BLOWOUT PENSTEMON: DESCRIPTION AND PRESENT SITUATION

Joyce Phillips Hardy, Ronald R. Weedon, and William R. Bowlin
Department of Biology, Chadron State College, Chadron, Nebraska 69337

Abstract: Blowout penstemon (*Penstemon haydenii* S. Wats.) appears to be the rarest flowering plant species endemic to Nebraska. It has received a great deal of attention, for endemism is rare in Great Plains states. This attractive species is confined to a small number of active blowout areas in the Nebraska Sandhills, often in relatively small colonies that are many kilometers apart in a relatively vast grassland. Blowout penstemon, thus, is confined to particular habitats which have distinct boundaries in space. It is also successional in nature, which places individual colonies in distinct and, perhaps, limited boundaries in time. It is apparent after eleven years of study that numbers of individuals in a particular colony may vary widely, with the tendency for catastrophic decline. The authors review the morphology of the species, its potential taxonomic relationships, and the fluctuations in known numbers of this species in the recent past.

Key Words. blowout penstemon, *Penstemon haydenii,* penstemon, blowouts, endangered species, Sandhills, Nebraska

INTRODUCTION

Blowout penstemon (*Penstemon haydenii* S. Wats.) has received a great deal of attention in the last eleven years. Endemism is rare in the Great Plains, and this species is limited to the Sandhills region of Nebraska. The plants are confined to a few relatively small active blowout areas, which are often quite distant from one another within these generally well vegetated sand dunes. The optimum habitat for blowout penstemon appears to be in the areas of sand deposition near the blowouts. The blowout penstemon populations decline in number and vigor as these blowouts become revegetated. The demographic problems of these colonies are comparable to those problems of oceanic island colonizing species, with the favorable blowout habitats isolated from one another by a vast sea of grassland prairie.

The authors have been involved in monitoring known blowout penstemon colonies through time. The fluctuations of nine representative colonies are presented. The morphology of blowout penstemon and its potential taxonomic relationships to other penstemon species in the area are discussed.

METHODS

During their early search for this plant, the authors relied heavily on a verbal description of blowout penstemon given by Claude A. Barr. His written description is quite accurate: "*Penstemon haydeni* (sic) has very long and narrow, channeled, waxy, glaucous green leaves, not basal but low on a heavy stalk that rises stiffly to 10 to 24 inches. Subtending the closely set and ample clusters of large, milky blue flowers are bracts of astonishing width, broadly spoon-shaped and sharp-tipped. They give the plant a distinctive effect. Enticing to bees and pleasing to the human sense, the flower has a strong and carrying fragrance. Branches put out from the lower leaf axils dip to the ground and turn up at the tip; these, when partly covered by drifting sand, strike root" (Barr 1983). Freeman (1981) stated that "morphologically, *Penstemon haydenii* is one of the most striking members of the *Coerulei* (section of *Penstemon*), due to its compact cylindrical inflorescence with prominent long-acuminate bracts and its habit of forming large multi-stemmed clumps . . . The species is apparently unique in the *Coerulei* in that its flowers possess a distinctive fragrance."

Extensive searches for new blowout penstemon populations have been conducted by the authors since 1977. Colonies of blowout penstemon have been observed through time, with population counts for these known colonies being recorded. The populations were counted in the late flowering-early fruiting stage when individual plants are most easily seen. Rooting stems from a single crown were determined to be a single organism. Separate plant crowns interconnected by rooting stems from a single crown were determined to be individual plants. Tabulations of the population size were recorded. Relative reproductive/vegetative ratios were recorded for many sites.

RESULTS

The figures present the tabulation results for nine representative populations of blowout penstemon. Figure 1 shows the relative

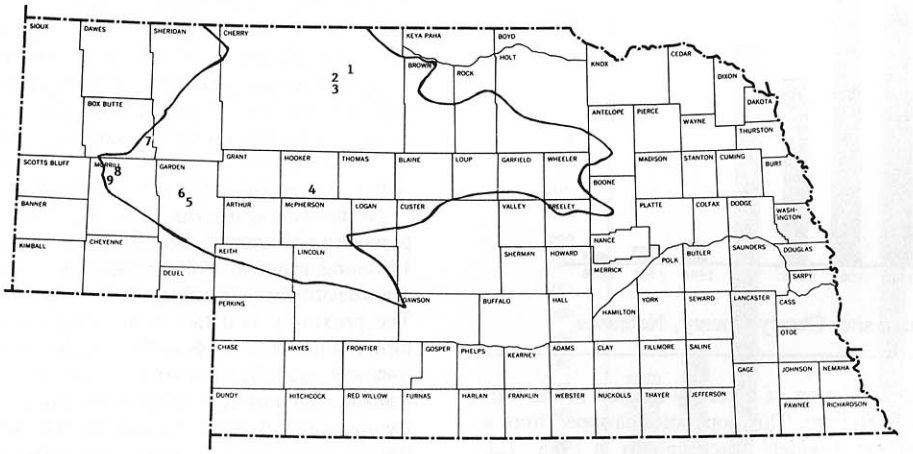

FIG. 1. General location of representative populations of *Penstemon haydenii* S. Wats. within the Nebraska Sandhills.

relationships of the different monitored sites of blowout penstemon. Figures 2 through 10 chart the population sizes at these sites. The solid lines represent total population counts for those years when the relative number of reproductive plants to vegetative plants was not available. The dark areas with white diagonal lines represent reproductive plants while the white areas with black hash lines represent vegetative plants.

In north-central Cherry County, north of the Valentine National Wildlife Refuge, a site has been monitored for ten years (Figure 1, Site 1). The colony has ranged in size from over 230 in 1982 to a low of 11 in 1987. This colony appears to be in poor condition, with few vegetative plants surviving among scattered, old plants (Figure 2).

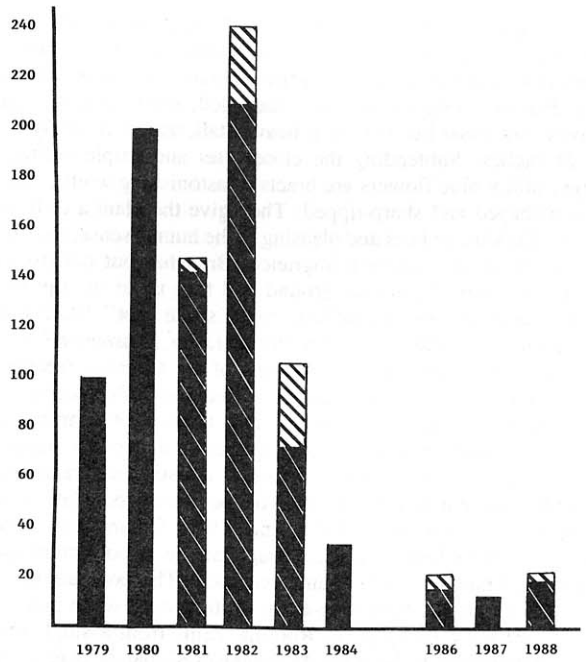

FIG. 2. Site north of wildlife refuge; Cherry County, Nebraska.

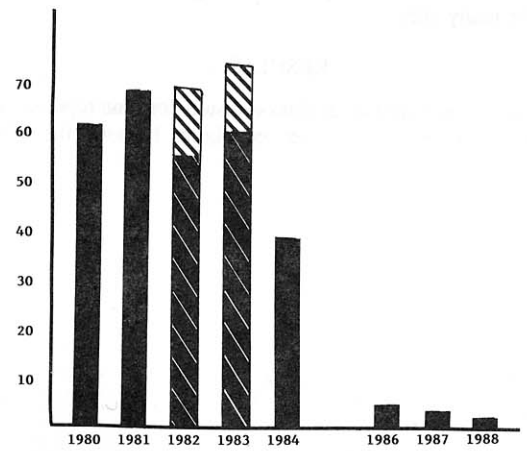

FIG. 3. Wildlife refuge site; Cherry County, Nebraska.

Figure 3 charts the population of a colony located in the Valentine National Wildlife Refuge. This population dropped from a high of 73 in 1983 to just 2 widely spaced plants in 1988. The future of this colony seems to be bleak (Figure 1, Site 2).

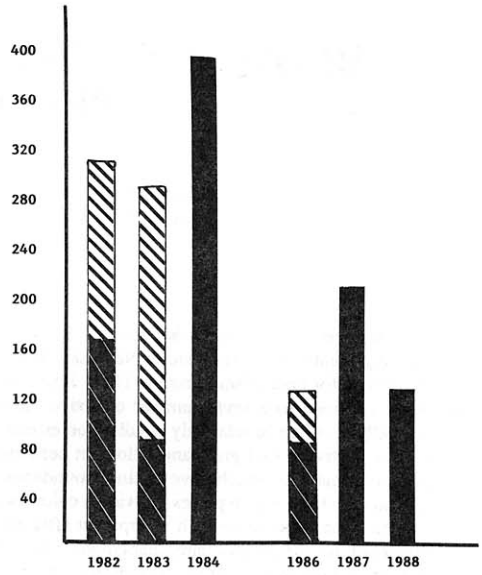

FIG. 4. Site near wildlife refuge; Cherry County, Nebraska.

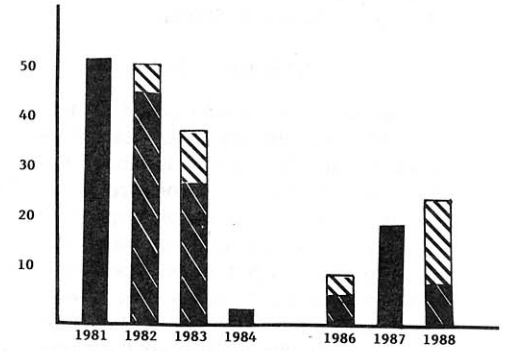

FIG. 5. Hooker County site.

Near the Valentine Wildlife Refuge exists a complex of blowouts which harbor blowout penstemon (Figure 1, Site 3). In 1984, 391 plants survived in the main blowout. In 1988, only 140 plants survived. This site has a history of high vegetative counts relative to reproductive counts (Figure 4).

The south-central Hooker County site is located approximately 100 km south and west of the previous sites (Figure 1, Site 4). In spite of extensive searching, this remains the nearest known population to the preceding three sites. This colony has remained small during the monitoring period, ranging from a high of 51 individuals in 1981 to a low of three in 1984. A slight resurgence in numbers within this colony occurred in 1987 and 1988 (Figure 5).

To the west and south in Garden County is the Crescent Lake population (Figure 1, Site 5). Over 900 plants were counted in 1982 and again in 1986 in the main blowout area (Figure 6). A dramatic increase in colony size occurred between 1981 and 1982. The proximity is dotted with many potential locations, and this blowout is situated relatively near the following colony. Immigration and establishment of new seedlings in this area is possible and may account for the dramatic resurgence in numbers seen in the last several years (Figure 6). The rejuvenating of blowouts through wind erosion during these years may also be involved.

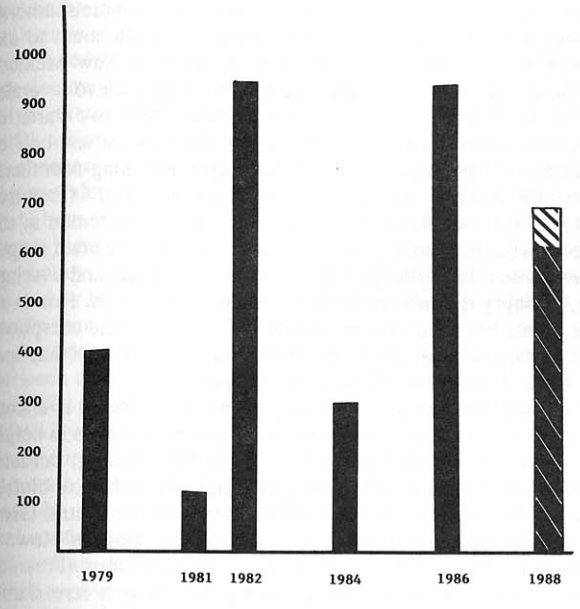

FIG. 6. Crescent Lake site; Garden County, Nebraska.

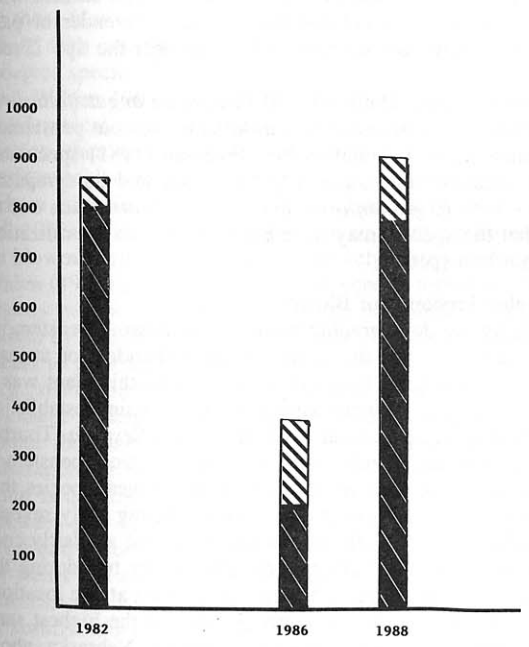

FIG. 7. Graves Ranch Preserve, Nature Conservancy; Garden County, Nebraska.

The Graves Ranch Preserve is located to the northwest of the Crescent Lake site and the Crescent Lake National Wildlife Refuge (Figure 1, Site 6). This area is owned by the Nature Conservancy, and land management is for the protection and preservation of blowout penstemon. Nine hundred plants were counted at the monitored blowout in 1988 (Figure 7).

To the west and north of this location is the Box Butte County site (Figure 1, Site 7). With the exception of 1984, this site has had a low colony count. The summer count in 1984 revealed mostly vegetative seedlings in the large area of newly deposited sand on the leeward side of the blowout (Figure 8).

A small complex of blowouts in northwestern Morrill County reveals a population which has fluctuated between 40 and 120 (Figure 1, Site 8). The choppy hills surrounding this area reveal

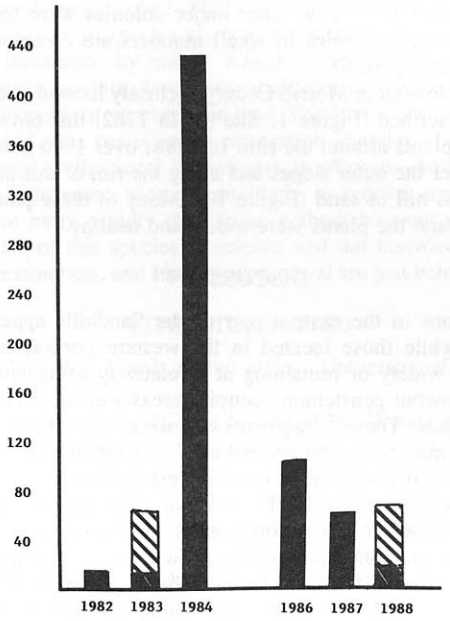

FIG. 8. Box Butte County site.

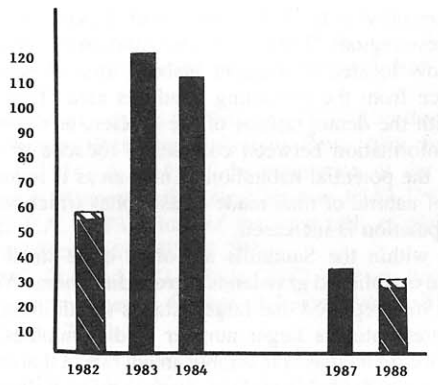

FIG. 9. Small blowout complex; Morrill County, Nebraska.

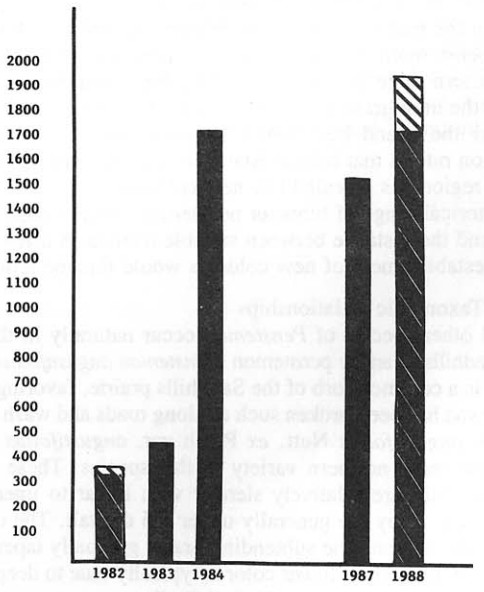

FIG. 10. Large blowout complex; Morrill County, Nebraska.

many potential sites. Few other major colonies were found, although scattered colonies of small numbers are common in the general area (Figure 9).

A large blowout in Morrill County is closely located to the small one just described (Figure 1, Site 9). In 1982, this blowout had about 350 plants around the rim. In 1988, over 1900 plants were counted over the outer slopes and along the rim of this enormous wind-eroded hill of sand (Figure 10). Many of these plants were flowering, and the plants were robust and healthy.

DISCUSSION

Populations in the eastern part of the Sandhills appear to be declining while those located in the western portion are either fluctuating widely or remaining at a relatively even number. At present, blowout penstemon occupies areas which are essentially habitat islands. These "fragments of habitat surrounded by other habitats of markedly different nature . . . contain sets of species which can be demarcated as more or less discrete communities" (Wilson and Bossert 1971). The relative distance between known colonies of blowout penstemon is great. Habitats which appear to provide suitable conditions for the growth of blowout penstemon often do not harbor the plant species. Possible causes of this may be the lack of seed in the area, unavailable moisture at the proper time for germination, deficiency of proper nutrients, or difference in size of the sand separates of that particular soil type. There appears to be great expanses of Sandhills area which, for some reason, do not provide habitable areas, even though blowouts are present in these regions. The major concentration of blowout penstemon is now located in a rather isolated area of Sandhills at some distance from the remaining Sandhills area. This presents problems with the demographics of the species, as the exchange of genetic information between colonies is reduced or virtually nonexistent, the potential habitation of new areas is reduced, and the chance of natural or man-made catastrophes which may eliminate the population is increased.

Blowouts within the Sandhills are often quite small in size, relative to the established grasslands surrounding them. Whitehead and Jones (1969) reported that larger islands should have a better chance of intercepting a larger number of disseminules through time, which would increase the establishment rate of that organism. Conversely, a smaller habitat island, such as a Sandhills blowout, has a reduced chance of propagule immigration. In addition, smaller islands hold smaller populations, which are subject to more frequent extinction (Wilson and Bossert 1971).

Through the past 11 years of the exploration and monitoring of blowout penstemon, a general decrease in numbers has occurred on the eastern edge of its range. Whitehead and Jones (1969) discussed the immigration rate to new habitats, and concluded that the further the island lies from a source region, the lower the immigration rate to that habitat island. Extensive searching of the Sandhills region has revealed few new colonies in the eastern part of the historical range of blowout penstemon. Source populations are few, and the distance between suitable habitats is often great. Potential establishment of new colonies would thus be reduced.

Potential Taxonomic Relationships

Several other species of *Penstemon* occur naturally in the Nebraska Sandhills. Narrow penstemon (*Penstemon angustifolius* Nutt. *ex* Pursh) is a common forb of the Sandhills prairie, favoring areas where the sod has been broken such as along roads and wash areas. *Penstemon angustifolius* Nutt. *ex* Pursh var. *angustifolius* is the western and more northern variety of this species. These plants characteristically are relatively slender with linear to linear-lanceolate leaves. They are generally under 4.5 dm tall. The corolla is 14-18 mm long and the subtending bracts gradually taper to an acute or acuminate tip. Flower color is typically blue to deep blue. Plants of the variety *caudatus* (Heller) Rydb. are more stout, with lanceolate to lance-ovate cauline leaves and corollas 16-20 (23) mm long. The bracts are usually broadened above the base and taper to short or long-acuminate tips. This variety is more southern, ranging from northwest and north-central Nebraska south to extreme western Kansas and Oklahoma to northern New Mexico. The flower color is often variable, ranging from pink to lavender or blue to deep blue. The characteristics of these two varieties intergrade where their ranges overlap in the western one-half of Nebraska. "The linear shape of the leaves and long-acuminate bracts of *P. haydenii* are suggestive of *P. angustifolius*" (Freeman 1981). In the vicinity of the colony of blowout penstemon at the large blowout in Morrill County (Figure 1, Site 9), the bract shapes of *Penstemon angustifolius* var. *caudatus* are cordate and overlapping, strongly resembling those of blowout penstemon. However, these plants have the smaller dark blue flowers and the caespitose habit of narrow penstemon, and taxonomically approach that species more closely than blowout penstemon.

Shell-leaf penstemon (*Penstemon grandiflorus* Nutt.) is a stout perennial which arises from a taprooted crown. It ranges in height from 5 to 9.5 dm. The interrupted thyrse has clasping, cordate-based bracts subtending 35-48 mm long pink to pale blue or bluish-lavender flowers. This species occurs mostly in the central Great Plains. The bracts on this species are similar to those of blowout penstemon. The leaves are thick, firm, and glaucous (Freeman 1986). "The flowers of *Penstemon haydenii* bear a remarkable resemblance to those of *P. grandiflorus*. Both species have corollas that are distinctly bilabiate, inflated and ventricose posteriorly, moderately ampliate, lined internally on the anterior surface with magenta guidelines and colored milky blue to lavender or pale lavender externally, and staminodes bearded near the tip" (Freeman 1981).

The morphological similarities of *Penstemon angustifolius* variety *caudatus* and *Penstemon grandiflorus* to blowout penstemon may indicate a genetic relationship. Freeman (1981) speculates that "the chimeric appearance of *P. haydenii* and its sympatric occurrence with *P. grandiflorus* and *P. angustifolius* leads one to suspect that the species may have evolved through hybridization of the latter two species."

Demographic Problems of Blowout Penstemon

In studying the demographic problems of blowout penstemon, it is often assumed that the plant was once abundant or at least common in this region. Pool (1914) stated that this plant was a principal species in blowout associations, becoming established after the first species, blowout grass [*Redfieldia flexuosa* (Thurb.) Vasey], became established in the blowout. Blowout penstemon was listed as one of the "more common and typical species that become a part of the blowout association" during early revegetation. "These later arrivals are not numerous but are fairly constant" (Pool 1914). In Rydberg's floristic survey trip during the summer of 1893, he collected blowout penstemon at one location. He found the species "in fruit only, on one of the highest sand hills, Plummer Ford", which is south of Seneca, Nebraska, about 24 km and then approximately 5 km east, on the Dismal River (Rydberg 1893). If this plant were abundant throughout the Sandhills, surely the striking beauty and fragrance would have enticed more collections than what are now known. Soulé (1983) pointed out that "some species might be rare from the time they become genetically independent of their forebearers and never become common relative to other species of a similar body size, taxonomic group, or tropic level . . . If such a rare species also is confined to a small geographic area, it will not persist long because it will be expunged by a local catastrophe, or be driven to extinction by stochastic events such as genetic drift or demographic stochasticity." This may be an alternate explanation for the demographic problems of this species.

One of the results of a small population size may be the lack of genetic variability that will allow for evolutionary adaptation to changing environments. The decreased vigor, viability, and fecundity that is associated with inbreeding depression can be the result of genetic deterioration which often occurs in small out-

crossing populations. Futuyma (1983) cited the following two major causes of populations extinctions: "In an unchanging environment a reduction in the sizes of the populations of an outbreeding species may result in inbreeding depression and a loss of fitness to the extent that the populations may dwindle to extinction. The other major cause of extinction is the failure of species to adapt to changes in the ecological environment that lower the fitness of the prevalent genotypes." While blowout penstemon may suffer from both of these causes, the situation is paradoxical. The species seems highly fecund and seed viability may be at a "reasonable" percentage, in nature. However, during the population studies conducted by the authors, natural seedlings in native populations were rarely seen.

A certain amount of genetic variability within a colony and between colonies seems to be present. Future detailed population analysis is necessary. While this analysis is forthcoming, it is relatively easy to conclude that the species is in danger, due to the decline in the number of suitable available habitat islands, and the increasing isolation of colonies from each other. The most healthy colonies are relatively narrowly confined to the extreme western and southwestern areas of the Nebraska Sandhills. Even if neither inbreeding depression nor a loss of fitness are involved in the bleak-appearing destiny of blowout penstemon, the decreasing range of viable colonies and the resulting increased restriction of suitable habitats is likely to be a factor.

A large amount of species interference is apparently occurring in these blowouts. "Species already present on habitat islands are faced with constant pressure of high immigration from less well-adapted species drawn from the surrounding habitats" (MacArthur and Wilson 1967). In addition, "if interference causes narrower fundamental niches and competitive exclusion of similar species occurs, then species growing at equilibrium in habitats where interference has been important should be more specialized than where other factors dominate evolutionary forces" (Del Moral *et al.* 1985). This interference between adjacent species has resulted in blowout penstemon having a relatively narrow niche width. Van Valen (1965) stated that, in general, species niches are "relatively tightly packed together by the action of stabilizing selection imposed by ecologically adjacent species." Blowout penstemon appears to be a successional species confined in or near blowouts, e.g., disturbed Sandhills prairie. It requires slightly stabilized soil. Nutrient presence and availability is usually sparse, and may be either the main limiting constituent or a contributing factor of limitation for the plants growing in this habitat. Blowout penstemon is usually found in blowouts with blowout grass or on the leeward side of blowouts in the loose sand which was deposited over native sod. It stabilizes the soil by means of its large clumps of stems and also its rooted decumbent stalks, thereby setting the successional stage for the next species, usually lemon scurfpea (*Psoralea lanceolata* Pursh).

Simberloff and Abele (1982) state that "conservation strategy should not treat all species as equal but must focus on species and habitats threatened by man." Range management techniques in the Nebraska Sandhills have historically stressed sodded grasslands and the decrease of wind-eroded land. This had lead to the decrease of potential sites for blowout penstemon colonies. The value of this species to the local landowners is obvious—blowouts with blowout penstemon seem more likely to recover and therefore revegetate more rapidly than those without blowout penstemon. The values of this species to science and our knowledge of speciation, extinction, and biological survival are just being realized.

LITERATURE CITED

Barr, C.A. 1983. Jewels of the plains. University of Minnesota Press, Minneapolis.

Del Moral, R., C.A. Clampitt, and D.M. Wood. 1985. Does interference cause niche differentiation? Evidence from subalpine plant communities. American Journal of Botany 72:1891-1901.

Freeman, C.C. 1981. A biosystematic study of the genus *Penstemon* (*Scrophulariaceae*) in the Great Plains. Master of Science Thesis, Kansas State University, Manhattan.

Freeman, C.C. 1986. *Penstemon*. Pages 774-789. *In* Great Plains Flora Association. Flora of the Great Plains. University Press of Kansas, Lawrence.

Futuyma, D.J. 1983. Interspecific interactions and the maintenance of genetic diversity. Pages 364-373. *In* C. M. Schonewald-Cox, *et al.* (eds.). Genetics and conservation. The Benjamin/Cumings Publishing Company, Incorporated, Menlo Park, California.

MacArthur, R.H, and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, New Jersey.

Pool, R.J. 1914. A study of the vegetation of the Sandhills of Nebraska. Minnesota Botanical Studies 4:189-312.

Rydberg, P.A. 1893. Flora of the sand hills of Nebraska. U.S. National Herbarium III:133-203.

Simberloff, D., and L.G. Abele. 1982. Refuge design in island biogeographic theory: Effects of fragmentation. The American Naturalist 120:41-50.

Soulé, M.E. 1983. What do we really know about extinction? Pages 111-124. *In* C.M. Schonewald-Cox *et al.* (eds.). Genetics and conservation. The Benjamin/Cumings Publishing Company, Incorporated, Menlo Park, California.

Van Valen, L. 1965. Morphological variation and width of ecological niche. The American Naturalist 99:377-390.

Whitehead, D.R., and C.E. Jones. 1969. Small islands and the equilibrium theory of insular biology. Evolution 23:171-179.

Wilson, E.O., and W.H. Bossert. 1971. A primer of population biology. Sinauer Associates, Incorporated, Stamford, Connecticut.