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Conservation Assessment of Hoary Willow in the Black Hills National Forest, South Dakota and Wyoming

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EXECUTIVE SUMMARY

Hoary willow, *Salix candida* Fluegge ex. Willd., is an obligate wetland shrub that occurs in fens and bogs in the northern United States and across Canada and Alaska (USDA NRCS 2001; NatureServe 2001). Disjunct, isolated occurrences of hoary willow in South Dakota, Wyoming, and Colorado may be relicts from the last Pleistocene glaciation. In Black Hills National Forest, hoary willow is currently known only from McIntosh Fen, a fen meadow complex that was privately owned from the 1930s until ca. 1980, when the Forest Service acquired it, subsequently designating it as a Botanical Area (USDA Forest Service 1997). Few if any surveys directed specifically at hoary willow have been done on the Black Hills National Forest, although no additional unsurveyed potential habitat sites for hoary willow are presently known on the Forest. Little is known about the absolute habitat requirements of hoary willow in the Black Hills National Forest. Ditching, agricultural use, loss of beaver (*Castor canadensis*), and fire suppression are believed to have altered the hydrology and species composition of McIntosh Fen (Reyher pers. comm. 2001). Restoration efforts beginning in 1997 included filling in ditches with straw bales, and more recently during October 2001, the first prescribed burn of adjacent upland spruce habitat to rejuvenate aspen stands and promote sustainability of future reintroduced beaver populations into the Castle Creek watershed. The site is also protected from off-road vehicles (except for snowmobile use restricted to a designated trail that is not in the known hoary willow locations) and livestock use.

Another rare willow species, autumn willow, (*Salix serissima* **(**Bailey) Fern.) occurs at McIntosh Fen, currently the only known Forest Service hoary willow site in the Black Hills, and has been the focus of additional restoration efforts including population censuses, planting of cuttings, and protection of young willow seedlings/sprouts with wire exclosures to limit wildlife browsing. Although overall expansion of the entire willow population at McIntosh Fen since the early 1990's may be due to a variety of factors such as more intensive surveys, better timing for identification, recent wet years, etc., surveys of autumn willow in June 2000 and 2001 suggest that the population may also be responding favorably to initial restoration efforts.

The basic management objectives for McIntosh Fen as a Botanical Area provide a good process-based conservation framework for minimizing risks to hoary willow in Black Hills National Forest by restricting road access, livestock use, and mineral development, and promoting restoration of natural disturbances such as fire and beaver activity. Continued expansion of upland forests, water table declines, and absence of beaver habitat and populations are the predominant natural risk factors. Conservation and enhancement of hydrologic resources throughout the watershed is essential, not only within McIntosh Fen, but also on upstream areas, including private lands. This may involve coordination with upstream landowners to minimize potentially harmful activities such as water diversions that could jeopardize resources within the fen. Additional vegetation treatments (i.e. significantly reducing adjacent conifer stand densities through timber harvest or thinning and/or prescribed burnings of uplands, adjacent meadows, and possibly the fen) may help to raise the water table, restore woody plants for beavers, and rejuvenate the willow population. Ultimately, reintroduction of beavers into the drainage is highly desirable to sustain this obligate wetland species.

Key words: hoary willow, beaver ecology, Black Hills, fen, *Salix candida*, wetland restoration.

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INTRODUCTION

The objective of this assessment is to review the status of hoary willow in the Black Hills and to synthesize information relevant to its management and long-term persistence. Detailed information about the habitat needs and life history of hoary willow, and its responses to management activities is generally lacking, resulting in a fairly low state of knowledge about this species. Since published literature on hoary willow and its habitats is sparse, other sources of information were important in developing this assessment. The USDA, NRCS PLANTS Database is referenced extensively in this document, although the geographical basis and source of specific habitat data is unknown and may not be directly applicable to the Black Hills in all instances. This document was developed in accordance with content and format requirements defined by the Black Hills National Forest.

Hoary willow, *Salix candida* Fluegge ex. Willd., is an obligate wetland shrub that occurs in Alaska and Canada, from Newfoundland to British Columbia, and across the northern portion of the United States, extending south to Colorado, Illinois, and Indiana (Figures 1-3) (Gleason and Cronquist 1991; USDA NRCS 2001; NatureServe 2001). Across the species' range, its conservation status varies from secure in northern boreal regions to imperiled or critically imperiled due to extreme rarity in southerly disjunct populations, probably due in part to habitat limitations at the periphery of its range (NatureServe 2001). Hoary willow is a "species of special concern" with the South Dakota Natural Heritage Program (Ode pers. comm. 2001). The rare occurrences in the Great Plains, Black Hills, and Rocky Mountains are likely relicts from the last Pleistocene glaciation 11,000 years ago (Froiland 1962; Price *et al*. 1996).

The only known occurrence of hoary willow in the Black Hills is at McIntosh Fen, a rare, calcareous fen meadow complex in Pennington County. McIntosh (1924) reported an additional location between Loring and Hot Springs, but this has not been located since his initial report, although the specimen has recently been authenticated as *Salix candida* by Dorn (Ode pers. comm. 2002). Several smaller populations are known from northeastern South Dakota, one on the Waubay National Wildlife Refuge, the other four on private land (SDNHP 1983, 1984, 1986, and 1995). The hoary willow population at McIntosh Fen is the largest in the state. At this time, it is unknown what activities are taking place at the hoary willow sites on private land. The approximately 640 A (259 ha) McIntosh Fen Botanical Area is administered by the Black Hills National Forest and includes approximately 20 A (8.1 ha) of spring-fed wetland surrounded by a large meadow buffer. The site is in a wide valley of the Castle Creek drainage where the western edge of the crystalline core (metamorphic material) meets the limestone plateau (sedimentary material) of the Black Hills (Froiland 1999). This geologic interface may be partially responsible for the existence of the fen. Arthur McIntosh originally described the fen's pristine, diverse plant community in 1924 as a "sedge moor", inhabited by autumn willow (*Salix serissima* **(**Bailey) Fern.), hoary willow, and numerous rare wetland species (McIntosh 1930). An earlier report by Lt. Colonel Dodge, circa 1876, suggests that beaver were historically a major habitat component in the fen (Turchen and McLaird 1975). Photos by McIntosh from the 1930's clearly show beaver dams within the fen (Ode pers. comm. 2002).

McIntosh Fen has been significantly altered by landscape scale ecological changes since non-native settlement of the region beginning in the late 1800s. In addition, agricultural use while the fen was under private ownership from 1930 until it was acquired by the Forest Service ca. 1980

has altered the hydrological functioning of the fen. The wetland and surrounding lowlands have been impacted on several fronts. The extirpation of beaver (*Castor canadensis*) from the Castle Creek drainage has lowered the water table and changed the floristic composition within the fen (Ode pers. comm. 2001). Fire suppression has resulted in an increased density of conifers, reduced aspen and other hardwoods in uplands, and likely has reduced groundwater flow into the fen. The fen was ditched for use as a hay field and livestock pasture while under private ownership (USDA Forest Service 2000).

The even rarer autumn willow also occurs at McIntosh Fen and has been the focus of census surveys and specific restoration efforts including plantings of cuttings and exclosures to limit wildlife browse. Autumn willow is rarer in all of the Region 2 Forests combined than hoary willow, but currently is not rarer than hoary willow in the Black Hills (Reyher pers. comm. 2001). Approximately fifty autumn willow plants remained at the site in 1984 (Reyher pers. comm. 2001). The Black Hills have experienced higher precipitation years since 1993 that likely benefited riparian/wetland species in general and likely has contributed to expansion of hoary and autumn willows as well. In 1995 (USDA Forest Service 1995), a meeting was held to discuss measures to protect and restore the hydrology and ecology of the fen and enhance the recovery of autumn willow. Implementation began in 1997 and by June 2000, a total of 357 autumn willow plants, including restored cuttings, were located within the fen and an additional 100 plants were found the following year. This may suggest a recovery response of autumn willow and similar benefits for hoary willow may also be expected to occur as restoration efforts continue and are expanded. Similar monitoring data could also be collected for hoary willow to assess its response to ongoing restoration efforts. Even if similar benefits are found to occur for hoary willow, the population may still be at risk due to changes to the fen's long-term hydrologic functioning and the potential for noxious weed invasion.

CURRENT MANAGEMENT SITUATION

Management Status

International

Global Heritage Status Rank: G5; secure worldwide, but possibly quite rare in parts of its range, especially at the periphery (NatureServe 2001).

Federal

Hoary willow has no special federal status and is not a designated "Sensitive" species in USFS Region 2 (USDA 1994) or "Special Status" plant species for the BLM (USDI BLM 1997).

Throughout its range, hoary willow is strongly associated with fens, bogs, and marshy habitats, frequently with a minerotrophic quality (i.e., high mineral content and high pH) (Mitsch and Grosslink 1993; Cooper 1996). As expected, hoary willow is rare where suitable habitat is more limited at the periphery of its range. In addition, human activities may have directly and indirectly impacted the quality, quantity, and distribution of hoary willow's wetland habitats. Accordingly, hoary willow is imperiled (S2) or critically imperiled due to extreme rarity (S1) at the southern limits of its range in South Dakota, Wyoming, and Colorado where suitable

available habitat is limited, while populations that occur in Montana, Connecticut, Vermont, and Canadian provinces are generally more secure since these areas may offer more abundant preferred habitat (NatureServe 2001).

A single population of hoary willow currently occurs on Black Hills National Forest (BHNF) in the McIntosh Fen Botanical Area. The fen and its surrounding uplands were given administrative designation as a Botanical Area in 1997 (USDA Forest Service 1997). Under this direction, the Botanical Area is to be managed in such a way that the attributes for which it was established are not impaired. The primary values for which the area was designated were the botanical features associated with McIntosh Fen, including hoary willow. Livestock have been excluded from the fen since ca. 1985, and beginning in 1997, active restoration of the fen began. Because the other smaller populations of hoary willow in South Dakota occur on private land outside of the Black Hills and population conditions are unknown, they are given limited consideration in this assessment. Further management details are presented in REVIEW OF CONSERVATION PRACTICES – Management Practices.

Conservation Status

State	RANK	COMMENTS	SOURCE
South Dakota	S1	Critically imperiled due to extreme rarity.	NatureServe 2001.

Conservation Status - Elsewhere

State/Province	Rank	Comments	Source
U.S.			
Colorado, Wyoming	S2	Imperiled	NatureServe 2001.
Washington, Maine, Pennsylvania	S1S2	Critically Imperiled - Imperiled	NatureServe 2001.
Idaho, Iowa, Ohio, New Jersey	S2	Imperiled	NatureServe 2001.
Alaska, Illinois	S2S3	Imperiled - Vulnerable	NatureServe 2001.
Vermont, Connecticut,	S3	Vulnerable	NatureServe 2001.
Montana	S3S4	Vulnerable – Apparently Secure	NatureServe 2001
North Dakota, Indiana, Minnesota, Nebraska, New Hampshire, New York, Wisconsin	SR	Reported	NatureServe 2001
Massachusetts, Michigan	S?	Unranked	NatureServe 2001
Canada			
Nova Scotia, Prince Edward Island	S1	Critically Imperiled	NatureServe 2001
Alberta	S4	Apparently Secure	NatureServe 2001
Ontario, Manitoba, Saskatchewan,	S5	Secure	NatureServe 2001
Labrador, New Brunswick, Newfoundland, Northwest Territories, Yukon Territory	SR	Reported	NatureServe 2001
British Columbia	S?	Unranked	NatureServe 2001

Existing Management Plans, Assessments Or Conservation Strategies

No other management documents were identified for hoary willow.

REVIEW OF TECHNICAL KNOWLEDGE

Systematics

Citation: Fluegge ex.Willd., Bot. Gaz. 17:152. 1892.

There are 23 *Salix* species in South Dakota, including four subspecies and varieties, and four introduced species and their hybrids (BONAP 2001). Hoary willow, *Salix candida* Fluegge ex. Willd., is classified as Class Magnoliopsida (Eudicots), Subclass Dilleniidae, Order Salicales, Family Salicaceae (Willow Family), Genus *Salix*, Subgenus Vetrix (Dumort.) Dumort., Section *Candidae* C. K. Schneider. (Dorn 1992; Argus 1999). Alternative taxonomic treatments include *Salix candidula* Nieuwl. Two varieties have been recognized, *S. candida* var. *denudata* Anderss., and *S. Candida* var. *tomentosa* Anderss. (ITIS 2001). *S. wiegandii* Fernald (Rhodora 35:243. 1933) is treated as a species of hybrid origin, *S. Calciola* x *S. candida* (Argus 1999). The Heritage Identifier for hoary willow (*Salix candida* Fluegge ex.Willd.) is PDSAL020K0. Although local specimens have been readily defined as hoary willow, no comprehensive range-wide review of specimens has been undertaken. According to Dorn (pers comm. 2002), Black Hills hoary willow material does not appear to depart significantly from descriptions of the species although specimens exhibit varying degrees of pubescence. Dorn is of the opinion that varietal status is not worth recognizing because of variability due to hybridization.

Species Description

Non-Technical

Hoary willow, also commonly known as sageleaf, sage, or bog willow is a perennial, deciduous shrub 3 to 9 ft (1 to 3 m) tall, with densely tomentose twigs and branchlets (Dorn 1997; USDA Forest Service Intermountain Region 1989; VanBruggen 1976). Distinguishing characteristics include: narrow, entire, revolute leaves with densely white-wooly pubescent undersides, and white wooly branchlets of the year (Dorn 1997; USDA Forest Service Intermountain Region 1989). The dense tomentum on branches and leaves readily distinguishes hoary willow from other Black Hills willows, resulting in an overall appearance the color of "sage".

Technical

"Low shrub to 1.5 m tall; twigs yellow to reddish-brown or brown, usually with patches of white tomentum; branchlets strongly ascending, yellow to brown, mostly white-tomentose. Leaves dark green and glabrate or thinly white-tomentose above, densely white-tomentose beneath, linear-oblong to oblong or narrowly lanceolate, acute at the tip, cuneate at the base, mostly 3-9(11) cm long, 0.5-1.5(2) cm wide, the margin revolute; petioles glandless, 3-10 mm long; stipules persistent, obliquely ovate to lanceolate, 2-10 mm long, tomentose, entire or serrulate. Catkins emerging with the leaves; pistillate catkins 1.5-4.5 cm long, on leafy branchlets 4-15 mm long, with 2 or 3 leaves; bracts persistent, yellow to brown, villous; stamens 2. Capsules narrowly ovoid, 4-8 mm long, white-tomentose; stipes 1 mm long. (2n=38) flowers May, fruits

May-June." (McGregor and Barkley 1986).

Species Significance

Although it ranges across the northern portion of the continent, hoary willow is present in Region 2 only as widely scattered occurrences. In the Black Hills, it is restricted to a single rich fen habitat, where it occurs as part of an unusual shrub carr, or wetland shrub, plant community (Ode pers. comm. 2001). As the largest occurrence of hoary willow currently known in the state, the McIntosh Fen population may be an important source of genetic diversity, although no specific data is available. It's also possible that additional populations and suitable habitat may exist on private land in other parts of the state that have not been surveyed. Due to their unique physical characteristics, fens commonly support assemblages of glacial relict species that have become reduced and isolated during the drying trend since the last Pleistocene glaciation 11,000 years ago (Steinauer 1992). Shrub carr vegetation provides habitat for wetland wildlife and creates microtopographic variation that supports other rare plant species at McIntosh Fen, and may influence other rare or relict species (Ode pers. comm. 2001; USDA Forest Service 1997; SDNHP 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, including hoary willow (Price *et al*. 1996). Insect pollinators and animal herbivores may utilize hoary 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 antihemmorhagic, and as a cold remedy (Moerman 1998). The bark of *S. lucida* 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 for *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 tribes including the Blackfoot, Cree, Dakota and Omaha (Moerman 1998). There is no record for the use of hoary willow as an ornamental species or for other commercial purposes.

Distribution And Abundance

Hoary willow is known from Alaska south and east through the boreal forest and northern prairies of Canada and northern United States (Welsh 1973). The species is secure throughout its range with a G5 ranking, but infrequent across much of the U.S. with Region 2 state numerical rankings ranging from S1, critically imperiled; to S2, imperiled (NatureServe 2001). In the Black Hills, Wyoming, and Colorado, hoary willow approaches the southern end of its range and generally occurs as scattered, disjunct populations (Ode pers. comm. 2001; NatureServe 2001). The first report of hoary willow in South Dakota was in 1924 at McIntosh Fen. This population remains the largest in South Dakota, and appears to have suffered only minor impacts as a result of historic ditching activities at the site (Ode pers. comm. 2001). Other currently known occurrences of hoary willow in South Dakota are restricted to cool, boreal remnant fen and seep habitats in the northeastern counties of Day, Roberts, Deuel, and Grant (SDNHP 1983, 1984, 1986, and 1995).

Distribution Recognized In Primary Literature

The Black Hills were not glaciated during the Pleistocene era and are known to have supported vegetation during that cooler and wetter period when coniferous forests may have linked the Hills with surrounding areas, including the Rocky Mountains to the west (Froiland 1999). The preference of hoary willow for fens and bogs and its distribution across the northern portion of the continent is consistent with a species that may have ranged farther south and at lower elevations during the Pleistocene. As the climate became warmer and drier, such relict species became more restricted and isolated in their range. Hoary willow occurs in fens, bogs, swamps, and marshes from Newfoundland to British Columbia and the Northwest Territories, and south to Illinois and Colorado; but is most common in peatlands of central Canada and the northern United States (Hitchcock *et al*, 1971; Argus 1973; NatureServe 2001; USDA NRCS 2001; Welsh 1973). Although reported from Nebraska according to NatureServe (2001), the Nebraska State Heritage Program is not aware of any published report of hoary willow from Nebraska, nor any Nebraska specimens so identified (Steinauer pers. comm. 2001). The species' distribution is presumably due to its obligate association with fen and bog wetlands. Its scattered distribution in the Rocky Mountains, Black Hills, and Great Plains is likely the result of the geographic isolation of wetland habitats in these regions during the current inter-glacial drying trend (Froiland 1962; Price *et al*. 1996). Hoary willow's current distribution closely parallels the distribution of calcareous fens in North America (Froiland 1962; Wendt 1984 in Reed 1985). The species was presumably more widespread historically when cooler, wetter climatic conditions prevailed in now disjunct habitat areas and prior to elimination of suitable habitat via human activities such as draining or filling of wetlands. The species' reported habitats in the Rocky Mountains are similar to those found at McIntosh Fen, i.e., cool, rich, minerotrophic fens (Lesica 1986; Cooper 1996). The metapopulation of hoary willow in the Black Hills is comprised of the single population at McIntosh Fen. It is not known if there is any genetic exchange between the other locations in the state or region, but it is not likely since the nearest populations to the Black Hills are at least 200 miles distant in any direction.

In Montana, hoary willow occurs in association with swamps and fens in western and central portions of the state (Lesica and Shelly 1991; Dorn 1992). The most well-known and documented occurrence in Montana is found at Pine Butte Swamp, a Nature Conservancy preserve in Teton County (Lesica 1986). While present as scattered individuals across much of Pine Butte Fen in Montana, hoary willow is a dominant shrub only in portions of the dwarf-carr community type, along with *Betula glandulosa, Cornus sericea*, and *Potentilla fruticosa* (Lesica 1986). Herbaceous associates include *Caex aquatilis*, *C. simulate*,*C. lasiocarpa*, *Juncus balticus*, *Triglochin maritima*, *Equisetum arvense*, *E. laevigatum*, and *Galium boreal* (Lesica 1986). In contrast to McIntosh Fen where numerous hoary willow individuals occupy water tracks, hoary willow and other shrubs and most forbs typically occupy hummocky areas, whereas graminoids and *Equisetum* spp. occupy water tracks in Montana's Pine Butte Fen (Lesica 1986). As in McIntosh Fen, acidophiles such as *Sphagnum* and various Ericaceous species are absent from Pine Butte Fen (Lesica 1986). Pine Butte Fen is situated at an elevation of 4600 feet with a mean annual temperature of 6.0 C and mean annual precipitation estimated at 430 mm (Lesica 1986). The Pine Butte area is underlain by calcareous glacial outwash comprised of limestones and shales. Water from the Teton River flows south through this permeable till and rises to the surface in Pine Butte Fen, providing a nearly constant supply of cold, nutrient–enriched water. Differing rates of water flow through the Pine Butte Fen may be responsible for much of the vegetation patterning flowing south (Lesica 1986).

Additional Information From Federal, State, And Other Records

Five additional occurrences of hoary willow in northeastern South Dakota have been located since 1982, four on private land and one on the Waubay National Wildlife Refuge managed by U. S. Fish and Wildlife Service (SDNHP 1983, 1984, 1986, and 1995). All South Dakota currently known element occurrences (EO's) are reported from fens except the Waubay occurrence which is reportedly a seep, subject to managed water levels. These areas reportedly range from approximately .5 acres to 80 acres in size, with population estimates generally absent, but ranging from "small population of two plants" to a "nice colony" approximately 10 meters in diameter. No other information regarding reproductive status of the plants was reported. One property owner indicated that "cattle readily browse this willow" and several areas were reportedly "overgrazed" (SDNHP 1983, 1984, 1986, and 1995). It may be assumed that hoary willow's wetland habitats on private lands could be at risk from agricultural land use and development.

According to Ode (pers. comm. 2002), "In addition to the McIntosh Fen occurrence of *Salix candida*, there is a second Black Hills record: "Hot Springs to Loring, SD. Moist clay hillside. 2 May, 1924. A. C. McIntosh #22 (RM)." Hot Springs is located in Fall River County, while the ghost town of Loring is located in Custer County. This is apparently the source of these counties being cited on various distribution maps (e.g. Dorn 1997, Gt. Plains Flora Assoc. 1977).

I've been aware of this specimen since the 1980's but questioned its identity until just recently when Bob Dorn verified the identification (pers. comm with Dr. Robert Dorn, Jan. 2002). It apparently puzzled Arthur McIntosh too, and I suspect that he originally sent it to Aven Nelson for identification. It also raises doubts when McIntosh never cited this specimen in any of his several publications on the plants of the Black Hills (i.e., McIntosh 1926, 1928a, 1928b, 1930, 1931). Nor was it cited by W. H. Over in his 1932 publication "Flora of South Dakota," nor was it cited by Froiland (1962).

In September 2001, Bob Dorn drove the back roads between Hot Springs and Loring Siding and did not see anything that resembled potential habitat. However, there is a lot of private land in this area and it's possible that there could still be a fen or seepage area that might support this willow (this landscape is one of the hottest, driest portions of the Black Hills; so this occurrence has always seemed improbable)." In Wyoming, the species is not tracked by the state Heritage Program (Fertig pers. comm. 2001). The Atlas of the Flora of Wyoming (Figure 3) depict hoary willow occurrences in the Medicine Bow Mountains of Albany County near Laramie, Yellowstone Park and adjacent Park County and in the Wind River Mountains in Sublette County (University of Wyoming 1998).

In Colorado, hoary willow occurs in nutrient rich fens, along edges of ponds and on river terraces, from 8800 to 10600 ft in Gunnison, Hinsdale, LaPlata, Larimer, and Park counties (Spackman *et al.* 1997). At High Creek Fen, a nutrient-enriched, calcareous fen in Park County, three rare species, hoary willow, autumn willow, and low blueberry willow (*Salix myrtillifolia*), reach the southern limit of their distributions in the most southerly location of extreme rich fen conditions found in North America (Cooper 1996). Hoary willow also occurs in several other calcareous fens in Park County although autumn willow is absent (Spackman *et al*. 1997). Hoary willow also occurs on the Arapahoe/Roosevelt National Forest/Pawnee National Grassland, Grand Mesa, Uncompahgre, and Gunnison National Forests, Pike and San Isabel National Forest/Comanche National Grassland, Rio Grande/San Juan National Forest, and may

be present on BLM Cañon District in the Royal Gorge Resource Area (Spackman *et al.* 1997).

Local Abundance

There are six Element Occurrence (EO) records for hoary willow in South Dakota. The only currently known occurrence of hoary willow in the Black Hills is from McIntosh Fen. As a result of early widespread botanical surveys during late 1800's expeditions, and ongoing surveys of all other similar habitat on BHNF, only one other verified specimen has been reported, but the population has never been relocated (Ode pers. comm. 2001). As with most of the Black Hills, beaver populations may have declined in the McIntosh Fen area by 1920-1930, although McIntosh's photos clearly show the presence of beaver dams (Ode pers. comm. 2001; Reyher pers. comm. 2001). Loss of beaver likely would have reduced the overall watertable elevation and available willow habitat in and around the fen. Although the fen was ditched during the 1930's, overall aerial coverage of willows does not seem much less extensive today than in historical pre-disturbance photos circa 1920-1930 (Ode pers. comm. 2001). The restricted currently known occurrence of hoary willow in the Black Hills may be due to naturally limited habitat availability (Ode pers. comm. 2001).

Population Trend

The long-term persistence of hoary willow in the Black Hills is likely dependent upon the continued maintenance and enhancement of the population at McIntosh Fen. No specific population trend monitoring data is available for hoary willow at McIntosh Fen. However, recent data gathered on a similar species, autumn willow, reveals a greater number of individuals than had been previously documented. It is suspected, but unknown, if the recent series of high precipitation years since 1993 and-recent restoration efforts, have contributed to the expansion (Reyher pers. comm. 2001). This may have favorable implications for the hoary willow population as well. However, the species' ability to disperse elsewhere in the Black Hills may be determined by the quality and extent of wetland habitats, which is primarily a function of availability of suitable minerotrophic fen habitat and the degree of beaver activity (Parrish *et al*. 1996).

Broad Scale Movement Patterns

The Black Hills populations of hoary willow are over a hundred miles away from the nearest populations, which are in southeast Wyoming and northeast South Dakota. Hoary willow seeds or pollen may be expected to travel considerable distance, but natural transfer of seed material from other hoary willow populations or export to other suitable habitat is unlikely. Water transport is conceivable on a localized basis, but not likely as a means of long range transport, especially in the absence of direct transfer routes. Migratory birds or insects may represent a likely mode of transfer under present climatic conditions. The disjunct Black Hills population of hoary willow may be an important source of genetic diversity. If the Black Hills population was extirpated, it is unlikely that natural recolonization would occur.

Habitat Characteristics

Hoary 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, and

stream banks at low to mid-elevations (Argus 1974; Lesica 1984; Gleason and Cronquist 1991; Scoggan 1978; Spackman *et al*. 1997). Based on available distributional records and habitat descriptions, hoary willow appears to be strongly associated with wetlands with relatively high nutrient availability and pH (5.7 to 8.3), often described as rich or extreme rich conditions (Lesica 1986; Cooper 1996; Spackman *et al*. 1997; Marriott and Faber-Langendoen 2000; USDA NRCS 2001). Hoary willow appears to require a shallow water table and saturated soils, as it is currently limited to the low-lying areas of the McIntosh Fen meadow complex, and exhibits a preference for similar conditions (e.g., springs and water tracks) where it occurs in Wyoming, Montana, and Colorado (Cooper 1996).

The hoary willow population at McIntosh Fen occurs in an open, low gradient portion of the Castle Creek drainage one mile west of Deerfield Reservoir within the single fen type, Hoary Willow Fen (*Salix candida*/*Carex rostrata* Shrubland; G3; CEGL001188), found in the Black Hills (McIntosh 1930; Marriott and Faber-Langendoen 2000). The McIntosh Fen Botanical Area encompasses approximately 640 A (259 ha), including the fen and a large meadow buffer. The site is at the eastern edge of the central Limestone Plateau of the Black Hills in a wide section of the Castle Creek drainage at 6000 ft (1829 m) elevation (Black Hills Community Inventory 1999). Castle Creek passes between the fen and County Road 308 from the northwest, and springs and seeps feed into the fen from calcareous bedrock on the southwest side of the valley (SDNHP no date). Silver Creek, a tributary of Castle Creek, and a large smooth brome *(Bromus inermis)* grass meadow bisect the Botanical Area into upper and lower regions, both of which contain concentrations of hoary willow. The current fen wetland area of approximately 15 to 20 A (6.1 to 8.1 ha) is smaller than originally reported, probably because the water table had been lowered by agricultural use while the site was under private ownership, and possibly because of declines in beaver populations (McIntosh 1930; Marriott and Faber-Langendoen 2000). However, a decline in overall willow cover is not evident based on comparison of historic (pre 1930 photos) and current conditions (Ode pers. comm. 2001). The fen's soils are an organic Histosol inclusion within the Cordeston-Marshbrook loams (thick Mollisols) typical of mountain meadows in the Crystalline Core area of the Black Hills (USDA SCS 1990).

Total annual precipitation at Deerfield Reservoir, Black Hills, South Dakota averages 23 in (58.4 cm), with average temperatures ranging from 0.8 (-17.4 C) (January) to 76.4 F (24.7 C) (July); precipitation is concentrated in the early summer months from April (2.59 in; 6.6 cm) through June (4.3 in; 10.9 cm); first frost is in early September and last frost in mid-June; average total annual snow fall is 155.7 in (395.5 cm); and extreme temperatures for 1998 and 1999 ranged from minus -17 to 90 F (-27.2 to 32.2 C) (High Plains Regional Climate Center 2001). Winter snows are often deep enough to cover willows at McIntosh Fen completely (Reyher pers. comm. 2001).

The McIntosh Fen meadow complex contains three primary plant community types: Hoary Willow Fen, Nebraska Sedge Wet Meadow (*Carex nebrascensis* Herbaceous Vegetation; G4; CEGL001813), and Baltic Rush Wet Meadow (*Juncus balticus* Herbaceous Vegetation; G5; CEGL001838) (Marriott and Faber-Langendoen 2000). The co-dominance of hoary willow and autumn willow distinguishes the Hoary Willow Fen from Bebb Willow or Sandbar Willow Shrubland community types (Marriott and Faber-Langendoen 2000). Willow species at McIntosh Fen include hoary willow, autumn willow, sandbar willow (*Salix interior*), bebb willow (*S. bebbiana*), and serviceberry willow (*S. pseudomonticola*). Both hoary willow and autumn willow are commonly associated with calcareous habitats (Cooper 1996) 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 Hoary Willow Fen. Baltic rush is the primary graminoid species at the fen, where it occurs in large dense patches with Nebraska sedge (*Carex nebrascensis*), Canadian reedgrass (*Calamagrostis canadensis*) and common timothy (*Phleum pratense*) (Marriott and Faber-Langendoen 2000). In the lowest elevations (having the highest water tables) of the McIntosh Fen Botanical Area, *Salix petiolaris*, *S. planifolia* var. *planifolia*, hoary willow, autumn willow and shrubby cinquefoil (*Pentaphylloides floribunda*) are common and sedges and grasses dominate the herbaceous layer (Marriott and Faber-Langendoen 2000). Spruce and aspen (*Populus tremuloides*) occupy the north-facing slopes just outside of the Botanical Area designated boundary. Aspen have apparently declined as spruce expanded their coverage due to fire prevention in the Black Hills over the last 120 years (Ode pers. comm. 2001).

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*) which prefers beaver-created habitats (Marriott pers. comm. 2001). These species have not been observed at the fen since it was altered ca. 1930 (SDNHP no date; Marriott and Faber-Langendoen 2000).

The autumn willow cuttings that were planted in 1997 have become established in and around the rehabilitated ditches, and there are also numerous individuals scattered throughout the lower and upper portions of the fen. At the smaller concentration in the upper fen, autumn willow occurs with hoary willow and large thickets of serviceberry willow. Aspen are scattered in both the lower and upper parts of the fen. The central and roadside portions of the Botanical Area consist primarily of non-native brome grass, presumably planted as a hay crop while the property was privately owned, interspersed with native and weedy grasses and forbs. 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 aquifer at McIntosh Fen may be fairly shallow as the area exhibits a relatively rapid response to short term climate fluctuations, such as seasonal droughts (Ode pers. comm. 2001). Attempts to reintroduce beaver to the McIntosh Fen area have proved unsuccessful to date, presumably due to the inadequacy of existing aspen stands to support on going beaver populations (Ode pers. comm. 2001).

The calcium carbonate-enriched spring water that feeds into McIntosh Fen has contributed to a unique assemblage of species that is distinctly different from other wetlands in the area (South Dakota Natural Heritage Program Records, no date). The plant community at McIntosh Fen does not display the microtopographic pattern of ridges and valleys often seen in boreal bogs and fens, nor does the fen possess an organic substrate comprised of decaying *Sphagnum* moss typical of boreal wetlands (Mitsch and Gosselink 1993; Slack *et al*. 1980; Lesica 1986). The lack of microtopographic features may be due to a variety of factors including fluvial disturbance from Castle Creek, backwater areas created by historic beaver activities, or physical disturbance by livestock and native big game species, including bison, most likely during periods of extended drought. Black Fox bog, an acidic iron fen eight miles to the north of McIntosh Fen, possesses numerous acid-loving species including *Sphagnum* and members of the Ericaceae (Cooper 1991; Walters and Keil 1996; Illinois State Museum 1992). Ericaceous species are common in acidic, nutrient depleted environments (Walters and Keil 1996; Lesica 1986), but are absent from McIntosh Fen. This is presumably due to the nutrient rich character of the fen. Black Fox is highly shaded due to a dense canopy of white spruce in contrast to McIntosh Fen which has an

open canopy, none of which is spruce related, and only an occasional aspen occurs within the Botanical Area.

The effect of fire as a disturbance factor on hoary willow in McIntosh Fen is unclear. Many bog and fen habitats appear to be relatively constant environments and may not be routinely affected by physical disturbance such as fire or fluvial action. Unlike what may occur at other fens, McIntosh Fen may have been and may still be periodically affected by the physical disturbance of fluvial action because of its close proximity to Castle Creek. It is conceivable that fluvial disturbance and historic beaver may have shifted the Castle Creek channel at times through portions of the Fen, especially if the Fen was bigger historically than at the time of McIntosh's photos or today. Also, during extended years of drought, it is conceivable that hot fires could have accessed drier conditions at this site and could have burned through willows, at least in a patchy manner. Bison are believed to have historically grazed grassy side slopes and did accessed areas of Castle Creek, as evidenced by numerous bison bones collected by Illinois State Museum during their research project at Castle Creek (Saunders 1996). Bison may be expected to have impacted the area through grazing and trampling within the fen, most likely during drought periods, although this is unknown.

Hoary willow occupies bog and fen habitats that originate from both granitic and calcareous parent material, which suggests that it is not exclusive to rich fens, although many known habitats within the Rocky Mountains have minerotrophic qualities (Cooper 1996; Lesica 1986; Fertig 1994). At McIntosh Fen, High Creek Fen in Colorado, Pine Butte Swamp in Montana, and other disjunct cordilleran locations, hoary willow appears to be limited to springs or seeps at mid to high elevations (McIntosh 1930; Froiland 1962; Lesica 1986; Cooper 1991, 1996). Hoary willows' habitat requirements in this portion of its range could be due to arid conditions or other factors and may be very different from its habitat needs to the north and east, where the species frequently occurs in relatively acidic wetlands (Scoggan 1978; Ode pers. comm. 2001). Hoary willow is typically associated with calcareous or alkaline wetlands in Canada, but is also frequently found in peat bogs of central Canada and the northern U. S. (Scoggan 1978; Ode pers. comm. 2001). Unoccupied potential habitats for hoary willow may occur in the Black Hills and in the intermediate areas between populations along the Rocky Mountains from Montana to southern Colorado. The reasons for the species absence from these habitats may be due to highly specific micro-site requirements, dispersal limitations, the absence of beaver or other disturbance that facilitates plant establishment, or habitat needs that have yet to be discovered.

The literature contains no specific references to competitive interactions that would limit the distribution of hoary willow in any portion of its range. Because hoary willow prefers saturated, nutrient rich habitats, both belowground and aboveground competition may be nominal, although some interspecific competition with other wetland shrubs, such as other willows, is likely. Hoary willow is presumably subject to the same risks as other native wetland plants from competitive exclusion by invasive wetland weed species. Grazing and browsing can have both direct and indirect negative effects on willow species (Cates *et al*. 1999; Hoffman and Alexander 1987). Browsing by deer, elk, insects, or livestock can reduce photosynthetic tissues and plant viability, particularly where the plant is already stressed (Cates *et al*. 1999). Livestock may directly impact hoary willow by trampling seedlings and young plants, and indirectly by altering the microtopography and nutrient dynamics of the species' habitats (USDA Forest Service 2000). The primary ecological stressors to hoary willow appear to be impacts to local hydrology, competition from weedy species, and predation 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 limitations or habitat requirements are a factor. The widely distributed Baltic Rush Wet Meadow (*Juncus balticus*) community type occurs in the Black Hills only at McIntosh Fen, though Baltic rush appears to have a broader ecological amplitude than hoary willow since it occurs elsewhere in the Hills (Marriott and Faber-Langendoen 2000). This pattern suggests that unique edaphic conditions or other ecological associations occur at the fen. The species' limited distribution may be partially due to the cumulative effects of human activities on wetlands and the resulting trend toward geographically isolated wetland habitats, although it is unknown as to whether any other place in the Hills actually provided for all of its ecological needs, even historically. Overall, it appears that the species' distribution is facilitated by a combination of geologic and hydrologic conditions and may include a facultative relationship with beaver in some areas.

Demography

Life History Characteristics

Hoary willow is a native perennial obligate wetland shrub associated with fens and marshes across its range (USDA NRCS 2001). It exhibits a high tolerance to or may even require anaerobic conditions, is an apparent calciphile, has high tolerance to fire, and is reportedly intolerant of salinity (USDA NRCS 2001). As with many willows, it is vernally adapted with active, rapid growth occurring in spring and summer. The flowering period is late spring across its range (USDA NRCS 2001) and May in South Dakota (Van Bruggen 1976). McIntosh Fen is a high elevation site and typically cold during May. This may limit the effectiveness of insect pollination in some years and suggests that wind pollination is important, although no specific information is available. Cold stratification is not required for seed germination but the species' reportedly has a minimum root depth requirement of 18 inches (USDA NRCS 2001).

As in all willow species, hoary willow produces small green flowers that lack petals and are arranged in catkins, which appear slightly before or with the leaves in hoary willow (Dorn 1997). Male and female flowers are mostly borne on separate plants (e.g., dioecious), although occasional monoecious catkins may occur on some species of willows (Glisson 1998). The male flowers have two stamens and female flowers consist of a single ovule with two stigmas (Dorn 1997; USDA Forest Service Intermountain Region 1989). Hoary willow's flowering time in May is consistent with several other willow species in its range except for the late flowering autumn willow. Hybridization is common in *Salix* species, and hoary willow reportedly has hybridized with the closely allied *S. calcicola*, a rare species known mostly from Canada, with the only United States population in Colorado. The resulting intermediate species, *S. wiegandii* Fernald, (Rhodora 35: 243. 1933), is recognized as a hybrid (Argus 1999). *S. calcicola* exhibits a similar preference for calcareous substrates, but does not share an affinity for wet, boggy, or fen sites (Spackman *et al*. 1997). Willow species' mostly dioecious nature generally prevents self-fertilization, and there is no reference to apomictic seed production (i.e., seed set without fertilization) in the available literature.

Survival And Reproduction

Willows are generally early seral species and produce large quantities of small, short-lived seeds covered in long hairs for wind-dispersal (Walters and Keil 1996). *Salix* species typically require

moist, open mineral or alluvial soils for one or more years for seed germination and plant establishment, and a source of soil disturbance via flooding, snowmelt, frost-heave or possibly fire. In many western fluvial systems, willow seed production, release, brief period of viability, and germination coincide with the availability of raw substrate as spring flood flows recede. However, disturbance driven models may be less applicable to hoary willow and other species adapted to stable environments such as peat-bogs and fens.

As obligate wetland species, many willows require continued access to the water table. In fluvial systems, seedlings, and presumably sprouts grown from cuttings, are particularly vulnerable life stages and often succumb to drought stress as young roots are unable to grow fast enough to access declining water tables following spring runoff. While fen adapted willow species seem to require wet, anaerobic conditions for most of their life, it is likely seedlings, and presumably sprouts grown from cuttings are vulnerable to water table declines that may occur during prolonged or intense drought periods. Vegetative reproduction may occur by coppice sprouting or ramification, where peripheral branches are forced into the ground by snow cover or some other mechanism to form clonal ramets (USDA NRCS 2001). Willows may be cultivated from stem cuttings, an approach that appears to have worked well initially for autumn willow restoration at McIntosh Fen.

Many willows are thought to have life spans of 200 years or more. Mature crown height has been used as an indicator of maximum root depth in some settings, suggesting mature hoary willow plants can withstand water table declines of 1-3 meters or more. This strategy might particularly benefit species co-adapted with beaver, allowing individual plants to survive the shifting locations of beaver dams in a watershed through time.

Although *Salix* catkins are positioned for wind-pollination, willows also possess "secondarily reacquired entomophily", that is they are flowering plants that evolved to favor wind pollination then re-adapted to insect pollination (Sacchi and Price 1988), as evidenced by the nectaries and type of pollen grains produced in willow flowers (Argus 1974). The pollen transfer mechanism is believed to be transitional between wind and insect pollination in *Salix* species, though the literature suggests that 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 hoary willow. As a semi-precocious willow species, wind pollination may represent a more viable form of pollination in hoary willow since physical obstruction from fully expanded leaves is less likely.

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 *et al*. 1996; Hesse 1979 in Proctor *et al*. 1996). However, in a riparian willow species elsewhere, insect pollination was found to be responsible for over ninety-nine percent of seed set (Sacchi and Price 1988). There is no direct evidence of specific pollinators of hoary willow, but *Salix* flowers are known to be 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 other isolated locations of hoary willow. Pollinator activity may be limited due to typically cold temperatures during the flowering season, although this has not been documented at McIntosh Fen. The present geographic isolation of Black Hills' hoary willow populations from the nearest locations in Wyoming, Colorado, and Montana would appear to prohibit any

interbreeding between them, although there is the limited possibility of seed or pollen transfer via birds or air masses. Hoary willow does not reportedly form hybrids with any other species in the Black Hills.

Local Density Estimates

Population estimates for hoary willow at McIntosh Fen were last reported as several hundred plants (SDNHP 1984). As of October 2001, the rehabilitated ditches at the core of McIntosh fen were partially reclaimed by plant growth on and around the straw bales, and autumn willow cuttings had become established in association with dense sedge and willow growth. Also, it appeared numerous young hoary and autumn willow plants had become established in addition to the restored autumn willow cuttings (Glisson pers. obs. 2001).

Limiting Factors

Long-term climate and hydrological changes, e.g. a general warming and drying trend, since the last Pleistocene glaciation, and the more recent decline in beaver have reduced the amount of habitat available to willow species throughout North America (Cates *et al*. 1999). Hoary willow's apparent affinity for cold, calcareous fens is undoubtedly a major limiting factor since these features are relatively rare in the Black Hills. In addition, in this portion of hoary willow's range, the distribution and character of riparian and wetland habitats are strongly influenced by fire, flooding, and beaver-created disturbances (Parrish *et al*. 1996). These disturbances may be important to hoary willow's long-term persistence in the Black Hills, and to its ability to occupy potential habitats, but no specific information is available in the literature.

It is possible that hoary willow was more widely distributed prior to European settlement, and the disjunct and isolated distribution that exists today is in part due to human impacts on the abundance and distribution of wetland habitats in North America. In the Black Hills, Great Plains, and Rocky Mountains, the natural disturbances that benefit wetland willow species, such as fire and beaver activity, have been reduced or eliminated (Parrish *et al*. 1996; Price *et al*. 1996). At the same time, timber production, mining, livestock use, agricultural use, and eradication of beaver since the late 1800s have resulted in a sharp downward trend in the quantity and distribution of willow species in the Black Hills (Parrish *et al*. 1996). Wetland habitats are often enhanced by the removal of encroaching conifers, increased groundwater flow from scorched uplands, and by the flooding, sediment deposit, and other disturbances created by beaver during dam building.

Metapopulation Structure

The size and density of the overall willow population at McIntosh Fen appears to have remained fairly stable since the 1920's based on the available photo record. Although no specific information is available for hoary willow, it also appears relatively stable in recent times (Ode pers. comm. 2001). Prehistoric disturbance regimes had been all but eliminated prior to recent restoration efforts at McIntosh Fen. If disturbance were a driving factor for ongoing recruitment, the size/age class structure of the overall willow stand would have been expected to trend toward greater representation of mature individuals, as opportunities for new recruitment would have been limited. However, such a trend was not readily apparent prior to restoration efforts, suggesting that ongoing recruitment may have continued even under impacted site conditions (Ode pers. comm. 2001). This implies that traditionally recognized disturbance mechanisms

such as fire and fluvial action may not be essential to ongoing maintenance of the hoary willow population at McIntosh Fen. A general observation of good young age or small size class representation of hoary willow in wet channels suggests that adequate hydrology may be a key requirement for recruitment of hoary willow at McIntosh Fen (Glisson pers. obs. 2001).

As regional disjuncts, the Black Hills populations are inherently less secure than populations in the core range of the species, although they have likely persisted since the last glacial period. If populations in the Black Hills area were extirpated, it is unlikely that natural recruitment from other extant stands would occur.

Propagation Or Cultivation

Hoary willow may be propagated by seed germination or bare root and sprig transplants, but reportedly has low seed abundance, a slow seed spread rate, low seedling vigor, and a slow vegetative spread rate (USDA NRCS 2001).

Although no specific data were collected for hoary willow, the initial response of the autumn willow population to improved hydrology at McIntosh Fen has been very promising. In addition to high survival of direct plantings, numerous young willow seedlings have been noted, presumably in response to a series of high precipitation years since 1993 and improved hydrologic conditions at the site (Reyher pers. comm. 2001).

Community Ecology

Browsers Or Grazers

According to property owners of private land where hoary willow occurs, the species is readily browsed by livestock (SDNHP 1986). If not carefully managed, livestock use is often harmful to palatable willow stands as young age classes become increasingly under represented over time and individual mature plants take on an "umbrella" growth form. However, occasional low levels of browse have been recognized as a beneficial form of disturbance in willows and found to stimulate new shoot growth. Beyond selective pressures from grazing, direct physical disturbance and transport of noxious weed propagules by livestock and wildlife may pose an additional risk to hoary willow habitat. Livestock use is not permitted in McIntosh Fen Botanical Area.

Competitors

Invasive wetland weeds such as purple loosestrife and Canada thistle may disrupt wetland ecosystems by rapidly overtaking native species and may out-compete woody plants as well. Unfortunately, weed 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. Noxious weeds further alter wetland ecosystems by reducing or eliminating the structural diversity and microhabitats that comprise native plant communities. Noxious weeds may adversely impact hoary willow and its habitats.

Encroachment by later successional or less fire-tolerant species such as spruce (already evident in the upper portion of the population) may displace hoary willow plants that might otherwise persist indefinitely under stable site conditions. Additional information pertaining to noxious

weeds at McIntosh Fen is presented in REVIEW OF TECHNICAL KNOWLEDGE - Risk Factors.

Parasites, Disease, And Mutualistic Interactions

Although there is no specific documentation of mycorrhizal associations with hoary willow, *Salix* species commonly form mycorrhizal associations with vesicular arbuscular mycorrhizae (VAM), and are capable of forming symbiotic relationships with both VAM and ectomycorrhizal (ECM) fungi (Newman and Reddell 1987; Dhillion 1994). However, this type of dual association is uncommon in North America, and the minerotrophic fen habitats where hoary willow occurs lack the conditions and acid-loving plant taxa that favor ECM associations (Newman and Reddell 1987; Dhillion 1994). Hoary willow presumably possesses one or more VAM symbionts, but the importance of these relationships to the species' establishment and persistence is not known.

Other Complex Interactions

Beaver may facilitate the establishment and persistence of hoary willow by creating flood disturbance and saturated wetland conditions (Olson and Hubert 1994), particularly in the arid western portions of the species' range. Even in more mesic, boreal regions of North America, beaver exert a strong influence on the quantity and quality of wetland habitats (Naiman *et al*. 1988). For this reason, it is likely that the metapopulation dynamics of hoary willow in the Black Hills are closely tied to the recent and historic distribution and abundance of beaver. However, because beaver may consume or otherwise damage willows, some localized impacts could occur, particularly where beaver populations are high. Moderate predation by beaver may stimulate sprouting in many willows, although the point at which beaver browsing becomes a stressor for this species is unknown In general, the long-term benefits beaver provide to hoary willow by creating and enhancing wetland habitats would appear to outweigh short-term impacts to individuals or populations.

Both biotic and abiotic disturbances may play a significant role in the distribution and abundance of hoary willow. Natural disturbances such as periodic insect outbreaks and fire benefit the species by the increased groundwater flow that results from the death of upland trees. Fire also serves to maintain the open character of wetland habitats and facilitates the regeneration of hardwoods favored by beaver. By damming and flooding lowlands, beaver effectively exclude invading tree species, raise local water tables, expand wetlands and create both large and small-scale soil disturbance (Olson and Hubert 1994). Once aspen forage has been depleted, beavers relocate to another section of the stream, thereby creating a mosaic of wetland habitats (Naiman *et al*. 1988; Parrish *et al*. 1996). These actions directly create and/or enhance habitats for hoary willow and other species. Willows may colonize disturbed soils and, where beaver have cut established plants, will readily sprout from existing rootstocks. Where suitable habitat conditions exist, hoary willow would be expected to quickly recover from beaver disturbance by coppice sprouting or colonization of disturbed soils. In general, natural disturbances that reduce upland tree densities, or facilitate hardwood regeneration and thereby beaver activity, will likely enhance hoary willow's occupied and potential habitats. The successional relationships and disturbance ecology of hoary willow are not well understood at this time.

Similarly, management activities that mimic the natural disturbances described above, such as

prescribed fire or thinning of upland forests, may also be expected to enhance hoary willow habitats in the Black Hills and elsewhere. Direct disturbances from trail, road, or highway construction, mining, or off-road vehicle use are all potentially detrimental to hoary willow and the structure and integrity of its wetland habitats. Road construction can impact wetlands directly and/or by altering local hydrological features, such as springs and seeps. In addition, roads, trails and highways can facilitate the introduction of noxious weeds into wetland habitats.

Risk Factors

Because hoary willow is an obligate wetland species that may require soil disturbance for seed germination and establishment, factors that impact wetland hydrology, or that reduce or eliminate flooding, beaver activity, and fire, may have negative effects on its long-term persistence in the Black Hills. The recent expansion of the McIntosh Fen autumn willow population in response to a relatively small increase in the water table suggests that local hydrology also plays a vital role in the reproductive success and long-term persistence of hoary willow. Potential exists for water diverting development on private land upstream from the fen, such as wells, pavement, and culverts, and could negatively affect the flow of water from streams, springs and seeps, lower the water table, and limit beneficial beaver activity in the drainage. In addition, short and long-term droughts may reduce water availability to the site. McIntosh Fen exhibits a fairly rapid and direct impact to seasonal drought, suggesting a fairly shallow aquifer (Ode pers. comm. 2001).

Noxious weeds and other invasive species pose a serious risk to hoary willow at McIntosh Fen. Canada thistle (*Cirsium arvense*), a noxious weed, is present in the planted smooth brome meadow surrounding the fen. Although both Canada thistle and smooth brome are invasive, high soil moisture levels in the fen will discourage their advancement into hoary willow habitat. Although purple loosestrife does not occur at McIntosh Fen, it has been documented along Rapid Creek near Rapid City, South Dakota and poses a potentially serious risk to the numerous rare wetland species in the fen if it were somehow introduced to the area (Ode pers. comm. 2001). If purple loosestrife were to invade McIntosh fen, it has the potential to out-compete riparian natives, and would represent a significant competitive risk to the hoary willow population at the fen. The occurrence of noxious weeds may also restrict the ability of hoary willow to disperse into other wetland habitats. Herbicides are potentially detrimental to hoary willow individuals, fen water quality, and herbaceous species, so broadcast spraying is not used at McIntosh Fen. Recent weed treatments at McIntosh Fen involved direct application of herbicide to individuals or clusters of Canada thistle.

Prolonged regional warming and or drying trends may risk hoary willow populations if site hydrology is sufficiently altered.

Response To Habitat Changes

Management Activities

Timber Harvest

Timber harvest is not allowed in McIntosh Fen Botanical Area.

Recreation

Recreational impacts associated with off-road vehicles and snowmobiles are the most serious potential recreational impact on the species (Reed 1985). Although prohibited in the McIntosh Fen Botanical Area, some evidence of trespass vehicle tracks have been observed along the snowmobile trail that passes between the upper and lower concentrations of hoary willow. Recreational access by hikers may also facilitate transfer of noxious weed propagules.

Livestock Grazing

Livestock may impact streamside communities through the effects of their grazing, trampling, resting, and trailing (Hoffman and Alexander 1987). Livestock and wildlife may also introduce noxious weeds. High populations of native ungulates, such as elk or deer, may increase the level of herbivore impacts on willow seedlings and young plants (Hoffman and Alexander 1987; Price *et al*. 1996). During the 2000 survey and later visits to the fen, whitetail deer were encountered throughout the fen; however, no direct impact to hoary willow plants was noted. No livestock use is permitted within the fen portion of the Botanical Area. Livestock and wildlife use may also be responsible for suppression of aspen regeneration in the area.

Mining

Mining is not allowed in McIntosh Fen Botanical Area.

Prescribed Fire

Presumed natural conditions in terms of fire frequency and tree cover in the Black Hills are controversial (Marriott *et al.* 1999). Management activities exert a strong influence on wetland hydrology throughout the Black Hills. The lack of fire and other disturbances in the uplands surrounding McIntosh Fen has resulted in an increased density of white spruce (*Picea glauca*), reduced groundwater flow into the fen, restricted the regeneration of aspen and other hardwoods, and has effectively excluded beaver from returning to the site. The same conditions likely occur in hoary willow's potential habitats in the Black Hills, where the lack of natural disturbance has reduced or eliminated the species' ability to become established. The absence of beaver from McIntosh Fen has changed the hydrology, species richness, and structure of the wetland (Ode pers. comm. 2001; USDA Forest Service 1995; Parrish *et al*. 1996). Although beaver reportedly built dams in the lower portion of the fen in the early 1990s, they did not remain, presumably due to limited availability of aspen within the fen complex. It appears that regeneration of the aspen stands within reach of the stream would be required to facilitate the return of beaver to the fen. Fire as a management tool in the fen itself may be of questionable value as it's unclear if fire was a significant disturbance factor in this wetland environment historically, although fire could have been a disturbance factor during extended drought periods historically.

Fire Suppression

Although hoary willow is reported to have a high fire tolerance, its successional status and disturbance ecology is not well understood. It is possible that fire suppression within the fen could adversely affect hoary willow since many willows respond with new growth following fire, although the population at McIntosh Fen does not appear to be overly decadent or dominated by late age classes.

Non-Native Plant Establishment And Control

There is no specific information available on this topic for hoary willow, although it may not compete well with aggressive species capable of exploiting its habitat such as Canada thistle (*Cirsium arvense*), smooth brome (*Bromus inermis*), and purple loosestrife (*Lythrum salicaria*).

Fuelwood Harvest

Fuelwood harvest is not allowed in McIntosh Fen Botanical Area.

Road Construction

No roads are present in McIntosh Fen Botanical Area and construction of new roads is not allowed.

Other

Collection of plant specimens is not likely to pose a risk. Although the species may appeal to some amateur botanists, it is not likely to be sought after by the general public.

Natural Disturbance

Insect Epidemics

No information is available regarding insect epidemics and hoary willow.

Wildfire

Hoary willow reportedly has high tolerance to fire (USDA NRCS 2001).

Wind Events

Wind events are not expected to pose a significant risk to hoary willow and may actually benefit the species by toppling woody species that may encroach into potential habitat.

Flooding

Hoary willow is apparently adapted to and dependent on inundation and/or saturated soils. Adverse impacts due to destructive floods are unlikely due to the off-channel position of much of the occupied habitat.

Other Events

In August 2001, a fungal infection was noted on the leaves of autumn willow plants at McIntosh Fen. The fungus was found to infect almost all the leaves of all autumn willow plants at the fen. The fungus was identified as a species of *Melampsora*, a major rust on *Salix* species (Reyher pers. comm. 2001). The species is suspected to be *M. ribesii-pupureae*, a rust that spends part of its life cycle on gooseberry species and has been found to not significantly impact other willow species, including bebb willow (*S. bebbiana*), (*S. glauca*), and (*S. scouleriana*). The U.S. Host Disease Index (ref.) lists the species *Melampsora paradoxa* as a specific autumn willow disease. It is not known if the rust is a significant risk to hoary willow.

Prolonged drought may adversely impact hoary willow, especially recruitment of new age

classes, but this is unknown.

REVIEW OF 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 1997). No specific management practices have been applied in the Black Hills or elsewhere for hoary willow. Many potentially beneficial management practices are already incorporated in the Forest Management Plan for the McIntosh Fen Botanical Area, arising from a central theme to "protect unusual or special characteristics" (USDA Black Hills National Forest 1996). This includes restrictions on roads, timber harvest, livestock use, and mineral development (as discussed in Section J), thereby minimizing impacts to existing populations. Timber harvest could serve as a valuable vegetation management alternative for removing conifers that may encroach on the species, or in the uplands to help provide for higher water yields to the Fen. Restoration of "fire to its natural role in the ecosystem" on surrounding uplands and possibly within the fen may improve water yield and site hydrology in the fen and potentially create new recruitment sites (USDA Black Hills National Forest 1996). Restoration efforts implemented at the fen complex beginning in 1997 were based upon recommendations from the South Dakota Department of Game, Fish and Parks, Black Hills National Forest and The Nature Conservancy (SDDGFP 1992; Marriott 1993; USDA Forest Service 1995). Ongoing review of proposed project activities on adjacent upland portions of the Black Hills National Forest will help to minimize potentially harmful activities and identify beneficial activities that could alter, maintain, or enhance hydrologic and botanical resources within the watershed and Botanical Area.

Non-administrative vehicles and off-road vehicles are restricted from the McIntosh Fen Botanical Area, but snowmobiles are permitted along a snowmobile trail that crosses the meadow from east to west. The trail is gated for seasonal use only, and this activity does not appear to directly impact hoary willow, provided that there is sufficient snow cover and snowmobiles are operated along designated routes away from hoary willow stands (USDA Forest Service 1996, 2000). Weed management vehicles traversed the central portions of the Botanical Area in July and August 2000 in order to chemically treat Canada thistle, but the vehicles did not travel through the fen wetland or any areas where hoary willow occurs. Interpretive trails and signage have been recommended for McIntosh Fen Botanical Area to create an awareness and appreciation for the unique qualities of the fen and other historic features of the area. Hoary willow is not used for any known commercial purposes or as a special forest product.

In general, conservation management of willow species involves restoring water tables and drainages, changing livestock management, providing open habitat for colonization, establishing seedlings or cuttings, and prescribed burning (Price *et al*. 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, management activities may need to focus on adjacent land use so that sources of groundwater draw down and/or contamination may be eliminated or

reduced (Reed 1985). Agricultural activities such as fertilization or drainage, and construction of impermeable surfaces (e.g. parking lots) in recharge zones may alter the quality and/or quantity of water entering the fen (Reed 1985). Ditching for drainage or utilities in the vicinity of fens can be detrimental due to direct impact on the flow and quality of groundwater (Reed 1985).

Prescribed burning is widely recommended for the conservation of willow species and other wetland vegetation (Reed 1985; SDDGFP 1992). Prescribed burn plans for the McIntosh fen could focus not only on the fen itself, but also on the meadows and slopes above the fen to improve local water yield. Smooth brome meadows above the fen can be burned in the late winter or early spring when smooth brome is actively growing to temporarily set back the brome and encourage native warm season species. Burning in successive years may be required to significantly suppress the brome. Upland slopes adjacent to the fen can be burned in the spring or fall, using prescriptions designed to reduce conifers and encourage aspen regeneration. High intensity burns may be particularly successful in reducing spruce and pine density and encouraging aspen advancement.

Burning of the fen itself also holds potential for maintaining hoary willow populations. While no specific information was available regarding hoary willow, the following information is available for autumn willow: burning can topkill stems, the root crowns, rhizomes or caudex quickly resprout, and the plant can return to pre-burn numbers within three years (USDA FS RMRS 2001). In the Black Hills region, 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). Although published information on the effect of fires is limited, many willow habitats in the region most likely evolved with severe fire disturbances in the past (Parrish *et al*. 1996; Sieg and Severson 1996; USDA FS RMRS 2001). In addition to stimulating sprouting of the willow, periodic prescribed burning can provide microsites for the establishment of willow seedlings. Frequent burning, such as every other year, can reduce woody plants and other undesirable species in fens (McGrath 1988; Rooney 1990; Rooney *et al*. 1992).

The critical role of fire as a natural disturbance mechanism at the landscape scale has been clearly defined in the Black Hills and elsewhere, but as noted earlier, the presumed natural conditions in terms of fire frequency and tree cover in the Black Hills are controversial (Marriott *et al.* 1999). However, the natural role of fire in cold, wet, otherwise stable micro-environments such as McIntosh Fen is less clear and prescribed fire should be approached with caution and only after other efforts such as restoration of site hydrology have been undertaken and evaluated (Ode pers. comm. 2001). It's possible that other variables such as frost heaving or water chemistry fluctuations over periods of drought may function as disturbance factors to create available habitat or serve as environmental triggers for seed germination. Since willow populations within the fen have reportedly remained fairly constant over time, restoration activities within the fen may be assigned lower initial priorities. Any subsequent use of prescribed fire within the fen could be localized and evaluated with a pre- and post-monitoring as discussed below.

Models

Various species specific or site ecological models may be developed for hoary willow and autumn willow at McIntosh Fen. These may include assessing hydrologic linkages within the fen and with adjacent uplands, such as changes in water yield in response to upland prescribed burns, timber removal, fuelwood harvest, etc., to gain insights to site hydrology. For example, does a 10 acre prescribed burn have a significant impact on base flows to the fen? Does the effect persist throughout the growing season? How closely are precipitation events temporally linked to the fen? Does water chemistry vary seasonally or over major wet or drought periods? Modeling efforts may include weekly or biweekly piezometer data during the growing season to measure groundwater fluctuations, precipitation data to measure effects of short and long-term events and cycles, linkages between Castle Creek and McIntosh Fen hydrology, up and downstream gage results for Castle Creek, etc.

Piezometer data may also be related to various plant responses such as annual stem growth, recruitment of new individuals, annual flowering density, and drought induced effects including reduced leaf area indices, early leaf abscission, etc. Any of the above models will require ongoing data collection and analysis.

Survey And Inventory Approaches

Surveys of Black Hills vegetation have primarily been conducted at the project level that have included the use of Ranger District personnel through agreements with The Nature Conservancy and by contracts. Data will be stored in the Forest Database (and potentially the National Database System, when available), Forest GIS system, Forest Plan Monitoring Files and respective State Natural Heritage Programs. Herbarium vouchers are sent to the Rocky Mountain Herbarium at the University of Wyoming in Laramie. Few if any surveys directed specifically at hoary willow have been done on Black Hills National Forest, although no additional unsurveyed potential habitat sites for hoary willow are presently known on the Forest. The Forest is beginning to use broader floristic surveys, and surveys with expanded lists of target species (not just Sensitive). In general, the Black Hills are under surveyed in regards to rare plant species, and the recent discoveries of new populations of species of concern (some representing significant range extensions) and new records for the Black Hills show this to be true. Known potential habitat could be identified and mapped, and periodic visits (e.g., every 5 years) to resurvey the sites could determine if new recruitment has occurred.

Monitoring Approaches

Monitoring of hoary willow by the Black Hills National Forest has not been performed to date, but the Forest has been developing a monitoring protocol for autumn willow at McIntosh Fen Botanical Area which could be expanded to include hoary willow depending on Forest priorities and appropriated funding. Starting in 2000, annual monitoring was performed during autumn willow's blooming period. The primary objective of annual monitoring is to detect changes in the population in order to counter risks to the species' long-term persistence on BHNF as quickly as possible. Monitoring data include: GPS positions of the end points of concentrations within the botanical area; a count of individuals during the blooming period; documentation of any occurrence of noxious weeds; where noxious weed species occur, active control measures are to be implemented; and beginning in 2001, annual measurements from one or more piezometers to

identify any changes in the height of the water table. In the event that the number of individuals has declined by more than ten percent, the Rocky Mountain Research Station will be consulted for more rigorous sampling methods.

The existing monitoring approach could be applied to include hoary willow and may be expanded through the use of fixed photopoints and quantitative sampling of fixed sample plots to assess subtle changes in population age structure (e.g., is natural recruitment occurring, are later seral species increasing, etc.,). Line intercept data and stem tallies may be used to quantify changes in woody species cover data and could be used to track age and/or size class of data for individual species. The data can be linked to physical location to provide an indication of new recruitment or death of particular individuals. This approach would help to clarify uncertainties with assigning age classes to willows on the basis of size (e.g., number of stems per clump, stem height, etc.,), which admittedly has some limitations, but has been used with success to assess site ecological status and trends. A survey-grade GPS data collection system could be used to map population or sub-population boundaries. Pre- and post-treatment data could be collected to evaluate the effectiveness of specific restoration approaches. Information gained through this approach would help to clarify critical issues surrounding the reproductive and disturbance ecology of the target species and overall site ecology at the fen, and be very useful in adaptively managing the site and selecting restoration measures.

ADDITIONAL INFORMATION NEEDS

Collection of additional baseline habitat and community ecology data for McIntosh Fen could provide a better understanding of the absolute habitat requirements and improve the scientific basis for management of hoary willow in the Black Hills, depending on available funding. This may include collection of detailed eco-data, such as cover class estimates of all associated species, canopy cover, age class of woody species, etc. Additionally, collection of detailed phenology and autecology data for hoary willow in the Black Hills, e.g., time of leaf emergence, biomass, flowering period, seed set, ripening, and germination, seedling survival rates, longevity of individual plants, etc., could also provide information that may benefit management of this species in the Black Hills. Other useful information may include examination of pollen transfer mechanisms of hoary willow. This may be accomplished by noting pollinators or pollinator activity present on data sheets, and photographing or collecting specimens if possible.

As noted under REVIEW OF CONSERVATION PRACTICES - Models, a variety of more research oriented data may help to better characterize site hydrology and linkages with nearby upland sites. This may include ongoing monitoring of piezometers as described above to track site hydrology, and possibly quantify the effects of forests on water yield. Additional useful information may include compilation of annual climate and precipitation data such as 50 year annual precipitation graphs, evaluation of stream gage data for Castle Creek above and below McIntosh Fen, and characterization of water chemistry and its variability in response to different hydrologic conditions.

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DEFINITIONS

THE NATURE CONSERVANCY NATURAL HERITAGE RANKS

GLOBAL RANK (G): based on range-wide status of a species

-G1 Critically imperiled globally because of extreme rarity (5 or fewer occurrences, or very few remaining individuals), or because of some factor of its biology making it especially vulnerable to extinction. (Critically endangered throughout its range).

-G2 Imperiled globally because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extinction throughout its range. (Endangered throughout its range).

-G3 Vulnerable throughout its range or found locally in a restricted range (21 to 100 occurrences). (Threatened throughout its range).

-G4 Apparently secure globally, though it might be quite rare in parts of its range, especially at the periphery.

-G5 Demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.

-GX Presumed extinct

-GQ Indicates uncertainty about taxonomic status.

-GU Unable to assign rank due to lack of available information.

-G? Indicates uncertainty about an assigned global rank.

TRINOMIAL RANK (T): used for subspecies or varieties. These taxa are ranked on the same criteria as G1-G5.

STATE RANK (S): based on the status of a species in an individual state. S ranks may differ between states based on the relative abundance of a species in each state.

-S1 Critically imperiled in state because of extreme rarity (5 or fewer occurrences, or very few remaining individuals, or because of some factor of its biology making it especially vulnerable to extirpation from the state. (Critically endangered in state).

-S2 Imperiled in state because of rarity (6 to 20 occurrences) or because of other factors demonstrably making it very vulnerable to extirpation from the state. (Endangered or risked in state).

-S3 Vulnerable in state (21 to 100 occurrences).

-S? Indicates uncertainty about an assigned state rank.

FIGURES

Figure 1: U.S. distribution for hoary willow (BONAP, 2001). Grey areas indicate confirmed presence.

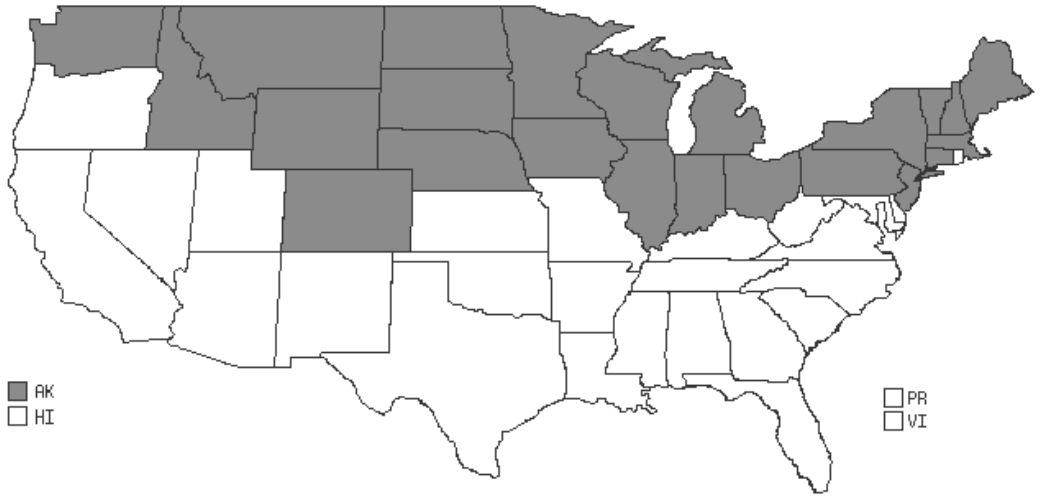

Figure 2. Reported South Dakota distribution for hoary willow (USDA NRCS, 2001), apparently includes questionable McIntosh specimen #22 (RM) in Custer County as mentioned earlier.

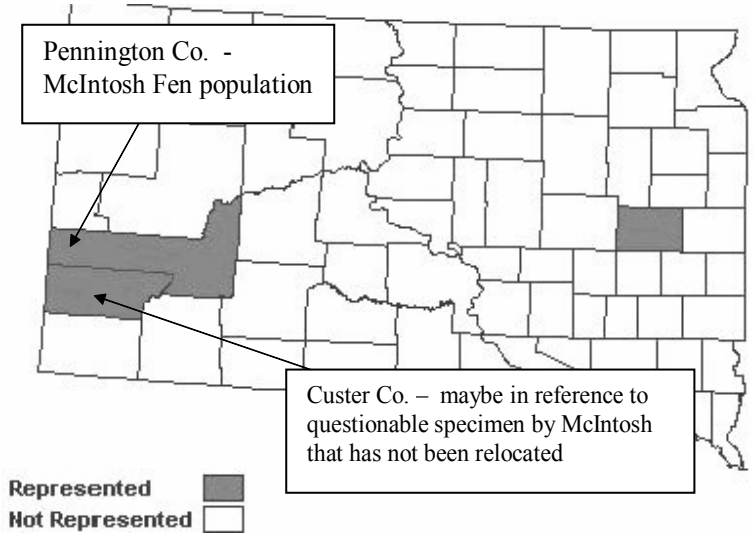

Figure 3. Wyoming distribution for hoary willow (University of Wyoming, 1998)

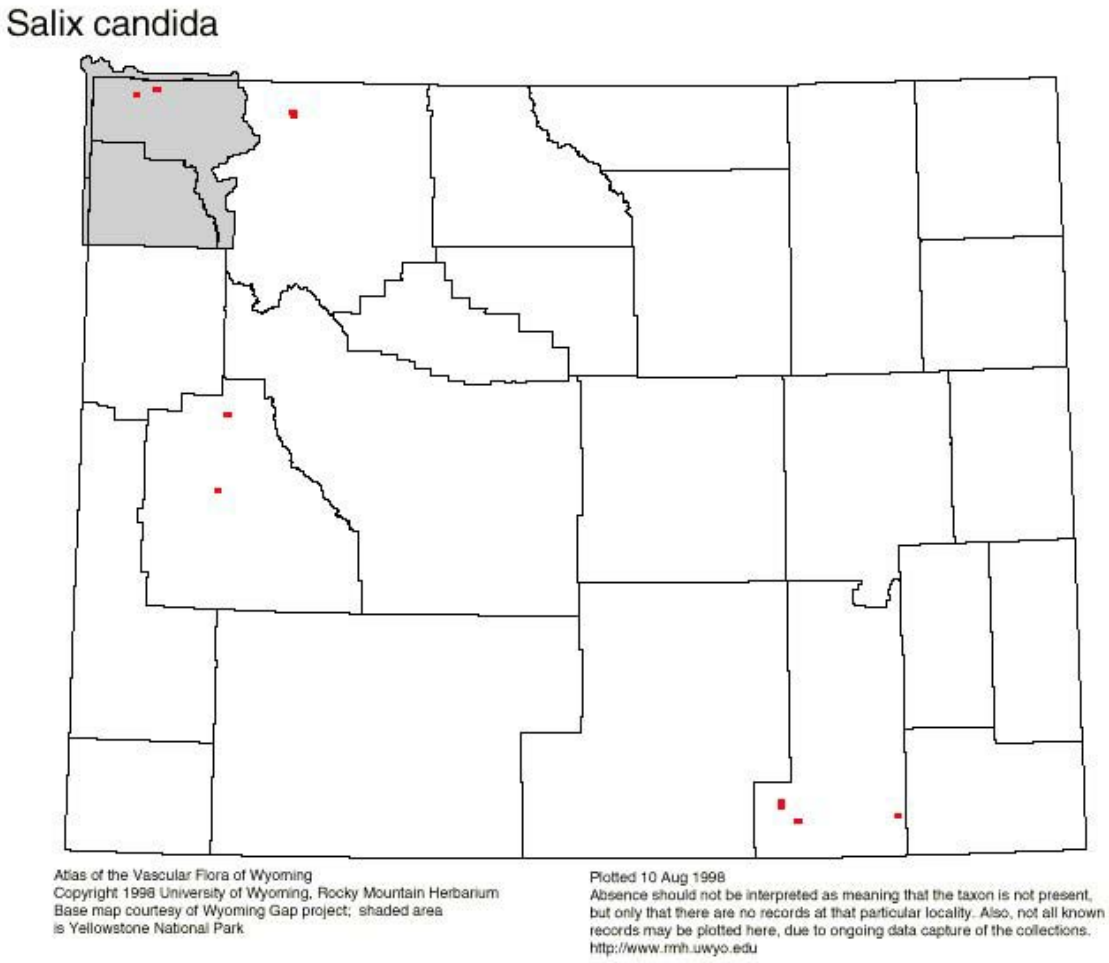

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Figure 4. Line drawing of hoary willow from USDA Forest Service Intermountain Region (1989).

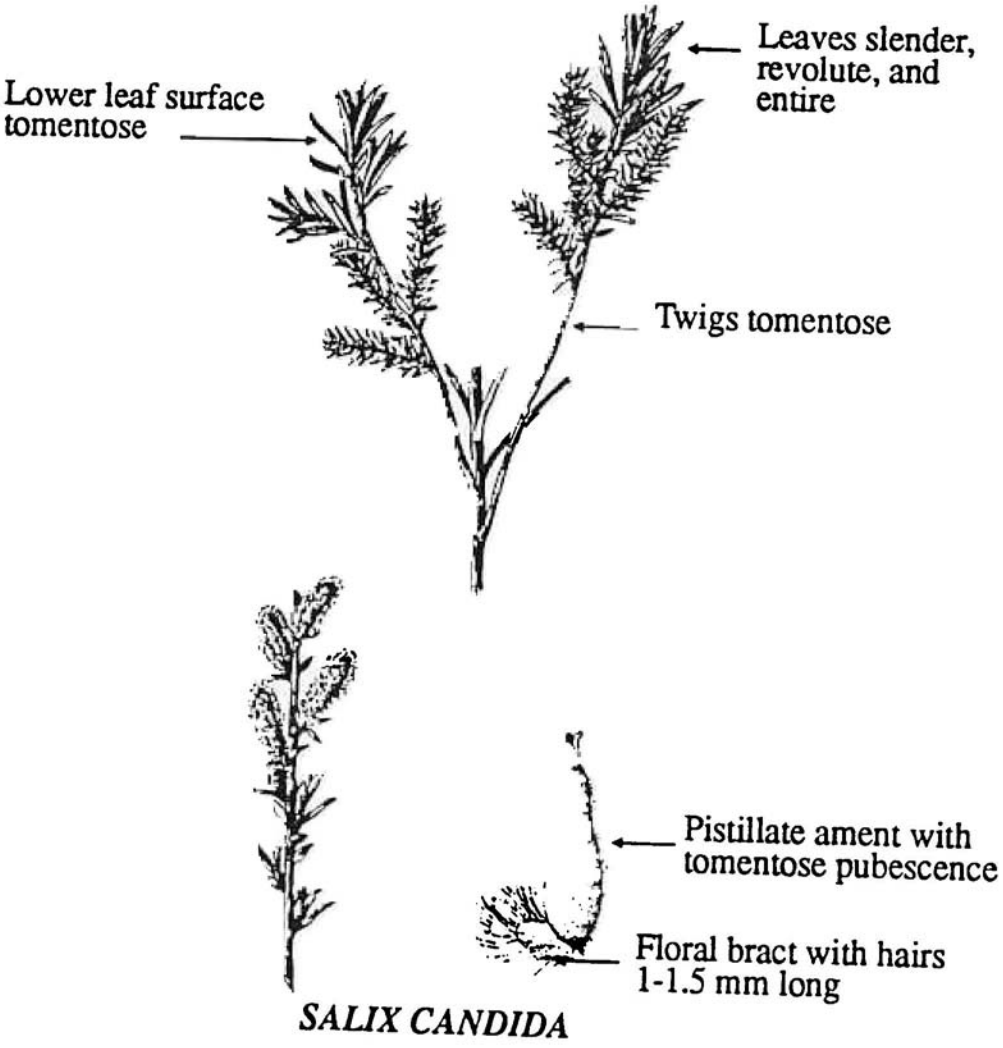

Figure 5. Photographs of hoary willow (Dorn 1997).

23. **Salix candida** Fluegge ex Willdenow Hoary Willow SACA4

Scale rod 0.9 meter

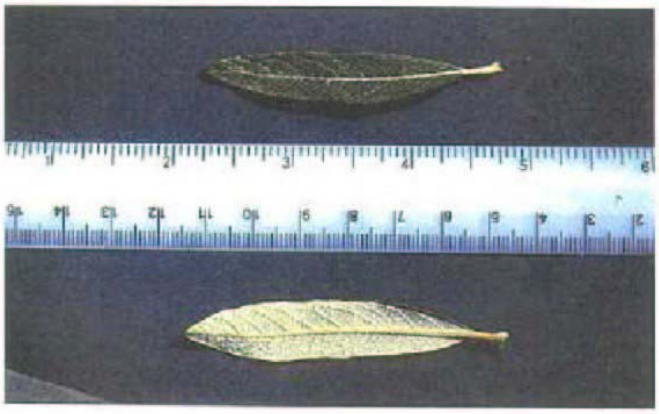

Figure 6. Photograph of hoary willow habitat, upper portion of McIntosh Fen (Glisson, 2001).

Figure 7. Photograph of hoary willow habitat, lower portion of McIntosh Fen (Glisson, 2001).