MULTIPLE INDICATOR MONITORING (MIM) OF PERENNIAL STREAMS IN THE BLACK HILLS, SOUTH DAKOTA

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EXECUTIVE SUMMARY

In 2008 citizen volunteers organized the Black Hills Citizen MIM Project to study streambanks and streamside vegetation on selected perennial streams in the Black Hills of South Dakota, and to document impacts of large herbivores and human-caused activities. Aquatic ecosystems make up only about 5% of the National Forest Service lands in Region 2, and perennial streams make up a smaller proportion of the landscape. Yet, streams provide a wide range of critical ecological and human services. Utilizing the Multiple Indicator Monitoring (MIM) of Streambanks and Streamside Vegetation protocol, project members collected data in 2009 and 2012 along representative sample sites (designated monitoring areas, or DMAs) within Ladyfinger Gulch, Slate Creek and Flynn Creek. The primary impact to these DMAs is due to livestock grazing. This report discloses the results and conclusions of this effort.

MIM quantifies or describes ten streamside metrics such as stubble height, bank alterations and stability, vegetative species, distance across streams between shorelines, and channel substrate composition. When quantified conditions of a stream are rated as high, the stream is able to provide the wide range of ecological services perennial streams must contribute to support ecosystems and FS multiple uses that depend on it. None of the DMAs monitored in this report rated high. One DMA is average and two are poor. Poor ratings indicate a high risk that future disturbances (from livestock grazing to drought to climate change) will result in decreased conditions. While all DMAs met minimum recommendations for key species stubble heights within the greenline, it is clear, as outlined below, that this metric should not be exclusively relied upon as a trigger to move livestock or as an indicator of streamside conditions.

- **Ladyfinger Gulch DMA**, a location of USDA/Forest Service Region 2 (R2) Sensitive Species *Carex alopecoidea* (foxtail sedge), had good contribution of plant species appropriate to wetlands. Woody species composition was extremely low. Quantified stream conditions demonstrated that streambank alterations (>67% both years) and stability (<34%) were not trending towards meeting Black Hills National Forest (BHNF) directives of 26% and 74%, respectively. Overall, ecological condition was poor. In 2007, Ladyfinger Gulch was identified as not meeting BHNF's established "desired conditions" and 5 years later, it shows no signs of improving.

- **Slate Creek DMA** had a good contribution of plant species appropriate to wetlands but woody species composition was extremely low. Slate Creek MIM showed an average resiliency to disturbances. Percent bank cover improved greatly (at 88% in 2012), trending towards meeting requirements for effective ground cover. Slate Creek showed a marked decline in streambank alterations and met BHNF directives of 26% by Fall 2012. Stability improved in three years which is a satisfactory condition. After a long history of use, the stream is making good progress. Overall, despite marked improvements within three years, Slate Creek's current ecological condition was average. With improvements in livestock management, Slate Creek should continue to trend towards BHNF's established "desired conditions."

- **Flynn Creek DMA** had a contribution of plant species appropriate to wetlands but the percent of plots with hydric species was seriously under-represented at below 36%. Woody species composition was extremely low. Flynn Creek MIM transect showed a decreasing ability to resist erosion. Because of its early ecological status, Flynn Creek shows a vulnerability rather than resilience to disturbances. Percent bank cover is low (<36% both monitoring years). Bank alterations of 33% (in 2012) are above the 20-26% goal as established by BHNF. Bank stability was <50% both years, well below the BHNF 74% requirement. Overall, ecological condition was poor. This is contrary to BHNF's non-quantified finding in 2006 of Flynn Creek meeting desired conditions.

The lack of reference conditions for Black Hills streams is a limitation to understanding the potential for streambanks and streamside vegetation. Despite this limitation, BHNF has set some thresholds and directives and has included "adaptive management" as means to meet established "desired conditions".

The Black Hills Citizen MIM Project hopes that this project contributes to development of a body of MIM data for Black Hills streams which will lead to a Black Hills landscape with streams having high resiliency and the ability to provide a wide range of ecological functions and human services.

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INTRODUCTION

Multiple Indicator Monitoring of Stream Channels and Streamside Vegetation, also known as "MIM", is a protocol designed to provide an objective, efficient, and effective approach to monitoring streambanks, stream channels, and streamside riparian vegetation in order to gather information that is critical for managing important riparian and aquatic resources (Burton et al. 2006). MIM is designed to provide repeatable, consistent methods to collect information that reveals annual triggers and long-term conditions and changes that occur as a result of livestock grazing, other large animal impacts and multiple uses along streams. MIM provides a rapid, accurate, and quantitative scientific approach to measurement and analysis that, given proper training, natural resource experts and the public alike can perform to monitor streams. A trained botanist or someone field skilled in plant identification is needed as a member of the monitoring team. The Black Hills Citizen MIM Project is hereafter referred to as the "MIM Project".

MIM protocol was originally developed to address the findings of the University of Idaho Stubble Height Study Report (Stubble Height Study Team. Approx. 2004). The report stated that integrating annual grazing use and long-term trend indicators allowed for evaluation of livestock grazing management actions. The Review Team concluded:

> *"Long- term monitoring of vegetation composition on the greenline, streambank stability and regeneration of woody species are true measures of whether riparian management objectives are being met."*

Since 2005, MIM protocol has been published annually by the Bureau of Land Management (BLM) Idaho State Office and Region 4 of the USDA/Forest Service (USFS) as an interagency Technical Bulletin (Burton et al. 2008). Over the years, annual updates have been made as a result of testing, field review and input from over 800 field specialists on over 65 low-gradient streams across the western United States. Continuous improvements have been made to minimize subjectivity, while maintaining a reasonable level of precision and accuracy. The most recent version was published in 2011 (Burton et al. 2011). Since 2005, many BLM, USFS, Natural Resource Conservation Service, universities, landowners and private citizens in the West have initiated use of this protocol (BLM: Riparian Monitoring Oregon/Washington. Unknown Date).

Perennial streams provide important habitat for a myriad of species on public and private lands in the Black Hills (Appendix 1). The condition of streambanks, stream channels and riparian vegetation influence water quality and quantity, and aquatic and near-stream terrestrial biota. Stream conditions define the health of the streams and thus, their ability to contribute to providing critical habitats for rare plants, plant species of concern, vertebrates and invertebrates. Streams serve as critical components of large landscape ecosystems and provide water for human and livestock consumption, agriculture and recreation. Ecological services include forage and browse production, wildlife use, species richness (plant and animal), structural diversity, watershed health and hydrologic function.

While the MIM protocol is mostly used as a stream assessment tool to evaluate livestock grazing management concerns, the protocol's long-term monitoring techniques provide useful data to describe general conditions and trends regardless of the types of multiple-use management activities occurring on the site.

The following report provides an overview of MIM, results from three stream assessments conducted by the MIM Project in 2009 and repeated in 2012, together with an analysis and interpretation of the MIM metrics. This report may be used by public land managers and others to provide input for implementing grazing management and other management activities affecting riparian resources.

PROJECT NEED

The public lands comprising the BHNF are managed by the US Forest Service (USFS). Under federal law, multiple-uses such as motorized and non-motorized recreation, logging and livestock grazing, and recreation are allowed on these public lands so long as those uses comply with national laws, USFS Handbooks and Manuals and local Forest Plan directives.

The MIM protocol will detect impacts to streamsides by any cause (motorized vehicles, mountain bikes, horses, wildlife, livestock, etc.) and by contrast, will detect changes in management of uses that brings about an upward trend to improve riparian conditions. For example, BHNF assesses motorized travel on forest lands and part of that process is to evaluate the public use of undeveloped or 2-track roads that crossed and impacted streams. Additionally, effects to riparian areas and water influence zones resulting from timber and logging practices on the BHNF are periodically evaluated through an

interdisciplinary team funded through the State Department of Environment and Natural Resources. However, after working on this project for four years, it is the experience of the MIM Project that there is a need to focus on an area-wide, quantitative, consistent and reliable process that measures both annual and long-term impacts to riparian areas, especially from wild and domestic large animals. In addition, no reference conditions (that MIM Project is aware of) have been established to provide guidance to managers about expectations for riparian area conditions.

The Black Hills Citizen MIM Project was created as an effort to bring awareness to public land users and State and Federal agencies of a quantitative protocol that can capture streamside conditions due to large animal disturbances, especially livestock grazing, and confidently track those conditions over time. The results of MIM monitoring give resource managers reliable data and a reflection of large animal use in riparian areas. It is recognized by the MIM Project that BHNF has selected a few MIM designated monitoring areas (DMAs). However, BHNF annual monitoring reports have yet to reveal MIM results and interpretations.

PROJECT OBJECTIVES

The Black Hills Citizen MIM Project established the following project objectives:

- Conduct fieldwork in 2009 on four streams (one per BHNF Ranger District) when riparian vegetation reached seasonal maturity, using the MIM protocol to document annual stream conditions and establish quantitative baseline conditions.
- Conduct fieldwork in 2010 on three additional streams on the BHNF.
- Repeat MIM fieldwork in 2012 on the four 2009 streams to document annual stream conditions and begin to establish long-term monitoring data.
- Repeat MIM fieldwork in 2013 on the three 2010 streams.
- Provide an assessment of annual triggers and long-term trends (if any) of stream conditions over the three years.
- Submit analysis of stream conditions to expert scientists (RMSMIM, L.L.C.) for critique.
- Communicate these data, project photographs, and data analysis conclusions to the public and State and Federal resource managers.

METHODS

Unless otherwise noted, all MIM descriptions, definitions and methodologies are taken verbatim or paraphrased from the two MIM Handbooks (Burton et al. 2008, 2011) and MIM Handout (Burton et al. 2009). In the interest of describing general but concise information, we refer the reader to the Handbooks for full discussion of statistical and model robustness of MIM methods. Two of the MIM authors have a consulting and data interpretation service (http://rmsmim.com/). The draft of this report was sent to RMSMIM, L.L.C. for review and clarification of methods, data interpretation, and guidance for a crosswalk to compare 2009 data (2008 methodology) to 2012 data (2011 methodology). The report's discussions and conclusions were drawn by the Black Hills Citizen MIM Project and are not the opinions or statements by RMSMIM, L.L.C. or the MIM developers.

In 2008, the Black Hills Citizen MIM Project hired MIM author, Ervin R. Cowley, to train the Project's volunteers and interested agency personnel from the USFS, the National Park Service, the US Geological Survey, and South Dakota Game Fish & Parks. In 2009, the MIM Project selected four designated monitoring areas (DMAs) or streams for MIM monitoring. In 2012, trend data was initiated by making repeat measurements at the 2009 DMAs. Those data are presented in this report. Three additional DMA sites were monitored in 2010 and repeated measurements will be conducted in 2013.

In 2011, the MIM protocol's developers changed some of the 2008 methodology to improve its reliability. The MIM Project again contracted one of the MIM developers to conduct a refresher course in the Black Hills in June 2012. Data collected in 2012 use the 2011 methodology. Changes to the methodology include (1) altering the Daubenmire readings from "dominant and subdominant" qualitative readings to quantitative percentages by species, (2) streambank stability parameters were changed to reduce observer bias, and (3) the addition of measuring stream pool and riffles for trout habitat were added. However, due to the drought in 2012, none of the BHNF stream DMAs had sufficient flows to measure pools and riffles.

The 2011 MIM protocol combines observations of 10 indicators along the same stream reach (DMA) using adaptations of the existing protocols. Specific rules have been developed to facilitate the use of a quadrat plot to reduce subjectivity and maintain consistency, precision, and accuracy of data collection

(Burton et al. 2006). Procedures were selected to monitor indicators of livestock and other large herbivores' impacts on steams (usually less than 10-m wide). The 2011 MIM protocol employs:

- Instructions for locating appropriate Designated Monitoring Areas (DMA's)
- Instructions for locating the greenline plot locations
- Detailed procedures for monitoring 7 long-term condition indicators or metrics:
    1. Greenline Composition
    2. Greenline to Greenline Width (GGW)
    3. Streambank Stability (and cover)
    4. Woody Species Age Class
    5. Woody Species Height Class
    6. Stream Substrate
    7. Residual Pool Depth and Pool Frequency
- Detailed procedures for monitoring 3 short-term (annual) use indicators or metrics:
    1. Stubble Height
    2. Streambank Alteration
    3. Woody Browse Use
- Automated electronic modules (Excel) for data entry and analysis.

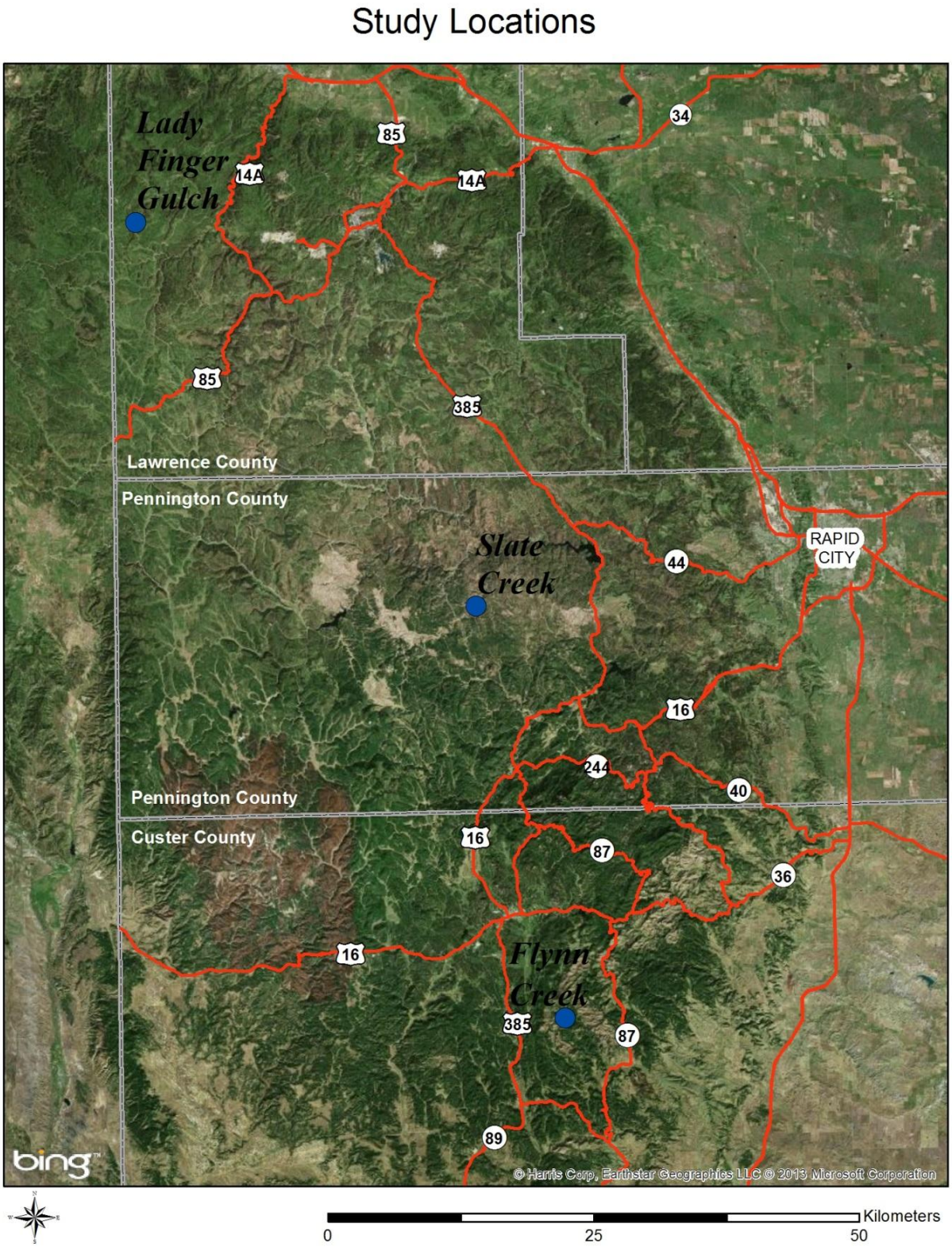
MIM Project used both hand-recorded data sheets and Juno Excel Programs for data collection in 2009 and 2012. All data were either transcribed from data sheets into the provided data entry module or in the case of the Juno data, it was directly downloaded to the data analysis module.

All 2009 through 2012 DMA sites were monitored in September or October toward the end of the grazing season, and generally after livestock grazing had ended on the pastures in which the DMAs were located. However, some DMAs still had late season cattle on site. Because Slate Creek was selected in 2012 for the second MIM training location, it was measured in 2012 both before grazing and at the end of the grazing rotation schedule.

DESIGNATED MONITORING AREAS (DMAs)

The Designated Monitoring Areas (DMAs) for MIM Project were chosen to be representative DMAs rather than reference or critical DMAs (Burton et al. 2011 at 7-9). One objective was to include a stream on each BHNF Ranger District in South Dakota (Table 1, Figure 1) that had been identified by BHNF as having some element of "existing conditions" that were not "meeting desired conditions" set by the agency. Each DMA occurred within a pasture that had recently been analyzed to establish livestock management direction. Specific directives come from federal laws, USFS Regional Office, BHNF Forest Plan or allotment Decision documents. Implementation of the MIM Project would test the BHNF directives with objective and quantitative assessments. The DMA on each stream was located in an area large enough to accommodate a MIM transect and was representative of consistent conditions along

Figure 1 - Locations of Three Black Hills Streams, or DMAs



that stream reach. The choice of DMA was made with the intention that established resource objectives could be monitored and measured. DMAs were located so they did not include, to the best of our knowledge, areas where livestock were concentrated by BHNF or grazing permittees, or where range or recreational structures occurred. DMA's were chosen in streams less than 5% gradient.

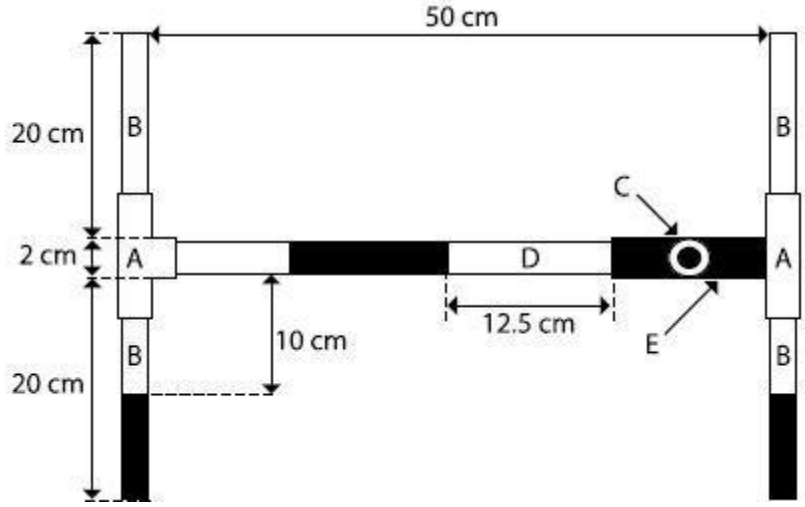
Table 1 - Information on Black Hills Streams, or DMAs

Stream/DMA	BHNF Ranger District	Dates monitored 2009	Dates monitored 2012
Ladyfinger Gulch	Northern Hills	9/26/09	10/14/12
Slate Creek	Mystic	9/19/09	6/10/12 + 9/23/12
Flynn Creek	Hell Canyon	9/29/09	10/3/12

MIM TRANSECT AND FRAME

MIM transects are 110-m (meters), and contain a minimum of 80 plots or frames; 40 on each side of the stream (Burton et al. 2011 at 9-10). The start and end of the 40 plots for each of the transects were GPS'd and photographed. The MIM frame is a modified Daubenmire (1959) frame with various markings and a handle to serve as measuring tools or visual cues for recorded data (Figure 2), (Burton et al. 2011 at 103-105). The frame is easily and inexpensively constructed out of PVC pipe.

Figure 2 - MIM Frame



SEVEN LONG-TERM MONITORING INDICATORS

Greenline

The most important task is to define and locate the stream's greenline. The greenline often coincides with the presence of water in the plant rooting zone, although in years of low flow, such as 2012, this may not be the strict case. Therefore, it is important that the greenline sampling process follow continuous lines of vegetation rather than the seasonally fluctuating water's edge (Winward 2000). Although the definition sounds simple, in practice it requires critical evaluation as the frame observers/readers must be similarly calibrated and synchronized to choose the most appropriate greenline, and therefore reduce observer bias. There are natural and/or user-created site-specific variables along a stream that make placement of each plot frame a calculated judgment. MIM guidebooks (Burton et al. 2008, 2011) and Winward (2000) provide excellent reference photos to assist in making greenline determinations.

The greenline is used as the basis for monitoring because it is the point of highest sensitivity to disturbance and serves as a reference for efficient monitoring that best reflects influences of grazing, high water events and other streamside physical alterations. When monitored, the greenline is the first area that can alert a manager to streamside annual concerns, which over time, contribute to long-term conditions. Secondly, evaluation of the greenline vegetation provides a good indication of a streambank's ability to buffer the hydrologic forces of moving water. In addition, since the greenline is located where the forces of water are greatest, a greenline measurement can provide an indication of the health of upstream conditions above the transect.

Greenline Species Composition

Greenline vegetation is measured by placing the MIM frame's center bar on the greenline so that half of the frame is non-vegetated, and the other half is vegetated (Burton et al. 2011 at pp. 14-19, 39-44). (Figure 2). The vegetated half of the frame (20-cm x 50-cm) is read similar to Daubenmire (1959) method for percent canopy cover by herbaceous species.

It is possible that there is no greenline at a particular plot. But, when possible, vegetation was identified to genus and species. Where grazing removed identifiable vegetative characteristics, vegetation was lumped into hydric categories such as "*Carex* species" or "*Juncu*s species". Upland graminoids were usually still identifiable to genus and species. Greenline species composition is a long-term monitoring

metric which can indicate a stable riparian vegetative community. A trend upward indicates the streambank is recapturing riparian vegetation. A trend downward indicates a loss of critical hydric vegetation and deteriorating conditions.

Greenline to Greenline Width (GGW)

This is the width across the stream from non-vegetative shoreline to non-vegetative shoreline, or "bankfull" width, and is perpendicular to the waterflow. GGW is another long-term indicator (Burton et al. 2011 at pp. 54-58). The purpose of measuring the GGW along the transect is to estimate the mean width (after peak flows), taking into account site variability. Changes (narrowing or widening) of the mean stream channel width may be a reflection of streambank disturbances to vegetation and soil stability. Flooding, flow rates, ice and debris, deposition and erosion can naturally change channel width. Impacts by livestock trampling (or any bank-altering activity), shearing and excessive grazing tend to widen stream channels and can either eventually flatten the contours from bank to bank, or in some areas, create a deeply incised channel where the stream is the major gap between two steep landforms or a common travel corridor for animals. There is an inverse relationship between stream narrowing and level of grazing intensity (Burton et al. 2011 at p. 55).

GGW together with greenline species composition and streambank stability (described below), generally indicate if the system in the representative DMA is stable with appropriate channel width and hydric shoreline vegetation. Over time, these MIM measurements help determine if the stream is stable, improving or if continued livestock use has caused the loss of a deep, rapidly flowing stream concomitant with the loss of hydric shoreline vegetation in favor of upland species.

When negative impacts to soils and vegetation coincide, streams become too shallow and warm for appropriate aquatic biota. Loss of critical, deep rooted hydric vegetation can cause a change in shoreline invertebrates (aquatic and terrestrial), loss of shoreline habitat, and loss of proper sediment filtering during high water events.

Streambank Stability and Cover

The "streambank" is defined as that part of the channel between the scour line and edge of the first relatively flat bench above the scour line (Burton et al. 2008, 2011). This area is vulnerable to erosion during high flows and influenced by presence and type of vegetation. Changes or losses to deep-rooted,

shoreline vegetation will decrease stability. Unstable banks result from mass wasting, breakoffs, hoof slides and shears and trampling by livestock or other physical disturbances.

MIM measures the proportion of streambank that is stable and vegetatively covered and is expressed as a percent. Streambanks are recorded as either depositional or erosional, and vegetatively covered or uncovered (Burton et al. 2011 at 50). Only erosional banks are assessed for stability class: fracture, slump, sluff, eroding or absent of eroding.

Woody Species Age and Height Classes

Classifying ages of woody species helps determine if there is a diversity of ages (seedling, young and mature) and also it is critical to determine if new shoots are continuously being successfully established. Woody structure (single stem vs. multiple stem) and density provides information as to plant composition and how animals may be using a stream (Burton et al. 2011 at pp. 51-54). Height classes are estimated as indicators of shading, biomass production, and monitoring plant structure (Burton et al. 2011 at pp. 44-47).

Stream Substrate

Determining the relative size (fine particles at 2-mm to cobble to imbedded rock) and percent of the channel's substrate are important metrics used to characterize streambed habitats for cold-water fish and other aquatic or semi-aquatic species (Burton et al. 2011 at pp. 58-64). The amount of fine substrate particle is indicative of excessive erosion, transport and deposition. Smaller particles can blanket or have a smothering effect both within the water column and streambed which are adverse to aquatic life. Streambed particle size was measured using a gravelometer or measuring embedded rock.

Residual Pool Depth and Pool Frequency

This metric was added to the 2011 MIM methodology primarily to aid in describing cold-water fisheries habitat (Burton et al. 2011 at pp. 64-67). Stream depth (thalweg) and width utilized in 2009 were dropped. Due to the severe drop in stream flows on the BHNF in September and October 2012, this metric was impossible to measure.

THREE SHORT-TERM (ANNUAL) MONITORING INDICATORS

Stubble Height (SH)

Stubble height is an annual indicator of herbivore grazing. For riparian areas, stubble is the measured height of residual key herbaceous vegetation along the greenline. Key species include *Carex* species,

Juncus species, *Scirpus* species, or other hydric graminoids that are indicators of moist and wet conditions associated with streambanks. Most of these species are palatable to livestock, especially later in the growing season when upland vegetation has dried and cured. Stubble height is an "end point" because it is measured at the end of the growing season and when livestock have been removed, but before the next high water event.

MIM measures residual height of individual key species occurring nearest the MIM frame handle within a 3-in (inch) diameter circle (Burton et al. 2011 at pp. 23-27). Residual leaf heights are averaged, seed heads are not included. If key species are not within the circle, the next closest key species within the frame is measured. Where streambank vegetation has been grazed to the degree that identification to genus and species is unreliable, identification is lumped (i.e.: "*Carex* species" or "*Juncus* species").

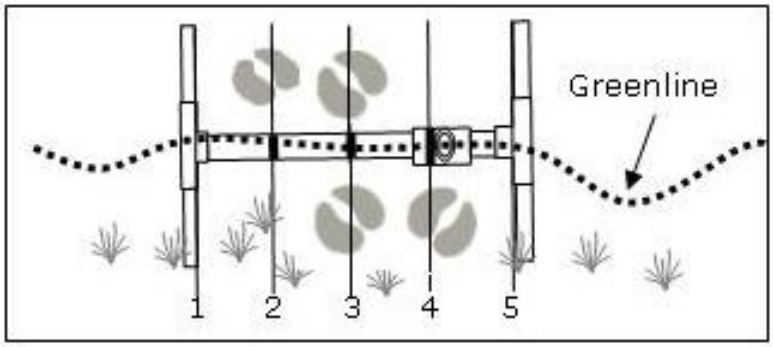
If key species are absent, the procedure is to leave the data cell blank, but the MIM Project measured stubble height of upland graminoids by species, which could be easily be separated from key species in the analysis. The MIM Project collected this additional data because the USFS Grazing Handbook (1996) offers local USFS managers the option to measure non-key species stubble height when key species are missing.

Streambank Alteration

Streambank alteration is direct disturbance by other than natural forces of water, ice, and debris. Large herbivores (e.g., cattle, sheep, horses, elk, and deer), humans, off- highway-vehicles, recreation use, road construction, logging, and mining are activities that can cause streambank alteration. (Cowley 2002). Streambank alterations can be measured by detecting obvious, physical impairments along the greenline made by large animals that walk along or cross the stream during the current grazing season (Burton et al. 2011 at pp. 27-34). The measurement is a presence/absence (a "percent of hits" by animals' hooves). The animals' weight and hooves can shear, trample or compact the streambank, expose roots and soil, create pedestals and rills, and break or cut vegetation.

The MIM frame's center bar is placed on the greenline and 5 cross-plot lines (lines perpendicular to the center bar) are visually projected 20-cm on either side of the greenline (Figure 3). If more than one alteration intercepts any of these 5 lines, on either or both sides of the center bar, a value of 1 is recorded. The highest degree of alteration is a hit on all 5 lines, or a value of 5. No alteration is scored as a value of 0. The spacing among the 5 lines approximates the width of a hoof print.

Figure 3 - Example of Hoof Prints Within the MIM Frame



Alterations include: depressed and exposed bare soil at least 13-mm (0.51-in) deep, broken vegetation with a hoof print at least 13-mm deep, or compacted soil from repeat walking even if less than 13-mm deep (Burton et al. 2011 at p. 32). The figure above represents a reading of 3 alterations.

Woody Browse Use

Browsing of woody plants, shrubs and hardwood trees by wild and domestic animals is an important metric to measure because these species add to shoreline diversity, hold soils in place, shade streams and provides critical nesting habitat and cover for birds (Burton et al. 2011 at pp. 34-39). Severe annual browsing eventually leads to long-term loss of this component or, at a minimum, reduction of the woody plants' function along a stream. Woody plant use is observed within 1-m on each side of the greenline and the interval between plots. Observers determine the available current year's growth on key species (such as willow, alder, birch, aspen) within reach of a grazing animal. MIM has established use classes from slight to severe.

RESULTS and DISCUSSION

Data analyses are presented for each of three streams monitored by the MIM Project: Ladyfinger Gulch, Slate Creek and Flynn Creek. MIM combines certain metrics and calculates a plant successional status (or Ecological Status), a rating of vegetation erosion resistance (Greenline Stability Rating) and a Wetland Rating. Refer to Burton et al. 2008 (at pp. 38-40) for discussion of these indicators. MIM also quantifiably validates Proper Functioning Condition (a qualitative assessment) but is not discussed in this report (see Burton et al. 2011 at pp. 72-73). Additional information on stream analysis, statistical significance, and confidence intervals (95%) of the metrics can be found in Burton et al. 2011 (at pp. 119-131) and Appendix 2. Plant species codes can be found in Appendices 3c, 4c and 5c.

To eliminate repetition, the data and analysis section for Ladyfinger Gulch is the most comprehensive of all streams. Should questions arise about the general importance or applicability of MIM metrics for other streams, the reader should refer back to the discussion for Ladyfinger Gulch.

The USFS has assessed "existing conditions" of riparian areas for each BHNF allotment analysis. If existing conditions do not meet USFS established "desired conditions", changes must be made to management of an allotment to "move towards" the agency's goals and objects for desired conditions. Desired conditions are sometimes defined by quantifiable thresholds such as percent allowable bank alteration. There are also BHNF and Region 2 directives that apply, such as bank stabilization will be at least 74% (USDA 2006). Therefore, BHNF has the flexibility to make site-specific determinations and not all streams will be required to meet the same values for the same metrics. This makes for somewhat cumbersome presentation of the data in this report.

For all of the DMAs and data analysis considered in this report, all measurements will list 2009 data/information first and 2012 second.

Some of the MIM 2008 protocol (Burton et al. 2008) was refined by its developers, RMSMIM, L.L.C. in 2011 (Burton et al. 2011) in order to generate improved results. RMSMIM provided the MIM Project with a crosswalk to compare the Project's 2009 and 2012 data for changed metrics. However, at the time this report was going to press, the MIM Project considered it premature to use that crosswalk to compare data with absolute certainty because programming procedures for the crosswalk were still being tested. Therefore, where metrics cannot be directly compared between 2009 and 2012, or compared with caution, it will be noted in this report.

Ladyfinger Gulch Results

Ladyfinger Gulch (Appendix 3a) is a relatively narrow (less than 8-ft GGW), perennial stream in the northern Black Hills. Gradient is 3.5-5.0%. The uncommon foxtail sedge (*Carex alopecoidea*) occurs in Ladyfinger Gulch and is listed by the USFS as a Region 2 Sensitive Species. The stream partially meanders through mature spruce (*Picea glauca*) dominated overstory. In the uplands, there are indications of logging activity but it is well out of the stream reach and gulch. There were no activities or impacts by logging within or to the measured transect. There is one small ATV/livestock trail that bisects the stream. MIM procedures include not measuring the greenline or other metrics at crossings such as this. No sign of recent or recurring wild ungulate trampling/hoof prints were noted along the measured transect in either monitoring year.

Table 2 - Species Composition, Ratings and Plant Diversity Index for Ladyfinger Gulch, 2009 and 2012

Year	Dom Key Species	Mean SH Key Species (Inches)	Mean SH All Species (Inches)	Plots with Hydric Herb. (%)	Winward Stability Rating	Ecological Rating	Site Wetland Rating	Plant Diversity Index
9/26/09	Carex spp	15.7 (+/- 1.6)*	13.1 (+/- 1.6)*	56%	3.89/Low (+/- 0.4)*	26/Early	62/Good (+/- 4)*	12.2
10/14/12	CAUT	6.6 (+/- 0.8)*	5.3 (+/- 1.0)*	45% (+/- 6%)*	3.23/Low (+/- 0.2)*	22/Early (+/- 6)*	66/Good (+/- 3)*	8.8

*Where Confidence Intervals were available, they are presented (+/-) at 95%

For this table and all other tables of MIM sampling measures in this report, the result will have the measure and, if available, the 95% confidence interval for the measure in parenthesis ( ). For more information on confidence intervals see Appendix 2 and the MIM Handbooks.

Salient Points:

- Dominant greenline key species included sedge species (*Carex* species) in 2009, and northwest territory sedge (*Carex utriculata*) in 2012; both are riparian plants.
- Annual stubble height of key species was significantly different between years.
- Mean stubble height of all species was significantly different between years.
- Plots with hydric herbaceous species dropped 11% between 2009 and 2012.

Table 3 - Greenline to Greenline, Bank and Substrate Metrics for Ladyfinger Gulch, 2009 and 2012

Year	Mean GGW Feet (Meters)	Covered Banks (%)	Streambank Alterations (%)	Stable Banks (%)	Substrate Fines (%)	Substrate Median Size (mm)
9/26/09	7.41 (2.26) (+/- 0.3 m)*	68%	86% (+/- 5%)*	0%	14%	16
10/14/12	7.15 (2.18) (+/- 0.3 m)*	69% (+/- 5%)*	67% (+/- 6%)*	34% (+/- 5%)*	57% (+/- 12%)*	2

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- Mean greenline to greenline width (GGW) was relatively similar in 2009 and 2012.
- Percentages of the streambanks covered for both years were similar.
- Annual streambank alterations for both years were high, but dropped by 19% in 2012.
- Bank stabilization increased.
- The percent of substrate fines increased 43% and substrate median size decreased from 16-mm to 2-mm.

Table 4 – Woody Species Metrics for Ladyfinger Gulch, 2009 and 2012

Year	# of Plots	Woody Species in Greenline (%)	Plots with Woody Species (%)	Woody Use (%)
9/26/09	80	6%	28%	15% (+/- 13%)*
10/14/12	80	1% (+/- 6%)*	15%	48% (+/- 20%)*

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- The most common woody species that we encountered for all streams are: BEPA, DS, PICEA, RIBES, and SALIX (Appendix 3c).
- The percent of woody vegetation that made up the species composition was extremely low.
- Woody species use increased 33% from 2009 to 2012.

Ladyfinger Gulch Discussion

Greenline Species Composition

Greenline species composition is a long-term monitoring metric. A trend upward indicates the streambank is recapturing riparian vegetation and a trend downward indicates a loss of critical hydric vegetation and conditions associated with wetter sites. Ladyfinger Gulch's species composition is low at 50% hydric *Carex* species which occurred in only half of the plots in the monitoring transects. While the Site Wetland Rating indicates that plant species dominating the streamside in Ladyfinger Gulch are species that U.S. Army Corps of Engineers (USACE 2012) has rated as appropriate for wetlands, the majority of MIM vegetation ratings for Ladyfinger Gulch indicate poor conditions in 2009 and 2012.

The Winward stability rating for Ladyfinger Gulch is quite telling. It indicates that that the greenline stability has a low amount of deep rooted vegetation along the channel margin and therefore, plant resistance to erosion is insufficient to allow streambanks to be in an upward trend.

The BHNF incorporated adaptive management into the current range analysis and Decision Notice that included Ladyfinger Gulch (USDA 2008a, 2008b), which provides:

> *"Monitor riparian habitat and* [foxtail carex] *Carex alopecoidea sites (CAAL8-19, CAAL8-20) and remove livestock when trigger points are reached...Limit livestock use of riparian areas through felling of spruce trees or fencing or eliminate livestock grazing from Ladyfinger Gulch by connecting existing fences."*

The range allotment Decision Notice did not indicate a specific trigger for foxtail sedge, but the current BHNF Forest Plan states:

> *"Implement additional measures to assure avoidance of livestock use on Carex alopecoidea. Restrict livestock use of all or portions of 5 of the largest geographically spaced occurrences at site numbers: CAAL8-19, CAAL8-20, CAAL8-22, CAAL8-30, CAAL8-31.* STANDARD 2505 (f).

The *Carex alopecoidea* site CAAL8-19 is in Ladyfinger Gulch and plants extend from the headwaters through the MIM transect area downstream to the private land boundary upstream of the confluence of Ladyfinger and Beaver Creek. The small exclosure (ca 30m x 30m) BHNF constructed to meet the above directive is approximately 50 yards downstream from the MIM Project transect. From most recently released BHNF monitoring report (2009):

"…Some vegetation inside the exclosure appeared to be lightly grazed (not foxtail sedge) and a few cow hoof-prints were seen inside the exclosure, but appeared to be from a few stray animals. The grazing was likely the result of a combination of wildlife and livestock. The west fence of the exclosure bisects a dense patch of foxtail sedge. Foxtail sedge in the exclosure is very dense and robust with many fruiting heads, whereas foxtail sedge outside the exclosure (near the fence) had been trampled to the point of exposing bare soil with only a few tufts of vegetation remaining. Botanists pulled brush next to the fence in this area in an attempt to discourage further trampling."

The majority of the CAAL8-19 site is outside the exclosure in conditions represented by the MIM transect – and therefore in poor ecological condition. Foxtail sedge, a Region 2 Sensitive Species, is being managed primarily in poor ecological conditions in Ladyfinger Gulch.

With proper management, this little drainage should develop an upward trend in hydric species over time. 2012 was rated as a drought year in the Black Hills (U.S. Drought Monitor, Appendix 6) and drainages such as Ladyfinger Gulch were a focus for livestock when very little green, nutritious forage or free water were widely available within the pasture.

Stubble Height

Sufficient stubble height at the end of the growing season is important for and directly relates to plant vigor, healthy root development, intact streambanks, reducing erosion, maintaining the proper composition of streambank vegetation and other riparian functioning. The Stubble Height Review Team (2006) and MIM protocol (Burton et al. 2008, 2011) use the stubble height measurement to annually trigger when livestock grazing along riparian corridors has reached a point where they should be removed from the area; to determine if current grazing practices need to be changed; to compare the height of key species from year to year as indicators of changes in livestock use; and, to help determine the degree to which livestock grazing is meeting management objectives. Stubble height alone is not a substitute for vegetation condition or trend.

The Stubble Height Review Team assessed the available literature across the West, and reported that stubble height recommendations varied from 2.8 to 7.9 inches of residual forage, indicating that local scientific validation and field testing are needed to arrive at a reasonable numeric value. Stubble height could be used on the BHNF as a refined and reliable trigger for "desired riparian resource objectives within a reasonable time frame" if this monitoring approach was better calibrated locally, rather than

adopting an untested USFS height (discussed below). The Review Team also suggested that federal agencies not use stubble height as the sole means to achieve long-term riparian management objectives.

If stubble height and other metrics indicate management is not meeting desired conditions, the Stubble Height Review Team recommended that managers and permit operators make appropriate changes in a timely manner, known as "adaptive management". Adaptive management is an interdisciplinary planning and implementation process relying heavily on monitoring so that decisions are made as part of an ongoing process. Adaptive management involves planning, implementing, monitoring, evaluating, and incorporating new knowledge into management approaches based on scientific findings and the needs of society (Stankey et al. 2005). As described by the Idaho Stubble Height Report (2004), adaptive management requires developing specific riparian and stream management objectives. Grazing management plans should be designed to meet those objectives and long-term monitoring criteria to evaluate success (Burton et al. 2008 at 1).

The BHNF Forest Plan (USDA 2005) directive for residual forage levels is Standard 2505:

> *". . . prescribed for riparian areas in the allotment management plan (AMP) or the annual letter of operating instructions (AOI) to the livestock permittee. Residual levels will be based upon specific objectives for the location in question and will consider season of use and range conditions."*

Stubble height trigger points for Ladyfinger Gulch are to be met along the greenline (USDA 2008A) and follow the Forest Service R2 Range Monitoring Handbook (USDA 1996) and Watershed Conservation Practices Handbook (USDA 2006a, 12.1 - Management Measure 3) which recommend:

> *"Developing site-specific riparian stubble height standards depending upon habitat needs. … levels for carex and juncus species: 3-4 inches in spring-use pastures and 4-6 inches in summer or autumn use pastures to leave adequate residual stubble height to retain effective ground cover. Riparian areas with no carex and juncus require local stubble heights."*

Stubble heights for hydric species in 2009 and 2012 were within the 4-6-in stubble heights for autumn pastures (referenced above). Data is available but was not calculated for stubble height of non-key species alone. Therefore, mean stubble heights of all species includes key and non-key species.

It should be noted that species dominance changed between 2009 and 2012. 2012 was a severe drought year with insufficient stream flows (Appendix 6). Stubble heights are not comparable between different species so no conclusions can be made about specific species changes between 2009 and 2012, or if the residual height of 4-6 in is locally appropriate for these species.

Greenline to Greenline Width (GGW)

Greenline to greenline width was unchanged between monitoring years in Ladyfinger Gulch. Bank alteration, stability and substrate data suggest a reasonable assumption that this stream should be narrower and contain clearer running water. The ATV stream-crossing may be contributing to sediment load below the crossing, but cannot explain conditions above the crossing.

Streambank and Substrate Metrics

In assessing the physical condition of streambanks, it is imperative to discuss streambank alterations (an annual metric) together with streambank stability (a long-term metric). Streams strive to stabilize and can achieve a certain degree of repair from annual alterations. Streambank alteration can be used as a trigger for determining when livestock need to be moved out of the riparian area. Streambank alteration can be measured prior to livestock entry to isolate the added effect of wildlife or other uses that impair streambanks.

Most low-gradient streams naturally resist erosive actions and remain in a high stability state. In a study of over 760 stream reaches in seemingly a natural, undisturbed state: 66% had over 95% stability, 80% had over 80% stability and only 8% had less than 50% stability (Overton as cited in Cowley 2002). The conclusion was that *"natural disturbances can reduce bank stability, although the probability of occurrence is low."* Therefore, there must be some other non-natural annual disturbance that causes streambank disturbances to reach a point of high erosion and impairment to rooted vegetation.

The USFS recommends that for "normal" grazing administration in riparian areas, streambank alteration should be monitored and livestock moved before unacceptable levels of streambank trampling occurs (USDA 1996). The amount of trampling allowed is adjusted by stream type and desired conditions set by the local Forest Plan (USDA 1996). In the water influence zone next to perennial and intermittent streams, the USFS allows "*only those actions that maintain or improve long-term stream health and*

riparian ecosystem condition " (USDA 2006a, MM3k). Design criteria established to achieve this direction includes:

> *" Maintain the extent of stable banks in each stream reach at 74% or more of reference conditions. Consider degree of livestock trampling and riparian vegetation utilization on or immediately adjacent to stream banks when timing livestock moves between units."*

Ladyfinger Gulch's streambank stability rating was 0% in 2009 and increased to 34% in 2012. A higher level of stability was achieved, but is two times lower than the target of 74%, regardless of being relative to a reference condition. MIM Project suggests slight caution in interpreting this 3-year differential. Similar to stability metrics on Slate and Flynn Creeks, the MIM methodology for evaluating streambank stability changed between 2009 and 2011. However, the methodology change does not invalidate the level reflective of both years as extremely low, despite an increase in stability. The methodology in 2012 was quantitative, which calculated a 34% value with confidence intervals.

The Environmental Assessment for Ladyfinger Gulch (USDA 2008a) stated that streambank alteration directives from the Watershed Conservation Practices Handbook (USDA 2006a) do not allow an acceptable level of streambank alteration in Ladyfinger Gulch and the BHNF's interdisciplinary planning team chose 26% as the preliminary guideline for bank alteration. The team qualified this recommendation by stating that:

> *" . . . this trigger point has not been validated on the various stream types in the Black Hills, and may be adjusted over time to ensure that the long term desired condition of stream bank stability is achieved and maintained."*

Annual alterations were 86% and 67% in 2009 and 2012, respectively, two and a half to three times higher than the 26% preliminary guideline for bank alteration favored by the BHNF interdisciplinary planning team. With annual streambank alterations this high, Ladyfinger Gulch has no reasonable expectation to self-heal, unless management meets resource objectives and livestock are removed from the riparian area well before 86-67% annual streambank alterations occur.

The excessive degree of streambank trampling is adverse to water quality, stream temperature, streambed substrate, channel configuration, aquatic habitat, and shoreline vegetation composition. Low precipitation and low water flows during the 2012 drought were not the cause of excessive

sediment loads of 57% fines (<2-mm in size). The smaller the substrate's particle size, the less efficiently the channel can dissipate energy when flows do occur. The stream channel in Ladyfinger Gulch is in poor balance.

Woody Species

Woody composition on Ladyfinger Gulch was extremely low but similar between 2009 and 2012, yet woody species use increased three-fold. Woody species data are difficult to interpret. The long history of varied uses on Black Hills streams, of which livestock use has been on ongoing contributor, has led to Black Hills-wide loss of streamside shrub components. There were no specific adaptive management strategies or triggers for woody use or condition in the Ladyfinger Gulch Decision Memo (USDA 2009b) other than compliance with general BHNF Forest Plan Standard 2505(c):

> *"Utilization of willows, shrubs, woody vines or young deciduous trees (such as aspen, birch and oak) in any year by livestock or wildlife is limited to browsing 40 percent of the total individual leaders produced in that year (not to be confused with 40 percent use on each and every leader produced)."*

Field observations and MIM tabulations for the upper reach of Ladyfinger Gulch indicated that desirable riparian shrubs (e.g. willows) are very limited. The low representation of young age classes indicates no change on the horizon for woody species establishment or significant growth of existing woody species on Ladyfinger Gulch. Even a 40% use of the total leaders may be too high to sustain riparian shrubs in this DMA.

Ladyfinger Gulch Summary

Two BHNF assessments indicated Ladyfinger Gulch was not meeting USFS directives (USDA 2008a, 2008c). Ladyfinger was classified as "functional at risk" (using a qualitative method called properly functioning condition) and "not meeting the trend toward desired conditions" due to:

> *"Trampling and hummocking evident in riparian and springs, mostly decadent willow but with recent regeneration. Sensitive Plants – Carex alopecoidea and habitat being impacted by livestock… Need to maintain at least 74% stable stream banks (Watershed Conservation Practices Handbook measure 3k. USDA 2006).*

The MIM Project's 2009 and 2012 monitoring data support the BHNF's findings of not meeting or trending towards desired conditions. Where and when livestock use the stream more for watering rather than for streambank grazing, stubble height alone may not trigger an appropriate management response. In Ladyfinger Gulch, streambank alteration and effective ground cover may be better triggers for a more appropriate adaptive management response. Using more than one MIM metric strengthens the data needed by managers to make immediate changes, rather than relying on just one metric as a trigger and risking falling out of compliance with USDA Regional and local Forest Plan and Allotment Plan directives.

Slate Creek Results

Slate Creek (Appendix 4a), is a perennial stream which meanders through a fairly wide, open meadow in the central Black Hills. It has a fairly flat, low gradient of 1.5%. There are essentially no mature or healthy reproducing riparian shrubs in the entire meadow stretch of Slate Creek. In the uplands, there are no indications of recent logging activity although mining was a historical use decades ago, especially on the adjacent slate rock hillsides. There are no motorized vehicle crossings in or near the selected DMA. No sign of recent or reoccurring wild ungulate trampling/hoof prints were noted along the measured transect. Slate Creek is the only DMA where the MIM Team measured metrics both before livestock and after livestock grazing.

Table 5 - Species Composition, Ratings and Plant Diversity Index for Slate Creek, 2009 and 2012

Year	Dom Key Species	Mean SH Key Species (Inches)	Mean SH All Species (Inches)	Plots with Hydric Herb. (%)	Winward Stability Rating	Ecological Rating	Site Wetland Rating	Plant Diversity Index
9/19/09	Carex spp	13.3 (+/- 1.1)*	13.17 (+/- 1.1)*	74%	4.67/Mid (+/- 0.4)*	48/Mid	66/Good (+/- 3)*	8.3
6/10/12	CAAQ	12.9 (+/- 0.8)*	12.92 (+/- 1.0)*	66% (+/- 6%)*	6.88/ High (+/- 0.2)*	81/Late (+/- 6)*	90/Very Good (+/- 3)*	8.2
9/23/12	CAAQ	7.13 (+/- 0.5)*	7.14 (+/- 1.0)*	72% (+/- 6%)*	5.29/ High (+/- 0.2)*	51/Mid (+/- 6)*	74/Good (+/- 4)*	11.0

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- Dominant greenline key species included sedge (*Carex* species) in 2009, and water sedge (*Carex aquatilus*) in 2012, both riparian plants.
- Annual stubble height of key species, post-grazing, were different between years.
- In 2012, the annual stubble height for key species showed a 5.77-in difference between pre- and post-grazing.
- The change in mean stubble height for all species in September was significant between the years 2009 and 2012.
- Percent hydric herbaceous species was unchanged (within confidence intervals) between post-grazing years.
- Plant diversity index was unchanged (within confidence intervals) between post-grazing years.

Table 6 - Greenline to Greenline, Bank and Substrate Metrics for Slate Creek, 2009 and 2012

Year	Mean GGW Feet (Meters)	Covered Banks (%)	Streambank Alterations (%)	Stable Banks (%)	Substrate Fines (%)	Substrate Median Size (mm)
9/19/09	10.96 (3.34) (+/- 0.2 m)*	42%	66% (+/- 7%)*	6%	7%	45
6/10/12	8.37 (2.55) (+/- 0.3 m)*	96% (+/- 5%)*	1% (+/- 6%)*	80% (+/- 5%)*	17% (+/- 12%)*	32
9/23/12	9.55 (2.91) (+/- 0.3 m)*	88% (+/- 5%)*	26% (+/- 6%)*	66% (+/- 5%)*	14% (+/- 12%)*	22.6

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- The mean greenline to greenline width (GGW) decreased 1.4-ft in 3 years.
- Percent of streambanks covered improved from 42% to 88% in 3 years.
- Annual streambank alterations decreased from 66% to 26% in 3 years. There was 25% increased alteration in one grazing season (2012).
- Bank stabilization improved within 3 years.

Table 7 - Woody Metrics for Slate Creek, 2009 and 2012

Year	# of Plots	Woody Species in Greenline (%)	Plots with Woody Species (%)	Woody Use (%)
9/19/09	92	1%	2%	75% (+/- 20%)*
6/10/12	70	0% (+/- 6%)*	1%	10% (+/- 5%)*
9/23/12	80	0% (+/- 6%)*	1%	10% (+/- 5%)*

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Point:

- The percent of greenline vegetative species composed of woodies was nearly absent in 2009 and absent in 2012. Plots with woody species were too low to make conclusions. The fact that woodies are a missing vegetative component should be noted.

Slate Creek Discussion

Greenline Species Composition

Slate Creek has slightly over 70% hydric species composition, approximately 6-8% below the threshold of 80% for a BHNF MIM site downstream (USDA 2010a). There is still a strong component of upland, non-hydric species along the greenline, but with adaptive management practices to reduce impacts by livestock, Slate Creek may maintain, if not improve, along the Slate Creek DMA. The Project's MIM data of an upland graminoid component along the greenline was consistent with the 2010 BHNF findings from its MIM monitoring site in the Slate Creek area (USDA 2010a).

Stubble Height

The BHNF range Record of Decision listed >4-in stubble height to meet their established "desired conditions" for the entire grazing season, but the Range Appendix design criteria listed the Watershed Conservation Practices (USDA 2006) standards of 3-4-in for spring pastures and 4-6-in for summer-autumn pastures (USDA 2010a). Post grazing stubble heights for key species in Slate Creek 2012 were above both FS directives.

Greenline to Greenline Width (GGW)

Mean GGW decreased over 2-ft under current grazing practices. This narrowing demonstrates this stream is attempting to heal itself given a reprieve from high annual streambank alterations.

Streambank and Substrate Metrics

It was not apparent in the BHNF range analysis for Slate Creek (USDA 2010a, USDAb) whether a trigger had been set by the USFS for an acceptable percentage of streambank alterations.

In a 3-year time period, the MIM Project detected that stability improved dramatically from 6% to 66%. Bank stability of 74% is the established level to meet "desired conditions" as set forth by the BHNF (USDA 2010a, 2010b). Within the MIM Project's 3-year monitoring time span, Slate Creek's streambanks were considerably more vegetatively covered, an improvement towards meeting FS directives of having "effective ground cover". An increase in cover helps to keep banks stable and less erodible material will enter the stream.

There were extremely low flows in Slate Creek during September 2012 due to drought (Appendix 6). While streambanks were considerably more covered in 2012, the stream's substrate experienced an

increase in the percent fine substrate, which is not uncommon during drought as there is not enough flow to move normal sediment load.

Woody Species

Woody species were significantly absent on the DMA, therefore the MIM Project does not consider the 3-year monitoring effort is sufficient to draw conclusions. The low representation of young age classes indicates no foreseeable change for the establishment and growth of woody species on Slate Creek.

Slate Creek Summary

Positive changes were recorded for several MIM metrics for Slate Creek within a 3-year time span. Physical attributes are "looking up" for Slate Creek. MIM ratings indicate Slate Creek has average resiliency to disturbance. If the current drought continues, the Creek's reparation process could be affected. The amount of fine sediment in Slate Creek may be a high risk to aquatic habitat and desirable aquatic life. It is premature to predict if the appropriate riparian vegetative community will continue to recapture the site.

Flynn Creek Results

Flynn Creek (Appendix 5a), is a perennial stream which meanders out of a hardwood enclosure and into a relatively flat, open meadow in the southern Black Hills. It has fairly flat, low gradient (4.5%), much like other perennial streams in the southern Hills. In the uplands, there are no indications of recent logging activity. There are no motorized vehicle crossings near the selected DMA but a year-round dirt, two-track road is less than 100-ft from Flynn Creek. During MIM Project's data collection, no sign of recent or reoccurring wild ungulate trampling or hoof prints were noted along the measured transect. There is an old dam structure which can cause some pooling or saturated soils along the greenline.

Table 8 - Species Composition, Ratings and Plant Diversity Index for Flynn Creek, 2009 and 2012

Year	Dom Key Species	Mean SH Key Species (Inches)	Mean SH All Species (Inches)	Plots with Hydric Herb. (%)	Winward Stability Rating	Ecological Rating	Site Wetland Rating	Plant Diversity Index
9/29/09	CANE	8.34 (+/- 2.1)*	8.16 (+/- 1.4)*	36%	5.05/Mid (+/- 0.4)*	39/Early	64/Good (+/- 3)*	17.4
10/3/12	CANE2	5.67 (+/- 0.8)*	6.27 (+/- 1.0)*	32% (+/- 6%)*	3.95/Low (+/- 0.2)*	35/Early (+/- 6)*	63/Good (+/- 3)*	15.4

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- Dominant key species included Nebraska sedge (*Carex nebrascensis*) in 2009, and bluejoint reedgrass *(Calamagrostis canadensis*) in 2012; both are riparian plants.
- Annual stubble height of key species were different in 2009 and 2012.
- Annual stubble height for all species (key and non-key) were similar to residual key species heights.
- Percent hydric herbaceous species were low in 2009 and 2012.
- The Windward greenline stability rating dropped from mid to low between 2009 and 2012.

Table 9 - Greenline to Greenline, Bank and Substrate Metrics for Flynn Creek, 2009 and 2012

Year	Mean GGW Feet (Meters)	Covered Banks (%)	Streambank Alterations (%)	Stable Banks (%)	Substrate Fines (%)	Substrate Median Size (mm)
9/29/09	12.3 (3.75) (+/ 0.4 m)*	66%	62% (+/ 9%)*	22%	44%	45
10/03/12	7.09 (2.16) (+/ 0.3 m)*	66% (+/ 5%)*	33% (+/ 6%)*	50% (+/ 5%)*	35% (+/ 12%)*	11

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Points:

- Mean greenline to greenline width decreased 5.21-ft between years. However, 2009 plot data show a point at which measurements increased by about 100%. Field notes indicate an old dam may have created saturated soil that increased GGW. It is possible that due to the 2012 drought, there was not enough water to create the same type of wet conditions seen in 2009. Therefore, the MIM Project does not consider GGW results as a reliable indicator of livestock management changes or the stream "healing" itself.
- Annual streambank alterations decreased greatly from 62% in 2009 to 33% in 2012.
- Bank stabilization improved within three years to a value of 50% in 2012.
- Median substrate size decreased from 45-mm in 2009 to 11-mm in 2012.

Table 10 - Woody Species Metrics for Flynn Creek, 2009 and 2012

Year	# of Plots	Woody Species in Greenline (%)	Plots with Woody Species (%)	Woody Use (%)
9/29/09	100	18%	69%	34% (+/ 5%)*
10/3/12	80	3% (+/ 6%)*	65%	10% (+/ 5%)*

*Where Confidence Intervals were available, they are presented (+/-) at 95%

Salient Point:

- Flynn Creek had the highest percentage of greenline species composition by woody vegetation of all three creeks monitored in 2009, but dropped to 3% in 2012.

Flynn Creek Discussion

Greenline Species Composition

Dominant greenline key species included Nebraska sedge (*Carex nebrascensis*) in 2009, which changed to bluejoint reedgrass *(Calamagrostis canadensis*) in 2012. Both are species that USACE has rated as appropriate for wetlands. However, percent hydric herbaceous species was low (mid-30%) and indicates a less than healthy riparian area. Lack of deep-rooted, late seral vegetation decreases the ability to resist erosion. Desirable, appropriate riparian species may be dwindling and without a significant change in greenline disturbances resulting from livestock grazing, the DMA vegetation along Flynn Creek may continue to be replaced by drier, upland species.

The Watershed Conservation and Practices Handbook (USDA 2006) states:

> *h. Manage dry meadow and upland plant communities, including Kentucky bluegrass types, that have invaded into wetland/riparian areas in a manner that will contribute to their replacement over time by more mesic native plant communities to the extent practicable.*

Stubble Height

Stubble height measurements for key species were close to, or within the Flynn Creek's residual height recommendations ranging from 3-4-in on spring pastures and 4-6-in summer-autumn pastures (USDA 2006c). Stubble height was similar on all species (including non-key) on the DMA, which likely indicates livestock were not selective and equally grazed sedges and graminoids along the greenline.

Greenline to Greenline Width (GGW)

The interpretation of decrease in greenline to greenline width was discussed in the salient points of Table 9.

Streambank and Substrate Metrics

Maximum streambank alteration for Flynn Creek is set by the BHNF at 20-25% in order to "*still maintain their* [streambank] *integrity*" (USDA 2006c). Looking at each monitoring year independently, annual streambank alteration was 66% in 2009 and much lower at 33% in 2012. While alterations dropped between 3-year measurements, Flynn Creek's streambank alteration was 8-13% higher than the BHNF's acceptable values to meet its desired streambank conditions.

While bank stabilization increased during the 3 years between the 2009 and 2012 monitoring sessions, it was 30% below the USFS acceptable level of 80% (USDA 2006c). Achieving long-term bank stability

requires a commitment to minimize annual alterations. The MIM Project suggests slight caution in interpreting a 3-year differential in bank stability from 22% to 50%. Similar to stability metrics on Ladyfinger Gulch and Slate Creek, the MIM methodology for evaluating streambank stability changed between 2009 and 2011. However, the methodology change does not invalidate the level reflective of both years as well below BHNF thresholds, despite an increase in stability. The methodology in 2012 was quantitative, which calculated a 50% value with confidence intervals.

The amount of fine sediment for the Flynn Creek DMA was high at 35% in 2012 and there was a corresponding decrease in particle size. Part of this may be due to only 66% bank cover (not effective ground cover) and low water flows in 2012 due to drought (Appendix 6).

Woody Species

Woody species composition was low and field observations indicated desirable shrubs are limited. The low percent woody composition and limited representation of young age classes indicates low possibility for foreseeable change relative to woody species establishment and growth on Flynn Creek.

Flynn Creek Summary

The BHNF reported that the 2006 "existing conditions" for Flynn Creek were "*meeting desired conditions and proper functioning condition*" (USDA 2006b). Proper functioning condition is a qualitative assessment process that should be strengthened with quantitative monitoring protocols generating data such as greenline composition, woody species regeneration, and vegetation cross section composition (Woodward 2000) or monitoring with the MIM protocol. (The cross section composition is described in Woodward (2000) and USDA (1996) and is not part of MIM.)

The overall MIM Project's results for Flynn Creek do not support the BHNF's 2006 conclusion that Flynn Creek was meeting "desired conditions and proper functioning." Rather, the low percentage of hydric species, the Creek's insufficient bank stabilization and bank cover, and high percentage of fine materials comprising Flynn Creek's substrate, suggest that Flynn Creek is in a poor ecological condition. There is a high preponderance of early seral species in the DMA which indicates shallow rooted species which have a low ability to resist a downward trend in condition. Flynn Creek does not meet USFS directives. Although Flynn Creek was within stubble height guidelines, other metrics obtained at the DMA demonstrate stubble height alone is not a sufficient indication of Flynn Creek's condition.

CONCLUSION

The Black Hills Citizen MIM Project collected streambank and streamside vegetation data on DMAs on three streams located on the Black Hills in 2009 and 2012. While the Project's monitoring on the DMAs revealed that streambanks met minimum guidelines for key species stubble heights within the greenline, it is clear, as explained throughout, that this metric alone should not be relied upon as indicator of stream and streambank condition. Stubble height should be used as one trigger, along with other metrics, to ensure livestock grazing achieves management goals designed to ensure stream and riparian conditions trend toward the "desired conditions" established by the BHNF.

When quantified stream conditions are rated as high, the three streams may be expected to be able to provide the wide range of ecological and human services a perennial stream must contribute to support their ecosystems and USFS multiple uses that depend on them. The MIM Project found that none of the DMAs monitored in 2009 and 2012 rated high. One DMA is average and two are poor. Poor ratings suggest a high risk that future disturbances and stresses from livestock grazing, other conflicting uses, and climate change may result in increasingly diminished stream conditions. Streams showing marked improvements in streambank alteration levels can be expected to begin to recover and achieve an upward trend in stream channel shape necessary to perform riparian functioning (Burton et al. 2011 at 28).

- **Ladyfinger Gulch DMA**, a location of R2 Sensitive Species *Carex alopecoidea* (foxtail sedge), had good contribution of plant species appropriate to wetlands but was low in percent hydric species. Woody species composition was extremely low. The Project's MIM monitoring of Ladyfinger Gulch suggests a low ability to resist erosion (Winward Greenline Stability Rating); and in combination with an early ecological status (Greenline Ecological Status Rating) and low percent of hydric species, suggests the stream is vulnerable rather than resilient to disturbances. The percentage of bank cover (69%) must improve to meet BHNF's directive for "effective ground cover". The quantified stream conditions for Ladyfinger Gulch make it highly likely that streambank alterations (86% in 2009 and 67% in 2012) are too high to achieve improvement. Bank stability (34% in 2012) was far below 74% BHNF bank stability directives. The high percent of fine materials in Ladyfinger Gulch's stream channel is detrimental to desired aquatic life that reflects high water quality. Overall, the

MIM results indicate the stream's ecological condition is poor. In 2008 the BHNF identified Ladyfinger Gulch as "not meeting desired conditions" and in 5 years' time, it is not trending towards improvement.

- **Slate Creek DMA** had a good contribution of plant species appropriate to wetlands but woody species composition was extremely low and may be very slow to recover. The Project's MIM monitoring of Slate Creek reveals a mid-range ability to resist erosion (Winward Greenline Stability Rating) which, along with its mid-range ecological status (Greenline Ecological Status Rating), indicates an average resiliency to disturbances. The percentage of transect plots with hydric species must improve in order to meet the 80% hydric plant threshold established by BHNF. The percentage of bank cover at the monitoring site improved greatly and at 88% bank cover, it appears to be trending towards effective ground cover. Slate Creek showed a marked decline in streambank alterations (at 26% in 2012) and a corresponding improvement in stability (66% in 2012), which approach BHNF thresholds. However, despite improvements, the MIM Project data indicate that Slate Creek's current ecological condition is average. Slate Creek was identified by BHNF as not meeting "desired conditions" (USDA 2010a, 2010b). With improvements in livestock grazing, it appears this DMA could continue an upward trend in condition.

- **Flynn Creek DMA** had a contribution of plant species appropriate to wetlands, but the percentage of plots with hydric species is seriously under-represented (32% in 2012). Woody species composition is extremely low. The Project's MIM monitoring of Flynn Creek shows a decreasing ability to resist erosion (change from mid to low in Winward Greenline Stability Rating 2009/2012), which in combination with an early ecological status (Greenline Ecological Status Rating), indicated vulnerability rather than resilience to disturbances. The percentage of streambank cover was 66% and must increase in order to meet BHNF directives and goals. Streambank stability at Flynn Creek is only 50%, which does not meet the BHNF's 74% streambank stability requirement and does not ensure "effective ground cover". Streambank alterations at 33% must be reduced to meet 20-25% level established by the BHNF which should aid in reducing the high percentage of fine substrate in the stream channel. The MIM data indicate that Flynn Creek's ecological condition is poor. Flynn Creek was identified by BHNF in 2006 (USDA 2006b, 2006c) as "meeting desired conditions." This suggests a rapid deterioration in Flynn Creek's condition between 2006 and 2009 which warrants

increased monitoring activity by the BHNF in the area and application of different adaptive management actions than in the past.

The lack of reference conditions for Black Hills streams is a limitation to understanding the potential for streambanks and streamside vegetation. Despite this limitation, BHNF has set some thresholds and directives and has included "adaptive management" as means to meet BHNF's established "desired conditions". Burton et al. 2011 (at pp. 79-80) cite pertinent FS Handbook directives which are to be adopted to determine if resource objectives are being achieved.

The Black Hills Citizen MIM Project will continue to collect additional data on streams covered in this report as well as other streams monitored in 2010. The MIM Project hopes to contribute to the development of a body of MIM data for Black Hills streams which will assist in achieving a landscape containing resilient streams capable of providing the wide range of ecological and human services required of the Black Hills.

ACKNOWLEDGEMENTS

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APPENDICES

Appendix 1. Species Which Depend Upon Black Hills Riparian Habitats

Species tracked by the South Dakota Department of Game Fish & Parks and the Black Hills National Forest and include, but are not limited to:

Plants:

Botrychium multifidum leathery grapefern

Carex alopecoidea foxtail sedge

Cypripedium parviflorum lesser yellow lady's slipper

Listera convallarioides broadlipped twayblade

Lycopodium annotinum stiff clubmoss

Lycopodium complanatum trailing clubmoss

Platanthera orbiculata lesser roundleaved orchid

Salix candida sageleaf willow

Salix lucida ssp. *caudata* shining willow

Salix serissima autumn willow

Sanguinaria canadensis bloodroot

Aquatic macroinvertebrates:

Indicators of clean water (*Ephemeroptera, Plecoptera, Trichoptera*)

Speyeria atlantis pahasapa Black Hills fritillary

Oreohelix strigosa cooperi Cooper's Rocky Mountain snail

Amphibians and Reptiles:

Storeria occipitomaculata pahasapae B>ack Hills Redbelly Snake

Lithobates pipiens Northern Leopard Frog

Liochlorophis vernalis Smooth Green Snake

Fish:

Phoxinum neogaeus Finescale Dace

Birds:

Haliaeetus leucocephalus Bald Eagle, winter

Pandion haliaetus Osprey

Accipiter gentilis Northern Goshawk

Buteo platypterus Broad-Winged Hawk

Accipiter striatus Sharp-Shinned Hawk

Cinclus mexicanus American Dipper

Melospiza melodia Song Sparrow

Catharus fuscescens Veery

Hylocichla mustelina Wood Thrush

Melanerpes lewis Lewis' Woodpecker

Picoides dorsalis American Three-toed Woodpecker

Mammals:

Black Hills Bat species, including

Corynorhinus townsendii Townsend's Big-Eared Bat

Myotis thysanodes Fringed myotis

Sorex spp. Shrews

Glaucomys sabrinus Northern Flying Squirrel

Castor canadensis Beaver

Zapus hudsonius campestris Meadow Jumping Mouse

Martes americana American Marten

Appendix 2. Statistics and Confidence Intervals

For each of the DMAs, we have listed in tables a number of sampling measures. Where possible, we included the 95% statistical confidence interval associated with the measure. For some measures, the 95% confidence interval was either (1) not meaningful because the data was not based on a measurable value and standard deviation, or (2) the 95% confidence interval was not determined or available.

Those measures without confidence intervals for both 2009 and 2012 are:

Dominant Key Species

Plant Diversity Index

Substrate Median Size (mm)

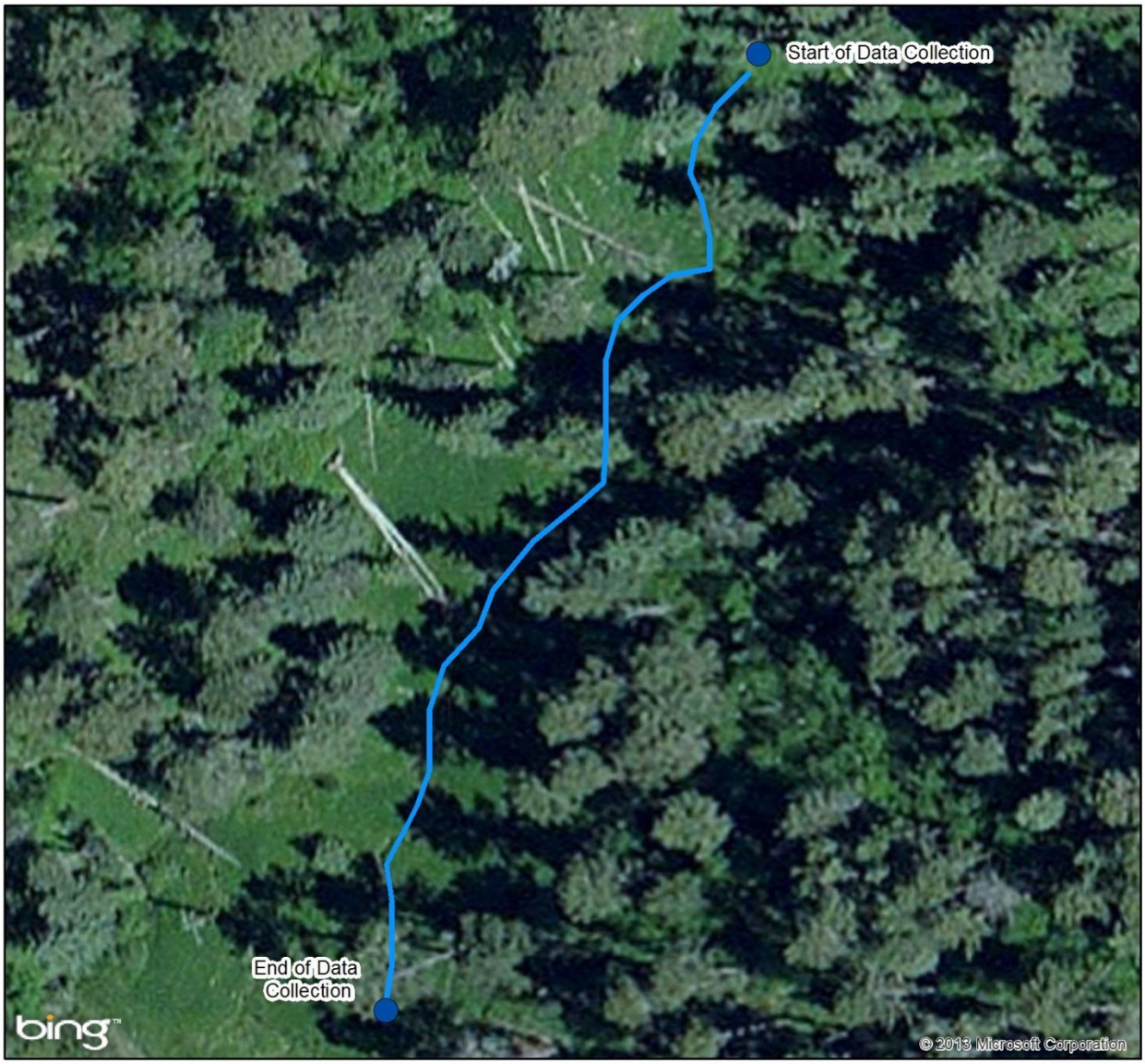
# of Plots

Plots with Woody Species (%)

For this report we have not attempted to compare two or more samples from different years based on statistical tests of significance.

Appendix 3a. Map of Ladyfinger Gulch

Lady Finger Gulch Study Location



Gradient: 3.5 - 5%
Note: Stream delineation is approximate.

Data collected in 2009 and 2012.

Appendix 3b. Photos of Ladyfinger Gulch

Photos clockwise (from top left):

Start of DMA 2009, Ladyfinger 2009, Ladyfinger 2012, & Start of DMA 2012

Appendix 3c. Ladyfinger Gulch Plant Species Composition

Code	Scientific Name	Common Name	Composition %	
			2009	2012
AGST2	*Agrostis stolonifera*	Creeping bentgrass	23.3%	39.5%
CACA	*Calamagrostis canadensis/Juncus balticus*	Blue-joint reedgrass/Baltic rush	0.4%	
CAREX	*Carex* species	Sedge species	15.4%	3.5%
CAUT	*Carex utriculata*	Beaked sedge	15.8%	10.3%
CIAR	*Cirsium arvense*	Canada thistle	0.4%	0.1%
DF	Dry Forb	Dry Forb	1.9%	0.1%
DS	Dry Shrub	Upland shrub	0.8%	
GABO2	*Galium boreale*	Northern bedstraw		0.1%
JUSP	*Juncus* spp.	Rush species	0.4%	
MEAR	*Mentha arvensis*	Field mint	1.1%	
MF	Mesic Forb	Mesic forb	0.8%	
MFE	Mesic Forb Early	Mesic forb early seral	2.3%	10.8%
MG	Mesic Grass	Mesic grass	1.1%	
PHPR	*Phleum pratense*	Timothy	1.5%	
PHPR3	*Phleum pratense*	Timothy		0.8%
PICEA	*Picea* spp.	Spruce species	3.8%	2.5%
POPR	*Poa pratensis*	Kentucky bluegrass	27.4%	24.0%
PRVI	*Prunus virginiana*	Chokecherry	0.4%	
RIBIES	*Ribes* spp.	Currant species	0.4%	
RK	Rock	Embedded Rock	0.8%	0.9%
SCIRP	*Scirpus* spp.	Bulrush species	0.4%	
SCMI	*Scirpus microcarpus*	Panicled bulrush	0.8%	
SCMI2	*Scirpus microcarpus*	Panicled bulrush		1.1%
TRRE3	*Trifolium repens*	White clover		3.2%
WD	Wood	Anchored Wood	1.1%	3.0%
			100.0%	100.0%

Appendix 4a. Map of Slate Creek

Slate Creek Study Location

Gradient: 1.5%

Data collected in 2009 and 2012.

Appendix 4b. Photos of Slate Creek

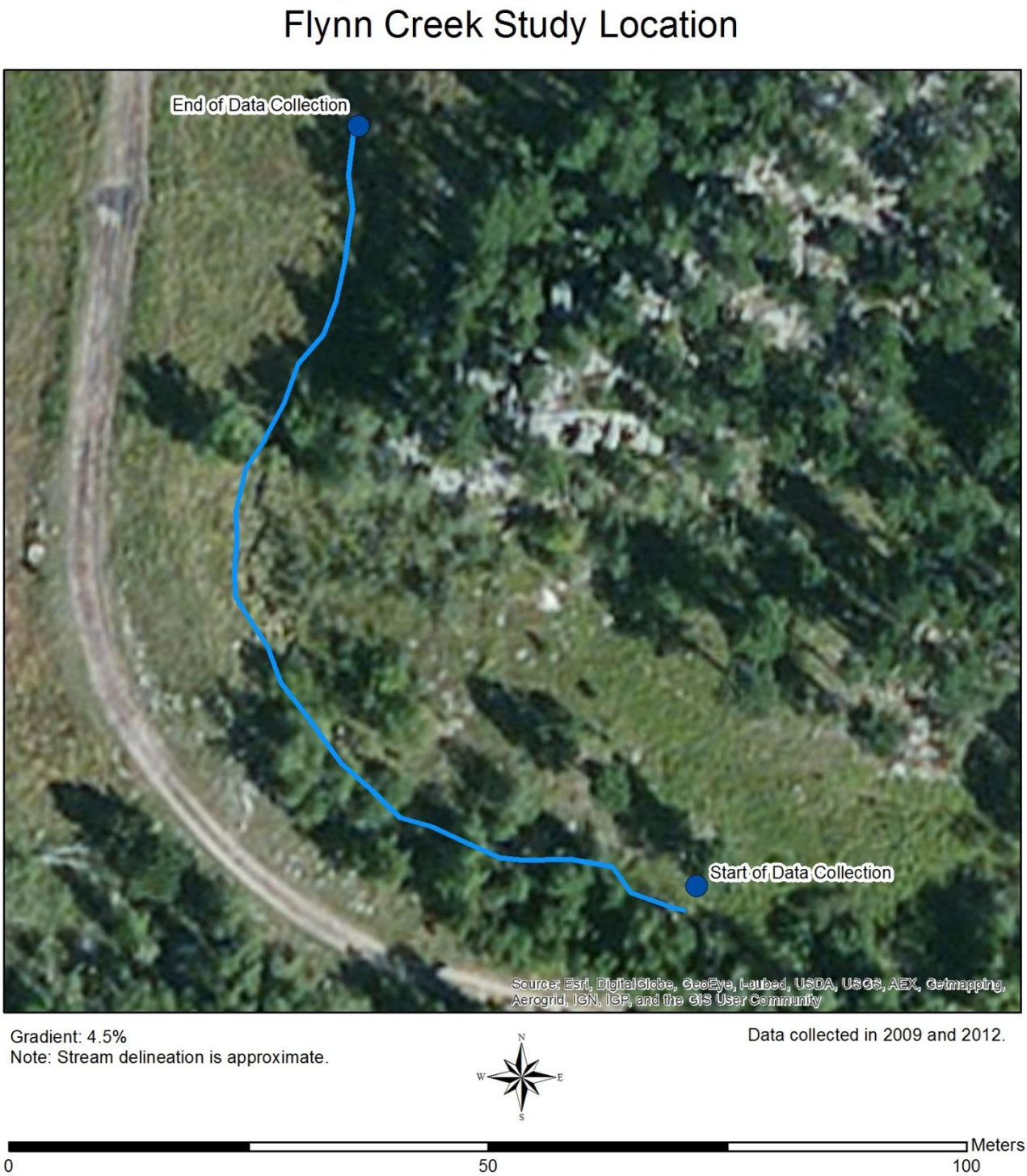
Photos clockwise (from top left)

Start of DMA 2009, Slate 2009, Start of DMA June 2012, & Start of DMA September 2012

Appendix 4c. Slate Creek Plant Species Composition:

Code	Scientific Name	Common Name	Composition %	
			2009	2012
ACMI2	*Achillea millefolium*	Common yarrow		0.4%
AGST2	*Agrostis stolonifera*	Creeping bentgrass	8.2%	23.7%
CAAQ	*Carex aquatilus*	Water sedge		28.8%
CACA	*Calamagrostis canadensis/Juncus balticus*	Blue-joint reedgrass/Baltic rush	3.4%	
CAHY4	*Carex hystericina*	Bottlebrush sedge		0.3%
CAREX	*Carex* species	Sedge species	37.6%	
CAUT	*Carex utriculata*	Beaked sedge	0.9%	15.7%
CIAR	*Cirsium arvense*	Canada thistle		0.1%
DF	Dry Forb	Dry Forb		0.6%
ELPA3	*Eleocharis palustris*	Common spikerush		0.6%
JUSP	*Juncus* spp.	Rush species	0.3%	
MEAR4	*Mentha arvensis*	Wild mint		0.6%
MFE	Mesic Forb Early	Mesic forb early seral	0.3%	3.3%
MFL	Mesic Forb Late	Mesic forb late seral		0.3%
PHAR	*Phalaris arundinacea*	Reed canarygrass	9.4%	
PHAR3	*Phalaris arundinacea*	Reed canarygrass		10.1%
PHPR	*Phleum pratense*	Timothy	1.3%	
POPR	*Poa pratensis*	Kentucky bluegrass	23.8%	9.9%
SALIX	*Salix* spp.	Willow species	0.6%	
SCMI	*Scirpus microcarpus*	Panicled bulrush	14.1%	
SCMI2	*Scirpus microcarpus*	Panicled bulrush		0.9%
TRRE3	*Trifolium repens*	White clover		4.8%
			100.0%	100.0%

Appendix 5a. Map of Flynn Creek



Appendix 5b. Photos of Flynn Creek

Photos clockwise (from top left):

Start of DMA 2009, Flynn 2009, Flynn 2012, & Start of DMA 2012

Appendix 5c. Flynn Creek Plant Species Composition

Code	Scientific Name	Common Name	Composition %	
			2009	2012
ACMI2	*Achillea millefolium*	Common yarrow		0.1%
AGST2	*Agrostis stolonifera*	Creeping bentgrass	18.9%	13.6%
BEPA	*Betula papyrifera*	Paper Birch	4.5%	2.4%
CACA	*Calamagrostis canadensis/Juncus balticus*	Blue-joint reedgrass/Baltic rush	2.8%	
CACA4	*Calamagrostis canadensis*	Blue-joint reedgrass		2.3%
CANE	*Carex nebrascensis*	Nebraska sedge	8.2%	
CANE2	*Carex nebrascensis*	Nebraska sedge		5.6%
CAREX	*Carex* spp.	Sedge species	4.8%	1.9%
CAUT	*Carex utriculata*	Beaked sedge	0.3%	1.4%
CIAR	*Cirsium arvense*	Canada thistle	1.7%	0.8%
CYOF	*Cynoglossum officinale*	Houndstongue		0.9%
DF	Dry Forb	Dry Forb	2.0%	0.5%
DG	Dry Graminoid	Upland grass		0.8%
DS	Dry Shrub	Upland shrub	1.7%	1.1%
EPCI	*Epilobium ciliatum*	Fringed willowherb		0.8%
EQLA	*Equisetum laevigatum*	Smooth horsetail		0.1%
EQUIS	*Equisetum spp.*	Horsetail species	0.3%	
GATR3	*Galium triflorum*	Fragrant bedstraw		0.4%
GLGR	*Glyceria grandis*	American mannagrass		0.6%
JUBA	*Juncus balticus*	Baltic rush	1.1%	0.4%
MEAR4	*Mentha arvensis*	Wild mint		1.6%
MF	Mesic Forb	Mesic forb	0.6%	2.6%
MFE	Mesic Forb Early	Mesic forb early seral	1.4%	0.5%
MFL	Mesic Forb Late	Mesic forb late seral		4.6%
MG	Mesic Grass	Mesic grass	0.3%	
MS	Mesic Shrub	Mesic shrub		1.9%
PHAR3	*Phalaris arundinacea*	Reed canarygrass		0.1%
PHPR	*Phleum pratense*	Timothy	3.1%	
PHPR3	*Phleum pratense*	Timothy		0.3%
POPR	*Poa pratensis*	Kentucky bluegrass	21.4%	36.6%
POTR	*Populus tremuloides*	Quaking aspen	3.7%	
POTR5	*Populus tremuloides*	Quaking aspen		0.3%
PRVI	*Prunus virginiana*	Chokecherry	1.1%	
RIBES	*Ribes* spp.	Currant species		0.9%
RIBIES	*Ribes* spp.	Currant species	0.3%	
RK	Rock	Embedded Rock	13.5%	10.2%
SABE	*Salix bebbiana*	Bebb willow	4.5%	
SCMI2	*Scirpus microcarpus*	Panicled bulrush		1.4%
SYOC	*Symphoricarpos occidentalis*	Western snowberry	2.0%	
TAOF	*Taraxacum officinale*	Common Dandelion		0.4%
TRIFO	Trifolium spp.	Clover species		0.8%
TRRE3	*Trifolium repens*	White clover		0.6%
URDI	*Urtica dioica*	Stinging nettle	1.4%	1.6%
WD	Wood	Anchored Wood	0.6%	0.4%
NG	No Greenline			1.30%
			100.0%	100.0%

Appendix 6. Drought Conditions for South Dakota 2009 - 2012.

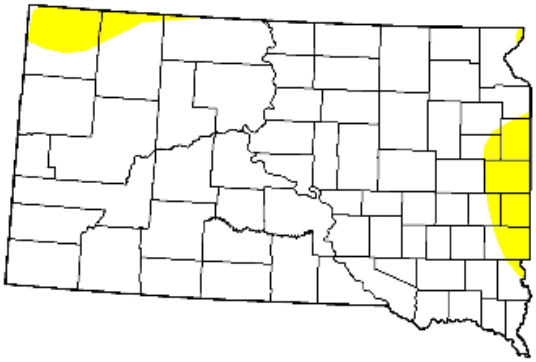
U.S. Drought Monitor

South Dakota

September 22, 2009
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	93.1	6.9	0.0	0.0	0.0	0.0
Last Week (09/15/2009 map)	94.5	5.5	0.0	0.0	0.0	0.0
3 Months Ago (06/30/2009 map)	85.8	14.2	0.0	0.0	0.0	0.0
Start of Calendar Year (01/06/2009 map)	99.5	0.5	0.0	0.0	0.0	0.0
Start of Water Year (10/07/2008 map)	73.9	26.1	0.8	0.0	0.0	0.0
One Year Ago (09/23/2008 map)	74.0	26.0	7.2	0.0	0.0	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

http://drought.unl.edu/dm

Released Thursday, September 24, 2009
Author: D. Miskus, JAWF/CPC/NOAA

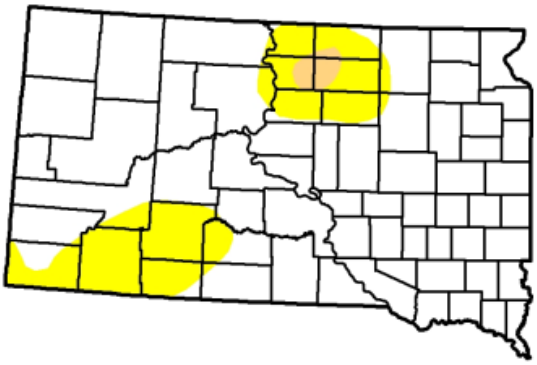
U.S. Drought Monitor

South Dakota

September 21, 2010
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	82.8	17.2	1.1	0.0	0.0	0.0
Last Week (09/14/2010 map)	84.0	16.0	2.8	0.0	0.0	0.0
3 Months Ago (06/29/2010 map)	100.0	0.0	0.0	0.0	0.0	0.0
Start of Calendar Year (01/05/2010 map)	100.0	0.0	0.0	0.0	0.0	0.0
Start of Water Year (10/06/2009 map)	97.0	3.0	0.0	0.0	0.0	0.0
One Year Ago (09/22/2009 map)	93.1	6.9	0.0	0.0	0.0	0.0



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

http://drought.unl.edu/dm

Released Thursday, September 23, 2010
Author: Richard Heim, NCDC/NOAA

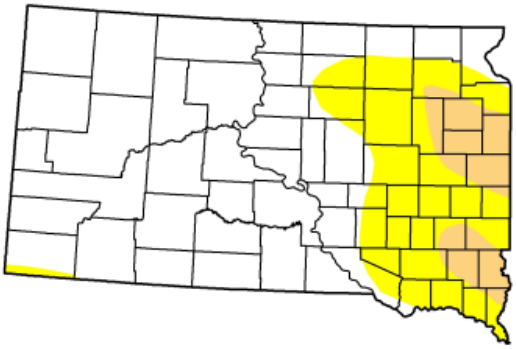
U.S. Drought Monitor

September 20, 2011
Valid 7 a.m. EST

South Dakota

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	71.39	28.61	7.36	0.00	0.00	0.00
Last Week (09/13/2011 map)	69.07	30.93	3.27	0.00	0.00	0.00
3 Months Ago (06/21/2011 map)	100.00	0.00	0.00	0.00	0.00	0.00
Start of Calendar Year (12/28/2010 map)	99.02	0.98	0.00	0.00	0.00	0.00
Start of Water Year (09/28/2010 map)	88.56	11.44	0.00	0.00	0.00	0.00
One Year Ago (09/14/2010 map)	83.97	16.03	2.81	0.00	0.00	0.00



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
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- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://drought.unl.edu/dm

Released Thursday, September 22, 2011
Michael Brewer, National Climatic Data Center/NOAA

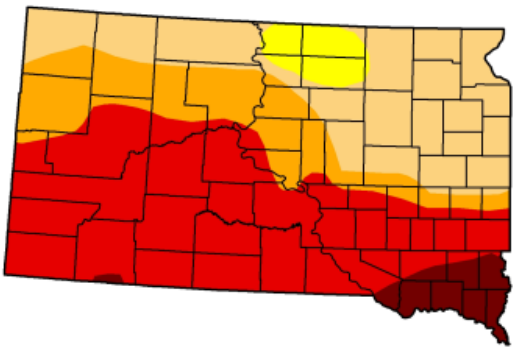
U.S. Drought Monitor

September 18, 2012
Valid 7 a.m. EST

South Dakota

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	96.07	68.27	50.61	4.77
Last Week (09/11/2012 map)	0.00	100.00	91.55	68.04	50.37	4.77
3 Months Ago (06/19/2012 map)	34.05	65.95	16.78	0.00	0.00	0.00
Start of Calendar Year (12/27/2011 map)	48.14	51.86	13.86	2.11	0.00	0.00
Start of Water Year (09/27/2011 map)	71.37	28.63	7.36	0.00	0.00	0.00
One Year Ago (09/13/2011 map)	69.07	30.93	3.27	0.00	0.00	0.00



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

http://droughtmonitor.unl.edu

Released Thursday, September 20, 2012
David Simeral, Western Regional Climate Center