SURVEYS FOR *ASTRAGALUS GILVIFLORUS* VAR. *PURPUREUS* (DUBOIS MILKVETCH) IN THE BIG HORN BASIN, WYOMING

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ABSTRACT

Surveys for *Astragalus gilviflorus* var. *purpureus* (Dubois milkvetch) were conducted in the Big Horn Basin in 2009-2010. Seven of eight sites previously reported in the eastern Big Horn Basin were surveyed and a ninth site was documented. The sites span 64 air miles, extending from about 15 miles southwest of Big Trails to about 13 miles southeast of Greybull. There were also surveys conducted in the southwestern Big Horn Basin, identified in modeling as having potential habitat, but only the common variety, *Astragalus gilviflorus* var. *gilviflorus* (plains milkvetch) was found. Basic taxonomic questions were raised at all sites of putative *A. g.* var. *purpureus* in the eastern Big Horn Basin because flower color is a primary distinguishing characteristic and most populations have mixed-color traits. This is also because the only pure-color purple-flowered populations have parts or all of the population distributed in man-made habitat of bladed road right-of-ways. The taxonomic status of Big Horn Basin material remains unresolved but an interim approach, with working hypotheses and tests are presented.

ACKNOWLEDGEMENTS

The location information and insights of Claire Leon (Story, WY) and both Eve Warren and Karen Hepp (Bureau of Land Management, Worland Field Office) are greatly appreciated. The coordination of Eve Warren was critical at all stages of project work. Robert Dorn provided comments on eastern Big Horn Basin specimens of Luanne Lum before fieldwork started, and commented on *Astragalus gilviflorus* var. *purpureus* characteristics. The facilities and resources of the Rocky Mountain Herbarium and expertise of Dr. Ronald Hartman and B.E. Nelson are acknowledged with gratitude. Joy Handley (WYNDD) provided GIS support before and after the field season. This study was conducted through a challenge cost-share agreement between BLM Worland Field Office and Wyoming Natural Diversity Database, University of Wyoming.

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Cover photo: Photograph of purple-flowered *Astragalus gilviflorus* in the Bighorn Basin, Rome Hill Road, by Claire Leon. Reprinted with permission of photographer.

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I. INTRODUCTION

Astragalus gilviflorus Sheld. var. *purpureus* Dorn (Dubois milkvetch) was designated sensitive by the Wyoming Bureau of Land Management (BLM) as a local state endemic of the Wind River Basin in Fremont County, Wyoming (USDI BLM 2001). It is a geographically isolated, purple-flowered counterpart to the widely-distributed, white-flowered *Astragalus gilviflorus* Sheld. var. *gilviflorus* (plains milkvetch). It was first recognized as a distinct taxonomic entity by M. L. Roberts (1977), but was not described as a new taxon until Dorn published a brief account in the first edition of *Vascular Plants of Wyoming* (Dorn 1988). The status of *A. g.* var. *purpureus* was addressed in a status report that included results of systematic surveys for it in the Dubois area (Fertig 1998). It was more recently addressed in a species conservation assessment (Ladyman 2004). Needs for an expanded baseline survey of *A. g.* var. *purpureus* were identified based on the following:

- Collections, photographs and observations were made of purple-flowered *A. gilviflorus* in the southeastern corner of the Big Horn Basin, far-removed from known populations of *A. g.* var. *purpureus* in the Wind River Basin, and were provisionally determined as *A. gilviflorus* var. *purpureus.*
- A potential distribution model was developed for *A. g.* var. *purpureus* which identified additional areas of potential habitat in the southwestern corner of the Big Horn Basin which had not been used in prior surveys.
- Digital orthophotographs also became available for use in aerial photointerpretation.

In 2009, the Bureau of Land Management (BLM) Wyoming State Office and Worland Field Office contracted with the Wyoming Natural Diversity Database (WYNDD) on a cost-share basis to conduct field surveys and evaluate the status of this taxon on BLM lands in the southern Big Horn Basin. The primary objectives of this study were to conduct systematic surveys for *A. g.* var. *purpureus* using the new records, the potential distribution model, and aerial photointerpretation in order to update its state status.

The scope of this study did not include *Astragalus gilviflorus* var. *purpureus* in the BLM Lander Field Office. But the prior surveys for it in the Lander Field Office, and resulting summary as reported by Fertig (1998), are integral to interpreting 2009-2010 results.

II. METHODS

At the start of this project, information on the habitat, known distribution, and potential distribution model of *Astragalus gilviflorus* var. *purpureus* were compiled and reviewed (Fertig 1998, Ladyman 2004, Fertig and Thurston 2003). Regional floristic work was also reviewed (Lum et al. 2003, Lum 2004), specimens were studied at the Rocky Mountain Herbarium (RM), and discussions were initiated with experts who had visited the purple-flowered *A. gilviflorus* of the southeastern corner of the Big Horn Basin. Luanne Lum made two collections in the Big Horn Basin in 2002 that were identified as *A. g.* var. *purpureus.* Claire Leon photographed a

striking image in 2006 that was identified as *A. g.* var. *purpureus* (see cover). Her photograph adorned the cover of the Bighorn Native Plant Society newsletter the next year. Eve Warren and Karen Hepp, Ecologist and Range Conservationist at the BLM Worland Field Office, respectively, later reported additional *A. g.* var. *purpureus* in the vicinity of the Leon photograph. In the summer of 2009, Claire Leon and BLM staff reported new locales for it along the Alkali Road north of Hyattville.

In preparation for fieldwork, the known *Astragalus gilviflorus* var. *purpureus* distribution, potential distribution polygons, and public land layer were overlain on digital orthophotos in ArcMap to seek habitat signatures and to determine public land access. Section lines were also superimposed. The barren rocky habitat of *A. g.* var. *purpureus* exhibits high reflectance, so tracts of public land were identified for survey if they were part of known distribution (three areas), polygons of potential distribution (Fertig and Thurston 2003), or other areas in the immediate vicinity with similar barren habitat. The survey area was contained within the BLM Worland Field Office, targeting BLM-administered lands.

The study area is in the southern and eastern portion of the Big Horn Basin, from Hyattville and Meeteetsee southward, including portions of Big Horn, Hot Springs, Park, and Washakie counties (Figure 1). Digital orthophotographs were printed out that contained known and potential *Astragalus gilviflorus* var. *purpureus* distribution and public land boundaries at a quarter-quad scale that corresponded closely to that of U.S.G.S. topographic maps (7.5') for reference in the field. The associated U.S.G.S. topographic maps (1:24,000), BLM land status maps (1:100,000), and geological map (Love and Christiansen 1985) were also used in the field to determine access and set survey priorities. The study area is a mixture of public and private tracts.

Surveys of *Astragalus gilviflorus* var. *purpureus* were timed to coincide with flowering because flower color is a primary characteristic. The surveys were conducted over two field seasons. The 2009 surveys were conducted between 21-24 May in the southeastern portion of the Big Horn Basin, and they evaluated and expanded upon prior collections and reports. The 2010 surveys conducted mainly over 1-2 June 2010 in the southwestern portion and northeastern portions of the Big Horn Basin to test the potential distribution model and evaluated additional reports.

Where *Astragalus gilviflorus* var. *purpureus* was found, field survey data were collected, field maps were marked with approximate area boundaries, and GPS coordinates were recorded for geo-referencing boundaries more accurately for later digitizing and entry into the central database as permanent electronic database records. Specimen vouchers were collected to represent the extent of distribution, and photographs were taken to represent the full array of colors present. Specimens were numbered and arranged to provide duplicate and triplicate sets of color variation for each population under a single collection number.

III. RESULTS - SPECIES INFORMATION

Throughout the following Species Information section of the report, text is reprinted from Fertig (1998) as reference because it is pertinent to this study and was not changed by this study. New information is identified as "Addition," based on 2009-2010 survey results in the eastern Big Horn Basin and more recent literature review.

A. CLASSIFICATION

1. SCIENTIFIC NAME: *Astragalus gilviflorus* Sheld. var. *purpureus* Dorn (Dorn 1988). Type specimen: USA, Wyoming, Fremont County, T42N R106W Sec 31 W¼, rocky barren hills, 7000 ft., 26 June 1980, *Dorn 3476* (RM).

2. SYNONYMS: Roberts (1977) proposed the name *Astragalus shoshonensis* for this taxon, but his description was never validly published.

3. COMMON NAMES: Dubois milkvetch.

4. FAMILY: Fabaceae or Leguminosae (Pea family).

5. SIZE OF GENUS: Worldwide, the genus *Astragalus* contains over 1600 species, with about 375 known from North America (Barneby 1989). Addition: Dorn (2001) lists 62 species and 18 varieties of *Astragalus* for Wyoming.

6. PHYLOGENETIC RELATIONSHIPS: *Astragalus gilviflorus* var. *purpureus* is most closely related to *A. g. var. gilviflorus* (plains milkvetch), differing primarily in flower color (Dorn 1988). Roberts (1977) considered it to be derived from *A. gilviflorus*, but also noted a superficial resemblance to *A. barrii*, an endemic of the northern Great Plains.

Addition: The large *Astragalus* genus has been divided into sections, and the Orophaca section as described by Iseley (1998) includes *A. gilviflorus* and many, but not all, low-growing scapose species of *Astragalus*. This section has been distinguished from other groups in the genus by the unique combination of hyaline stipules, palmately trifoliate leaves, small, unilocular deciduous pods, long, medifixed hairs, as well as the caespitose habit. For the purpose of this report, all low-growing scapose species of *Astragalus* are referred to as tufted milkvetches. They include 12 recognized species for Wyoming (Table 1; Figure 1). Phylogenetic relations within this group were researched by Roberts (1977), who reported chromosome counts of $2n=12$. His flavone research documented compounds in common between his study set that differed from possibly-related European species. Isoenzyme analysis documented that there was large heterozygosity within populations but there was not enough data to determine if any of the alleles were species-specific. The large differences between populations in seed protein patterns suggested that "gene flow between populations is infrequent, resulting in distinctive patterns due

to genetic drift or the founder effect" though results were otherwise ambiguous for phylogenetic or systematic interpretation. The seed protein results contrasted with isoenzyme research in that he found homogeneity within populations, but divergence between them.

More recently, pilot work on chloroplast DNA found low differentiation of using restriction site analysis in tufted milkvetches (*Astragalus barrii*, *A. hyalinus*), and these results have been interpreted to suggest that divergence in this group was relatively recent, within which cpDNA variation has had no time to evolve (Matt Lavin personal communication 2009). More recent molecular phylogenetic research throughout the *Astragalus* genus has subsequently documented that members of the Orophaca section belong to the much larger aneuploid North American Neo-Astragalus group (Wojciechowski et al. 1999), with its recent, rapid radiate evolution (Wojciechowski 2005). This much larger group includes other caespitose Wyoming species such as *A. sericeous* var. *aretioides*, and many leafy-stemmed or upright species such as *A. kentrophyta* varieties, *A. miser* varieties, *A. bisulcatus*, and others.

B. PRESENT LEGAL OR OTHER FORMAL STATUS:

1. NATIONAL:

a. LEGAL STATUS: *Astragalus gilviflorus* var. *purpureus* was formerly a Category 2 (C2) candidate for listing under the Endangered Species Act (US Fish and Wildlife Service 1993). The C2 list included species that might have warranted listing as Threatened or Endangered, but for which the USFWS lacked sufficient biological data to support a listing proposal. In February 1996, the USFWS revised its candidate policy and eliminated the C2 designation (US Fish and Wildlife Service 1996). As a result, *A. g.* var. *purpureus* currently has no legal status.

b. HERITAGE RANK: *Astragalus gilviflorus* is ranked G5 in the NatureServe network of Natural Heritage programs originally established through The Nature Conservancy. This rank indicates that the full species is "demonstrably secure" over its whole range. Variety *purpureus* is ranked T2, indicating that this taxon is "imperiled because of rarity" (with 6-20 extant occurrences) or because of other factors making it vulnerable to extinction.

2. STATE:

a. LEGAL STATUS: None.

b. HERITAGE RANK: *Astragalus gilviflorus* var. *purpureus* is ranked S2, indicating that it is imperiled because of rarity in the state of Wyoming (Heidel 2007).

C. DESCRIPTION

1. GENERAL NON-TECHNICAL DESCRIPTION: *Astragalus gilviflorus* var. *purpureus* is a loosely matted, perennial herb with a branching rootstalk. The leaves are silvery-pubescent,

long-petioled, and divided into 3 oval leaflets 7-30 mm long. Pea-like flowers are borne in pairs among the densely packed basal rosette of leaves. The banner petal is blue or purple (occasionally pinkish), 12-28 mm long, and has a spoon-shaped blade that tapers evenly to a narrow base. Fruits are upright, elliptical pods that are often hidden among the leaf bases (Roberts 1977; Dorn 1988, 2001; Barneby 1989; Fertig et al. 1994).

2. TECHNICAL DESCRIPTION: Caespitose herb from a much-branched caudex covered by a thatch of persistent petioles; herbage appearing silvery due to the lustrous, appressed, verrucose dolabriform vesture, the hairs longer and somewhat spreading on the petioles; stipules ovate, corrugate, hyaline, ciliate, nearly glabrous; leaves 1-4 cm long, those emerging at anthesis shorter with smaller and broader leaflets, early leaflets ovate to obovate-cuneate and acute to obtuse, the later leaflets 6-15 mm long, 3-6 mm wide, narrowly lanceolate, acute, slightly keeled, the terminal leaflet exceeding the lateral in length, especially in the younger leaves; racemes essentially sessile, capitate, flowers 2; bracts hyaline, trilobate, obcordate in general outline with the central lobe aristate, the lateral lobes shorter, obtuse to nearly truncate, ciliate on the margins and lightly pubescent toward the base; pedicels to 1 mm long; bracteoles linear-oblanceolate, glabrous; calyx 9-14.5 mm long, cylindric, the tube 7-11.5 mm long, becoming scarious and distended by the enlarging ovary; petals blue to purple, the banner with a white striate lozenge, the wings lighter toward the tips, the whole marcescent and yellowing in age; banner recurved 40-60°, obovate, cuneate to the claw, emarginate, 15-25 mm long, 5-7.2 mm wide, wings 18.7-22 mm long, the claws 9-13 mm long, 2-2.2 mm wide, spreading, flat; keel 16-19 mm long, the claws 9-12.5 mm long, the blades 5-6.5 mm long, obliquely elliptic, the apex bluntly triangular, incurved through ± 90°; anthers 0.5-0.7 mm long, orange; style upcurved, slightly protruding at the apex of the keel; pod erect, nearly sessile, concealed by the persistent petioles and stipules and enclosed in the marcescent calyx, ovules 15-19, at maturity ovoid-ellipsoid, 6.8-11.5 mm long, 2.8-4 mm in diameter, obtuse at the base, contracted apically to a short cusp, slightly compressed dorsally, the valves fleshy and becoming cartilaginous or sub-woody, densely strigose; seeds brown, smooth and dull, 2-5 maturing, 2-2.5 mm long (after Roberts 1977).

3. LOCAL FIELD CHARACTERISTICS: *Astragalus gilviflorus* var. *purpureus* can be recognized in the field by its matted growth form, silvery leaves with 3 leaflets, and large, bluish-purple pea-like flowers with a spoon-shaped banner. Flower color and banner shape are needed to positively distinguish it from related species.

4. SIMILAR SPECIES: *Astragalus gilviflorus* var. *gilviflorus* has white or cream-colored flowers. *A. proimanthus*, *A. hyalinus*, and an undescribed species from Park County, Wyoming

Table 1. Distinguishing characteristics among tufted milkvetches in Wyoming[1]

Species	Leaves	Growth form	No. of flowers	stipule pubescence	peduncle length	calyx	banner length	banner color	banner pubescence	banner shape	wing length	keel length	ovules	pod	Phenlogy (WY)
A. barrii	compound	dense cushion	2-5	ciliate on margins, sometimes glabrous dorsally	7-24 mm	3.6-6.5 mm	10-16 mm	purple with light purple veins*	very sparse dorsally to glabrous*	spathulate	9-13 mm	7.5-10.5 mm	(1-3)	lanceoloid w/ long beak, compressed, turgid	late April-early June
A. calycosus	compound (5 lflts present)	Tufted or cushion	1-17	glabrous dorsally	(pedicel)	3.6-6.5	9.5-15	variable; whitish, pale blue or pink, bright purple	glabrous	spathulate	7-11.6	67.5-10.5	13-28	oblong-ellipsoi, trigonously compressed	late May-early June
A. drabelliformis	simple	loose mat	1-5	glabrous	(pedicel)	2.5-5	5-7	pink-purple	glabrous dorsally	spathulate			7-10	trigonous, turgid, grooved dorsally	June
A. gilviflorus var. gilviflorus	compound, 3 lflets	loose mat	2 (rarely 1 or 3)	glabrous dorsally except at base	Obsolete or nearly so	9.3-20 (10-15)	16-28	white or ochroleucus; sometimes tipped with purple	glabrous dorsally	oblanceolate to spathulate; tapering evenly to base	12.2-24.2	10.4-21.8		ovoid-ellipsoid, 6-10 x 2.5-5.	May-early June
A. gilviflorus var. purpureus	compound, 3 lflets	loose mat	2	Ciliate, nearly glabrous	Obsolete or nearly so	9-14.5 (7-11)	12-22	purple	glabrous dorsally	oblanceolate to spathulate; tapering evenly to base	18.7-22	16-19	15-19	ovoid-ellipsoid, 6.8-11.5 x 2.8-4.	(late May) June-early July (Fremont Co.)
A. hyalinus	compound; 3 lflets	dense mat	1-2 (3)	ciliate on margins	none - 3.5 mm	5.5-7 mm	12-18 mm	whitish corolla with purplish tips	villous dorsally	fiddle-shape	10-17 mm	10-13 mm	8-9	ovoid-ellipsoid, 5-6	late June-early July
A. proimanthus	compound; 3 lflets	dense mat		glabrous	obsolete or nearly so	8-10.5		predom. yellow; sometimes white w/ purplish markings	glabrous dorsally	fiddle-shape	11.1-16	11.1-12.8	11-14	narrowly ellipsoid, straight or slightly decurved, ~laterally compressed	late April-early June

[1] From Dorn (2001), Iseley (1998), Barneby (1989)

Species	Leaves	Growth form	No. of flowers	stipule pubescence	peduncle length	calyx	banner length	banner color	banner pubescence	banner shape	wing length	keel length	ovules	pod	Phenlogy
A. serioleucus var. aretioides	compound; 3 lflets	dense cushion	(2) 3-5	glabrous dorsally except upper margin	(pedicel)	2.5-4.2	5-8	vivid pink, magenta, reddish violet	glabrous dorsally	spatulate	(5-7)	4-4.5	6-11	Ovoid-ellipsoid, slightly compressed	June
A. serioleucus var. serioleucus	compound; 3 lflets	stems often elongate-creeping	2	pilose dorsally	1-2.5, gen exserted above lvs	2.5-4.2	5-8	dark purple		spatulate	5-6	5-5.8		ovoid-acuminate to lanceolate, laterally compressed but turgid, 4-6.5	June
A. simplicifolius	simple	dense cushion	1-4	ciliate on margins	0.5-1.8	4.5-7	10.5-16	pink-purple		spatulate	9.8-11.6	7-9.6	11-14	laterally compressed, 6-13 mm long	May-mid June
A. spatulatus	simple	variable	1-11			2.5-5	6-9.5	pink-purple		spatulate	6-8	4.5-6		laterally compressed	May-June
A. tridactylicus	compound; 3 lflets	tufted or prostrate cushion	2-4	lower stipules pilose dorsally	2-10	1.5-3.8	7-9	pink-purple	glabrous dorsally	1.8-3.5		4.5-7.2		ellipsoid and turgid	June
Undescribed species (see Dorn 2001)	compound, 3 lflets	Loose cushion						white, usually lined or tinged w/ lavendar, drying yellowish		fiddle-shape			6-8		June
Marriott 11545 (reported in Heidel and Marriott 1996)	compound; 3 lflets			ciliate on margins	none to very short	5 mm	10.5 mm	yellowish-cream with purple veins	strigose dorsally		slightly <10 mm	8.5 mm			

have yellowish or white banners that are fiddle-shaped. These are the only other white-flowered tufted milkvetches in Wyoming. Other *Astragalus* species with 3 leaflets, including *A. barrii,* typically have smaller flowers and shorter calyx tubes (Dorn 2001; Fertig et al. 1994).

Addition: A detailed table for comparing characteristics of tufted milkvetches in Wyoming was developed prior to the 2009 field season for reference in the field, later expanded with herbarium research and additional literature review (Table 1). There are multiple character combinations among tufted milkvetches in Wyoming rather than discrete branches with completely separate sets of traits. The distinctions are primarily in flower size, flower color, and phenology, in addition to leaf structure (Table 1). Of the 12 tufted milkvetch species in Wyoming, three are state endemics, six are regional endemics, and three are widespread taxa. In the field, there was some variation in calyx length and banner length, so a 3-way comparison of these measurements with flower color was initiated in the Rome Hill population - #017 (n=50) without finding any patterns.

D. GEOGRAPHICAL DISTRIBUTION

1. RANGE: *Astragalus gilviflorus* var. *purpureus* has been regarded as endemic to the Dubois Badlands of the northwestern Wind River Basin and the adjacent foothills of the northeastern Wind River and southern Absaroka ranges in Fremont County, Wyoming (Fertig 1998). The entire known range of the taxon extended from White Pass (approximately 9 air miles northwest of Dubois) east 28 miles to Johnson Draw on the Wind River Indian Reservation and south approximately 15 miles to Torrey Rim and the Wind River. Roberts (1977) indicated that the range of the species extends about 40 miles southeast of Dubois, but no specimens have been found to confirm this.

Addition: In 2008, surveys were conducted for The Nature Conservancy about 40 miles southeast of Dubois, and all that were found were uniformly white-flowered *Astragalus gilviflorus* with faint lavender colored banner, purple veins, purple keel, and white wings (*Heidel 3059* RM). The material was photographed, collected and provisionally determined as the type variety. The population was small and most plants were vegetative. The habitat was also noted as inconsistent with any environmental characteristics of *A. g.* var. *purpureus*. It grew on glacial till at 5820 ft, elevation below the lower limit of *A. g.* var. *purpureus* at 6400 ft. whereas the *A. g.* var. *purpureus* was known only from the western end of the Wind River Basin, farther west (Rocky Mountain Herbarium 2010).

The 2009-2010 surveys in the Big Horn Basin covered all reported locations of *Astragalus gilviflorus var. purpureus,* documented additional sites, and conducted surveys at each site. The occurrences span 64 miles, extending from about 15 miles southwest of Big Trails to about 13 miles southeast of Greybull. The conclusion drawn from this work is that there is material that keys out to *A. g.* var. *purpureus,* though its taxonomic status is uncertain because most populations are mixed-color, and the two that are "pure purple" are partly or wholly on

disturbance zones. The taxonomic status of Big Horn Basin material remains unresolved, so occurrences are represented by "?" (Figure 1, Appendix A). A full set of photographs representing plants in the Bighorn Basin are represented in Appendix B, and the species abstract has been updated to reflect this unresolved taxonomic question in the Big Horn Basin (Appendix C).

All collections and reports of *Astragalus gilviflorus* var. *purpureus* from the Big Horn Basin surveyed in 2009 were based on mixed-color populations of *A. gilviflorus.* The fact that Luanne Lum had collected white-flowered *A. gilviflorus* at the same locale as purple-flowered members was not learned until afterward. The two newest reports of *A. g. var. purpureus* from the eastern Big Horn Basin were surveyed in 2010 and represented uniformly purple-color populations of *A. gilviflorus* but some or all of the local populations were confined to bladed road corridor. All surveys of potential habitat in the southwestern corner of the Big Horn Basin turned up uniformly white-color populations of *A. gilviflorus* with the exception that a solitary lavender-flowered plant was found in one of the five white-flowered populations surveyed. Thus, there were no homogeneously purple-flowered plant populations restricted to native habitat and "putative" prefaces all mention of *A. g. var. purpureus* in the Big Horn Basin through the report.

The purple-membered *Astragalus gilviflorus* populations south of Hyattville spanned a distance of at least 44.6 miles, north to south, with the southernmost populations having the highest proportion of white and pale-flowered members vs. northern populations having the highest proportion of purple and deep lavender-flowered members. By contrast, the purple-flowered *A. gilviflorus* populations north of Hyattville populations were uniformly purple, and there were only two complexes documented, but it appeared as though flower size also changed on a north-south gradient with smaller flowers to the north. There are no populations of *Astragalus barrii* known from the west side of the Bighorn Mountains (Figure 2). It is the nearest purple-flowered member of the genus to the Big Horn Basin surveyed populations, and its main center of distribution is in the Powder River Basin of northeastern Wyoming and southeastern Montana, extending across parts of western South Dakota. There are populations of *A. aretioides* at the north end of the Big Horn Basin, as documented in the foothills of the Pryor Mountains in Montana (Figure 2), the only purple-flowered tufted milkvetch located within the Basin. Its main center of distribution is in south-central Wyoming. Both of these purple-flowered species have distinctly smaller flowers than any of the *Astragalus gilviflorus* as described in the literature or observed in the eastern Big Horn Basin.

There are no other reports of mixed-color tufted milkvetches in Wyoming, despite the specimen review and collecting of Roberts (1977). All populations surveyed in 2009-2010 are vouchered at RM and entered in the central WYNDD database as records of *Astragalus gilviflorus* var. *purpureus* that have unresolved identification questions. Copies of this report will be conveyed to the *Flora of North America* author on the genus. Possible interpretations are presented in Section IV with discussion.

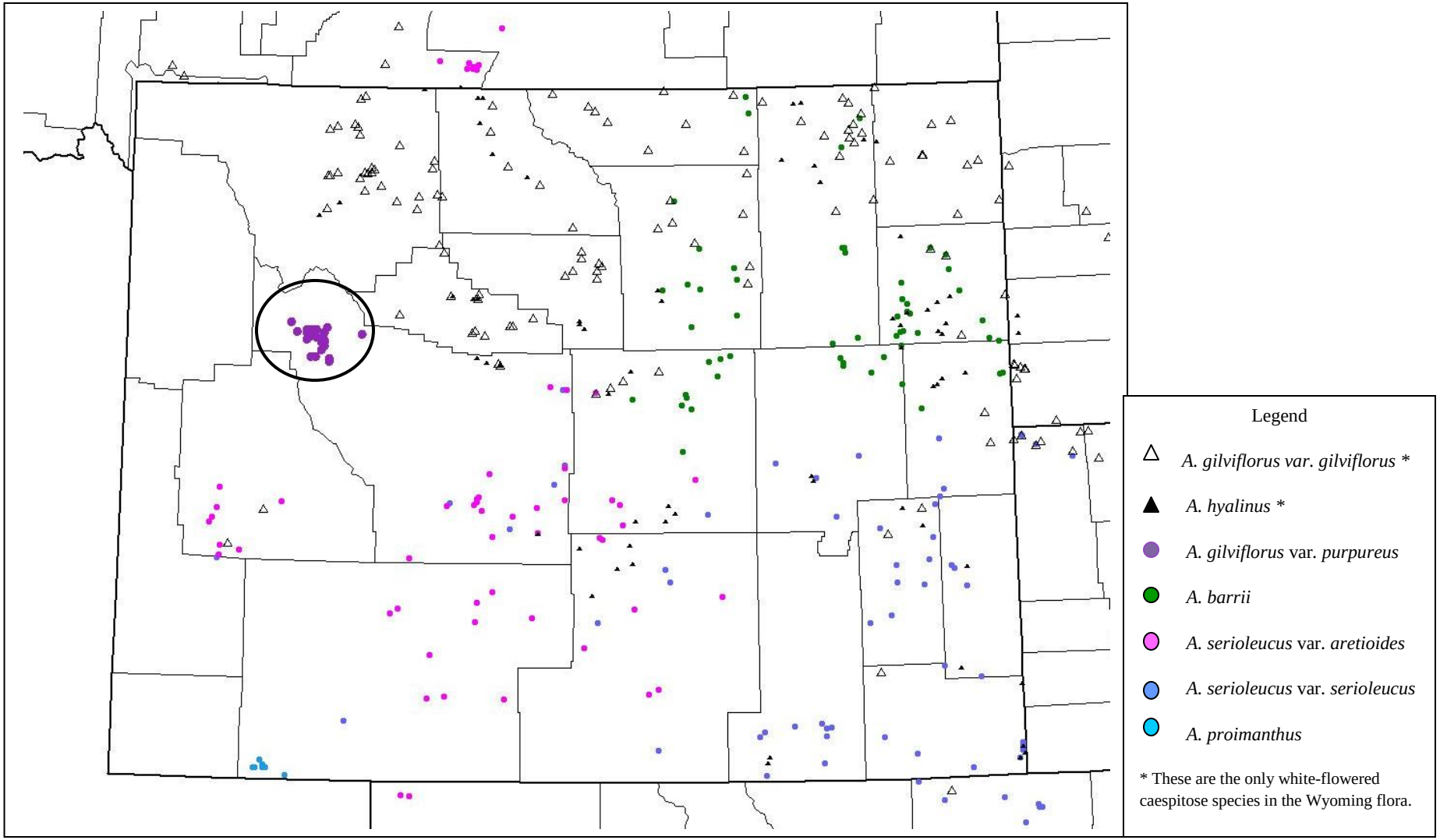

Figure 1. Known distribution of *Astragalus gilviflorus* var. *purpureus* and select tufted milkvetches of Wyoming[2],[3]. Recent *A. gilviflorus* specimens cited in this report have yet to be accessioned at RM and are not represented on this map.

[2] From: Rocky Mountain Herbarium online database. 2010. Posted at: http://www.rmh.uwyo.edu/ ; plus added records of *A. s.*var. *aretioides* from MTNHP.
[3] Does not include the 2008 specimen of *Astragalus gilviflorus* var. *gilviflorus* as the only Fremont County record along the flanks of the Wind River Range.

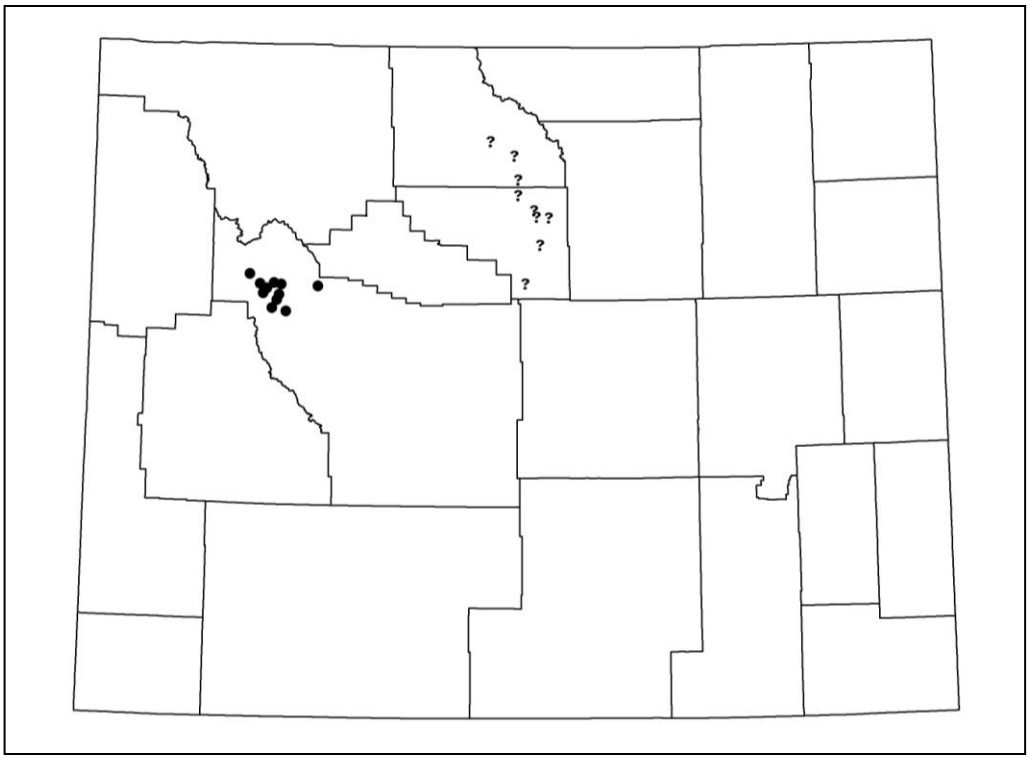

Figure 2. *Astragalus gilviflorus* var. *purpureus* distribution

Table 2. Location information for *Astragalus gilviflorus* var. *purpureus* in the Big Horn Basin

EO#	Location	County	Legal Description	Elev.	USGS 7.5' Quad	Ownership
015	Red Gulch, 7 mi NW of Tensleep	Washakie	T48N R89W Sec. 21	4320-4420	Wild Horse Hill	BLM
016	Tensleep vicinity, 0.7 mi NW to 4 mi SE	Washakie	T47N R87W Sec. 19 T47N R88W Sec. 17, 22-24	4550-4620	Old Maid Gulch Ten Sleep	BLM
017	Rome Hill Rd area, 6-10 mi ESE of Tensleep	Washakie	T46N R87W Sec. 1, 2, 3, 11 T47N R87W Sec. 28, 33-35	5000-5890	Big Trails NE Old Maid Gulch	BLM
018	N side of Cornell Gulch, along the Blue Bank Rd, ca 40 mi SE of Worland.	Washakie	T42N R89W Sec. 24	5800	Cornell Gulch	BLM, pvt?
019	S. side of Alkali Cr., ca 29 mi ESE of Worland	Washakie	T47N R88W Sec. 36	4600	Joe Emge Creek	BLM
020	Fatty Allen, ca 1 mi NE of Buffalo Cr. mouth on Nowood R., ca 33 air miles ESE of	Washakie	T45N R87W Sec. 31	4860	Big Trails	BLM
021	Northwest end of Cedar Mtn., ca. 3.5-5 mi SE of Hyattville	Big Horn	T49N R.89W Sec. 15, 16, 22	4900-5100	Hyattville	BLM
022	Alkali Creek Rd, 13.5-15 mi SE of Greybull	Big Horn	T52N R91W Sec. 27, 34, 35	5140-5360	Manderson NE	BLM
023	Alkali Creek Rd, 7 mi ENE of Hyattville	Big Horn	T51N R89W Sec. 32	5630-5690	Hyatt Ranch	BLM

2. EXTANT SITES: *Astragalus gilviflorus* var. *purpureus* is currently known from 11 extant occurrences in the Wind River Basin, 9 of which have been discovered or relocated since 1990. These occurrences consist of 38 subpopulations and occupy a known area of at least 400 acres (with more extensive areas of habitat probably available). One new occurrence (EO #003) was discovered during field surveys in 1996 (Fertig 1997b).

Addition: There are nine extant *Astragalus gilviflorus* var. *purpureus* occurrences of unresolved taxonomic status in the eastern Big Horn Basin (Big Horn and Washakie counties). The southwestern corner of the Big Horn Basin had only *A. g.* var. *gilviflorus* although it was predicted as having potential habitat for *A. g.* var. *purpureus* in the potential distribution model (Fertig and Thurston 2003). All reports of purple-flowered *Astragalus gilviflorus* are represented in Figure 2 and Table 2.

3. UNVERIFIED/UNDOCUMENTED REPORTS: In the "Representative Specimens" section of his thesis, Roberts (1977) cited nine of his own Fremont County collections of "*Astragalus shoshonensis*", but does not provide any specific location information. None of these specimens have been deposited at the RM (B.E. Nelson, RM manager, personal communication to W. Fertig).

4. SITES WHERE PRESENT STATUS NOT KNOWN: The populations from Johnson Draw on the Wind River Indian Reservation (EO #004) and White Pass (EO #012) have not been relocated since 1981 and 1984, respectively.

5. AREAS SURVEYED BUT SPECIES NOT LOCATED: Potential habitat was surveyed on BLM lands in the Alkali Creek and EA Mountain areas in 1997, but no populations of this species were found.

Addition: A potential distribution model was developed for *Astragalus gilviflorus* var. *purpureus* (Fertig and Thurston 2003; Figure 3, Appendix D) that had never been field-tested. The only area identified as having potential habitat in the BLM Worland Field Office was in the southwestern corner of the Big Horn Basin (Park County). Only one purple-flowered *Astragalus gilviflorus* var. *gilviflorus* was found in this area among four white-flowered plants, where the population numbered in the low hundreds . Some of the high likelihood habitat in the BLM Cody Field Office corresponds closely to that of *Shoshonea pulvinata*, an early-blooming sensitive species that has been surveyed extensively (Heidel 2011). There were no areas of high likelihood habitat identified by the potential distribution model in Big Horn or Washakie counties in the eastern Big Horn Basin.

6. AREAS OF UNSURVEYED POTENTIAL HABITAT: Fertig (1998) reported that additional unsurveyed potential habitat may exist in the badlands of the Chimney Rock Gulch

area, ca 4 air miles west of Dubois and on the Wind River Indian Reservation in the Bain Draw, Sand Draw, and Crow Creek areas.

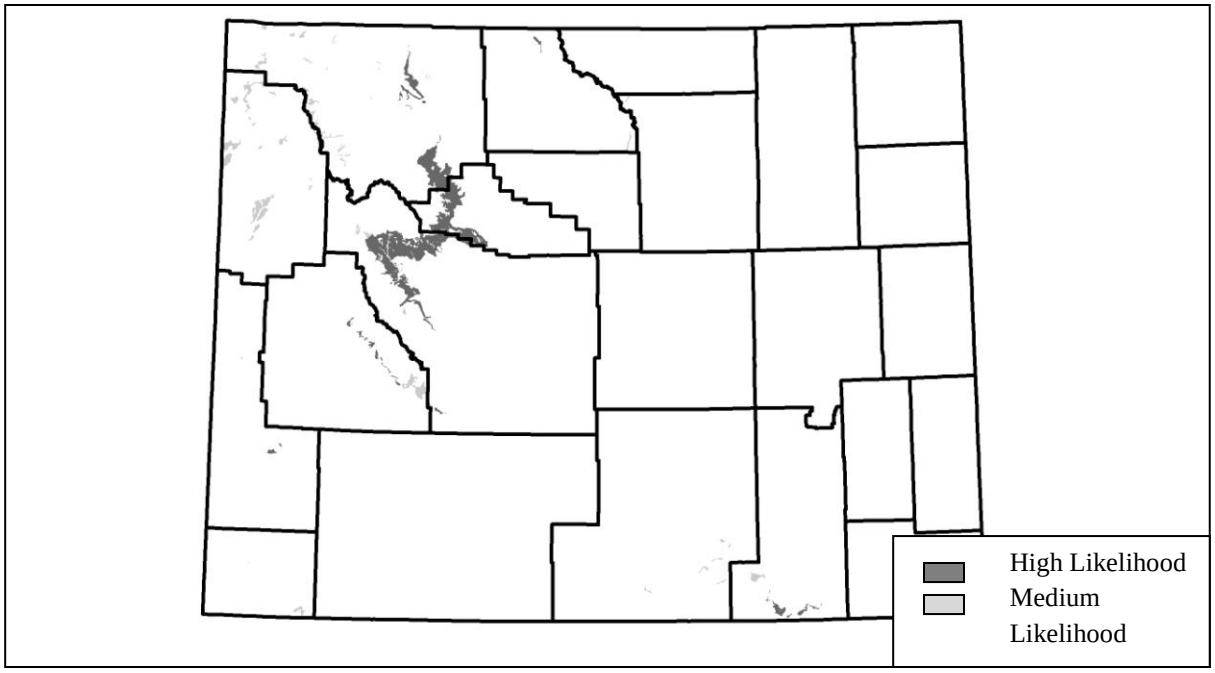

Figure 3. Potential distribution of *Astragalus gilviflorus* var. *purpureus* (from Fertig and Thurston 2003). More information on this model is presented in Appendix D.

E. HABITAT

1. ASSOCIATED VEGETATION: In the Dubois area, *Astragalus gilviflorus* var. *purpureus* occurs primarily in sparsely vegetated cushion plant/bunchgrass communities on sandy-clay soils with abundant surface gravel (Fertig 1998). These communities may lack a shrub component, or contain widely scattered individuals of Wyoming big sagebrush, mountain big sagebrush, or black sagebrush. It may represent a "climax" condition maintained by edaphic properties.

The Dubois area habitat is found on mid to upper slopes of badlands slopes actively eroding below the occupied habitat. This combination of cushion plant community and active badlands erosion are characteristic in the Dubois area.

Addition: In the eastern Big Horn Basin, putative *Astragalus gilviflorus* var. *purpureus* is associated with sparse grassland, cushion plant vegetation and barrens, often dominated by *Elymus spicatus* (bluebunch wheatgrass) and *Gutierrezia sarothrae* (broom snakeweed), usually within prairie and less often within *Artemisia tridentata* ssp. *wyomingensis* (Wyoming big sagebrush) steppe or *Juniperus osteosperma* (Utah juniper) woodlands. It is not usually present on the eroding slopes of *Eriogonum pauciflorum* (few-flowered buckwheat). Most of the Bighorn Basin settings had a well-developed cryptobiotic crust with a rolling texture typical of

very cool deserts. Even some of the roadcut settings had well-developed cryptobiotic crusts. Habitat photographs are represented in Appendix E.

2. FREQUENTLY ASSOCIATED SPECIES: Less than half of the species frequently associated with *Astragalus gilviflorus* var. *purpureus* in the Wind River Basin are also frequently associated with the putative *Astragalus gilviflorus* var. *purpureus* populations in the Big Horn Basin (Table 3).

Table 3. Species frequently associated with *Astragalus gilviflorus* var. *purpureus*

Scientific name (Common name)	**Dubois area**	**East Big Horn Basin**
Artemisia nova (Black sagebrush)	Present	Present
Artemisia tridentata var. vaseyana (Mountain big sagebrush)	Present	Absent
Artemisia tridentata var. wyomingensis (Wyoming big sagebrush)	Present	Present
Astragalus chamaeluece (Cicada milkvetch)	Present	Absent
Astragalus miser var. decumbens (Weedy milkvetch)	Present	Absent
Astragalus purshii (Pursh's milkvetch)	Absent	Present
Carex filifolia (Threadleaf sedge)	Present	Absent?
Cryptantha spp. (Miner's-candle)	Absent	Present
Elymus spicatus (Bluebunch wheatgrass)	Present	Present
Eremogone hookeri (*Arenaria hookeri;* Hooker's sandwort)	Present	Present
Eriogonum brevicaule (Shortstem buckwheat)	Present	Absent
Gutierrezia sarothrae (Broom snakeweed)	Absent	Present
Haplopappus nuttallii (Gumweed aster)	Present	Present
Hymenoxys acaulis (Stemless hymenoxys)	Present	Absent?
Koeleria macrantha (Prairie junegrass)	Present	Present
Leptodactylon pungens (Prickly-phlox)	Present	Present
Lesquerella alpina (Alpine bladderpod)	Present	Present
Leucopoa kingii (Spike fescue)	Present	Absent
Mentzelia spp. (Blazingstar)	Absent	Present
Oryzopsis hymenoides (Indian ricegrass)	Present	Absent?
Oxytropis lagopus var. lagopus (Hare's-foot locoweed)	Present	Absent
Oxytropis nana (Wyoming locoweed)	Present	Absent
Oxytropis sericea var. sericea (Silvery locoweed)	Present	Absent
Phlox hoodii (Hood's phlox)	Absent	Present
Phlox muscoides (Moss phlox)	Present	Present
Poa secunda (Sandberg's bluegrass)	Absent	Present
Potentilla ovina (Sheep cinquefoil)	Present	Absent
Psoralidium lanceolatum (Lemon scurfpea)	Present	Absent
Senecio canus (Woolly groundsel)	Present	Absent
Stenotus acaulis (*Haplopappus acaulis;* Stemless mock goldenweed)	Absent	Present
Stipa comata (Needle-and-thread)	Present	Present
Yucca glauca (Yucca, Spanish bayonet)	Absent	Present

3. TOPOGRAPHY: In the Dubois area, *Astragalus gilviflorus* var. *purpureus* typically occurs convex-shaped on mid to upper slopes of 1-20° near the crest of badlands ridges or low knolls. Less commonly, populations can be found on gravelly outwash fans or at the toe of low slopes. This taxon is largely absent from deeply incised draws or slopes. Known occurrences range in elevation from 6400-8800 ft (1950-2680 m).

Addition: In the eastern Big Horn Basin, putative *Astragalus gilviflorus* var. *purpureus* occurs on flat rims and convex-shaped upper or mid slopes of dissected tableland and basin margins. This taxon is largely absent from deeply incised draws or slopes. Known occurrences range in elevation from 4320-5890 ft.

4. SOIL RELATIONSHIPS: Most of the populations of *Astragalus gilviflorus* var. *purpureus* in the Dubois badlands area occur on sparsely vegetated, pinkish-white or pale brown sandy clays with abundant surface gravel derived from the Tertiary Wind River or Indian Meadows formations (Love and Christiansen 1985). Usually, these populations are located on upper slopes above the multi-colored badlands outcrops. One small subpopulation along the East Fork Road apparently occurs on a localized outcrop of the Cretaceous age Cody Shale (EO #007).

Populations at the southern edge of the species' range in the Wind River Basin occur on reddish or brown substrates derived from the Triassic Chugwater and Dinwoody formations. At the base of Torrey Rim these outcrops may have a surface layer of limestone or granitic gravel (EO #003). *Astragalus gilviflorus* var. *purpureus* has also been reported from limestone substrates (EO #004) and gravelly moraines (EO #010).

Addition: Populations in the eastern Big Horn Basin occur on soils that are reddish brown silt and sandy silt, with limited profile development, derived from a unit mapped as the Tensleep Sandstone and Amsden Formation, and from a unit mapped as Goose Egg Formation and Chugwater Formation (Love and Christiansen 1985). These formations are sometimes interbedded with calcareous strata.

5. REGIONAL CLIMATE: Average annual precipitation in the Dubois area is 8.17 inches (20.75 cm), with peak levels from April-June. Mean annual temperature is 39.4° F (4.1°C), with mean maximum and minimum temperatures in January of 33.4° and 9.9° F (0.7° and - 12.2° C) and mean maximum and minimum temperatures in July of 79.3° and 41.6° F (26.2° and 5.3° C) (Martner 1986).

Addition: Average annual precipitation values in the Greybull and Worland areas are 7.7 in and 8.0 in (19.6 cm and 20.3 cm, respectively), with peak levels over May-June. Mean annual temperatures are 60.9° and 59.7° F (16.1° and 15.4° C) for Greybull and Worland. Climate extremes are also similar between the two towns. In Greybull, mean maximum and minimum

temperatures in January are 3.9° F to 30.2° F (-15.6° to -1.0° C) and mean maximum and minimum temperatures in July are 56.2° F to 90.4° F (13.4° to 32.4° C). Likewise, In Worland, mean maximum and minimum temperatures in January are 3.8° F to 30.2° F (-15.6° C to -1.0° C) and mean maximum and minimum temperatures in July are 56.5° F to 90.3° F (13.6° to 32.4° C) (USDI NOAA 2010).

6. LOCAL MICROCLIMATE: *Astragalus gilviflorus var. purpureus* typically occurs on light-colored, semi-barren substrates on the rims of steep slopes in the Wind River Basin. These sites are exposed to high levels of solar radiation and wind, and are likely to be drier and have higher daytime surface temperatures than adjacent, more highly vegetated sites.

Addition: In the Big Horn Basin, putative *Astragalus gilviflorus var. purpureus* has considerable bare ground with or without gravel. These sites are exposed to microclimate conditions that resemble those in the Wind River Basin.

F. POPULATION BIOLOGY AND DEMOGRAPHY

1. PHENOLOGY: In the Dubois area, *Astragalus gilviflorus* var. *purpureus* flowers primarily from mid-June to early July, while fruits are produced from mid-June to July. Based on field observations and herbarium specimens, flowering has been documented from May 28-July 10 and fruiting from June 20-July 18. The peak flowering appears to be in mid June.

Addition: In the eastern Big Horn Basin, putative *Astragalus gilviflorus* var. *purpureus* flowers in early or mid-May though early June. Based on herbarium specimens and photographs, flowering has been documented from 18 May-2 June, generally two-three weeks earlier than in the southeastern Wind River Basin. Almost all flowers bloom in synchrony, and sometimes there is a very short window for finding flowers on plants early and late in bloom.

2. POPULATION SIZE AND CONDITION: *Astragalus gilviflorus* var. *purpureus* is known from 11 extant occurrences in the Dubois area, divided into at least 38 subpopulations. Approximately 50,000-68,000 plants were counted at 15 subpopulations in 6 of these occurrences in 1996 (Table 2). Based on the amount of additional, unsurveyed potential habitat, the total population is conservatively estimated at 100,000-150,000. Nearly 90% of the total population, however, is found in a single, extensive occurrence in the Dubois Badlands on the south side of Table Mountain and west of the East Fork Road (EO #007).

With the exception of a few large and extensive populations of 1000-5000 plants, typical colonies of *Astragalus gilviflorus* var. *purpureus* consist of 40-100 plants in an area of 1-2 acres. Populations may be patchy to densely clustered, depending on the topography of the site and the presence of suitable substrates. Most populations consist of medium to large rosettes with few to

no seedlings present. Seedling survival and establishment is probably low in most years due to harsh environmental conditions or low fruit production. Trend data are lacking for most occurrences of *A. g.* var. *purpureus*. Hollis Marriott estimated the total population at "several thousand" plants at two large sites that she surveyed for The Nature Conservancy in 1990. Two additional populations surveyed in 1990, however, contained only about 30 plants each. These latter sites were revisited in 1996 and found to contain approximately the same number of individuals. Based on the present condition of the habitat in the Dubois area, this species is probably essentially stable at the present time, although some habitat may have been lost to residential or agricultural development in the past century.

Addition: Putative *Astragalus gilviflorus* var. *purpureus* is known from nine extant occurrences in the eastern Big Horn Basin, divided into at least 40 subpopulations that span at least 100 acres total (Table 4). No populations have been censused and estimates are preliminary, with tallies of over 2000 plants, i.e., total numbers in the low 1000's. Close to half of total numbers and area are in the extensive Rome Hill population (#017) and it is possible that further survey would find continuity between it and the Tensleep population (#016), treating them as a single population complex. The habitat appears to be stable at present. Most populations consist of medium to large rosettes with few to no seedlings present.

Table 4. Size and extent of *Astragalus gilviflorus* var. *purpureus* populations

EO#	**Population Size**	**Numbers/Extent ha (ac)**
015	Est. 100-300	(1.4)
016	Est. 300-400+	(16.4)
017	Est. 1500+	(54.5)
018	No estimate	No estimate
019	No estimate	(3+)
020	No estimate	(1.5+)
021	Est. 250+	(20.5)
022	Est. 50-100	(0.2)
023	Est. 80+	(0.2)
TOTAL	[2300-2700]	(~100 ac)

3. REPRODUCTIVE BIOLOGY:

a. TYPE OF REPRODUCTION: *Astragalus gilviflorus* var. *purpureus* reproduces primarily by seed.

Addition: *Astragalus gilviflorus* var. *purpureus* was thought to be able to spread to a limited degree by vegetative growth and branching of the caudex (Fertig 1998). However, no patterns

were originally reported or subsequently observed to suggest that vegetative reproduction takes place.

b. POLLINATION BIOLOGY: Black ants and large bumblebees were observed pollinating the flowers of *Astragalus gilviflorus* var. *purpureus* in 1996 (Fertig 1998).

Addition: *Bombus* spp. (bumblebees) were frequently observed visiting *Astragalus gilviflorus* in the eastern Big Horn Basin (Appendix E).

c. SEED DISPERSAL AND BIOLOGY: The fruits of *Astragalus gilviflorus* var. *purpureus* produce 2-5 mature seeds (Roberts 1977). The seeds probably rely on animals or gravity for dispersal. The clumped distribution pattern of many colonies may indicate that dispersal distances are short.

G. POPULATION ECOLOGY

1. GENERAL SUMMARY: In the Dubois area, most populations of *Astragalus gilviflorus* var. *purpureus* are often small and localized, with plants clustered to widely spaced. Seedling establishment appears to be low, perhaps due to poor fruit production, or harsh conditions affecting seed germination or survival. The matted, perennial growth habit and apparently low reproductive potential of *A. g.* var. *purpureus* appears to be an adaptation to survive under these extreme conditions. Trend data are not available to determine the long-term survival of plants in intact habitat or at disturbed sites.

Addition: Likewise, in the eastern Big Horn Basin, most populations of the putative *Astragalus gilviflorus* var. *purpureus* are small and localized, with plants clustered to widely spaced. Seedling establishment appears to be low, perhaps due to poor fruit production, or harsh conditions affecting seed germination or survival. The matted, perennial growth habit and apparently low reproductive potential of *A. g.* var. *purpureus* appears to be an adaptation to survive under these extreme conditions. Trend data are not available to determine the long-term survival of plants in intact habitat or at disturbed sites. Plants exhibit radial growth, and there were occasionally plants that had died in the center of the cushion plant growth form.

3. HERBIVORY: No evidence of herbivory on leaves, stems, or flowers was observed during field surveys in 1996 (Fertig 1998). The low, matted growth form and presence of distasteful chemical compounds in the foliage probably protects this species from grazing by most livestock and wildlife. Low fruit production, however, may possibly be related to herbivory by insects or rodents.

Addition: In 2009, flower herbivory was often seen, possibly associated with beetles, and was particularly heavy in the population nearest Hyattvile. This flower herbivory may have lead to fruit herbivory.

4. HYBRIDIZATION: There was no strong evidence of hybridization between *Astragalus gilviflorus* var. *purpureus* and other related species in the field reported by Fertig (1998). Occasional plants can be found with light pink flowers, but these may be the result of natural variation or age rather than hybridization. Marriott noted on unpublished survey notes that some populations in the Dubois area may contain both *A. g.* var. *purpureus* and *A. g.*var. *gilviflorus*, but her observations were based on vegetative plants that were past flowering. Roberts (1977) reports that the nearest population of var. *gilviflorus* occurs near Thermopolis, Wyoming, nearly 50 miles east of the closest *A. g.* var. *purpureus* site.

Addition: If the *Astragalus gilviflorus* var. *purpureus* genome is present in the eastern Big Horn Basin, the mixed-color populations may represent hybridization between both varieties of *A. gilviflorus* (relict, progenitor, or waif). Alternatively, they could reflect past hybridization between species, however recent or ancient, involving *A. g.* var. *gilviflorus* and purple-flowered species such as *A. barrii* to the east or *A. serioleucus* var. *aretioides* to the north and south.

H. LAND OWNERSHIP - see Fertig (1998)

Addition: All lands surveyed in 2009-2010 were on BLM Worland Field Office lands.

IV. 2009-2010 SURVEY RESULTS

Collection sites or reported sites of putative *Astragalus gilviflorus* var. *purpureus* were surveyed in 2009 in the southeastern corner of the Big Horn Basin south of Hyattville. They included the two original collection sites of Lum (#015, #016), the photography site of Leon as expanded by BLM, three of the four photography sites of BLM staff (#017, #018, #019); and one new site (#021) sympatric with *A. jejunus* var. *articulatus* (Hyattville milkvetch). Subsequently, two sites of *A. g.* var. *purpureus* were surveyed in 2010 north of Hyattville as reported by both Leon and BLM staff. Contiguous sections of public land were also surveyed in most cases.

All of the 2009 sites had mixed-color populations. At each surveyed site, the range of flower color present and the prevalent color were noted, in addition to the original survey and mapping tasks. There was no segregation of the different-colored flowering plants by habitat or other spatial patterns. Flowering appeared to be synchronous regardless of flower color, i.e., there was no phenological offset or segregation of the different-colored flowering plants in flowering time.

Surveys were conducted close to peak flowering in the third week of May. The spring flowering was characterized as late in 2009 by at least a week for this area compared to previous years

(Hepp pers. commun., Leon pers. commun.). Vouchers were collected at each site to represent the "spectrum." The color spectrum does not sort locally by phenology, habitat, or location within the population. These occurrences are in the WYNDD database as putative records of *A. g.* var. *purpureus* that warrant taxonomic research.

Flower color was characterized by the color of banner and wings, while the keel was typically dark purple. Throughout the populations, nearly all plants were in flower. There were slight shifts in hue as the flowers aged so that some white-flowered plants had older flowers that seemed to take on a pale lavender hue, and these plants appeared to be slightly multi-colored. The outer surface of the petal was also sometimes darker than the inner surface, sometimes giving buds the appearance of having purple-hued color when the flower color was white.

In general, the three southernmost sites of putative *Astragalus gilviflorus* var. *purpureus* had a preponderance of white-flowered plants, the site nearest Hyattville had a preponderance of purple-flowered plants, and the three intermediate sites had a preponderance of lavender-colored plants. The north-south gradient did not correspond to an elevation gradient. Elevations ranged from 4320-5800 ft (1317-1768 m). The southern populations were possibly a week earlier in their phenology.

Both sites surveyed in 2010 had pure-color populations. They were located almost 9 miles from the nearest-known mixed-color population, and they spanned a distance of about 13 miles. The total range of putative *A. g.* var. *purpureus* extends for at least 64 miles along the Basin margins. One uniformly purple population clearly fit *A. g.* var. *purpureus* but it was restricted to road right-of-way, stopping abruptly at the r.o.w. fenceline. The other uniformly purple population farther north was predominantly in native habitat, with a few plants in bladed right-of-way. It is the only "pure" population in native habitat, but its flowers seem smaller than the other populations. Calyx length seemed to fit *A. g.* var. *purpureus* but approached *A. barrii*; possibly smaller than at all the other sites. *A. barrii* is not known from the Big Horn Basin and is not known to cross with *A. g.* var. *gilviflorus* despite the latter overlapping in distribution.

Mixed-color populations of *Astragalus gilviflorus* or any other tufted milkvetches are not discussed in the taxonomic keys (Dorn 2001, Isely 1998) or in a detailed Master thesis on the tufted milkvetches of Wyoming (Roberts 1977) that included complete specimen review. Robert Dorn was consulted and he mentioned that there may be growth form differences that distinguish *Astragalus gilviflorus* var. *purpureus* from the type variety that have not been incorporated into keys. Dorn reiterated the need for closer taxonomic research among the tufted milkvetches, including what may represent an undescribed taxon in Park County.

Sketched out below are four possible interpretations of the taxonomic status of mixed-color populations of *Astragalus gilviflorus* in the Big Horn Basin.

Nongenetic variation – Plants may exhibit variation that does not have genetic basis. The isolation and habitat specialization of *Astragalus gilviflorus* var. *purpureus* in the Wind River Basin does not necessarily apply in the Big Horn Basin because it is not geographically isolated from the type variety and because there is not a consistency of character traits associated with it. However, flower color traits usually have a genetic basis. Greenhouse experiments would be the simplest tool for testing the alternatives. Sensitive species policy would not apply if flower color is nongenetic variation.

Genetic differences that do not confer taxonomic distinctions – Genetic differences can be expressed as ecotypic plasticity, albinoism, phenotypic polymorphism, or Mendelian variation. Plants may exhibit variation that is or is not selective. Ecotype variation and phenotypic plasticity are unlikely in the absence of any habitat-sorting or phenology-sorting by flower color. Lab experiments would be needed. Sensitive species policy would not apply if flower color does not confer taxonomic distinctions.

Genetic differences that are incompletely sorted for conferring taxonomic distinctions, whether representing genetic change in progress, vestigial, or intermediary. - Plants may exhibit trends in variation that are intermediate across a gradient of species distinctions, as divergence-in-progress or vestiges of divergence. It is also possible that the mixed-color populations and the isolated pure-color populations represent some unsorted evolutionary intermediaries or hybridization complex. Lab experiments would be needed. This is a gray area in the application of sensitive species policy.

In keeping with this possibility, it is noted that there are purple-flowered tufted species of milkvetches in all four compass directions but not in the Basin (Figure 2). It may be significant that *Astragalus serioleucus* var. *aretioides* is present in a widespread pattern to the south of the Big Horn Basin, and also in the Pryor Mountains to the north, the only place where it is present in Montana (Figure 1). The *A. gilviflorus* var. *gilviflorus* populations in the southeastern Big Horn Basin may provide clues to the origin of *A. g.* var. *purpureus.*

Hybridization between incompletely separated varieties is hypothesized to account for intermediate flower colors in another Big Horn Basin species, *Penstemon laricifolius* (larchleaf penstemon), in which the rarer of the two varieties is the white-flowered *P. l.* ssp. *exilifolius*. However, in this case, there are large areas of Wyoming where the two varieties do not overlap, and there seems to be a distinct elevation gradient in the Bighorn Mountains that corresponds with color sorting and which is thought to reflect the relative contribution of the parent taxa (Heidel and Handley 2007).

The presence of pure-color purple-flowered *Astragalus gilviflorus* populations at the north end may represent some sort of genetic relict or isolated introduction. If it were the genetic source

responsible for the medley of flower colors, it must have some antiquity to account for the 60+ mile extent of progeny. Another set of working hypotheses could be developed and tested to determine what it represents. It is inferred that the population restricted to the road corridor was accidentally introduced from some parent population. At face value, only the northernmost *A. g*. var. *purpureus,* with its pure-color purple-flowered population in predominantly native habitat, fits the color-based taxonomic criteria and the policy of maintaining sensitive plants in their native habitat.

IV. ASSESSMENT AND MANAGEMENT RECOMMENDATIONS

The following information does not include any information in Fertig (1998) but is based strictly on field surveys in the Big Horn Basin. All recommendations are tempered by unresolved taxonomic questions.

A. POTENTIAL THREATS TO CURRENTLY KNOWN POPULATIONS: Routine road maintenance or indiscriminate weed spraying pose potential threats to *Astragalus gilviflorus* var. *purpureus* where it occurs in road right-of-ways. Exotic species were scarce or absent, and the roadside exotics such as *Poa bulbosa* (bulbous bluegrass) were limited to the road corridors.

Some population sites have soil with high gravel contents such that the species could be impacted if there were quarrying. Part of the Rome Hill population (#017) is on level ground that has been used for vehicle turn-around and habitat could be further degraded if it were turned into a parking lot for roadwork machinery. A small part of the population closest to Tensleep (#016) is crossed by ORV trails, in the middle of concentrated use.

B. MANAGEMENT PRACTICES AND RESPONSE: There were no signs indicating that livestock grazing affects *Astragalus gilviflorus* var. *purpureus*. Thinning of *Juniperus osteosperma* (Utah juniper) was proposed in proximity to the Rome Hill Road population (#017). However, *J. osteosperma* does not occupy the same habitat as *A. g.* var. *purpureus*, so the biggest considerations associated with any management practices, whether thinning is accomplished by mechanical treatment or prescribed burn, is avoidance of secondary impacts. These impacts might include introduction of weeds, fire escape, offroad traffic, and erosion.

C. CONSERVATION RECOMMENDATIONS

1. Recommendations regarding present or anticipated activities: It is a fundamental question whether BLM sensitive species policy does or does not apply in this case. Preliminary evidence has been provided why the *Astragalus gilviflorus* of the eastern Big Horn Basin is

not *A. g.* var. *purpureus.* Adding another layer of complexity, roadcut population segments might be treated differently than those in native rangeland habitat.

2. Notification of BLM personnel of locations on BLM lands: Complete GIS information has been provided via the BLM data export for reference in the BLM State and Worland Field Office.

3. Status recommendations: The updated state species abstract (Appendix C) with its dot distribution map for *Astragalus gilviflorus* var. *purpureus* will replace earlier versions to reflect that the taxonomic status of *A. g.* var. *purpureus* in the Big Horn Basin as undetermined. The symbol "?" will represent eastern Big Horn Basin populations. All sensitive status recommendations hinge on taxonomic determinations. This document will be put out for review in consulting with taxonomists and geneticists.

D. SUMMARY: Surveys were conducted for *Astragalus gilviflorus* var. *purpureus* in the Big Horn Basin in 2009-2010 that documented the geographic extent and habitat conditions of purple-flowered plants. It was neither proven nor disproven that they represent *A. g.* var. *purpureus.* They span 64 air miles, and each of the nine populations had either a mixture of flower color traits, or habitat variability that included man-made disturbance. Greenhouse investigations could address two possible explanations for mixed-color populations, beyond which molecular taxonomic research in the laboratory is needed. The potential distribution model falsely predicted habitat in the southwestern Big Horn Basin and failed to predict the putative *A. g.* var. *purpureus* in the southeastern Big Horn Basin.

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