United States
Department of
Agriculture

Forest Service

Rocky
Mountain
Region

Black Hills
National
Forest

Custer,
South Dakota

April 2003

Conservation Assessment for the Autumn Willow in the Black Hills National Forest, South Dakota and Wyoming

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Species Assessment
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EXECUTIVE SUMMARY

Autumn willow, *Salix serissima* (Bailey) Fern., is an obligate wetland shrub that occurs in fens and bogs in the northeastern United States and eastern Canada. Disjunct populations of autumn willow occur in the Black Hills of South Dakota. Only two populations occur on Black Hills National Forest lands: a large population at McIntosh Fen and a small population on Middle Boxelder Creek. Both populations occur in association with specific geologic and hydrologic conditions that have resulted in an elevated water table, fen-like habitats and saturated organic substrates. These habitats are extremely rare in the Black Hills. Monitoring data indicate the McIntosh Fen population is stable to increasing, perhaps in response to recent restoration efforts and several years of high precipitation. These results are encouraging, but whether restoration of autumn willow habitat is possible at the newly discovered site on Middle Boxelder Creek remains to be seen. The persistence of autumn willow in the Black Hills is dependent on conserving these two populations on public land, which makes the species highly vulnerable to catastrophes such as severe declines in the water table, spread of diseases or invasions by noxious weeds and other invasive species.

Key words: autumn willow, beaver ecology, Black Hills, fen, *Salix serissima*, wetland restoration

ACKNOWLEDGMENTS

Many individuals have contributed to our understanding of autumn willow's distribution in the Black Hills. Dr. Eric Grimm of the Illinois State Museum, Dr. Gary Larson of South Dakota State University, and Dave Ode of the South Dakota Natural Heritage Program provided invaluable insights and expertise in their reviews of the manuscript. Katherine Zacharkevics, Dr. Reed Crook, Darcie Bacon, and Susan Corey of the Black Hills National Forest conducted field surveys and collected a large part of the data used in this assessment. Rudy King, Rocky Mountain Research Station, provided insights and suggestions on the design of the monitoring plan. Ken Marchand and Lorrie Martinez, Black Hills National Forest, produced the Black Hills distribution map and Noah Barstatis, Rocky Mountain Research Station, produced the North American distribution map. In addition, numerous biologists and ecologists from The Nature Conservancy and South Dakota Natural Heritage Program, and Black Hills National Forest district biologists and range conservationists provided invaluable data and field surveys.

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INTRODUCTION

Autumn willow, *Salix serissima* (Bailey) Fern., is an obligate wetland shrub that occurs in the northeastern United States and Canada from Newfoundland to British Columbia and south to New Jersey, Illinois, and Colorado (Gleason and Cronquist 1991; USDA NRCS 2001; NatureServe 2001) (fig. 1). Across the species' range, its conservation status varies from secure in northern boreal regions, to critically imperiled due to extreme rarity in southerly disjunct populations (NatureServe 2001). Rare occurrences in the northern Great Plains, Black Hills, and Rocky Mountains may be relicts from the last Pleistocene glaciation 11,000 years ago (Froiland 1962; Price and others 1996) or the species may have immigrated within the past 4,000 years due to cooler, wetter conditions in the region (Grimm 2000).

In the Black Hills National Forest, a large population of autumn willow occurs at McIntosh Fen, a rare, calcareous fen meadow complex in Pennington County, and a much smaller population occurs on Middle Boxelder Creek in Lawrence County (fig. 3).

The objectives of this assessment are to review information on the occurrence and distribution of autumn willow in the Black Hills National Forest and to synthesize information relevant to the management, monitoring and long-term persistence of the species. Published literature on autumn willow and its habitats is sparse. For the most part, we relied on information from other areas to develop this assessment. Species nomenclature follows the USDA NRCS Plants Database (2001).

CURRENT CONSERVATION SITUATION

The global conservation status of autumn willow is G4 (apparently secure) (NatureServe 2001). It is nationally unranked (N?) in the United States and Canada and is not under federal protection by the U.S. Fish and Wildlife Service (NatureServe 2001; Dorn 1970). Autumn willow is currently on the USDA Forest Service Region 2 Sensitive Species List.

Throughout its range, autumn willow is strongly associated with fens, bogs, and permanently marshy habitats, frequently with a minerotrophic quality (high mineral content and alkaline pH) (Voss 1985; Lesica 1986; Cooper 1996). Autumn willow is rare in the northern Great Plains because wetlands that meet its habitat requirements are rare. Accordingly, autumn willow is critically imperiled due to extreme rarity (S1) or imperiled due to rarity (S2) at the western limits of its range in South Dakota, Montana, Wyoming, and Colorado, while populations that occur in the Great Lakes states and Canadian provinces are generally more secure (Fertig 1994; NatureServe 2001) (table 1).

Two populations of autumn willow are currently known to occur in the Black Hills National Forest: one estimated at 453 plants in 2001 at McIntosh Fen Botanical Area; and a small population estimated at 13 plants in 2002 ca. 12 mi (19.3 km) north of McIntosh Fen on Middle Boxelder Creek. The fen and its surrounding uplands were designated as a botanical area in 1997 (USDA Forest Service 1996). Under this direction, the botanical area is to be managed in such a way that the fen and associated botanical features for which it was established are not impaired. There are two verified populations of autumn willow on private lands in Lawrence County, South Dakota (McIntosh 1930; Fertig 1994). There is also an unverified report from

Custer County (Great Plains Flora Association and others 1977). Populations on private lands cannot be conserved or managed by Black Hills National Forest and are therefore beyond the scope of this assessment.

REVIEW OF TECHNICAL KNOWLEDGE

Species Taxonomy

Autumn willow is classified as Class Magnoliopsida (Eudicots), Subclass Dilleniidae, Order Salicales, Family Salicaceae (Willow Family), Genus *Salix*, Subgenus *Salix*, Section *Salicaster* Dumort. (Dorn 1992; Argus 1999). *Salix serissima* has been frequently classified as a variety of *S. lucida* Muhl. and was included in the *S. lucida* complex prior to its recognition as a distinct species in 1904 [(L. H. Bailey) Fernald, M. L. Rhodora, Vol. 6 (61). 1904]. Alternative taxonomic treatments include: *Salix lucida* Muhl. var. *serissima* Bailey; *Salix arguta* Andersson var. *alpigena* Anderss.; *Salix arguta* Anderss. var. *pallescens* Anderss.; and an undetermined variety of *Salix lucida* Muhl. (Fernald 1904).

The Plants of the Black Hills and Bear Lodge Mountains (Larson and Johnson 1999) lists 11 species of willow native to the Black Hills, a twelfth species is given by Van Bruggen (1996). White willow, *Salix alba* var. *vitellina*, has become naturalized in the Black Hills (Larson and Johnson 1999).

Species Description

Autumn willow is a perennial, deciduous shrub 3 to 13 ft (1 to 4 m) tall, with bark ranging from olive to gray on the older branches, yellowish on younger branches and shiny red-brown on the youngest twigs. Distinguishing characteristics include: glandular petioles at the base of finely toothed, taper-tipped leaves; smooth, distinct capsules; and the species' unique flowering period from June to September, while other *Salix* species usually flower in spring or early summer (Britton and Brown 1970; Dorn 1970, 1992; Fertig 1994; Spackman and others 1997) (fig. 9) (see Appendix A for a more detailed species description).

Shining willow, *Salix lucida*, is a closely related, more widely distributed species (Voss 1985) that is distinguishable from autumn willow by its long-tapered leaf tips, and the length of the capsules, which are about ¼ to less than ½ in (7 to 10 mm) long in autumn willow and 1/8 to ¼ in (4 to 6.5 mm) in shining willow (Great Plains Flora Association 1986). *Salix lucida* ssp. *caudata* is similar to autumn willow in its shining, long acuminate leaves and glandular petioles, but has capsules ¼ in (7 mm) long and flowers earlier in the season (Spackman and others 1997; Colorado Natural Heritage Program 1999). However, confusion is unlikely since *S. lucida* is more rare than autumn willow in the Black Hills.

Species Significance

Some ecologists consider fens "glacial relicts" that have become reduced and isolated during the drying trend since the last Pleistocene glaciation 11,000 years ago (Steinauer 1992). However, there is evidence that some inhabitants considered to be "glacial relicts" in fens south of the main distributions might have immigrated to these fens in the late Holocene (Grimm 2000). In either case, fens are rare, restricted habitats in this region and commonly support unusual species for this reason. In the Black Hills, autumn willow may be an indicator of rich fen habitats, where it

occurs as part of a shrub carr, or wetland shrub, plant community (Lesica 1986). Shrub carr species like autumn willow provide habitat for wetland wildlife and create microtopographic variation that supports other rare plant species dependent on permanently saturated habitats (Marriott 1993; USDA Forest Service 1996; South Dakota Natural Heritage Program no date). It is possible there are species, such as butterflies or other invertebrates, mosses or other non-vascular species, that are restricted to McIntosh Fen and are directly or indirectly dependent upon the plant community found there (Price and others 1996). Insect pollinators and animal herbivores utilize autumn willow as well.

In addition to their use as raw materials, *Salix* species have been used by Native Americans to treat gastrointestinal ailments, as a contraceptive, as an anti-hemmorhagic, and as a cold remedy (Moerman 1998). The bark of shining willow was historically used as a hemostatic for sores and bleeding cuts, a respiratory aid for asthma, and a smoking tobacco (Moerman 1998). No traditional uses of *Salix* were found for the Lakota peoples in the Black Hills region, although *Salix* is reportedly used for the medicinal purposes described above, and for basketry and ceremonial purposes by other regional native peoples including the Blackfoot, Cree, Dakota and Omaha (Moerman 1998). There is no record of the use of autumn willow as an ornamental species or for other commercial purposes.

Life History

Autumn willow produces small flowers that lack petals and sepals and are arranged in catkins. All willow species are dioecious, where the male and female flowers are borne on separate plants. The male flowers each have three to seven stamens and the female flowers consist of a single pistil with two stigmas (Gleason and Cronquist 1991). Autumn willow's flowering time from June to September is considerably later than other willow species in its range. This characteristic may serve the species by reducing competition for pollinators and thereby increasing fertilization and seed production, and/or by reproductively isolating it from hybridization with other willow species. Hybridization is common in *Salix*, but we found no documentation of hybridization in autumn willow. The species' dioecious nature prevents self-fertilization, and there is no reference to apomictic seed production (seed set without fertilization) in the literature.

Although *Salix* catkins are positioned for wind-pollination, willows are believed to possess "secondarily reacquired entomophily", where an insect-pollinated species evolved to favor wind pollination and then re-adapted to insect pollination (Sacchi and Price 1988). This is evidenced by the pollinator-attracting nectaries and aerodynamic pollen grains that willow flowers produce (Argus 1974). The pollen transfer mechanism is believed to be transitional between wind and insect pollination in *Salix* species, although wind pollination is inefficient for fertilization and seed production (Sacchi and Price 1988). Pollination syndromes need to be examined on a species-specific basis (Proctor 1978), and no such examination has been performed for autumn willow. However, the species' late summer flowering period reduces the likelihood of wind-pollination due to full leaf cover that limits air movement at that time.

Autumn willow's isolated pattern of distribution may indicate that insects are vital for pollen delivery, but it has been suggested that willows favor insect pollination early in their flowering period when their pollen is sticky, and wind pollination occurs after the pollen has dried (Proctor and others 1996; Hesse 1979 in Proctor and others 1996). However, in a northern Arizona riparian species, arroyo willow (*S. lasiolepis*), insect pollination was responsible for over 99

percent of seed set (Sacchi and Price 1988). There is no evidence of specialized pollinators of autumn willow. *Salix* flowers are visited by hover flies (Syrphidae), sweat bees (Halictidae), and Andrenid bees in particular (*Andrena* species, Andrenidae) (Sacchi and Price 1988). Because these taxa represent diverse groups of generalist pollinators, it is likely that suitable pollinators occur in the Black Hills and at other isolated locations of autumn willow. Large numbers of bees have been noted at McIntosh Fen during autumn willow's flowering period and at other times during the growing season, although no pollinator visits to autumn willow flowers have been noted to date.

Willows are generally colonizer species and produce large quantities of small, short-lived seeds covered in long hairs for wind-dispersal (Gleason and Cronquist 1991; Argus 1999). *Salix* species in general require moist, open mineral or alluvial soils for one or more years for seed germination and plant establishment to occur, and soil disturbance like that produced by flooding, snowmelt, or fire is particularly favorable (Price and others 1996). However, disturbance facilitated plant establishment may not apply to autumn willow because it is adapted to relatively stable hydrologic conditions and anaerobic substrates associated with bogs and fens.

Vegetative reproduction may occur by coppice sprouting or ramification, where peripheral branches are forced into the ground by snow cover or some other mechanism and root to form clonal ramets (stems) (Price and others 1996). Willows can be cultivated from stem cuttings as well (USDA Forest Service 1995), although success has been sporadic. The geographic isolation of Black Hills' autumn willow populations from the nearest locations in Wyoming, Colorado and Montana would appear to prohibit any genetic exchange between them. There is a limited possibility of seed or pollen transfer via birds or meteorological events.

There is no specific documentation of mycorrhizal associations with autumn willow, however, *Salix* species commonly form mycorrhizal associations with vesicular arbuscular mycorrhizae (VAM) fungi. These fungi occupy the cortical cells in the plant's fine, lateral roots in exchange for enhanced nutrient absorption by the host plant (Smith and Read 1997). Willows are capable of forming symbiotic relationships with both VAM and ectomycorrhizal (ECM) fungi (Newman and Reddell 1987; Dhillion 1994). The latter do not penetrate the root cells of the host (Smith and Read 1997). This type of dual association is uncommon in North America, and the fen and marsh habitats where autumn willow occurs in the Black Hills lack the conditions and acid-loving plant taxa that favor ECM associations (Newman and Reddell 1987; Dhillion 1994). Autumn willow presumably possesses one or more VAM fungal symbionts, but the importance of these relationships to the species' establishment and persistence is not known.

Distribution And Local Abundance

Autumn willow occurs in fens, bogs, swamps, and marshes from Newfoundland to British Columbia and the Northwest Territories and south to New Jersey, Ohio, Illinois, Minnesota, Colorado and Montana, but is most common in northeastern North America (Froiland 1962; Gleason and Cronquist 1991; Lesica and Shelly 1991) (fig. 1). Cordilleran populations of autumn willow are distributed along an elevational gradient from north to south, where the species occurs from approximately 3,000 to 4,000 ft (914 to 1,219 km) in Alberta, Canada; 4,500 to 5,300 ft (1,372 to 1,615 m) in Montana (Lesica and Shelly 1991); 5,200 to 6,000 ft (1,585 to 1,829 m) in the Black Hills; 7,900 ft (2,408 m) in southern Wyoming (Fertig 1996); and to 9,300 ft (2,835 m) at its southernmost extent in Colorado (Spackman and others 1997).

Autumn willow's fen habitats have become more isolated during the drying trend since the last Pleistocene glaciation 11,000 years ago (Steinauer 1992). The Black Hills are believed to have been significantly drier during the mid-Holocene than they are today, and conditions have become generally cooler and wetter over the last few thousand years (Grimm 2000). For this reason, autumn willow may have migrated to the Great Plains and Rocky Mountains fairly recently.

In the Black Hills, Wyoming, Montana and Colorado, autumn willow occurs far to the south and west of its main distribution (Froiland 1962) (fig. 1). The species' distribution is presumably due to its obligate association with fen and bog wetlands, and its disjunct distribution in the Rocky Mountains, Black Hills, and Great Plains is likely the result of the rarity of wetland habitats in these regions (Froiland 1962; Price and others 1996). The species may have been more widespread historically, but it is unlikely that its minerotrophic fen habitats have ever been common. Autumn willow's current distribution closely parallels the distribution of calcareous fens in North America (Froiland 1962; Wendt 1984 in Reed 1985) (fig. 2), which suggests that it is restricted by its habitat requirements. However, autumn willow occurs in disjunct populations outside of this range in the northern Great Plains, Black Hills, and Rocky Mountains. The closest populations of autumn willow to the Black Hills are 250 mi (402 km) to the southwest in Wyoming, 400 mi (644 km) to the south in Colorado, and 600 mi (966 km) to the northwest on the Montana Rocky Mountain Front (fig. 1).

In Montana, autumn willow occurs in association with swamps and fens in six locations along the Rocky Mountain Front (Lesica and Shelly 1991; Dorn 1970). The most well-known and best-documented population in Montana is found at Pine Butte Swamp, a calcareous fen and Nature Conservancy preserve in Teton County (Lesica 1986). A single population was reported from Glacier National Park, but is presumed extirpated (Lesica and Shelly 1991).

In Wyoming, a single population of 80 to 100 autumn willow plants occurs in a bog on the Medicine Bow National Forest, Albany County (Fertig 1994). The approximately 4-A (1.6-ha) site is dominated by bebb willow (*Salix bebbiana*) and a sedge understory (*Carex rostrata*, *C. aquatilis*), with sage willow (*S. candida*) and marsh felwort (*Lomatogonium rotatum*), strap-leaf willow (*S. ligulifolia*), diamond leaf willow (*S. planifolia*), and short-fruit willow (*S. brachycarpa*) (Fertig 1994; Fertig, personal communication). Unlike other western locations of autumn willow, this wetland ecosystem is slightly acidic due to the granitic bedrock (Fertig, personal communication).

In Colorado, there are six known autumn willow populations in marshes and fens from 7,800 to 9,300 ft (2,377 to 2,835 m) in Larimer, Park, and Routt Counties (Weber and Wittmann 1996; Spackman and others 1997). At High Creek Fen, a nutrient-enriched, calcareous fen in Park County, three rare willow species, autumn willow, sage willow, and low blueberry willow (*S. myrtillifolia*), reach the southern limits of their distributions in the most southerly location of extreme rich fen conditions found in North America (Cooper 1996). Autumn willow is absent from several other calcareous fens in Park County where sage and/or low blueberry willow occur (Spackman and others 1997). Autumn willow is also suspected to occur on the Arapahoe/Roosevelt National Forest/Pawnee National Grassland, Pike and San Isabel National Forest/Comanche National Grassland, and BLM Cañon District in the Royal Gorge Resource Area (Spackman and others 1997).

Known occurrences of autumn willow in the Black Hills consist of two populations on Black

Hills National Forest lands and two populations on private lands. The McIntosh Fen population occurs at 6,000 ft (1,830 m) elevation in Pennington County, South Dakota. Approximately 50 autumn willow plants were documented at the site in 1984 and the population did not substantially expand during the following decade (South Dakota Natural Heritage Program Records). On June 21, 2000, 357 plants were counted in two concentrations: 332 plants over a 15-A (6-ha) area in the southern portion of the fen, and 25 plants in a 5- to 10-A (2- to 4-ha) area at the northern end. As of June 2000, the rehabilitated ditches at the core of McIntosh fen were partially revegetated on and around the straw bales, and autumn willow cuttings had become established. Of the plants counted in June 2000, 87 were female, 124 were male, and 146 were non-reproductive, possibly due to immaturity. Developing fruit was evident at that time. The June 2001 survey showed a 28 percent increase in the population from 357 to 457 individuals: 111 females, 167 males, and 179 non-reproductive plants. Numerous young autumn willow plants were observed in addition to the planted cuttings. The population was essentially continuous between the two previously known locations along Castle Creek and to the east of the main concentration at the southern end of the fen.

The population on Middle Boxelder Creek occurs 13 miles (21 km) north of McIntosh Fen in Lawrence County, South Dakota at 5,800 ft (1,770 m) elevation along a narrow section of the drainage within a sedge marsh with a large meadow above it. In 1956, Froiland (1962) reported several individuals from a site at 5,600 feet (1,700 m) north of Nahant and the site was revisited in 1982 (South Dakota Natural Heritage Program records). Due to mapping difficulties, this site was not relocated until June 2002. The population consists of 13 plants: 7 males, 3 females and 3 non-reproductive individuals.

There are at least two autumn willow populations on private lands in Lawrence County in the central Black Hills. One population occurs on private land north of Rochford and was first observed by Ode (1986), who stated that autumn willow was "common in (a) wide meadow along (the) north fork of Rapid Creek". Exact numbers were not given for the 100-A (40.5-ha) site, but the habitat was reported as "degraded" with autumn willow common in the saturated organic substrate of fen areas along the creek with diamond leaf willow, bebb willow, and dwarf birch (*Betula glandulosa*) (Ode 1986). A second confirmed population on private land occurs along Jim Creek at 5,200 ft (1,800 m) elevation west of Merritt. One additional population was reported from Custer County in the Atlas of the Flora of the Great Plains (Great Plains Flora Association and others 1977), but this account has not been verified. The status of autumn willow populations on private lands is unknown.

There are no known populations of autumn willow in the Bighorn Mountains of Wyoming or in the intervening areas between Montana, South Dakota and Colorado populations (Froiland 1962). Autumn willow may occur elsewhere in the Black Hills National Forest (Dorn 1992; Fertig 1994), but the species has been located only once during repeated survey efforts since 1993, and that turned out to be the Middle Boxelder Creek, or "Nahant" population originally reported by Froiland in 1962. The persistence of autumn willow in the Black Hills is likely dependent upon the maintenance and enhancement of the populations at McIntosh Fen and Middle Boxelder Creek. The current upward trend in the McIntosh Fen population could be the result of initial restoration of the local hydrology, recent high precipitation years (NOAA 1996-2001), or a combination of these and other favorable environmental conditions. However, the species' ability to disperse elsewhere in the Black Hills is limited by the rarity of suitable wetland habitats.

Habitat Relationship

Autumn willow is an obligate wetland species (USDA NRCS 2001) that occurs predominantly in boreal regions, where it occupies cold, often calcareous bogs and fens, swamps, lakeshores, sandy habitats, and stream banks at low to mid-elevations (Fernald 1912; Morely 1969; Britton and Brown 1970; Lesica 1984; Voss 1985; Gleason and Cronquist 1991). Based upon available distributional records and habitat descriptions, autumn willow is associated with wetlands with relatively high nutrient availability and pH, often described as rich or extreme rich fen conditions (Fernald 1912; Voss 1985; Lesica 1986; Fertig 1994; Cooper 1996; Spackman and others 1997; Chadde and others 1998; Marriott and Faber-Langendoen 2000). However, in the main part of its range to the north and east, the species frequently occurs in relatively acidic wetlands (Fernald 1912; Britton and Brown 1970; Gleason and Cronquist 1991), and it occupies fen habitats on both granitic and calcareous parent material. It may be the occurrence of saturated, peaty substrates derived from sedges, grasses or mosses (*Sphagnum* sp.) that these habitats have in common. Therefore, autumn willow is not exclusive to rich fens, although some of its habitats in the Rocky Mountains are reported to have minerotrophic qualities (Cooper 1996; Lesica 1986; Fertig 1994) and this may be the case in the Black Hills as well. The species' limited habitats in the semi-arid southern limits of its range are likely due to relatively unstable wetland hydrology that significantly limits the development of saturated organic substrates. At McIntosh Fen (McIntosh 1930), Middle Boxelder Creek, High Creek Fen in Colorado (Cooper 1991, 1996), and Pine Butte Swamp in Montana (Lesica 1986), autumn willow is limited to habitats influenced by springs or seeps and cool microclimatic conditions at mid to high elevations.

In the Black Hills, autumn willow's known habitats are limited to cold seep or spring-fed saturated substrates that are produced by unusual hydrologic conditions where sedimentary layers of the Limestone Plateau intersect impermeable schist or shale of the crystalline Central Core. At both the McIntosh Fen and Middle Boxelder Creek sites, the water table is elevated by impermeable parent rock and fed by groundwater that seeps from sedimentary layers beneath surrounding uplands. Because these sites are at high elevations, the result is a cold, permanently saturated wetland with an organic (peaty) substrate derived from the slow decay of grasses and sedges. Unlike most willow species, which require exposed mineral soils for seed germination (Price and others 1996), autumn willow seed germination and plant establishment occurs on undisturbed organic substrates, as evidenced by the successful restoration of rooted cuttings in saturated hay bales and the establishment of new plants in sedge peat at McIntosh Fen. The willow currently occupies low-lying areas of the McIntosh Fen meadow complex and saturated sedge marsh on Middle Boxelder Creek. Similar conditions are described where the willow occurs in Wyoming (Fertig 1994), Montana (Lesica 1986) and Colorado (Cooper 1996). The species is therefore unlikely to persist in association with intermittent stream courses or seasonally wet habitats in the Black Hills.

It is unknown if additional potential autumn willow habitats occur in the Black Hills. There may be other areas where the high limestone plateau meets the Central Core that could have historically supported saturated fen-like conditions. An acidic fen, Black Fox Bog, occurs north of McIntosh Fen, but the willow does not occur there, presumably due to the acidic environment or low light conditions beneath the bog's spruce canopy (South Dakota Natural Heritage Program Records). Based on the species' known distribution in open wetlands and shrub carrs, it prefers open, high light environments, although it is possible that partial shade would maintain cool, high moisture conditions in some cases. The climate at McIntosh Fen and Middle Boxelder

Creek is described in Appendix B.

The autumn willow population at McIntosh Fen occurs in an open, low gradient portion of the Castle Creek drainage 1 mile (1.6 km) west of Deerfield Reservoir within the only true fen community type in the Black Hills, classified as a sage willow fen (*Salix candida*/*Carex rostrata* shrubland), (McIntosh 1930; Marriott and Faber-Langendoen 2000). The McIntosh Fen Botanical Area encompasses approximately 640 A (259 ha), including the spring-fed fen wetland, and portions of Silver Creek and Castle Creek, surrounded by a large meadow. The site is in a wide valley of the Castle Creek drainage where the central Limestone Plateau (sedimentary material) meets the Central Core (metamorphic material) of the Black Hills (Black Hills Community Inventory 1999). Like the Middle Boxelder Creek site, these conditions undoubtedly contribute to the specific hydrology of the site. The fen area is included in soils classified as thick Mollisols within the Cordeston-Marshbrook loam complex typical of mountain meadows in the Crystalline Core area of the Black Hills (USDA Soil Conservation Service 1990). The fen's wetland soils likely meet the Histic (organic) soil pedon requirements, at least in part, but there currently are no Histosol inclusions defined for soil map units in the Black Hills, and this location has not been sampled for soil classification purposes (Cooley, personal communication).

McIntosh Fen occurs 6,000 ft (1,830 m) elevation. Castle Creek flows from the northwest between the fen and County Road 308, and springs and seeps feed into the fen from calcareous bedrock on the southwest side of the valley (South Dakota Natural Heritage Program). This suggests that it is a flow-through fen, that is, a fen maintained by a continuous flow of ground and surface water (Moore and Bellamy 1974 in Chadde and others 1998). Silver Creek, a tributary of Castle Creek, and a large smooth brome grass *(Bromus inermis)* meadow dissect the botanical area into upper and lower regions, both of which contain concentrations of autumn willow. The current fen wetland area of approximately 15 to 20 A (6.1 to 8.1 ha) is smaller than originally reported by McIntosh (1930), apparently because the water table was lowered by drainage ditches created while the site was under private ownership (Marriott and Faber-Langendoen 2000) (figs. 4, 5 and 6).

The McIntosh Fen meadow complex contains three primary plant community types: sage willow fen, Nebraska sedge (*Carex nebrascensis*) wet meadow, and Baltic rush (*Juncus balticus)* wet meadow (Marriott and Faber-Langendoen 2000). The co-dominance of sage willow and autumn willow distinguishes the sage willow fen from bebb willow or sandbar willow (*S. interior*) community types (Marriott and Faber-Langendoen 2000), which occur primarily in association with the floodplains along Castle Creek and Silver Creek. Willow species at McIntosh Fen include autumn willow, sage willow, sandbar willow, bebb willow, and false mountain willow (*S. pseudomonticola*) (table 2). Both autumn willow and sage willow are commonly associated with calcareous habitats (Voss 1985), but are not restricted to them and are believed to have been historically more widespread (Marriott and Faber-Langendoen 2000). Nebraska sedge and Baltic rush wet meadow community types are interspersed with the saturated sage willow fen. Baltic rush is the primary graminoid species at the fen, where it occurs in large dense patches with Nebraska sedge, Canadian reedgrass (*Calamagrostis canadensis*) and an exotic grass, common timothy (*Phleum pratense*) (Marriott and Faber-Langendoen 2000). The dominant species assemblage at the fen is characteristic of rich fen habitats elsewhere (Glaser 1987). In the lowest elevations of the McIntosh Fen Botanical Area, meadow willow (*S. petiolaris*), diamondleaf willow (*S. planifolia* var. *planifolia)*, sage willow, autumn willow and shrubby cinquefoil

(*Dasiphora floribunda* (Pursh) Kartesz, comb. nov. ined.) are common and sedges and grasses dominate the herbaceous layer (Marriott and Faber-Langendoen 2000). This lower elevation portion of the fen has standing water at least in wet years or during wet seasons in some years. White spruce (*Picea glauca*) and aspen (*Populus tremuloides*) occupy the north-facing slopes just outside of the designated botanical area boundary.

Arthur McIntosh originally described the fen's plant community in 1924 as a "sedge moor", inhabited by autumn willow, sage willow (*Salix candida*) and numerous other disjunct wetland species (McIntosh 1930) (fig. 4). The plant community described by McIntosh (1930) included a more extensive list of species than what exists at the fen today, including greenish sedge (*Carex viridula*) and bog buckbean (*Menyanthes trifoliata*). Neither of these species has been observed at the fen since it was altered ca. 1930 (South Dakota Natural Heritage Program; Marriott and Faber-Langendoen 2000). Whether their seeds remain in the seed bank is unknown. Several species were later documented at the fen: northern bog aster (*Symphyotrichum boreale*, syn.= *Aster junciformis*), tall cottongrass (*Eriophorum angustifolium* ssp. *subarcticum*, syn. = *E. polystachion*), and marsh muhly (*Muhlenbergia glomerata*) (South Dakota Natural Heritage Program).

As of June 2000, some of the autumn willow cuttings that were planted in 1997 had become established in and around the rehabilitated ditches, with numerous individuals scattered throughout the lower and upper portions of the fen. In the upper fen, autumn willow occurs with sage willow and large thickets of diamondleaf willow. Aspen are scattered in both the lower and upper parts of the fen. Autumn willow is nearly continuous along Castle Creek between the upper and lower parts of the fen. The willow and sedge meadow communities give way to aspen and spruce to the west and densely forested uplands form the western border of the botanical area.

The calcium carbonate-enriched spring water that feeds into McIntosh Fen from the Limestone Plateau has contributed to an assemblage of species that is distinctly different from other wetlands in the area (South Dakota Natural Heritage Program) and characterizes the site as a rich fen (Glaser 1987). The climate (see Appendix B) and more southern latitude of the Black Hills prevent the formation of microtopographic ridges and valleys often seen in boreal bogs and fens (Grittinger 1970; Thompson 1983; Chadde and others 1998). Also, the fen does not possess an organic substrate comprised of decaying *Sphagnum* moss typical of boreal wetlands (Sjors 1950; Gorham 1957; Slack and others 1980; Lesica 1986), although it does have peat derived from decaying sedge, grass and moss. Black Fox fen, an acidic iron fen located 8 mi (12.9 km) to the north of McIntosh Fen, supports numerous species that are tolerant of acidic conditions including some *Sphagnum* species and members of the Ericaceae family (Grimm, personal communication). Ericaceous species are common in acidic, nutrient depleted environments (Sjors 1950), but are absent from McIntosh Fen, presumably due its more nutrient rich character. Beaver ponds present in the late 1800s (McLaird and Turchen 1975) and early 1990s (Grimm, personal communication), as well as past bison use along Castle Creek (Saunders 1996) also might have influenced the species composition and microtopography of the fen. Because McIntosh Fen has water inlets and outlets, it is well suited for beaver, which exert a strong influence on seral development and floristic diversity in peatlands (Bursik and Henderson 1995; Chadde and others 1998).

The autumn willow population on Middle Boxelder Creek is in a sedge-willow marsh with fen-

like characteristics: it is fed by seeps from adjacent sedimentary rock, there is water flowing through the site, and the lowermost elevations of the site have thick sedge hummocks and mats. The existing saturated wetland area is ca. 5 A (2 ha) or less with the lowest elevations dominated by bebb willow, diamondleaf willow and a sedge understory. There are several old beaver structures in the meadow above the marsh. The beaver dams, an intermittent stream channel that orginates in uplands south of the site and passes through the upper portions of the meadow, numerous very large bebb willows bordering the meadow, and dead willows within the meadow all suggest that the water table was historically much higher at the site.

The plant community in the sedge-willow marsh on Middle Boxelder Creek could be characterized as a bebb willow shrubland (Marriott and Faber-Langendoen 2000), but may have historically been more like the sage willow fen community at McIntosh Fen. The understory marsh and upland meadow have not been thoroughly surveyed to date, but could possess components of Nebraska sedge wet meadow, Baltic rush wet meadow, Black Hills streamside vegetation or other grassland community types. In addition, there is a small cattail (*Typha latifolia*) stand below the old beaver dams in the upland meadow.

The literature contains no specific references to competitive interactions that would limit the distribution of autumn willow in any portion of its range. Because autumn willow prefers saturated habitats, both belowground and aboveground competition may be nominal, although some interspecific competition with other wetland shrubs, such as sage willow, is likely. Autumn willow is presumably subject to the same risks as other native wetland plants from competitive exclusion by noxious and other invasive plant species such as Canada thistle (*Cirsium arvense*). Livestock and wildlife use can have both direct and indirect negative effects on willow species (Cates and others 1999; Hoffman and Alexander 1987). Browsing by deer, elk, or livestock, and predation by insects can reduce photosynthetic tissues and overall plant health, particularly where the plant is already stressed (Cates and others 1999). Livestock directly impact autumn willow by trampling seedlings and young plants, and indirectly by altering the microtopography and nutrient dynamics of the species' habitats (USDA Forest Service 2000). At the two currently known populations, the primary ecological stressors to autumn willow appear to be impacts to local hydrology, competition from other woody species and noxious and invasive plants, and impacts? by wildlife.

The plant communities and habitat types with which the species is associated are more widely distributed than the species itself, which suggests that dispersal or specialized associations are limiting factors. The widely distributed Baltic rush wet meadow community type occurs in the Black Hills only at McIntosh Fen, though Baltic rush occurs elsewhere in the Hills (Marriott and Faber-Langendoen 2000). This may indicate that unique edaphic conditions or ecological associations occur at the fen. The species' limited distribution is at least in part due to the cumulative effects of human activities on wetlands. Overall, it appears that the species' distribution is facilitated by a combination of specific natural hydrologic features and edaphic conditions (freshwater fed fens, bogs, or marsh wetlands), and could include a facultative relationship with beaver activities that raise water tables and create wetland meadows in this portion of its range.

In the Black Hills, the presence of a permanently saturated organic substrate appears to be the determining factor in autumn willow's distribution. At both known populations on Black Hills National Forest lands, these conditions are produced where permeable and impermeable geologic

types intersect to create an elevated water table fed by groundwater from sedimentary strata. Also, both sites occur in cool microclimates at high elevations that limit the decomposition of organic matter.

Disturbance Ecology

Flooding, wildlife use and fire historically influenced riparian ecosystems of the Black Hills. A paleoenvironmental excavation in 1993 of the Kenzy site on Castle Creek in the central Black Hills documented floodplain deposits that have accumulated over the last 340 years, as well as bison (*Bos bison*) remains, several of which were butchered, elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*) and deer (*Odocoileus hemionus and/or O. virginianus*) remains, and charcoal remnants of previous fires (Saunders 1996). In addition to these historic disturbances, there is evidence that beavers *(Castor canadensis)* were numerous in riparian systems of the Black Hills before widespread settlement (Dodge 1965). The interactions of these disturbances in producing autumn willow habitat were quite different from interactions that created habitat for other species of willow.

Saturated soil conditions and the accumulation of organic peat are the key components of autumn willow habitat. Maintenance of these conditions is dependent on the steady supply of water throughout the growing season as well as the slow decomposition of organic materials characteristic of northern climates. Because of autumn willow's preference for boggy marshes, the role of flooding and other disturbances in maintaining its habitats is quite different from other willow species that readily colonize recently scoured stream banks and freshly deposited sediments. Further, the presence of standing water in autumn willow habitat makes it less attractive to browsing animals, more resistant to burning and less likely to be invaded by plant species unable to persist in standing water. Finally, at both McIntosh Fen and Middle Boxelder Creek where geologic and hydrologic conditions exist to permanently elevate the water table, there is evidence that the presence of beaver dams functioned to sustain the saturated soil conditions preferred by autumn willow.

Beaver dams impound water and create habitat for plants adapted to water-saturated soils (Parrish and others 1996). Even in more mesic, boreal regions of North America, beaver exert a strong influence on the quantity and quality of wetland habitats (Naiman and others 1988). Complexes of beaver dams in association with wet meadows function like a sponge and serve to moderate the impact of floods and extend flows well into the summer months, which is particularly important in semi-arid portions of the species' range. In autumn willow habitats, beaver dams may benefit the species by increasing the area of saturated organic substrates by further elevating the water table. Also, even during severe drought, the raised water table that results from beaver dams (Olson and Hubert 1994) would deter invasion by upland woody species that would ultimately promote succession from sedge marsh/shrub carr to lowland forest (Reuter 1986). Autumn willow's habitat associations suggest that it is not a good competitor with other woody species, including other willows, but its preference for saturated organic habitats apparently exempts it to some degree from interspecific competition. With the exception of sage willow and a few other willow species that also tolerate saturated soils, autumn willow habitats exclude many woody plants, including bebb willow and aspen.

Other natural disturbances, such as periodic pine insect outbreaks and fire, potentially benefit autumn willow by increasing groundwater infiltration and discharge from springs. Fire maintains the open character of wetland habitats and facilitates the regeneration of hardwoods

favored by beaver. In the Black Hills, natural historic fires occurred most often late in the growing season (Brown and Sieg 1996, 1999). Fens and other riparian and wetland habitats in the region remain moist and green throughout most of the growing season, and therefore are not likely to burn until vegetation has cured and soil moisture decreases (Sieg 1997; Sieg and Wright 1996). Literature on the historic effects of fire in the Black Hills (Williams 1990; Parrish and others 1996; Sieg and Severson 1996) suggests that willow habitats in the region have persisted despite severe fire disturbance in surrounding uplands and occasional fire in the meadows surrounding wetland habitats depending upon drought conditions. Tree ring evidence indicates that the Black Hills have sustained very severe droughts within the past 400 years (Bunkers and others 1999) during which McIntosh Fen and other autumn willow habitats may have dried out enough to allow some if not all of the peat to burn. However, fires in wetland habitats were infrequent, and therefore the effects of fire on autumn willow habitat were usually indirect – that is, upland fires that reduced conifer density and increased available water had the greatest influence on these sites.

The complex interactions in riparian systems were greatly altered beginning in the late 1800s with widespread settlement of the Black Hills. Perennial streams were mined, and low gradient riparian meadows became preferred locations for farming, livestock grazing, and roads (Parrish and others 1996). At the same time, beavers were nearly eliminated from the Black Hills by the turn of the century (Turner 1974) and the natural fire regime was greatly altered (Brown and Sieg 1996, 1999). Both known autumn willow locations in the Black Hills have been greatly impacted by these early and continuing human impacts (figs. 4 - 8). While under private ownership from 1930 until about1980 when the Forest Service acquired it, McIntosh Fen was ditched to facilitate use as a hay field and livestock pasture (USDA Forest Service 2000). This combined with the extirpation of beaver () from the Castle Creek drainage contributed to the lowered water table and altered the vegetative species composition of the fen. In addition, fire suppression has resulted in an increased density of conifers and a decline in aspen and other hardwoods on surrounding uplands, and has likely reduced groundwater flow into the fen. Restoration efforts beginning in 1997 at McIntosh fen have reversed these impacts to some degree, as evidenced by the apparent recovery of autumn willow.

Given the dynamic nature of historic disturbances in the Black Hills, it is likely that riparian communities were far from static. Beaver colonies tend to increase in response to high moisture levels and abundant food resources, then decline or move in response to drought and depleted foods (Parrish and others 1996). In this manner, a patchy distribution of ponds, saturated soils and depleted riparian stands was maintained, and these patches tended to shift both spatially and in time. This shifting allowed depleted aspen and willow stands to recover and new marshes to develop. The current rarity of alternative riparian habitats needed to support beavers displaced by limited food resources, or provide alternate habitat for autumn willow, results in a much more static system than once existed.

Key Risk Factors

The persistence of autumn willow in the Black Hills is currently dependent on maintaining the two known populations on public land. Because autumn willow is an obligate wetland species, the primary risk to its persistence in the Black Hills is any lowering of the water table where autumn willow occurs, whether natural or human-induced. As is suggested by the apparent recent expansion of the McIntosh Fen population, perhaps in response to a relatively small

increase in the water table, local hydrology plays a vital role in the reproductive success and persistence of autumn willow. The stressed autumn willow plants at Middle Boxelder Creek, where the water table has apparently dropped in recent years, further support the importance of local hydrology to the species. The potential exists for water diverting development, such as wells, pavement, and culverts, on private land upstream from McIntosh Fen that could reduce or alter the flow of water from streams, springs and seeps, lower the water table, and limit the potential for beaver reoccupation in the drainage. This could be a significant risk, in that well over 50 percent of the perennial portion of Castle Creek, upstream from the fen, is privately owned.

Other factors that lessen the likelihood of maintaining saturated soils in autumn willow habitat are long-term drought, conifer encroachment in autumn willow habitats, and management that maintains high tree densities on uplands. Decreased fire frequency and timber harvest strategies in the Black Hills over the past century has contributed to increased density of conifers, reduced groundwater flow and decreased regeneration of aspen and other hardwoods (Parrish and others 1996). These factors not only contribute to reducing available water in streams and springs, but also make the successful reintroduction of beavers less likely due to low water flows and limited food resources.

Both autumn willow populations are highly vulnerable to other disturbances such as fungal or insect infections, or invasions by noxious plants or other invasive species. In August 2001, a fungal infection was noted on the leaves of autumn willow plants at McIntosh Fen. The fungus was identified as a species of *Melampsora*, a rust of *Salix* species, and is suspected to be *Melampsora ribesii-pupureae* (Gabel, personal communication). The fungus is a rust or smut that uses gooseberry (*Ribes* spp.) as its alternative host. *Ribes lacustre* has been documented at the small northern portion of the fen (South Dakota Natural Heritage Program). This fungus infects other willow species, including bebb willow, grayleaf willow (*S. glauca*), and Scouler's willow (*S. scouleriana*). The U.S. Host Disease Index lists the species *Melampsora paradoxa* as a specific autumn willow disease (Gabel, personal communication). Because the rust appears late in the growing season, it may not present a risk to the population. However, plans are to monitor the fungus for the next several years to determine the time and degree of infection, and any negative effects to the plants. There is no sign of the rust fungus on autumn willow plants at Middle Boxelder Creek and the rust's host species, gooseberry, is not known to occur there. However, willow borers have damaged or killed autumn willow plants at the Middle Boxelder Creek site. Willow borers have been reported to infect bebb willow in particular (Froiland 1962), which is common at the Middle Boxelder Creek site.

Invasive plants, including both planted exotic species and accidentally introduced noxious species, may seriously impact autumn willow and its habitats. Invasive species potentially disrupt wetland ecosystems by out competing native plants, including woody species. Invasive plants may further alter wetland ecosystems by reducing or eliminating the structural diversity and microhabitats that comprise native plant communities and enhance overall biological diversity (Atsatt and O'Dowd 1976.). Canada thistle (*Cirsium arvense*), a highly invasive forb, is present in the planted smooth brome meadow surrounding McIntosh Fen and is also abundant in the exclosure on Middle Boxelder Creek. Canada thistle and 'butter and eggs' (*Linaria vulgaris*) occur on elevated portions of the marsh and in the meadow above the autumn willow population at Middle Boxelder Creek. Another invasive species, houndstongue (*Cynoglossum officinale*), occurs on the open slopes above the Middle Boxelder Creek site. Smooth brome can

be invasive in some Black Hills settings as well (Larson and Johnson 1999). Unfortunately, invasive plant control treatments can be equally detrimental to native vegetation and insect pollinators, and may indirectly impact native species by reducing the quantity and/or diversity of pollinating insects. Recent treatments of invasive plant species at McIntosh Fen Botanical Area involved direct application of herbicide to individuals or patches of Canada thistle. High soil moisture levels in the fen itself appear to exclude both Canada thistle and smooth brome from autumn willow habitat.

As a word of caution, if the water table continues to rise in the fen in response to restoration efforts, and is restored at Middle Boxelder creek, both sites will become vulnerable to invasion by purple loosestrife (*Lythrum salicaria*). Purple loosestrife is a noxious, aggressive herbaceous plant species and wetland invader that prefers saturated conditions (Mullin 1999). Although purple loosestrife does not currently occur at either McIntosh Fen or Middle Boxelder Creek, it has been documented along Rapid Creek near Rapid City, South Dakota (South Dakota Natural Heritage Program) ca. 20 to 25 miles (32 to 40 km) east of the sites. Should purple loosestrife invade known autumn willow habitats, it has the potential to out compete riparian natives and may represent a significant competitive risk to autumn willow populations. The occurrence of purple loosestrife and other noxious plants in potential habitats would likely limit the ability of autumn willow to become established there.

The largest known population of autumn willow in the Black Hills National Forest is within a designated botanical area; so direct disturbances are not expected from road or highway construction, mining, or off-road vehicle use. There are roads and highways outside of the fenced McIntosh Fen Botanical Area boundary that may indirectly affect hydrological flows and provide conduits for the introduction of exotic species. The road adjacent to Middle Boxelder Creek could similarly affect the autumn willow population there. Although off-road vehicles are prohibited in the McIntosh Fen Botanical Area, trespass vehicle tracks have been observed along the snowmobile trail that passes between the upper and lower concentrations of autumn willow. A snowmobile route crosses the botanical area, but snowmobiles are restricted to the designated trail, which does not cross the areas where autumn willow plants occur. There are currently no trails within the McIntosh Fen Botanical Area, nor are there plans for building any. However, recreational impacts are also a potential risk at McIntosh Fen. In southeastern Wisconsin, trampling from recreationists was considered a risk to the integrity of fen vegetation (Reed 1985). Castle Creek is considered a top fishery in the Black Hills and anglers have been observed along the banks of the creek within the botanical area.

Trespass livestock and wildlife are a potential risk to autumn willow at both sites. High levels of livestock, elk *(Cervus elaphus)* and deer *(Odocoileus spp.)* may impact streamside communities through grazing, trampling, resting and trailing (Hoffman and Alexander 1987, Price and others 1996), and animals could introduce invasive plant species into autumn willow populations. Livestock use is restricted within the fenced portion of McIntosh Fen Botanical Area and within the exclosure on Middle Boxelder Creek. However, trespass livestock have been observed at the fen and damaged fence lines have been noted at the upper end of the meadow at the Middle Boxelder Creek exclosure. White-tailed deer *(Odocoileus virginianus)* were encountered in McIntosh Fen during the 2000 survey and later site visits and elk have been observed in adjacent areas. Deer and elk sign have been noted within the Middle Boxelder Creek exclosure and nearby the wet sedge marsh where autumn willow occurs. However, to date, no impacts to autumn willow plants have been noted from the wildlife or from trespass cattle at either site.

CONSERVATION PRACTICES

Management Practices

The McIntosh Fen Botanical Area was designated in 1997 and is administered by the Mystic (formerly Harney and Pactola) Ranger District, Black Hills National Forest (USDA Forest Service 1996). Restoration efforts implemented in 1997 at the fen complex were based upon information from the South Dakota Department of Game, Fish and Parks (1992), Black Hills National Forest (USDA Forest Service 1995), and The Nature Conservancy (Marriott 1993). Non-administrative vehicles and off-road wheeled vehicles are restricted from the McIntosh Fen Botanical Area. Snowmobiles are permitted, but restricted to a designated snowmobile trail that crosses the meadow from east to west (USDA Forest Service 1996, 2000). The Mystic Ranger District plans to install metal gates at the Botanical Area during 2002 to prevent trespass vehicles and cattle. Signs have recently been installed at parking areas along a nearby road and the snowmobile trail to create awareness and appreciation of the unique qualities of the fen and other historic features of the area.

The autumn willow population on Middle Boxelder Creek is fenced to exclude livestock. The exclosure was established in 1991 and is also known as the "Crago Flats" exclosure. The exclosure was constructed for three reasons: "(1) to protect the key riparian vegetation types and spring sources, (2) to serve as reference areas demonstrating riparian area potential, and (3) to remove livestock impacts" (Martinez, personal communication).

Conservation management of willow species involves restoring water tables and drainages, potentially changing livestock management, providing open habitat for colonization, establishing seedlings or cuttings, and prescribed burning (Price and others 1996). In fen habitats, conservation requires the maintenance of groundwater flow, water chemistry, and the structure and integrity of the vegetation (Reed 1985). Because the sources of groundwater flow and recharge areas for fens are often difficult to determine, there may be a need to focus on adjacent land use so that sources of groundwater draw down and/or contamination can be eliminated or reduced (Reed 1985). These considerations apply to the seep hydrology at Middle Boxelder Creek as well.

Initial restoration efforts at McIntosh Fen were designed to restore the hydrologic function of the fen and enhance population levels of autumn willow. These included filling ditches with straw bales and planting rooted autumn willow cuttings. Autumn willow cuttings from McIntosh Fen have been sent to the Forest Service Nursery (Bessey Nursery) to attempt to grow "stooling" plants that are held in reserve for future planting stock for McIntosh Fen. Additional restoration activities at McIntosh fen have focused on reducing conifer density on uplands and stimulating aspen on the margins of the fen. In the fall of 2001, a 185-acre (75-ha) prescribed burn was ignited on hill slopes just downstream from the McIntosh Fen Botanical Area. In addition to reducing conifers, the burn may also benefit autumn willow by decreasing the chances that wildfire would destroy the fen's peat substrate in the event of a catastrophic drought. The possibility of burning meadows adjacent to the fen has also been proposed. Smooth brome meadows can be burned in the late winter or early spring when brome is actively growing to temporarily set back the brome in favor of native species (Willson 1990). Burning in successive years may be required to significantly suppress the brome. However, if warm season species are not present, herbicide treatments may be required to suppress smooth brome (Willson and Stubbendieck 1996).

A restoration plan for the recently discovered autumn willow population at Middle Boxelder Creek has not been developed. There is a need to carefully evaluate the current conditions to determine if restoration is possible. The primary need is restoration of saturated soils. Assuming saturated soil conditions can be restored, autumn willow cuttings from the McIntosh Fen population could be used to enhance the population at Middle Boxelder Creek. Prescribed burning the slope on the southeastern edge of the marsh could be considered to kill encroaching spruce and stimulate aspen.

Conservation Measures

The persistence of the species in the Black Hills would likely be enhanced by the protection and/or acquisition of other known locations of autumn willow. To this end, The Nature Conservancy (TNC) has identified both the Castle Creek drainage and all currently known populations of autumn willow as priorities for conservation in its ecoregional conservation plan for the Black Hills (Hall and others 2002). Acquisition of additional sites could potentially be achieved through TNC easements or long-term Forest Service/TNC acquisition, but this is dependent upon funding, land availability, and landowner willingness to participate. In the event that boggy meadows or calcareous fens characteristic of autumn willow habitat are discovered, these sites could be evaluated for their potential for supporting this species. Seed collection, with seed stored in certified repositories, and off-site propagation of stem cuttings could facilitate the reintroduction of autumn willow to known and potential sites.

Survey, Inventory And Monitoring Approach

The distribution of autumn willow in the Black Hills National Forest is limited to two currently known populations. The status of two additional autumn willow sites on private land is unknown and the odds of finding additional populations in the Black Hills are low. Surveys of even marginally suitable habitats will continue in areas where projects are proposed, and in other areas, as funding becomes available.

The persistence of this species in the Black Hills is contingent on conserving the large population at McIntosh Fen and conserving or enhancing the smaller population on Middle Boxelder Creek. The current monitoring protocol is designed to detect and respond in a timely manner to changes in the extent and health of autumn willow and its habitat at the McIntosh Fen Botanical Area, and similar protocol has been implemented at the population along Middle Boxelder Creek. The current protocol focuses on annually monitoring: 1) the extent of the population, 2) total number of individuals and number of reproductive plants, 3) number of plants infected with rust fungus or other damaging agents, 4) water table level, and 5) presence of exotic invasive species. The extent of the autumn willow population will be estimated by recording GPS readings at the end points of concentrations within the botanical area. Population levels and reproductive status will be estimated by counting the total number of plants and the number of reproductive plants during the flowering period. The number of diseased or damaged plants will be noted to monitor the extent of the rust fungus and other damaging agents. Two piezometers were installed at McIntosh Fen in 2001 and annual monitoring of water table levels are proposed to begin in 2002 by taking at least one annual measurement during the flowering period, plus monthly measurements during the growing season. The presence of exotic species, especially those known to be invasive, is to be documented by systematically searching the autumn willow habitat and adjacent areas. These monitoring data will be reviewed periodically to determine if changes in the protocol are warranted. In particular, declines in the number of individuals of

more than 10 percent or increases in the number of diseased or damaged plants will trigger consultations with species experts and a knowledgeable biometrician.

CONCLUSIONS AND INFORMATION NEEDS

The long-term persistence of autumn willow in the Black Hills is uncertain. With only two known locations on public land and two verified small populations on private land that are unprotected and of unknown status, the species' future is precarious. Any decline in the water table that results in the loss of saturated conditions at McIntosh Fen or Middle Boxelder Creek could be detrimental to the species' persistence in the Black Hills. Disease or insect outbreak could also extirpate the species from the Black Hills. The population at Middle Boxelder Creek appears to be in decline due to changes in the water table and competition from invading woody species, and management to enhance conditions at the site is warranted. Due to the limited number of populations and the rarity of its highly specialized habitats, autumn willow is not secure in the Black Hills National Forest at this time.

Because of the limited occurrence of this species in the Black Hills and the numerous risks associated with having only two protected sites, plant cuttings from McIntosh Fen have been used to grow plants off site. Other *ex situ* measures, such as collecting seed from known locations and storing them at certified repositories are also warranted. The Nature Conservancy has targeted the Castle Creek drainage and the autumn willow population there for conservation. Because of the limited number of populations that can be conserved, it is likely that The Nature Conservancy will adopt the same conservation strategy for the Middle Boxelder Creek autumn willow population as well. In the event that additional potential habitat is discovered in the Black Hills, the feasibility of establishing autumn willow could be considered.

Due to the importance of conserving this large population on Forest Service land, a rigorous monitoring program was implemented at McIntosh Fen in 2000. Annual monitoring was initiated at the Middle Boxelder Creek population when it was discovered in June 2002. The hope is to stabilize both populations and detect and respond in a timely manner to population declines or degradation of the habitat. As data become available, the monitoring plan may need to be revised and augmented. In the meantime, additional restoration efforts are being planned for the fen and need to be evaluated for the Middle Boxelder Creek site. In addition to continued efforts to restore the hydrologic functioning in the fen, adjacent uplands have been prescribe burned to remove conifers and stimulate aspen regeneration. Ultimately, the goal is to restore beavers to McIntosh Fen and possibly to Middle Boxelder Creek as well. Unfortunately, even if these restoration efforts are successful, the future of autumn willow in the Black Hills is tenuous.

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APPENDICES

Appendix A. Technical description of autumn willow, Salix serissima (L. H. Bailey) Fern.

Autumn willow is a perennial, deciduous shrub 1 to 4 m (3 to 13 feet) tall, with bark ranging from olive to gray on the older branches, yellowish on younger branches and shiny red-brown on the youngest twigs (fig. 9). The leaves are 4 to 8 cm (1.5 to 3 inches) long, 1 to 2.5 cm (½ to 1 inches) wide, alternate on the stem, smooth and shiny above, paler to minutely hairy below, and finely toothed on the margins with long tapered tips. The leaf petioles have a pair of distinct glands just below the leaf blades. The plant is dioecious, that is the male and female catkins occur on separate plants. The female catkins are 1.5 to 3.5 cm (¾ to 1 ½ inches) long at maturity and the male catkins are 1.5 to 3 cm (¾ to 1 ¼ inches) long, both are borne on leafy branchlets 1 to 3.5 cm (½ to 1 ½ inches) long. Light yellow, hairy bracts or scales subtend the flowers, and those on the female flowers fall off before the capsules mature. The plants flower in June in this portion of their range and the fruit matures from late summer to early fall. The fruit is a narrow, smooth capsule 7 to 10 mm (¼ to ½ inch) with a long neck and is borne on stalks 0.5 to 2 mm (1/32nd to 1/8th of an inch) long. Seeds are produced in large numbers and are covered with long, filamentous hairs to assist in wind dispersal (Gleason and Cronquist 1991; Dorn 1970) (fig. 9). Distinguishing characteristics include: glandular petioles at the base of finely glandular-toothed, long taper-tipped leaves; smooth, distinct capsules (see above); and the species' unique flowering period from June to September, where other *Salix* species usually flower in spring or early summer (Britton and Brown 1970; Dorn 1970, 1992; Larson 1993; Fertig 1994; Spackman and others 1997).

Appendix B. Climate summary for autumn willow in Black Hills National Forest.

Average temperature extremes, annual precipitation and total snowfall at the climate stations in closest proximity to Black Hills autumn willow populations are given in the table below.

The Deerfield Climate Station at Deerfield Reservoir, South Dakota is ca. 2.5 mi (4.0 km) east of the McIntosh Fen population. First frost is in early September and last frost in mid-June; and extreme temperatures for 1998 and 1999 ranged from minus -17° to 90° F (-27.2° to 32.2° C) (National Oceanic and Atmospheric Administration 1998, 1999).

The closest climate station to the autumn willow population on Middle Boxelder Creek near Nahant is ca. 4 mi (6.4 km) to the west-northwest at Buskala Ranch, South Dakota. Temperature data is limited for this station, but minimum, maximum and extreme temperatures are likely similar to those at Deerfield. Precipitation at both climate stations is concentrated in May, June, and July (High Plains Regional Climate Center 2001).

Climate summary for autumn willow occurrences, Black Hills National Forest (High Plains Regional Climate Center 2001):

Climate Station	**Period of Record**	**Average min. temp. (January)**	**Average max. temp. (July)**	**Total annual avg. precip.**	**Average annual snowfall**
Deerfield	1948 to 1980	0.8° F (-17.4° C)	77.1° F (25° C)	22.95 in (58.3 cm)	155.7 in (395.5 cm)
Buskala Ranch	1948 to 1997	Insufficient data	Insufficient data	23.40 in (59.4 cm)	145.1 in (368.5 cm)

FIGURES

Figure 1. North American distribution of autumn willow*, Salix serissima* (Froiland 1962 with additions from Fertig 1994; Spackman and others 1997; Montana Natural Heritage Program 2002; USDA-NRCS 2002)

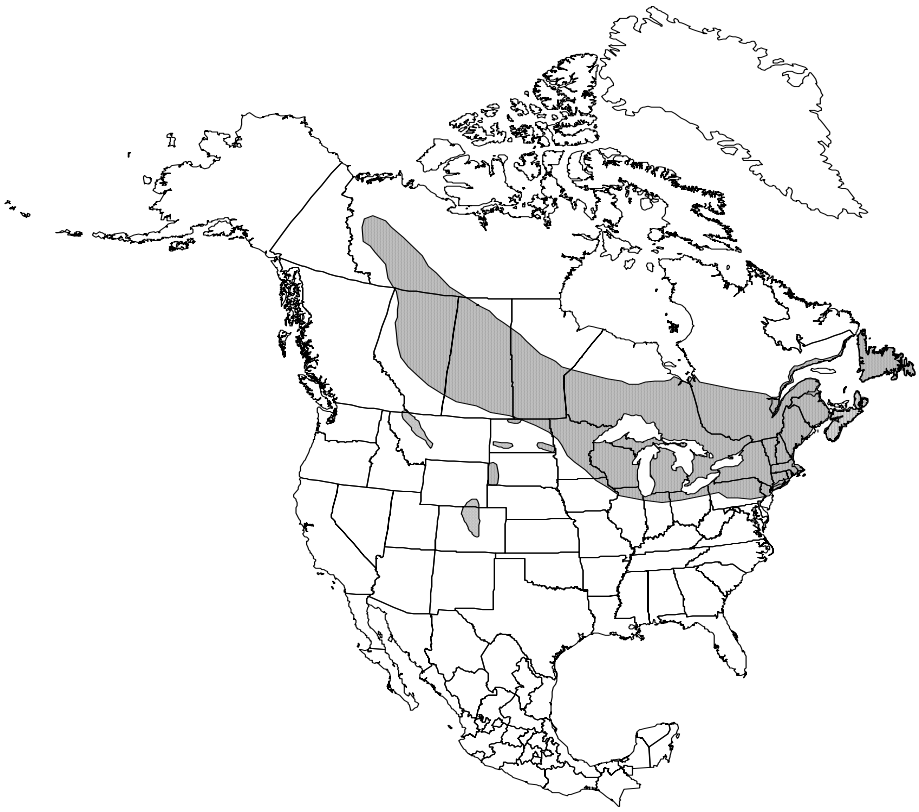

Figure 2. North American distribution of rich fen habitats (Wendt 1984 In Reed1985).

Figure 3. Black Hills distribution of autumn willow, *Salix serissima* (Bailey) Fern.

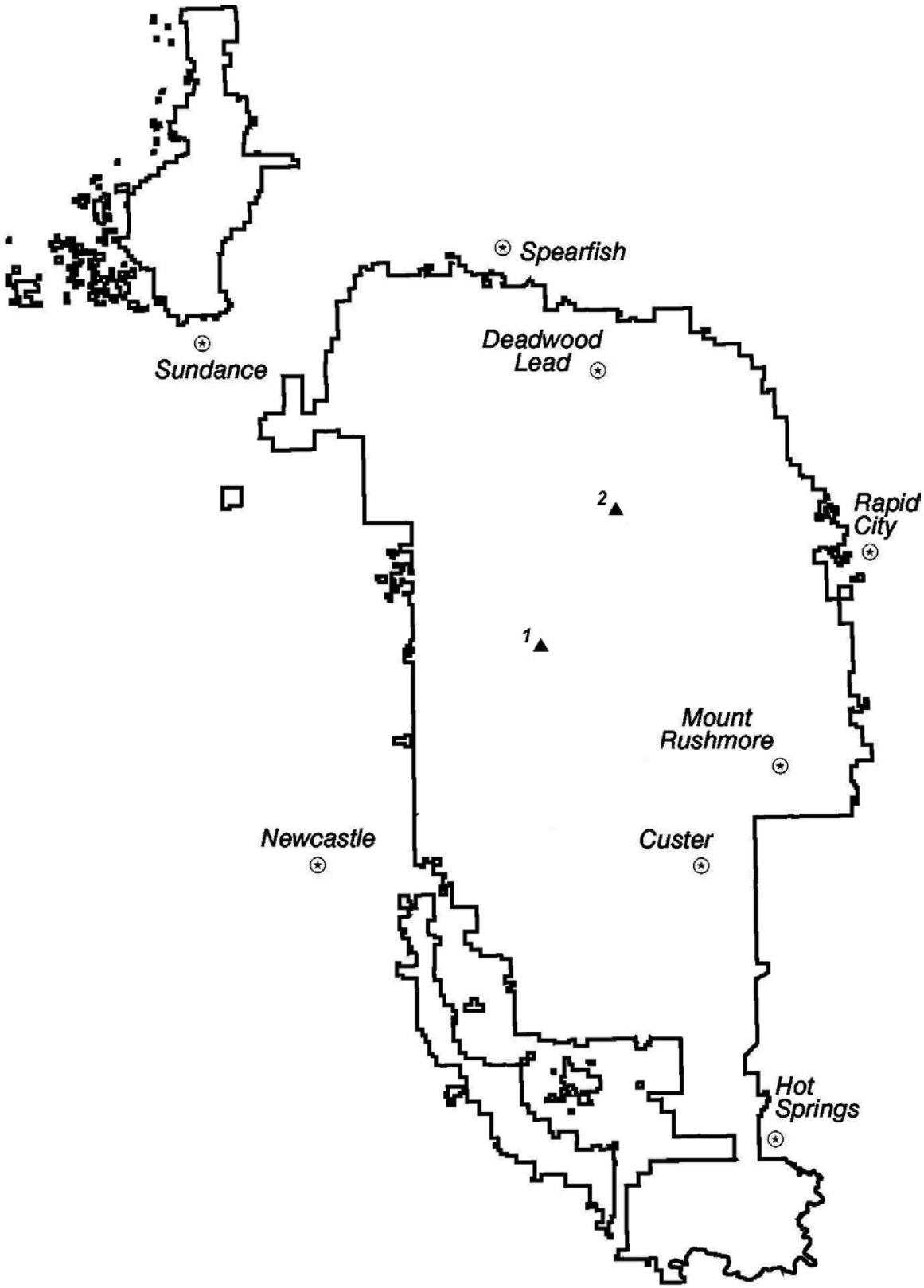

Figure 4. Photograph of McIntosh fen, taken by Arthur McIntosh in about 1930.

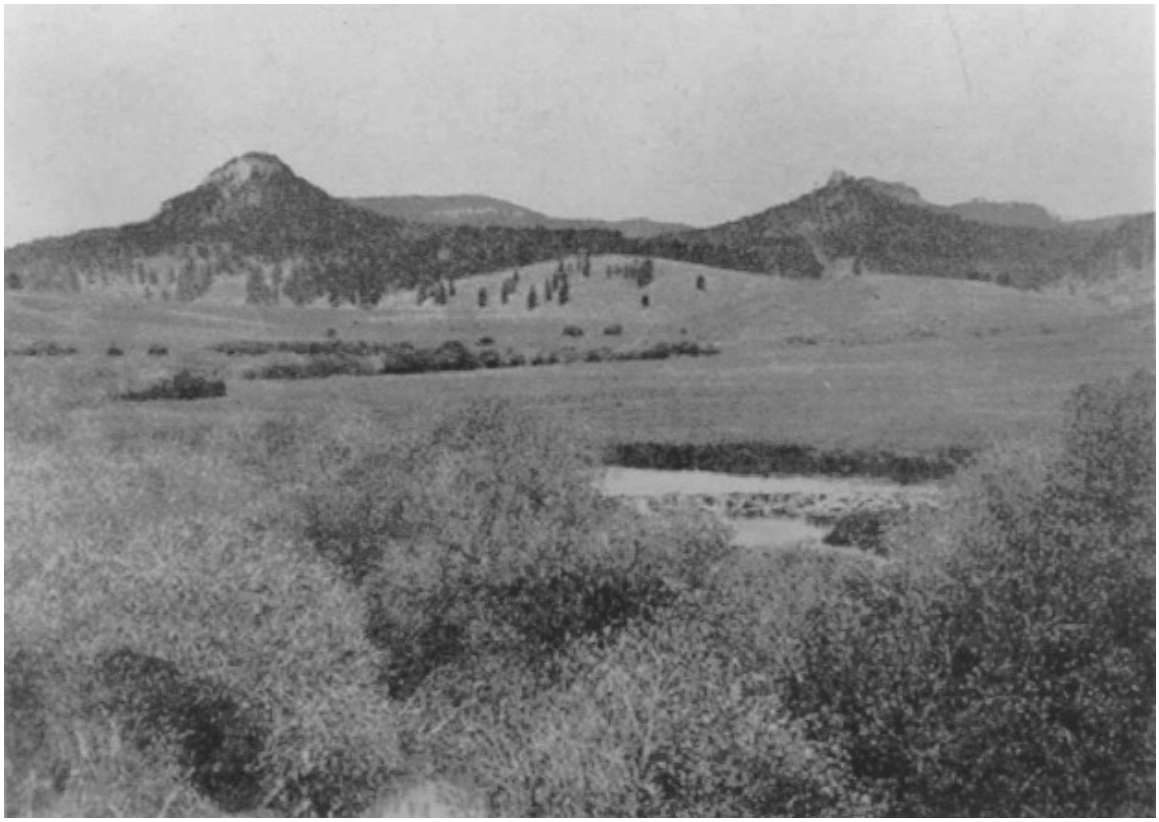

Figure 5. Photograph of McIntosh fen taken in 1985 by D.J. Ode (note loss of bebb willow zone and beaver).

Figure 6. Autumn willow habitat at McIntosh fen in June 2001.

Figure 7. Figure 10-A from Progulske (1974) taken in 1874, showing valley adjacent to McIntosh fen.

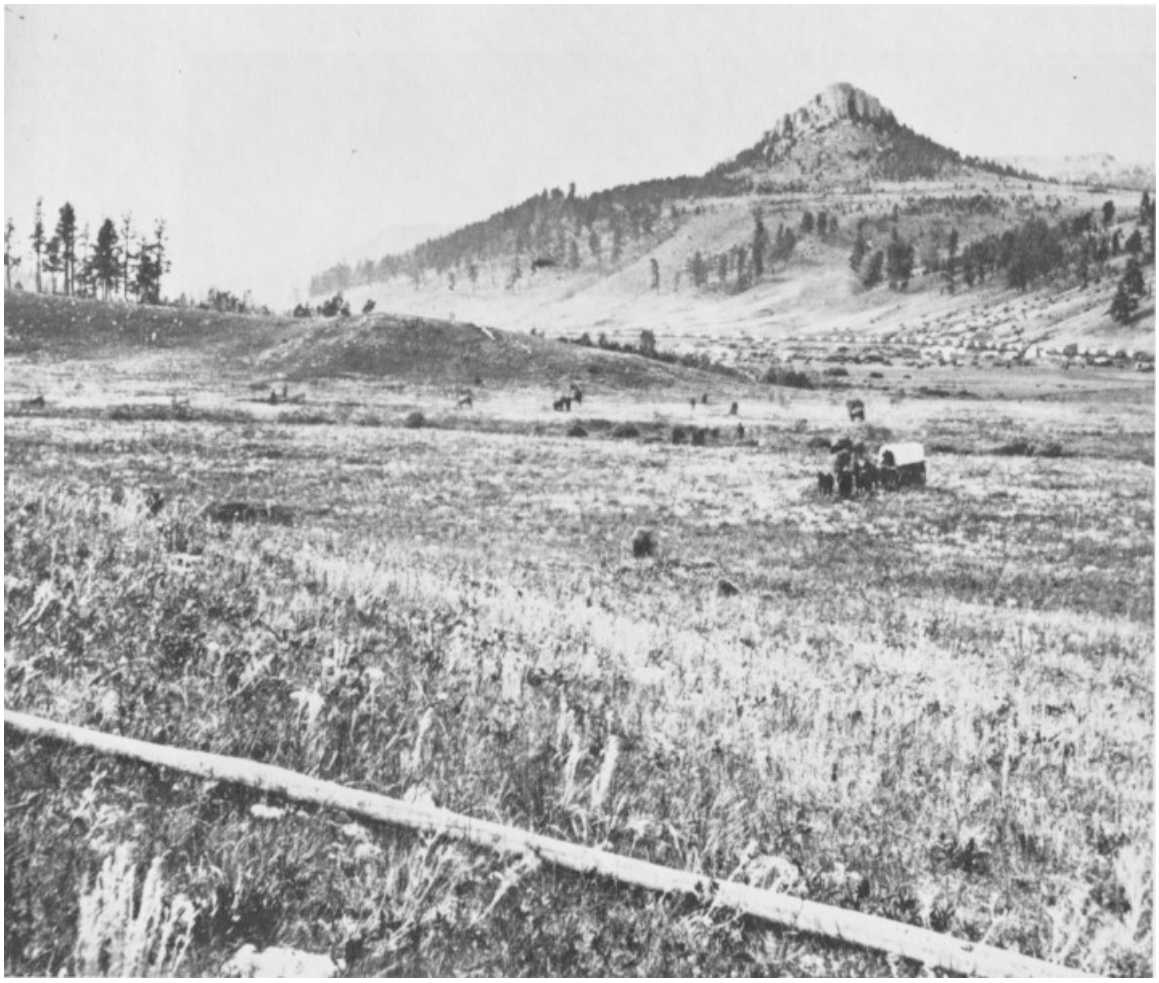

Figure 8. Figure 10-B from Progulske (1974), a repeat photograph taken in 1974, showing the valley adjacent to McIntosh fen.

Figure 9. Illustration of autumn willow, *Salix serissima* (Eduardo Salgado In Britton and Brown 1952, Holmgren 1998).

TABLES

Table 1. Conservation status of autumn willow, *Salix serissima*, in the United States and Canada (NatureServe 2001).

State/Province	Rank	Comments
Colorado	S1	Critically imperiled due to extreme rarity.
Illinois	S1	Critically imperiled due to extreme rarity.
New Brunswick	S1	Critically imperiled due to extreme rarity.
South Dakota	S1	Critically imperiled due to extreme rarity.
Vermont	S1	Critically imperiled due to extreme rarity.
Wyoming	S1	Critically imperiled due to extreme rarity.
Indiana	S2	Imperiled.
Montana	S2	Imperiled.
New Jersey	S2	Imperiled.
Newfoundland Is.	S2	Imperiled.
Ohio	S2	Imperiled.
Pennsylvania	S2	Imperiled.
British Columbia	S2S3	Vulnerable to Imperiled.
Connecticut	S3	Vulnerable to extirpation or extinction.
Massachusetts	S3	Vulnerable to extirpation or extinction.
Alberta	S4	Apparently secure.
Manitoba	S4	Apparently secure.
Ontario	S5	Demonstrably widespread, abundant and secure.
Saskatchewan	S5	Demonstrably widespread, abundant and secure.
Labrador (NF)	S?	Unranked.
Michigan	S?	Unranked.
Quebec	S?	Unranked.
Minnesota	SR	Reported.
New York	SR	Reported.
North Dakota	SR	Reported.
Northwest Territories	SR	Reported.
Wisconsin	SR	Reported.

Table 2. *Salix serissima* species associates, McIntosh Fen, Black Hills National Forest (Marriott and Faber-Langendoen 2000; Black Hills National Forest, June 2000).

Scientific Name	**Common Name**	**Family**
Achillea millefolium	Yarrow	Asteraceae
Agoseris glauca	False dandelion	Asteraceae
Argentina anserina	Silverweed	Rosaceae
Symphyotrichum falcatum var. falcatum	White prairie aster	Asteraceae
Aster spp.	Aster species	Asteraceae
Betula occidentalis	Water birch	Betulaceae
Bromus ciliatus	Brome grass	Poaceae
Calamagrostis canadensis	Canadian reedgrass	Poaceae
Carex nebrascensis	Nebraska sedge	Cyperaceae
Carex retrorsa	Knotsheath sedge	Cyperaceae
Carex rostrata	Beaked sedge	Cyperaceae
Cirsium arvense	Canada thistle	Asteraceae
Dasiphora (Pentaphylloides) floribunda	Shrubby cinquefoil	Rosaceae
Erigeron sp.	Fleabane	Asteraceae
Eriophorum polystachion	Tall cotton grass	Cyperaceae
Fragaria virginiana	Wild strawberry	Rosaceae
Galium boreale	Northern bedstraw	Rubiaceae
Gaillardia aristata	Blanket flower	Asteraceae
Gentiana affinis	Pleated gentian	Gentianaceae
Geum aleppicum	Yellow avens	Rosaceae

Scientific Name	Common Name	Family
Juncus balticus	Baltic rush	Juncaeae
Mentha arvensis	Field mint	Lamiaceae
Phleum pratense	Common timothy	Poaceae
Poa palustris	Fowl meadow-grass	Poaceae
Populus tremuloides	Quaking aspen	Salicaceae
Ranunculus aquaticus var. fenestratus	Whitewater crowfoot	Ranunculaceae
Salix bebbiana	Bebb willow	Salicaceae
Salix candida	Sage willow	Salicaceae
Salix interior Rowlee [*S. exigua* Nutt. ssp. *interior* (Rowlee) Cronq.]	Sandbar willow	Salicaceae
Salix petiolaris	Meadow willow	Salicaceae
Salix planifolia var. planifolia	Diamondleaf willow	Salicaceae
Salix pseudomonticola	False mountain willow	Salicaceae
Senecio pseudoaureus	Heart-leaved groundsel	Asteraceae
Thalictrum sp.	Meadow-rue	Ranunculaceae
Trifolium pratense	Red clover	Fabaceae
Valeriana dioica	Marsh valerian	Valerianaceae
Valeriana edulis	Tobacco root	Valerianaceae
Vicia americana	American vetch	Fabaceae
Viola sp.	Violet	Violaceae
Zizia aptera	Golden alexanders	Apiaceae