex utriculata*; beaked sedge – in a different pasture at 001). Haying was curtailed in almost all *S. diluvialis* habitat in 2006 (except for 005) because of the severe drought and stunted forage production as a result. There are no signs or reports of fires in its habitat, so flooding and grazing are presumed to be the primary natural disturbances.

Spiranthes diluvialis is palatable to livestock and to wildlife. Grazing on flowering and fruiting inflorescences of *S. diluvialis* has been observed at sites that are grazed by cattle in late summer (Arft 1995a). Grazing on flowering or fruiting inflorescences of *S. diluvialis* was previously noted in the original four Wyoming sites for at least one or more plant(s) in the population (Fertig 2001). Repeated visits to one population in a winter pasture implicated wildlife herbivory in reducing numbers over the flowering period (Figure 17), and whitetail deer have been observed eating plants of *S. diluvialis* by one landowner (004).

Figure 17. Herbivory on flowering stem and leaf of *Spiranthes diluvialis*, Photo by Sarah Bucklin-Comiskey (002)

Arft (1995a) found that herbivory by voles (*Microtus* spp.) was a significant source of *Spiranthes diluvialis* inflorescence destruction at a grazed and mowed site near Boulder, Colorado. Reduction of cover or an increase in meso-predators (foxes, skunks, weasels) could help control vole numbers and thus increase *S. diluvialis* fruit production. Similar impacts from voles have not been reported at other sites. Most sites have gopher burrows above the wet meadow zone. There are few if any burrows in occupied habitat, and no evidence to suggest that there is underground herbivory.

Drought is not usually considered to be a threat to the viability of native species, but the accompanying vegetation conditions may make it a deterrent, particularly under prolonged drought that forces a cutback in agricultural operations. High vegetation cover resulting from idle conditions (Parcel 2 of 001) or under winter grazing by sheep (007) both limit light and water, and potential signify competition for *Spiranthes diluvialis.*

Collecting impacts have not been reported for *Spiranthes diluvialis* in Wyoming. Many orchid species worldwide are vulnerable to over-harvest by collectors.

There are no known conflicting or complementary management issues with other rare species identified at *Spiranthes diluvialis* occurrences with one exception. It is at the same site as Colorado butterfly plant (*Gaura neomexicana* ssp. *coloradensis*), an overlap discovered by Tyler Abbott (personal communication 2006) for the first time in the entire distributions of the two species. In general, both of these Threatened plant taxa occupy wet meadows, both flower late in the growing season, and both are poor competitors, so management objectives are likely to be complementary. *Spiranthes diluvialis* appears to be a long-lived perennial, and is usually in short vegetation, while *G. n*. ssp. *coloradensis* is a biennial and can be in either short or tall wet meadow vegetation.

Spiranthes diluvialis is not known to overlap with Preble's meadow jumping mouse (Wyoming Natural Diversity Database 2007), although Preble's meadow jumping mouse has been surveyed in only scattered riparian areas throughout eastern Wyoming. Among animals that have been considered for Threatened or Endangered status, *S. diluvialis* is present in the Antelope Creek area in the vicinity of greater sage grouse and mountain plover. It is present in the Niobrara River in the vicinity of swift fox. It is present in the Horse Creek area in the vicinity of mountain plover, swift fox, and a historic wolverine record that had vague description of location. None of these species are listed as Threatened or Endangered. In addition, northern leopard frogs were noted and have previously been documented in the latter two areas, and pearl dace are known from the Niobrara River area. There is no federal or state management plan in place for these animal species affecting these areas.

Survey Guidelines

The current study lends credence to the hypothesis that *Spiranthes diluvialis* is intrinsically rare in Wyoming rather than made rare by habitat loss or degradation. While riparian corridors are largely intact over large areas, the *S. diluvialis* occurrences are few. Intrinsic rarity of *S. diluvialis* can be due to high habitat specificity or constraints on species biology, e.g., associated with dispersal, and associated elements of chance. High habitat specificity has been proposed (e.g., Hartman and Nelson 1995). Accordingly, it is worthwhile to continue surveys for *Spiranthes diluvialis* and promote species' research as a Threatened species, as long as there are appropriate survey guidelines.

The original Section 7 consultation guidelines developed for *Spiranthes diluvialis* by the U.S. Fish and Wildlife Service used watershed criteria (U.S. Fish and Wildlife Service 1995). In Wyoming, it is present in portions of the Horse Creek (North Platte River tributary), Antelope Creek (Cheyenne River tributary) and Niobrara River watersheds. Later discoveries of *S. diluvialis* in neighboring states included watersheds that have their headwaters in Wyoming, including the Green River and Snake River. It was also discovered at the headwaters of the Missouri River, and there are other Missouri River tributaries originating in Wyoming (including the Big Horn and Powder River watersheds). For want of more information, the scope of current Section 7 guidelines for *S. diluvialis* addresses 22 of 23 counties in Wyoming, generally below 7000 feet in elevation (excluding Teton County, where there have been extensive *S. diluvialis* surveys).

In Wyoming, many drainage patterns have ancient origins that pre-date periods of burial and exhumation and which differ dramatically from current topography (Lageson and Spearing 1988). This adds to the challenges of applying watershed criteria to species' survey guidelines in Wyoming. It is possible but not proven that the geological features of *Spiranthes diluvialis* sites in these Great Plains landscapes correspond with buried foothills, with foothills hydrological conditions, with groundwater-bearing faults, or with other groundwater conditions that dictate over *S. diluvialis* habitat.

An elevation threshold has also been used in combination with watershed criteria in most states to demarcate the potential distribution of *Spiranthes diluvialis*, which is generally found at lower elevations, from that of *S. romanzoffiana* (higher elevation). While the two species differ in their elevation range over most of Wyoming, the distribution of *S. romanzoffiana* in the Black Hills of Wyoming reaches a lower elevation than that of *S. diluvialis*, as low as 4500 ft (*Evert 4449 RM*). The upper elevation reaches of *S. diluvialis* in Utah reach 7000 ft (2130 m); greatly exceeding the 4650-5420 ft (1420-1650 m) range as currently known in Wyoming.

Instead, there is a composite set of remote sensing characteristics that can be used to identify potential habitat including the GIS themes used in the detailed potential distribution model (Fertig and Thurston 2003) with its interesting combination of both subterranean features (bedrock) and surface features (alluvium). A buffered GIS layer is recommended for use in the six-county area, and with surveys required for projects in the potential habitat polygons or within a 1-mile buffer if there are also surface features evident on aerial photos. The diagnostic features to seek in photointerpretation include surface water in the riparian corridor (sometimes not visible for small channels on aerial photos), late-season photosynthetic activity (intense red color), and deposition patterns that indicate alluvial processes (meanders, bands of deposits, oxbows; Figure 18).

There are also a composite set of field characteristics that can be used to identify potential habitat in field surveys including emergent vegetation, presence of *Chara* spp. or other submerged calciphiles, and native, low-stature wet meadow habitat (Figure 19). In addition, soils data suggest that soils with a significant clay content or with a significant sodium absorption value are generally unsuitable (sample sizes need to be expanded to propose thresholds).

The use of both remote sensing and field survey approaches has merit at different stages of review. This tiered review, while more complicated than existing standards, might serve to greatly-reduce the number of sites for intensive survey during flowering, and might ultimately reshape the survey standards.

The four state tracts for which we did not have private access permission would ideally be surveyed for *Spiranthese diluvialis* if access permission is granted in the future. Even considering the number of state and private tracts that were excluded from survey, their number and extent is limited.

Figure 18. Color infrared aerial photograph (digital ortho) of suitable but unoccupied habitat (corresponds with Figure 19). Note prominent subirrigated wet meadow zones, active river meanders, and surface water at the end of the growing season. Length of the photo equals approximately one mile.

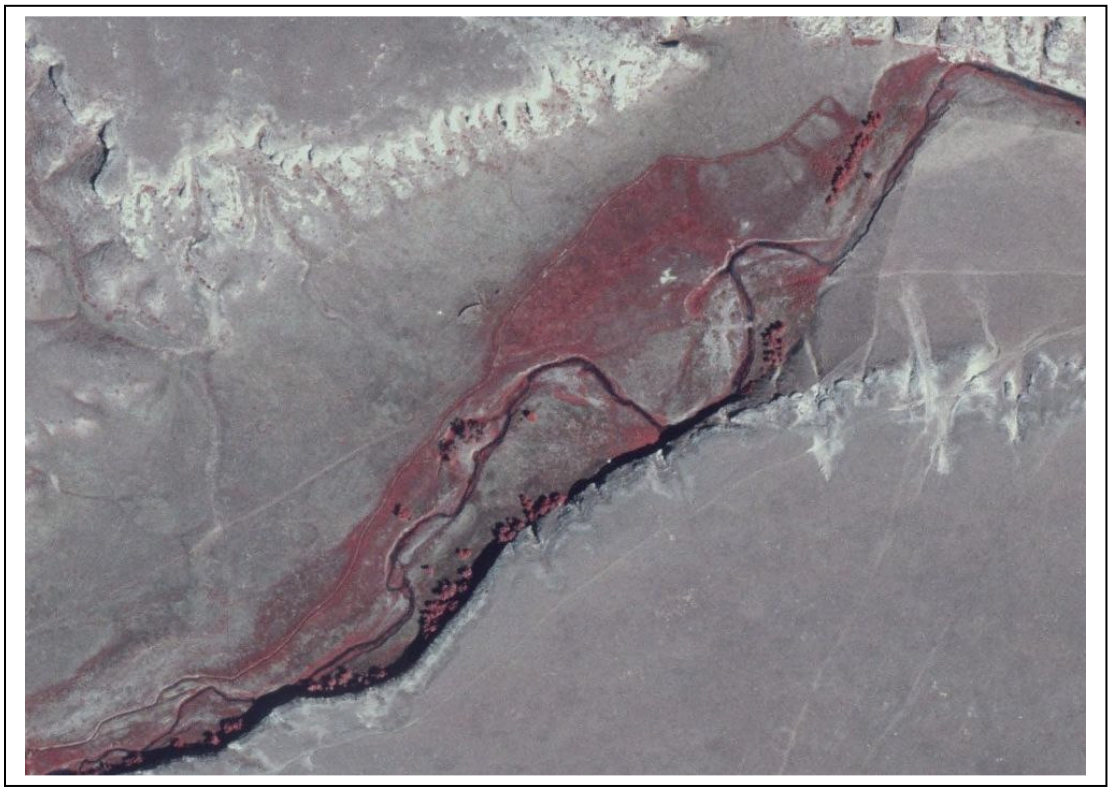


Figure 19. Suitable but unoccupied habitat. Note perennial stream and emergent vegetation (*Schoenoplectus tabermontanei*). Submerged vegetation is *Potamogeton diversifolius*; but *Chara* spp. is present in vicinity. (corresponds with Figure 18, above). Photo by B. Heidel

However, fieldwork documented that the subirrigated conditions were associated with a ditch, non-native grasses dominated most of the wet meadows, and *S. diluvialis* could not be found in the most-intact of streamside meadows.

It would be constructive to revisit the smallest known population of *Spiranthese diluvialis* in Wyoming, where no plants could be found in 2006. This may be used to add caveats to the current guidelines that potential habitat should be surveyed in at least two years to address whether the species is present. It is hypothesized that Wyoming sites, separate as they are from major perennial rivers, are more analogous to Colorado and Montana meadow populations than those on major perennial rivers, and are not subject to seasonal dormancy of the entire population except in cases of especially small populations under prolonged drought conditions.

Concluding Statements

Concerted surveys in the vicinity of known *Spiranthese diluvialis* occurrences might have produced much the same results as remote sensing (potential distribution model with photointerpretation) produced in 2005-06 surveys. However, the remote sensing methods greatly increased efficiency, contributed to habitat documentation, and is pertinent in addressing the rest of the six-county area apart from known occurrences. The remote sensing methods used in this *Spiranthese diluvialis* survey, including photointerpretation and potential distribution models (Fertig and Thurston 2003), has the advantage of providing a framework for screening and prioritizing proposed project areas for field survey in the six-county study area.

It would be constructive to test the applicability of this survey for *Spiranthese diluvialis* to the rest of the counties in the state. There is no basis for direct extrapolation from the potential distribution model of Fertig and Thurston (2003) because it is based on the environmental commonalities in the four-county area. If surveys were pursued in other areas of the state, they might be approached as pilot survey trials, using the photointerpretation criteria and on-site characteristics identified in this study, as well as information compiled from the rest of species' distribution (Fertig et al. 2005).

Meanwhile, *Spiranthes diluvialis* occurrence data has been placed in a category that falls under the Wyoming Natural Diversity sensitive data policy. Under the sensitive data policy, WYNDD does not convey location information of this species at any finer precision than the township. This same convention is applied to public lands as well in order to protect both the species and the interests of private landowners, because there are no open-access public lands where the species can readily be found for viewing and where the occurrence is limited to public land and with fences for demarcating private from public land.

The information provided in this report represents an update to the Wyoming status of *Spiranthese diluvialis*. The information produced in this study has applicability in refining survey guidelines. We do not have the benefit of a U.S. Fish and Wildlife Service decision on the *Spiranthese diluvialis* de-listing petition that will provide overarching context for this study. Whatever the outcome, this study underscores the characterization of *S. diluvialis* as a habitat specialist of limited distribution in Wyoming, though with up to 10% of all the occurrences of the species across its distribution. Moreover, it provides a tiered method for identifying potential habitat and ruling it out, using remote sensing and field survey standards.

ACKNOWLEDGEMENTS

This study builds on the *Spiranthes diluvialis* status survey information for Wyoming prepared by Walter Fertig (Wyoming Natural Diversity Database; WYNDD), earlier foundation-laying reports on *S. diluvialis* for Wyoming (Hartman and Nelson 1994a, Hazelett 1996, 1997) and later rangewide information also compiled by Walter Fertig. Soil tests were coordinated by Ramona Belden (UW Soils Testing Laboratory). Terri Hildebrand, previously contracted by the Nebraska Game and Parks Commission, provided a copy of her Nebraska report on *S. diluvialis* survey that includes soils data from two Wyoming sites. Lucy Jordan (FWS) facilitated information exchange between botanists surveying the species. Jeff Carroll (BLM) reviewed a draft of this report and coordinated the 2006 field workshop. The following individuals have kindly shared *S. diluvialis* survey results in Wyoming: Tyler Abbott (FWS), Jeff Carroll (BLM), Charmaine Delmatier, Jim Glennon (BLM), Ron Hartman (Rocky Mountain Herbarium), Don Hazlett, Terri Hildebrand, George Jones (WYNDD), B. Ernie Nelson (RM), Jim Orpet (Intermountain Resources), Brenda Schladweiler (BKS Environmental Associates, Inc.), B. Steinauer (Nebraska Game and Parks Commission), and Paige Wolken. Sarah Bucklin-Comiskey and Charlie Fifield (BLM) surveyed and collected from a new occurrence of *S. diluvialis* on a BLM tract with public access, and Sarah provided phenology insights from repeat visits to another of the BLM occurrences. Many, many more biologists have provided negative survey data as record of searches where it was not found. Additional soil samples from sites where *S. diluvialis* does not occur were provided by Thunder Basin National Grassland. The database and map representing surveys where *S. diluvialis* was sought but not found was prepared by Joy Handley (WYNDD). The discussions and interest of participants at workshops in 2005 and 2006 are gratefully acknowledged. Thanks are extended to Ronald Hartman and B.E. Nelson and for use of the Rocky Mountain Herbarium facilities. James Whalen (Office of State Lands and Investments) provided the information needed to contact state lease holders. Special thanks are extended to all leaseholders and landowners. This project was made possible by two challenge cost-share agreements coordinated by Frank Blomquist (BLM) and John Proctor (U.S. Forest Service) and their respective offices, in cooperation with WYNDD.

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