BLOWOUT PENSTEMON

PENSTEMON HAYDENII S. WATSON

RECOVERY PLAN

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Literature citations should read as follows:

> U.S. Fish and Wildlife Service. 1992. Blowout Penstemon (Penstemon haydenii) Recovery Plan. U.S. Fish and Wildlife Service, Denver, Colorado. 40 pp.

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EXECUTIVE SUMMARY

Current Status: Blowout penstemon (*Penstemon haydenii*) was listed as an endangered species on September 1, 1987. Blowout penstemon is currently known to exist in six population centers located in four counties in Nebraska. The species has a documented population of approximately 7,000 individuals. Presently, it appears that populations located in the eastern part of the species range are declining, while those located in the western portion are either fluctuating widely or remaining stable.

Habitat Requirements and Limiting Factors: Blowout penstemon, a species endemic to the Nebraska Sandhills (Sandhills), is restricted to active blowouts in the Sandhills. Improved range management practices, which stabilize the sand dunes, are a major cause of the species decline. Insects and periods of drought may be the greatest natural threats to the survival of this species.

Recovery Objective: Delisting.

Recovery Criteria: Blowout penstemon will be considered eligible for reclassification to threatened when:

1. a minimum of 10,000 individuals in at least 5 population groups is established; and
2. the 5 populations have the minimum level of protection that will ensure their continued existence.

Blowout penstemon will be considered eligible for delisting when:

1. a minimum of 15,000 individuals in at least 10 population groups, each with a minimum population of 300 plants is established; and
2. the 10 populations are demonstrated to be at minimum viable population levels.

Actions Needed:

1. Protect and monitor naturally occurring, reintroduced, and introduced populations.
2. Inventory suitable habitat for naturally occurring populations and determine potential reintroduction sites.
3. Conduct research to determine life history, minimum viable population parameters, and management criteria.
4. Establish new populations of blowout penstemon.
5. Establish and implement management plans for each population.

Cost of Recovery: Estimated to be $1,039,000, to reach recovery criteria set out above.

Date of Recovery: Delisting should be initiated in 2007, if recovery criteria have been met.

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I. INTRODUCTION

Blowout penstemon (Penstemon haydenii S. Watson) was listed as an endangered species effective October 1, 1987. This recovery plan outlines a course of action which, if implemented, will result in the protection and expansion of the populations and habitat of blowout penstemon to a point at which the survival of the species is ensured. Once this goal has been achieved, blowout penstemon can be removed from endangered status.

Taxonomy

Blowout penstemon was first collected along the North Loup River in the Sandhills area of Nebraska by Ferdinand V. Hayden, probably in 1857 (Sutherland 1988). This specimen was without flowers or fruits and was referred to as sharp leaf penstemon (Penstemon acuminatus Dougl. ex Lindl.). Senero Watson originally named and described the species as Pentstemon haydeni, based on a collection made by H. L. Webber near the Dismal River in Thomas County, Nebraska, in 1891 (Watson 1891). Later, Francis W. Pennell could not locate the original 1857 Hayden specimen, and he substituted the Webber specimen as the type collection (Pennell 1920). Both the Hayden specimen and type specimen were deposited at the Gray Herbarium at Harvard. A second "i" has been added recently to the specific epithet "haydeni" to make it etymologically correct (Sutherland 1988).

Two other species occurring within the Sandhills region of Nebraska, shell-leaf penstemon (Penstemon grandiflorus Nutt.) and narrowleaf penstemon (Penstemon angustifolius Nutt. ex Pursh), exhibit morphological characteristics similar to those of blowout penstemon. It has been speculated that these species may be genetically related to blowout penstemon (Freeman 1981, Hardy et al. 1989). Freeman (1981) also has speculated that blowout penstemon may have evolved through hybridization of shell-leaf penstemon and narrowleaf penstemon.

Morphology

The most recent morphological description of blowout penstemon published in the Flora of the Great Plains (Great Plains Flora Association 1986) is as follows:

> Penstemon haydenii S. Wats., Hayden's penstemon. Stout perennial herb; stems decumbent to ascending, (1.5)2-4.5 dm tall, glabrous, 1 to many from a subterranean caudex surmounting a deep taproot. Leaves entire, glabrous and somewhat glaucous, firm; basal and lower cauline leaves linear to linear-lanceolate, (2.5)5.5-11(13) cm long, 0.3-1 cm wide, acuminate to acute, sessile and clasping, upper cauline leaves linear to occasionally lanceolate, 6-11(12) cm long, 0.7-3 cm wide, acuminate with a long narrow tapering tip, sessile and clasping, the vegetative shoots with long linear leaves. Thyrse 6-16 cm long, with (4)6-10(12) verticillasters, very compact, cylindrical and not secund, leafy-bracted, individual cymes with 4-6 fragrant flowers; 2-8 mm long; bracts longer than broad and very distinct from cauline leaves, the lower bracts tapering to a long narrow acuminate or caudate tip, the bases cordate and broadly overlapping,

concealing the peduncles and most pedicels. Calyx glabrous, lobes subequal, linear to linear-lanceolate, 8-13 mm long, 1-3 mm wide, acuminate, entire, herbaceous throughout or with scarious margins near the base; corolla 23-25 mm long, distinctly bilabiate, milky blue to milky lavender, glabrous internally and externally, the throat 9-11 mm broad, well inflated and ventricose posteriorly, moderately ampliate, lined internally with magenta nectar guides anteriorly in mature unopened or freshly opened flowers, lobes of the upper lip arched-projecting, lobes of the lower lip projecting to spreading; staminode included, distally flattened, minutely bifurcate and slightly recurved, densely pubescent near the tip with golden-yellow hairs to 1 mm long; anther sacs 1.8-2 mm long, widely divergent, dehiscing the full length and across the connective, prominently papillose along the sutures; style glabrous. Capsule 13-16 mm long; seeds 2.5-4 mm long, discoid, light brown to brown. (n=8) May-Jul. Endemic to dune blowouts in the Sandhills of NE; NE: Cherry, Garden, Hooker, Thomas.

Morphologically, P. haydenii is one of the most striking members of sect. Coerulei, due to its compact cylindrical inflorescence with prominent long-acuminate bracts and its habit of forming large multistemmed clumps. The stems of P. haydenii root adventitiously, thus maintaining the plant in shifting sands of dune blowouts. The species is apparently unique in the Coerulei in that its flowers possess a distinctive fragrance.

Distribution

Present

Blowout penstemon occurs naturally only within the Sandhills region of Nebraska in relatively few blowouts (Weedon et al. 1982b). Presently, six population and population complexes are known to occur within four counties, including Cherry, Garden, Box Butte, and Morrill Counties (Figure 1). The majority of plants occur in isolated areas of Garden, Box Butte, and Morrill Counties.

Historical

Blowout penstemon was once a common plant in blowouts in the Nebraska Sandhills (Pool 1914). All herbarium and most literature citations indicate that it has never been collected outside of Nebraska. However, collection of the plant has been infrequent and sporadic (Weedon et al. 1982c). Consequently, the species was thought to be extinct from 1940 until it was rediscovered in 1968 (Stubbendieck et al. 1983).

The reason(s) for its decline from being a common plant in the early 1900's to its current population is unknown. With wildfire control and improved range management practices, the amount of Sandhills blowout habitat has greatly decreased (Stubbendieck et al. 1982b). The drought of the 1930's negatively impacted numerous prairie plant species, and it may also have had a negative influence on blowout penstemon. Larvae of a pyralid moth did extensive damage to one population of blowout penstemon in 1990. These insects may be one of the primary causes of declines in other populations.

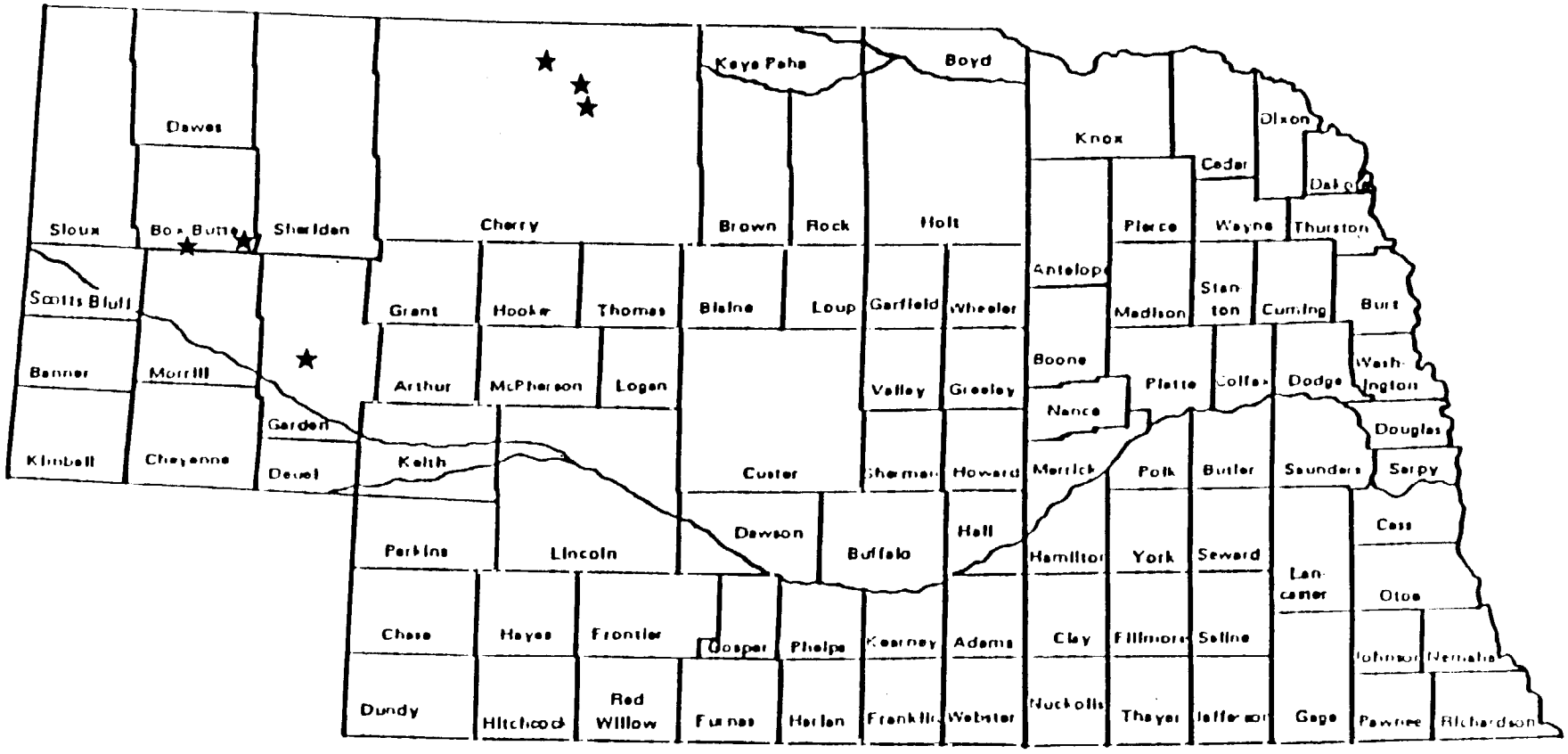

Figure 1. Location of naturally occurring blowout penstemon populations (1 centimeter = 30 kilometers).

Potential

A large number of blowouts occur within the Nebraska Sandhills region that have the proper combination of soils, environmental conditions, and associated vegetation to provide suitable growing conditions for blowout penstemon. Thus, the potential distribution for the species could include the entire Sandhills region. However, as a primary invader, blowout penstemon is not relatively competitive; once secondary invasion of the blowout begins, it disappears from the site (Flessner 1988, Tolstead 1942, Weedon et al. 1982c). Blowout penstemon requires a substrate of eroding and shifting sand. The typical source of this substrate is a blowout. However, the required habitat at one minor site is maintained by soil slippage due to streambank erosion. The continuation of this species is thus dependent on continuing wind erosion to maintain blowouts or a source of new blowouts.

Habitat

The Nebraska Sandhills is an extensive area with unique vegetation and soils. Blowouts, the habitat of blowout penstemon, are depressions in the topography caused by wind erosion (Stubbendieck, et al. 1989). Vegetation associated with blowouts is distinctly different than vegetation associated with adjacent, noneroding areas.

Soils and Climate

The Nebraska Sandhills occupies over 5 million hectares of north-central Nebraska (Keech and Bentall 1971, Bose 1977, Bleed and Flowerday 1989). It is the largest sand dune area in the Western Hemisphere, with nearly level areas and rolling hills with slopes exceeding 30 percent (Bleed and Flowerday 1989, Keech and Bentall 1971). The area is primarily used for cattle grazing on relatively large ranches (Burzlaff 1962, Gosey 1986, Stubbendieck 1989). The sandy soils (mixed, mesic Typic Ustipsamment) are characterized by low organic matter, low water-holding capacity, low natural fertility, and a high risk of wind erosion if the soil is exposed (Elder 1969, Keech and Bentall 1971). The soil is stabilized by a grass cover.

The climate of the area may be classified as continental, with 70 percent of the total precipitation (425-625 mm) falling during the growing season (Burzlaff 1962, U.S. Department of Commerce 1973, Wilhite and Hubbard 1989). The frost-free period is 130-155 days (Neild 1977). Cold winters and warm summers are characteristic. Average maximum and minimum temperatures for January are about 1 degree centigrade and -12 degrees centigrade (Neild et al. 1967). Extreme lows of less than -40 degrees centigrade have been recorded. July is the hottest month with maximum and minimum temperatures of about 32 degrees centigrade and 15 degrees centigrade (Neild et al. 1967). Extreme highs of more than 45 degrees centigrade have been recorded.

Wind is an ever-present part of the climate of the Nebraska Sandhills. Winds can attain high velocities due to little surface relief in the area. Winds are generally strongest in winter and early spring and blow from a northwesterly direction (Dewey 1977, Wilhite and Hubbard 1989). During these periods,

sustained winds of about 50 m sec^{-1} with gusts to nearly double that velocity are not uncommon. Wind erosion and blowout formation do not occur as long as vegetative cover is undisturbed. Once wind erosion starts, it is difficult to stop.

Blowouts

Blowouts are one of the most striking features of the Sandhills. Blowouts are irregularly conical or rounded depressions of varying depth and diameter. They usually occur on the northwest sides of upper slopes and hills. These blowouts are different in form and ecological relationships from those in historical reports from other parts of the world (Cowles 1899, Gleason 1910, Cockayne 1911). Blowouts originate on the exposed upper slopes when the vegetative cover is disturbed or removed. Historically, repeated fires and concentrations of grazing animals caused the disturbances (Pool 1914). Over the period of a few years to a few decades, an embryonic blowout develops into a full scale, active blowout. Sand is blown from the exposed windward side of the slope and deposited onto the leeward side. As the erosion becomes more active and the blowout deepens, roots of the prairie vegetation are exposed, and soon whole plants blow away. As the crater deepens, the sand along the sides slides into the depression. The sharp, steep edges caused by the sliding sand help to catch the wind and cause increased turbulence breaking more sand particles free. The loose sand is quickly blown out and deposited on the leeward side of the crater (Pool 1914).

The northwest inner slope of an active blowout generally has a gradient of about 30 degrees and has the longest slope. This side is never directly exposed to the wind. The opposite side is usually much steeper, sometimes nearly perpendicular, because sand continually rolls down from this side and is blown out over the side. The leeward side of the blowout, the area of sand deposition, usually has a gradient of about 60 degrees. This slope is usually vegetated by perennial grass species that can yearly grow up through 0.2-0.7 meters of deposited sand (Pool 1914). Blowout penstemon may be found in the crater and on the leeward side of blowouts.

The northwest side of the rim is usually much lower than the southeast rim. Sand is continually deposited in a southeasterly direction building that rim. Initially, blowouts may cover a few square meters and be a few centimeters deep. Extreme cases may reach an area of more than 3 hectares (7.5 acres) and a depth of over 30 meters. An average size is about 0.1 to 0.3 hectares in area and 4 to 10 meters in depth.

These natural blowouts should not be confused with wind eroded fields or plane sand sweeps. Nor should they be confused with eroded areas around windmills or in other areas where livestock congregate and disturb the vegetation. The term "Blowout" should be restricted to the naturally occurring, crater-shaped depressions.

A blowout is not static (Stubbendieck et al. 1989). The area of active wind erosion continually moves across the landscape at the speed of a few meters a year. Succession constantly occurs on the windward side. A blowout may exist

for decades before it reaches maturity. Maturity is reached when the blowing sand is deposited in a deep valley or lake, and no longer accumulates on the leeward side (Pool 1914). The leeward side is then lowered as the wind blows through the hilltop. The steep front slope is eliminated, which eliminates the wind turbulence and the erosive force of the wind.

Vegetation

The first careful botanical work in the Sandhills was done by H. J. Webber in 1889 (Pool 1914). Webber made a list of the plant species and carefully recorded notes for each of his collections. Smith (1892) described the distribution of plants in the Sandhills as well as the topography. A taxonomic study by Rydberg (1895) produced the most extensive collection of plants and notes on the Sandhills up to that time.

Raymond Pool (1914) conducted an extensive study of the vegetation of the Sandhills. His doctoral thesis included an inventory and ecological interpretation of the flora based on plant community associations. Pool (1914) named and described the Bunchgrass, Muhlenbergia, Speargrass, Wiregrass Transition, and Blowout Associations as occurring on sandhill upland.

Dominants of the Blowout Association were prairie sandreed [Calamovilfa longifolia (Hook.) Scribn.], lemon scurfpea (Psoralea lanceolata Pursh), and blowoutgrass [Redfieldia flexuosa (Thurb.) Vasey]. Other important species were cristatella (Cristatella jamesii T. & G.), sand lovegrass [Eragrostis trichodes (Nutt.) Wood], plains muhly [Muhlenbergia cuspidata (Torr.) Rydb.], sandhill muhly (Muhlenbergia pungens Thurb.), birdegg milkvetch [Astragalus ceramicus Sheld. var. filifolius (Gray) Germ.], clammyweed [Polanisia dodecandra (L.) DC. subsp. trachysperma (T.& G.) Iltis], and blowout penstemon.

Burzlaff (1962) subdivided the grasslands of the Nebraska Sandhills into three range sites: the dry valley, the rolling sands, and choppy sandhill range site. Each site possessed different soil and vegetation characteristics. Blowouts are most common on choppy sandhill range sites. Tall grasses, prairie sandreed and sand bluestem [Andropogon gerardii var. paucipilus (Nash) Fern.], dominated the choppy sandhill range site. Subdominants, little bluestem [Schizachyrium scoparium (Michx.) Nash] and sand lovegrass, were restricted to the north and east-facing slopes of the choppy hills. Sandhill muhly and hairy grama (Bouteloua hirsuta Lag.) were more common on ridge tops and south and west exposures. Soils were classified as stabilized dune sand. Although blowoutgrass was of minor importance on stabilized soils of the choppy sandhill site, it is the first to establish in blowouts, or other areas of wind erosion, followed by lemon scurfpea, sandhill muhly, and other grasses and forbs (Weaver 1965). Currently, dominant species on choppy sandhill sites are sand bluestem, little bluestem, prairie sandreed, and needle-and-thread grass (Stipa comata Trin. & Rupr.) (Weaver 1965, U.S. Department of Agriculture 1981).

Another of the initial species to establish in a blowout was blowout penstemon. This perennial, multistemmed forb is generally found growing in areas of bare sand or in association with blowoutgrass within the blowout and near its leeward side, in the area of sand deposition (Weedon et al. 1982b). Blowout

penstemon is especially well adapted to blowouts, for its stems root adventitiously, maintaining the plant in the shifting sands of these sites (Stubbendieck et al. 1983, 1984; Stubbendieck and Weedon 1984). Also, its nearly horizontal buried stems produce fibrous roots, providing anchorage in this unstable environment (Weedon et al. 1982b). As mentioned earlier, blowout penstemon is successional in nature. It colonizes the blowout, aids in physically stabilizing the sand, and declines when other vegetation becomes well established (Weedon et al. 1982b).

Population Biology

Demography

Population numbers: Presently, approximately 7,000 plants are known to exist over its entire known range. Individual populations vary in size from 25 or fewer to over 2,000 plants.

General demographic details: Blowout penstemon does not exhibit a uniform distribution throughout its range but tends to occur in population centers. The total area of all the blowouts containing blowout penstemon is less than 10 hectares (25 acres).

Density: The number of individuals of blowout penstemon per unit area varies tremendously. They are generally widely spaced, and not more than one individual will be found within one-square meter or as few as one or two specimens with no other blowout penstemon plants within several hundred meters.

Presence of dispersed seeds: The fruit (capsule) matures and splits in early to mid-August, and the seeds either fall near the base of the plant or are transported primarily by wind to other areas within the blowout or outside of the blowout. All healthy, flowering plants that were visited produced seed.

Evidence of reproduction: Blowout penstemon primarily reproduces by rhizomes, and naturally occurring seedlings are relatively rare (Stubbendieck et al. 1983, 1984; Stubbendieck and Weedon 1984). Soil seed reserves at two sites also have been found to be low, although a large number of seeds are produced (about 1,500 per plant) (Flessner 1988). The species may be dependent on vegetative reproduction for survival.

Evidence of population expansion or decline: Individual populations of blowout penstemon have exhibited large fluctuations in size during the past 10 years of monitoring (Hardy et al. 1989, Weedon et al. 1991). For example, the Graves' Ranch site in Garden County contained 768 individuals in 1985, increased to 1,614 in 1988, and declined to 774 again in 1991 (The Nature Conservancy 1991). A nearby population on the Eldred Ranch was made up of over 1,100 individuals in 1986. It decreased to about 1,000 in 1987 and has continued to decrease to 800 in 1989. The total population number also has exhibited tremendous variation. For example, Stubbendieck and Weedon (1984) noted a population

decrease of nearly 35 percent from 1982 to 1983. Presently, it appears that populations located in the eastern part of the Sandhills are declining, while those located in the western portion are either fluctuating widely or remaining stable (Hardy et al. 1989). Reasons for these population fluctuations are as yet unknown.

Age of plants before reproduction: Most blowout penstemon plants begin to bloom at 2 to 3 years of age. However, transplants have been observed in flower after 1 year of age. (Flessner 1988).

Phenology

Budding time: Plants have been observed to form buds from early May through early June.

Flowering time: Plants have been observed in flower from mid-May through mid- to late-June. A few plants may bloom from early August through early September.

Fruit formation: Fruits have been observed to develop from late May through early July.

Seed formation: It is estimated that seed formation begins in late May and continues through early July.

Fruit dehiscence: It is estimated that the capsules begin dehiscing in late July or early August.

Seeds: It is estimated that an average of 1,500 seeds are produced per plant (approximately 25-35 seeds per capsule), although seed production varies greatly between individual and year. Wind is the major factor in seed dispersal. However, it is not known if birds, rodents, insects, and/or other animals play a role in the dispersal of blowout penstemon seeds. Given the wide distribution of the species, it would seem logical that animals are an important factor in seed dispersal.

Germinability of blowout penstemon seeds is usually low (Stubbendieck et al. 1982a, b; Stubbendieck et al. 1983; Stubbendieck et al. 1984; Stubbendieck and Weedon 1984; Weedon et al. 1982a). These researchers have been able to increase germination to greater than 90 percent through a combination of hand-scarification and removal of soluble inhibitors. Sulfuric acid scarification also has been found to significantly enhance germination of blowout penstemon seeds (Flessner 1988). Sulfuric acid scarification may substitute for hand-scarification as the resulting germination percentages are adequate and the procedure is much less time-consuming. Cold-moist stratification and mechanical scarification failed to consistently enhance germination, and germinability was not enhanced by light and alternating temperatures (Flessner 1988). Also, freshly harvested seeds did not exhibit afterripening requirements (Flessner 1988).

Given that a plant produces an average of 1,500 seeds, a population of 100 plants would thus potentially produce approximately 150,000 seeds annually. However, as mentioned earlier, seed bank reserves are low and few seedlings have been observed in the field. It is likely then, that under field conditions the germinability of blowout penstemon seeds is also very low, seedling mortality is high, and/or seed dispersal rates are high.

Associated Species

Plants: Frequently associated plant species include blowoutgrass, lemon scurfpea, sandhill muhly, sand bluestem, prairie sandreed, and birdegg milkvetch.

Insect Vectors: Blowout penstemon is primarily cross-pollinated by insects (Flessner and Stubbendieck 1992a). The most important insect pollinators of blowout penstemon appear to be four species of megachilid bees, including Hoplitis pilosifrons (Cr.), Osmia distincta Cr., Osmia cyaneonitens Ckll., and Osmia integra Cr. (Lawson et al. 1989). Several other species of insects, including wasps, flies, beetles, and butterflies, have been observed visiting flowers of blowout penstemon, and it is likely that some of these insects are also pollinators.

Landownership

Approximately 73 percent of the entire population of blowout penstemon occurs on private land, and 25 percent and 2 percent occurs on Federal and State lands, respectively. Any successful recovery effort will thus require the participation and cooperation of these private landowners. Two populations occur on Federal lands; these are under the administration of the Fish and Wildlife Service. Two populations occur on State land, one is under the administration of the Nebraska Game and Parks Commission, and the second population occurs on State land administered by the Board of Educational Lands and Funds.

Impacts and Threats

Blowout penstemon is endemic to the Nebraska Sandhills. Its historic range was larger than the present range, but the historic range also was restricted to the Sandhills. Early collections and references erroneously indicated its presence in Wyoming, Colorado, and Kansas (Watson 1891, Britton and Brown 1913, Pennell 1920).

Blowout penstemon is a member of early successional vegetation and requires sites that are devoid or nearly devoid of vegetation. These are usually sites of active wind erosion. As succession progresses, blowout penstemon is unable to compete with the succeeding Sandhills prairie plants and gradually is eliminated. Within limits, activities or processes promoting wind erosion will favor the continuation of the species. Conversely, advancing succession, a primary goal of range management, will cause a reduction in the habitat and numbers of blowout penstemon plants.

Improved Range Management Practices

Historically, prairie fires were common in the Nebraska Sandhills (Stubbendieck 1989). Fires removed the protective cover from the soil resulting in shifting dune sand and blowouts. Control of prairie fires followed the 1870-1910 settlement period (Miller 1989, Stubbendieck 1989). Virtual elimination of fire from the Sandhills ecosystem allowed vegetation to advance into the majority of the eroded areas and to stabilize the sand, resulting in a decline in suitable habitat for blowout penstemon.

Continual summer grazing by cattle during the first half of this century caused enough disturbance to maintain many blowouts. Increased use of planned grazing systems (rotational grazing) during the past 30 years greatly reduced disturbance and has been responsible for decreasing wind erosion. During the past 5 years, the USDA Soil Conservation Service has focused upon providing technical assistance to determine grazing management strategies for erosion control in blowout prone areas.

More advanced grazing methods, commonly termed "holistic resource management," may further decrease sites of active erosion. Other advanced range management practices, including techniques to more evenly distribute livestock on rangeland, have been responsible for decreasing blowout penstemon habitat, numbers of populations, and numbers of individual plants.

Livestock Trampling and Utilization

Cattle and horses are the only types of domestic livestock commonly found on Sandhills rangeland, but the influence of horses on blowout penstemon has not been documented. Various breeds of beef cows, bulls, calves, and yearlings frequently have been observed near blowout penstemon plants. Many individual plants have been inspected during and after grazing periods. When adequate other forage is available, cattle occasionally graze on a portion of a plant but seldom consume more than a part of one shoot. The plants appear to be a matter of curiosity rather than a desired species. The occasional removal of a terminal portion of a shoot may be desirable because growth of axillary shoots is stimulated. Other forage may be limited during years of deficient precipitation or near the end of a period of intensive grazing. During these times of limited forage availability, cattle have been observed to closely graze nearly every available blowout penstemon plant. One occurrence of close grazing may or may not impact blowout penstemon, but repeated years of close grazing will severely weaken plants and may be the direct cause of plant death.

Cattle trampling of established plants has not been observed to be a problem. Infrequently, they break a shoot, which poses no threat to the plant. Trampling does have the potential to destroy seedlings. But, seedlings are rarely observed, and the chances of trampling are remote.

Collection

Private and commercial collectors have had little impact on blowout penstemon. It would be an attractive and desirable landscape plant, but most of the plants are in rather remote and inaccessible locations. One population is on privately owned land adjacent to a State highway, and a second is on State-owned land near public access. These small populations may be in jeopardy if their locations become known to the public. Collection of even a few plants over several years could deplete these small populations. The decision not to identify site locations in the proposed or final listing in the Federal Register has served to discourage some collectors, although others continue to seek the location of populations.

Highway or Road Building

The populations are not threatened by formal road building nor by the potential for ranch trails. Ranchers avoid driving near or through blowouts because of the possibility of becoming stuck. Ranch trails and roads are seldom placed in the high, choppy Sandhills habitat of blowout penstemon.

Off-Road Vehicle Impact

Off-road vehicle (ORV) use by a three-wheeler has been observed within the largest and most remote blowout penstemon population, with many plants being damaged. While most private landowners do not allow public access for ORV's, their own use of such vehicles in ranch managment or for recreation does pose a threat to populations. Another population with the potential for ORV use is on State property with public access administered by the Nebraska Game and Parks Commission. The population is located in a blowout near the top of a hill about 100 meters from a county road. Hill climbing and associated ORV activities may ensure continued disturbance and erosion in the area, but driving over plants would cause a severe negative impact to the population.

Powerline and Pipeline Construction

No powerlines or pipelines currently cross populations. No new construction is planned, and it is highly unlikely that any new powerlines or pipelines will be built in these areas. If construction should occur, populations would be severely impacted.

Pesticide Use

No research has been conducted on the influence of herbicides on blowout penstemon. It is highly probable that broadleaf weed killers would negatively influence members of this species. Fortunately, herbicides are seldom used on Nebraska Sandhills rangeland. It is doubtful that ranchers would even inadvertently apply an herbicide to blowout penstemon, because most try to encourage the growth of any vegetation in blowouts. The extant populations are surrounded by grassland, and herbicide drift from cropland or State highway right-of-way spraying is not a threat.

Insecticides could negatively influence the pollinators of blowout penstemon. As discussed earlier, numerous types of insects may be responsible for pollination; however, it is unlikely that localized insecticide use would completely eliminate insect pollination. Broad-scale insecticide use, such as the USDA Animal and Plant Health Inspection Service (APHIS) Cooperative Rangeland Grasshopper Control Program, could be potentially dangerous. Blocks of a minimum of 4,000 hectares (10,000 acres) are sprayed with ULV Malathion in late June or early July. Although the time of insecticide application is after flowering of blowout penstemon, the insecticide may influence levels of pollinators in future years. Due primarily to costs to the landowners, this project has not been active in Nebraska since 1982.

It is important to note that some seeds are produced by self-pollination (Flessner 1988). Therefore, complete eradication of insects would not stop all seed production. In addition, most of the propagation appears to be by vegetative means rather than from seeds.

Natural Threats

Circumstantial evidence indicates that periods of drought may be the greatest natural threat to the survival of this species. Blowout penstemon was listed as one of the most common species in blowouts 75 years ago, and it was occasionally collected into the 1930's (Pool 1914, Stubbendieck 1986). With one exception in 1959, it was not collected again until 1968. Many botanists thought that it was extinct after the 1930's (Stubbendieck et al. 1983). The only significant change, either natural or in management, during the period of 1914 to 1939, was the drought of the 1930's that severely influenced the vegetation of the Great Plains (Weaver 1954). Currently, the majority of the plants are located near the Box Butte-Morrill County line and in Garden County. The distance between these plants is about 100 kilometers (60 miles). A localized drought of a few-years duration may eliminate most of the remaining blowout penstemon plants.

Several insects (and arachnids) have been observed feeding on blowout penstemon plants, including spider mites, grasshoppers, and an insect larvae which burrows into the inflorescence. Populations of these pests are generally at low levels. However, large numbers of Aphis pentstemonicola Gillette and Palmer, the penstemon aphid, were observed on two individual transplants growing in a blowout near Alliance, Nebraska. Foliage of the infested plants appeared wilted, grayish-green, and stunted. Several seed predators, including Endothenia hebesana Walker, are active on blowout penstemon. The most serious insect threat appears to be a pyralid moth. Adults deposit eggs on the blowout penstemon plants. After hatching, the larvae burrow into the stems and are active until reaching the pupal stage. They frequently damage or kill the plants by boring activities in the crown area below the buds. It is known to occur in one natural population, but it may have caused the decline in other populations. Collections of this insect have been sent to the USDA for identification. These insects could pose a threat to both natural and transplant populations of blowout penstemon, and thus must be monitored closely. Blowout penstemon plants are also quite susceptible to fungal root rots. Plants infected with these fungi wilt, rot, and usually die.

Blowout penstemon is well adapted to the rigorous environment of an actively eroding blowout, but it does not grow in close association with plants other than blowoutgrass. It generally grows as widely spaced plants in nearly bare sand indicating that these plants may not have the ability to compete with each other or plants of other species for moisture. Its associate, blowoutgrass, does not use large amounts of soil moisture. As described earlier, blowout penstemon is an early successional species. It rapidly declines as members of new species, primarily sand bluestem and prairie sandreed, increase following stabilization of the sand and begin to use significant amounts of soil moisture. Research at the University of Nebraska on placement of blowout penstemon transplants into various plant communities in blowouts has documented its inability to successfully compete (Flessner 1988).

Man's activities, rather than natural processes, have greatly reduced the habitat available for blowout penstemon. Increase in habitat will probably not occur unless there is a significant change in the climate. Enough blowouts are available for colonies. However, the great distances between present populations prohibit natural movement of seed, and weather conditions allowing seed germination and seedling establishment occur infrequently.

Research to Date

Research has been funded by the Nebraska Game and Parks Commission and conducted at the University of Nebraska to develop propagation techniques and to determine some of the ecological characteristics of blowout penstemon. Germination of seeds was found to be only in the range on 4-13 percent. Therefore, several laboratory studies were conducted to determine the effect of cold-moist stratification, mechanical and chemical stratification, light and various alternating temperature regimes, and afterripening procedures on germination. Early research showed that soaking seeds or washing them with water for several hours was necessary to enhance germination, and all germination experiments included this step. Processing seeds through a mechanical alfalfa seed scarifier did not enhance germination. Cold-moist stratification increased germination (21 percent) over control seeds, but hand scarification (93 percent) and chemical scarification (48 percent) were the most effective germination-enhancing treatments. Due to the high labor requirements of hand scarification, chemical scarification (soaking seeds in concentrated sulfuric acid for 15 minutes) has been adopted as a standard propagation technique.

Various concentrations of several rooting hormones were evaluated to vegetatively propagate blowout penstemon from cuttings. This research has led to the development of standard methods for vegetative propagation. Methods for tissue culture have not been successful. Callus growth has been obtained, but roots have not been formed.

Greenhouse and field studies were conducted to develop methods of producing and successfully establishing transplants in their natural habitat. Nitrogen and phosphorus fertilization produced vigorous transplants, and cutting back foliage immediately before transplanting improved establishment. High survival rates (over 70 percent) were recorded 1 year following transplanting at several

locations. Members of this species are not highly competitive with other plants, as greater survival was recorded for transplants placed into blowoutgrass [Redfieldia flexuosa (Thurb.) Vasey] communities than for those placed in other plant communities in blowouts. Transplants placed in bare sand were susceptible to wind erosion. Death commonly was caused by erosion of all of the soil surrounding the roots.

Other field studies were conducted to evaluate the mycorrhizal associations, pollination characteristics, seed bank reserves, and direct seeding of blowout penstemon. Low to moderate levels of mycorrhizal infection and low mycorrhizal inoculum potentials were observed in blowout penstemon roots and in the bare sand of blowouts, respectively (Flessner and Stubbendieck 1992b). Blowout penstemon was largely cross-pollinated by insects (Flessner and Stubbendieck 1992a). Seed production was relatively high, but seeds quickly were removed from the seed bank leaving low numbers in the soil only a few weeks following seed dispersal. Several experiments with a variety of treatments were conducted to determine the feasibility of direct seeding. Fewer than 1 in each 1,000 seeds of the best treatment produced an established seedling. Therefore, propagation must be done in the greenhouse, and transplants moved to the field. A more complete summary of the research may be found in Flessner 1988, and Flessner and Stubbendieck 1989a and 1989b.

All populations of blowout penstemon were surveyed for insect damage in 1991. Seed predators were common in all populations, but the most serious insect threat, a pyralid moth, was found in only one population. It appears to have been the cause of a serious decline in that population. Two systemic insecticides applied to established plants in propagated populations were determined to be not phytotoxic. Additional research in the greenhouse showed that Cygon (dimethoate) and Orthene (acephate) were not phytotoxic to seedlings. Therefore, either insecticide may be used to control the moth.

II. RECOVERY

Objectives

The initial objective of this recovery plan is to downlist Penstemon haydenii from endangered to threatened species classification. This reclassification will be considered when a minimum of 10,000 individuals in at least 5 stable populations have the minimum level of protection that will ensure their continued existence.

The primary objective of this recovery plan is to delist Penstemon haydenii as an endangered or threatened species. The basic population goals for delisting are to protect a minimum of 15,000 individuals in at least 10 population groups and their habitats. Penstemon haydenii will be considered for delisting when the following recovery and protection criteria are achieved:

1. A total population of at least 15,000 established individuals with documented stability.

2. A minimum of 10 population groups, each with a minimum of 300 plants at the low point of population fluctuations, that are documented to be naturally-reproducing and self-sustaining. These groups will be comprised of naturally occurring, extant population groups, population groups reintroduced into areas of historic occurrences, and population groups introduced to new locations within the species historic range in order to ensure demographic stability. In total, these groups should represent a viable population that is demographically stable, able to maintain genetic variation, and evolve. They should be able to withstand and adapt to significant natural disturbances and environmental variations.

3. A minimum level of protection that will ensure the continued viability of each population group. The highest level of protection should be afforded the above 10 population groups to prevent their destruction, habitat degradation or exploitation, and guarantee their status as a viable population.

4. A management plan is established and implemented for each population group that will maintain it as a naturally reproducing, self-sustaining population. The plan should enable the group to evolve and withstand natural disturbances and environmental variations in its habitat.

The projected period required to meet criteria for downlisting is 10 years from the initiation of the recovery plan. The projected period to meet Recovery Plan criteria for delisting is 15 years from the initiation of the Recovery Plan. The above criteria for downlisting and delisting are based on current knowledge and information. As additional data is obtained from the research proposed in this Recovery Plan, it may be necessary to change the criteria required to delist the species.

Stepdown Outline

1. Protect naturally occurring, reintroduced and introduced populations and their habitat.
   - 1.1 Prioritize and protect extant naturally occurring populations.
     - 1.11 Prioritize naturally occurring populations for protection.
     - 1.12 Determine and obtain appropriate level of protection for each naturally occurring population.
   - 1.2 Prioritize and protect reintroduced and introduced populations.
   - 1.3 Enforce all International, Federal, and State endangered species laws and regulations.
   - 1.4 Monitor and eliminate threats to populations.
     - 1.41 Eliminate the suppression of disturbance factors.
     - 1.42 Prevent overutilization by livestock.
     - 1.43 Eliminate threat from the collecting of plants.
     - 1.44 Prevent detrimental use of pesticides in population areas.
     - 1.45 Prevent loss due to development or construction.
     - 1.46 Prevent loss due to off-road vehicle impact.
     - 1.47 Minimize impacts of natural threats.

2. Locate additional naturally occurring populations and suitable habitat for establishing new populations.

3. Monitor populations and conduct research to determine species life history, minimum viable population parameters, habitat requirements, and management criteria.
   - 3.1 Monitor the status and trend of each population.
   - 3.2 Determine the effects of grazing and other disturbance factors as management techniques.
   - 3.3 Determine the parameters required for a viable population.
     - 3.31 Determine factors required for germination and establishment of new plants under natural conditions.
     - 3.32 Determine seed banking and viability.
     - 3.33 Assess the influence of native birds and mammals on the species life history.
     - 3.34 Identify pollinators, insect pests, and diseases and their effects on populations.
     - 3.35 Determine the life history, population dynamics, ecological requirements, and limiting factors for the species.
   - 3.4 Develop propagation techniques.
   - 3.5 Delineate requirements for flowering in greenhouse grown seedlings.
   - 3.6 Assess genetic variability.

4. Reintroduce populations in areas of historic occurrence and introduce new populations in suitable habitat within the species range.

5. Develop and implement management plans for naturally occurring and new populations.
   - 5.1 Develop management plans for each naturally occurring population.
     - 5.11 Identify management needs of small populations.
     - 5.12 Identify management needs of large population complexes.

5.13 Identify management needs of population in nontypical habitat.
5.2 Develop management plans for each newly established population.

6. Maintain seed source and genetic variability in an artificial seed bank.

7. Carry out public education to develop awareness and support for the conservation of Penstemon haydenii.

Narrative Outline for Recovery Actions

1. Protect naturally occurring, reintroduced, and introduced populations and their habitat.

Protection is necessary not only to prevent the degradation or outright destruction of a population from human impact but also to provide the habitat requirements needed for the continued viability of individual populations and the species. In addition, the area to be protected for each population should reflect the total habitat needs of that population. For small populations, the area protected must include the entire population, the habitat essential to the population's survival, and a buffer to protect the population from encroachment. Except in cases where protection is solely for population maintenance, the area protected should also include habitat for growth and expansion. Large populations which are spread over a substantial geographic area and whose habitat is comprised of a complex of blowouts are of the greatest importance for protection. These occurrences represent the best remaining examples of complete population dynamics under near-natural conditions. It may not be feasible to protect all individual plants in large population complexes. In these cases, the area protected must encompass the majority of individuals, provide essential habitat for all aspects of population dynamics, and include a buffer zone.

In meeting the delisting criteria for full protection of 10 populations, the populations protected should represent both the historic distribution of the species and the largest possible geographic distribution within the species range. This will serve to minimize the impact from large-scale environmental threats such as drought, disease, and insects.

As a requirement for downlisting, the two largest, naturally occurring, extant populations must have the minimum level of protection that will ensure their continued existence. As a requirement for delisting, the three largest, naturally occurring, extant populations must have the highest level of protection in order to guarantee their existence as viable self-sustaining populations. The remaining number of populations required for downlisting or delisting will be selected from the highest ranking naturally occurring, reintroduced or introduced populations as prioritized below. Selection will be based on their ability to meet recovery plan requirements for downlisting or delisting and the level of protection obtainable for that population.

1.1 Prioritize and protect extant, naturally occurring populations.
Currently, six naturally occurring populations and population complexes are known and with future field surveys additional natural occurrences may be discovered. These occurrences represent the total gene pool of Penstemon haydenii. The protection of these populations and their habitat is crucial to the viability of the species genetic resource. All extant, naturally occurring populations should receive the appropriate level of protection based on their priority. Information on the general location and ownership of known extant, naturally occurring populations is listed in Appendix A.

1.11 Evaluate and prioritize naturally occurring populations for protection.
In order to determine the level of protection needed, populations should be prioritized based on an evaluation of each occurrence for a number of critical factors. Factors to be assessed for each population include: the number of individuals in the occurrence, its geographic size, habitat quality, the vigor and viability of the population, threats, and defensibility. Large population types, unique genotypic varieties, and nontypical habitat are factors that should receive emphasis in the prioritization process.

1.12 Determine and obtain the appropriate level of protection for each naturally occurring population.
Once the priority is determined for each population, the most appropriate and/or highest attainable level of protection should be secured. The most secure form of protection is for a public agency to own or hold a permanent lease or easement on the property of occurrence with an approved management plan. The stated primary objective of the plan should be the protection and preservation of that population. Private conservation organizations offer the second strongest level of protection through ownership or holding of conservation easements. However, they do not offer the same protection possessed by the State or Federal government on public lands. One of the best methods of ensuring protection on private land would be voluntary, binding agreements between landowners and the State or Federal government.

1.2 Prioritize and protect reintroduced and introduced populations.
If surveys do not locate additional naturally occurring populations that can fulfill recovery plan goals, it will be necessary to establish new populations of P. haydenii. Once established, these reintroduced and introduced populations should be prioritized for protection using the same criteria as those for naturally occurring populations. Protection should also follow the same process as that for natural occurrences.

1.3 Enforce all International, Federal, and State endangered species laws and regulations relevant to Penstemon haydenii.
All International, Federal, and State treaties, laws and regulations that protect endangered species and are applicable to Penstemon haydenii are to be enforced. The strong enforcement of laws already enacted can provide a significant measure of protection for endangered species. The Convention on International Trade in Endangered Species (CITES) was established to regulate the sale and trade of endangered species.

The Endangered Species Act of 1973 (Act), in conjunction with CITES, also prohibits the import, export, and foreign trade in endangered plant species, as well as their interstate sales and shipment. The Act also prohibits the removal or destruction of endangered species from Federal lands and restricts their taking or destruction on private property. Furthermore, the Act directs Federal Agencies such as the Forest Service and the Fish and Wildlife Service to manage for endangered species. They are also required to follow all other regulations and guidelines dealing with endangered species, such as those in the National Environmental Policy Act (NEPA), in assessing the impact of mineral, energy, road, building and water development. Under Section 7 of the Act, Federal Agencies are required to consult with the Fish and Wildlife Service on any project involving Federal permits, funding, etc., which might affect P. haydenii.

The State of Nebraska Nongame and Endangered Species Conservation Act of 1975 prohibits the export, possession, sale or transportation of an endangered plant species. This act is administered by the Nebraska Game and Parks Commission.

1.4 Monitor and eliminate threats to populations.
Of the number of identified threats to individual populations and the species, only a few are active threats while most represent potential conflicts. The majority of threats are due either to the direct actions of man or are human influenced. Most suspected natural threats are localized in effect or in the case of large-scale, region wide threats such as drought, they are exacerbated by man's manipulation and fragmentation of the species habitat.

1.41 Eliminate the suppression of disturbance factors.
The largest single impact or threat to Penstemon haydenii is the loss of early successional habitat which occurs primarily in the form of blowouts. This loss of habitat is due to the suppression of disturbance factors such as fire and overgrazing throughout the species range and the direct action to stabilize blowouts when they occur. The optimum management of areas with P. haydenii populations should not only eliminate the suppression of disturbance but should require active disturbance to maintain and create early successional habitat. For areas where such type of management is not feasible, management plans should designate the creation of disturbances, such as

overgrazing, and allow natural processes, such as wind erosion, to occur in or near extant populations. The scope of such management must be adequate to meet recovery plan criteria for at least 10 populations.

Areas where changes in management can be accomplished most quickly and effectively are those on public lands owned by the Fish and Wildlife Service, the Forest Service, and Nebraska Game and Parks Commission. Changes in management practices on private lands will require management agreements through voluntary cooperation, conservation easements, leases, etc.

Through a number of its programs, the Soil Conservation Service works with private landowners to reduce disturbance and control soil erosion. Several of these projects deal directly with the stabilization, revegetation, and prevention of blowouts. As a Federal Agency, the Soil Conservation Service is required under Section 7 to assess and avoid impacts of its programs on endangered and threatened species. Through consultation with the Fish and Wildlife Service and the Nebraska Game and Parks Commission, the Soil Conservation Service should be apprised of the locations and habitat requirements of P. haydenii. This will aid the Soil Conservation Service in preventing detrimental impacts to known populations or potential habitat through the advice it provides private landowners.

1.42 Prevent overutilization by livestock. Under normal range conditions, the use of high stocking rates of livestock as a disturbance factor to maintain habitat for P. haydenii is considered beneficial. Under these conditions, little negative impact has been observed. However, at the end of prolonged periods of heavy grazing or during periods of drought, when preferred forage is scarce, livestock will heavily browse P. haydenii plants, dramatically reducing their aboveground vegetative growth. Repeated grazing of the plants may reduce their vigor and may cause their death and the destruction of that population. Livestock age class may also affect the utilization of plants. Yearling cattle are less selective in their grazing and may have a greater impact on populations than older cows which graze more selectively. High stocking rates, adverse climatic conditions, and livestock age class all require the close monitoring of P. haydenii to prevent overutilization and potential loss.

1.43 Eliminate threat from the collecting of plants. P. haydenii's numerous, large, showy and fragrant flowers makes it desirable to collectors for use as a garden ornamental. A number of inquiries have been made by collectors trying to find the location of populations. For this reason, the precise location of populations has not been published in the final listing in the Federal Register or this recovery plan. Populations should

be inspected for evidence of collecting; and flower catalogs and trade publications should be monitored for sales of plants or seeds. Any violation should be prosecuted under the appropriate international, Federal, or State laws.

If monitoring indicates that collecting poses a substantial threat or if a significant horticultural demand develops, consideration should be given to allow or promote the commercial propagation of P. haydenii. Guidelines will be developed by the Fish and Wildlife Service and the Nebraska Game and Parks Commission for the release of plant propagation material to legitimate horticulturalists. The source of this plant material should be from cultivated material of institutes such as the University of Nebraska, Chadron State College, or the Nebraska Statewide Arboretum. Regulations for the sale of plant material will also be established.

1.44 Prevent detrimental use of pesticides in population areas. Herbicide use is not currently a threat to populations nor is large-scale use on P. haydenii habitat or drift from adjacent areas likely to pose a threat. However, poor application methods or improper use of herbicides to control localized occurrences of noxious weeds is a potential threat. The use of herbicides for control of noxious weeds on rangeland should not be permitted in close proximity of P. haydenii populations. To prevent impact on P. haydenii, populations should be monitored for any such occurrences of weeds or other herbicide use. Landowners or area managers should be advised of such problems and alternate control methods should be utilized.

Localized use of insecticides pose only a minimal threat to blowout penstemon populations. Large-scale insecticide use such as the USDA APHIS program does represent a potential threat to an individual population's viability through the elimination of pollinators necessary for seed production. Monitoring for conditions which may initiate the enactment of an APHIS program and coordination with the USDA is crucial to prevent the detrimental use of insecticides on P. haydenii or its habitat. Under Section 7, APHIS is required to consult with the Fish and Wildlife Service on the potential impact of its programs on endangered and threatened species. APHIS coordination with the Fish and Wildlife Service and the Nebraska Game and Parks Commission on the pesticide used and the method of application can avoid detrimental impact to P. haydenii.

1.45 Prevent loss due to development or construction. Threats from development such as road widening and construction or powerline or pipeline construction is low. No construction or development of this type is known to be planned at this time for areas with P. haydenii populations. Other development such as the construction of trails or buildings is unlikely in the

rough terrain typical of the species habitat. Despite the low probability of these types of threats, it is extremely important to monitor all development in the vicinity of populations. Each project should be assessed for possible detrimental impacts. Such assessment is mandatory on Federal and State lands and for projects on private lands requiring Federal or State review. Federal agencies are required to comply with Section 7 and consult with the Fish and Wildlife Service on any project involving Federal permits, monies, etc., which may effect P. haydenii.

1.46 Prevent loss due to off-road vehicle impact.
Off-road vehicle use has been observed within the largest and most remote population, with many plants being damaged. A population located on Nebraska Game and Parks Commission land is also vulnerable to this threat. Actions such as fence or barrier construction should be undertaken on this and other public lands to prevent loss if this becomes a threat. Populations on private lands should be monitored with landowner contacts and agreements negotiated to eliminate this threat on these areas as well.

1.47 Minimize impacts of natural threats.
In many cases, it is not feasible or even possible to eliminate natural threats, and to the extent that natural "threats" are necessary to the species evolution, it is inappropriate to completely eliminate them. However, due to man's manipulation of the species habitat, it may be necessary to minimize the impact of a natural threat to prevent the loss of a population or the species. Although P. haydenii evolved with periods of prolonged drought, the stabilization and fragmentation of its habitat has made drought a threat to the species survival. In order to minimize the impacts of localized droughts, it is critical to protect populations throughout the species range. The climatic and habitat variations between populations also increases the chances of a population surviving a regionwide drought.

Larvae of one or more species of pyralid moth appear to have severely damaged one natural population and one introduced population. The threat to P. haydenii from pests such as grasshoppers, spider mites, and insect larvae is not known. The penstemon aphid (Aphis penstemonicola) appears to be a potential threat to individual plants. Research is needed to fully ascertain the threat from these types of pests. Monitoring of populations and individual plants is needed to detect large-scale infestations that may present a threat. Control methods should employ the minimum level needed to eliminate the threat.

Currently, the only disease which appears to be a threat to the species is a fungal root rot to which plants are quite susceptible. If research shows this to be a serious problem, actions should be taken to minimize its impact. Populations should be monitored for this and any other diseases which may pose a threat.

2. Conduct systematic surveys for additional naturally occurring populations and suitable habitat for establishing new populations.
The recovery criteria of 10 populations throughout the species range dictates that up to eight new reintroduced or introduced populations may need to be established. Plotting the locations of extant and historical occurrences on a map shows that vast areas of the Sandhills within the species range have no recorded occurrences of blowout penstemon. Suitable habitat is known to exist in these areas and with it the potential for extant populations. Surveys of these areas are needed to locate any extant occurrences and to find habitat suitable for establishing new populations. Since the search for extant populations requires the locating of suitable habitat, these surveys can be conducted concurrently.

Due to the large area to be surveyed, the most effective methods of survey are the use of remote sensing technologies. Blowouts, the primary habitat of blowout penstemon, are distinctive physiographic features readily identified through remote sensing. Technologies should be evaluated on the basis of effectiveness, accuracy, and cost. Methods to be considered include computer-aided analysis of Landsat imagery, air video or air photography, and the manual inspection of color infrared photos, color slides, and black and white photos. Once a survey method is selected, search criteria should be established to produce an accurate and consistent survey. Search criteria should consider factors such as area of historical occurrence, blowout size, vegetative cover, overall size, and the number of blowouts in a complex. The survey process may entail a multilevel approach. For instance, computer analysis of aerial photos would be used to initially identify likely sites, these would then be evaluated by the manual inspection of color infrared photos. Sites selected from the review would then be checked from aircraft with the final review level being a ground search.

Potential sites identified from the final review level above should be ground searched for populations of P. haydenii. Ground inspection should be conducted during the flowering period in late May and early June when plants are most easily detected. Due to the size of the area to be inspected, it will be necessary to conduct the survey over a several year period, with the areas exhibiting the greatest potential being surveyed first.

If no plants are found during the ground search, the site should be further evaluated for its suitability as a site for the establishment of a new population. Criteria to consider for use as an establishment site include: occurrence on public land, vicinity to historical occurrence, size, potential blowout life, threats, and defensibility. Based on this

evaluation, all ground surveyed sites should be prioritized on their suitability for new population establishment. Highest priority sites should be large with a long blowout life, have low threat and high defensibility, occur in the area of a historical occurrence and on public land.

3. Monitor populations and conduct research to determine species life history, minimum viable population parameters, habitat requirements, and management criteria.
Although some aspects on the basic biology, life history, and effects of management practices for P. haydenii are known, a great deal of research is still needed. Research to develop standardized monitoring techniques, assess impacts of various management practices, and determine parameters for viable populations is necessary.

The development of usable monitoring techniques is required to standardize data collection and provide accurate information. This in turn forms the basis from which to assess the effects of management practices and determine life history and viable population parameters. Monitoring will be necessary when downlisting and delisting criteria have been met.

Research on the effects of various management practices is essential to determine the optimum management needed for all aspects of the species life history. This will enable the implementation of long-term management plans that will ensure individual population and species viability. It is also critical in designing management plans that will provide the maximum length of life or recovery for declining populations.

Research into viable population parameters will identify factors required for seed germination, plant growth, reproduction, and population viability. Once identified, these will be used in developing management plans, the recovery of declining populations, and the establishment of new populations.

3.1 Monitor the status and trend of each population.
Develop standardized monitoring techniques that will accurately reflect status and trend for individual populations and the species as a whole. Methods should be compatible between large, small, wild, and reintroduced populations. Some of the parameters monitored should include overall population numbers, plant density, population age profile to reflect mortality and recruitment, population boundaries to detect changes in geographic size and distribution, uniform technique for counting stems/plants, and number of flowering stalks, etc. Monitoring should also incorporate climatic data such as amount and timing of precipitation, temperature, etc. Results will be used to determine the species life history and population dynamics. Monitoring should continue until the species is delisted and for 5 years thereafter, then periodically at 5-year intervals.

3.2 Determine the effects of grazing and other disturbance factors as management techniques.

Maintaining active blowouts is considered a prerequisite for the continued survival of blowout penstemon. Erosion from wind and disturbance from grazing are the two factors currently responsible for maintaining blowouts. Historically, fire would also have been a major disturbance factor in maintaining and promoting blowouts. Under present day range management, the use of fire is not considered an acceptable management practice in the Sandhills because of the potential threat of wildfire. However, because fire in the form of prescribed burning represents an effective management tool, research should be conducted to determine its effect on P. haydenii habitat and its potential use as a limited management practice for small areas. Prescribed burning may be a possibility on federally controlled lands. Research is needed to determine the timing, stocking rate, and duration of grazing that is beneficial to blowout penstemon survival and under what conditions it may threaten a population's survival. Methods of increasing disturbance, such as concentrating animal activity by feeding cattle in or near blowouts, should also be researched. Additional research is needed to determine if methods of mechanical disturbance, such as discing or grading, can be used to maintain and create suitable habitat.

3.3 Determine the parameters required for a minimum viable population.

Data obtained from this category of research in conjunction with that in 3.1 and 3.2 will be used to determine the parameters of a viable population for P. haydenii. Information obtained from this research will help determine the number, size, and distribution of individual populations needed for delisting. It will also aid in evaluating and prioritizing recovery objectives. The results will be necessary to determine what types of management techniques are needed for species recovery. Research in a number of areas is necessary to provide the required information for this category.

3.31 Determine factors required for germination and establishment of new plants in a natural environment.

Very little natural recruitment has been observed in natural populations; however, laboratory research has shown that consistent high rates of germination and seedling establishment is possible. Results will determine if the low recruitment observed in the field is a natural condition and identify the factors limiting seedling establishment. Factors to consider in this research include micorrohiza, soil moisture, pH and texture, slope, vegetative competition, wind, and/or grazing disturbance. The establishment of test populations will be required for this research.

3.32 Determine seed banking and viability.

Collect soil samples from extant populations and sites known to have had plants to determine presence of seed. Conduct buried seed studies under natural and laboratory conditions to

determine viability of seeds. Results are important in determining the species life history and necessary to provide a viable seed source to maintain genetic variability and plants for research and transplanting.

3.33 Assess the influence of native birds and mammals on the species life history.
Areas of investigation include: predation and/or seed caching by rodents; predation (grazing) and subsequent effects of digestion on seed germination by large herbivores including cattle, bison and possibly elk; and seed dispersal and effects on germination by birds. Results will determine what possible role, if any, native animals play in the life history of blowout penstemon.

3.34 Identify pollinators, insect pests, and diseases and their effect on populations.
P. haydenii is the only member of the sect. Coerulei to produce a fragrance. Research is needed to determine what insects act as pollinators and if small populations of plants do not support or attract pollinators to produce adequate amounts of viable seed for reproduction. Insect damage has been observed on P. haydenii populations. Research is needed to evaluate the level at which insects/pests pose a threat to a population's survival. Research is also needed to identify diseases that may threaten a population's survival.

3.35 Determine the life history, population dynamics, ecological requirements, and limiting factors for the species.
This area of research is crucial to determine the age profile of a self-sustaining population, and normal fluctuations in population numbers. Research should be conducted to determine these parameters and to identify the natural processes that are the plant's ecological requirements and its ability to respond to environmental stress. Research is needed to determine the limiting factors for a plant's growth and survival in the form of nutrients, moisture, and substrate.

3.4 Develop propagation techniques.
Recent surveys indicate that one known population of P. haydenii has become extinct and that several other populations are declining with at least one of these threatened with extinction in the very near future. One color variety is also known to be lost from the wild, although seed from this variety was collected and is being held in storage. These cases illustrate the critical importance in being able to propagate the species and to successfully transplant it back into the wild. Research is required to identify efficient and economical germination of seeds for direct seeding into the wild and also for the production of seedlings for transplanting. Research is needed to

develop the propagation of cuttings for use in transplanting. Research is also required to determine the best method of introduction in the field to ensure transplant survival. The ability to successfully establish transplant populations will preserve genetic diversity and maintain the known distribution of the species.

3.5 Determine requirements for flowering in greenhouse grown seedlings. This project would determine the photoperiod and fertilization regime needed to induce 1- and 2-year old greenhouse grown plants to bloom. This is needed to provide a source of seed for research purposes without depleting wild populations. It would also provide information on factors leading to seed production in the wild.

3.6 Determine genetic variability. Research to determine the genetic variability of intra- and interpopulation plants would further describe the species, enable maximum diversity in transplant populations, and provide valuable information on species distribution and evolution. The most appropriate technology, such as that utilizing allozymes, should be used.

4. Reintroduce populations in areas of historic occurrence and introduce new populations in suitable habitat within the species range. To meet the recovery criteria of 10 naturally reproducing, self-sustaining populations and to maintain genotypic varieties under natural conditions, it may be necessary to establish up to 8 new populations. Populations will be reintroduced into areas of recorded occurrences and new introduced populations will be established in suitable habitat within the species potential range. Information obtained from research in 3.4 will be used in the establishment of these populations. For populations threatened with extinction or loss, the best method of preserving that occurrence's gene pool is the propagation of plants using genetic material from that population. The reintroduction of these plants into the sites where the material was obtained along with appropriate management may restore these occurrences to viable populations. The State-owned Cherry County site faces the possibility of extinction and may require this type of action. For all sites where new populations are established, the genetic background of the plant material used should correspond with that of the naturally occurring populations of the area.

   Sites selected for the establishment of new populations will be those identified from surveys and prioritized according to their habitat suitability as identified in 2. Sites occurring on public land, such as the Fish and Wildlife Service Valentine National Wildlife Refuge, will receive the highest priority.

5. Develop and implement management plans addressing the requirements of each naturally occurring and newly established population. Human intervention has suppressed natural disturbance factors which maintained suitable habitat for P. haydenii. Consequently, human intervention in the form of habitat management is necessary to create and

maintain suitable habitat for the species. As stated in the recovery criteria, the management objective is to provide habitat for each population that will maintain the species as a whole as a minimum viable population. The overall effect of management should be to maintain the earliest stage of succession; minimize or eliminate competition; and maintain an open, bare sand substrate which is the critical habitat of blowout penstemon. To the extent possible, management practices should simulate the natural processes which historically maintained suitable habitat at each occurrence site. The full impacts of all potential management practices are not yet known; however, some, such as grazing, are understood sufficiently to encourage their use for initial management purposes. Information gathered from research in 3. will be used to develop long-term management plans.

5.1 Develop and implement management plans for each naturally occurring population.

Most extant populations are comprised of plants in several vegetative forms and various life stages. The management of these populations should attempt to maintain all of these existing plants while promoting the establishment of all age classes necessary for a self-sustaining population. The management needs of each population should be identified in a management plan established and implemented to address these needs.

Currently, the accepted management practice for P. haydenii is to graze at very high stocking rates in order to overgraze the area and maintain suitable habitat. Management plans utilizing grazing or other management practices should be tailored to the specific identified needs of each population. All management practices should be closely monitored to prevent any detrimental impact or threat to the population. Management plans should be initiated on a priority basis with the most threatened sites receiving first action. The State-owned Cherry County site is threatened with extinction and should receive immediate action.

5.11 Identify management needs of small populations.

The management needs of a small population may be to reduce competition, reduce the vegetative cover, and provide suitable substrate for seedling establishment both in the immediate blowout and in adjacent areas. Intensive grazing will accomplish most of these needs, although the high impact poses a threat to existing plants. To prevent their loss, portions of the population or even individual plants may need to be fenced. The population at the Box Butte County site typifies this type of management need.

The State-owned Cherry County site is a small population threatened with extinction and in need of immediate action to save the genetic resource it represents. The population at this site is declining in number and vigor of individual plants. Although not documented, the decline is apparently due to insect

damage and the stabilization of the blowout resulting in the loss of essential habitat. Probable causes for this stabilization are the lack of disturbance and changes in edaphic factors due to the "aging" of the blowout.

A now extinct population in Hooker County declined over the past decade to a single observed plant in 1990. Actions were taken to secure plant material from this individual for vegetative propagation under controlled greenhouse conditions in an effort to maintain this population's genetic resource. Site inspections in 1991 determined that no plants remained at this site. The site should be evaluated to determine if propagules from the salvaged plant material should be used to reestablish the original population or to establish a new population at a more viable site in the vicinity.

Although not as dramatic, the population at the State-owned Cherry County site has had a decrease in the number of plants and a decline in vigor. The underlying causes appear to be a lack of disturbance, changes in edaphic factors due to blowout "aging", and insect damage. However, because there are a number of plants still extant, a concerted effort should be made to maintain the population as long as possible. Management practices to create disturbances either through grazing or by mechanical means should be implemented immediately. A study to evaluate insect damage has been initiated and control measures resulting from the study should be implemented. Seed should be collected and placed in storage to preserve the genetic resource of the population.

5.12 Identify management needs of large population complexes. Conversely, for large populations occurring within a complex of blowouts, management shifts from the management of small areas intent on protecting each existing plant to large areas where the maintenance and promotion of population dynamics becomes primary. Due to the larger area to be managed and landownership by several parties, it may be necessary to establish a rotational grazing system or use a number of herds. In this situation, the negative impact to a few plants is to be tolerated. The Box Butte-Morrill County site and the Garden County site represent sites where this type of management can and, in most instances, is currently being used.

5.13 Identify management needs of populations in nontypical habitats. Populations occurring in nontypical habitats should be evaluated to determine what type of disturbance factor is responsible for the creation and maintenance of suitable habitat at that site. Management plans should then be adopted to ensure that the disturbance mechanism is protected or a suitable substitute is devised. The Cherry County river site is an example of a nontypical habitat. Here, an eroding riverbank provides the

suitable habitat for a population of P. haydenii. Management at this site should prevent any nonnatural manipulation of the riverflow that would alter the river channel and stop or drastically accelerate the erosion of the river bank. Management must also allow for the natural, unimpeded erosion of the upland.

5.2 Develop and implement management plans for each newly established population.
Newly established populations will require different management than those occurring naturally. These new populations will be established either by direct seedings, by planting propagated plants, or both. In all cases, the initial establishment process will probably be carried out over a several year period. Management during this period will be determined by the results of establishment research required in this recovery plan. Once established, these populations should receive the same management as naturally occurring populations.

6. Maintain seed source and genetic variability in an artificial seed bank.
The genetic variability of blowout penstemon should be maintained by depositing seeds in a qualified artificial seed bank with long-term storage capabilities. The seeds should be collected from all naturally occurring populations and all recognized varieties. Seeds required for research and reintroduction should be held in short-term storage under appropriate conditions in University facilities.

7. Carry out public education to develop awareness and support for the preservation of Penstemon haydenii.
Educating the public and landowners of blowout penstemon's significance and its conservation needs is very important to the long-term recovery of the species. Posters and brochures should be developed to respond to public inquiries and for distribution at information displays, fairs, workshops, and informational programs. Educational material should be developed for use in schools, conferences, and workshops. Articles should be published for use in newspapers, regional magazines, and scientific publications. News releases and interviews should be generated for radio and television.

Perhaps the most important aspect of public information is landowner contact. Landowners should be made aware of the occurrence of blowout penstemon on their property. They should also be made aware of the plant's significance and any restrictions that may affect them. A positive first contact is crucial as it may influence future cooperative efforts to protect and manage that population.

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PART III
IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and costs for the recovery program. It is a guide for meeting the objectives elaborated in Part II of this plan. This schedule indicates the recovery plan tasks, corresponding outline numbers, task priorities, duration of tasks ("ongoing" denotes a task that once begun, should continue on an annual basis), the responsible agencies, and lastly, estimated costs. These actions, when accomplished, should bring about the recovery of the blowout penstemon and protect its habitat.

KEY TO IMPLEMENTATION SCHEDULE COLUMNS

Definition of Priorities

Priority 1: All actions that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

Priority 2: All actions that must be taken to prevent a significant decline in species population/habitat quality, or some other significant negative impact short of extinction.

Priority 3: All actions necessary to provide for full recovery (or reclassification) of the species.

Abbreviations Used in Implementation Schedule

APHIS	Animal and Plant Health Inspection Service
FS	U.S. Forest Service, Nebraska National Forest
FWE	Fish and Wildlife Enhancement, U.S. Fish and Wildlife Service
NGPC	Nebraska Game and Parks Commission
RW	Refuges and Wildlife, U.S. Fish and Wildlife Service
SCS	USDA Soil Conservation Service
TNC	The Nature Conservancy

Part III - Implementation Schedule
Blowout Penstemon

Priority Number	Task Number	Plan Task	Task Duration	Responsible Agencies FWS Region/Program	Responsible Agencies Other	Cost Estimates (x $1000) FY-1	FY-2	FY-3	Comments
1	3.1	Monitor populations	ongoing	6 FWE, RW	NGPC, FS TNC	8	8	8	Monitor status and trend
1	3.34	Study pollinators, insect pests and diseases	6	6 FWE	NGPC	5	5	5	Partially completed
1	5.11	Manage small populations	5	6 FWE, RW	NGPC, FS, TNC	20	20	20	Develop and implement management plans
1	6.	Maintain seed bank	ongoing	6	NGPC	1	--	--	Maintains genetic variability
2	1.11	Protect natural populations	ongoing	6 FWE, RW	NGPC	1	--	--	Coincides with Task 3.1
2	1.12	Protect natural populations	10	6 FWE, RW	NGPC, FS, TNC	10	10	10	Provide for the development and implementation of management plans
2	1.2	Protect reintroduced and introduced populations	13	6 FWE, RW	NGPC, FS, TNC	--	--	10	Develop and implement management plans
2	1.3	Enforce laws and regulations	ongoing	6 FWE, RW	NGPC, FS	--	--	--	Done with existing personnel and funds
2	1.41	Eliminate disturbance factors	ongoing	6 FWE, RW	NGPC, FS TNC, SCS	1	--	1	Factors affecting blowout development
2	1.42	Prevent overgrazing	ongoing	6 FWE, RW	NGPC, FS, TNC	1	--	1	Monitor potential problem areas

Part III - Implementation Schedule
Blowout Penstemon

Priority Number	Task Number	Plan Task	Task Duration	Responsible Agencies FWS Region/Program	Responsible Agencies Other	Cost Estimates (x $1000) FY-1	FY-2	FY-3	Comments
2	1.44	Prevent pesticide damage	ongoing	6 FWE, RW	NGPC, FS, TNC, APHIS	--	--	--	Costs absorbed by Tasks 3.1 and 5.11
2	1.46	Protect from off-road vehicles	ongoing	6 FWE, RW	NGPC	--	--	--	Done with existing personnel and funds
2	1.47	Minimize natural threats	ongoing	6 FWE, RW	NGPC, FS, TNC	--	--	--	Costs absorbed by Tasks 3.1 and 5.11
2	2.	Survey for new populations and suitable habitat	5	6 FWE, RW	NGPC, FS	30	30	30	Identify and ground search potential habitat
2	3.2	Develop management techniques	6	6 FWE, RW	NGPC, FS	15	15	15	Methods to maintain active blowouts and viable populations
2	3.31	Determine natural reproduction factors	6	6 FWE, RW	NGPC, FS	20	20	20	Methods to increase natural recruitment
2	3.32	Determine soil seed bank and viability	6	6 FWE, RW	NGPC, FS	--	--	--	Costs included in Task 3.31
2	3.35	Determine population parameters	6	6 FWE, RW	NGPC, FS	--	--	--	Costs included in Task 3.31
2	3.4	Develop propagation techniques	10	6 FWE, RW	NGPC, FS	1	1	1	Partially completed
2	3.6	Determine genetic variability	3	6	NGPC	3	3	3	Will allow maximum diversity in new populations

Part III - Implementation Schedule
Blowout Penstemon

Priority Number	Task Number	Plan Task	Task Duration	Responsible Agencies: Region/Program	FWS	Other	Cost Estimates (x $1000): FY-1	FY-2	FY-3	Comments
2	4.	Reintroduce and introduce new populations	6	6	FWE, RW	NGPC, FS	10	10	10	Establish up to eight populations
2	5.12	Manage large populations	ongoing	6	FWE, RW	NGPC, FS	1	1	1	Develop and implement management plans
2	5.13	Manage populations in non-typical habitat	ongoing	6	FWE, RW	NGPC, FS	--	--	--	Costs included in Task 5.12
2	5.2	Manage newly established populations	ongoing	6	FWE, RW	NGPC, FS, TNC	--	--	--	Costs included in Task 5.12
2	7.	Public education	ongoing	6	FWE, RW	NGPC, FS	5	2	2	Administration costs, education materials
3	1.43	Protect from illegal collecting	ongoing	6	FWE, RW	NGPC, FS	--	--	--	Costs included in Task 3.1
3	1.45	Protect from development	ongoing	6	FWE, RW	NGPC, FS	--	--	--	Done with existing personnel and funds
3	3.33	Study seed dispersal and predation by wildlife	6	6	FWE	NGPC	--	--	--	Costs included in Task 3.31
3	3.5	Determine flowering requirements in greenhouse	4	6		NGPC	2	2	2	Would provide seed source

APPENDIX A.

The information on population size, location, and ownership is intentionally vague to prevent loss or degradation from collecting and vandalism.

1. Box Butte-Morrill County site, largest population complex known for species, private ownership.

2. Box Butte County site, small population, private ownership.

3. Garden County site, second largest population complex, Federal (Crescent Lake National Wildlife Refuge) and private ownership.

4. Cherry County state site, very small population, state ownership.

5. Cherry County site, small population complex, Federal (Valentine National Wildlife Refuge) and private ownership.

6. Cherry County river site, small population, state ownership.

This recovery plan was made available to the public for comment as required by the 1988 amendments to the Endangered Species Act of 1973. The public comment period was announced in the Federal Register (56 F.R. 29974) on July 1, 1991 and closed on August 30, 1991. Over 90 press releases were sent to the print media located in Nebraska.

During the public comment period ten letters were received. The comments provided in these letters have been considered, and incorporated as appropriate. Comments addressing recovery tasks that are the responsibility of an agency other than the U.S. Fish and Wildlife Service have been sent to that agency as required by the 1988 amendments to the Act.