STATUS SURVEY FOR ASTRAGALUS BARRII
WALL RANGER DISTRICT
NEBRASKA NATIONAL FOREST
JUNE 1993

INTRODUCTION

Astragalus barrii, or Barr's Milkvetch, is a plant under notice for review for potential listing as a threatened species under the U.S. Endangered Species Act of 1973. It is listed as a sensitive species by the U.S. Forest Service for Region 1.The Nature Conservancy lists it as "very rare and local throughout it's range or found locally (even abundantly at some of it's locations) in a restricted range." It is listed as "rare in Montana" by the Montana Natural Heritage Program, "rare in South Dakota" by the South Dakota Natural Heritage Program, and "rare in Wyoming" by the Wyoming Natural Diversity Database. A comprehensive census of A. barrii in Montana conducted from 1986 to 1989 produced approximately 18,000 plants. However, under the Endangered Species Act it is included in Category 2. Taxa in this category have indications that a listing as threatened or sensitive is in order, but lack sufficient data on biological vulnerability and threats to state this with a certainty. Such taxa require more research and study to determine their status.

To provide more data on A. barrii, surveys were initiated on known populations of A. barrii on the Buffalo Gap National Grassland and intermingled private land in southwestern South Dakota. In May of 1991 populations of A. barrii were sighted within a five-mile radius from the town of Scenic, SD, in what is known as the Scenic Basin. A total of 4447 plants were observed. On May 14-27, 1993 surveys were revisited upon these populations and their surroundings. Surveys were conducted to **1)** verify the presence of A. barrii, **2)** to discover other populations of A. barrii on lands not previously surveyed, **3)** to delineate and measure the area of populations, **4)** to arrive at population densities and totals, **5)** to determine the nature of the preferred habitat of the populations, **6)** to determine more about the preferred habitat of A. barrii by conducting surveys on Astragalus gilvafloris, a closely related species, and **7)** To determine the hours of labor necessary to perform surveys on A. barrii.

METHODS

General: Surveys were conducted in May of 1993 to coincide with the flowering of A. barrii. The flower color proves to be most effective in distinguishing A. barrii from A. gilvafloris. Sites were accessed by means of pickup truck, All Terrain Vehicle (ATV), and on foot. Five persons were involved in gathering the information in this survey. To locate the sightings of 1991, cartographic records of the 1991 survey were used. Surrounding areas with similar habitat were then inspected for A. barrii.

Mapping: The area surveyed and the areas supporting populations of A. barrii were mapped. This was done either by means of the Geographic Positioning System, or by visually locating the boundaries of an area in the field, and representing this on a topographic map. Areas were then measured in terms of acres, either by means of the GPS for those sites mapped by GPS, or by means of a Numonics electronic planimeter and coordinate digitizer for those sites mapped ocularly.

Population Densities: In typical or representative populations, population densities were estimated by replicated sampling of plot frames along a transect. The plot frame used in this survey measured 1 ft. by 2 ft or .1858 square meters. The transect would be established within the boundaries of an area containing A. barrii. At regularly spaced intervals along this transect, the number of individual plants of A. barrii that fell within the borders of the plot frame were counted. The densities of A. barrii along each transect were averaged. The densities for all transacts were then averaged. This was converted to plants per acre, and then multiplied by the total acreage containing A. barrii, giving a fair estimate of the total population of A. barrii found in the survey.

Documentation: At sites bearing clues as to the nature of the species, photographs were taken. These included photographs of habitat, associated vegetation, and close-ups of A. barrii and associated species. A photographic directory was produced. This directory is found in ***Table 7***, “Directory and Contents of Astragalus barrii Photographs". **[Tables are not included in this webversion]**

Survey Form: For each population or area of A. barrii found a form entitled "Plant Species of Special Concern Survey Form" was completed. This form recorded the vital habitat characteristics of the areas harboring the populations of A. barrii, as well as details concerning population size, location, and documentation.

Similar Species: Populations of A. gilvafloris selected for survey were those found during the same surveys of 1991. For each site, the "Plant Species of Special Concern Survey Form" was completed. No mapping or population estimations were completed beyond those called for on the form or those completed in 1991.

Hours of Labor: The hours of labor necessary to generate this survey, both in terms of fieldwork and office work, including writing of this report, were tabulated. The acreage surveyed was divided by the hour figures to give an idea of the labor necessary to survey a given area of A. barrii habitat.

RESULTS AND DISCUSSION

1) Verification of 1991 Sites: In 1991 a total of 32.29 acres of land in the Scenic Basin had been observed to contain populations of A. barrii. Of those acres, 13.62 acres were confirmed to have A. barrii. The remaining 18.67 acres either had no plants to be observed, or were not accessed. It appears that mapping error is to blame for the bulk of these unconfirmed sites. On sites that were surveyed where no plants were found, the habitat that was present bore little resemblance to the prime A. barrii habitat seen elsewhere, and in fact exhibited some of the features that seemed to exclude A. barrii. The remaining unconfirmed acreage was not surveyed due to time limitations, the need to study the prime habitat while flowering maintained it's distinction, and the appearance from a distance, and from all maps available, that it too was less than prime habitat.

2) Discovery of New Populations: It was not more than a few hours into this survey that it was realized that populations of A. barrii well beyond the boundaries and census of the previous survey were at hand. New sites could be seen from the roadsides, new sites were encountered along the way to old sites, and an abundance of apparently prime habitat was seen throughout the basin. This could be attributed to three factors: One, growing conditions. As seen in ***Table 1***, Weather Data from Cottonwood Research Station," the past three years of above normal rainfall and below normal temperatures may have contributed to the profusion of flowers on the A. barrii and the significant numbers of seedlings and young plants seen in this survey. This made for ready identification of populations. Two, time. The survey of 1991 was limited to about five days, and was combined with surveys for *Eriogonum visheri*. Three, bad weather. In 1991 surveys were hampered by rainstorms and hail.

To grasp the sum of the new populations engaged throughout the entire survey, it is best to compare the previous figures of 1991 - 4447 plants on 32.29 acres - with those compiled in items 3 and 4.

3) Delineation and Area of Populations: The ocular mapping of populations proved to be a difficult thing, due to the meandering borders and immensity of the area covered. As a result, the borders assigned to a given population by ocular method are approximate to the extent that relatively small patches devoid of A. barrii are included. These would be in the form of islets within a large expanse of A. barrii, or narrow extensions of land into a population of A. barrii. To accommodate this approximation, effort was made in population density counts to include these barren patches in the transects. This would occur naturally as the transects were placed within the borders arrived at ocularly. At the same time, effort was made to run transacts where the borders arrived at ocularly and through GPS were in coincidence. As a result, the potential to inflate the population totals by the inclusion of land bereft of A. barrii in the acreage tabulations was offset by the inclusion of these patches in the population density counts. Also, population density counts would be representative of both ocular and GPS delineated land.

The lands alleged to possess A. barrii by the 1991 survey and not verified in this survey were also delineated by the ocular method. As mentioned, the likelihood that this land does in fact support A. barrii is doubtful.

The area outlined by the ocular method in this survey, as extracted by the Numonics digitizer, was 398.87 acres. The area of land of the 1991 survey not verified amounted to 18.67 acres. This is a sum of 407.74 acres of land.

The GPS method of mapping populations is renowned for it's accuracy. The convenience of operation coupled with the use of the four-wheeler enabled the delineation of areas of A. barrii with far less approximation than the ocular method. It was possible to outline the borders with the exclusion of many of the narrow inlets and the islets lacking A. barrii. As a result, the acreage totals for GPS are less than those for ocular method. Nevertheless, to arrive at accurate density counts and population totals, effort was made to conduct density counts on areas where GPS and ocular boundaries coincided.

[GPS data was not derived for this report. Thus, it was not possible to correct the acreage estimates] The area figures arrived at through the GPS are **?** acres This figure does not include all areas of A. barrii mapped. There were 118.15 acres of land exhibiting A. barrii that were not outlined by GPS that were outlined by the ocular method. Both GPS and ocular mapping were performed on the remaining A. barrii habitat. Herein a deviation is found: By GPS these remaining acres amounted to **?** acres, while by the ocular method these amounted to 270.92 acres. This suggests that the 118.15 non-GPS acres could be reduced by an average of **?**% to **?** acres. This also suggests that the 18.67 unverified, non-GPS acres could be reduced by **?**% to **?** acres. Using *correction factors* that were typical of each site, an adjusted total acreage of A. barrii sites amounted to **?** acres. Excluding the non-verified land, this amounts to **?** acres. The total area surveyed in this survey, including areas where A. barrii was not found, is 2,371.91 acres.

The acreage of all areas surveyed for A. barrii is described in ***Table 2***, "Acreage of All Areas Surveyed for Astragalus barrii". The acreage of all sites found to contain A. barrii is listed in ***Table 3***, "Acreage of Astragalus barrii Sites".

4) Population Densities and Totals: Densities of the species would vary widely within the boundaries of the population. Thus, 13 transacts were traversed across all degrees of density. Transects had from 12 to 64 readings, with intervals of 5 to 20 meters. Accordingly, numbers of plants per frame varied from a high of 22, to a low of zero. Some transacts had as many as 17 consecutive plot frame readings without a single A. barrii. Other transacts had as many as 81% of the plot frame readings with at least one plant. This translated into a range of 0.081 to 2.657 A. barrii per square foot for individual transacts. All 13 transacts combined for an average of 0.721 plants per square foot. Converting to plants per acre, this resulted in readings as low as 3,506.58 and as high as 115,738.92, with an average of 31,406.76.

Using the figures arrived at through ocular mapping and Numonics digitizer, the population total for 407.74 acres of A. barrii, based on the average density, is 12,813,797 plants. Were the highest density used, this arrives at a figure of 47,181,284 plants. Were the lowest density used, this arrives at a figure of 1,432,449 plants. Should the verified land total of 398.87 acres be used, these population totals are an average of 12,527,214 plants, a high figure of 46,164,783 plants, and a low figure of 1,407,357 plants.

[GPS data was not derived for this report. Thus, it was not possible to correct the population density estimates]

A small plot, 4 meters by 2 meters in dimension, was established within a colony of A. barrii within the Bear Creek-01 site. This is purposed to monitor population densities and totals over time. The number of A. barrii within the plot numbered 94, giving a density of 1.31 plants per square foot.

These population densities and totals can be seen in ***Table 4***, "Population Counts for Astragalus barrii".

5) Nature of Preferred Habitat: A number of patterns or tendencies arose in the A. barrii habitat. These, in turn, served as indicators of the presence of A. barrii. Listed in order of importance as indicators, these patterns were in the areas of **a)** parent material, **b)** soil type, **c)** disturbance, **d)** associated vegetation, **e)** slope, **f)** light exposure, **g)** vegetation structure, and **h)** range type. Exceptions to these patterns are considered in i). All habitat data is summarized in ***Table 5***, "Habitat Description for Astragalus barrii.

a) Parent Material: The parent material evident on sites of A. barrii was most often the Chadron Formation claystone, either in the form of unaltered exposures or alluvium derived from erosional products. These alluvial deposits include outwash fans, deltas, and pediments. The Chadron Formation claystone is a badland formation characterized by occasional channel sandstone and limestone, large beds of chalcedony and abundant calcium carbonates. Rarely did A. barrii appear on any other sort of parent material. In those rare instances (at Imlay Sheep and High Dive-9), it was in older alluvium in which Chadron debris was mixed with offscourings of the Brule Formation (see slide ***30B***). The Brule Formation is a badland formation which overlays the Chadron and contains claystones, sandstones, volcanic ash, channel sandstones, clastic dikes, chalcedony veinlets, and calcareous cement (see slide ***28B***, ***30B***, ***31B***).

Of the 17 sites bearing A. barrii, five were found on unaltered exposures of Chadron, two of the sites were found on Chadron alluvium, and 7 were found on a combination of unaltered Chadron and Chadron alluvium. Three of the sites were found in alluvium composed of a mixture of Brule and Chadron. No sites were without some measure of Chadron material. In terms of area, the sites that had some Brule material intermixed were less than 4% of the total A. barrii habitat encountered.

The aversion of A. barrii to non-Chadron parent material was very pronounced. In one instance, at site High Dive-09, it could be seen growing on the south side of a small intermittent stream in the midst of the characteristically white erosional debris of the Chadron. The other bank, only a half meter away from these plants, was pinkish with the erosional outwash of the Brule formation that formed a wall to the northeast. Not a single A. barrii plant was to be found along this bank (see slide ***31B***). In another instance, at site Bear Creek-01, A. barrii could be observed growing within the Chadron along the outwash and slumps along a badlands wall. Streams had cut into the Chadron at some places, exposing the yellowish Interior paleosol of Pierre Shale that underlies the Chadron throughout the basin. Not a single A. barrii specimen could be found growing in the Pierre Shale, while only a meter away, within the greyish-green claystone of the Chadron, a colony of the plants seemed to be thriving.

Indeed, parent material proved to be the strongest indicator of a potential for an A. barrii colony. Often colonies were discovered simply by seeking out the Chadron formations in the basin. The strength of this indication leads to the conclusion that this factor is a determinant of the suitability of the habitat for A. barrii.

b) Soil Type: Within the Chadron Formation claystones two soil series exhibited A. barrii: Badland and Interior. The Badland soil series refers to outcrops of Badland formations, actually too unstable for significant soil development. Most plants were found up to but not on the badland. The Interior soil series refers to the deep, light gray, stratified soil found on the floodplains and fans at the base of badlands outcrops, and is derived from the badlands material. This is where most of the plants were found. The Cedarpass soil series are also located near the base of vertical exposures of badlands, but more often they are found on uplands and terraces, places where A. barrii were not found in this survey.

Astragalus barrii was found most frequently on the Interior soils, less frequently on the Badland formation itself. Of the 17 sites surveyed, 12 were on both Interior and Badlands soils, four were on Interior soil alone, and one was on Badlands soil alone. On those sites where both soils were present, Interior was the dominant soil.

The physical and chemical properties of the Interior soil series are noteworthy. Interior soils are formed in sodium rich, loamy, silty alluvium. Salinity ranges from <2 to <4 mmhos/cm. This is considered non-salty or normal soil, as some soils in the vicinity are over 16 mmhos/cm. The absence of A. barrii on highly saline soils may correlate with the absence of A. barrii where *Atriplex sp*. (Saltbush) was in abundance. This would be expected since *Atriplex* is an indicator of highly saline soils. Interior soils are moderately to strongly alkaline, pH being from 7.4 to 9.0 in the upper 411 of soil, and 7.9 to 9.0 from 4" to 60". They are described as high in calcium (or magnesium) carbonate. They are very low in organic matter, having less than one percent. They have moderate erosion potential. Permeability is moderately slow, 0.2-2.0 inches/hour.

This presents a picture of the harsh soil environment in which A. barrii plants will thrive. The conditions of pH, soil organic matter, sodicity, and permeability are beyond the comfort and tolerance of most species in this basin.

Interestingly, the Cedarpass soils, which are in proximity to the Interior and Badlands soils yet did not present any A. barrii, differ from the Interior soils mainly in the relative acidity and organic matter content of their upper horizons. These may have a pH as low as 6.1, a result of the good drainage afforded by the Cedarpass soil's position on uplands and terraces. Organic matter content is 1-3%. Hence, the fertility of this soil is much higher than Interior soil. These factors, along with the resultant increase in vegetative cover, may account for the absence of A. barrii on these soils.

The foregoing suggests that soil type is more than a very strong indicator of the presence of A. barrii, and actually determines the suitability of the habitat for this species.

While Badlands soils do not have the development of a true soil, being in essence the Chadron formation parent material, it may be safe to surmise that the properties of the Interior soil series are reflected in the Chadron formation that spawned the Interior soil.

c) Disturbance: Disturbance plays a major role in the life of this plant. Never did the species occur outside of a zone of moderate disturbance. The forms of disturbance active at the majority of the sites were erosion and deposition. Less common were human activity such as road building and animal activity in the form of cattle trails.

Erosion and deposition were indicated in geomorphic features such as small channels and deltas as well as openness and sparseness of vegetation. The open areas experience high erosion and deposition activity. Runoff is rapid, and down cutting is high on the slopes of the badlands. This effectively reduces vegetation. As the runoff leaves the steeper slopes of the badlands for the outwash plains, it quickly decelerates. Consequently, a sediment load is deposited, resulting in a buildup of the erosional debris of the badland around the base of the badland. This too, effectively reduces vegetation. Astragalus barrii appeared to prefer this latter, deposition-induced openness. At most sites A. barrii was found on the outwash fans that radiate from the base of Chadron formations (see slides ***12A***, ***27A***, ***34A***).

While A. barrii prefers open soil and sparse vegetation, it does so only where the disturbance process maintains the openness without exposing it's root system to an excess. For example, on outwash fans A. barrii would thin out as erosion increased and deposition decreased, subjecting the plant roots to increasing exposure. A rule of thumb: Where the exposure of roots of *Eriogonum pauciflorum* reached 2ʺ (6cm), A. barrii would not be found (see slide ***27B***). Thus, on a regular basis it was seen in streambeds, from the point of origin of the stream on the fans at the base of the badland to the point where down cutting accelerated, producing steep-walled canyons (see slides **33A**, ***34A***).

Where A. barrii was found on areas where down cutting was high, as on the side slope of a badland, it did so with the aid of some sort of soil stabilizer. Most often this was in the form of fragments of chalcedony scattered across the slope in a tile-like fashion or across the contours like a terrace (see slides ***33B***, ***34B***).

Three morphological features appear to enable this plant to survive in these areas of intense erosion and deposition. One is its pincushion-like, matted form, which traps sediments around its base. The second is it's stout root, which avails it of stability, moisture, and nutrients. The third is it's perennial growth form, which enables it to establish itself in an area and remain there even as habitat characteristics, such as erosion gradients, change over time. Hence, A. barrii is equipped to dwell in a zone where competition for light, water, and nutrients is limited, where vegetation is rare, and light exposure is open.

In less common instances the disturbance was in the form of cattle trails, old roadbeds, and ditches (see slide ***15A***). Here too, the result was an openness and sparseness of vegetation that reduced competition. These sites also carried healthy populations of A. barrii.

There was not any evidence that the plants served as food for anything other than pollinating insects, especially bees. Some plants were recently trampled, but appeared to suffer no ill effects.

This demand for disturbed sites suggests that disturbance is more than a very strong indicator of the presence of A. barrii. It is likely that this is a determinant of the suitability of the habitat for this species.

d) Associated Vegetation: Associated vegetation had some strong tendencies. In order of abundance, the following plants would be found in association: *Musineon divaricatum* (Leafy Musineon), *Agropyron smithii* (Western Wheatgrass), *Phlox hoodii* (Hood Phlox), *Eriogonum pauciflorum* (Ballhead Eriogonum), *Allium textile* (Textile Onion), *Grindelia squarrosa* (Curleycup Gumweed), *Oenothera caespitosa* (Gumbo Lily), and *Gutierrezia sarothrae* (Matchbrush). This tendency was so strong that a colony of A. barrii could often be located simply by seeking out a colony of these associates. A strong indicator that A. barrii would not be in evidence was found in *Astragalus racemosus* (Racemed Poisonvetch). This was also true for *Atriplex sp.* (Saltbush), though to a lesser extent.

Other than the proximity of occasional *Comandra umbellate*, associated vegetation did not appear to have any symbiotic or parasitic relationships with A. barrii. Hence, it is more likely that associated vegetation simply indicated the presence of A. barrii and the presence of parent material, soil type, disturbance, light exposure, and vegetation structure that determine the suitability of the habitat for A. barrii.

e) Slope: The A. barrii plants tended to grow on level to nearly level slopes, usually 0 to 10 degrees. On those rare occasions that it would grow on steeper slopes, it would do so in the midst of some sort of natural micro-terracing, most often a mosaic of Chalcedony fragments. It appeared to grow on all slope shapes, on all aspects, and on all topographic positions. However, where the slopes were steeper, the plants were rare on crests, upper slopes, and bottoms.

The rarity of A. barrii on steeper slopes can be attributed to the determination slope has on erosion gradients. Steeper slopes experience greater erosion, eventually exceeding the erosion tolerance of A. barrii. This suggests that slope is simply a fair indicator of the presence of A. barrii and influences the disturbance that determines the suitability of the habitat for A. barrii.

f) Light Exposure: Invariably, the A. barrii grew in open light conditions, with no overstory or shading. Even where it grew along sod terraces, it appeared to grow at such a distance from the terrace to not entertain the respite it would find from direct sun. Where A. barrii would grade into the surrounding grass communities, it would experience a measure of shading from the taller grasses, such as Western Wheatgrass. Where grasses formed a sod, the A. barrii would be in absence. This may be as a result of shading, as well as competition for water, nutrients, or seedbeds.

This preference for open light seems to be according to a demand for limited competition for light as well as water, nutrients, and seeding sites. As noted, the openness on these sites is a product of disturbance factors. Thus, A. barrii's preference for open light conditions likely involves a tolerance for the disturbances that produce the open light conditions.

The foregoing suggests that light exposure is an indicator of the presence of A. barrii and of other factors that determine the suitability of the habitat for A. barrii and is itself a factor that determines the suitability of the habitat for A. barrii. However, this factor was not a strong indicator of the potential for A. barrii, as the majority of the landscape in the Scenic Basin, even the bulk of Western South Dakota, is in open light, whether from disturbance factors or not. Being in the Mixed grass Prairie, there is a dearth of trees, shrubs, and tall grass. Shading usually comes in the form of the shadow of a badland formation.

g) Vegetation Structure: The vegetation structure exhibited in A. barrii populations was consistent in it's lack of an overstory, in the lack of shrubs and trees. Bare ground cover regularly ran from 70-90%. The vegetation cover tended to have more grasses than forbs, especially on the outer edges of a population where the colony gave way to nearly pure stands of grass.

This preference for bare ground in the vegetation structure seems to be according to a demand for limited competition for light, water, nutrients, and seeding sites. As with light exposure, the vegetation structure on these sites appears to be influenced by disturbance factors. Thus, A. barrii's preference for bare ground cover also involves a tolerance for the disturbances that produce the bare ground.

Evidently then, vegetation structure is an indicator of the presence of A. barrii and of other factors that determine the suitability of the habitat for A. barrii and is itself a factor that determines the suitability of the habitat for A. barrii. This factor was a good indicator of the presence of A. barrii. Generally, where vegetation cover exceeded 40% A. barrii would no longer be found.

h) Range Type: The range sites corresponding to these soil series are as follows: For Interior, Thin Upland. For Badlands, Badland.

Since Range Type is a broader classification scheme based on soil type, it is not as valuable an indicator of the presence of A. barrii as soil type.

i) Exceptions: While A. barrii grew in what appears to be a discreet habitat, it was not found in all areas that exhibited these characters, that had the indicators of it's presence. Three conclusions arise: First, it can be speculated that this may be a result of the lack of a seed source in these other areas. If this is the case, it may be possible to introduce A. barrii into these areas with success. Second, the absence may be due to some difference in habitat not recognized, such as grazing, farming, or fire history, chemistry, or seasonal inundation. Third, the failure to find a perfect indicator of the presence of A. barrii suggests that some of these indicators are indirect, pointing to another, more relevant factor such as soil or parent material.

6) *Astragalus gilvafloris* Survey: *Astragalus gilvafloris*, a species very similar in appearance, was surveyed at this time as well. An effort was made to discern any correlations between the habitat of this and A. barrii. Little were found other than the broad correlations of open light conditions, and soil family, conditions that exist throughout the majority of the Mixed-grass Prairie. Generally, A gilvafloris existed on a much wider array of habitats than A. barrii. For example, A. gilvafloris grew on Pierre shale, Chadron, and Brule formations with fair consistency. Also, the associated species varied on as many as half of the species from site to site, and many of the species in association with A. gilvafloris never appeared with A. barrii.

7) Hours of Labor Required: Five persons were involved in this survey. A total of 348 hours of labor were required to prepare, perform, and write it. Thus, the total of 2,371.91 acres surveyed required 0.147 hours of labor per acre surveyed. The total A. barrii habitat of 407.74 acres required 0.853 hours of labor per acre surveyed.

These figures are contained in ***Table 6***, "Hours of Labor Invested in Astragalus barrii Survey".

SUMMARY AND MANAGEMENT IMPLICATIONS

This survey has provided data, which may be useful in determining the status of A. barrii. It has given estimates of the area inhabited be the species in Scenic Basin: 407.74 acres. It has given population estimates for the species in the basin: 12,813,797 plants.
This survey has also provided a glimpse into why A. barrii grows in Scenic Basin. This may give a clue as to why it grows in other areas as well. Parent material, soil type, disturbance, light exposure, and vegetation structure appear to be indicators of the presence of A. barrii and determinants of the suitability of the habitat for A. barrii. Slope appears to be merely an indicator of the presence of A. barrii, and has an influence on the disturbance processes that determine the suitability of the habitat for A. barrii. Associated vegetation appears to merely indicate the presence of A. barrii and suitable parent material, soil type, disturbance, and light exposure. Seasonal weather variations may have the greatest determination on the presence and health of the A. barrii populations.

In this survey, the strongest indicators of the presence A. barrii in the Scenic Basin are, in order of importance: **1)** Chadron Formation Badlands, **2)** Interior soil series, less commonly, Badlands soil series, **3)** Moderate Disturbance producing 70-90% bare ground, whether by erosion, human, or animal activity, and 4) Associated Vegetation. In order of abundance, *Musineon divaricatum* (Leafy Musineon), *Agropyron smithii* (Western Wheatgrass), *Phlox hoodii* (Hood Phlox), *Eriogonum pauciflorum* (Ballhead Eriogonum), *Allium textile* (Textile Onion), *Grindelia squarrosa* (Curleycup Gumweed), *Oenothera caespitosa* (Gumbo Lily), and *Gutierrezia sarothrae* (Matchbrush), were all common associates in this basin. Negative indicators of A. barrii were *Atriplex sp*. and *Astragalus racemosus*.

These indicators of the presence of A. barrii provide a useful tool in locating new populations of A. barrii. It is suggested that when searching for new populations of A. barrii, these steps are followed: First, locate all exposures of Chadron formation material in the area to be surveyed, restricting the survey to these. Second, further limit the survey to, in order of importance, Interior, then Badland soil series or their equivalents that are found on the Chadron formation. Third, within these soil types, limit the survey to zones of moderate disturbance, which produces 70-90% bare ground, often zones of high deposition or erosion. Fourth, seek out colonies of *Musineon divaricatum* (Leafy Musineon), *Agropyron smithii* (Western Wheatgrass), *Phlox hoodii* (Hood Phlox), *Eriogonum pauciflorum* (Ballhead Eriogonum), *Allium textile* (Textile Onion), *Grindelia squarrosa* (Curleycup Gumweed), *Oenothera caespitosa* (Gumbo Lily), and *Gutierrezia sarothrae* (Matchbrush) within these zones of moderate disturbance. Areas with *Atriplex sp*. and *Astragalus racemosus* may be avoided. A fifth step of limiting the survey to slopes of 0-10 degrees may be considered, but surveys should extend to steeper slopes where erosion gradients are in check, as by chalcedony fragments.

The absence of A. barrii in areas with characteristics suggesting its presence could be due to a lack of a seed source or some unseen difference in habitat. The possibility exists that A. barrii could be introduced into these areas with success.

Present management strategies appear to be comparable with the needs of A. barrii. The extent of human and animal activities that now obtain in the Scenic Basin do not appear to have any adverse effects on A. barrii populations. In fact, it seems that some of the human and animal activity has actually created favorable conditions for the species, most notably in the form of old roadbeds and cattle trails. Grazing and trampling do not have any appreciable impacts. It does not seem necessary to establish some sort of protected area for this species in the Scenic basin.

As a result of this survey, a large number of plants and a sizeable acreage have been discovered. However, it is opined that this does not warrant the removal of this species from listing under the Endangered Species Act. According to all available data, the area occupied by this species and it's peculiar habitat preferences are in reality very limited. Compared to its cousin, A. gilvafloris, which appears on Pierre Shale, Chadron, and Brule parent materials and on many more soil types, A. barrii's limited habitat demands become evident. Comparing it to a species like the common Dandelion, which grow on a tremendous variety of habitats, the limitations of this species become glaringly apparent. Were the data from other A. barrii surveys in other locations to be included, this picture would not alter. Also, out of 591,754 acres in the Buffalo Gap National grassland, it appears on but 407.74 acres, or less than 7/100%. Were the total A. barrii acreage from all known sites in the Midwest included, this percentage may very well decrease, as Scenic Basin houses the largest site yet to be discovered. Yet, species such as *Agropyron smithii, Opuntia polyacantha*, or *Melilotus officinalis* are found throughout the grassland, on some sites comprising 90% of the biomass by weight. Thus, the area occupied by A. barrii is by comparison quite small. For these reasons it is opined that Astragalus barrii, as we know it, is a rare species with specialized habitat requirements. It is recommended that its listing under the Endangered Species Act should remain until further surveys should indicate otherwise.

At least four points for further research remain: **1)** The potential for other A. barrii sites is strong. The Chadron formation exists along the White River, Sage Creek, and Cheyenne River drainages, and along the Pine Ridge. Colonies may exist in these areas. Does A. barrii grow in these areas? **2)** There may be significant correlations between the A. barrii sites in Montana, Wyoming, Nebraska, and South Dakota in terms of geology, soils, biology and associated vegetation. What correlations are there between these sites? **3)** It is evident that A. barrii does not grow on other sites that seem to have the characteristics that could support populations of A. barrii. What differences are there between these sites that may account for this? **4)** It may be possible to propagate A. barrii on sites with suitable characteristics where it does not presently exist. Can this be done? This further research will provide data vital to the determination of the proper status of A. barrii.

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