FINAL REPORT

State: South Dakota Grant Number: T-45-R1

Project Title: Survey and Mapping of Black Hills Montane Grasslands

Period Covered: 1 July, 2010 – 31 December, 2012

Objectives:

1. Digitally map higher quality Black Hills montane grasslands; construct a montane grassland GIS layer in cooperation with public agencies;
2. Provide a set of photos of survey sites from relocatable points;
3. Thoroughly characterize the Black Hills montane grassland vegetation type;
4. Develop a field key to the type;
5. Share information through national databases and publication in an academic journal.

Accomplishments:

1. See attached Final Report.
2. Shapefiles of montane grassland polygons with attribute tables and photographs have been received by GFP and archived or mapped within Biotics.
3. A final manuscript has been completed and is being submitted for publication.

Amount Obligated: $60,600

Actual cost to date: (1 July 2010 – 31 Dec. 2012) $57,028.04

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Survey and Mapping of Black Hills Montane Grasslands

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Prepared for the South Dakota Department of Game, Fish and Parks.
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Abstract

Visitors have raved about the flower-filled mountain meadows of the western Black Hills since Lt. Col. George A. Custer's expedition in 1874. Unfortunately, even by the time of the first detailed studies of these meadows in the late 1920s, they were already being taken over by non-native grasses. During the Black Hills Community Inventory in the late 1990s, there was widespread concern that native Black Hills montane grasslands had disappeared entirely. Reconnaissance in 1998 followed by surveys in 1999 confirmed that most montane grasslands are dominated by non-native hay grasses and clovers. However some native stands still exist, including several that are quite large.

The current project, funded by South Dakota Game, Fish and Parks, was designed to find, characterize, evaluate and map remaining native montane grasslands. The study area included the Limestone Plateau of the western Black Hills as well as the large grasslands or prairies in the vicinity of Deerfield Lake. Results were combined with those of earlier projects to provide a comprehensive picture of montane grasslands in the South Dakota part of the Black Hills. A digital map of Black Hills montane grasslands was created for the State of South Dakota's Geographic Information System.

Native montane grasslands are rare, and are restricted to dry drainages in the southern part of the Limestone Plateau. All are *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* Herbaceous Vegetation, or Black Hills montane grasslands, similar to the well-drained slope mountain meadow type described by McIntosh in 1930. He also described a type from lower meadows, already dominated by timothy in the late 1920s. Our surveys provided no insight as to original native composition of these lower meadows. Throughout much of the study area, timothy and smooth brome dominate moister montane grassland habitat.

Many Black Hills montane grasslands are grazed, and have some form of water development for livestock. Many are cut for hay, especially on private land. Most are traversed by roads of various kinds. Recently, subdivision of privately-owned montane grasslands and construction of residences have increased dramatically.

Black Hills montane grassland vegetation occurs only in the Black Hills, and is rare locally as well. While there is extensive grassland habitat on the Limestone Plateau, most stands are partially or largely non-native. Only eight of the 78 Black Hills montane grasslands surveyed in 2011 and previous projects ranked high in ecological integrity assessment. Due to limited global distribution, rarity of native stands, significant habitat loss in the past, continued habitat loss, and low level of protection afforded remaining stands, Black Hills montane grassland vegetation is ranked G1S1 in South Dakota and Wyoming, "critically imperiled" on a global and local basis.

Montane grasslands in the Wyoming portion of the Black Hills will be surveyed in 2012, with funding from Black Hills National Forest.

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A. Plant names used in report.

B. Mountain meadow species list from Hayward (1928) and McIntosh (1930, 1931).

C. Black Hills montane grassland scorecard.

D. Field forms for Black Hills montane grassland surveys and plots.

E. Stand summary table for Black Hills montane grasslands.

Acknowledgements

I have been involved with Black Hills montane grasslands since 1998, and given all the years that have passed, there are many people to acknowledge. First and foremost, I thank my long-time colleague and friend, Dave Ode, botanist/ecologist with the South Dakota Department of Game, Fish and Parks, Wildlife Division. Dave was the reason this project happened, and was the number-one source of information, advice and support -- as he has been so often during the past 30 years.

Don Faber-Langendoen, Senior Ecologist with NatureServe, provided field assistance and most importantly, theoretical expertise on classification and assessment of grasslands. Don's background running the Black Hills Community Inventory was invaluable for this project, and it was a pleasure to collaborate once again.

Beth Burkhart, now Park Botanist at Wind Cave National Park, worked with me surveying montane grasslands in 1998 and 1999, supplying lots of enthusiasm and hard work. During the 2011 field season, she organized a montane grassland field trip for the Great Plains Native Plant Society. Cheryl Mayer and Helen McGranahan, long-time field botanists with Black Hills National Forest (BHNF), were my treasured co-workers during the 2011 project. They were of tremendous help in collecting data and discussing vegetation issues. I look forward to more in 2012.

Great Plains Native Plant Society field trip, August 2011. Beth Burkhart second from right. Photo by Cheryl Mayer, Black Hills National Forest.

Chelsea Monks, BHNF Botanist, generously contributed staff for field surveys. Jill Larson-Welborn, Botanist for the Northern Hills District, was a good soundboard in trying to figure out the heavily-impacted montane grasslands of the northern Black Hills. Long-time friend and colleague Deanna Rehyer (BHNF) supplied ideas and moral support as she has for so many years ... much appreciated.

Finally, I want to acknowledge my dogs. Patches was a dedicated surveyor, covering all grasslands visited in 1998 and 1999. Sparky helped in 2011. He didn't have near the work ethic, but his whimsical nature more than made up for it.

Patches as hood ornament.

Sparky enjoys a riot of floral color in a Black Hills mountain meadow.

Introduction

In 1874, Lt. Col. George A. Custer lead his expedition of some 100 wagons and close to 1000 men into the high Black Hills, after more than three weeks of travel across the "dry and woodless country" of Dakota and Wyoming Territories. There they found themselves in grasslands quite unlike those of the plains. The change was so striking and so welcome that the soldiers reveled in the lush grass, and decorated the headgear of their horses with wildflowers. Custer named the spot "Floral Valley". For the next few days they traveled through idyllic meadows, with spectacular shows of wildflowers and grass sometimes as high as a horse's shoulder (Ludlow 1875).

During the next 100-plus years, high-elevation meadows in the Black Hills received little attention from botanists, with the exception of brief descriptions by Rydberg (1896) Hayward (1928) and McIntosh (1930, 1931). By the time of the Black Hills Community Inventory (BHCI) by the Nature Conservancy (Marriott et al. 1999), there was widespread concern that no native mountain meadow vegetation remained.

But there had been no comprehensive inventory of high-elevation grasslands in the Black Hills. Furthermore, the meadows of the high Limestone Plateau were well-known among local residents for wildflower displays, suggesting that native mountain meadows were still around. In 1998, a week was spent looking at montane grasslands as part of the BHCI. Several small stands were found with the species reported by Hayward and McIntosh (Marriott and Faber-Langendoen 2000). Continued survey in 1999 showed that while the majority of montane grassland habitat is dominated by non-native hay grasses, native grasslands still exist, including several that are quite large (Marriott 2000).

The State of South Dakota has recognized that all habitats and vegetation types need to be conserved in order to successfully manage wildlife: "If most of the historical plant communities still exist in the state in sufficient acreage and quality, the needs of the majority of wildlife species should be met" (SDGFP 2006). At least four wildlife species of concern are known or are likely to be associated with Black Hills montane grasslands, including the Bear Lodge meadow jumping mouse (*Zapus hudsonius campestris)*, Black Hills red-bellied snake (*Storeria occipitomaculata pahasapae*) and Black Hills fritillary (*Speyeria atlantis pahasapa*).

Because Black Hills montane grassland habitat has undergone major decline since presettlement times, remaining native stands need to be documented and characterized to conserve and manage habitat for species of concern. Towards this end, the South Dakota Department of Game, Fish and Parks (SDGFP) funded a comprehensive survey of Black Hills montane grassland habitat in 2011, with support from the US Fish and Wildlife Service. Black Hills National Forest has funded similar work in the Wyoming part of the Black Hills; those results will be available at the end of 2012.

The Black Hills

The Black Hills are a small mountain range in western South Dakota and northeastern Wyoming, roughly 120 miles in length and 40 to 50 miles across (Figure 1). They were uplifted 75-35 million years ago, during the episode of mountain building that created the Rocky Mountains -- the Laramie Orogeny (Bird 1998). The Black Hills are similar to many of the ranges of the Rockies, with a broad crest and relatively-steep flanks. Erosion has exposed Precambrian igneous and metamorphic rocks at highest elevations, surrounded by progressively-younger sedimentary formations underlying plateaus, hogbacks and strike valleys (Figure 2).

Figure 1. The Black Hills in western South Dakota and northeastern Wyoming. Project study area outlined in green (modified from Marriott et al. 1999).

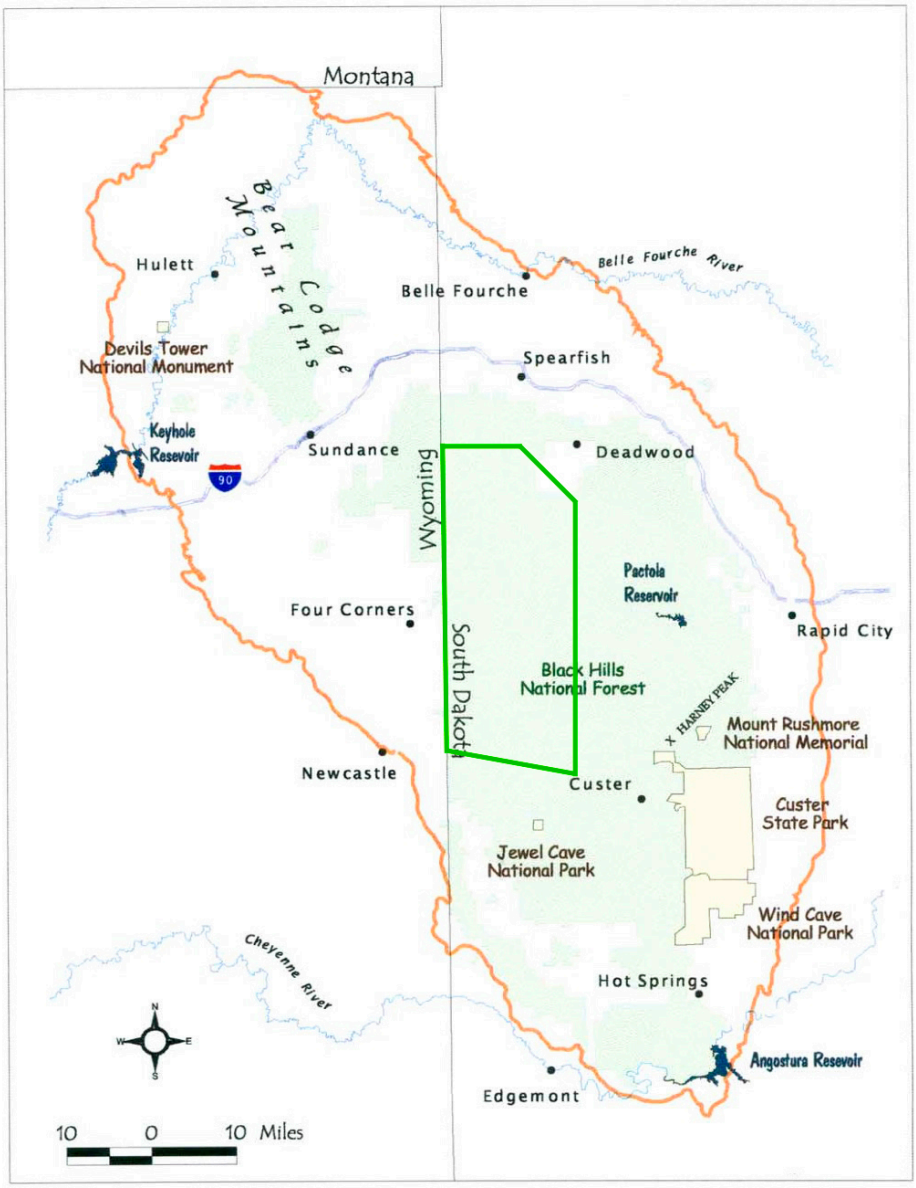
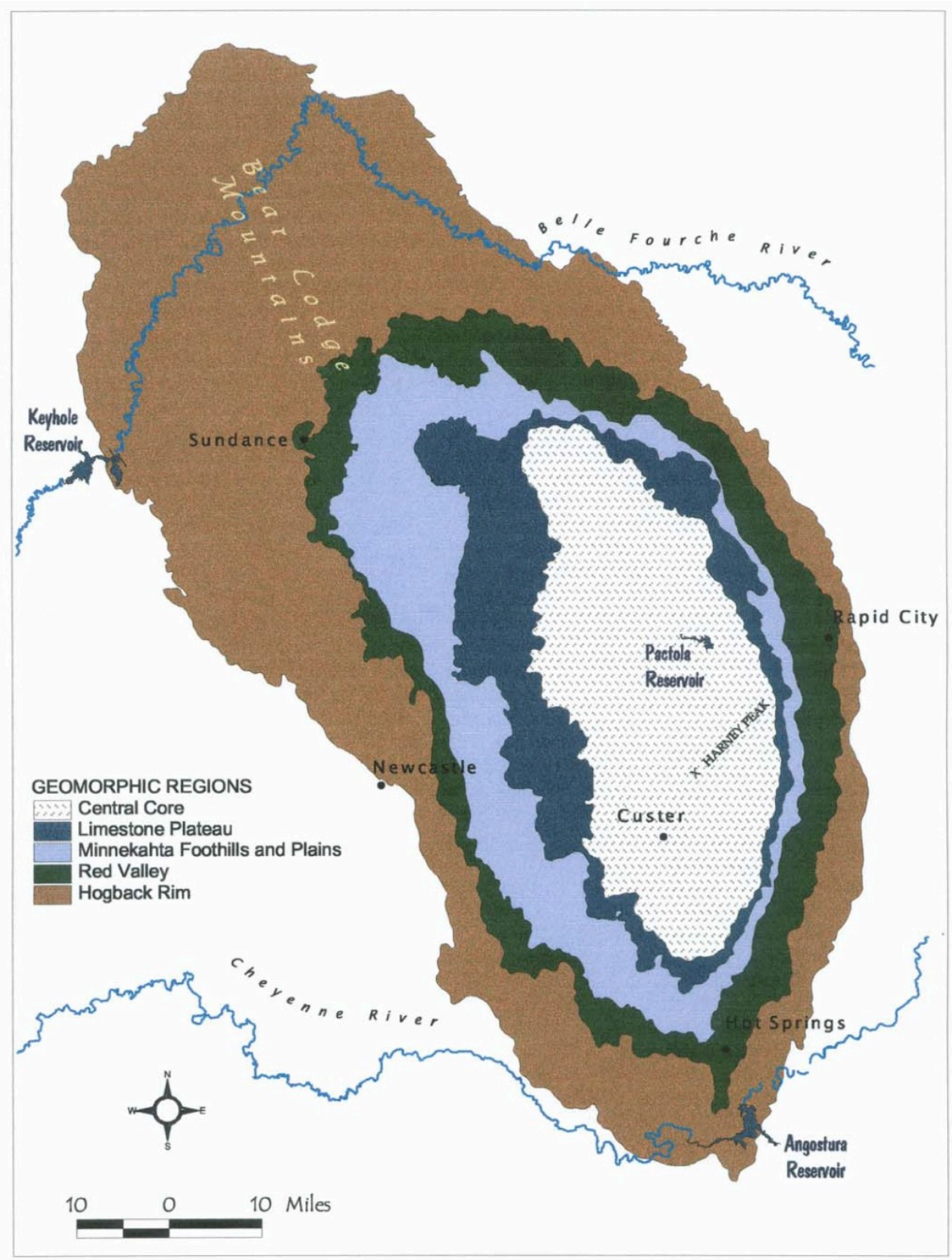


Figure 2. "Bird's eye view of the Black Hills to illustrate the geological structure" (Newton and Jenney 1880).

The conspicuous concentric geomorphology of the Black Hills is reflected in local names: the Granite, the Limestone, the Racetrack and the Hogback. These features were more formally described by Darton and Paige (1925) and Froiland (1990) (Figure 3). In the high Central Core are Precambrian granites and metamorphic rocks, the core of the uplift. These are surrounded by the Paleozoic Pahasapa limestone. To the west of the Central Core, Pahasapa strata dip gently and form a broad area of rolling topography called the Limestone Plateau. Elevations drop sharply from the Limestone Plateau through the Minnelusa Foothills to the Red Valley or Racetrack, underlain by the easily-eroded Spearfish Formation (Mesozoic). Beyond, the Mesozoic sandstone and shale formations of the Hogback Rim make up the outer part of the uplift.

Figure 3. Geomorphic regions of the Black Hills (modified from Marriott et al. 1999, after Froiland 1990).



Much of the Black Hills is forested with ponderosa pine, and they appear as a black hummocky ridge above the surrounding grasslands, hence the name. Grasslands are a significant component of the vegetation as well. At lower elevations, they are dominated by species of the Great Plains, including little bluestem, needle and thread, blue grama, western wheatgrass and green needlegrass[1]. At higher elevations, they include distinctive combinations of grasses and forbs that differ from Great Plains grasslands. High-elevation grasslands are best developed on the Limestone Plateau, but there also are several very large ones just east of the Plateau near Deerfield Lake, on sites underlain by Precambrian schists and slates.

Early Descriptions of Black Hills Montane Grasslands

Lt. Col. George A. Custer provided an early glimpse of the mountain meadows of the high Black Hills, during his expedition of 1874:

> "Every step of our march that day was amid flowers of the most exquisite colors and perfume ... it was a strange sight to glance back at the advancing columns of cavalry, and behold the men with beautiful bouquets in their hands, while the head-gear of the horses was decorated with wreaths of flowers fit to crown a queen of May. Deeming it a most fitting appellation, I named this Floral Valley ... Professor Donaldson, the botanist of the expedition, estimated the number of flowers in bloom in Floral Valley at 50, while an equal number of varieties had bloomed, or were yet to bloom. The number of trees, shrubs, and grasses was estimated at 25, making the total flora of the valley embrace 125 species." (Custer 1875)

In a letter to the editor of the *St. Paul Pioneer*, Donaldson noted:

> "Everybody was making bouquets. All sorts of interjections were used to express wonder and admiration. Some said they would give a hundred dollars just to have their wives see the floral richness for even one hour." (Donaldson 1875)

Donaldson and expedition geologist N.H. Winchell compiled a list of trees, shrubs and other plants for the final report (Ludlow 1875), but they did not note which species were found in mountain meadows.

In 1892, botanist P. A. Rydberg was commissioned by the US Department of Agriculture to investigate the flora of the Black Hills. In late July he traveled to the "Limestone District" northwest of Custer, where he too was taken by the lush mountain meadows and impressive floral displays:

> "The plateau is 1,800 to 2,000 meters high, the highest point, Crooks Tower, being, next to Harney Peak, the highest in the hills. [Later survey established nearby

[1] In this report, common names are used for plants in most cases (USDA NRCS 2012). For scientific names, see Appendix A.

> Odakota Mountain as higher at 7198 ft, just 46 ft short of the summit of Harney Peak.] The surface is made up of pine-covered ridges running north and south. The valleys between these ridges are composed of excellent hay land. The region resembles much some parts of Sweden [Rydberg's homeland]. The pine-covered hills were here, so also the meadows with the knee-deep grass, and the flowers were in greater profusion and greater variety of color than I have seen elsewhere in America. The Swedish species were seldom present, but they had their counterparts ..." (Rydberg 1896)

Rydberg prepared a list of forbs and shrubs of the Limestone District. He also compiled a "Catalogue of Species" for the entire study area. Though some collection location information was provided for each species, it is not possible to assign any specifically to mountain meadows on the Limestone Plateau.

The first to describe mountain meadows in detail was H. E. Hayward (1928). He developed a vegetation classification for the Black Hills following contemporary concepts of succession (e.g. Clements 1916). High-elevation "upland meadows" were considered preclimax or developmental stages leading to willow and aspen and finally to montane forest. Hayward found the best examples of upland meadows in the northwest part of the Limestone Plateau, where he had three study sites: one mile east of Hardy Ranger Station on US Highway 85; near Crooks Tower "5 miles south of Mountain View Ranch"; and at the head of Castle Creek "12 miles west of Deerfield". Like Custer and Rydberg, Hayward wrote glowing descriptions of the meadows:

> "The finest examples of the upland meadow are located in the northwest portion of the Limestone District. Here they reach their highest development, and exhibit the most luxuriant growth of meadow grasses and herbs to be found anywhere in the Hills. ... These two factors [precipitation and elevation] operate together to supply sufficient moisture for the development of an abundant meadow flora. This reaches its most brilliant aspect in late June and early July, when the meadows are very colorful."

Hayward's list of plant species from upland meadows is included in Appendix B. He noted the "continued grazing and haying", which he felt helped maintain meadows by preventing seedling establishment and forest invasion.

McIntosh, in his treatments of the Black Hills flora and vegetation (1930, 1931), generally followed Hayward's vegetation classification. However, he recognized two variants of mountain meadows: lower meadows commonly dominated by timothy; and well-drained slopes with spear-grasses (today's needlegrasses) and dropseed "most conspicuous". He described the meadows as "brilliant with a riot of color" in July and August, when the dominant grasses were "temporarily obscured by an avalanche of showy flowered species". McIntosh expanded the list of known mountain meadow species, largely with additions from drier well-drained slope habitat (Appendix B).

Recent Surveys of Black Hills Montane Grasslands

After the early work of Hayward and McIntosh, montane grasslands in the Black Hills received little attention for almost 70 years. In the early 1990s, several grasslands on the Limestone Plateau were included in a riparian vegetation survey on Black Hills National Forest (Girard ca. 1991), but data analysis produced no types restricted to higher elevations, and there were no stands similar to the meadows described by Hayward and McIntosh.

In the preliminary vegetation classification for the Black Hills Community Inventory (Marriott et al. 1999, Marriott and Faber-Langendoen 2000), the mountain meadow descriptions of Hayward and McIntosh were the basis for *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* (prairie dropseed - Richardson's needlegrass - timber oatgrass) Herbaceous Vegetation, or Black Hills montane grasslands. In 1998, a week of reconnaissance focused on potential habitat for montane grasslands on the Limestone Plateau. Most stands visited were dominated by timothy, or a mix of timothy and non-native clovers. However, some were found to contain both non-natives and the mountain meadow species reported by Hayward and McIntosh.

In 1999, the South Dakota Department of Game, Fish and Parks (SDGFP) funded additional survey for Black Hills montane grasslands in South Dakota. Of the 76 sites visited in 1998 and 1999, only 26 were considered of sufficient quality for detailed survey, and only seven of these were considered high quality (Marriott 2000). It was clear that Black Hills montane grasslands were of conservation concern, due to highly-restricted global range, significant habitat loss in the past, continued habitat loss, and low level of protection afforded remaining stands.

Methods

The State of South Dakota has taken a habitat approach to managing wildlife: "If most of the historical plant communities still exist in the state in sufficient acreage and quality, the needs of the majority of wildlife species should be met" (SDGFP 2006). Black Hills montane grasslands are among the rarest plant communities. The extent of the type has shrunk significantly with human settlement, due mainly to conversion to non-native species. The current project was undertaken to find, characterize, evaluate and map remaining native montane grasslands. Specific objectives included:

1. Digitally map high-quality Black Hills montane grasslands; construct a montane grassland GIS layer in cooperation with public agencies;
2. Provide photos of survey sites from relocatable points;
3. Thoroughly characterize the Black Hills montane grassland vegetation type;
4. Develop a field key to the type;
5. Share information through national databases and publication in an academic journal.

Study Area

The study area is located in the western Black Hills, mainly on the Limestone Plateau (included in Figure 1). Most survey sites were above 6000 ft elevation, shown to be the lower limit of montane grassland habitat in earlier work. The South Dakota - Wyoming state line bounds the area on the west. The large upland grasslands in the vicinity of Deerfield Lake -- Reynolds, Slate and Gillette Prairies -- were included also. These are underlain by Precambrian metamorphic rocks, mainly slate and schist.

Survey Site Selection

A database of grassland sites from previous work (Marriott 2000) was imported into a database for the current project. Additional candidates were selected from online aerial photography: ArcGIS Map Viewer (ESRI 2012), Google Earth, and The National Map Viewer (USGS 2012). Black Hills National Forest staff provided information for several sites. Grasslands smaller than 5 ha (12 ac) were not considered. Small patches lack variability, are subject to conversion to adjacent community types, and are susceptible to invasion from any adjacent weedy edges (Marriott et al. 1999). We did not survey burned slopes with grassy seral vegetation transitional to ponderosa pine, common within the perimeter of the 2000 Jasper fire. Large wet meadows were excluded also.

The resulting list contained almost a hundred candidate sites. Highest priority were grasslands identified as high-quality in earlier work, grasslands where condition was unclear in earlier visits, and new sites. Stands previously assigned a condition rank of C (50-84% native cover) were revisited where time and proximity allowed. Stands previously assigned a rank of D (<50% native cover), were revisited only when convenient.

Ecological Integrity Assessment (Grassland Quality)

In earlier work, Black Hills montane grasslands were evaluated using the EORANK (element occurrence rank) methodology of the Natural Heritage Program network, a mix of qualitative and semi-quantitative criteria (Marriott et al. 1999). Each was assigned ranks for condition, size, landscape context and overall quality. In the current project, we evaluated grasslands using the ecological integrity assessment (EIA) framework of NatureServe (Faber-Langendoen et al. 2009). This protocol is consistent with earlier projects, but uses explicit metrics and criteria developed specifically for Black Hills montane grasslands (Table 1), resulting in greater consistency, both for a single worker and among workers, as well as greater transparency.

Table 1. Ecological integrity (EIA) metrics for Black Hills montane grasslands.

CONDITION		**Assessment level**
Relative cover native species	% overall cover contributed by native plants	Level 2 (field)
Cover exotic invasive species	% cover of non-natives considered invasive	Level 2 (field)
Native increaser species	native species in concentrations beyond natural range of variation	Level 2 (field)
Soil surface condition	% area with bare soil or old disturbances visible as altered vegetation; due to human activities, including livestock	Level 2 (field)
SIZE		
Absolute size	current size (area) of the occurrence or stand	Level 1 (aerial photos in GIS)
LANDSCAPE CONTEXT		
Landscape connectivity	percent unaltered (natural) habitat within specified landscape area (1000 ha, 2471 ac)	Level 1 (aerial photos in GIS), some Level 2 (field)

Ranks for each of the six metrics ranged from A (highest) to D (Tables 2 and 3). Criteria for absolute size and landscape connectivity criteria were straightforward, based largely on measurable quantities. Criteria for ranking condition required more thought. Categories and criteria had to cover the range of variation we expected to encounter, and be doable -- within the scope of human discrimination. Knowledge from previous work provided a substantial advantage over starting from scratch. Condition metrics were tested during the first week of fieldwork, and some criteria were modified to better represent range of variation.

Table 2. Ranks and criteria for EIA Level 1 metrics for Black Hills montane grasslands.

Metric	A	B	C	D
Absolute Size	> 100 ha (247 ac)	25-100 ha (62-247 ac)	5 - 24 ha (12-59 ac)	< 5 ha (12 ac)
Landscape Connectivity (across 1000 ha, 2471 ac)	> 90% of assessment area is intact	60 - 90% of assessment area is intact.	20 - 59% of assessment area is intact.	< 20% of assessment area is intact.

Table 3. Ranks and criteria for EIA Level 2 metrics for Black Hills montane grasslands.

Metric	A	A-	B	C	D
Relative Cover Native Species	Native spp >99% relative cover.	Native spp 95-99% relative cover.	Native spp 85-94% relative cover.	Native spp 50-84% relative cover.	Native spp <50% relative cover.
Cover Exotic Invasive Species	Exotic invasive spp <1% absolute cover.		Exotic invasive spp 1-2% absolute cover.	Exotic invasive spp 2-10% absolute cover.	Exotic invasive spp >10% absolute cover.
Native Increaser Species	Concentrations of increasers absent or <10% of stand area		Concentrations of increasers occupy 10%-25% of stand area.	Concentrations of increasers occupy 25-50% of stand area.	Concentrations of increasers occupy >50% of stand area.
Soil Surface Condition [Natural disturbances at natural densities not included in total.]	<1 % of area with bare soil or old disturbances visible as altered vegetation; due to human activities, including livestock.		1-10 % of area with bare soil or old disturbances visible as altered vegetation; due to human activities, including livestock.	10-25 % of area with bare soil or old disturbances visible as altered vegetation; due to human activities, including livestock.	>25 % of area with bare soil or old disturbances visible as altered vegetation; due to human activities, including livestock.

NOTE: Kentucky bluegrass, *Poa pratensis*, is widely-naturalized in the Black Hills and elsewhere in western North America. It was not treated as non-native in EIA, but was counted as a native increaser species in some situations.

Condition

Grassland condition metrics were assessed in the field. We also assigned a tentative overall condition rank to incorporate professional judgement where needed. After the field season, ranks for the individual condition metrics were combined using a point-based formula to produce overall condition ranks (Table 4). Native cover was heavily weighted, as native stands are rare. Grasslands ranked D for native cover received an overall rank of D automatically. For grasslands surveyed in earlier work but not revisited during this project, the original condition rank was used as overall condition rank in EIA.

Table 4. Formulas for calculating overall ranks from ranks for individual metrics.

Points for ranks: A 5; A- 4.375; B 3.75; C 2.5; D 1.25
Scores for overall ranks: A = 4.4 – 5, B = 3.1 – 4.3, C = 1.9 – 3.1, D < 1.9

Overall Condition	(8*native cover + exotic invasives + native increasers + soil surface condit.)/11
Example -- Gillette Canyon, Upper	Native cover A, exotic invasives A, native increasers A, soil surface condition B. ((8 x 5) + 5 + 5 + 3.75)/11 = 4.89, for an overall condition rank of A.
Overall Rank	(8*overall condition + absolute size + landscape connectivity)/10
Example -- Smith Draw South	Overall condition A, absolute size B, landscape connectivity B. ((8 x 5) + 3.75 + 3.75)/10 = 4.75, for an overall rank of A.

Absolute size

Grassland size was measured in ArcGIS 9.3.1 Desktop from 2010 NAIP imagery. In ranking size, we assume bigger is better. Larger stands are better buffered from adjacent disturbance, and are more likely to maintain species composition and natural processes if some part were disturbed. However, we don't know the point beyond which increased size has minimal effect on viability. For this reason, absolute size was subordinate to condition in calculating overall ecological integrity (quality).

Another confounding factor in size assessment is the fact that many of the grasslands on the Limestone Plateau continue across divides into adjacent drainages. These networks could be considered giant grasslands, but this would be problematic for survey and management. We subdivided these most commonly based on differences in ownership and quality.

Landscape connectivity

Landscape connectivity was assessed for the 1000 ha (2471 ac) surrounding a montane grassland. The most common down-ranking factors were roads, buildings, livestock facilities, hay fields and cultivated land. Categories for the landscape connectivity metric are broad and easy to apply to public lands the Black Hills, where the much of the landscape is intact but utilized to some extent.

Overall ecological integrity (quality) ranks

Ranks for absolute size, landscape connectivity and overall condition were combined using a point-based system to produce an overall rank for each grassland (Table 4, above). Condition rank was heavily weighted due to rarity of native stands, and overall rank reflects the condition rank of a grassland in most cases.

Black Hills Montane Grassland Scorecard

Black Hills National Forest staff requested a scorecard for identifying Black Hills montane grassland vegetation in the field. A draft scorecard was developed, and was tested before the field season with plot data from earlier projects (Appendix C). During fieldwork, we tested it on montane grasslands representing a range of conditions.

Field Survey

Survey began July 27 and continued through September 12, 2011. This time period was chosen to be consistent with earlier projects, and worked well for the most part. During the first surveys, one of the diagnostic grass species, prairie dropseed, was just beginning to bloom at some sites. By the end of fieldwork, grasses still were identifiable

but the forb component was more difficult to characterize. Because sites were visited in order of priority, all higher-quality grasslands had been surveyed before late season.

Field forms were designed to collect information tracked by NatureServe and the South Dakota Natural Heritage Program, including site location and description, montane grassland description and condition, human use of the site, and boundary information for mapping. Blank forms are included in Appendix D. The field crew worked together during the first week to "calibrate" grassland characterization and assessment, and to test condition metrics.

We evaluated grassland condition metrics at all sites visited. Stands ranked D for native cover (<50%) were not surveyed further. Other stands were walked until condition metrics could be assessed. High-quality stands (>85% native cover) were walked in their entirety for mapping purposes. Observations, documented with GPS, were noted for the site, habitat, vegetation, the montane grassland, human use, disturbances and boundaries. All survey forms were then completed for the site.

In-depth surveys were limited to public land, under management by Black Hills National Forest or the State of South Dakota. Privately-owned grasslands were observed from roadsides and adjacent public lands to better assess overall status of the type. Any high-quality grasslands were to be surveyed if permission could be obtained from landowners, but none qualified.

We took photos of representative areas in high-quality grasslands, and in examples of lower-quality stands. These were provided to SDGFP as jpeg files. Photo points were documented with GPS, and locations are included in the Observation Points GIS layer.

Information Management

After the field season, most of the information in field forms was entered into the project database. Records were exported to an Excel spreadsheet to accompany GIS layers. Raw observation data remain in hardcopy form. All field forms were photocopied and provided to SDGFP.

A digital map of Black Hills montane grasslands in South Dakota was created in ArcGIS 9.3.1 Desktop. Grassland boundaries were heads-up digitized from 2010 NAIP imagery at a scale of 1:5000. Observation and photo point locations were imported from GPS units into a separate layer.

Quantitative Data Analysis

Quantitative data were collected from high-quality grasslands not sampled in earlier work, following methodology used in the Black Hills Community Inventory (Marriott et al. 1999) and in earlier surveys of Black Hills montane grasslands (Marriott 2000).

Plots were 10 x 10 m in size. Environmental data collected included elevation, slope, aspect, soil moisture, and non-vegetative cover. Canopy cover was estimated both for strata and for all species present. A blank plot form is included in Appendix D.

Plots from this project and earlier work were combined with the grassland data set from the Black Hills Community Inventory (Marriott and Faber-Langendoen 2000) and analyzed in the PC-ORD software package to clarify circumscription of the montane grassland vegetation type and its relationship to other grassland and shrubland types. Plot data also were summarized in table form. The stand summary table is included in Appendix E.

Results

Of the roughly one hundred candidate sites initially identified, 63 were visited during the 2011 field season. All sites known to have higher-quality grasslands were surveyed, as were those where condition could not be assessed in prior surveys. Most sites newly-identified in 2011 were visited. Two could not be accessed due to logging; these probably are poor quality as they are in areas where montane grassland habitat is dominated by non-native grasses. After all high-priority sites had been surveyed, we revisited 40 sites identified as lower quality in earlier work. Thirty-five low-quality grasslands surveyed in previous projects were not revisited in 2011, but are included in the project database and digital map.

Surveys in 2011, combined with results from earlier projects, provide a comprehensive view of Black Hills montane grasslands in South Dakota (the Wyoming portion of the Black Hills will be surveyed in 2012). Native montane grasslands are rare, and are found in dry drainages in the southern part of the Limestone Plateau. All are *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* (prairie dropseed - Richardson's needlegrass - timber oatgrass) Herbaceous Vegetation, similar to the well-drained slope mountain meadow vegetation described by McIntosh (1930, 1931). The majority of the grasslands surveyed have a large component of non-native species, most commonly timothy and smooth brome. These hay grasses dominate many meadows in the northern Black Hills.

At lowest elevations in the southern part of the study area, grasslands are a mix of Black Hills montane grassland species and those of lower elevations. In the large prairies just east of the Limestone Plateau near Deerfield Lake, montane grassland occurs as small patches in a mosaic of grassland types.

Vegetation Description

We found little variation in composition and structure of native montane grasslands; all fit the concept of *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* Herbaceous Vegetation as described in earlier projects (Marriott and Faber-Langendoen 2000, Marriott 2000). This type is very similar to the well-drained slope mountain meadow vegetation described by McIntosh (1930, 1931).

Herbaceous cover in Black Hills montane grasslands typically is 75-100%, but may be less in drier habitat. In more mesic habitat, especially in drainage bottoms, cover often reaches 100%. Common and diagnostic grasses include prairie dropseed, Richardson's needlegrass, timber oatgrass and shortbristle needle and thread. Subsecund slender wheatgrass and Porter brome often are present but less abundant. Kentucky bluegrass and green needlegrass are common, but are not diagnostic of the type, and they are frequent components of other grassland types in the Black Hills.

Black Hills montane grasslands are dominated by graminoids, but are forb-rich. The ratio of graminoid cover to forb cover ranged from 4:1 to 2:1 in grasslands surveyed. The forb component is diverse; stands often contain more than 30 species. Total forb richness for plots done in montane grasslands is 82 species (see stand summary table in Appendix E).

Figure 4. Black Hills montane grassland in upper part of Gillette Canyon. This stand had more grass cover than others surveyed, but forb diversity was high as well. Standing dead ponderosa pines in the distance burned in the 2000 Jasper fire.

Forb cover can increase with grazing or other disturbance that favors certain native species ("native increasers"), and the large forb component in some grasslands may be due in part to disturbance. While the natural range of variation in forb cover is not known precisely, the earliest reports were clear that these mountain meadows were rich in wildflowers (e.g. Custer 1875, Donaldson 1875, Rydberg 1896).

Figure 5. Large Black Hills montane grassland in the broad upper part of Redbird Canyon, at the Sixmile Road (Forest Service 301).

Shrub cover is significant in some montane grasslands, contributed by wolfberry and shrubby cinquefoil. The former appears to be more common in drainage bottoms, the latter on lower slopes in the central west and southwest parts of the study area. Both can increase with heavy grazing.

McIntosh (1930, 1931) recognized two types of mountain meadow vegetation -- lower meadows dominated by hay grasses, and drier well-drained slopes dominated by dropseed and spear-grasses (today's needlegrasses). We found this situation repeatedly in the central and northern parts of the study area. Bottoms were dominated by timothy or smooth brome, with patches of native grassland in drier habitat such as slopes or rockier sites. Native patches are smaller and less common going north in the study area, with hay grasses more abundant.

In meadows in the drier southern part of the Limestone Plateau, there aren't such obvious differences between drainage bottoms and slopes. Species of McIntosh's well-drained slopes occur across sites, though abundance may vary. For example, prairie dropseed tends to be more common in drier habitat; Kentucky bluegrass and green needlegrass often are more abundant in mesic bottoms.

At lowest elevations in the southern part of the study area, grasslands are a mix of Black Hills montane grassland species and those of lower elevations, such as green needlegrass and western wheatgrass. The large grasslands of Reynolds, Slate and Gillette Prairies in the central eastern part of the study area are mosaics of grassland types, with western wheatgrass / needle-and-thread mixed-grass prairie most common, and smaller patches of Black Hills montane grassland and little bluestem (Figure 6).

Figure 6. Grasslands of Reynolds Prairie, looking east from Flag Mountain.

Quantitative analysis

Quantitative analysis confirmed the distinctiveness of Black Hills montane grasslands. Montane grassland samples (plots) clustered together based on species composition, clearly distinct from other types (Figures 7 and 8).

Figure 7. Results of cluster analysis of Black Hills grassland and shrubland plots (Marriott et al. 2012).

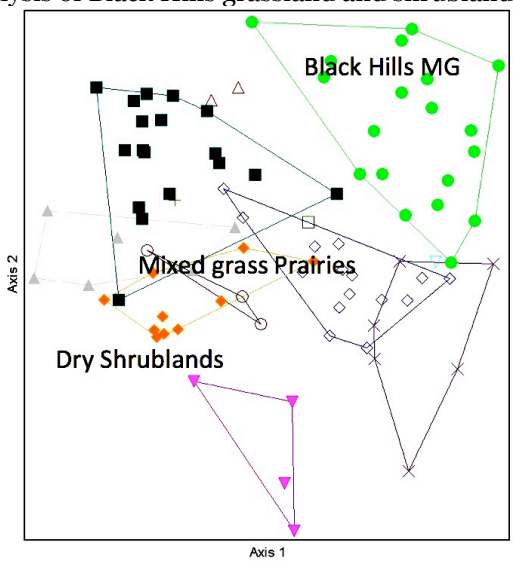
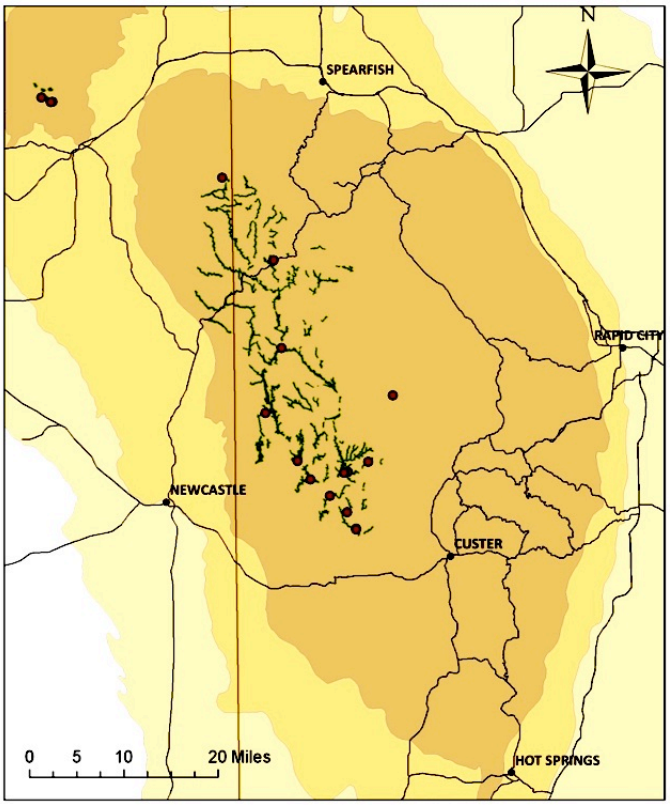


Figure 8. Black Hills montane grassland plot locations (dots). Dark green areas are surveyed montane grasslands (Marriott et al. 2012).



Black Hills montane grassland scorecard

The scorecard for Black Hills montane grasslands (Appendix C) consistently verified known stands -- not surprising given the consistency of species composition of the type. It received only limited testing in other grassland types, and potential for false positives is not known. We will continue to test the scorecard during the 2012 field season.

Environmental Setting

Surveys in 2011 confirmed that Black Hills montane grasslands in South Dakota are restricted to elevations above 6000 ft; the highest documented site is at 6900 ft. (Montane grasslands have been documented as low as 5100 ft in the Black Hills in Wyoming.) Snow usually accumulates through the winter in these areas, in contrast with lower elevations where snow cover is intermittent (Froiland 1990).

In South Dakota, Black Hills montane grasslands occupy dry drainage bottoms and adjacent slopes on sites underlain by the Pahasapa limestone of the Limestone Plateau. The largest are found in areas of rolling topography, often at the heads of drainages and on intervening divides (Figure 9). Montane grasslands also occupy narrower winding canyons, especially where drainages leave the Limestone Plateau. In these situations, grasslands often are intermittent with ponderosa pine woodland, quaking aspen forest and wolfberry shrubland.

Figure 9. Large Black Hills montane grasslands on rolling topography of the Limestone Plateau near junction of Sixmile and Boles Canyon roads; scale bar is 0.4 mi (from ArcGIS online, ESRI 2012).

Distribution

Most Black Hills montane grasslands are located on the Limestone Plateau, at elevations above 6000 ft (see maps in Figure 10). On the northwest Limestone Plateau in Wyoming, stands have been documented as low as 5100 ft. Two disjunct occurrences are known from sites underlain by igneous rocks, at Cement Ridge and Warren Peaks in the Wyoming Black Hills (Marriott and Faber-Langendoen 2000).

Black Hills montane grassland vegetation is not found outside the Black Hills. The type is ranked G1S1 in South Dakota and Wyoming, rare both globally, and at the state level due to rarity of native stands (NatureServe 2012).

Land Use

The mountain meadows of the Limestone Plateau have attracted humans since the first days of settlement, in spite of long winters and the frequent scarcity of water. Quite a few are privately owned; others are managed by Black Hills National Forest, or the State of South Dakota in a few cases. Montane grasslands continue to be the focus of human activities, some of which have increased dramatically in recent years.

Many of the grasslands are grazed and have some form of water development -- stock dams to catch intermittent water flow and stock tanks supplied by wells or hauled water. Many are cut for hay, especially on private land.

Most montane grasslands are traversed by roads, including old overgrown two-tracks, dirt roads, gravel roads, and paved roads in a few cases. Recreational off-road vehicle use is very popular on the Limestone Plateau, and now is intensively managed by Black Hills National Forest. Riders are required to stay on designated roads and trails. Snowmobiling is equally popular in winter.

There have been scattered residences in the meadows of the Limestone Plateau since the early days of settlement, usually associated with ranching. Recently, subdivision of privately-owned montane grasslands and construction of recreational and second homes have increased dramatically.

Figure 10. Maps of surveyed Black Hills montane grasslands in South Dakota, color-coded by overall rank. Pale blue polygons (NA) contain other grassland types. Maps are ordered north to south.

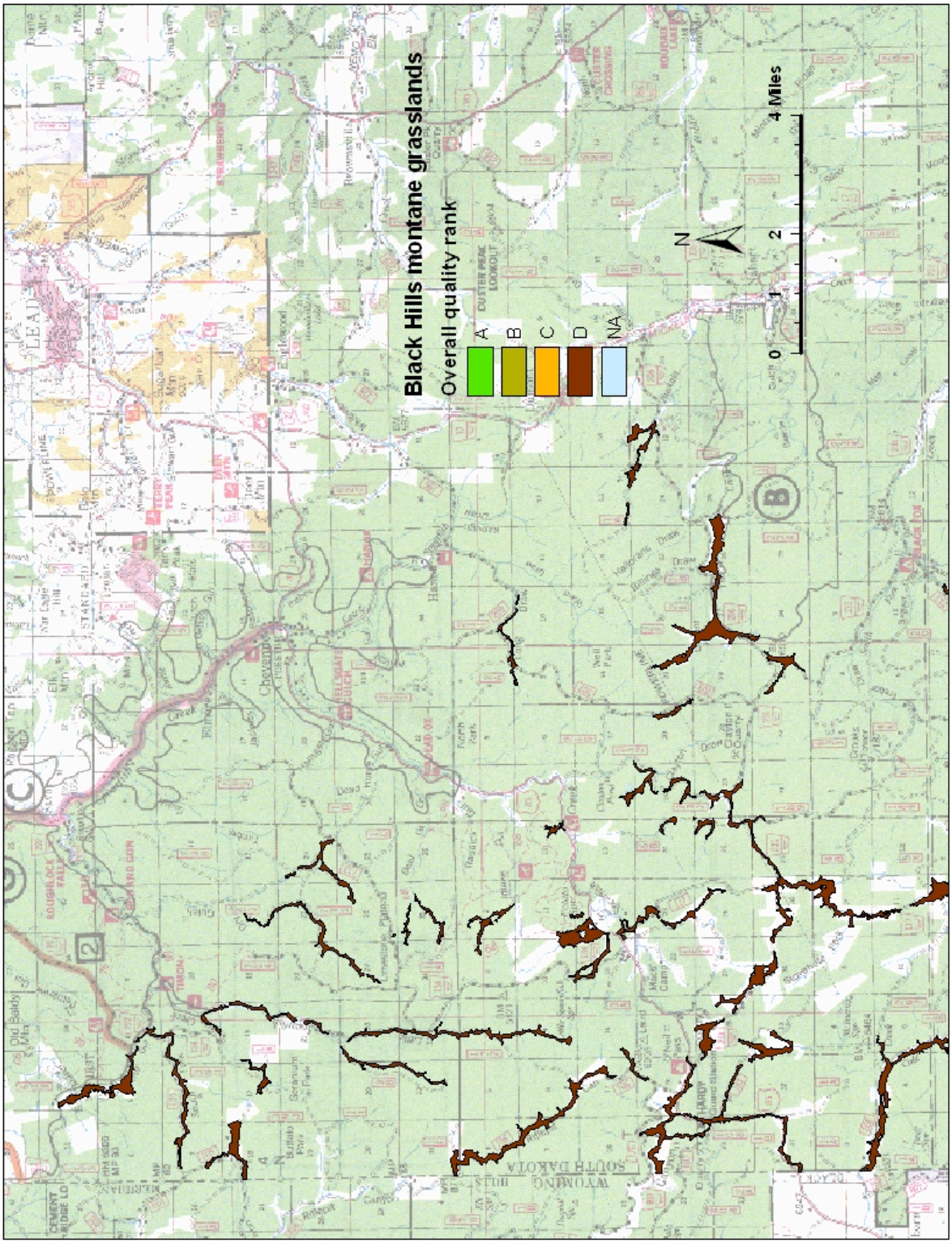


Figure 10, continued. Maps of surveyed Black Hills montane grasslands in South Dakota, color-coded by overall rank. Pale blue polygons (NA) contain other grassland types.

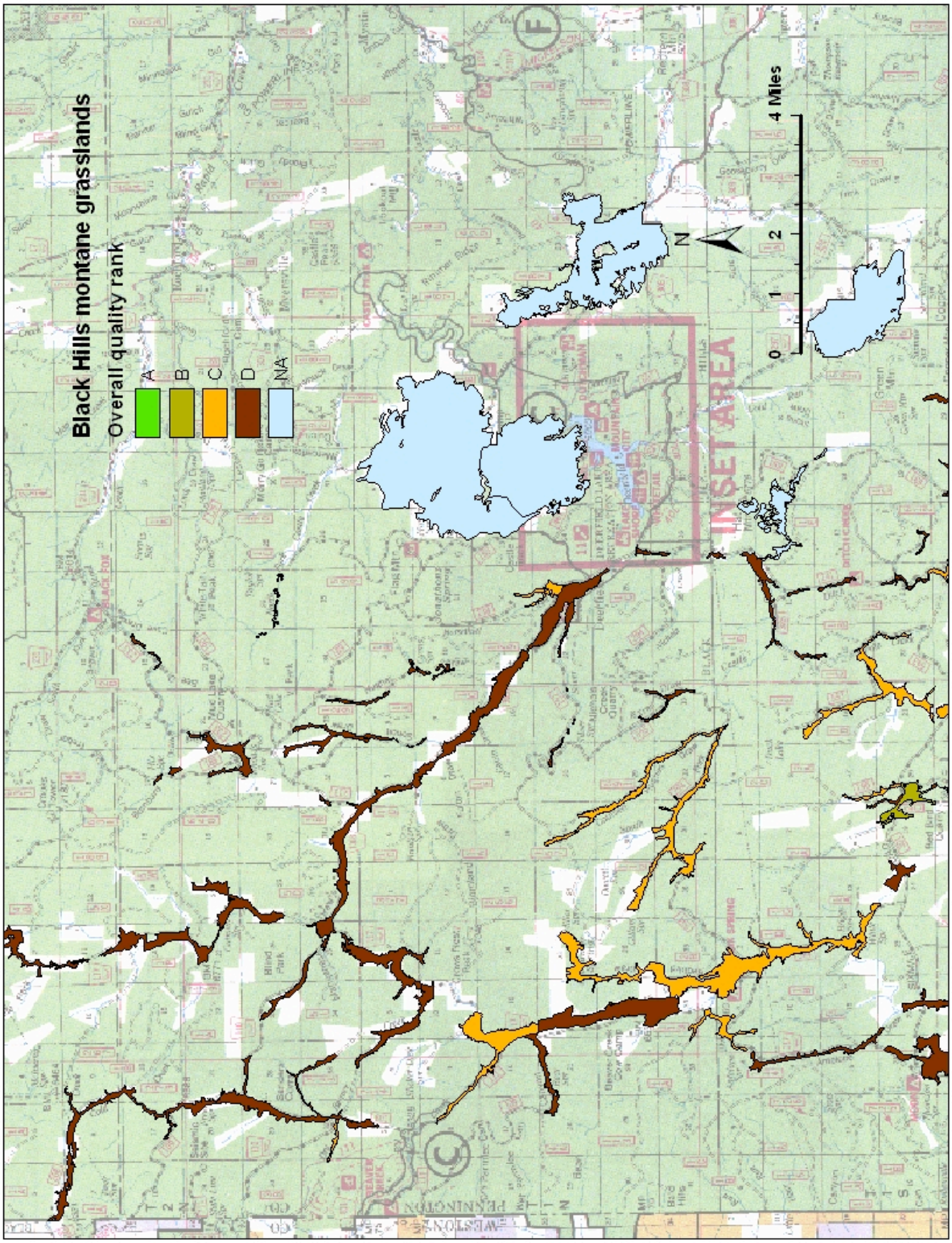
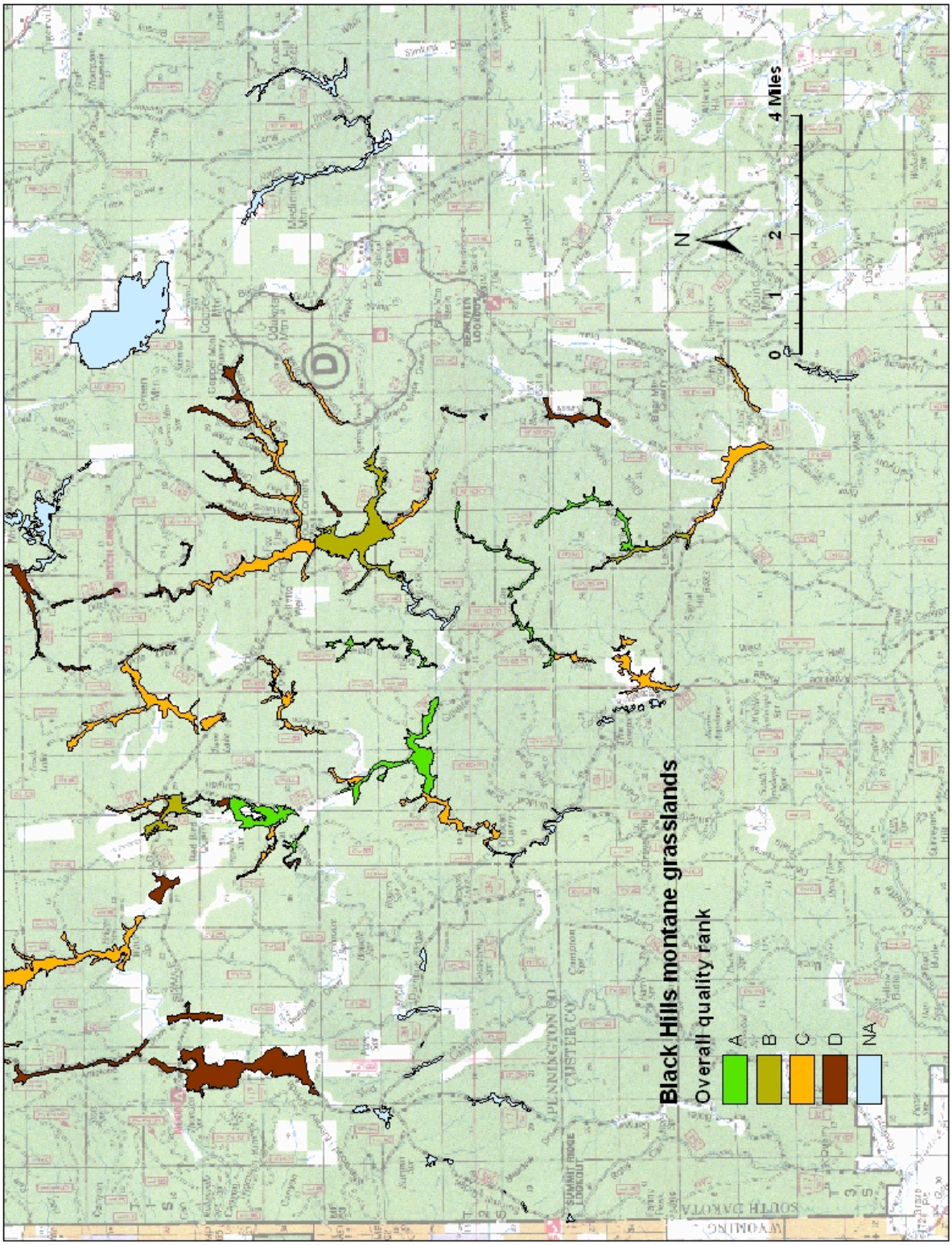


Figure 10, continued. Maps of surveyed Black Hills montane grasslands in South Dakota, color-coded by overall rank. Pale blue polygons (NA) contain other grassland types.



Ecological Integrity (Grassland Quality)

Of the 78 Black Hills montane grasslands assessed in 2011 and earlier projects, only eight are considered high-quality, i.e. with an overall rank of A or B (Table 5). These grasslands are composed largely of native species. The rest are a mix of natives and non-natives, or are heavily-dominated by non-natives. There is a distinct geographic pattern to grassland quality (see maps in Figure 10). Montane grasslands strongly dominated by native grasses are found only in the southern quarter of the study area, roughly south of the Sixmile Road (Forest Service Road 301). From the Sixmile Road north to Castle Creek, non-native hay grasses are more common and sometimes dominant. Further north, they are abundant in most meadow bottoms.

Table 5. Numbers and areas of surveyed Black Hills montane grasslands, by overall quality rank.

Overall Rank	# Grassland Sites	Area, ha (ac)	% of habitat surveyed
A	5	289.5 (715.4)	6.3
B	3	259.3 (640.7)	5.6
C	20	1274.9 (3150.3)	27.7
D	50	2776 (6859.7)	60.4
(total)	78	4599.5 (11,365.6)	

Eight Black Hills montane grasslands received an overall rank of A or B (Tables 5 and 6); taken together, they represent less than 12% of montane grassland habitat surveyed and mapped. All are located in the southern quarter of the study area (see maps in Figure 10). Species composition is largely native. Down-ranking factors include surface disturbance and concentrations of native increaser species.

Table 6. Highly-ranked Black Hills montane grasslands.

Site Name	Overall Rank	EIA Summary
Gillette Canyon, Upper	A	Mostly native species; indicator grasses common; graminoids dominant, with good forb diversity. Some limited areas of native increaser species.
Smith Draw South	A	Dominated by montane grassland indicator species with appropriate forb diversity. Only small patches of non-natives. No significant concentrations of native increaser species.
Lemming Draw, Upper	A	Large continuous areas of native grassland with indicator species well-represented. Non-natives present but not a significant component. No significant concentrations of native increaser species.
Redbird Canyon South	A	Large continuous areas of native grassland with indicator species well-represented. Non-natives present locally but not enough to down-rank. Some concentrations of native increaser species, restricted to old disturbances.
West Hell Canyon, Upper	A	Most areas with good coverage of native grassland; some with more non-natives, but natives dominant. Limited presence of native increaser species.
Gillette Canyon Headwaters	B	Large continuous areas of native grassland with indicator species well-represented. Non-natives present locally. Local concentrations of native increaser species, especially on old disturbances.
Redbird Canyon at Sixmile	B	Large continuous areas of native grassland with indicator species well-represented. Non-natives present locally. Some areas with concentrations of native increaser species.
Lemming Draw, Lower	B	Native grassland with few non-natives. Old surface disturbances and concentrations of native increaser species are down-ranking factors.

The highest-ranking Black Hills montane grasslands were found in drainages with limited or no water development for livestock. Grazing doesn't necessarily alter grassland composition significantly; many of the native grasslands were grazed at the time of survey, or had been in the past. However, water development concentrates use, and can lead to local dominance by less-palatable non-native and native species. Increased soil surface disturbance can open habitat for invasive plants.

Twenty grasslands received overall ranks of C, representing 28% of montane grassland habitat surveyed and mapped. Most of these have a mix of natives and non-natives. Condition often is coarsely patchy, with some areas better than others.

Fifty grasslands received overall ranks of D, representing 60% of montane grassland habitat surveyed and mapped. Non-native species, especially hay grasses, are abundant or dominant. If present, native montane grassland plants are uncommon to rare and restricted to small patches of drier habitat. Exotic invasive plants often are present, sometimes in large stands.

Condition metics

Relative cover of native species turned out to be the most important metric in ecological integrity assessment, due to rarity of native stands. Condition ranks and overall ranks for grasslands reflect this metric in most cases. The hay grasses, timothy and smooth brome, are the most common non-native species in Black Hills montane grasslands. Non-native clovers (red, white and possibly alsike) frequently are present and sometimes abundant. Non-native grasses and clovers are most abundant in the northern part of the study area, but they can be locally common or even dominant in stands further south, especially in narrow drainages. A few side drainages dominated by timothy were found even in the large high-quality grasslands of the southern Limestone Plateau.

Exotic invasive species were sporadic in the southern part of the study area, becoming much more common in the northern part. Canada thistle and musk thistle were the most common invasive species.

Native increaser species sometimes were a down-ranking factor in the southern part of the study area, where there is more native grassland. Though natural variation of forb cover in Black Hills montane grasslands is not known precisely, heavy concentrations of just a few forb species clearly are outside the natural range, and indicative of past disturbance. The most commonly observed native increasers were rigid golden rod, western yarrow, tarragon and woolly cinquefoil. In some grasslands, there was heavy cover of wolfberry or shrubby cinquefoil; both are increasers under heavy grazing.

Surface disturbances were found in all grasslands surveyed; none were ranked A for soil surface condition. In a few cases, surface disturbance was sufficient to reduce the overall condition rank. The most common disturbances were roads -- both active with bare soil, and abandoned but still visible due to altered vegetation.

Absolute size

Black Hills montane grasslands surveyed ranged in size from ca 6 to greater than 300 ha (15 to 741 ac). High-quality Black Hills montane grasslands, ranked A or B, ranged in size from 25 to 215 ha (62 to 531 ac). Many of the grasslands on the Limestone Plateau continue across divides into adjacent drainages, and these networks could be considered giant grasslands. We subdivided huge grasslands for various reasons, most commonly differences in ownership and quality.

Landscape connectivity

For most grasslands assessed and for all high-quality ones, landscape connectivity was ranked B, i.e. 60-90% of the surrounding landscape (1000 ha or 2471 ac) intact. No areas received a rank of A, due mainly to the abundance of roads in the Black Hills. Other common human alterations included residences, livestock facilities and mown or cultivated fields.

Discussion

Black Hills montane grassland surveys in 1998, 1999 and 2011 provide a comprehensive view of the type in the South Dakota part of the Black Hills. Native stands are rare, and occur only in the drier southern part of the Limestone Plateau. All are *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* Herbaceous Vegetation, similar to the well-drained slope mountain meadow vegetation of McIntosh (1930, 1931).

McIntosh described a second type of mountain meadow vegetation, found in meadows below the well-drained slopes. Even at that time, these lower meadows often were dominated by timothy. Our surveys provided no insight as to original native composition of the lower meadows. Throughout much of the study area, timothy and smooth brome dominate moister montane grassland habitat. Even in the southern part, stands of timothy often occur in narrow side draws, or in narrower sections of drainages, suggesting that it thrives in more mesic habitat, with native grasslands on drier sites.

The current project has greatly improved our concept of Black Hills montane grassland vegetation with regards to both composition and quality. During the first surveys in 1998, when the existence of montane grasslands was in doubt, we were satisfied to find any grasslands with the mountain meadow species reported by Hayward and McIntosh. Then inventory in 1999 documented higher-quality stands, revealing that many of those surveyed in 1998 were relatively-poor examples. Following this trend, some 1999 quality ranks were changed during the current project, not because grassland quality had changed, but because we now have a better perspective on the type as a whole. This experience emphasizes the importance of "getting to know" a vegetation type and its context before putting a lot of work into characterization and evaluation.

The graminoid indicators of Black Hills montane grassland vegetation are an interesting mix of species, in keeping with the "botanical crossroads" nature of the Black Hills flora (McIntosh 1927, Hayward 1928). Richardson's needlegrass is a northern and Rocky Mountain species, ranging from the Yukon Territory to Washington and Manitoba, and south in the Rocky Mountains as far as western South Dakota and northern Colorado. Timber oatgrass grows from southeastern-most Russia across Canada and south through much of the western US, in habitat ranging from alpine to plains. Shortbristle

needle and thread is a northern grassland species, found across Canada and south in the US only as far as the Black Hills. Prairie dropseed is a grass of lowland and upland prairies mainly in the Midwest, with scattered occurrences as far west as the Black Hills, western Nebraska, central Colorado and northeastern New Mexico (distribution information from Barkworth et al. 2012).

Conservation Status

Black Hills montane grassland vegetation is endemic to the Black Hills, i.e. not found elsewhere. It is rare locally as well. While there is extensive montane grassland habitat on the Limestone Plateau, most stands are partially or largely non-native. Only eight of the 78 Black Hills montane grasslands surveyed in 2011 and previous projects were found to be strongly-dominated by native grasses. Due to limited global distribution and rarity of native stands, Black Hills montane grassland vegetation is ranked G1S1 in South Dakota and Wyoming, "critically imperiled" on a global and local basis (NatureServe 2012).

Management Needs

Given the rarity of native Black Hills montane grasslands, the high-quality stands are obvious conservation targets. All are on public lands and therefore protected from subdivision and residential development. Most are within grazing allotments; notably, the highest ranking were found in drainages with limited or no water development for livestock. While grazing per se doesn't necessarily alter grasslands significantly, water development concentrates use. This can lead to locally-heavy utilization, dominance by less-palatable species, and increased soil surface disturbance that opens habitat for invasive plants.

Twenty of the Black Hills montane grasslands surveyed received overall ranks of C. Condition often is coarsely patchy, and some parts have good native cover. These grasslands may be good candidates for experimental management to improve condition (Table 7).

Table 7. Examples of C-ranked Black Hills montane grasslands with some areas in better condition (more native cover). Comments are from 2011 field forms.

Site	Point within site	Comments
Sawmill Draw	596678E 4863906N (WGS84)	"has a nice but short section that would have made it B if larger"
Ditch Creek, Upper	593161E 4865823N (WGS84)	"drainage bottom is a mosaic of montane grassland with non-natives mixed in and stands of non-natives ... slopes tend to have more natives"
West Hell Canyon, Lower (includes State land - Cooper Ranch)	590442E 4853491N (WGS84)	"In upper part, indicator species present with diverse forbs, but also non-natives and native increasers which become more common going downstream."
Coulsen Hughes Draw	588789E 4871952N (NAD83)	"mix of patches dominated by natives and patches with heavy non-natives. Large patches of dense Phleum pratense in areas, mixed with fairly large patches of predominantly native vegetation"
Cameron Draw	590074E 4863638N (NAD83)	"mosaic of montane grassland, Phleum pratense, and native increaser species. The upstream part is strongly dominated by Phleum pratense ... another instance of more native montane grassland in wider sections of drainage"
Redbird Draw, Upper (includes White Springs)	581686E 4871515N (WGS84)	"mix of natives and non-natives. There are some areas that are mostly native" (Much of this grassland was difficult to assess due to heavy utilization.)

D-ranked montane grasslands are common in the northern Black Hills. Some are heavily-dominated by hay grasses. Others are a mix of native and non-native species. These might be candidates for management to improve condition (Table 8).

Table 8. Examples of D-ranked Black Hills montane grasslands with patches of native grassland species or other vegetation of interest. Comments are from 2011 field forms.

Site	Point within site	Comments
Eagle Cliffs, West	582331E 4897370N (WGS84)	"Small patches of montane grassland on lower slopes; bottoms predominantly non-native grasses, clovers."
Upper Spearfish, Clayton Pond	585682E 4896314N (WGS84)	"On some drier slopes, montane grassland species were found mixed with Phleum pratense (less timothy cover than in bottom)" Includes wet meadow of interest above Clayton Pond.
Trail Draw	589945E 4872691N (NAD83)	"Phleum pratense and Poa pratensis as dominant graminoids, but still with interspersed native Black Hills montane grassland species" (Difficult to assess due to heavy utilization.)

Survey Needs

In 2011, all high-quality Black Hills montane grasslands were surveyed and mapped in detail. Many C-ranked grasslands were surveyed in their entirety to determine overall condition. However, other C-ranked and all D-ranked stands were covered less thoroughly, and boundaries of many were digitized with less confidence. In particular, boundaries between C- and D-ranked grasslands often are estimates only.

Surveys in 1998, 1999 and 2011 focused on on public lands. Privately-owned grasslands were observed from roadsides and adjacent public lands. Any high-quality grasslands were to be surveyed if permission could be obtained from land-owners, but none qualified. However, privately-owned C-ranked grasslands might be of conservation interest and worth surveying if the owner were open to managing for improved condition.

Comprehensive survey of Black Hills montane grasslands has been limited to the South Dakota part of the Black Hills. Reconnaissance in the Wyoming Black Hills in 1998 documented montane grasslands in drainages on the Limestone Plateau, and on two upland sites underlain by igneous rocks -- Cement Ridge and Warren Peaks (Marriott and Faber-Langendoen 2000). A comprehensive survey of Black Hills montane grasslands in Wyoming is being done by the Wyoming Natural Diversity Database, with funding from Black Hills National Forest. Results will be available at the end of 2012.

Additional Work

Upon completion of montane grassland surveys in the Wyoming Black Hills, an article about Black Hills montane grassland vegetation will be prepared for submission to an academic journal. NatureServe's *Ecological Association Comprehensive Report* for the type will be updated, and representative plots will be submitted to *Vegbank*, the vegetation plot database of the Ecological Society of America's Panel on Vegetation Classification (http://vegbank.org/vegbank/index.jsp).

Literature Cited

Barkworth, M.E., K.M. Capels, S.Long, L.K. Anderton, and M.B. Piep (eds.). Poaceae *in* Flora of North America. http://herbarium.usu.edu/webmanual. Accessed 14 July 2012.

Bird, P. 1998. Kinematic history of the Laramide orogeny in latitudes 35°-49°N, western United States. Tectonics 17:780-801.

Clements, F.E. 1916. Plant succession. Carnegie Inst. Washington, Publ. 242.

Custer, G.A. 1875. Expedition to the Black Hills. *in* 43rd Congr 2nd Sess, Ex. Doc. 32.

Darton, N.H., and S. Paige. 1925. Central Black Hills Folio, South Dakota. USGS-219. Washington, DC: US Geol. Folio 1-34.

Donaldson, A.B. 1875. The Black Hills expedition [letter to the editor of the St. Paul Pioneer] *in* South Dakota State Historical Society. 1914. South Dakota historical collections, Volume 7. Available at http://books.google.com/books?id=z98UAAAAYAAJ&dq=donaldson+%22the+black+hills+expedition%22&source=gbs_navlinks_s. Accessed 14 July 2012.

ESRI. 2012. ArcGIS Map Viewer. http://www.arcgis.com/home/index.html Accessed 14 July 2012.

Faber-Langendoen, D., J. Rocchio, E. Byers, P. Comer, T. Foti, S. Gawler, C. Josse , G. Kittel, R. Lyons, S. Menard, E. Muldavin, C. Nordman, M. Schafale, L. Sneddon, L. Vance. 2009 (draft). Assessing the condition of ecosystems to guide conservation and management: an overview of NatureServe's ecological integrity assessment methods. NatureServe, Arlington, VA. + Appendices.

Froiland, S. G. 1990. Natural history of the Black Hills and Badlands. Sioux Falls, SD: Center for Western Studies, Augustana College.

Girard, M. ca. 1991. ECODATA survey of riparian communities of Black Hills National Forest, 1986-1990. Unpublished files, field forms, notes, data analyses and type descriptions. Custer, SD: Black Hills National Forest, Supervisor's Office.

Hayward, H. E. 1928. Studies of plants in the Black Hills of South Dakota. Bot. Gaz. 85:353-412.

Ludlow, W. 1875. Report of a reconnaissance of the Black Hills of Dakota, made in the summer of 1874. Washington, Govt. Printing Office. [Trees and shrubs were identified by expedition geologist N.H. Winchell. Plants collected by expedition botanist A.B. Donaldson were identified by J.M. Coulter.]

McIntosh, A.C. 1927. Some sources of the Black Hills flora. Black Hills Engineer 15:38-44

McIntosh, A.C. 1930. Botanical features of the northern Black Hills. Black Hills Engineer 11:79-107.

McIntosh, A.C. 1931. A botanical survey of the Black Hills of South Dakota. Black Hills Engineer 12:159-276.

Marriott, Hollis. 2000. Survey of Black Hills Montane Grasslands. prepared for the Wildlife Division of the South Dakota Department of Game, Fish and Parks, Pierre, SD.

Marriott, Hollis, Don Faber-Langendoen, Amanda McAdams, Diane Stutzman, and Beth Burkhart. 1999. Black Hills Community Inventory. Final report to The Nature Conservancy, Midwestern Resource Office, Minneapolis, MN. 175 pp.

Marriott, Hollis and Don Faber-Langendoen. 2000. Black Hills Community Inventory. Volume 2: plant community descriptions. Prepared for The Nature Conservancy, Midwestern Resource Office, Minneapolis, MN. 326 pp.

Marriott, H.J., Faber-Langendoen, D. and Ode, D.J. 2012. Rediscovering the Black Hills montane grassland. NatureServe conference presentation 120424_A4_DFaber-Langendoen, http://connect.natureserve.org/files/bwb2012/120424_A4_DFaber-Langendoen.pdf Accessed 14 July 2012.

NatureServe 2012. Ecological Association Comprehensive Report for *Sporobolus heterolepis - Achnatherum richardsonii - Danthonia intermedia* Herbaceous Vegetation. http://www.natureserve.org/explorer/servlet/NatureServe (search page). Accessed 14 July 2012.

Newton, H. and W. P. Jenney. 1880. Report on the geology and resources of the Black Hills of Dakota : with atlas. USGS , Rocky Mountain Region. GPO, Washington DC. 557 pp., 12 pls. + atlas.

Rydberg, P. A. 1896. Flora of the Black Hills of South Dakota. Contrib. from the U.S. Nat. Herb. 3:463-536.

South Dakota Department of Game, Fish and Parks (SDGFP). 2006. South Dakota comprehensive Wildlife conservation Plan. SD Game, Fish and Parks Department, Wildlife Division Report #2006-08, Pierre, SD.

USDA, NRCS. 2012. The PLANTS Database (http://plants.usda.gov, 14 July 2012). National Plant Data Team, Greensboro, NC 27401-4901 USA.

US Geological Survey (USGS). 2012. The National Map Viewer http://viewer.nationalmap.gov/viewer/. Accessed 14 July 2012.

Appendices

Appendix A. Plant names used in report.

Nomenclature follows USDA NRCS (2012).

Common Name	Scientific Name
alsike clover	*Trifolium hybridum*
blue grama	*Bouteloua gracilis*
canada thistle	*Cirsium arvense*
green needlegrass	*Nassella viridula*
Kentucky bluegrass	*Poa pratensis*
little bluestem	*Schizachyrium scoparium*
musk thistle	*Carduus nutans*
needle and thread	*Hesperostipa comata*
ponderosa pine	*Pinus ponderosa*
Porter brome	*Bromus porteri*
prairie dropseed	*Sporobolus heterolepis*
quaking aspen	*Populus tremuloides*
red clover	*Trifolium pratense*
Richardson's needlegrass	*Achnatherum richardsonii*
rigid goldenrod	*Oligoneuron rigidum*
shortbristle needle and thread	*Hesperostipa curtiseta*
shrubby cinquefoil	*Dasiophora fruticosa*
smooth brome	*Bromus inermis*
subsecund slender wheatgrass	*Elymus trachycaulus* spp. *subsecundus*
tarragon	*Artemisia dracunculus*
timber oatgrass	*Danthonia intermedia*
timothy	*Phleum pratense*
western wheatgrass	*Pascopyrum smithii*
western yarrow	*Achillea millefolium*
wolfberry	*Symphoricarpos occidentalis*
woolly cinquefoil	*Potentilla hippiana*

Appendix B. Mountain meadow species lists from Hayward (1928) and McIntosh (1930, 1931).

Black Hills upland meadow species from Hayward (1928), and mountain meadow species added by McIntosh (1930, 1931). The first 17, above the bold line, were considered dominants by Hayward. Nomenclature follows USDA NRCS (2012).

reported by Hayward	**USDA PLANTS database**	**PLANTS common name**
Torresia odorata	*Hierochyloe odorata*	sweetgrass
Stipa richardsonii	*Achnatherum richardsonii*	Richardson's needlegrass
Oryzopsis asperifolia		roughleaf ricegrass
Phleum pratense		timothy
Agrostis hiemalis	*Agrostis hyemalis*	winter bentgrass
Danthonia intermedia		timber oatgrass
Poa compressa		Canada bluegrass
Poa fendleriana		muttongrass
Poa interior	*P. nemoralis* ssp. *interior*	inland bluegrass
Poa pratensis		Kentucky bluegrass
Bromus marginatus		mountain brome
Bromus porteri		Porter brome
Agropyron repens	*Elymus repens*	quackgrass
Elymus innovatus	*Leymus innovtus*	downy ryegrass
Carex festivella	*Carex microptera*	smallwing sedge
Carex hoodii		Hood's sedge
Carex tenera		quill sedge
Juncoides comosum	*Luzula* sp.	woodrush
Juncus confusus		Colorado rush
Iris missouriensis		Rocky Mountain iris
Sisyrinchium angustifolium	*S. montanum*	narrowleaf blue-eyed grass
Delphinium bicolor		little larkspur
Aconitum ramosum	*A. columbianum*	Columbian monkshood
Anemone globosa	*A. multifida* var. *multifida*	Pacific anemone
Ranunculus cardiophyllus		heartleaf buttercup

Thalictrum venulosum		veiny meadow-rue
Sieversia ciliata	*Geum triflorum*	prairie smoke
Astragalus alpinus		alpine milkvetch
Oxytropis gracilis	*O. monticola*	yellowflower locoweed
Lupinus sericeus		silky lupine
Geranium viscosissimum		sticky purple geranium
Viola adunca		hookedspur violet
Viola canadensis		Canadian white violet
Dodecatheon pauciflorum	*D. pulchellum*	darkthroat shootingstar
Valeriana ceratophylla		valerian (species unknown)
Antennaria rosea	possibly *A. microphylla*	pussytoes
Rudbeckia hirta		blackeyed susan
Balsamorrhiza sagittata		arrowleaf balsamroot
Helianthella quinquinervis		fivenerve helianthella
Gaillardia aristata		blanketflower
Crepis riparia	*Crepis runcinata*	fiddleleaf hawksbeard
additional species reported by McIntosh		
Stipa spartea curtiseta	*Hesperostipa curtiseta*	shortbristle needle and thread
Stipa viridula	*Nassella viridula*	green needlegrass
Sporobolus heterolepis		prairie dropseed
Koeleria cristata	*K. macrantha*	prairie junegrass
Agropyron caninum	*Elymus trachycaulus*	slender wheatgrass
Calochortus gunnisonii		Gunnison's mariposa lily
Spiranthes stricta	*S. romanzoffiana*	hooded lady's tresses
Potentilla nuttallii	*P. gracilis*	slender cinquefoil
Dasiphora fruticosa		shrubby cinquefoil
Lupinus argenteus		silvery lupine
Linum lewisii		Lewis flax
Carum gairdneri	*Perideridia gairdneri*	Gairdner's yampah
Gentiana strictiflora	*Gentianella amarella*	autumn dwarf gentian

Mertensia foliosa	*M. lanceolata*	prairie bluebells
Monarda menthaefolia	*M. fistulosa*	wild bergamot
Castilleja sulphurea		sulphur Indian paintbrush
Orthocarpus luteus		yellow owl's-clover
Valeriana furfurescens	*V. edulis*	tobacco root
Campanula rotundifolia		bluebell bellflower
Lacinaria ligulistylis	*Liatris ligulistylis*	Rocky Mountain blazing star
Solidago concinna	*S. missouriensis*	Missouri goldenrod
Solidago pulcherrima	*S. nemoralis*	gray goldenrod
Oligoneuron canescens	*O. rigidum*	stiff goldenrod
Aster multiflorus	*Symphyotrichum* sp.	white prairie aster
Erigeron macranthus	*E. speciosus* var. *macranthus*	aspen fleabane
Achillea lanulosa	*A. millefolium*	common yarrow
Agoseris glauca		pale agoseris

Appendix C. Black Hills montane grassland scorecard.

Black Hills Montane Grassland Project 2011
Type Verification Scorecard

This scorecard can be used mid-July through early September in a typical season. Good plant id skills are required. Assess as large an area as possible, dominated by native species.

1. Estimated tree cover _____% Estimated shrub cover _____ %

   Tree, shrub species _____

2. Indicate which are present. Scores: Grasses _____ Forbs _____

   2.a. Grasses (4 points each, minimum 8 points)
   _____ Elymus trachycaulus ssp. subsecundus
   _____ Sporobolus heterolepis
   _____ Danthonia intermedia
   _____ Achnatherum richardsonii

   2.b. Forbs (1 point each, minimum 5 points)
   _____ Achillea millefolium
   _____ Agoseris glauca
   _____ Allium cernuum
   _____ Anemone cylindrica, A. multifida
   _____ Campanula rotundifolia
   _____ Cerastium arvense
   _____ Dodecatheon pulchellum
   _____ Erigeron subtrinervis
   _____ Galium boreale
   _____ Gaillardia aristata
   _____ Geranium viscosissimum
   _____ Gentianella amarella
   _____ Geum triflorum
   _____ Heterotheca villosa
   _____ Heuchera richardsonii
   _____ Iris missouriensis
   _____ Orthocarpus luteus
   _____ Pulsatilla patens
   _____ Sisyrinchium montanum
   _____ Thalictrum dasycarpum
   _____ Vicia americana

If you feel that contrary to the above scores the stand *is* or *is not* a montane grassland, explain: _____

_____

Other comments _____

_____

Appendix D. Field forms for Black Hills montane grassland surveys and plots.

Black Hills Montane Grassland Project 2011

Site Reconnaissance

Site _____ **SiteID** _____ **Date** _____

Surveyors _____ **Aerial photos used:** _____

Observation Pts _____ **Photos** _____

Directions Update, expand or clarify Directions given in Site Report, if needed; note any restrictions, e.g. 4WD required.

Starting point of survey: **GPS Unit** _____

Zone _____ **Datum** _____ **Accuracy** _____ **UTM E** _____ **UTM N** _____

Location _____

Brief Site Description Landscape, geology, vegetation, montane grassland, human use (more thorough if no further survey will be done).

Type Determination: **Verified BHMG?** _____ **Scorecard?** _____ **Score:** **grasses** _____ **forbs** _____

Comments:

Is the montane grassland at least 12 acres (5 ha)? _____

Ecological Integrity Assessment L2: Score, Summary (complete EIA L2 only if stand is sufficiently large)

Survey Needs Describe areas covered in Reconnaissance; note if detailed Survey was done, why (not). What work still needs to be done?

Black Hills Montane Grassland Project 2011

Site Survey

Site _____ **SiteID** _____ **Date** _____

Surveyors _____

Site Description

Landscape Context Describe landscape context (landforms, topography, hydrology, geology, vegetation), and the distribution of montane grassland in relation to topography and other vegetation types.

B.H. Montane Grassland Brief description of montane grassland: habitat characteristics, characteristic species, any significant variation within stand and how it relates to environmental factors, inclusion of other communities.

Black Hills Montane Grassland Project 2011

Site Survey

Site _____

Site Drawing

Include prominent human and natural landmarks, starting point of survey, montane grassland and adjacent vegetation. Include at least one cross-section showing typical topography and vegetation. Indicate location of cross-section on drawing. Show compass directions.

Black Hills Montane Grassland Project 2011

Site Survey

Site _____

Boundaries

Where needed, mark boundaries on aerial photos. Discuss issues, unusual situations, human-caused boundaries. Reference observation pts.

Land Use and Impacts Describe human use of site, and discuss any obvious impacts on the montane grassland.

Other Site Comments

Black Hills Montane Grassland Project 2011

EIA Level 2

Site _____ **SiteID** _____ **Date** _____

Surveyors _____

Relative Cover Native Species **Rank and Points:** _____ **Comments:**

Exotic Invasive Species **Rank and Points:** _____ **Comments:**

Native Increaser Species **-1 if significant:** _____ **Comments:**

Soil Surface Condition **Rank and Points:** _____ **Comments:**

Total Score and Overall Condition Rank Use Condition Rank Calculator; explain choices, overrides in Other Comments.

Other Comments For example which areas were visited, omitted, why. Explain any choices, overrides in Overall Condition Rank.

Black Hills Montane Grassland Project 2011

Observation Points and Photos

Page _____ of _____

Site _____ **SiteID** _____ **Date** _____

Surveyors _____

Obs Pt ID	UTM-E	UTM-N	Accuracy	Notes and photos

Black Hills Montane Grassland Project 2011

Plot Form

Site Name	
Site ID	
Plot Number	
Plot Size	
Date	
Surveyor(s)	
Photos	

Location	
UTM_E	
UTM_N	
Accuracy	
Zone, Datum	

Elevation	
Slope	
Aspect	
Parent material	
Landform	

Unvegetated Surface	CovCl	Unvegetated Surface	CovCl
Bedrock		**Litter, duff**	
Large Rocks, >10 cm		**Wood**	
Small Rocks, 0.2 - 10 cm		**Water**	
Bare Soil		**Other:**	

% Cover	Cover Class
<1%	01
1-5	02
5-25	03
25-50	04
50-75	05
75-100	06

Plot representativeness

Topographic sketch: show cross-section through site, vegetation types, location of plot, any notable landmarks. Indicate direction.

Site Name	
Plot Number	

	height class	cover class
T1 Tree canopy		
T2 Tree sub-canopy		
S1 Tall shrub		
S2 Short shrub		
H Herbaceous		
N Non-vascular		

List species by stratum. Use an * to mark additional species found outside plot.

Species	Cov Cl	Species	Cov Cl	Species	Cov Cl

Appendix E. Stand summary table for Black Hills montane grassland plots.

Constancy is % plots in which species occurs; average cover is across all plots, including where absent; range is minimum, maximum cover values. Cover values are midpoints of cover classes (see plot form in Appendix D).poor Herbaceous species sorted by constancy.

Species	Constancy	Av. Cover	Range
Short Shrub			
Amelanchier alnifolia	16%	1%	1-15
Arctostaphylos uva-ursi	16%	1%	1-15
Artemisia dracunculus	16%	1%	1
Artemisia frigida	26%	1%	1
Dasiphora fruticosa ssp. floribunda	11%	1%	1-15
Juniperus communis	16%	1%	1
Mahonia repens	5%	1%	1
Pinus ponderosa	16%	1%	1
Rosa arkansana	16%	1%	1
Symphoricarpos occidentalis	11%	1%	1-15
Herbaceous			
Campanula rotundifolia	95%	1%	1
Geum triflorum	95%	3%	1-15
Poa pratensis	95%	7%	1-38
Achillea millefolium	89%	1%	1-3
Agoseris glauca	79%	1%	1-3
Elymus trachycaulus ssp. subsecundus	74%	1%	1
Koeleria macrantha	63%	1%	1
Oligoneuron rigidum	63%	3%	1-38
Orthocarpus luteus	63%	1%	1
Sporobolus heterolepis	63%	11%	1-38
Anemone cylindrica	58%	1%	1
Danthonia intermedia	58%	2%	1-15
Nassella viridula	58%	1%	1-3
Potentilla gracilis	47%	1%	1-3
Potentilla hippiana	47%	2%	1-15
Achnatherum richardsonii	42%	4%	1-38
Artemisia ludoviciana	42%	1%	1-3
Festuca saximontana	42%	1%	1-3
Gentianella amarella	42%	1%	1
Solidago missouriensis	42%	1%	1-3
Erigeron formosissimus	37%	1%	1-3
Gaillardia aristata	37%	1%	1
Geranium viscosissimum	37%	1%	1-15

Species	Constancy	Av. Cover	Range
Heterotheca villosa	37%	1%	1-3
Heuchera richardsonii	37%	1%	1
Iris missouriensis	37%	1%	1-3
Linum lewisii	37%	1%	1
Phleum pratense	37%	2%	1-15
Sisyrinchium montanum	37%	1%	1
Anemone multifida	32%	1%	1
Astragalus flexuosus	32%	1%	1-3
Cerastium arvense	32%	1%	1
Galium boreale	32%	1%	1
Pulsatilla patens	32%	1%	1
Solidago nemoralis	32%	1%	1-15
Symphyotrichum falcatum	32%	1%	1-3
Symphyotrichum laeve	32%	1%	1-3
Trifolium pratense	32%	1%	1-3
Vicia americana	32%	1%	1
Allium cernuum	26%	1%	1
Dodecatheon pulchellum	26%	1%	1
Monarda fistulosa	26%	1%	1-3
Artemisia campestris	21%	1%	1
Cirsium drummondii	21%	1%	1
Hesperostipa curtiseta	21%	1%	1-15
Oligoneuron album	21%	1%	1-3
Perideridia gairdneri	21%	1%	1-3
Thalictrum dasycarpum	21%	1%	1
Trifolium repens	21%	1%	1-3
Agrostis scabra	16%	1%	1
Astragalus crassicarpus	16%	1%	1
Bromus inermis	16%	1%	1-3
Bromus porteri	16%	1%	1
Calochortus gunnisonii	16%	1%	1
Carex inops ssp. heliophila	16%	1%	1-3
Comandra umbellata	16%	1%	1
Dalea purpurea	16%	1%	1
Hesperostipa comata ssp. comata	16%	1%	1-3
Liatris ligulistylis	16%	1%	1
Liatris punctata	16%	1%	1-3
Melilotus officinalis	16%	1%	1

Species	Constancy	Av. Cover	Range
Polygonum douglasii	16%	1%	1
Potentilla arguta	16%	1%	1
Rudbeckia hirta	16%	1%	1
Selaginella densa	16%	1%	1-3
Tragopogon dubius	16%	1%	1
Zizia aptera	16%	1%	1
Antennaria microphylla	11%	1%	1
Astragalus laxmanii. var. robustior	11%	1%	1-3
Balsamorhiza sagittata	11%	1%	1-15
Besseya wyomingensis	11%	1%	1
Carex praegracilis	11%	1%	1-3
Hesperostipa spartea	11%	1%	1
Lupinus sericeus	11%	1%	1-3
Muhlenbergia cuspidata	11%	1%	1
Oxytropis campestris	11%	1%	1
Paronychia depressa	11%	1%	1
Pediomelum argophyllum	11%	1%	1
Schizachyrium scoparium	11%	1%	1-15
Senecio canus	11%	1%	1
Senecio integerrimus	11%	1%	1
Tetraneuris acaulis	11%	1%	1
Thermopsis rhombifolia	11%	1%	1-3
Valeriana edulis	11%	1%	1
Astragalus spatulatus	5%	1%	1
Bouteloua gracilis	5%	1%	1
Bromus ciliatus	5%	1%	1
Castilleja sessiliflora	5%	1%	1
Cirsium arvense	5%	1%	1
Corydalis aurea	5%	1%	1
Elymus elymoides	5%	1%	1
Erigeron canus	5%	1%	1
Erigeron strigosus	5%	1%	1
Fragaria virginiana	5%	1%	1
Hedysarum boreale	5%	1%	1
Helianthus pauciflorus	5%	1%	1
Medicago lupulina	5%	1%	1
Pascopyrum smithii	5%	1%	1
Pediomelum esculentum	5%	1%	1

Species	Constancy	Av. Cover	Range
Poa nemoralis ssp. interior	5%	1%	1
Potentilla glandulosa	5%	1%	1
Potentilla pensylvanica	5%	1%	1
Sedum lanceolatum	5%	1%	1
Silene drummondii	5%	1%	1