Past and Current Vegetation Conditions of Core Sagebrush Habitat and Leks of the Greater Sage-Grouse (*Centrocercus urophasianus*) at the eastern most extent of its range in Western South Dakota (Butte, Harding and Fall River Counties, SD)

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Past and Recent Vegetation Conditions of Sagebrush Habitat and Habitat of the Greater Sage-Grouse (*Centrocercus urophasianus*) in Western South Dakota

by

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With a Special Acknowledgement to Art Carter, Chuck Berdan and Bob Hodorff, all former wildlife biologists with the SD Dept. of Game, Fish and Parks, Bureau of Land Management and USFS Buffalo Gap National Grasslands, respectively.

Introduction

This report is a compilation and summary of vegetation data collected in sagebrush steppe habitat in western South Dakota (SD) since 1992. Wildlife biologists began to collect data on greater sage-grouse (*Centrocercus urophasianus*) numbers in 1970 and collected habitat information beginning in 1992. Data collected in 2012 in Harding, Butte, and Fall River Counties in SD are the most recent. Data contained in this report can be considered baseline data and potentially the initial phase of a long-term monitoring program of sagebrush steppe habitat in western SD. Vegetation data in this report will be summarized and displayed at various spatial scales, the smallest is the individual site level, and then county, and finally data compiled and summarized for western SD.

Vegetation characteristics thought to be important for greater sage-grouse are summarized and displayed in tables and graphs by year for comparison purposes. These comparisons are done to demonstrate that vegetation trends can be viewed at various spatial scales with the same data. Most site level comparisons will be displayed in tables in Appendix at the end of the report. Data summaries available from other studies in the same areas were included (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011).

The project area includes greater sage-grouse habitat. Greater sage-grouse is a bird that currently inhabits the western portion of SD (Harding, Butte, and Fall River Counties, Figure 1) and is a sagebrush obligate. South Dakota's sagebrush habitat represents the eastern most current and historical range of greater sage-grouse. Because SD's habitat is on the fringe and somewhat fragmented from larger contiguous sagebrush habitats in Wyoming, Montana and North Dakota, it may be one of the first areas to show declines in healthy sagebrush and sage-grouse abundance and distribution.

Sagebrush steppe habitat is also desirable habitat for the short-horned lizard (*Phrynosoa hemandesi*), sage thrasher (*Oreoscoptes montanus*), sagebrush vole (*Lemmiscus curtatus*), and pronghorn (*Antilocapra americana*) and many other species not yet identified as at risk. The goal for sage-grouse management by the South Dakota Game, Fish and Parks (SDGFP) is to monitor and maintain a sage-grouse population and habitats consistent with the ecological, social, and aesthetics values of SD citizens while addressing the concerns and issues of both residents and visitors of SD (SDGFP 2008). Sagebrush habitat in western SD is currently managed by SDGFP, Bureau of Land Management (BLM), the United States Forest Service,

Buffalo Gap National Grasslands (BGNG), SD School and Public Lands, private landowners, and possibly others. Sage-grouse populations are counted jointly among SDGFP, BLM and BGNG by conducting spring bird counts on known leks.

Objectives

Project objectives were to:

1. Summarize available sagebrush steppe vegetation data that has been collected in western SD` from 1992 to 2012.
2. Develop a baseline data set to document past and current vegetation condition and trend of sagebrush steppe habitat, particularly vegetation characteristics that may be important for sage-grouse, and
3. Examine and compile information about sagebrush habitat restoration methods.

Unpublished vegetation data collected in 1992 and 1993 near and at known sage-grouse leks in Harding and Butte Counties are compared to data collected at the same lek locations in 2012 using the same data collections methods. The 1992-93 data is referred to as "Carter data" in reference to Art Carter, a retired SDGFP Wildlife Biologist who, together with Chuck Berdan, BLM, and Bob Hodorff, BGNG, initiated vegetation data collection in 1992. The Carter data was collected in areas determined at the time to be some of the best sage-grouse habitat. Data collected by other studies between 1992 and 2012 are included as tabular summaries or figures within Harding, Butte, and Fall River Counties, but are often at different locations (some random, others where sage-grouse were found). We have compiled this data including GPS coordinate information which will give researchers a spatial component of this long-term data set.

A similar summary of data collected in sagebrush steppe habitat throughout the Buffalo Gap National Grasslands (BGNG) in Fall River County is also included. This data has been collected in three time periods (1992, 2003, and 2012). Carter data collected in 1992 was from a smaller portion of the sagebrush steppe habitat located in the northwest portion of BGNG. It is summarized and presented as part of the long-term County summaries. Data collected in 2003 (SDGFP and BGNG) and 2012 were collected from the same locations in Fall River County.

The various forms of data from all sources were not collected using the same methodologies. One recommendation resulting from this project is the need to standardize vegetation data collection methods for all three Counties. Having comparable data will make future studies, data collection, and potential vegetation monitoring more uniform and give it more power for determining vegetation trend. It is best for vegetation and sage-grouse monitoring projects to have specific objectives and goals determined before monitoring details are finalized and results from this project may aid towards strategic planning efforts.

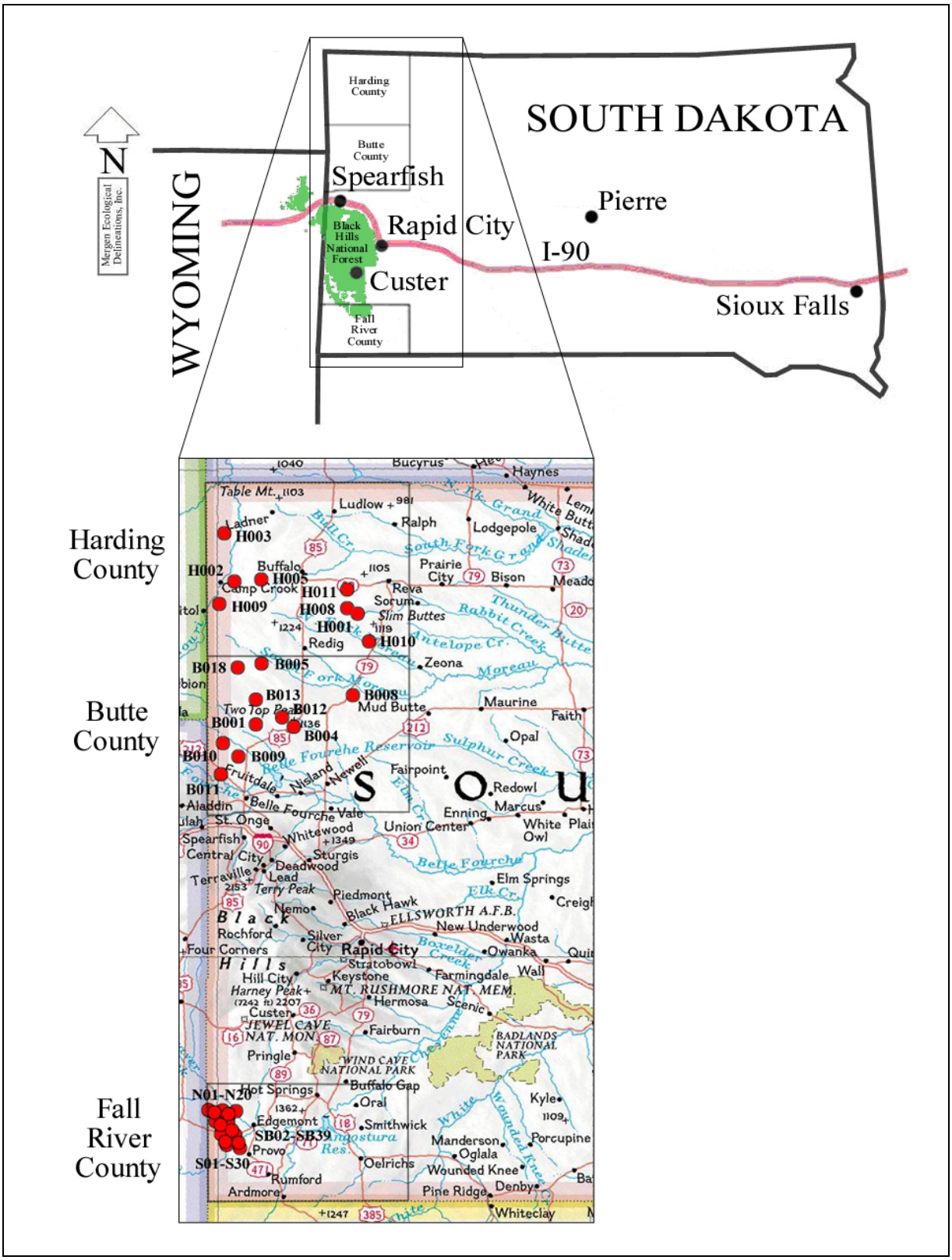

Figure 1. Vicinity map of the western part of South Dakota. The areas with the red dots represent locations within the sagebrush-steppe ecotype where data were collected within western South Dakota (Harding, Butte, and Fall River Counties).

Methods

Method instructions were not included with the Carter data but former biologists that worked on the original project were consulted. The Carter data was collected in 1992 and 1993. Some data for a particular lek location were collected in both years. In a summary of the Carter data, data collected from these two years were combined to simplify comparisons. The 1992-93 data can be thought of as baseline data for sagebrush habitat 20 years ago.

The Carter sites in Butte and Harding Counties were lek locations identified using Natural Resources Conservation Service (NRCS) soil survey maps. In 2012, Global Position Coordinates (GPS) of the Carter locations were generated, downloaded to a handheld GPS unit and used to re-locate the original Carter sites in Harding and Butte Counties. In the process of re-sampling the Carter sites in 2012, it was discovered that several of the sites were marked with a green t-post and wooden survey stakes that marked transect locations of the original Carter data. The sites marked with permanent markers were sites that Art Carter and Chuck Berdan determined to be some of the best habitat for sage-grouse in northwestern SD. Using the original maps to generate GPS coordinates in both Harding and Butte Counties generally worked well enough to get one within sight of previously placed t-posts and wooden stakes enough times that one may be assured the 2012 locations highly correspond to the original Carter locations. If not exactly placed, the 2012 sites were very near the original sites where data was collected in 1992-93. A few 2012 sites were moved or not sampled because of access issues across private lands. The Carter data was collected at additional locations radiating out from the center of the study sites, however the distance or directions were unknown and sample sizes varied in 1992-93. The 2012 data was only collected from the center of the study sites.

In Fall River County, an original GPS file with coordinates labeled as UTM NAD83 (Universal Transverse Mercator coordinate system, North American Datum 83) was downloaded to handheld GPS units. These points were located in the field and in most cases the GPS coordinate corresponded to the previous study with 20-year old green t-posts and wooden stakes. Previously placed t-post and wooden stakes were found on approximately 65% of the 72 sites. In some instances, the specified location lacked a t-post or wooden stake and a new location (GPS coordinates) was recorded and data was collected. New locations were selected within sagebrush steppe habitat and transect locations were selected to remain within an area of similar sagebrush density. Newly placed transects were orientated along a similar contour to reduce site variability.

Methods used in both areas (Carter data and 2003 Fall River data) included collecting canopy cover and frequency by species using the Daubenmire (1959) method along two parallel, 30 m long transects. Transects are 20 m apart and canopy cover by species, total cover, litter, bare ground, and rock were estimated at 1 m intervals along each transect. Therefore, canopy cover and frequency data were collected within thirty $0.1m^2$ plots along each of two transects for 60 total estimates per site. Another method was to measure herbaceous plant height. The tallest forb and tallest graminoid was collected within each of the thirty $0.1m^2$ plots along each transect for an average tallest forb and tallest graminoid height.

In Harding and Butte Counties, Robel pole (Visual Observation Readings or VOR) data was collected that included both a high and a low reading. This was collected along a 200 m transect

at 10 m intervals. Four readings per station were collected and data were averaged. The high estimate gave a reading of the greatest height of vegetation observed on the Robel pole. The low measurement recorded the lowest ½ inch band width visible. VOR data was not collected in Fall River County. VOR data collected in 1992-93 was always recorded as an even number band and the band width could not be determined. For lack of knowing the band width, the 1992-93 data was assumed to be ½ inch bands because a 1-inch band would have made the residual vegetation height illogical. The 1992-93 VOR data should not be considered as baseline information until knowledge of which incremental reading can be resolved. Therefore, as of this report, no direct comparison of 1992-93 VOR has been included.

Shrub heights and shrub densities were also collected by species within a belt transect 10 m wide by 30 m long in 2012 in Harding and Butte Counties. Shrub heights were measured to the nearest 5 cm within the belt. Shrub height and shrub density data was collected in 1992-93 in Harding and Butte Counties, but various areas of the belt transect was used, often based on shrub densities encountered at a site. Plot shape also varied. The 1992-93 belt transects were various sized sample areas, but were generally set at 450 m^2 (15 m x 30 m) or less when noted on the data sheets. The 1992-93 data were converted to a 450 m^2 area (15 m x 30 m) if actual area surveyed was not recorded; an appropriate conversion factor was used for plot sizes less than 450 m^2. For comparison with 2012 data, all 1992-93 shrub data was converted to shrub numbers per category based on an area of 300 m^2 and plotted for Harding and Butte Counties. Shrub densities were converted to shrubs per m^2 for comparisons.

Since the 2012 data could be the initial phases of long-term monitoring, data summaries and comparisons are made at the individual site level, county level, and summary comparison for all 3 counties representing western SD. The data could also be summarized and compared based on individual ranch plans (Harding and Butte County data) or by specific allotment and pastures (Fall River County data). Land and wildlife managers knowledgeable of these specific counties, sagebrush, and sage-grouse or other species may have better ideas as to how data could be summarized for their specific purposes and objectives. This project and report offer the 3 agencies (SDGFP, BLM and BGNG) time to discuss the data, relate it to agency planning efforts, and decide how best to analyze the data. Other summaries could easily be accomplished with the current data stored as an Excel file.

The 1992-93 data included many unknown plant species. Some species were identified by 4-12 letter codes, which do not match any plants known or suspected to occur in western South Dakota. Therefore, we retained or assigned all plant species or plant species codes with a number. Some of the unknown plants may be represented by several unknown codes because they were collected by different persons over different years. Throughout all the tables we included the scientific name of each plant species only. In Appendix E is the species list for all three counties combined. This species list can be easily referenced for the PLANTS (http://plants.usda.gov/java/) database code, scientific name, common name, and codes used in the past. Tables listed in Appendix Tables generally contain the most common or most frequent plant species and often do not list every species (including unknowns) within the list. All species are included on the digital files of data for each county.

Details of all sample methodologies are described in the Methods section in Appendix E. Data compiled from other studies list reference citations. Refer to each citation for specific methodologies.

Canopy cover data was summarized as percent canopy cover by life forms, bare ground, litter, dung, rock, and individual plant species. Percent frequency of life form, bare ground, litter, dung, rock, and individual plant species was also included in tables to show if a plant was rarely observed or frequently occurred at each site. An Index also calculated is a product of percent canopy cover and percent frequency. An Index is just another method that can give temporal data more stability between years when data comparisons are made. Cover of some perennial species can change between years base on preceding precipitation and grazing intensity, however the frequency of occurrence may remain similar. All data comparisons of between and among years were made graphically, by percentage changes, calculated differences, or using simple linear regression (trend lines) for graphic displays only. Statistical test procedures were not included at this time. Data will be further analyzed and published at a later date.

Project Purpose and Needs

Carter data represents some of the best leks and sage-grouse habitat known in 1992. The areas studied may be of greatest biological importance and should be considered for conservation of some of the most productive locations that meet life history requirements of sage-grouse in western SD.

The purpose of this project was to organize and compile available data. The provided data baseline can be used to initiate a discussion among agencies to look at the feasibility and implementation of a long-term sage-grouse and sagebrush habitat monitoring. Comparisons between years were to demonstrate changes in vegetation such as canopy cover, frequency, density, heights, or other vegetation characteristic. Comparisons were generally variables that have been identified as important for sage-grouse (Connelly 2000) or variables that demonstrate potential ecological consequences.

The needs are to assure management of greater sage-grouse and other sagebrush steppe species are considered in management decisions and provide managers the best available data and information to maintain and/or restore areas within this unique ecological community.

This study and future publications will provide land managers with quantitative vegetation data concerning sagebrush habitat of some of the most important sage grouse breeding areas and best habitat identified in SD and provide a detailed vegetation description of the past and recent sagebrush habitat within the eastern most distribution of greater sage-grouse. Managers will have quantitative spatial data at a landscape scale to map and analyze risk and propose the necessary conservation, management plans, and restoration measures to maintain good management practices and to prevent further habitat degradation, loss, or fragmentation.

Results and Discussions

Data collected were summarized into tables and are arranged in Appendix A-C by county. Currently, all data is designated for internal use only until inter-agency coordination can be completed and final publication of data. For purposes of sensitivity of data and lek locations, all

raw data for Appendices A-D and G are retained for internal use only. The plant species list with codes, life forms, common plant names, and scientific names and all methodologies used to collect the vegetation data in this study are in Appendix E. Precipitation data is in Appendix F.

Vegetation characteristics of total vegetation cover, graminoid cover, forbs, shrubs, litter cover, bare soil, big sagebrush (*Artemisia tridentata*) cover, also shrub, graminoid, and forb heights, and VOR were compared. Shrub density was also included. Most dominant plant species were included in tabular comparisons among sites. Because GPS coordinates were taken for each individual site, the dataset can be easily incorporated into ArcView for both spatial and temporal display based on future project objectives.

Individual site comparisons

Data for each site located within each of the three counties were summarized by year and are displayed in Appendix A, B, C for Harding, Butte, and Fall River Counties respectively (data for internal use only). Six sites are directly compared in Harding County, 7 sites in Butte County, and 72 in Fall River County. Some of the observed differences among individual sites are discussed for Harding County and Butte County only.

Harding County (Individual leks 1, 2, 3, 5, 9, and 10)

Details can be viewed in tables for the 6 direct individual lek comparisons for Harding County in Appendix A (data for internal use only). Comparing a site over time can give very specific species trend data for each site. Although these locations are identified as leks, they represent sage-grouse and sagebrush habitat and may be the center of a lek, adjacent to a lek, or be some unknown distance from a lek.

Lek 1

Total graminoid cover decreased 13% from 1992-93 to 2012. Blue grama (*Bouteloua gracilis*), western wheatgrass (*Pascopyrum smithii*), and all bluegrass species combined (*Poa* spp.) decreased 41%, 6%, and 4% respectively. Buffalograss (*Bouteloua dactyloides*) and combined Japanese brome (*Bromus arvensis*, also known as field brome) and downy brome (*Bromus tectorum*, also known as cheatgrass) increased 15% and 2% respectively. Total shrubs increased 2% which was an increase of big sagebrush.

Lek 2

Total grass cover decreased 46% and total forb cover decreased 33% from 1992-93 to 2012. Blue grama, western wheatgrass, all Carex species, and all bluegrasses combined decreased 6%, 12%, 4% and 2% respectively. Total shrub cover remained similar, but big sagebrush increased about 6% over this period. Fringed sagewort (*Artemisia frigida*) decreased about 6% also over this period. The amount of litter decreased about 50% and bare soil increased 29% on lek 2.

Lek 3

Total grass cover increased 60% and total forb cover increased 8% from 1992-93 to 2012. Blue grama, buffalograss and green needlegrass (*Nassella viridula*) all increased 4% while western wheatgrass increased 11%. Total shrub cover was similar, but big sagebrush decreased about 1% over this period. Fringed sagewort increased about 2% over this period. The amount of litter increased about 76% and bare soil decreased 78% on lek 3 over this time period.

Lek 5

Total grass cover increased 48% and total forb cover decreased 17% from 1992-93 to 2012. Blue grama increased 27% while western wheatgrass remained near equal. All the Carex species combined increased about 8%. Total shrubs and big sagebrush decreased 17% over this period. Litter cover decreased about 22% and bare soil decreased by 32% on lek 3 over this time period. Most forbs decreased on this lek over time.

Lek 9

Total grass cover decreased 21% and total forb remained the same while total shrub cover increased 9% (8% increase in big sagebrush) from 1992-93 to 2012. Blue grama increased 39% and western wheatgrass decreased 22% on this lek over time.

Lek 10

Total grass and total forb cover decreased 13% and 22% from years 1992-93 to 2012 while total shrub decreased about 6%. Blue grama increased 9% and western wheatgrass and all bluegrasses decreased 8% on this lek. Most graminoids and forbs decreased with the exception of cheatgrass (*Bromus tectorum*) and field brome (*Bromus arvensis*) which increased about 0.5%. All the Carex species combined decreased about 2%. Total shrubs decreased 6% over this period including about a 1% decrease of big sagebrush and loss of silver sagebrush (*Artemisia cana*) and broom snakeweed (*Gutierrezia sarothrae*).

These observed changes at the site level were among some of the most dominant plant species recorded. Canopy cover was only discussed, but frequencies were also observed. These differences noted are for single site comparisons only. A single site (2 transects of canopy cover data) compared to a single site about 20 years later show some mixed results in that some sites had increased amount of canopy cover while other showed decreased results.

Harding County Combined Lek Results

Details can be viewed between averages from all transect data collected in 1992-93 from 7 sites and the 7 collected in 2012 on the Harding County leks in Appendix A (data for internal use only). Comparing at the county level can give trend data for lek conditions over time. It may be possible to extrapolate the data for the general sagebrush habitat condition and trend within Harding County. Comparisons between life forms, litter, bare ground and plant species with values greater than 1% were reviewed to determine if changes were observed between the 1992-93 Carter data compared to data collected in 2012.

Total vegetation cover increased approximately 6%, graminoid cover remained equal, but there were declines of 10% and 12% for total forb and total shrub cover respectively. The frequency that shrubs were recorded over the 20-year period was about 29% less in 2012 compared to 1992-93. Canopy cover of lichen species combined decreased about 4% while frequency of lichen increased slightly (5%). Big sagebrush cover declined 6-7% and frequency of big sagebrush declined 10%. Broom snakeweed, although less than 1% in canopy cover, doubled in both cover and frequency over the same time period.

Graminoid cover remained about 57-58% over the 20-year period. However, there was a major shift in species composition over this same time period. Blue grama and buffalograss increased

3-4% in cover and 10-15% in frequency while four other major forage grasses declined. Canopy cover of needle and thread grass (*Hesperostipa comata*) and green needlegrass decreased about 2-4% and frequency of occurrence of needle and thread grass decreased by 9% while it increased by 7% for green needlegrass. Prairie Junegrass (*Koeleria macrantha*) declined by about half for both cover and frequency while western wheatgrass declined over 7%. Frequency of occurrence of western wheatgrass increased about 7% from 1992-93 to 2012.

Fringed sagewort remained the same and pricklypear (*Opuntia* spp.) declined about half, although it represented less than 2% cover. Scurfpeas species (*Psoralidium* spp.) combined declined about 5% and frequency declined about 25% overall. Most other forbs recorded in 1992-93 showed decline in cover when compared to 2012 data. Forb cover represented by many species with low cover (<1%) and frequency amounts.

Figure 2 illustrates two methods this data can be used for long-term monitoring. The top two graphs show averages by sample periods for total vegetation cover, total graminoid cover, total forb cover, and total shrub cover. Along with values recorded in 1992-93 and 2012 are long-term means. Long-term means were calculated as an average of all sample periods, in this case there were only 2 sample periods. The long-term mean, also called the running average, gives a true long-term average in Harding County for each specific variable. It is only calculated for 4 variables in Figure 2, but can be calculated for each variable. Data averages collected in 1992-93 and 2012 can be compared with each other and with the long-term mean.

Total vegetation cover illustrates an increase, total graminoid cover little or no change, and total forb cover a decrease over the two sample periods. Total shrub cover shows a greater decrease compared to the previous 3 variables. Also included are values for big sagebrush and broom snakeweed. Big sagebrush was similar to the long-term mean value of total shrubs in 1992-93, but has since declined in canopy cover over the near 20-year period. Broom snakeweed shows very little change over time and represents very little canopy (less than 0.5%) cover either year.

The bottom two graphs show average values recorded in Harding County of the major forage grasses recorded and primary weedy grasses. Blue grama and buffalograss both show increases over time in canopy cover while needle and thread, prairie Junegrass, green needlegrass, and western wheatgrass all show decreases in canopy cover. During this same period there has been an increase in canopy cover of cheatgrass while field brome and a combined category of these two brome species used in 1992-93 show declines. Graphically, the brome species shows canopy cover values less than 1%; however, it can also be viewed as an increase in these species, particularly cheatgrass at 5 times greater.

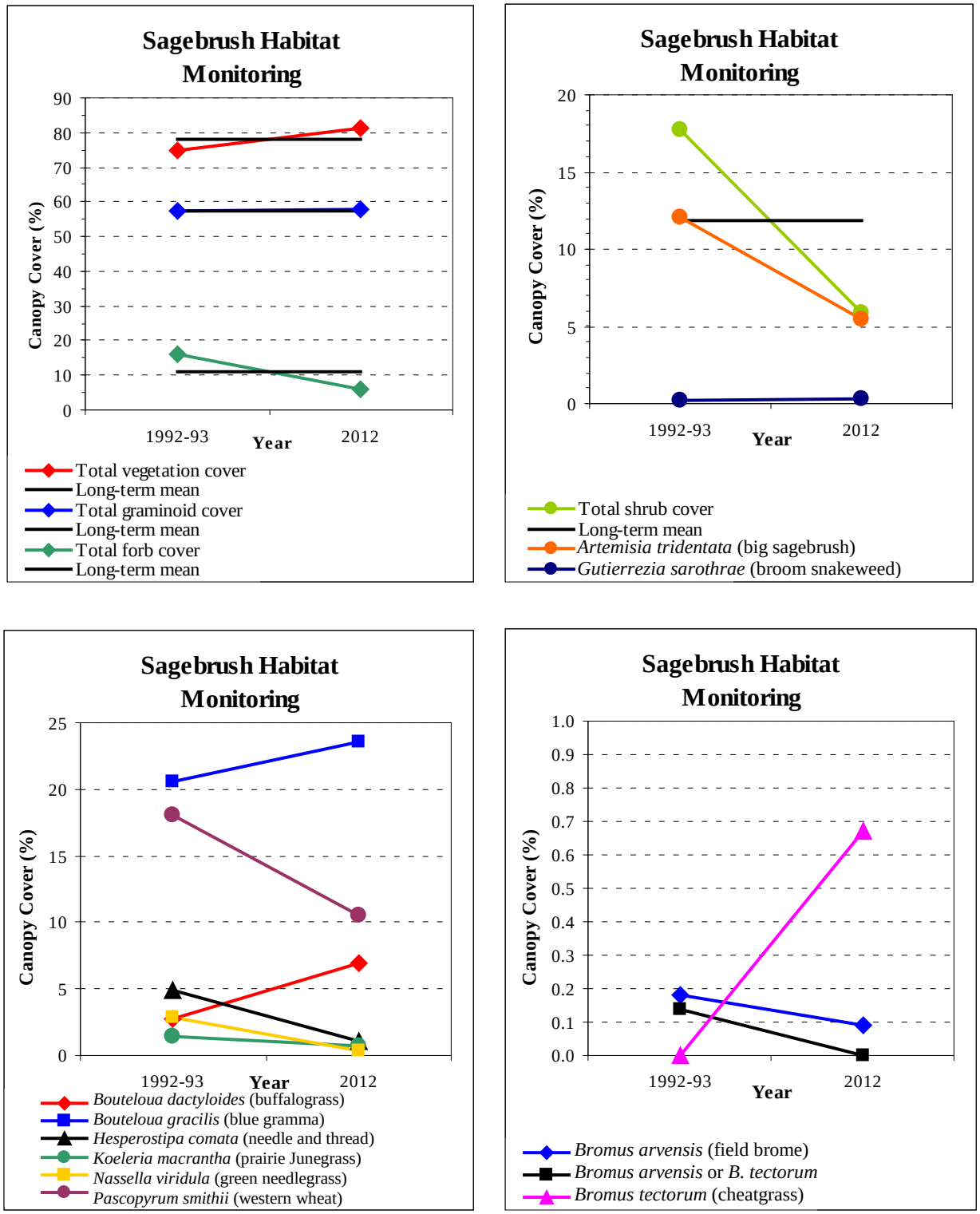

Figure 2. Canopy cover of most common plant species, life forms, and total cover among two time periods (1992-93 and 2012) in Harding County. Top two graphs show the long-term means plotted on the graph as horizontal black lines. Long-term means were calculated as an average of values for the two sample periods.

Sagebrush heights and densities were measured in a belt transect (plot) and counted based on shrub height categories. Plot sizes used in 1992-93 were variable, but based on 15 m x 30 m plot size (450 m^2). Plot shape sometimes varied also. All 2012 data were collected in 10 m x 30 m plots (300 m^2). All 1992-93 data were converted to 300 m^2 areas and plotted with 2012 data for comparisons (Figure 3).

The numbers of shrubs observed in the 1992-93 data are greater compared to 2012 shrub data (Figure 3). The general shape of the two monitoring years' mean lines in Figure 3 represent sagebrush height demographics in Harding County appear similar. This indicates that numbers of plants representing certain heights have declined in most categories over the last 20 years. Shorter plants show the greatest declines in number. This large decrease in small shrubs (5-15 cm tall) could be an indication that recruitment of new shrubs is lacking. There appears to be a decrease in the tallest shrubs based on graph as well, but this could be from fewer samples (smaller sample area) collected at each lek in 2012 compared to 1992-93. The results of fewer shrubs observed in 2012 may be why the canopy cover, frequency of shrubs, and shrub densities have decreased over the 20-year period.

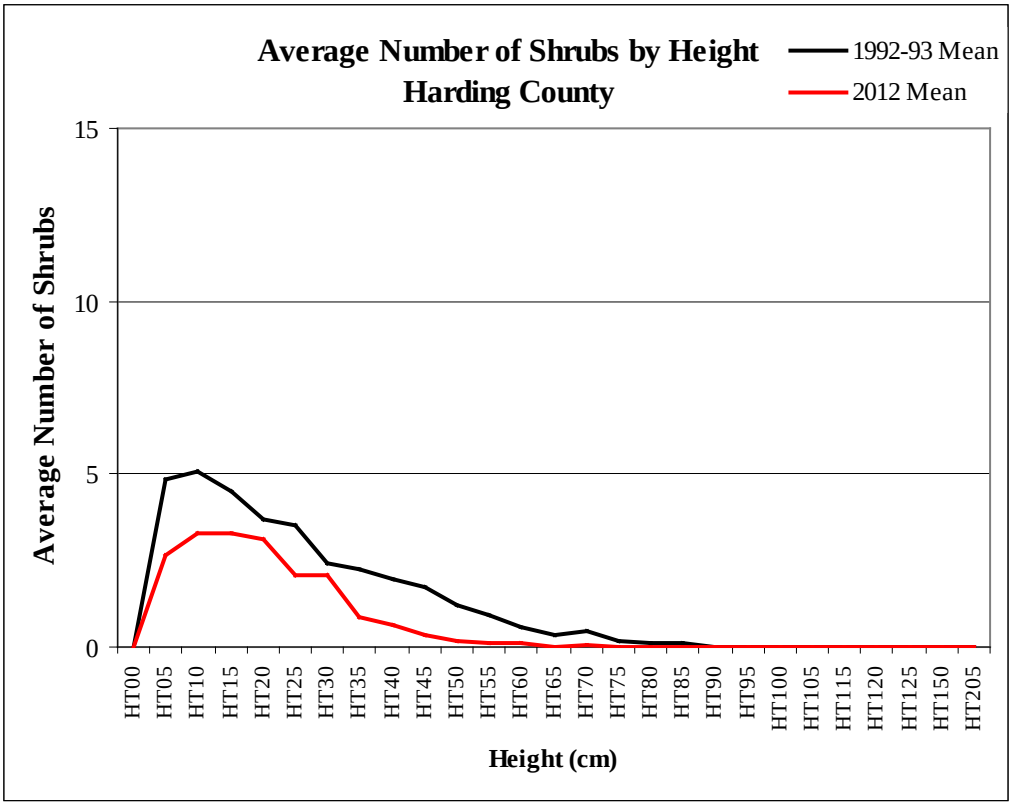

Figure 3. Average number of shrubs by shrub height classes in Harding County showing a decline in the number of shrubs from 1992-93 to 2012. This decrease in shrub numbers has impacted all height categories of shrubs.

Harding County Summary

Although total cover and total graminoids remained about the same over the 20-year period there were declines in total shrubs. Total forbs and graminoid composition appears to have changed or is changing to more dominant C4 (warm season) species while C3 (cool season) species decline. Big sagebrush canopy cover declined 12% and frequency of occurrence was recorded 29% less. The forb decline could be expected in 2012 since precipitation was below average. However, there was an increase in warm season grasses that are more tolerant to drought and grazing (blue grama and buffalograss) while the major cool season grasses like needle and thread, green needlegrass, prairie Junegrass, and western wheatgrass all decreased in amount of canopy and often in frequency.

Butte County (Individual leks 1, 4, 5, 8, 11, 12, and 13)

Details can be viewed in tables for the 7 direct individual lek comparisons for Butte County in Appendix B (data for internal use only). Comparing a site over time can give very specific species trend data for each site.

Lek 1

Total graminoid cover increased about 3%, but total forb and total shrub cover decreased 7% and 12% respectively from 1992-93 to 2012. Big sagebrush decreased 9% and broom snakeweed and greasewood (*Sarcobatus vermiculatus*) decreased 3% or less. Blue grama decreased 5%, Carex species combined increased about 2%, green needlegrass, and all bluegrasses decreased 6% and 11% respectively. Western wheatgrass, prairie Junegrass, sand dropseed (*Sporobolus cryptandrus*), and needle and thread all increased 2% or less. Buffalograss increased 19% over the same time. Differences in forb species were generally less than 1% with the exception of a decrease of about 2% for *Trifolium* species. Litter increased about 9% and bare ground decreased about 13%.

Lek 4

Total graminoid cover decreased 33% and total shrub cover decreased 7%, but total forb cover increased 9% from 1992-93 to 2012. Big sagebrush decreased 6% and fourwing saltbush (*Atriplex canescens*) increased about 1%. Silver sagebrush was not recorded in 2012. Bentgrass (*Agrostis* spp.) and fescue (*Festuca* spp.) species both decreased 3-4% and western wheatgrass decreased by 6%. Crested wheatgrass (*Agropyron cristatum*) increased by 2% and all bluegrasses combined increased only 1%. Differences in forb species were generally less than 1%. Litter was about the same and bare ground increased about 12%.

Lek 5

Total graminoid cover increased 5%, but total forb and total shrub cover decreased 9% and 10% respectively from 1992-93 to 2012. Big sagebrush decreased 10%. Broom snakeweed and fourwing saltbush increased slightly (0.1-0.3%). Western wheatgrass increased 3% while other graminoids were very uncommon. Differences in forb species were generally less than 1% with the exception of a near 8% decrease for textile onion (*Allium textile*). Litter increased about 11% and bare ground decreased about 20%.

Lek 8

Total graminoid, forb, and shrub cover decreased 19%, 5%, and 10% respectively from 1992-93

to 2012. Big sagebrush decreased 10% and was the only shrub recorded either time. Blue grama indicated a 5% increase, however *Bouteloua* species showed an approximately 50% decline. Buffalograss showed a 14% increase. These differences could be indicative of species misidentification in 1992-93 and the combining of blue grama and buffalograss into a *Bouteloua* species category because the difficulty in identifying these two short grasses. Western wheatgrass decreased 7% and bluegrass declined about 3%. Litter increased about 22% and bare ground decreased about 3%.

Lek 11

This lek had few species recorded in either sample period. Total graminoid cover increased 25% and total forb increased 6%, but total shrub cover decreased 46% between 1992-93 and 2012. Big sagebrush indicated a 46% decrease. Carex species combined and western wheatgrass increased by 13% and 5% respectively in canopy cover. Differences in forb species were generally less than 1% with the exception of a 6% increased cover of common yarrow (*Achillea millefolium*). Litter decreased 2% and bare ground decreased about 12%.

Lek 12

Total graminoid cover increased 18% and shrub cover decreased 28% while total forb cover remained about the same from 1992-93 to 2012. Big sagebrush decreased 27%. Results of this lek showed a category of *Agropyron* species (wheatgrasses combined) recorded in 2012 was 23% and very little western wheatgrass was recorded (0.1%) in 2012. Data collected in 1992-93 resulted in 23% western wheatgrass and no *Agropyron* species. The condition of wheatgrasses (drought, grazing, or both) could not be easily differentiated in the field in 2012 at this site so a genera group was created to include all species thought to be wheatgrasses. Therefore, results of wheatgrasses indicated no change occurred. Buffalograss increased about 16% between dates. Differences in forb species were generally less than 1%. Litter increased over 81% and bare ground decreased 50%.

Lek 13

This lek had many species recorded in both sample periods. Total graminoid and shrub cover both decreased 3%. Total forb cover increased 1% and the 3% shrub decline was from big sagebrush. Western wheatgrass decreased by 4% and bluegrasses decreased 0.5%. Two unidentified grasses recorded in 1992-93 either disappeared or were identified in 2012, this accounted for 4% change. Green needlegrass accounted for 10% canopy cover in 2012 while a *Stipa* group in 1992-93 had about 1% of this grass recorded. Differences in forb species were generally less than 1%. Litter cover increased 17% and bare ground decreased about 35%.

The observed changes at the site level were among some of the most dominant plant species recorded. Canopy cover was only discussed, but observations among frequencies were also observed. The differences noted are for single site comparisons only. A single site (2 transects of canopy cover data) compared to a single site about 20 years later show some mixed results in that some sites had increased amount of canopy cover while other showed decreased results.

Butte County Combined Lek Results

Details can be viewed between averages from transect data collected in 1992-93 from 11 leks and 7 collected in 2012 in the Butte County (Appendix B (data for internal use only)).

Comparing at the county level can give trend data for leks over time. It may be possible to extrapolate the data to show general sagebrush habitat condition and trend in Butte County.

Comparisons between life forms, litter, bare ground and plant species with values greater than 1% were reviewed to determine changes observed between the 1992-93 Carter data compared to data collected in 2012. Total vegetation cover increased approximately 7%, graminoid cover remained equal, but there were declines of 6% and 14% for total forb and total shrub cover respectively. The average frequency that shrubs were recorded over the 20-year period was about 29% less in 2012. Canopy cover of lichen species combined was nearly equal while frequency increased 24%. Big sagebrush declined 12-13% and frequency of big sagebrush declined 27%, while all other shrubs species (although less than 1% canopy cover) declined except for fourwing saltbush which was similar.

Graminoid cover remained 32% over the 20-year period. However, there was a shift in species composition over the same time period. Blue grama cover remained the same over the 20 years but frequency of occurrence increased over 13%. Buffalograss increased 6% in canopy cover and 25% in frequency. Needle and thread grass, green needlegrass, and a *Stipa* species group (assumed to represent needle and thread and green needlegrass combined show slight increases (less than 1%). Prairie Junegrass also decreased less than 1% and western wheatgrass decreased 5% from 1992-93 to 2012 but frequency remained about equal. All bluegrass species combined resulted in a 3-4% decline in these grasses over the 20-year time.

Fringed sagewort remained about the same, pricklypear declined about 1% in cover and about half in frequency, although it represented less than 2% cover total. Common yarrow increased very little. There was a decline of over 2% in cover and 23% in frequency of American vetch (*Vicia americana*). Most other forbs recorded in 1992-93 showed decline in cover when compared to 2012 data.

Figure 4 illustrates two methods this data can be used for long-term monitoring. The top two graphs show averages by sample periods for total vegetation cover, total graminoid cover, total forb cover, and total shrub cover. Along with values recorded in 1992-93 and 2012 are long-term means. Long-term means were calculated as an average of all sample periods, in this case there were only 2 sample periods. The long-term mean also called the running average gives a true long-term average in Butte County for each specific variable. Long-term means were only calculated for 4 variables in Figure 4, but can be calculated for each variable. Data averages collected in 1992-93 and 2012 can be compared with each other and with the long-term mean.

Total vegetation cover illustrates an increase, total graminoid cover little or no change, and total forb cover a decrease over the two sample periods (Figure 4). Total shrub cover shows a greater decrease compared to the previous 3 variables. Also included are two sample values for big sagebrush. Big sagebrush shows similar declines as total shrubs and about 7-8% less canopy cover compared to the long-term mean of total shrubs over the near 20-year period.

The bottom two graphs show average values recorded in Butte County of the major forage grasses recorded and primary weedy grasses (Figure 4). Buffalograss shows an increase over time in canopy cover while prairie Junegrass, western wheatgrass, and all bluegrasses combined

all show decreases in canopy cover. The needle grasses remained near equal over the 20 years in canopy cover. During this same period there has been little change or a slight decrease in canopy cover of cheatgrass. Field brome shows a slight increase over time while the combined category of these two brome species used in 1992-93 show declines. Graphically, the brome species shows canopy cover values less than 1%.

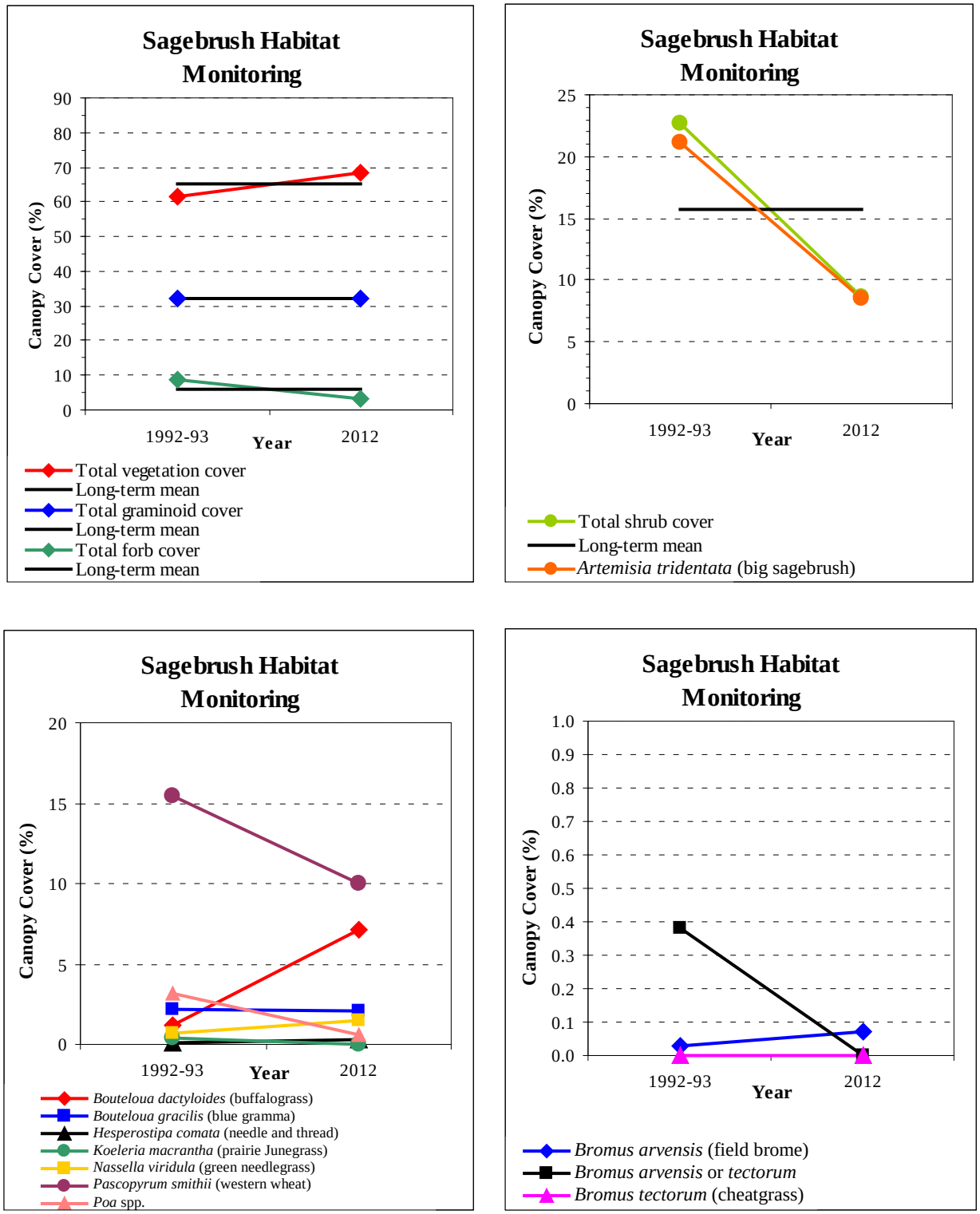

Figure 4. Canopy cover of most common plant species, life forms, and total cover among two time periods (1992-93 and 2012) in Butte County. Top two graphs show the long-term means plotted on the graph as horizontal black lines. Long-term means were calculated as an average of values for the two sample periods.

Sagebrush heights and densities were measured in a belt transect (plot) and counted based on shrub height categories. Plot sizes used in 1992-93 were variable, but based on 15 m x 30 m plot size (450 m^2). Plot shape sometimes varied also. All 2012 data were collected in 10 m x 30 m plots (300 m^2). All 1992-93 data were converted to 300 m^2 areas and plotted with 2012 data for comparisons (Figure 5).

The numbers of shrubs observed in the 1992-93 data are greater compared to 2012 shrub data (Figure 5). The general shape of the two monitoring years' mean lines in Figure 5 represent sagebrush height demographics in Butte County appear similar. This indicates that numbers of plants representing certain heights have declined in every category over the last 20 years. Shorter plants show the greatest declines in number. This large decrease in small shrubs (less than 20 cm tall) could be an indication that recruitment of new shrubs is lacking or reduced. There appears to be a decrease in the tallest plants based on graph as well, but this could be from fewer samples (smaller sample area) collected at each lek in 2012 compared to 1992-93. The results of fewer shrub observed in 2012 may be why the canopy cover and frequency of shrubs have decreased over the 20-year period.

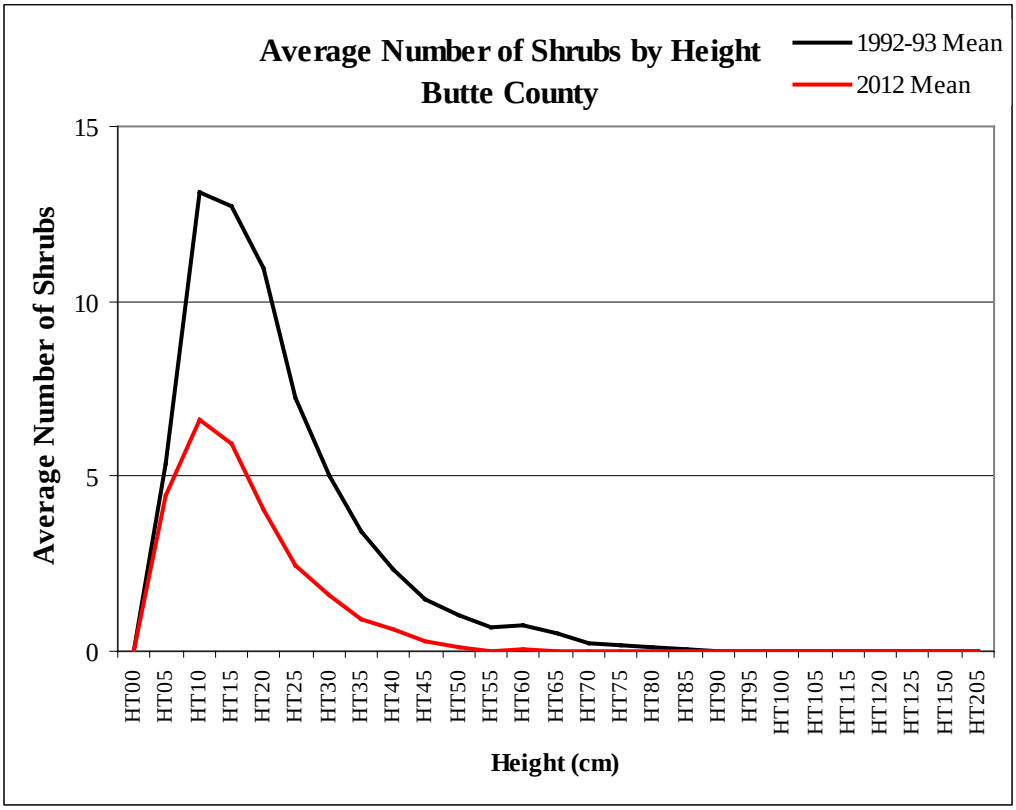

Figure 5. Average number of shrubs by shrub height classes in Butte County showing a decline in the number of shrubs from 1992-93 to 2012. This decrease in shrub numbers has impacted all height categories of shrubs.

Butte County Summary

Although total cover and total graminoids remained about the same (32%) over the 20-year period there were declines in total shrubs (14%) and total forbs (6%). Graminoid composition appears to have changed or is currently changing to more dominant C4 (warm season) species while C3 (cool season) species decline or remain similar. Big sagebrush canopy cover declined 13% and frequency of occurrence was recorded 27% less. The forb decline could be expected in 2012 since precipitation was below average. However, there was an increase in warm season grasses that were more tolerant to drought and grazing (buffalograss and blue grama) while the major cool season grasses like needle and thread and green needlegrass changed little. Prairie Junegrass almost disappeared from the sample and western wheatgrass decreased over 5%. All bluegrass species combined decreased about 3% over the 20 years.

Fall River County (Individual leks not included)

Tables for the 44 sites collected in 1992, 72 sites collected in 2003, and 69 sites collected in 2012 provide vegetation data summaries and comparisons for Fall River County and can be viewed in Appendix C (data for internal use only). Three sites were burned in a wildfire in 2012 and had no live vegetation present and data were not collected. Comparing a single site can give very specific species trend data for each site and identify plant species change. Butte and Harding County vegetation data was collected at or near leks determined to be some of the best lek habitat in the early 1990's. Fall River County collection sites were not established based on past, current, best leks, or best sagebrush habitat. Sites are distributed throughout sagebrush habitat on BGNG but do include known lek sites in Fall River. There were a greater number of sites established within this area of Fall River County. Data viewed at the County level can give good estimates of vegetation trend over time. Data in Fall River County represents a smaller area sampled (compared to Harding and Butte Counties) and it was sampled at a greater density.

Discussion of individual site comparison for each of the 72 sites in Fall River County will be omitted here due to the large number of sites for possible comparisons. The data collected from all 72 sites in 2003 and 2012 can be viewed and compared individually in Appendix C (data for internal use only). All 1992 data at the county level was compared to the 72 sites collected in both 2003 and 2012.

The three sites (sites SB13, SB14, and SB15) located at the most northwestern part of the 2003 and 2012 project area were burned during a wildfire in 2012 and sampling took place shortly after the fire. These 3 sites represent about 4% of the dataset. Data collected in 2003 resulted in total cover being 74-81% on these three sites. Total graminoids were recorded as 34-53% cover and forb cover was less than 4%. Canopy cover of sagebrush on these three sites averaged between 13-21%. Data was not collected from the three sites in 2012 because of the severity of the burn resulting in a lack of vegetation. All live vegetation cover burned and no vegetation had re-grown by the time of the 2012 sample. All sagebrush on these sites had been completely burned and sagebrush plants were assumed to be dead. The loss of sagebrush at the 3 sites was included as missing data. If samples had been collected and zero data were included (instead of missing data) the percentage of sagebrush at the county level would have been less than reported for 2012 data.

Each site in the Fall River data can be easily assigned to an individual BGNG allotment and to an

individual pasture based on Forest Service management. Summarizing data by each allotment and pasture could be another method of monitoring with the dataset. This could be the best method if there were ever a change in management at a pasture or allotment level. All sites sampled appeared to have been grazed by cattle, domestic sheep, and wildlife. Changes in AUM (animal unit months) at a pasture level could probably be detected over time in amount of species cover, frequency recorded or both.

Fall River County Sites Results

Tables for the Fall River County comparisons can be viewed in Appendix C (data for internal use only). Details can be viewed between averages from the 69 Fall River County sites collected in 2012 and all transect data collected in 1992 and 2003. Comparing at the county level can give trend data for lek conditions over time and it may be possible to extrapolate for the general sagebrush habitat condition and trend.

Fall River has three years of data collected over a twenty year time period (1992, 2003 and 2012) which can be used as a summary of sagebrush habitat, particularly on BGNG. However, data collected in 1992 represents a smaller geographical area compared to data collected in 2003 and 2012 so differences observed between 1992 and later years must be treated with knowledge of potential greater spatial variation associated with this county summary. Data for most common species and life forms have been used in a graphical representation (Figure 6) over three sample periods; a long-term mean (also referred to as a running mean) has been calculated from all three years of data. Over time the long-term mean represents the best possible estimate for vegetation cover that is site specific and each sample can be easily viewed as exceeding or being below the long-term mean in addition to comparisons with previous annual samples.

Canopy cover of plant species were compared for species with canopy cover values greater than 1%. Total cover was shown to increase about 10% when 1992 and 2003 data were compared and decreased less than 2% between 2003 and 2012 (tables in Appendix C (data for internal use only) and Figure 6). Total graminoid cover fluctuated slightly between 43-47% over the 20 years. Total forb cover showed about a 3% decrease from 1992 to 2003 and a 1% increase from 2003 to 2012 based on the Fall River county data combined. Total litter showed an increase in 2003 followed by a decrease in 2012, whereas bare ground showed a steady decline over the 20-year period.

Big sagebrush, one of the most dominant plant species within the study area, was examined based on canopy cover and frequency of occurrence. Comparing canopy cover over time shows there was a 7% decline, followed by a slight (0.7%) increase between 2003 and 2012. Percent frequency of big sagebrush was compared over time and its trend showed a 13% decline between 1992 and 2003 followed by another 3% decline from 2003 to 2012. Although canopy cover of big sagebrush has changed little since 2003, its frequency of occurrence decreased. Sagebrush would have been less if zero data would have been collected and summarized from the 3 burned sites.

Individual grasses compared include blue grama, buffalograss, needle and thread, and western wheatgrass. There was little difference in either blue grama or buffalograss between 2003 and 2012, but greater increases since 1992. Needle and thread grass more than doubled between

2003 and 2012. Western wheatgrass showed over a 13% decline from 1992 to 2003 followed by a 4-5% increase from 2003-2012 (Figure 6). Another grass, not included in the figure, was crested wheatgrass; it has shown a 2-3% increase in 2012 compared to either previous sample. This could be an indication crested wheatgrass has either been planted since 2003, conditions in 2012 were excellent, or it made an increase from previous natural seedings from plants recorded in 1992 and 2003.

Figure 6 illustrates two methods this data can be used for long-term monitoring. The top two graphs show averages by sample periods for total vegetation cover, total graminoid cover, total forb cover, total litter, total bare soil, and total shrub cover. Along with values recorded in 1992, 2003, and 2012 are long-term means. Long-term means were calculated as an average of all three sample periods. The long-term mean gives a true long-term average in Fall River County for each specific variable. It is only calculated for 6 variables in Figure 6, but can be calculated for any variable. Data averages collected in 1992, 2003, and 2012 can be compared with each other and to the long-term mean.

Total vegetation cover, total graminoid, and total forb cover show little change over the past 20 years and slight fluctuations among the three sample years. Long-term means are similar to values recorded. Total litter cover shows an increase in 2003 followed by a decrease in 2012. This larger fluctuation in canopy cover of litter is partially explained by available monthly precipitation and cumulative precipitation. Precipitation in 2003 was above average most months except May and July while in 2012 monthly totals were below or near average each month. Cumulative precipitation in 2003 was above average all months and below average in 2012 (Appendix F). Bare soil shows little change over the past 20 years and three sample dates. Total shrub cover shows a great decrease from 1992 to 2003 followed by a slight increase with 2012 data.

Blue grama and buffalograss (bottom graphs of Figure 6) show an increase since 1992 while western wheatgrass has declined with a slight increase in 2012. Needle and thread has remained relatively the same since 1992. Field brome and cheatgrass show great increases in 2003 followed by decreases in 2012, which again could be fluctuation in available precipitation levels. Precipitation amounts in 1992 were more similar to 2012, being average or below average most months, with greater precipitation in 2003. The weedy grasses are present throughout the grasslands and depending upon precipitation amounts and timing will determine the number of plants that germinate, survive and be recorded as canopy cover.

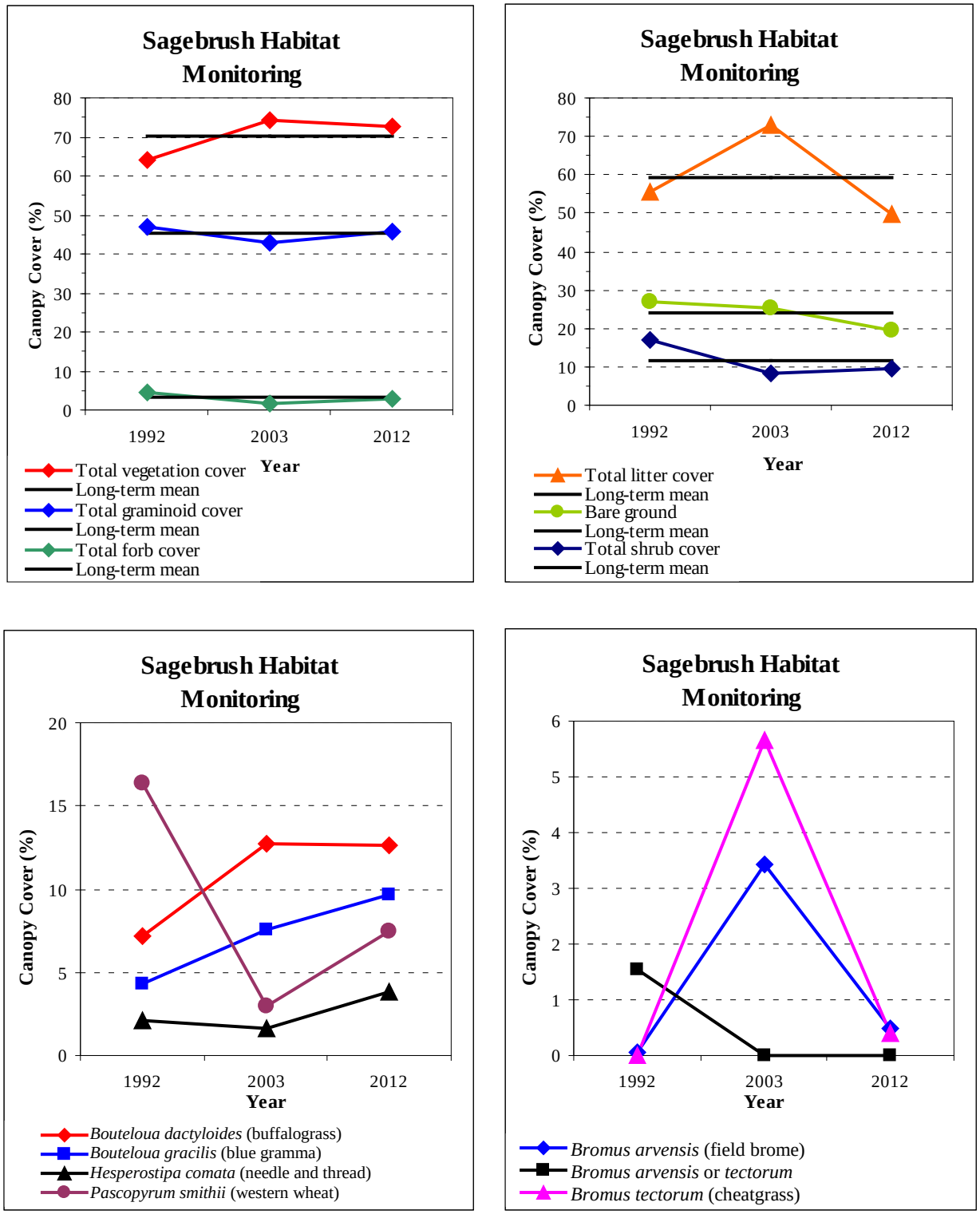

Figure 6. Canopy cover of most common plant species, life forms, total cover, bare ground, and litter among three years (1992, 2003 and 2012) in Fall River County. Top two graphs show the long-term means plotted on the graph as horizontal black lines. Long-term means are calculated as an average of values for all three sample periods.

Fall River County Summary

From the initial comparisons of the most dominant grasses, big sagebrush, total cover, total forb, litter and bare ground there is little change in percent cover among the three sample periods. This lack of change can be interpreted in different ways. The vegetation community sampled in Fall River County has changed little (measured as percent change in canopy cover) the past 20 years. Little change may mean the sagebrush-grass plant community is at a relatively stable state, management practices have changed little over the past 20 years and the differences observed may represent sample variability of some type or influences in precipitation amounts over time and coinciding with sample dates.

Changes in canopy cover of blue grama and buffalograss continue to increase or remain near equal over the three sample periods while needle and thread has declined overall since 1992 and western wheatgrass decreased from 1992 to 2003 and increased little since 2003. Both these C3 plants represent less canopy cover compared to the C4 blue grama and buffalograss.

Sagebrush data compiled for western South Dakota 1992-2012

Habitats that sage-grouse select change based on the specific life history stage in western South Dakota (Connelly 2000, Crawford et al. 2004). All stages are important understanding components of population dynamics in sage-grouse numbers observed over the past 40 years. Shrub heights, canopy, and density may be the most important characteristics of the vegetation required for sage-grouse. Results of this project indicate canopy cover, frequency, shrub height, and shrub density has been decreasing in the three counties in western SD over the past 20 years. Components of critical habitat include tall grasses (>18 cm) and an adequate canopy cover of tall grasses (Crawford et al. 2004). Results of this study suggest tall grasses (C3 grasses) are being replaced with short stature grasses (C4 grasses). Forb cover is important because of its forage value and invertebrate habitat (invertebrates provide critical protein in grouse diets). Overall cover and forb cover appears to be decreasing in western SD. Riparian plant species are also determined to be important for certain life stages of sage-grouse and these, while not specifically measured in this study, should be monitored to determine if this ecological zone follows similar declines as observed in upland habitat.

Data compiled for sagebrush steppe habitat in western SD include the following data:

1. 1992-93 in Harding, Butte and Fall River Counties by Carter, Berdan and Hodorff (SDGFP, BLM, BGNG unpublished data)
2. 2012 in Harding, Butte and Fall River Counties by this project Mergen, Corely and Deisch (SDGFP unpublished data)
3. 2003 in Fall River County by Deisch and Hodorff (SDGFP and BGNG unpublished data)

This unpublished data was compiled into a single data set that included published data values from the following;

1. Smith 2003
2. Lewis 2004
3. Herman-Brunson 2007, Herman-Brundon et al. 2009
4. Kaczor 2008, Kaczor et al. 2011
5. Swanson 2009

The published values reported in thesis, dissertations, and published articles contain mean values for some vegetation characteristics that have been determined to be important for sage-grouse (Connelly et al. 2000). In addition, some of the published values were for specific portions of sage-grouse life stages: nests, brood, and winter habitats, also random. Some published data was designed to collect information on bird species richness and use, and not designed specifically for sage-grouse knowledge, but was collected in sagebrush habitat in western SD. All these data sources were sorted by date and means were plotted with a trend line (Excel 2003).

Canopy cover percent

Long-term trends based on available data for this project include a downward trend for total vegetation cover, total graminoid cover, total forb cover, total shrub cover, big sagebrush cover, litter cover, and bare ground. The results for western SD were similar to results reported at the county level and include additional sources with data sampled between 1992 and 2012 (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011). The canopy cover variables values and bare ground values were expected to fluctuate over time since they were collected during years with different amounts and timing of rainfall and possibly different amounts and timing of livestock and wildlife grazing.

The trend lines are somewhat similar to data observed at the county levels, except total vegetation cover and total graminoid cover were similar between the twenty year span of 1992-93 Carter data and 2012 data. Graminoid information at the county levels identified changes in grass species composition over time. Data collected for the project influences trend lines since it is at the end of Figures 7-18, but overall trends show downward trends of all canopy cover variables displayed.

Total vegetation canopy cover over western SD shows a decreasing trend even though 2012 data is greater than most values reported for total vegetation cover (Figure 7). Total vegetation canopy cover collected at random sites is generally less when compared to sites sampled that were selected by sage-grouse.

Total graminoid cover in western SD also has a declining trend line (Figure 8). Most data show greater graminoid cover at sites selected by sage-grouse with the exception of winter sites (Swanson 2009). Figure 9 shows a decreasing forb canopy cover over time, based on data and associated trend line. Forb cover has been less than 10% in most data collections. Less forb data was reported compared to total vegetation and total graminoids.

Total shrub cover (Figure 10) and big sagebrush cover (Figure 11) both show a decreasing amount of shrub and big sagebrush canopy cover throughout western SD over the past 20 years. More big sagebrush data was reported, and in the 2012 sample, indicate the majority of shrub cover is composed of big sagebrush. Randomly selected sites in studies between 1992 and 2012 had less sagebrush cover reported than sample sites that were selected based on known sage-grouse use.

Sagebrush is one of the most important variables sampled, as it has been determined to be important to sage-grouse during most life stages. All information supports a decline in sagebrush over the past two decades.

Both total litter cover and bare ground recorded (Figures 12 and 13, respectively) show declines in both values for western SD. Litter cover (Figure 12) is quite variable and may be influenced by precipitation received the year prior to sampling or the year of sampling. Bare ground also shows a slight decline, which could be seen as a positive impact. Less bare soil is generally associated with less sediment yield. However, this slight decrease in bare soil could be an indication the amount of bare soil observed is declining because the amount of sagebrush is declining. There is often greater bare soil recorded under sagebrush compared to areas without sagebrush.

Plant heights and shrub density

Long-term declines in trend were observed with shrub heights, and VOR over 20 years. Increases in shrub density and forbs heights were observed with trend lines of all compiled data. Graminoids height showed only a slight increase

Shrub height showed a decrease over time as expected when canopy cover of shrubs, particularly big sagebrush was decreasing over time. Figures 3 and 5 clearly indicate a decrease in shrub numbers by every height category measured. On a per meter basis, shrub density has also shown a decline of about 50% in both Harding and Butte Counties between 1992-93 and 2012. Figure 14 also shows data selected randomly generally was shorter than data selected by sage-grouse. The exception was random sagebrush data collected by Swanson (2009) was taller than sagebrush selected for winter use.

Shrub density, greatly influenced by Swanson's (2009) winter use and random data, indicated an increase over time (Figure 15). However, all other data shows shrub densities to be less than 1 shrub per m^2. There were declines in shrub heights, big sagebrush, and total shrubs.

Grass and forb heights are greatly influenced by precipitation received before the sample date and the grazing intensity before data were collected. Grass height recorded in many studies is quite variable and has been determined to be important for sage-grouse habitat (Figure 16). Forb height on the other hand was only recorded or reported in 2012 (Figure 17). Both of these variables are recommended to be collected before nesting of sage-grouse, but all data collected for forb height was collected after sage-grouse nesting. Much of the 2012 data were collected in July through September.

Visual obstruction readings (VOR) were collected in many studies (Figure 18). The VOR readings may be a better method than simply collecting the height of the tallest grass or forb along transects or within a 0.1 m^2 plot. The VOR method of collecting data includes not only height of vegetation, but also density. The method needs to be standardized among studies so VOR is collected using the same methodology. A result of plotting all VOR data indicates a decrease in VOR over time (Figure 18).

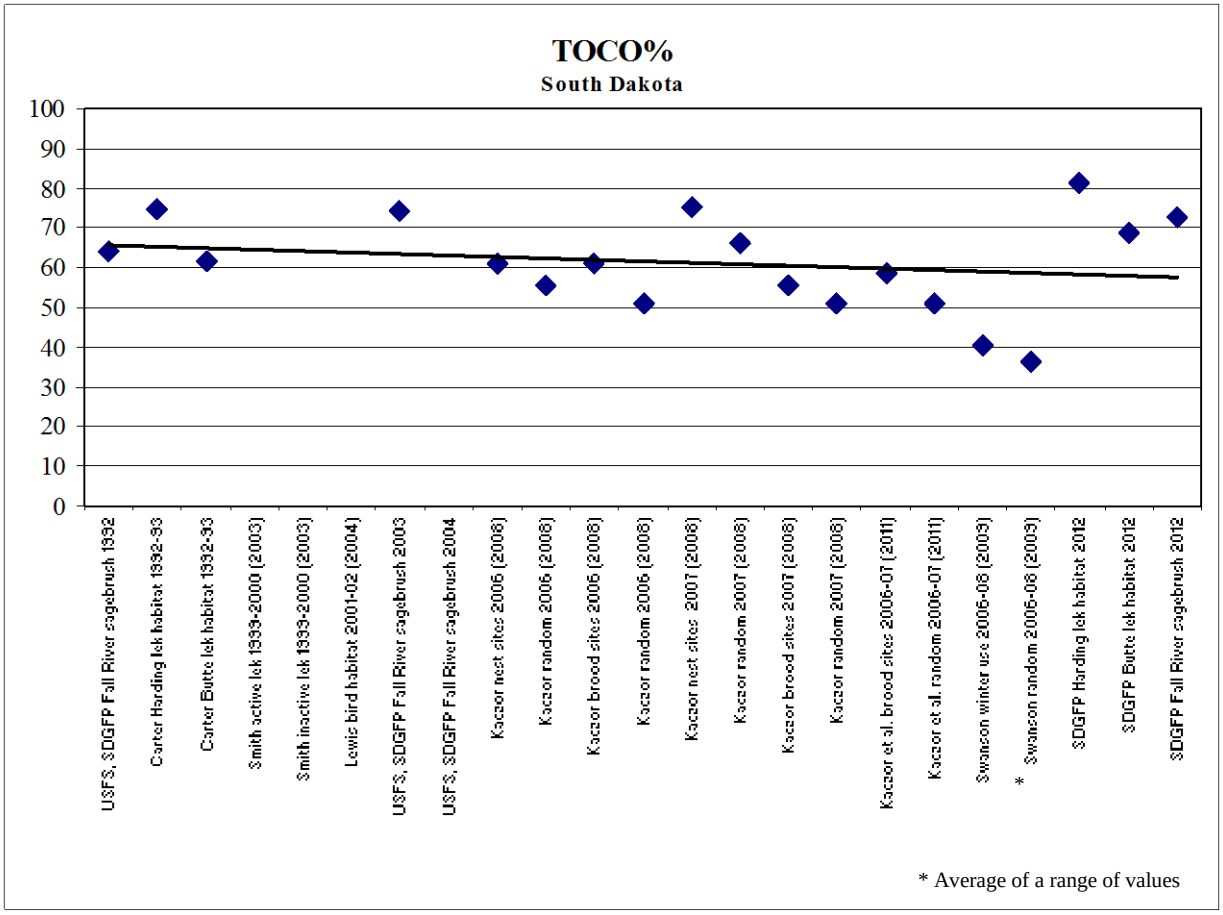

Figure 7. Mean values for total vegetation cover (TOCO%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

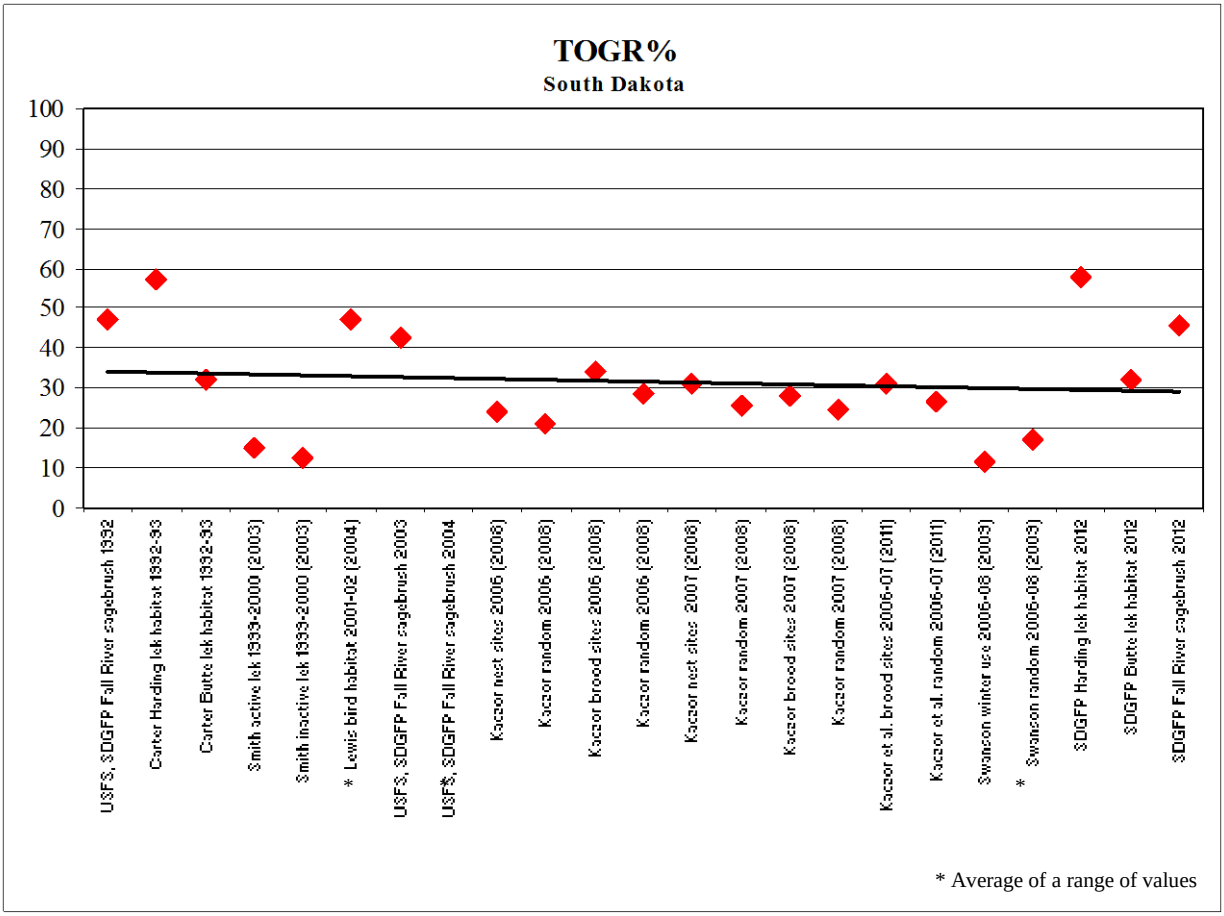

Figure 8. Mean values for total graminoid cover (TOGR%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

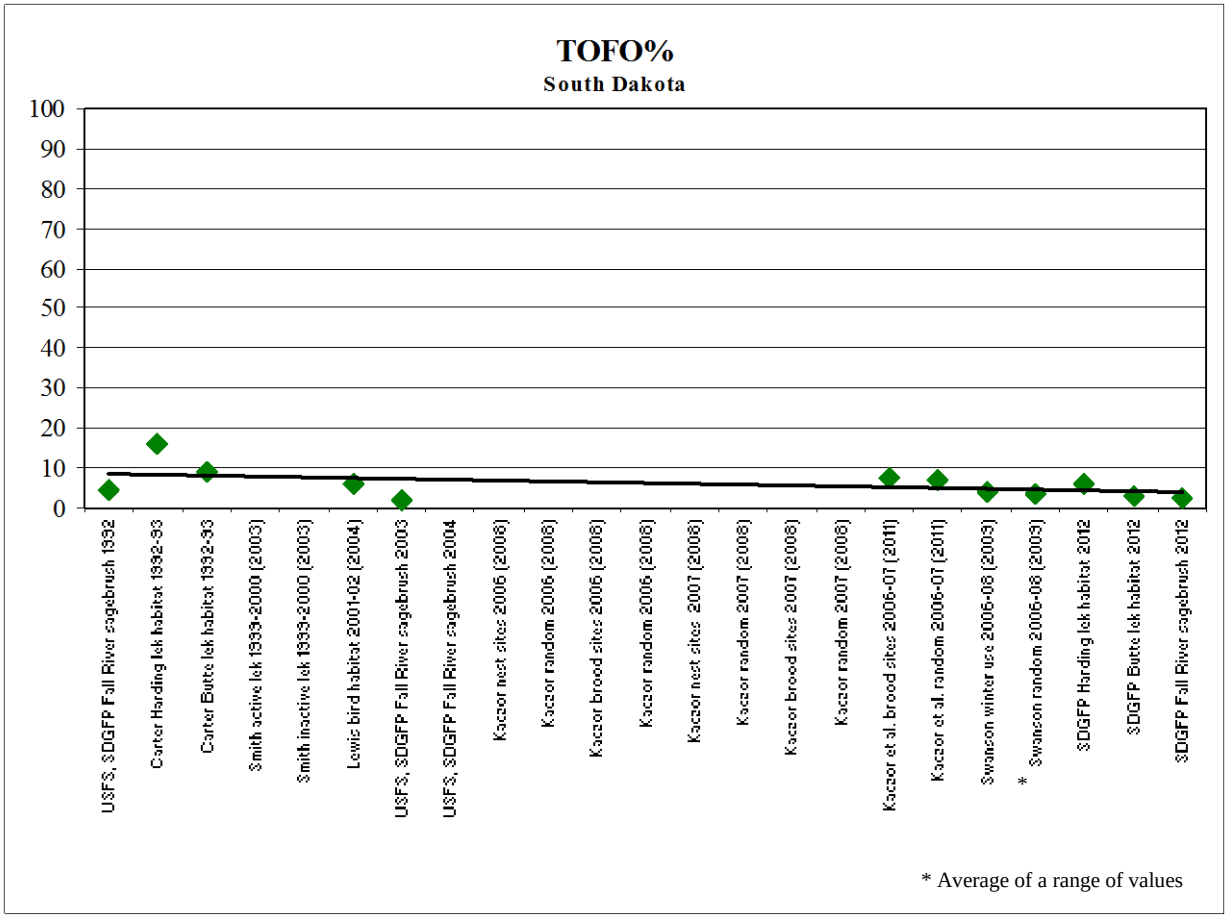

Figure 9. Mean values for total forb cover (TOFO%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

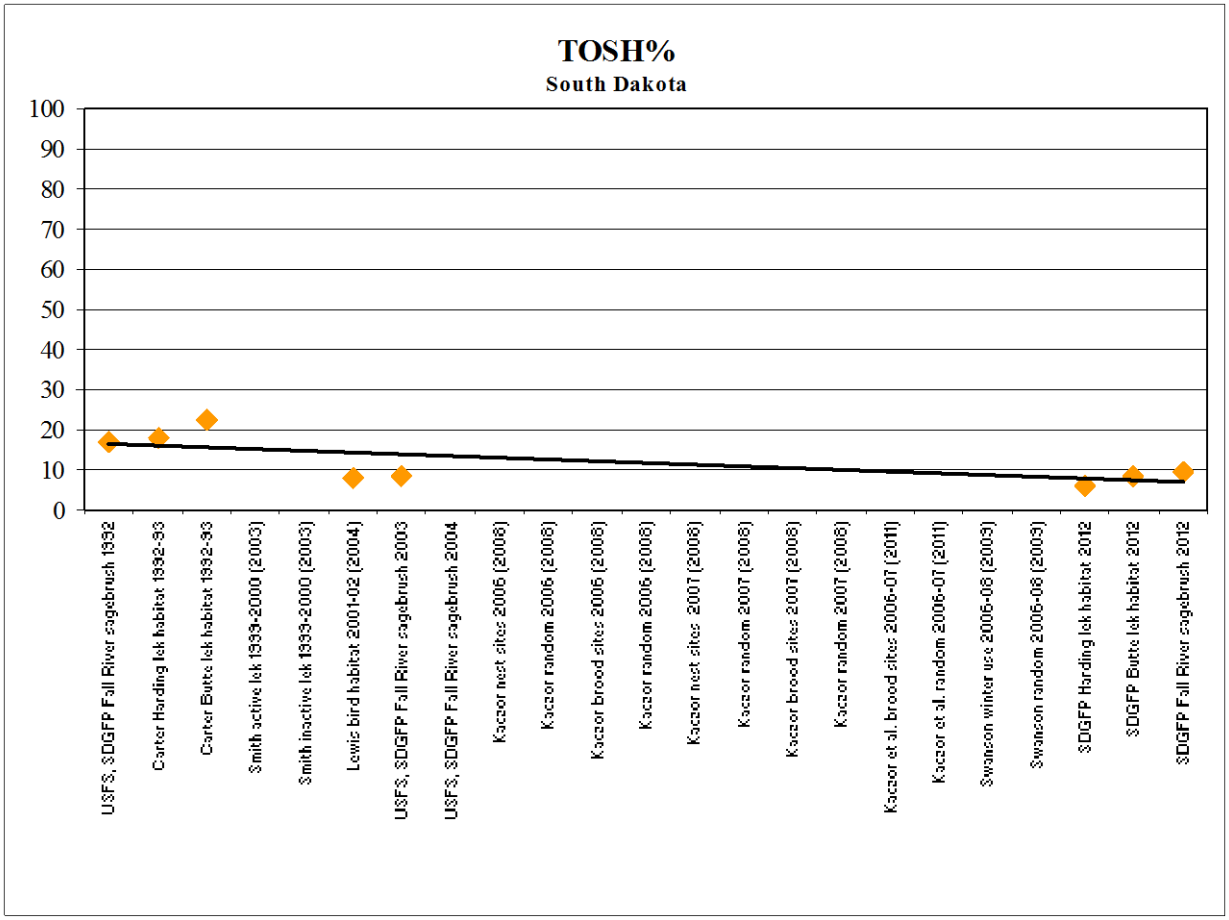

Figure 10. Mean values for total shrub cover (TOSH%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

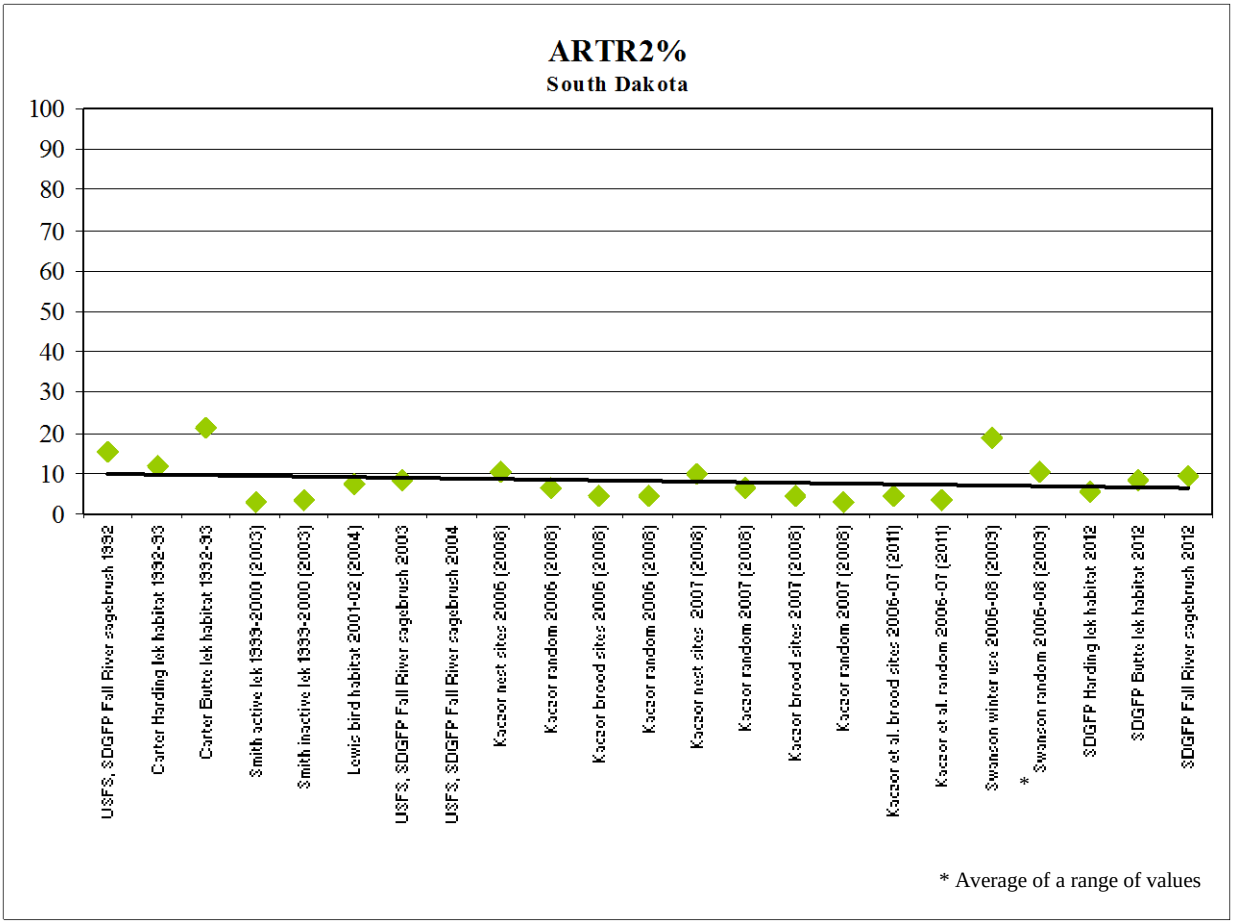

Figure 11. Mean values for big sagebrush cover (ARTR2%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

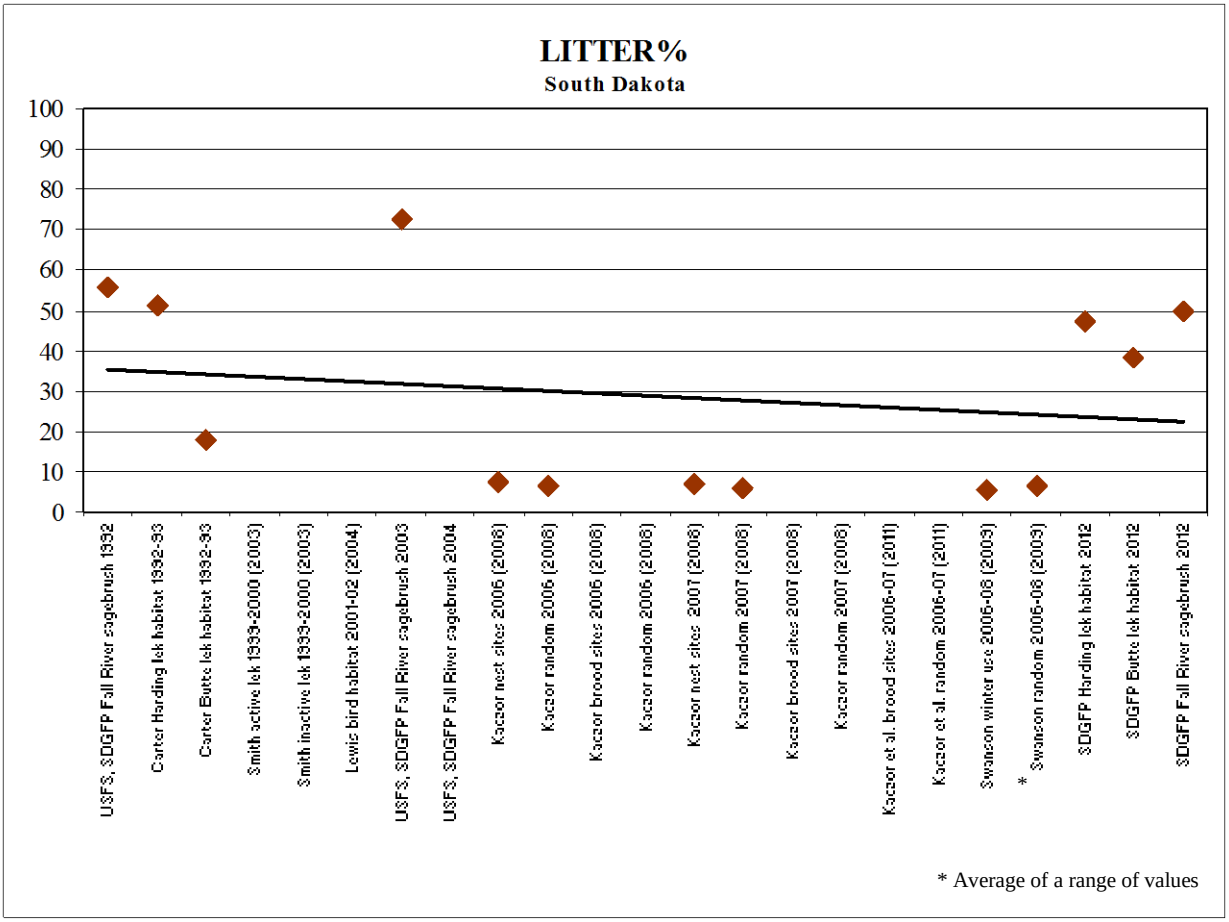

Figure 12. Mean values for total litter cover (LITTER%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

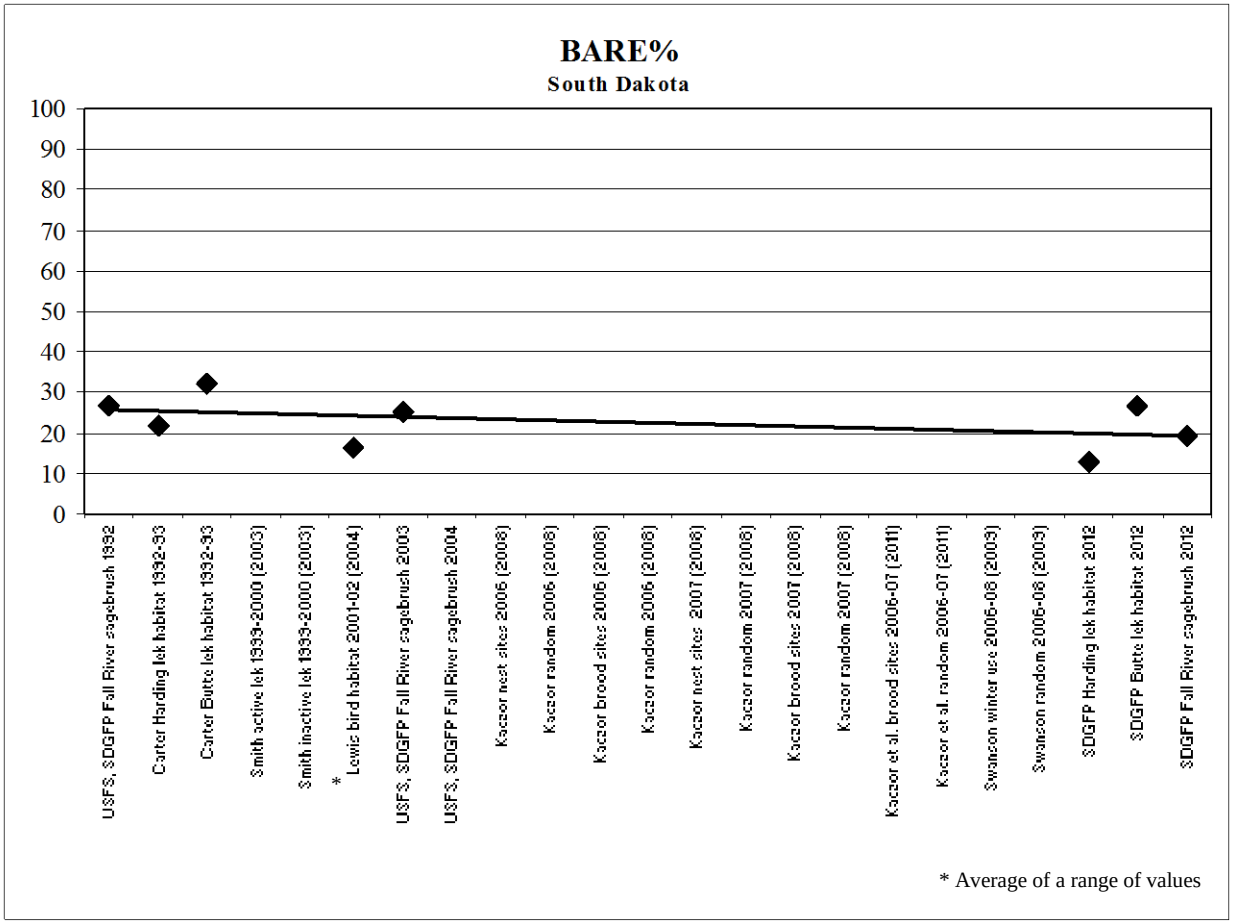

Figure 13. Mean values for bare ground (BARE%) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

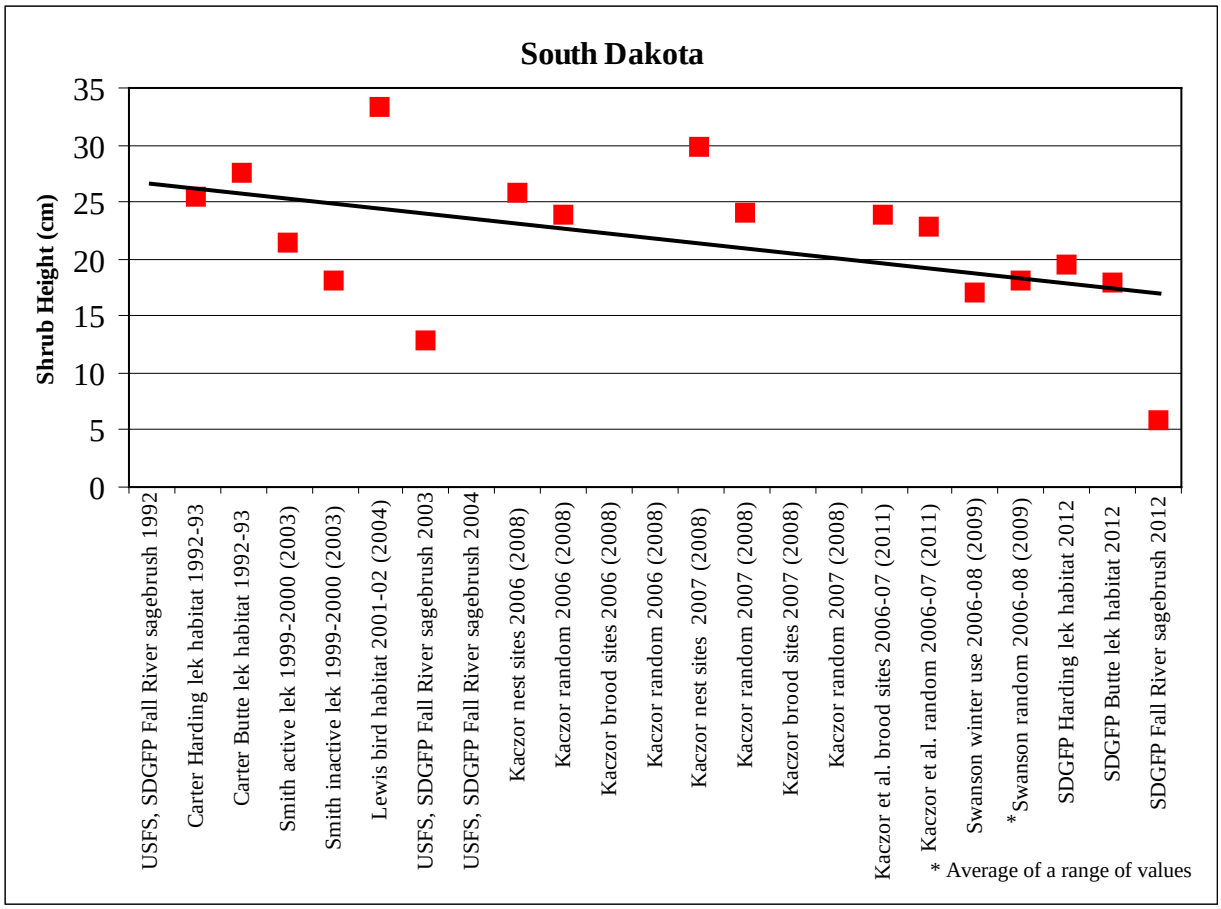

Figure 14. Mean values for shrub heights recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

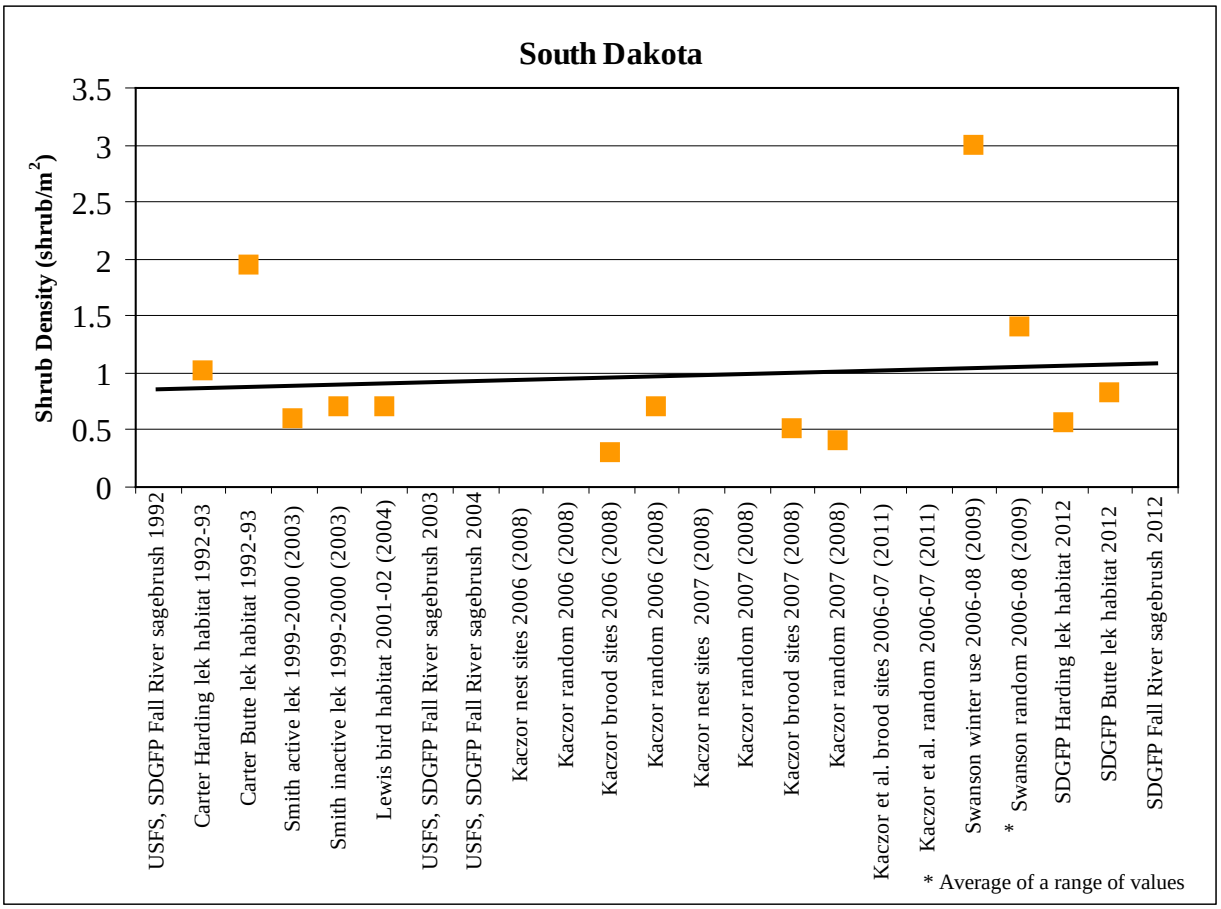

Figure 15. Mean values for shrub densities per square meter recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

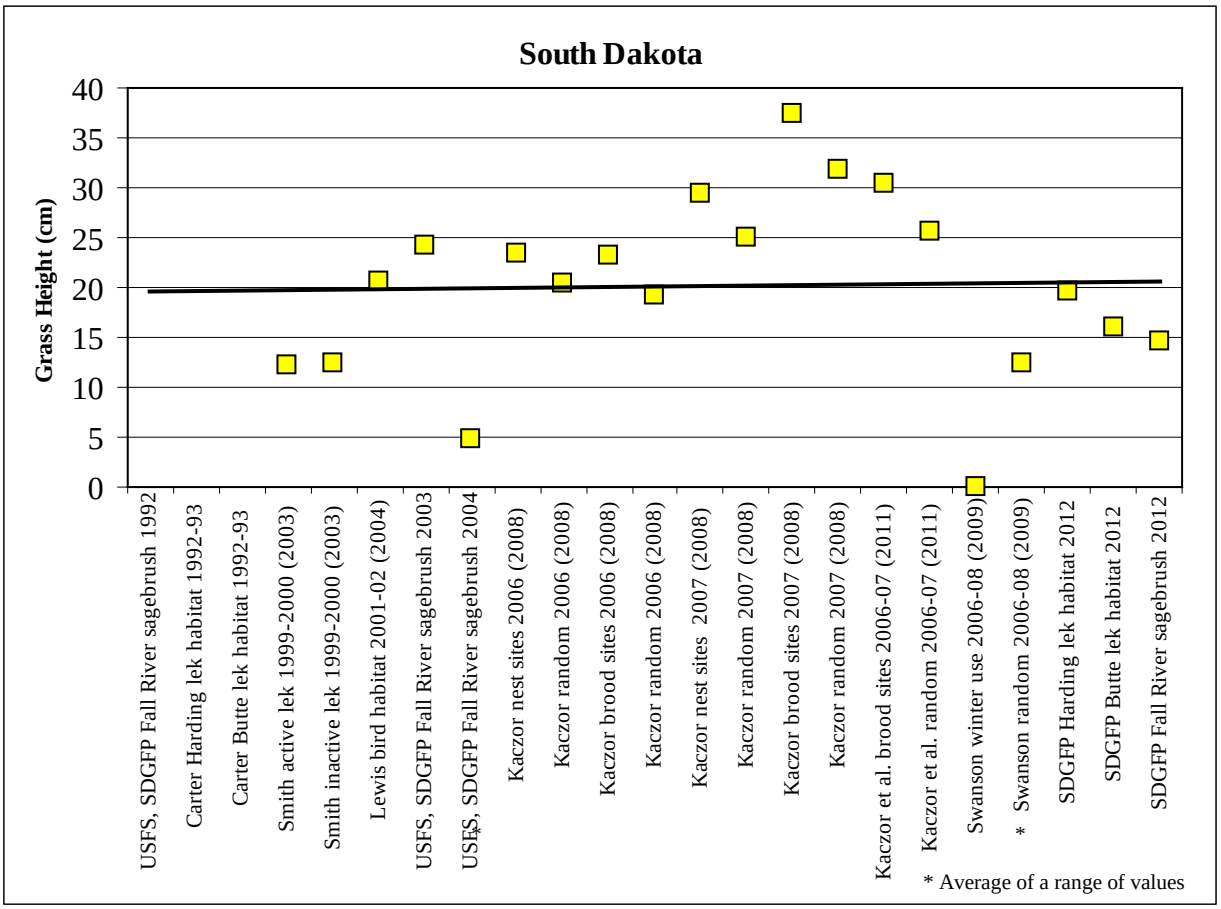

Figure 16. Mean values for total graminoid height (cm) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

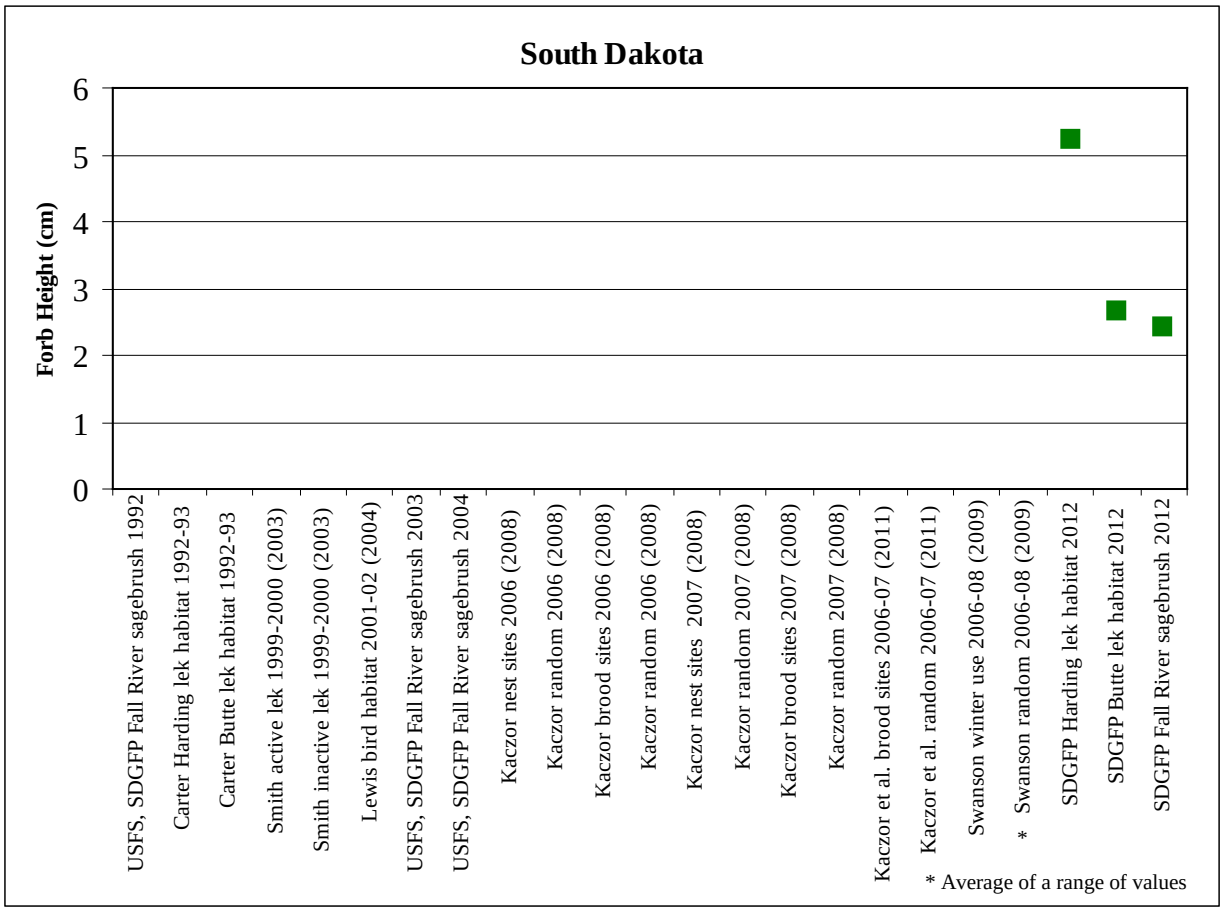

Figure 17. Mean values for total forb height (cm) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

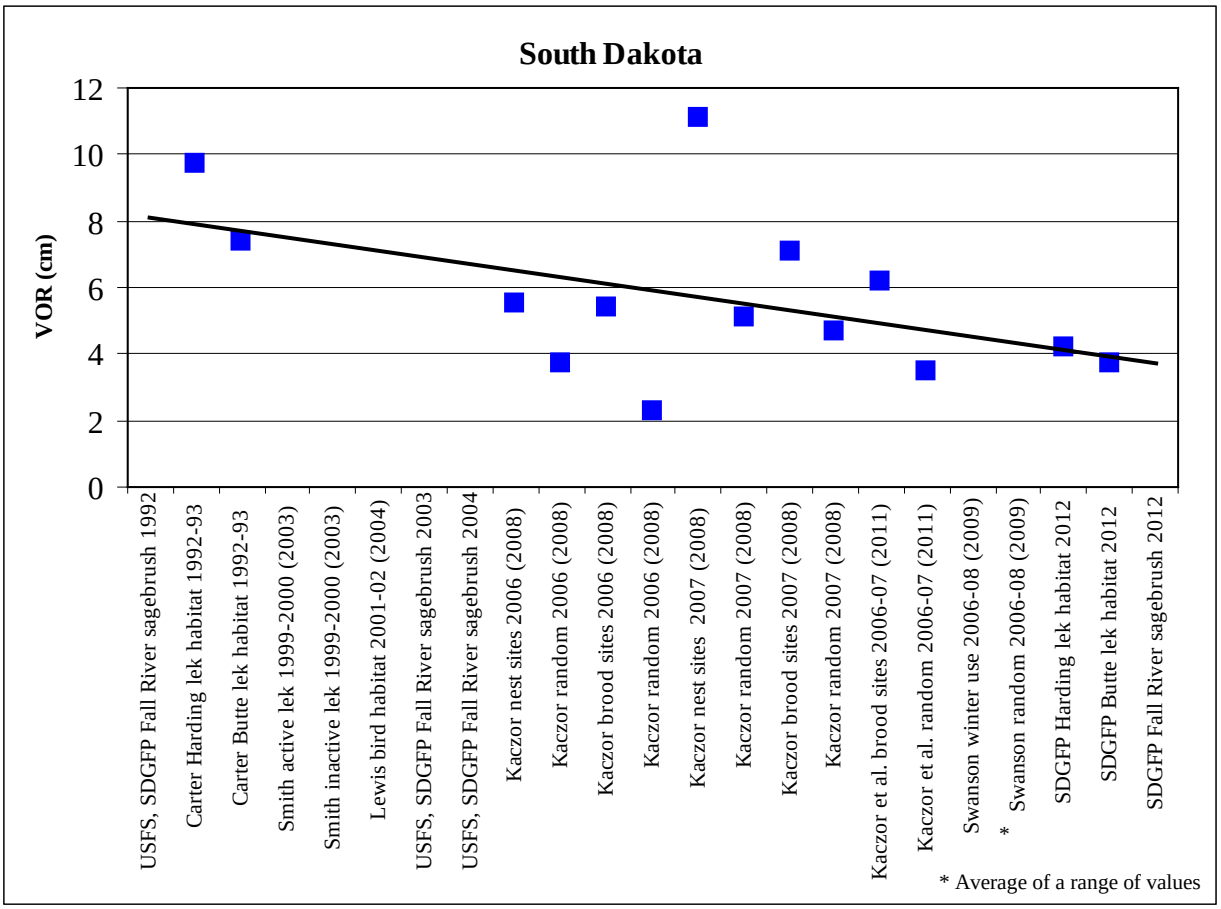

Figure 18. Mean values for visual obstruction readings (cm) recorded in sagebrush habitat in western South Dakota from this project and others (Smith 2003, Lewis 2004, Herman-Brunson 2007, Kaczor 2008, Swanson 2009, Herman-Brunson et al. 2009 and Kaczor et al. 2011) and plotted with 1992-93 Carter data to 2012 data collected in Harding, Butte, and Fall River Counties.

Sage-grouse data compiled for western South Dakota 1970-2012

Data of sage-grouse counts were summarized by lek but after discussions with SDGFP staff, it was determined that only the priority leks should be considered. Appropriate lek data will be considered in upcoming analysis.

Sagebrush restoration methods

Restoration activities can be implemented as active or passive methods. Active methods would be to restore or reclaim disturbed sagebrush habitat with plantings, seedings, weed treatment, soil amendments, or soil preparation following any disturbance, but commonly used following large fires or human induced disturbances like road and pad creation during oil and gas exploration or installation of pipelines. Passive restoration is a simple and less costly method and is done by management actions. Reducing or limiting livestock grazing or basing livestock use on prior precipitation amounts and available forage or herbage (instead of historic use) would be the easiest method to attempt to restore sagebrush habitats to 1992-93 levels.

Results of comparisons of 1992-93 data and 2012 data at the individual site, County level, and for western South Dakota indicate declines in many vegetation characteristics determined to be important to sage-grouse ecology. Restoration activities could be initiated in an attempt to restore vegetation conditions to those observed in 1992-93 or some other determined values. However, clear defined objectives and goals, including timelines should be determined before any restoration activities begin. Vegetation monitoring (based on stated objectives), including times of re-sampling areas, should be established before spending efforts and monies on restoration activities.

For example, a specific objective could be to decrease C4 graminoids to 1992-93 levels measured as canopy cover (+/- 5%), increase big sagebrush canopy by 10% and increase the number of forb species at sage-grouse lek habitat and surrounding area in Harding County similar to the values observed in 1992-93 within 5 years. This clear objective with very specific vegetation characteristics slated for change, including specific goals and a timeline for specific change. A specific vegetation monitoring plan could be established to measure desired changes. The current land management practices, particularly livestock grazing and energy developments must be closely reviewed before any active restoration activities are started Changing current land management practices permanently on public lands has potential to create desired restoration goals (1992-93 vegetation levels) without use of plantings or seedings or other labor intense restoration methods. It is unknown how climate change plays a factor in the changing vegetation composition and structure. However, making no changes in land uses regardless of climate change, most likely will result in declining trends in vegetation characteristics. Compounding factors of climate and vegetation changes and land use patterns may have impacts on all sage obligate species. West Nile may also play a factor with sage-grouse.

Large scale fires, increases in energy development, or other man-made or environmental events not yet considered could quickly make restoration of sagebrush habitat a priority. Therefore, common methods of restoration were briefly reviewed for this report. Restoration plans could be based on providing the greatest benefits for sage-grouse and sagebrush habitat. Data collected in 1992-93 could be used as the reference or baseline data to set agency management directives.

Models based on vegetation, topography, and sage-grouse avoidance to oil and gas development can be used to identify the best remaining winter habitats, and potentially other critical habitats in an area to mitigate oil and gas development (Doherty et al. 2008). Sedgwick (2004) provides a literature review for sage-grouse habitat restoration. In Shaw et al. (2005) papers are provided from a restoration proceedings symposium on sage-grouse habitat restoration.

Plantings and seedings

Much information in the literature exists for site specific results of various active restoration methods like plantings and seedings. Plantings and seedings would be required for degradation of habitats from fires, roads and development associated with oil, gas development or powerline or pipeline installations, severe long-term drought, exotic weed invasion, or other impacts failed to be considered or combinations of these

Prior to planting or seeding big sagebrush as restoration methods, site specifics such as soils, potential and capabilities of plant communities should be considered. Plant species diversity,

production, sagebrush varieties, and potential for sage-grouse habitat should all be considered for a specific site when planning restoration (Goodrich 2005). Since some sites have potential to be more productive because of better soils these areas may be the first to be avoided but as a last resort for restoration, they may have the best potential for restoration efforts. However, critical habitat and spatial location should also be considered during planning.

Strategies used to enhance structure and species diversity in crested wheatgrass stands can be employed to enhance sage-grouse habitat (Pellant and Lysne 2005). This strategy is to reduce crested wheatgrass with treatments that include herbicide, burning, mechanical treatment, or livestock grazing, or drought and then seed or plant seedlings to increase desired structure and diversity.

Seeding of silver sagebrush worked best in northern mixed prairies when seeds were broadcast in existing stands of perennial grasses and done in the fall after temperatures reached freezing or in the spring shortly after snowmelt. Disturbing the seedbed increased the density of seedlings, but it was not necessary and would be based on situation, particularly if disturbance was associated with erosion or weed risk (Romo and Grilz 2002).

Seeding big sagebrush at shallow depths using rollers that have ridges and valleys to ensure seeds are in contact with soil (Lysne 2005) increase germination and survival. Increasing soil surface roughness is more conducive to slowing or retaining runoff (allowing greater time for infiltration) in small topographic depressions that result in with greater soil moisture, thus increasing likelihood of greater seed germination, survival and establishment.

Transplanting bare root containerized big sagebrush may be preferred in sagebrush stands determined to be critical habitats (Lysne 2005). Critical habitat could be winter, brood, nest, or migratory corridors and would provide greatest benefit to sagebrush restoration and sage-grouse habitat. Plantings may perform better compared to seedings because of the variability of precipitation received in western South Dakota.

Current land management practices such as livestock grazing must be considered if any restoration is planned. It is recommended that seedings of native plants including big sagebrush should be allowed to become establish (a minimum of 3-5 years) before livestock grazing is allowed (Lambert 2005).

Treatments of sagebrush habitat

Hess and Beck (2012) found burning or mechanical treatment (mowing) of sagebrush reduced big sagebrush canopy and height below minimum levels for adequate sage-grouse habitat. Grass canopy increased with burning but not height. They concluded that treatment of big sagebrush should not be done since it took 19 years for burned sites to meet sage-grouse minimums of cover and height and 9 years for mowed sites to recover. They recommended no treatments to maintain sagebrush and improve livestock grazing to increase grass height and cover.

Most burning, mechanical treatment, and mowing that reduced sagebrush canopy and height decreased sage-grouse habitat minimums below those recommended by Connelly et al. (2000) and had mixed results with herbaceous vegetation height, cover, and production. Therefore, any

planned treatment to sagebrush habitat should be avoided since benefits generally fail to be greater than detriments to habitat.

Livestock grazing

Livestock grazing currently can be considered a continuous treatment to sagebrush and sage-grouse habitat in western SD. When previous precipitation, herbaceous height and density, and forage or herbage are not considered and accounted for each year concurrent with livestock grazing, it is likely that periods of average and especially below average precipitation can negatively impact sagebrush and sage-grouse habitats.

Changes in grazing can include early season light to moderate grazing to promote forb abundance and availability in upland and riparian habitat while greater utilization decreases herbaceous cover and may promote invasion of undesirable plants like weeds or low-stature grasses. Changes in vegetation composition since 1992-93 indicate forb abundance and availability has decreased as have the amount of tall cool season grasses.

Summary of restoration

Treatments to sagebrush should be avoided or reduced because negative impacts to habitat are greater or are not returned to minimum conditions suitable for sage-grouse for up to 20 years. Plantings and seedings are a proven method to enhance sagebrush and sage-grouse habitat. Details of any restoration activity should be planned for site specific areas based on desired goals, site community potential, and location of critical habitat. A specific vegetation monitoring plan should be included with all restoration, including re-sample times, and specific goals to be achieved based on a referenced vegetation community. The reference vegetation community can be based on results of 1992-93 data summaries which represent a baseline vegetation of sage-grouse habitat that was selected because it represented the best remaining sage-grouse habitat in Harding, Butte and Fall River Counties at that time.

Conclusions

The preliminary results of this project certainly indicate a more thorough and robust analysis of the data is needed. The preliminary findings also suggest that we need to determine if there is a correlation of changes with vegetation to changes in land uses, such as livestock grazing, energy developments, fire, herbicide applications, etc., and ultimately determine if there is a correlation to sage-grouse abundance, distribution or population dynamics. Something is causing changes in vegetation, which will result in impacts to all sage obligates and historical uses of public lands. SDGFP, BLM, BGGN need time to further analyze data and incorporate agency management strategies before making any hard conclusions at this time.

Data at the individual site level can be important especially if single plant species are determined important to sage-grouse or other species and can clearly demonstrate year to year variability of vegetation characteristics collected. Differences observed based a single plant species can be greatly influenced by error in transect relocation and orientation of transects to be sampled. Relocating transects and transect orientation introduce variation into results of vegetation cover estimates. It is better to collect a large number of transects at each sample time within a monitoring site compared than to an attempt to collect data from a few transects that are permanently located (Bonham and Reich 2009). Land managers can determine which levels of

comparisons are to be made based on their specific objectives.

Including long-term means over time as presented in Figures 2, 4 and 6 can better demonstrate long-term averages and can provide more reliability to site averages over time. Data can be compared with reference to the long-term mean as well as all previous samples. In addition, fluctuations can be closely tied to precipitation over the long term and may explain much of the variation observed.

Similar trend data has been presented for vegetation characteristics identified within the core regions of sage-grouse habitat as important to sage-grouse life histories (Connelly et al. 2000). Most of the vegetation characteristics identified as important to sage-grouse survival also indicate decline. In addition, changes were detected in the major grasses that species compositional changes over 20 years may be occurring. Taller bunchgrass species (dominant C3 grasses) are being replaced with shorter stature C4 sod grasses which may be less beneficial to sage-grouse. Sagebrush is declining in height, canopy cover, frequency, and VOR. Forb height appears to be increasing while forb cover is declining, especially at the county level of comparison. It would be interesting to conduct an invertebrate abundance and diversity study to see how changes in plant species and structure may affect invertebrates, a critical protein source for sage-grouse.

This project has established a defensible source of data and information compiled over 20 years that can be used as a foundation to maintain or modify land management practices that enhance sagebrush steppe habitat in western SD. This baseline data can be used to compare monitoring results of these activities at set time intervals to determine if goals are being met. Results provide an array of vegetation data that can be used for long-term monitoring of all sagebrush steppe habitats in western SD.

Recommendations

Vegetation data should be collected on a much shorter time frame than 20 years (Elzinga 1998). Specific objectives, including time frames and set goals should be determined so an actual vegetation monitoring program can be developed and achieved. All future studies initiated within sagebrush steppe habitat and funded by land and resource management agencies in western SD should encourage all participants to collect basic vegetation data using the same methods used in this study so future comparisons of data can be reliable. Because this report offers preliminary findings, no statistical analysis has been conducted and this report should not be cited as final, definitive conclusions. The authors and agencies reserve the right to further analysis, presentations and/or publications of our data.

Acknowledgments

We greatly appreciate Art Carter and Chuck Berdan with the foresight and knowledge twenty years ago to initiate vegetation data collection in Butte and Harding Counties. Bob Hodorff is also recognized for his efforts to collect wildlife habitat data over time in Fall River County. Thank you to SDGFP employees and graduate students that have spent many summer days tracking and studying sage-grouse or other sage steppe species in western SD. Thanks are also extended to all former technicians that helped collect data compiled in this report and to all persons that provided comments and suggestions in reviews of this report. We look forward to further analysis of the data.

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APPENDIX A
Harding County

Data for Internal Use Only

APPENDIX B
Butte County

Data for Internal Use Only

APPENDIX C
Fall River County

Data for Internal Use Only

APPENDIX D
Western South Dakota tables and figures

Data for Internal Use Only

APPENDIX E
Species list and methods

Plant Species List

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
TOCO	A1	Total vegetation cover	Total vegetation cover		
TOGR	A2	Total graminoid cover	Total graminoid cover		
TOFO	A3	Total forb cover	Total forb cover		
TOSH	A4	Total shrub cover	Total shrub cover		
LITT	A5	Total litter cover	Total litter cover		
BARE	A6	Bare ground	Bare ground		
ROCK	A7	Total rock cover	Total rock cover		
LICH	L	Total lichen cover	Total lichen cover		
SELAG	E	Total *Selaginella* cover	Total *Selaginella* cover		
FUNGI	M	Total fungi cover	Total fungi cover		
DUNG	D	Ground covered with dung	Ground covered with dung		
		SHRUBS			
ARCA13	S	Silver sagebrush	*Artemisia cana*		ARTCAN, ARCA
ARFI2	S	Sand sagebrush	*Artemisia filifolia*		
ARTEM	S	Sagebrush	*Artemisia* spp.		
ARTR2	S	Big sagebrush	*Artemisia tridentata*		ARTTRI
ATCA2	S	Fourwing saltbush	*Atriplex canescens*		
ATRIP	S	Saltbush	*Atriplex* spp.		
ERNA10	S	Rubber rabbitbrush	*Ericameria nauseosa*		ERINAU, CHNA
GUSA2	S	Broom snakeweed	*Gutierrezia sarothrae*		GUTSAR, GUSA
KRLA2	S	Winterfat	*Krashkinninikovia lanata*		KRALAN, EULA, CELA
RHTR	S	Skunkbush sumac	*Rhus trilobata*		RHUARO
ROAR3	S	Prairie rose	*Rosa arkansana*		ROSARK
ROSA5	S	Rose	*Rosa* spp.		
ROWO	S	Wood's rose	*Rosa woodsii*		
SAVE4	S	Greasewood	*Sarcobatus vermiculatus*		SAVE
SYOC	S	Western snowberry	*Symphoricapos occidentalis*		
		GRAMINOIDS			
ACHY	G	Indian ricegrass	*Achnatherum hymenoides*		ACHHYM
AGCR	G	Crested wheatgrass	*Agropyron cristatum*		ACGCRI

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
AGFR	G	Siberian wheatgrass	*Agropyron fragile*		
AGROP2	G	Wheatgrass	*Agropyron* spp.		AGSP
AGROS2	G	Bentgrass	*Agrostis* spp.		
AGST2	G	Creeping bentgrass	*Agrostis stolonifera*		AGST
ARPU9	G	Red threeawn	*Aristida purpurpea*	All *Aristida* labeled as this	ARIPUR, ARLO
BOCU	G	Sideoats grama	*Bouteloua curtipendula*		BOUCUR
BODA2	G	Buffalograss	*Bouteloua dactyloides*	*Buchloe dactyloides*	BUCDAC, BUDA
BOGR2	G	Blue grama	*Bouteloua gracilis*		BOUGRA
BOHI	G	Hairy grama	*Bouteloua hirsuta*		
BOUTE	G	Grama grass	*Bouteloua* spp.		
BROMU			*Bromus* (*arvensis* or *tectorum*)		BROM
BRAR5	G	Field brome (Japanese brome)	*Bromus arvensis*	*Bromus japonicus* (Japanese brome)	BROJAP, BRJA
BRIN2	G	Smooth brome	*Bromus inermis*		
BRTE	G	Downy brome (cheatgrass)	*Bromus tectorum*		BROTEC
CALO	G	Prairie sandreed	*Calamovilfa longifolia*		CALLON
CADU6	G	Needleleaf sedge	*Carex duriuscula*		CARDUR, CAEL
CAFI	G	Threadleaf sedge	*Carex filifolia*		CARFIL
CAIN9	G	Sun sedge	*Carex inops*		CARINO
CAINH2	G	Sun sedge	*Carex inops* ssp. *heliophila*		
CAREX	G	Carex species	*Carex* spp.		
DAGL	G	Orchardgrass	*Dactylis glomerata*		
DISP	G	Inland saltgrass	*Distichlis spicata*		DISSPI
ELEL5	G	Squirreltail	*Elymus elymoides*		ELYELY, SIHY
ELELE	G	Squirreltail	*Elymus elymoides* ssp. *elymoides*		SIHY
ELLA3	G	Thickspike wheatgrass	*Elymus lanceolatus*		
ELTRT	G	Slender wheatgrass	*Elymus trachycaulus*		AGCA
ERSP	G	Purple lovegrass	*Eragrostis spectabilis*		
FESTU	G	Fescue	*Festuca* spp.		
HECO26	G	Needle and thread	*Hesperostipa comata*		STICOM, STCO
STIPA	G	Needle and thread	*Hesperostipa* or *Nassella*		STSP, STIPA
HOJU	G	Foxtail barley	*Hordeum jubatum*		HORJUB
HOPU	G	Little barley	*Hordeum pusillum*		HORPUS
KOMA	G	Prairie Junegrass	*Koeleria macrantha*		KOEMAC, KOCR

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
MUAS	G	Scratchgrass	*Muhlenbergia asperifolia*		SPAS, SPAS3
NAVI4	G	Green needlegrass	*Nassella viridula*		NASVIR
PAVI2	G	Switchgrass	*Panicum virgatum*		PAVI
PASM	G	Western wheatgrass	*Pascopyrum smithii*		PASSMI, AGSM
POCO	G	Canada bluegrass	*Poa compressa*		
POGL	G	Glaucous bluegrass	*Poa glaucous*		
POPR	G	Kentucky bluegrass	*Poa pratensis*		POAPRA
POSE	G	Sandberg's bluegrass	*Poa secunda*		POASEC
POSP	G	Bluegrass	*Poa* spp.		POA, POSA, UNPOA
PSSP6	G	Bluebunch wheatgrass	*Pseudoroegneria spicata*		PSUSPI
SCPA	G	Tumblegrass	*Schedonnardus paniculatus*		SCHPAN
SCSC	G	Little bluestem	*Schizachyrium scoparium*		SCHSCO
SPPE	G	Prairie cordgrass	*Spartina pectinata*		
SPAI	G	Alkali sacaton	*Sporobolus airoides*		SPOAIR
SPCR	G	Sand dropseed	*Sporobolus cryptandrus*		SPOCRY
THIN6	G	Intermediate wheatgrass	*Thinopyrum intermedium*		AGIN
VUOC	G	Sixweeks fescue	*Vulpia octoflora*		VULOCT, VUOC
		FORBS			
ACMI2	F	Common yarrow	*Achillea millefolium*		
AGGL	F	False dandelion	*Agoseris glauca*		AGOGLA
ALLIU	F	Onion	*Allium* spp.		
ALTE	F	Textile onion	*Allium textile*		
ALDE	F	Dwarf alyssum	*Alyssum desertorum*		ALYDES
AMARA	F	Pigweed	*Amaranthus* spp.		AMAR
AMPS	F	Cuman ragweed	*Ambrosia psilostachya*		
AMBRO	F	Ragweed	*Ambrosia* spp.		
ANOC2	F	Western rock jasmine	*Androsace occidentalis*		
ANSE4	F	Rock jasmine	*Androsace septentrionalis*		ANDSEP
ANNE	F	Field pussytoes	*Antennaria neglecta*		
ANPA4	F	Small-leaf pussytoes	*Antennaria parvifolia*		ANTPAR
ANRO2	F	Rosy pussytoes	*Antennaria rosea*		
ANTEN	F	Pussytoes	*Antennaria* spp.		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
ARHOC	F	Collins rockcress	*Arabis holboellii* var. *collinsii*		ARHOC
ARFR4	F	Fringed sagewort	*Artemisia frigida*		ARTFRI, ARFR
ARLU	F	White sage	*Artemisia ludoviciana*		ARTLUD
ASSP	F	Showy milkweed	*Asclepias speciosa*		
ASTER	F	Aster	*Aster* or other genera		
DAISY	F	Unidentified aster species	*Aster* or other genera		
ASDR3	F	Drummond's milkvetch	*Astragalus drummondii*		ASTDRU
ASMI10	F	Missouri milkvetch	*Astragalus missouriensis*		ASTMIS
ASRA2	F	Creamy poison vetch	*Astragalus racemosus*		ASTRAC
ASSP6	F	Tufted milkvetch	*Astragalus spatulatus*		ASTSPA
ASTRA	F	Vetch	*Astragalus* spp.		
BASC5	F	Burning bush	*Bassia scoparia*		KOSC
BRASS2	F	Unidentified mustard species	*Brassicaceae* spp.		MUSTARD
BREUC	F	False boneset	*Brickellia eupatorioides* var. *coymbulosa*		
CAMI2	F	Littlepod false flax	*Camelina microcarpa*		
CASE5	F	Downy paintbrush	*Castilleja sessiliflora*		CASSES
CEAR4	F	Field chickweed	*Cerastium arvense*		
CHSE4	F	Matted sandmat	*Chamaesyce serpens*		
CHAL7	F	Lambsquarters	*Chenopodium album*		CHAL
CHDE	F	Aridland goosefoot	*Chenopodium desiccatum*		
CIAR4	F	Canada thistle	*Cirsium arvense*		
CIRSI	F	Thistle species	*Cirsium* spp.		
CIUN	F	Wavyleaf thistle	*Cirsium undulatum*		CIRUND
COLI2	F	Tiny trumpet	*Collomia linearis*		
COUM	F	Bastard toadflax	*Comandra umbellata*		COUMP
COUMP	F	Pale bastard toadflax	*Comandra umbellata* ssp. *pallida*		
COCA5	F	Horseweed	*Conyza canadensis*		CONCAN
CORYP	F	Beehive cactus	*Coryphantha* spp.		
DAPU5	F	Purple prairie clover	*Dalea purpurea*		DALPUR
DAUCU	F	Wild carrot	*Daucus* spp.		
DESO2	F	Flixweed tansymustard	*Descuriania sophia*		DESSOP
DRRE2	F	Carolina draba	*Draba reptans*		
DYPA	F	Fetid marigold	*Dyssodia papposa*		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
ERPU2	F	Shaggy fleabane	*Erigeron pumilus*		ERIPUM
ERIGE2	F	Fleabane	*Erigeron* spp.		
ERPA9	F	Littleleaf eriogonum	*Eriogonum pauciflorum*		ERIPAU
ERPAP6	F	Fewflowered eriogonum	*Eriogonum pauciflorum* var. *pauciflorum*		
ERIOG	F	Buckwheat	*Eriogonum* spp.		
ERAS2	F	Western wallflower	*Erysimum asperum*		ERIASP, ERAS
ESCOB	F	Foxtail cactus	*Escobaria* (syn. *Coryphantha)* spp.		
ESMI3	F	Missouri pincushion	*Escobaria missouriensis*		CORMIS, COMI
GACO5	F	Scarlet gaura	*Gaura coccinea*		GAUCOC, GACO
GEUM	F	Avens	*Geum* spp.		
GNPA	F	Western marsh cudweed	*Gnaphalium palustre*		GNAPAL
GRSQ	F	Curlycup gumweed	*Grindelia squarrosa*		GRISQU
HAFL2	F	Manyflower stickseed	*Hackelia floribunda*		HACFLO
HALOG	F	Saltlover	*Halogeton* spp.		
HAPLO11	F	Haplopappus	*Haplopappus* spp.		
HEDR	F	Drummond's false pennyroyal	*Hedeoma drummondii*		
HEHI	F	False pennyroyal	*Hedeoma hispida*		HEDHIS
HEAN3	F	Annual sunflower	*Helianthus annuus*		HEAN
HEPE	F	Prairie sunflower	*Helianthus petiolaris*		
HEVI4	F	Hairy goldaster	*Heterotheca villosa*		HETVIL
HYFI	F	Fineleaf hymenopappus	*Hymenopappus filifolius*		HYMFIL
TEACA2	F	Stemless hymenoxys	*Hymenoxys acaulis*		HYMACA
LABI	F	Tall blue lettuce	*Lactuca biennis*		LASP
LACTU	F	Lettuce	*Lactuca* spp.		
LAPO2	F	Manystem pea	*Lathyrus polymorphus*		
LEDE	F	Common pepperweed	*Lepidium densiflorum*		
LEAL	F	Alpine bladderpod	*Lesquerella alpina*		
LELU	F	Foothill bladderpod	*Lesquerella ludoviciana*		LESLUD
LESQU	F	Bladderpod	*Lesquerella* spp.		
LIPU	F	Dotted gayfeather	*Liatris punctata*		LIAPUN
LIRI	F	Stiffstem flax	*Linum rigidum*		LINRIG
LINUM	F	Flax	*Linum* spp.		
LIIN2	F	Narrowleaf stoneseed	*Lithospermum incisum*		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
LOFO	F	Desert biscuitroot	*Lomatium foeniculaceum*		LOMFOE
LUPIN	F	Lupine	*Lupinus* spp.		
LYJU	F	Rush skeletal plant	*Lygodesmia juncea*		LYGJUN
MACA2	F	Hoary tansyaster	*Machaeranthera canescens*		MACSPI
MAGR2	F	Rayless tansyaster	*Machaeranthera grindelioides*		
MAPI	F	Lacy tansyaster	*Machaeranthera pinnatifida*		MACPIN
MAPIP4	F	Lacy tansyaster	*Machaeranthera pinnatifida* ssp. *pinnatifida*		
MEDIC	F	Alfalfa	*Medicago* spp.		
MEOF	F	Yellow sweetclover	*Melilotus officinalis*		MELOFF
MELIL	F	Sweetclover	*Melilotus* spp.		
MERTE	F	Bluebells	*Mertensia* spp.		
MIAL5	F	Winged four o'clock	*Mirabilis alipes*	unknown in area - wrong code?	MIRLIN
MIHI	F	Hairy four o'clock	*Mirabilis hirsuta*		
MILI3	F	Narrowleaf four o'clock	*Mirabilis linearis*		
MUDI	F	Leafy wildparsley	*Musineon divaricatum*		MUSDIV
MUSIN	F	Wildparsley	*Musineon* spp.		
OECA10	F	Tufted evening primrose	*Oenothera caespitosa*		
OENOT	F	Evening primrose	*Oenothera* spp.		
OPFR	F	Fragile pricklypear	*Opuntia fragilis*		OPUFRA
OPPO	F	Plains pricklypear	*Opuntia polyacantha*		OPUPOL
OPSP	F	Pricklypear	*Opuntia* spp.		
ORLU2	F	Yellow owl's-clover	*Orthocarpus luteus*		ORLU4
OXLA3	F	Purple locoweed	*Oxytropis lambertii*		
OXSE	F	White locoweed	*Oxytropis sericea*		
OXYTR	F	Locoweed	*Oxytropis* spp.		
PEAR6	F	Silverleaf scurfpea	*Pediomelum argophylla*		PEDARG, PSAR
PECU3	F	Tall breadroot scurfpea	*Pediomelum cuspidata*		PEDCUS
PEES	F	Large Indian breadroot	*Pediomelum esculentum*		
PENST	F	Penstemon	*Penstemon* spp.		PEN (Sp)
PHHO	F	Hood's phlox	*Phlox hoodii*		PHLHOO
PHLO	F	Longleaf phlox	*Phlox longifolia*		
PHLOX	F	Phlox	*Phlox* spp.		
PLPA2	F	Indianwheat	*Plantago patagonica*		PLAPAT, PLSP

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
POAL4	F	White milkwort	*Polygala alba*		
POLYG4	F	Knotweed	*Polygonum* spp.		KNOT
POTEN	F	Cinquefoil	*Potentilla* spp.		
PSLA3	F	Lemon scurfpea	*Psoralidium lanceolatum*		
PSORA2	F	Scurfpea	*Psoralidium* spp.		PSORALEA
PSTE5	F	Slimflower scurfpea	*Psoralidium tenuiflora*		PEDTEN
RACO3	F	Upright paririe coneflower	*Ratibida columnifera*		
RATIB	F	Prairie coneflower	*Ratibida* spp.		
RUDBE	F	Coneflower	*Rudbeckia* spp.		
SIAL2	F	Tall tumblemustard	*Sisymbrium altissimum*		SIAL
SORO	F	Buffalobur nightshade	*Solanum rostratum*		
SOLAN	F	Nightshade	*Solanum* spp.		
SOMI2	F	Missouri goldenrod	*Solidago missouriensis*		SOLMIS
SOLID	F	Goldenrod	*Solidago* spp.		
SOSP	F	Goldenrod	*Solidago* spp.		SOSP
SPCO	F	Scarlet globemallow	*Sphaeralcea coccinea*		SPHCOC
SYER	F	Heath aster	*Symphiotrichum ericoides*		SYMERI
SYLA3	F	Smooth blue aster	*Symphyotrichum laeve*		
TAOF	F	Dandelion	*Taraxacum officinalis*		TAROFF
TEAC	F	Stemless four-nerve daisy	*Tetraneuris acaulis*		
THRH	F	Prairie goldenpea	*Thermopsis rhombifolia*		THERHO
THAR5	F	Field pennycress	*Thlaspi arvense*		THAR
TRBR	F	Longbract spiderwort	*Tradescantia bracteata*		
TRDU	F	Salsify	*Tragopogon dubius*		TRADUB
TRIFO	F	Clover	*Trifolium* spp.		
UNKF63	F	Unknown plant/code	UDEW, UGRX, UNFORBG, UNKPLANT combined		
MANYAST	F	Unknown aster	Unidentified *Aster*		MANYASTER
MONYAST	F	Unknown aster	Unidentified *Aster*		
GOLDAST	F	Aster species	Unidentified *Aster*		GOLDASTER
UNASTER1	F	Unknown aster	Unidentified *Aster*		
BORAGE	F	Boraginaceae	Unidentified Boraginaceae		
CACTUS	F	Cactus species	Unidentified Cactus		
CLOVER	F	Clover species	Unidentified clover		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
MINT	F	Unidentified mint	Unidentified mint		
VIAM	F	American vetch	*Vicia americana*		VICAME
VINU2	F	Nuttall's violet	*Viola nuttallii*		
VIOLA	F	Violet	*Viola* spp.		
XYGL	F	Smooth woodyaster	*Xylorhiza glabriuscula*		XYLGLA
ZIDE	F	Showy deathcamas	*Zigadenus elegans*		ZIGDEN?, ZIEL?
ZIVE	F	Meadow death camas	*Zigadenus venenosus*		
		Unidentified shrubs			
UNKS01	S	Unidentified shrub species	Unidentified shrub		
UNKS1	S	Unidentified shrub species	Unidentified shrub		
UNKS1	S	Unidentified shrub species	Unidentified shrub		UNKS1
UNKS2	S	Unidentified shrub species	Unidentified shrub		
UNSHRUB1	S	Unidentified shrub species	Unidentified shrub		
UNSHRUB2	S	Unidentified shrub species	Unidentified shrub		
		Unidentified graminoids			
GRASSA	G	Unidentified graminoid species	Unidentified grass		
GRASSC	G	Unidentified graminoid species	Unidentified grass		
GRX	G	Unidentified graminoid species	Unidentified grass		
UNGRAS1	G	Unidentified graminoid species	Unidentified grass		
UNGRAS2	G	Unidentified graminoid species	Unidentified grass		
UNGRAS3	G	Unidentified graminoid species	Unidentified grass		
UNGRAS4	G	Unidentified graminoid species	Unidentified grass		
UNKG01	G	Unidentified graminoid species	Unidentified grass		
UNKG02	G	Unidentified graminoid species	Unidentified grass		
UNKG03	G	Unidentified graminoid species	Unidentified grass		
UNKG04	G	Unidentified graminoid species	Unidentified grass		
UNKG05	G	Unidentified graminoid species	Unidentified grass		
UNKG06	G	Unidentified graminoid species	Unidentified grass		
UNKG07	G	Unidentified graminoid species	Unidentified grass		
UNKG08	G	Unidentified graminoid species	Unidentified grass		
UNKG09	G	Unidentified graminoid species	Unidentified grass		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
UNKG10	G	Unidentified graminoid species	Unidentified grass		
UNKG11	G	Unidentified graminoid species	Unidentified grass		
UNKG12	G	Unidentified graminoid species	Unidentified grass		
		Unidentified forbs			
ASBI	F	Unidentified forb species	Unidentified forb		
ASCR	F	Unidentified forb species	Unidentified forb		
ASMT	F	Unidentified forb species	Unidentified forb		
ASRA	F	Unidentified forb species	Unidentified forb		
ATNU	F	Unidentified forb species	Unidentified forb		
CEAL	F	Unidentified forb species	Unidentified forb		
COCO	F	Unidentified forb species	Unidentified forb		
COCR	F	Unidentified forb species	Unidentified forb		
COOR	F	Unidentified forb species	Unidentified forb		
CRESS	F	Unidentified forb species	Unidentified forb		
DEW	F	Unidentified forb species	Unidentified forb		
ERCAC	F	Unidentified forb species	Unidentified forb		
FORBD	F	Unidentified forb species	Unidentified forb		
FORBE	F	Unidentified forb species	Unidentified forb		
FORBF	F	Unidentified forb species	Unidentified forb		
HASP	F	Unidentified forb species	Unidentified forb		
HYRI	F	Unidentified forb species	Unidentified forb		
LEDU	F	Unidentified forb species	Unidentified forb		
LYDU	F	Unidentified forb species	Unidentified forb		
ORLU4	F	Unidentified forb species	Unidentified forb		
POPA	F	Unidentified forb species	Unidentified forb		
ROGEED	F	Unidentified forb species	Unidentified forb		
ROSET	F	Unidentified forb species	Unidentified forb		
SIDEWALK	F	Unidentified forb species	Unidentified forb		
SIH4	F	Unidentified forb species	Unidentified forb		
UNFORB1	F	Unidentified forb species	Unidentified forb		
UNFORB10	F	Unidentified forb species	Unidentified forb		
UNFORB11	F	Unidentified forb species	Unidentified forb		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
UNFORB12	F	Unidentified forb species	Unidentified forb		
UNFORB13	F	Unidentified forb species	Unidentified forb		
UNFORB14	F	Unidentified forb species	Unidentified forb		
UNFORB15	F	Unidentified forb species	Unidentified forb		
UNFORB16	F	Unidentified forb species	Unidentified forb		
UNFORB17	F	Unidentified forb species	Unidentified forb		
UNFORB18	F	Unidentified forb species	Unidentified forb		
UNFORB2	F	Unidentified forb species	Unidentified forb		
UNFORB3	F	Unidentified forb species	Unidentified forb		
UNFORB4	F	Unidentified forb species	Unidentified forb		
UNFORB5	F	Unidentified forb species	Unidentified forb		
UNFORB6	F	Unidentified forb species	Unidentified forb		
UNFORB7	F	Unidentified forb species	Unidentified forb		
UNFORB8	F	Unidentified forb species	Unidentified forb		
UNFORB9	F	Unidentified forb species	Unidentified forb		
UNK	F	Unidentified forb species	Unidentified forb		
UNK1	F	Unidentified forb species	Unidentified forb		
UNK2	F	Unidentified forb species	Unidentified forb		
UNK3	F	Unidentified forb species	Unidentified forb		
UNKF	F	Unidentified forb species	Unidentified forb		
UNKF	F	Unidentified forb species	Unidentified forb		UNKF
UNKF01	F	Unidentified forb species	Unidentified forb		
UNKF01	F	Unidentified forb species	Unidentified forb		UNKF01
UNKF02	F	Unidentified forb species	Unidentified forb		
UNKF02	F	Unidentified forb species	Unidentified forb		UNKF02
UNKF03	F	Unidentified forb species	Unidentified forb		
UNKF03	F	Unidentified forb species	Unidentified forb		UNKF03
UNKF04	F	Unidentified forb species	Unidentified forb		
UNKF04	F	Unidentified forb species	Unidentified forb		UNKF04
UNKF05	F	Unidentified forb species	Unidentified forb		
UNKF05	F	Unidentified forb species	Unidentified forb		UNKF05
UNKF06	F	Unidentified forb species	Unidentified forb		
UNKF06	F	Unidentified forb species	Unidentified forb		UNKF06

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
UNKF07	F	Unidentified forb species	Unidentified forb		
UNKF07	F	Unidentified forb species	Unidentified forb		UNKF07
UNKF08	F	Unidentified forb species	Unidentified forb		
UNKF08	F	Unidentified forb species	Unidentified forb		UNKF08
UNKF09	F	Unidentified forb species	Unidentified forb		
UNKF09	F	Unidentified forb species	Unidentified forb		UNKF09
UNKF1	F	Unidentified forb species	Unidentified forb		
UNKF10	F	Unidentified forb species	Unidentified forb		
UNKF10	F	Unidentified forb species	Unidentified forb		UNKF10
UNKF11	F	Unidentified forb species	Unidentified forb		
UNKF11	F	Unidentified forb species	Unidentified forb		UNKF11
UNKF12	F	Unidentified forb species	Unidentified forb		
UNKF12	F	Unidentified forb species	Unidentified forb		UNKF12
UNKF13	F	Unidentified forb species	Unidentified forb		
UNKF14	F	Unidentified forb species	Unidentified forb		
UNKF15	F	Unidentified forb species	Unidentified forb		
UNKF16	F	Unidentified forb species	Unidentified forb		
UNKF17	F	Unidentified forb species	Unidentified forb		
UNKF18	F	Unidentified forb species	Unidentified forb		
UNKF19	F	Unidentified forb species	Unidentified forb		
UNKF2	F	Unidentified forb species	Unidentified forb		
UNKF20	F	Unidentified forb species	Unidentified forb		
UNKF21	F	Unidentified forb species	Unidentified forb		
UNKF22	F	Unidentified forb species	Unidentified forb		
UNKF22	F	Unidentified forb species	Unidentified forb		
UNKF23	F	Unidentified forb species	Unidentified forb		
UNKF24	F	Unidentified forb species	Unidentified forb		
UNKF25	F	Unidentified forb species	Unidentified forb		
UNKF26	F	Unidentified forb species	Unidentified forb		
UNKF27	F	Unidentified forb species	Unidentified forb		
UNKF28	F	Unidentified forb species	Unidentified forb		
UNKF29	F	Unidentified forb species	Unidentified forb		
UNKF3	F	Unidentified forb species	Unidentified forb		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
UNKF30	F	Unidentified forb species	Unidentified forb		
UNKF31	F	Unidentified forb species	Unidentified forb		
UNKF32	F	Unidentified forb species	Unidentified forb		
UNKF33	F	Unidentified forb species	Unidentified forb		
UNKF34	F	Unidentified forb species	Unidentified forb		
UNKF35	F	Unidentified forb species	Unidentified forb		
UNKF36	F	Unidentified forb species	Unidentified forb		
UNKF37	F	Unidentified forb species	Unidentified forb		
UNKF38	F	Unidentified forb species	Unidentified forb		
UNKF39	F	Unidentified forb species	Unidentified forb		
UNKF40	F	Unidentified forb species	Unidentified forb		
UNKF41	F	Unidentified forb species	Unidentified forb		
UNKF42	F	Unidentified forb species	Unidentified forb		
UNKF43	F	Unidentified forb species	Unidentified forb		
UNKF44	F	Unidentified forb species	Unidentified forb		
UNKF45	F	Unidentified forb species	Unidentified forb		
UNKF46	F	Unidentified forb species	Unidentified forb		
UNKF47	F	Unidentified forb species	Unidentified forb		
UNKF48	F	Unidentified forb species	Unidentified forb		
UNKF49	F	Unidentified forb species	Unidentified forb		
UNKF50	F	Unidentified forb species	Unidentified forb		
UNKF51	F	Unidentified forb species	Unidentified forb		
UNKF52	F	Unidentified forb species	Unidentified forb		
UNKF53	F	Unidentified forb species	Unidentified forb		
UNKF54	F	Unidentified forb species	Unidentified forb		
UNKF55	F	Unidentified forb species	Unidentified forb		
UNKF56	F	Unidentified forb species	Unidentified forb		
UNKF57	F	Unidentified forb species	Unidentified forb		
UNKF58	F	Unidentified forb species	Unidentified forb		
UNKF59	F	Unidentified forb species	Unidentified forb		
UNKF60	F	Unidentified forb species	Unidentified forb		
UNKF61	F	Unidentified forb species	Unidentified forb		
UNKF62	F	Unidentified forb species	Unidentified forb		

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
UNKFDBL	F	Unidentified forb species	Unidentified forb		
UNONDE	F	Unidentified forb species	Unidentified forb		
UNTRMA	F	Unidentified forb species	Unidentified forb		
UNTROU	F	Unidentified forb species	Unidentified forb		
UNVERE	F	Unidentified forb species	Unidentified forb		
		Unidentified plant species or code			
ANSC	U	Unidentified plant species or code	Unidentified plant		
ANSP	U	Unidentified plant species or code	Unidentified plant		UANSP
ANSP	U	Unidentified plant species or code	Unidentified plant		UANSP
APPO	U	Unidentified plant species or code	Unidentified plant		
ASER	U	Unidentified plant species or code	Unidentified plant		
BOGA	U	Unidentified plant species or code	Unidentified plant		
BRSA	U	Unidentified plant species or code	Unidentified plant		
BRSA	U	Unidentified plant species or code	Unidentified plant		UBRSA
BRSP	U	Unidentified plant species or code	Unidentified plant		
BRSP	U	Unidentified plant species or code	Unidentified plant		UBRSP
BRTR	U	Unidentified plant species or code	Unidentified plant		
CAMUS	U	Unidentified plant species or code	Unidentified plant		
CHSP	U	Unidentified plant species or code	Unidentified plant		UCHSP
CHSP	U	Unidentified plant species or code	Unidentified plant		UCHSP
COVI	U	Unidentified plant species or code	Unidentified plant		UCOVI
COVI	U	Unidentified plant species or code	Unidentified plant		UCOVI
ELEA	U	Unidentified plant species or code	Unidentified plant		UELEA
ELEA	U	Unidentified plant species or code	Unidentified plant		UELEA
ERSP	U	Unidentified plant species or code	Unidentified plant		UERSP
ERSP	U	Unidentified plant species or code	Unidentified plant		UERSP
FLEA	U	Unidentified plant species or code	Unidentified plant		UFLEA
FLEA	U	Unidentified plant species or code	Unidentified plant		UFLEA
HEHN	U	Unidentified plant species or code	Unidentified plant		UHEHN
HEHN	U	Unidentified plant species or code	Unidentified plant		UHEHN
HESP	U	Unidentified plant species or code	Unidentified plant		
HYPA	U	Unidentified plant species or code	Unidentified plant		UHYPA

CODE	LF*	Common name or other Life Forms	Scientific name or other Life Forms	Comments	Alternative code used
HYPA	U	Unidentified plant species or code	Unidentified plant		UHYPA
LISP	U	Unidentified plant species or code	Unidentified plant		ULISP
LISP	U	Unidentified plant species or code	Unidentified plant		ULISP
PLANT	U	Unidentified plant species or code	Unidentified plant		
PSSP	U	Unidentified plant species or code	Unidentified plant		UPSSP
PSSP	U	Unidentified plant species or code	Unidentified plant		UPSSP
SAKI	U	Unidentified plant species or code	Unidentified plant		
UNK	U	Unidentified plant species or code	Unidentified plant		UNK
UNK1	U	Unidentified plant species or code	Unidentified plant		UNK1
UNK2	U	Unidentified plant species or code	Unidentified plant		UNK2
UNK92	u	Unidentified plant species or code	Unidentified plant		UNK
UNK92	U	Unidentified plant species or code	Unidentified plant		UNK92
UNPOAR	U	Unidentified plant species or code	Unidentified plant		
UNSHPA	U	Unidentified plant species or code	Unidentified plant		
USAKI	U	Unidentified plant species or code	Unidentified plant		UUSAKI
		Other codes included			
TOHE	Z3	Total herbaceous cover	Total herbaceous plant cover		TOHE
TOSH DA	Z4	Total Shrub DA	Total shrubs other than canopy cover		TOSH DA
TOSH LI	Z5	Big sagebrush	*Artemisia tridentata* by Line Intercept method		TOSH LI
TOSH LI	Z6	Total Shrub LI	Total shrubs by Line Intercept method		TOSH LI

*LF stands for life form

Methods used to collect 1992-93 and 2012 data

Site selection

Sites in Harding and Butte Counties were originally selected because they represented the best sage-grouse habitat in these counties at the time (1992). Since then data from other studies have been selected based on sage-grouse or lek locations, or random sites near grouse locations or leks. Most data is sampled within sagebrush habitat that represents sage-grouse habitat. Most recent site selection has Global Position Coordinates (GPS) of these locations. Some of the original locations established in 1992 and 1993 had a t-post to represent the plot center at the edge and 4 wooden stakes to establish the two parallel 30 m long transects. Figure 1 shows a general layout of data collected at each site. A site represents a single location where all vegetation data were collected. Future samples should include GPS coordinates with all data collected at each site.

In Fall River County sites included GPS coordinates labeled as UTM NAD83 (Universal Transverse Mercator coordinate system, North American Datum 83). Data in 1992 lacked any map or location information other than a small scale map with site locations. The Fall River data does include known sage-grouse leks within the project areas, but it was not specifically designed to collect data on the best sagebrush or sage-grouse habitat.

Plot layout

Located at each site the following plot layout can be seen in Figure 1 below.

Canopy cover and frequency of plant species

Methods used in both areas (Carter data and Fall River data) include collecting canopy cover and frequency by species using the Daubenmire (1959) method along two parallel, 30 m long transects. Transects are set 20 m apart and canopy cover by species, total cover, litter, bare ground, and rock were estimated at 1 m intervals along each transect. Therefore, canopy cover and frequency data were collected within thirty $0.1m^2$ plots along each of two transects for 60 total estimates per site.

Plant heights

To measure herbaceous plant height we used a meter stick and recorded the tallest forb and tallest graminoid present within each of the thirty $0.1m^2$ plots along each transect. All these data were averaged for provide an average height measure for the tallest forb and graminoid at each site. This data was recorded on the canopy cover data sheet and collected before estimating canopy cover.

Visual Obstruction Readings VOR

In Harding and Butte County Robel VOR data was collected since it was collected in 1992-93. A modified Robel pole was used to collected VOR data that included both a high and a low reading. Data in 2012 use a modified Robel pole with ½ inch bands. This was collected along a 200 m transect at 10 m intervals. Four readings per station were collected and data were averaged (80 readings per transect). The high estimate gave a reading of the greatest height of vegetation observed on the Robel pole. The low measurement recorded the lowest ½ inch band width visible. Data collected in 1992-93 using the Robel pole was always recorded as an even

number and the band width could not be determined. We treated the 1992-93 data as ½ inch band, but the 1992-93 Carter VOR data should not be considered as baseline information and knowledge of this problem.

Shrub heights and shrub densities

Shrub heights and shrub densities were also collected by species within a belt transect 10 m wide by 30 m long in 2012 in Harding and Butte Counties. Shrub heights were measured to the nearest 5 cm with a meter stick within this belt. Shrub numbers per height category based on 5 cm height differences were counted within the 300 m^2 belt transect (also referred to as a plot). We summarized the shrub counts to calculate a shrub density with this data. We divided this total number of shrubs counted within a 300 m^2 plot by 300 to produce a shrub density per meter square. We also plotted the shrub counts by each height category to give a condition of shrub demographics in Harding and Butte Counties.

Data collected in 1992-93 in Harding and Butte Counties generally used a belt transect 450 m^2 area (15 m x 30 m). The plots used were various sized and shaped sample areas, but were generally set at 450 m^2 (15 m x 30 m) or less and noted on the data sheets.

Line intercept

Line intercept of shrubs were collected along a 50 m transect located between the two 30 m long parallel transects used to collect canopy cover. Plant height was also collected along this transect to measure the tallest graminoid and tallest forb. The length of the shrub that intersected the 50 m transect was used to give another estimate of cover of shrubs (Bonham 2013).

Summary of Methods

Specifics of each method, biases associated with each method, alternative methods, can be found in Bonham (2013) or other sources. We are recommending following the specific plot layout (Figure 1) in the future because it is an efficient method and can be easily modified to collect more or fewer vegetation variables. We are not recommending collecting all the variables collected in 2012, some duplication was done, but we were including past methods for the 2012 sample.

Specifics for future vegetation data collection to be used for monitoring purposes will need to be determined based on specific objectives determined by resource and land managers. Line intercept method and canopy cover by Daubenmire (1959) method both give canopy cover estimates of all shrubs by species, both methods may not be required. The modified Robel pole method (Uresk and Benzon 2007) with ½ inch bands may be better method than measuring the tallest plant along transects because it gives an average plant height along with density of vegetation included in the measurement. In addition, this data can be easily modeled to relate herbage (lbs $acre^{-1}$ or kg ha^{-1}) based on band width.

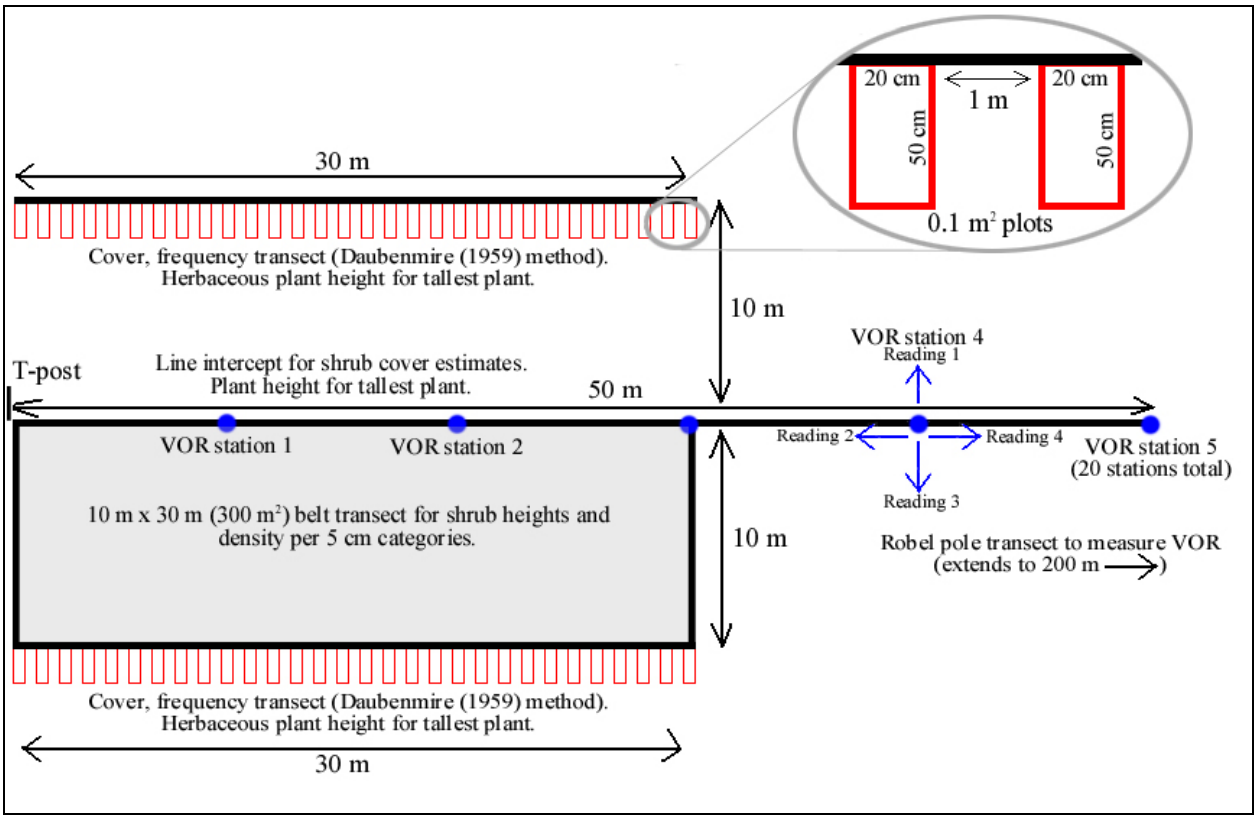


Figure 1. Methods layout.

Database File

Codes used for identification of life forms in data base files.

TOCO = A1; represents total plant canopy cover
TOGR = A2; represents total grass canopy cover
TOFO = A3; represents total forb canopy cover
TOSH = A4; represents total shrub canopy cover
LITT = A5; represents total litter cover on soil surface
BARE = A6; represents total bare ground
ROCK = A7; represents total rock cover
DUNG = D; represents total fecal material encountered on soil surface
FUNGI = M; represents total fungi canopy cover
LICH = L; represents total lichen canopy cover
SELAG = E; represents total Selaginella canopy cover

APPENDIX F
Precipitation

Precipitation

Harding County, South Dakota

The combined long-term monthly precipitation totals are from January 1893 to March 2013; the long-term average was calculated from all available data from Antelope Range Station SD (3/1/1951 to 1/31/2008), Camp Crook SD (1/1/1893 to 3/31/2013), Ellingson 1 NW SD (6/1/1909 to 8/31/1963), Harding 3 SE SD (12/2/1951 to 3/31/2013), Ludlow SD (3/11/1924 to 3/31/2013), Ralph 3 NW SD (6/1/1941 to 7/31/2003), Redig 9 NE SD (10/13/1914 to 12/31/2011), and Knobs MT (9/5/1951 to 3/31/2013) listed on the High Plains Regional Climate Center website (http://www.hprcc.unl.edu/data/historical/ -- specifically monthly precipitation totals at http://www.hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?sd0223, sd1294, sd2614, sd3560, sd5048, sd6907, sd7062, and mt4715). Precipitation data was compiled for 1991, 1992, 1993, 2011, and 2012 from Antelope Range Station, Camp Crook, Harding 3 SE, Ludlow, Ralph 3 NW, Redig 9 NE, South Dakota and Knobs, Montana. The combined long-term average is compared graphically with the average 1991, 1992, 1993, 2011, and 2012 monthly precipitation amounts below.

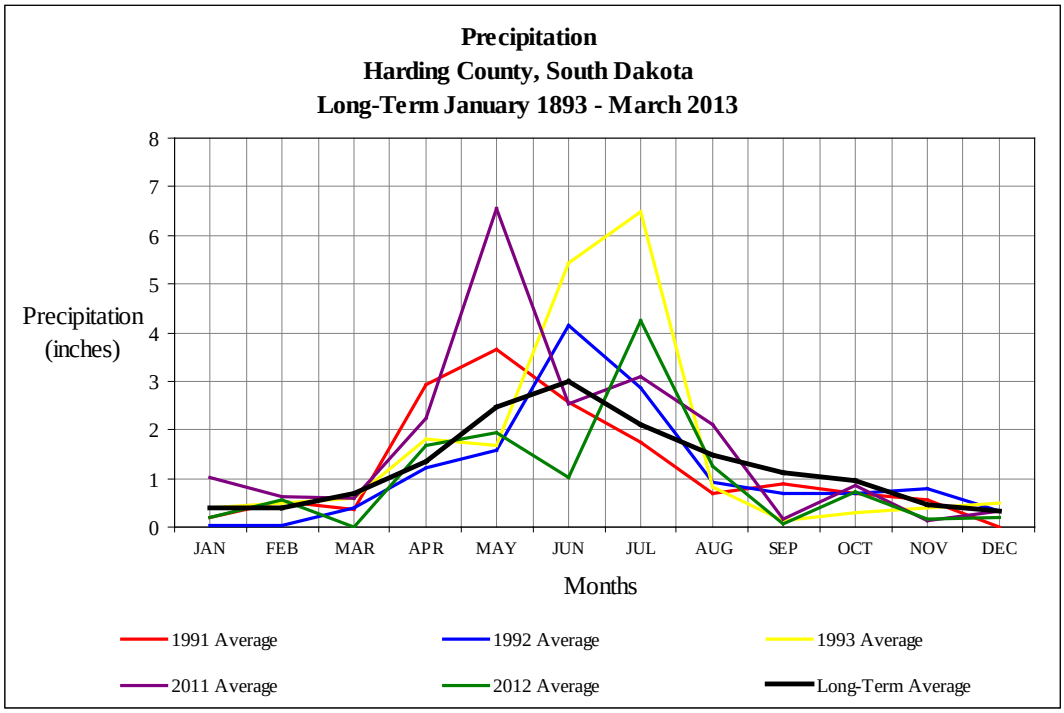


Figure 1. Harding County long-term average (January 1893 – March 2013) is compared with the average precipitation data for 1991, 1992, 1993, 2011, and 2012.

Table 1. Harding County long-term average (January 1893 – March 2013) is compared with the average precipitation data for 1991, 1992, 1993, 2011, and 2012.

	JAN	FEB	MAR	ARP	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Harding County, SD Long-Term Average	0.39	0.38	0.69	1.36	2.47	3.00	2.12	1.47	1.12	0.95	0.45	0.32
1991 Average	0.21	0.54	0.36	2.93	3.67	2.58	1.74	0.68	0.89	0.71	0.55	0.00
1992 Average	0.03	0.02	0.39	1.21	1.57	4.16	2.88	0.91	0.70	0.68	0.79	0.32
1993 Average	0.41	0.51	0.59	1.80	1.68	5.43	6.49	0.83	0.13	0.31	0.41	0.50
2011 Average	1.03	0.62	0.60	2.25	6.54	2.53	3.08	2.09	0.17	0.84	0.15	0.35
2012 Average	0.21	0.55	0.00	1.67	1.95	1.04	4.24	1.26	0.07	0.72	0.17	0.20

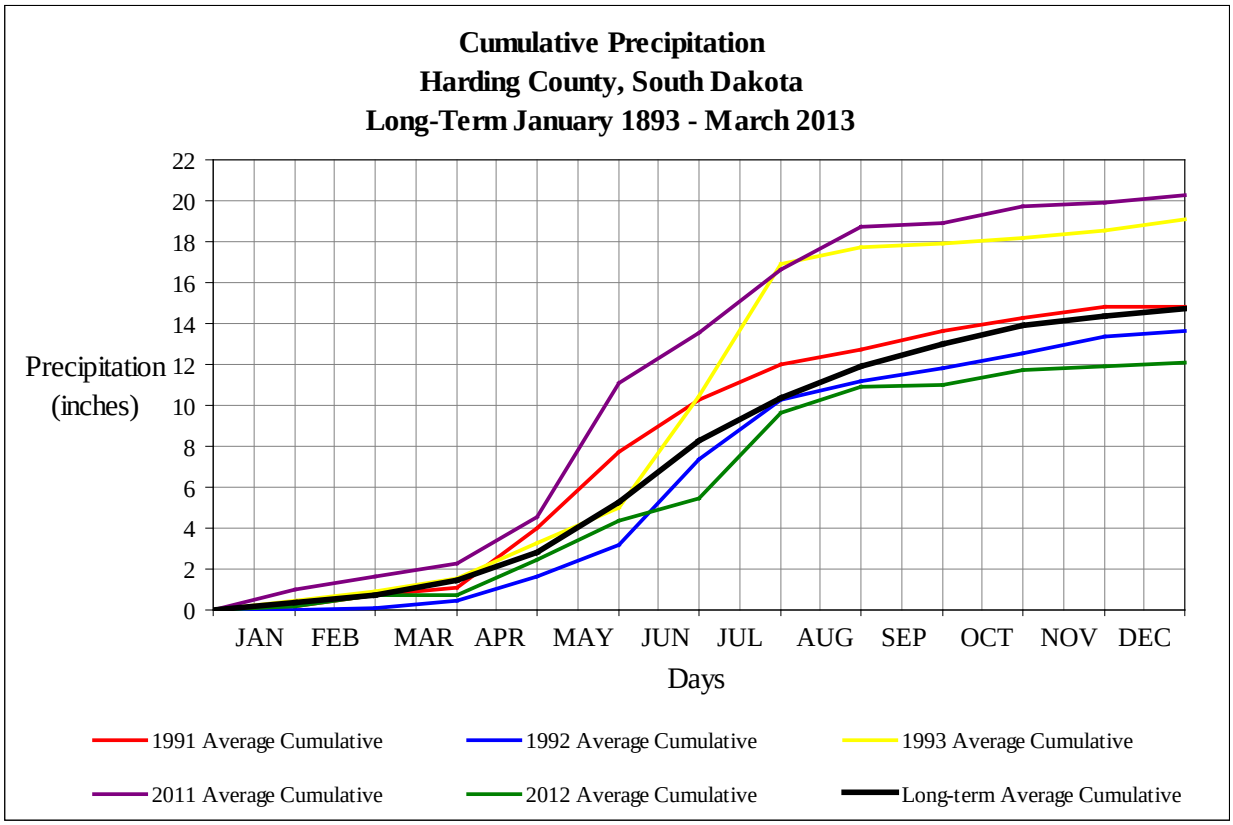


Figure 2. Harding County long-term average cumulative precipitation (January 1893 – March 2013) is compared with the average cumulative precipitation data for 1991, 1992, 1993, 2011, and 2012.

The long-term monthly precipitation data recorded at eight weather stations throughout Harding County are compared with average monthly precipitation data for 1991, 1992, 1993, 2011, and 2012 recorded at Antelope Range Station, Camp Crook, Harding 3 SE, Ludlow, Ralph 3 NW, Redig 9 NE, South Dakota and Knobs, Montana. Figure 2 shows 2012 monthly average cumulative precipitation in Harding County was below the long-term average cumulative precipitation for the entire year (12 months). Cumulative precipitation from January through June 2012 was 2.9 inches less compared to the long-term average (8.3). By the end of September 2012 cumulative precipitation was 2.0 inches less compared to the long-term average. By the end of December 2012 cumulative precipitation was 2.6 inches below the long-term average. Less than average precipitation and the lack of adequate residual measured in 2012 may have greater negative impacts in 2013 compared to 2012. Monthly precipitation within Harding County could be characterized as below average for 2012.

Butte County, South Dakota

The combined long-term monthly precipitation totals are from January 1893 to March 2013; the long-term average was calculated from all available data from Belle Fourche 20 NNE SD (6/1/1962 to 5/31/1970), Belle Fourche 22 NNW SD (5/1/1980 to 2/28/2013), Belle Fourche 29 NNW SD (7/1/1951 to 9/30/1979), Belle Fourche SD (6/1/1908 to 3/31/2013), Newell SD (9/1/1920 to 3/31/2013), Orman SD (5/1/1906 to 6/30/1974), Sulphur 2 W SD (8/1/1949 to 9/30/1957), Vale SD (2/15/1908 to 7/31/1978), and Zeona 10 SSW SD (8/1/1949 to 6/30/2002) listed on the High Plains Regional Climate Center website (http://www.hprcc.unl.edu/data/historical/ -- specifically monthly precipitation totals at http://www.hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?sd1560, sd0565, sd0567, sd0559, sd6054, sd6357, sd8107, sd8552 and sd9537). Precipitation data was compiled for 1991, 1992, 1993, 2011, and 2012 from Belle Fourche 22 NNW, Belle Fourche, Newell, and Zeona 10 SSW, South Dakota. The combined long-term average is compared graphically with the average 1991, 1992, 1993, 2011, and 2012 monthly precipitation amounts below.

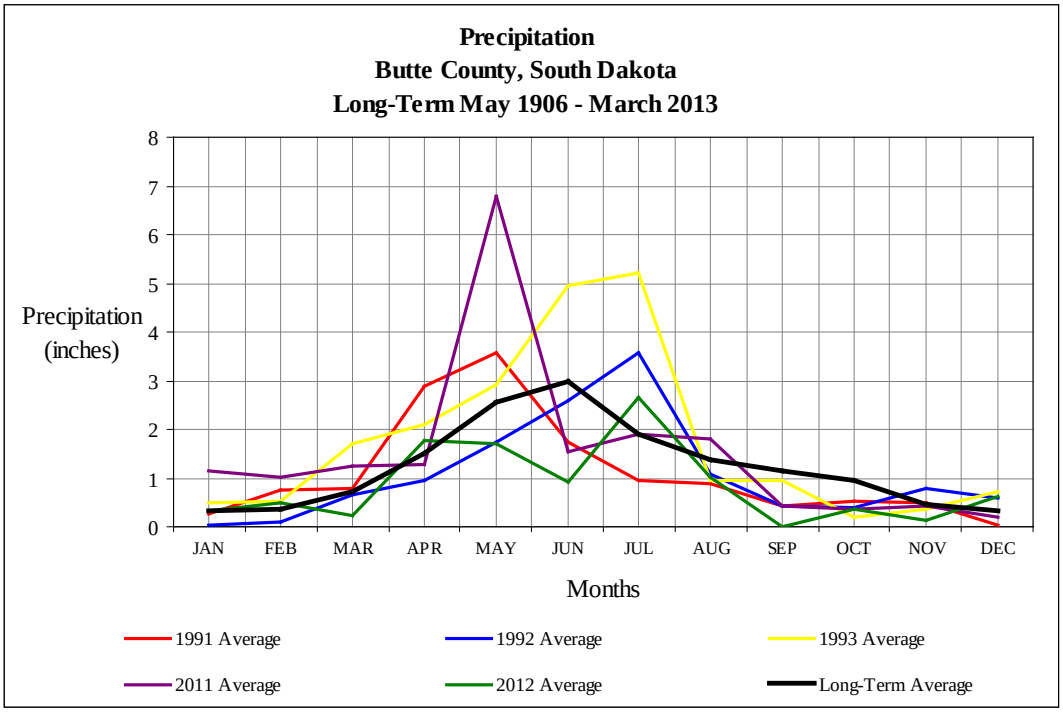


Figure 3. Butte County long-term average (May 1906 – March 2013) is compared with the average precipitation data for 1991, 1992, 1993, 2011, and 2012.

Table 2. Butte County long-term average (May 1906 – March 2013) is compared with the average precipitation data for 1991, 1992, 1993, 2011, and 2012.

	JAN	FEB	MAR	ARP	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Butte County, SD Long-Term Average	0.31	0.38	0.71	1.50	2.57	2.99	1.89	1.38	1.15	0.94	0.47	0.34
1991 Average	0.25	0.76	0.80	2.89	3.58	1.74	0.95	0.90	0.44	0.53	0.50	0.02
1992 Average	0.04	0.10	0.64	0.96	1.75	2.60	3.59	1.09	0.41	0.40	0.78	0.59
1993 Average	0.50	0.53	1.69	2.11	2.92	4.97	5.22	0.94	0.94	0.18	0.37	0.74
2011 Average	1.16	1.03	1.26	1.27	6.79	1.55	1.91	1.82	0.41	0.35	0.42	0.21
2012 Average	0.34	0.48	0.22	1.77	1.71	0.92	2.65	1.01	0.00	0.36	0.13	0.63

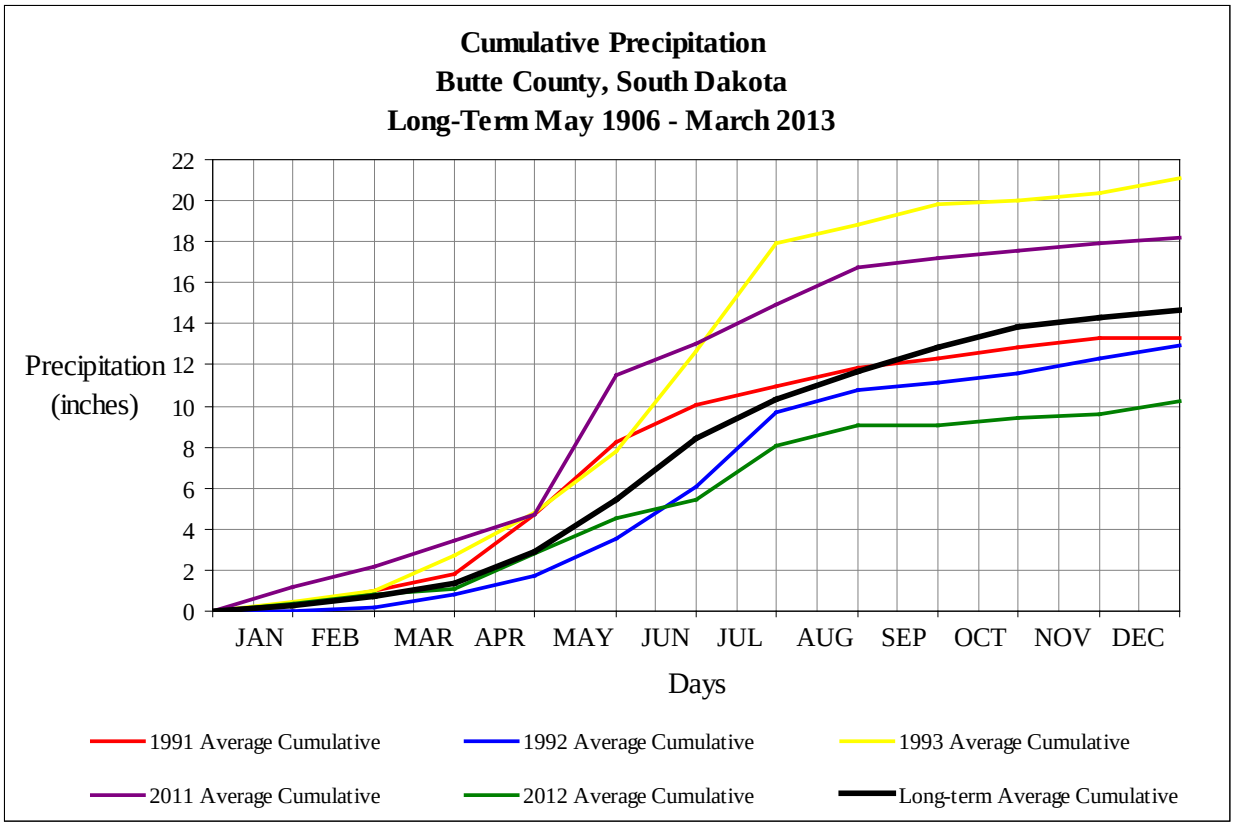


Figure 4. Butte County long-term average cumulative precipitation (May 1906 – March 2013) is compared with the average cumulative precipitation data for 1991, 1992, 1993, 2011, and 2012.

The long-term monthly precipitation data recorded at nine weather stations throughout Butte County are compared with average monthly precipitation data for 1991, 1992, 1993, 2011, and 2012 recorded at Belle Fourche 22 NNW, Belle Fourche, Newell, and Zeona 10 SSW, South Dakota. Monthly precipitation for 2012 were near equal or slightly greater than the long-term average values for January, February, and March. Figure 4 shows 2012 monthly average cumulative precipitation in Butte County was below the long-term average cumulative precipitation from April to December (9 months). Cumulative precipitation from January through June 2012 was 3.0 inches less compared to the long-term average (8.5). By the end of September 2012 cumulative precipitation was 3.8 inches less compared to the long-term average. By the end of December 2012 cumulative precipitation was 4.4 inches below the long-term average. Less than average precipitation and the lack of adequate residual measured in 2012 may have greater negative impacts in 2013 compared to 2012. Monthly precipitation within Butte County could be characterized as below average for 2012.

Fall River County, South Dakota

The combined long-term monthly precipitation totals are from January 1893 to March 2013; the long-term average was calculated from all available data from Angostura Dam SD (10/1/1947 to 5/12/1971), Ardmore 4 NNE SD (11/1/1908 to 3/31/2013), Dewey SD (11/1/1948 to 9/30/1957), Edgemont 10 N SD (11/1/1948 to 9/27/1957), Edgemont 23 NNW SD (10/1/1989 to 1/31/2013), Edgemont SD (8/1/1948 to 3/31/2013), Hot Springs 7 W SD (11/1/1948 to 6/30/1958), Hot Springs 9 SW SD (11/1/1948 to 9/29/1957), Hot Springs SD (2/1/1894 to 3/31/2013), Oelrichs 8 W SD (11/1/1948 to 6/30/1958), Oelrichs SD (1/1/1893 to 3/31/2013), Oral SD (5/1/1971 to 3/31/2013), Provo SD (11/1/1948 to 6/30/1958), Rumford SD (11/1/1948 to 6/30/1958), and Smithwick 6 SW SD (11/1/1948 to 8/31/1957) listed on the High Plains Regional Climate Center website (http://www.hprcc.unl.edu/data/historical/ -- specifically monthly precipitation totals at http://www.hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?sd0217, sd0236, sd2312, sd2559, sd2565, sd2557, sd4009, sd4010, sd4007, sd6214, sd6212, sd6304, sd6812, sd7367, and sd7797). Precipitation data was compiled for 1991, 1992, 2002, 2003, 2004, 2011, and 2012 from Ardmore 4 NNE, Edgemont 23 NNW, Edgemont, Hot Springs, Oelrichs, and Oral, South Dakota. The combined long-term average is compared graphically with the average 1991, 1992, 2002, 2003, 2004, 2011, and 2012 monthly precipitation amounts below.

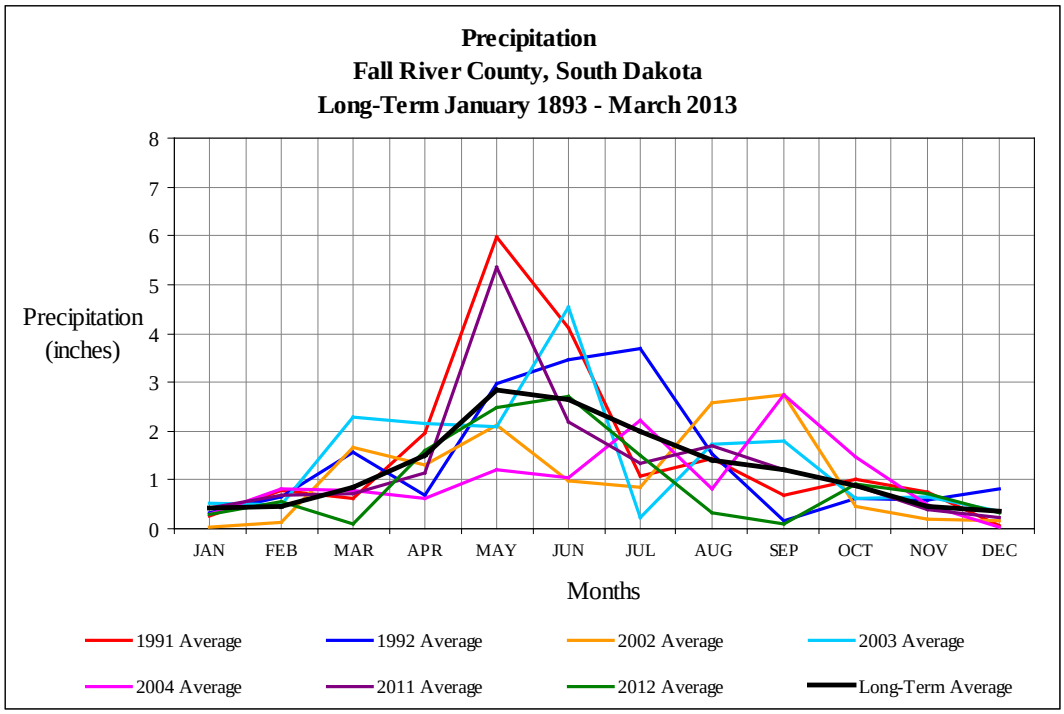


Figure 5. Fall River County long-term average (January 1893 – March 2013) is compared with the average precipitation data for 1991, 1992, 2002, 2003, 2004, 2011, and 2012.

Table 3. Fall River County long-term average (January 1893 – March 2013) is compared with the average precipitation data for 1991, 1992, 2002, 2003, 2004, 2011, and 2012.

	JAN	FEB	MAR	ARP	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Fall River County, SD Long-Term Average	0.42	0.46	0.85	1.50	2.84	2.63	1.98	1.40	1.22	0.89	0.46	0.36
1991 Average	0.26	0.78	0.61	1.95	5.98	4.13	1.08	1.45	0.69	1.02	0.75	0.07
1992 Average	0.34	0.67	1.57	0.70	2.99	3.45	3.70	1.54	0.17	0.62	0.59	0.81
2002 Average	0.05	0.14	1.66	1.32	2.14	0.99	0.84	2.59	2.74	0.45	0.19	0.16

	JAN	FEB	MAR	ARP	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2003 Average	0.51	0.48	2.27	2.16	2.08	4.53	0.24	1.73	1.80	0.61	0.65	0.35
2004 Average	0.29	0.83	0.80	0.62	1.20	1.05	2.23	0.83	2.74	1.49	0.51	0.03
2011 Average	0.42	0.70	0.73	1.14	5.35	2.19	1.34	1.70	1.21	0.87	0.40	0.23
2012 Average	0.29	0.54	0.11	1.59	2.48	2.71	1.52	0.33	0.09	0.93	0.73	0.32

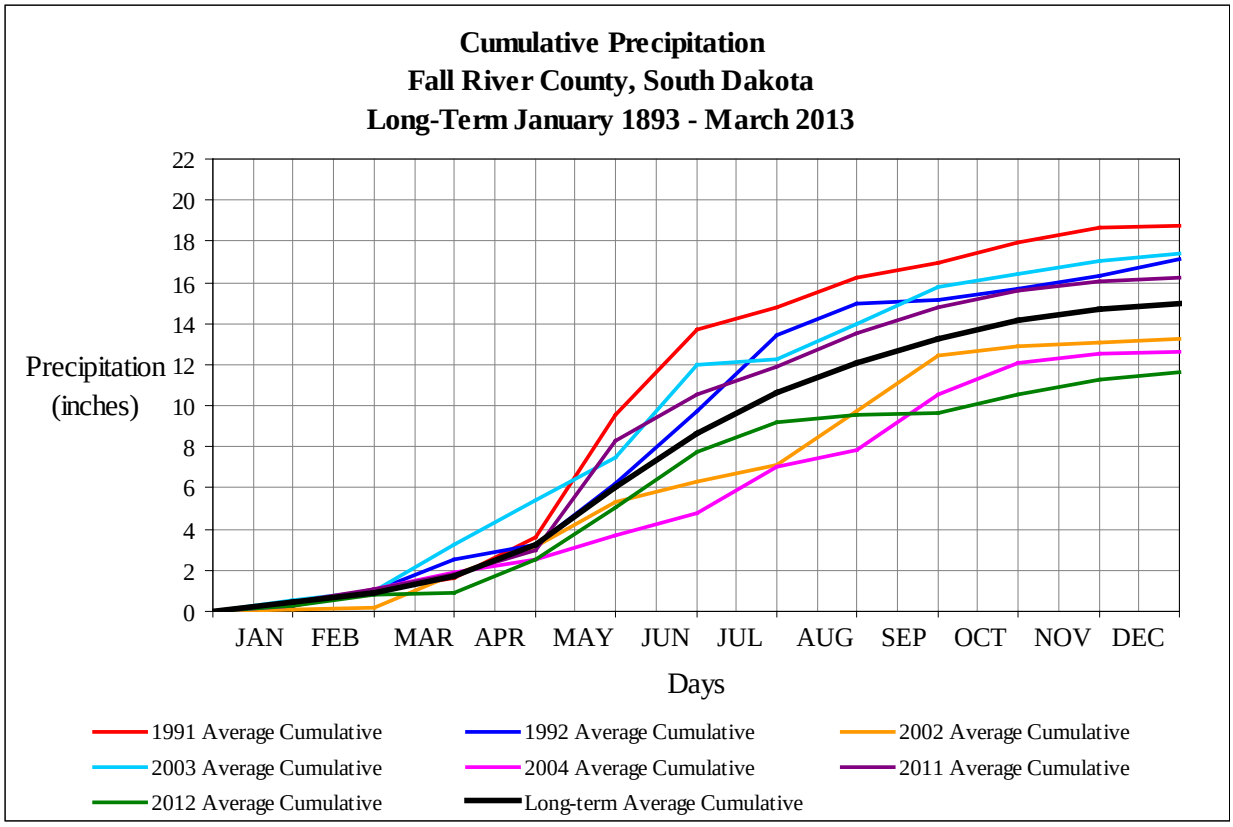


Figure 6. Fall River County long-term average cumulative precipitation (January 1893 – March 2013) is compared with the average cumulative precipitation data for 1991, 1992, 2002, 2003, 2004, 2011, and 2012.

The long-term monthly precipitation data recorded at fifteen weather stations throughout Fall River County are compared with average monthly precipitation data for 1991, 1992, 2002, 2003, 2004, 2011, and 2012 recorded at Ardmore 4 NNE, Edgemont 23 NNW, Edgemont, Hot Springs, Oelrichs, and Oral, South Dakota. Figure 6 shows 2012 monthly average cumulative precipitation in Fall River County was below the long-term average cumulative precipitation for the entire year (12 months). Cumulative precipitation from January through June 2012 was 1.0 inches less compared to the long-term average (8.7). By the end of September 2012 cumulative precipitation was 3.7 inches less compared to the long-term average. By the end of December 2012 cumulative precipitation was 3.4 inches below the long-term average. Less than average precipitation and the lack of adequate residual measured in 2012 may have greater negative impacts in 2013 compared to 2012. Monthly precipitation within Fall River County could be characterized as below average for 2012.

APPENDIX G
GPS, maps and sage-grouse numbers

Data for Internal Use Only

APPENDIX H
Lewis 2004

APPENDIX H Table 1. Locations of study sites are listed below with their UTM coordinates. The Datum was WGS84 and the Zone was 13 unless otherwise specified. (Lewis 2004)

Site Code	State	County	Easting	Northing
FR1Control	SD	Fall River	641309	4796079
FR101	SD	Fall River	631302	4800136
FR103	SD	Fall River	639628	4796043
FR104	SD	Fall River	640916	4797365
FR105	SD	Fall River	631986	4795637
FR106	SD	Fall River	583536	4794872
FR107	SD	Fall River	594067	4795052
FR108	SD	Fall River	594690	4793585
FR109	SD	Fall River	593370	4792093
FR110	SD	Fall River	592082	4791282
FR111A	SD	Fall River	588789	4789619
FR111B	SD	Fall River	588789	4789619
FR112	SD	Fall River	584878	4790405
FR113	SD	Fall River	583393	4790067
FR114	SD	Fall River	583287	4787415
FR115	SD	Fall River	578656	4786899
FR116	SD	Fall River	579085	4786960
FR117	SD	Fall River	588795	4763733
FR121	SD	Fall River	595108	4791775
FR125	SD	Fall River	581409	4796209
FR126	SD	Fall River	581515	4796901
FR127	SD	Fall River	581931	4796872
FR128	SD	Fall River	582756	4797008
FR129	SD	Fall River	582653	4798166
FR2Control	SD	Fall River	642373	4784000
FR201	SD	Fall River	631310	4800105
FR203	SD	Fall River	644035	4804341
FR204	SD	Fall River	637466	4795813
FR204Control	SD	Fall River	641313	4796104
FR205	SD	Fall River	633341	4796734
FR205Control	SD	Fall River	640689	4797695
FR206	SD	Fall River	587222	4793023
FR207	SD	Fall River	593686	4794231
FR208	SD	Fall River	594690	4793585
FR209	SD	Fall River	593370	4792093
FR210	SD	Fall River	592082	4791255
FR211A	SD	Fall River	588820	4789668
FR211B	SD	Fall River	588789	4789619
FR212	SD	Fall River	585319	4789933
FR213	SD	Fall River	583315	4789969
FR213Control	SD	Fall River	583246	4790360
FR214	SD	Fall River	583353	4787467
FR215	SD	Fall River	579845	4786535
FR216	SD	Fall River	579206	4786928
FR221	SD	Fall River	595108	4791775

Site Code	State	County	Easting	Northing
FR222	SD	Fall River	593563	4791718
FR225	SD	Fall River	581842	4796146
FR226	SD	Fall River	581786	4796596
FR227	SD	Fall River	581931	4796507
FR227Control	SD	Fall River	583115	4787172
FR228	SD	Fall River	582706	4797072
FR229	SD	Fall River	582653	4798166
FR231	SD	Fall River	591219	4805112
FR233Control	SD	Fall River	580105	4786577
H101	SD	Harding	613505	5020952
H102	SD	Harding	614022	5031781
H103	SD	Harding	613509	5034002
H104	SD	Harding	629294	5045862
H105	SD	Harding	637202	5044518
H106	SD	Harding	649156	5038704
H107	SD	Harding	644410	5029586
H108	SD	Harding	644231	5021802
H109	SD	Harding	644345	5019182
H110	SD	Harding	634826	5014735
H110A	SD	Harding	639319	5014795
H110B	SD	Harding	636385	5014339
H110C	SD	Harding	631851	5013896
H111	SD	Harding	616780	5013930
H112	SD	Harding	622773	5030399
H113	SD	Harding	633281	5030649
H115	SD	Harding	631517	5039326
H116	SD	Harding	617493	5060109
H119	SD	Harding	580109	5074474
H120	SD	Harding	579410	5065160
H121	SD	Harding	579842	5055121
H123	SD	Harding	580022	5020515
H124	SD	Harding	577809	5026532
H124A	SD	Harding	576724	5030010
H126	SD	Harding	577097	5034147
H127	SD	Harding	578553	5038053
H129	SD	Harding	580084	5040596
H129Control	SD	Harding	580734	5042244
H130	SD	Harding	583108	5044512
H131	SD	Harding	588709	5046552
H133	SD	Harding	591018	5036219
H134	SD	Harding	609005	5017624
H135	SD	Harding	611584	5017927
H135Control	SD	Harding	610473	5017514
H138	SD	Harding	611600	5058117
H139	SD	Harding	610372	5062910
H140A	SD	Harding	609064	5063955
H140B	SD	Harding	608164	5069677

Site Code	State	County	Easting	Northing
H140C	SD	Harding	607266	5073589
H142	SD	Harding	601657	5080379
H143	SD	Harding	602634	5085838
H144	SD	Harding	609675	5083749
H145	SD	Harding	614530	5084944
H146	SD	Harding	595109	5065076
H148	SD	Harding	607695	5049995
H201	SD	Harding	613505	5020952
H206	SD	Harding	648742	5038652
H207	SD	Harding	644410	5029586
H208	SD	Harding	644171	5021257
H209	SD	Harding	644345	5019182
H210	SD	Harding	634826	5014735
H210A	SD	Harding	639133	5015154
H210B	SD	Harding	636519	5014269
H210C	SD	Harding	631851	5013896
H211	SD	Harding	616738	5013714
H212	SD	Harding	622879	5030482
H215	SD	Harding	631492	5039360
H216	SD	Harding	617716	5061335
H217	SD	Harding	581449	5078110
H218	SD	Harding	577933	5070359
H219	SD	Harding	580109	5074474
H220	SD	Harding	579410	5065160
H221	SD	Harding	579904	5055079
H223	SD	Harding	591032	5036248
H224	SD	Harding	576725	5027862
H224A	SD	Harding	576724	5030010
H226	SD	Harding	577050	5034233
H227	SD	Harding	578553	5038053
H229	SD	Harding	580137	5040451
H230	SD	Harding	584160	5044838
H231	SD	Harding	588716	5046464
H233	SD	Harding	579972	5020949
H234	SD	Harding	611601	5017923
H235	SD	Harding	611584	5017927
H238	SD	Harding	611573	5057875
H239	SD	Harding	610372	5062910
H240	SD	Harding	608191	5072142
H243	SD	Harding	602325	5085374
H244	SD	Harding	609709	5083841
H245	SD	Harding	614567	5085148
H246	SD	Harding	595135	5064169
H248	SD	Harding	607695	5049995
H249	SD	Harding	606752	5066281
H250	SD	Harding	602843	5065494
H1Control	SD	Harding	614790	5084888

Site Code	State	County	Easting	Northing
H2Control	SD	Harding	582675	5069592
H3Control	SD	Harding	611237	5017413
H4Control	SD	Harding	590869	5041214
H5Control	SD	Harding	580098	5039107
U101	SD	Butte	582977	4955129
U101B	SD	Butte	583921	4954727
U102	SD	Butte	590879	4960861
U103	SD	Butte	590578	4961801
U104	SD	Butte	593054	4967656
U105Control	SD	Butte	596874	4981716
U105A	SD	Butte	596596	4979474
U105B	SD	Butte	596972	4977291
U106Control	SD	Butte	596734	4990910
U106A	SD	Butte	596470	4988170
U106B	SD	Butte	596492	4986685
U107	SD	Butte	609763	5005782
U108A	SD	Butte	602835	4973304
U108B	SD	Butte	602359	4973083
U109	SD	Butte	609178	4977301
U111	SD	Butte	614354	4993239
U112	SD	Butte	613934	4999703
U114	SD	Butte	605103	4954935
U115	SD	Butte	600449	4958945
U116	SD	Butte	590700	4972959
U117	SD	Butte	590677	4974362
U118	SD	Butte	590475	4976999
U119	SD	Butte	585643	5000608
U119Control	SD	Butte	586106	4996131
U120	SD	Butte	581505	4976041
U121	SD	Butte	588485	4971792
U122	SD	Butte	587705	4972412
U123	SD	Butte	599504	4956194
U124	SD	Butte	606780	4969900
U201	SD	Butte	583816	4954366
U202	SD	Butte	590879	4960861
U203	SD	Butte	590472	4962231
U204	SD	Butte	592124	4968674
U205A	SD	Butte	596596	4979474
U205B	SD	Butte	596657	4977065
U205Control	SD	Butte	596874	4981716
U206A	SD	Butte	596470	4988170
U206B	SD	Butte	596370	4994139
U206Control	SD	Butte	596734	4990910
U207	SD	Butte	604989	5003207
U208A	SD	Butte	602333	4973429
U208B	SD	Butte	606876	4975615
U209	SD	Butte	610119	4978273

Site Code	State	County	Easting	Northing
U211	SD	Butte	613849	4993443
U212	SD	Butte	613763	5006188
U214	SD	Butte	605103	4954935
U215	SD	Butte	603082	4960378
U216	SD	Butte	590502	4972194
U217	SD	Butte	590574	4976168
U218	SD	Butte	589547	4977907
U219	SD	Butte	586149	4994841
U219Control	SD	Butte	586106	4996131
U220	SD	Butte	582334	4974922
U221	SD	Butte	588787	4971749
U222	SD	Butte	587914	4973071
U223	SD	Butte	602660	4951588
U224	SD	Butte	606780	4969900
GV102	ND	Golden Valley	579966	5159625
GV202	ND	Golden Valley	579966	5159625
S103	ND	Slope	582337	5131936
S104	ND	Slope	581850	5133674
S105	ND	Slope	581640	5134387
S106	ND	Slope	581290	5135319
S106Control	ND	Slope	581312	5135100
S107	ND	Slope	581537	5136580
S108	ND	Slope	580399	5139445
S109A	ND	Slope	577417	5141062
S109B	ND	Slope	576729	5141521
S109C	ND	Slope	576635	5141856
S110	ND	Slope	576505	5143314
S111	ND	Slope	576833	5144460
S112	ND	Slope	576628	5144663
S113	ND	Slope	577169	5146633
S114A	ND	Slope	576612	5147319
S114B	ND	Slope	576558	5147102
S115	ND	Slope	576354	5149241
S116	ND	Slope	576383	5149985
S116Control	ND	Slope	575867	5150200
S117	ND	Slope	594286	5132466
S118	ND	Slope	592042	5132525
S119	ND	Slope	587353	5129098
S120	ND	Slope	586353	5129108
S120Control	ND	Slope	585166	5128268
S122	ND	Slope	593221	5156579
S203	ND	Slope	582930	5132355
S204	ND	Slope	581498	5134393
S206Control	ND	Slope	581222	5133849
S207	ND	Slope	580797	5137785
S208	ND	Slope	580664	5139641
S209A	ND	Slope	516317	5141853

Site Code	State	County	Easting	Northing
S209B	ND	Slope	576907	5141419
S209C	ND	Slope	575961	5142897
S210	ND	Slope	576505	5143314
S211	ND	Slope	577223	5143683
S212	ND	Slope	576628	5144663
S213	ND	Slope	576383	5145114
S214A	ND	Slope	576982	5145656
S214B	ND	Slope	577217	5146609
S215	ND	Slope	576354	5149241
S216	ND	Slope	575754	5150678
S216Control	ND	Slope	576147	5152403
S217	ND	Slope	594286	5132466
S218	ND	Slope	589472	5132398
S219	ND	Slope	586844	5128690
S220	ND	Slope	585719	5128245
S220Control	ND	Slope	585189	5728389
S222	ND	Slope	592940	5156643
O101	ND	Bowman	603535	5101612
O102	ND	Bowman	601780	5098159
O103	ND	Bowman	594951	5097678
O104	ND	Bowman	591718	5096629
O105	ND	Bowman	590730	5093237
O106	ND	Bowman	585946	5096133
O108	ND	Bowman	587281	5106544
O109	ND	Bowman	588004	5106616
O110	ND	Bowman	589241	5105308
O111	ND	Bowman	589962	5107201
O113	ND	Bowman	597218	5111029
O114	ND	Bowman	580966	5124542
O115	ND	Bowman	581064	5120937
O116A	ND	Bowman	580252	5103407
O116B	ND	Bowman	580430	5104617
O117	ND	Bowman	579945	5099073
O118	ND	Bowman	581280	5095951
O120	ND	Bowman	603027	5091863
O121	ND	Bowman	601501	5095152
O122	ND	Bowman	599401	5091291
O124	ND	Bowman	601932	5103159
O125	ND	Bowman	598599	5103544
O127	ND	Bowman	595436	5105126
O201	ND	Bowman	603535	5101612
O202	ND	Bowman	601653	5098132
O203	ND	Bowman	594853	5097562
O204	ND	Bowman	591521	5096359
O205	ND	Bowman	590730	5093237
O206	ND	Bowman	585815	5095972
O209	ND	Bowman	588004	5106616

Site Code	State	County	Easting	Northing
O210	ND	Bowman	589247	5105144
O211	ND	Bowman	590196	5107399
O213	ND	Bowman	595617	5104491
O214	ND	Bowman	580686	5125036
O215	ND	Bowman	580200	5120368
O216A	ND	Bowman	580252	5103407
O216B	ND	Bowman	580448	5103165
O217	ND	Bowman	579945	5099073
O218	ND	Bowman	580279	5095488
O219	ND	Bowman	583835	5093851
O220	ND	Bowman	602456	5091795
O221	ND	Bowman	600704	5094801
O222	ND	Bowman	598176	5090973
O224	ND	Bowman	598691	5101369
O227	ND	Bowman	595443	5104690
W201	WY	Natrona	349163	4712512
W202	WY	Natrona	349446	4707930
W203	WY	Fremont	12T 733496	4763389
W204	WY	Natrona	343056	4723402
W205	WY	Natrona	351593	4724543
W206	WY	Natrona	358705	4728685
W207	WY	Natrona	366786	4734830
W208	WY	Natrona	364206	4742537
W209	WY	Natrona	356591	4745332
W210	WY	Natrona	369082	4765044
W211	WY	Natrona	371280	4776515
W212	WY	Natrona	370085	4781441
W213	WY	Natrona	370024	4786563
W214	WY	Natrona	364293	4797061
W215	WY	Natrona	361944	4800278
W216	WY	Natrona	357839	4802391
W217	WY	Fremont	283208	4744768
W218	WY	Fremont	279551	4749353
W219	WY	Fremont	272011	4753180
W220	WY	Fremont	270283	4753889
W221	WY	Fremont	258159	4761923
W222	WY	Fremont	12T 742684	4761945
W223	WY	Fremont	12T 738915	4762318
W224	WY	Natrona	355058	4726706
W225	WY	Natrona	371258	4769407
W214Control	WY	Natrona	363183	4798819
W218Control	WY	Fremont	276880	4750738

APPENDIX I
Herman-Brunson 2007

APPENDIX I Table 6. Combined average distributions of vegetation characteristics for nest-sites and random sites of sage-grouse in southwestern North Dakota using MRPP, 2005-2006. (Herman-Brunson 2007)

Variable	Nest 0 (n=34)	Random 0 (n=50)	p-value
Total cover (%)	70	54	<0.001
Total grass (%)	27	19	0.0111
Total forb (%)	15	11	<0.001
Total sagebrush (%)	10	7	0.003
Bare ground (%)	21	33	0.0058
Litter (%)	13	8	<0.001
Sagebrush density/hectare	2,576.1	1,399.4	<0.001
Nest-VOR	9.3	7	0.0019

APPENDIX I Table 7. Average vegetation characteristics of nest-site and random sites between years for sage-grouse in southwestern North Dakota using MRPP, during 2005-2006. (Herman-Brunson 2007)

Variable	Nest 2005 (n=17)	Nest 2006 (n=17)	p-value	Random 2005 (n=17)	Random 2006 (n=33)	p-value
Total Forb (%)	23	8	<0.001*	16	8	<0.001*
Total Sage (%)	11	8	0.0242*	9	6	0.0238*
Bare ground (%)	27	16	0.0269*			
Grass hgt. in shrub (cm)	35.1	29.9	0.0185*	41.5	32.2	0.0041*
Avg. width of shrubs (cm)	41.5	53	0.0061*	48.5	31.8	<0.001*
Nest-VOR (in)	9.7	8.9	0.6525	23.6	6.7	<0.001*
VOR 1m	4.1	3.7	0.7094	9.9	2.4	<0.001*
VOR 2m	3.4	2.5	0.3131	7.8	2.2	<0.001*
VOR 3m	2.6	2.4	0.2705	6.6	2.1	<0.001*
VOR 4m	2.2	2.6	0.6016	7.1	2.1	<0.001*
VOR 5m	2.3	2.1	0.9263	7.3	2.2	<0.001*
VOR 10m	2.2	2.2	0.8988	8.4	1.8	<0.001*
VOR 20m	1.6	2.2	0.1289	6.8	1.4	<0.001*
VOR 30m	2.2	2.2	0.7868	7.3	1.5	<0.001*
VOR 40m	2.1	2.2	0.6366	6.6	1.5	<0.001*
VOR 50m				5	1.1	<0.001*

Asterisks (*) indicates significant difference between nests of 2005 and 2006, and significant differences between random sites compared between 2005 and 2006.

APPENDIX I Table 15. Average vegetation characteristic of sage-grouse brood and random sites used in the best model to explain brood sites in southwestern North Dakota, USA, 2005-2006. (Herman-Brunson 2007)

	Broods 2005	Randoms 2005	Broods 2006	Randoms 2006
Variable	0	0	0	0
Forb cover (%)	16	13	6	4
Grass cover (%)	29	23	34	19
Sagebrush cover (%)	5	5	5	3
Bare ground cover (%)	25	35	11	29
Sagebrush height (cm)	38	38	30	29
Sagebrush width (cm)	53	55	50	47

APPENDIX I Table 11. Combined average distributions of vegetation characteristics for brood sites and random sites of sage-grouse in southwestern North Dakota using MRPP, 2005-2006. (Herman-Brunson 2007)

Variable	Brood (n=130)	Random (n=107)	p-value
Vegetative cover (%)	74	55	<0.001*
Grass cover (%)	32	21	<0.001*
Forb cover (%)	11	9	<0.001*
Sagebrush cover (%)	5	4	0.041*
Bare ground cover (%)	17	32	<0.001*
Site-VOR (in)	3	2	0.107*
Sagebrush density/hectare	2,300	1,546	<0.001*
Sage (%)	5	3	<0.001*
Vegetation height/site (in)	12	14	0.065*
Grass height beneath the sagebrush (cm)	41	42	0.431
Sagebrush height (cm)	33	33	0.646
Sagebrush width (cm)	48	48	0.298

Asterisks (*) indicates significance. (Definition of each variable in Herman-Brunson 2007 Appendix E).

APPENDIX I Table 12. Combined average distributions of habitat characteristics for brood sites compared between years and random sites compared between years of sage-grouse in southwestern North Dakota using MRPP, 2005-2006. (Herman-Brunson 2007)

Variable	Brood 2005 (n=55)	Brood 2006 (n=75)	p-value	Random 2005 (n=47)	Random 2006 (n=60)	p-value
Vegetative cover (%)	67	79	<0.001*	57	54	0.429
Forb cover (%)	16	6	<0.001*	13	6	<0.001*
Grass cover (%)	29	33	0.145	23	19	0.249
Sagebrush cover (%)	5	5	0.334	5	3	0.016*
Bare ground cover (%)	25	10	<0.001*	34	29	0.113
Site-VOR (cm)	6	1	<0.001*	3	1	<0.001*
Sagebrush density/hectare	1,619	2,991	0.001*	1,011	1,966	<0.103*
Sagebrush (%)	5	5	0.4075	4	3	0.22
Grass hgt beneath the sagebrush (cm)	48	36	<0.001*	49	37	<0.001*
Sagebrush hgt (cm)	38	30	<0.001*	38	29	<0.001*
Sagebrush width (cm)	51	45	0.011*	53	44	<0.002*

Asterisks (*) indicates significance. (Definition of each variable in Herman-Brunson 2007 Appendix E).

APPENDIX I Table 13. Logistic regression models predicting greater sage-grouse brood sites (*n* = 130) versus random sites (*n* = 107) using vegetal data collected in North Dakota, USA, 2005-2006. Loglikelihood *(-2 ln [L])*, number of parameters including year indicator variable plus 2 *(intercept + SE) (K)*, Akaike's Information Criterion adjusted for small sample size *(AICc*), difference in AICc *()AICc)*, Akaike weights *(wi*). Models with)AICc < 2 are highlighted as the best model. (Herman-Brunson 2007)

Model	**Loglikelihood**	**K**	**AICc**	**)AICc**	**Wi**
Togr(+)+Tofo(+)+Tosh(+)+Bare(-)Shrubhgt(-)+Shrubw(-)	-135.97149	9	258.9682	0	0.89
Toco(+)+cover(+)+Shrubhgt(-)+Shrubw(-)	-123.91192	7	263.215	4.247	0.106
Toco(+)	-123.78395	8	271.0118	12.044	0.002
Tofo(+)+Togr(+)+Tosh(+)+Bare(-)+Cover(+)	-140.64085	8	271.943	12.975	0.001
Tofo(+)+Togr(+)+Tosh(+)	-145.71992	6	288.5111	29.543	<0.001
Tofo(+)+Togr(+)+Tosh(+)+Bare(-)	-137.64685	7	288.5452	29.577	<0.001
Toco(+)+Cover(+)+Shrubden(+)	-136.44906	6	289.1771	30.209	<0.001
Tofo(+)+Togr(+)+Cover(+)+Shrubden(+)	-137.97987	7	296.9288	37.961	<0.001
Tofo(+)+Togr(+)+Cover(+)	-146.78395	6	304.6572	45.689	<0.001
Tofo(+)+Togr(+)+Tosh(+)+Bare(-)+Height(-)+Shrubw(-)	-134.03130	9	314.2952	55.327	<0.001

a I [Herman-Brunson] included the following vegetation variables in my models: total vegetative cover (TOCO), percent forb cover (TOFO), percent grass cover (TOGR), percent sagebrush cover (TOSH), sagebrush height (SHRUB HGT), sagebrush width (SHRUB W), site-VOR (COVER), percent bareground cover (BARE), sagebrush density/hectare (SHRUB DEN), and grass height around the Robel pole (HEIGHT).
b To facilitate interpretation, I [Herman-Brunson] excluded year indicator variable from model column.

APPENDIX J
Kaczor 2008

APPENDIX J Table 1. Mean vegetation characteristics of nest sites and random sites between years for greater sage-grouse used in logistic regression models in northwestern South Dakota, USA, using MRPP (Mielke and Berry 2001), 2006-2007. (Kaczor 2008)

	Nest			**Random**			**Both Years**		
	2006	2007		2006	2007		Nest	Random	
Variable	(n=34)	(n=39)	P-value	(n=35)	(n=39)	P-value	(n=73)	(n=74)	P-value
Total Cover (%)	61.1	75.1	<0.01	55.8	66.1	<0.01	68.6	61.2	<0.01
Litter Cover (%)	7.6	7.1	0.79	6.5	6.1	0.88	7.4	6.3	0.04
Grass Cover (%)	24.2	31.4	0.01	21.1	25.8	0.21	28.1	23.6	0.01
Max Grass Hgt. (cm)	23.4	29.5	<0.01	20.4	25.0	<0.01	26.7	22.8	<0.01
Max Grass Hgt. 0-5 (cm)	25.7	30.9	0.02	20.3	24.3	0.01	28.5	22.4	<0.01
Visual Obstruction (cm)	5.5	11.1	<0.01	3.7	5.1	0.14	8.5	4.4	<0.01
Visual Obstruction 0m (cm)	20.8	29.4	<0.01	10.5	8.9	0.13	25.4	9.6	<0.01
Visual Obstruction 1m (cm)	7.3	13.7	<0.01	3.7	4.1	0.05	10.7	3.9	<0.01
Sagebrush Cover (%)	10.3	10.1	0.75	6.3	6.3	0.98	10.2	6.2	<0.01
Sagebrush Hgt. (cm)	25.8	29.7	0.04	23.8	24.0	0.97	27.9	23.9	<0.01

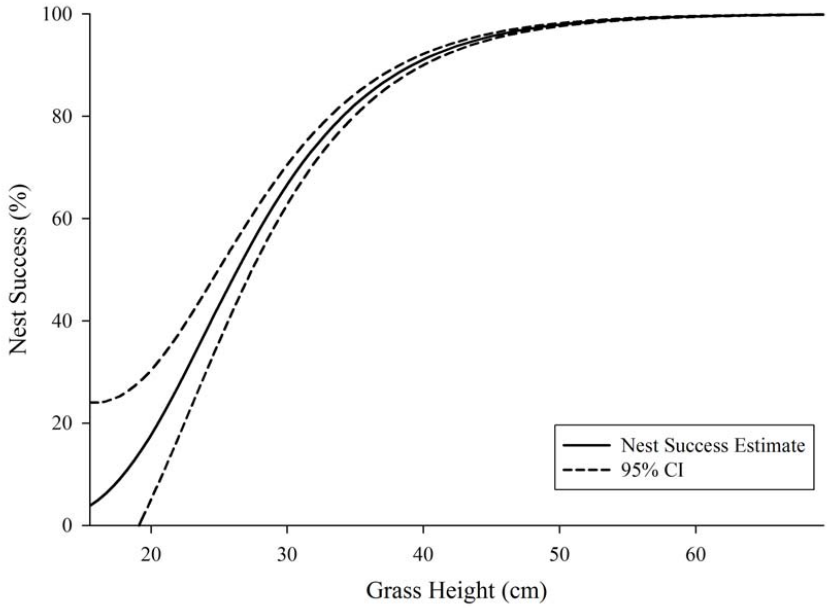
APPENDIX J Table 2. Observed mean values for habitat variables between greater sage-grouse successful and failed nests used in nest success models in northwestern South Dakota, USA, using MRPP (Mielke and Berry 2001) 2006-2007. (Kaczor 2008)

	Successful (n=33)		**Failed (n=40)**		
Variable	**Mean**	**SE**	**Mean**	**SE**	**P-value**
Max Grass Hgt. (cm)	30.64	1.6	23.4	1.0	<0.01
Litter Cover (%)	6.4	0.5	8.1	0.8	0.07
Forb Cover 0m (%)	5.3	0.8	3.9	0.6	0.09
Visual Obstruction (cm)	10.2	1.1	7.2	0.8	0.02

APPENDIX J Table 8. Observed mean values for habitat variables between greater sage-grouse brood-rearing and random sites, and between years used in logistic regression in northwestern South Dakota, USA, using MRPP (Mielke and Berry 2001) 2006-2007. (Kaczor 2008)

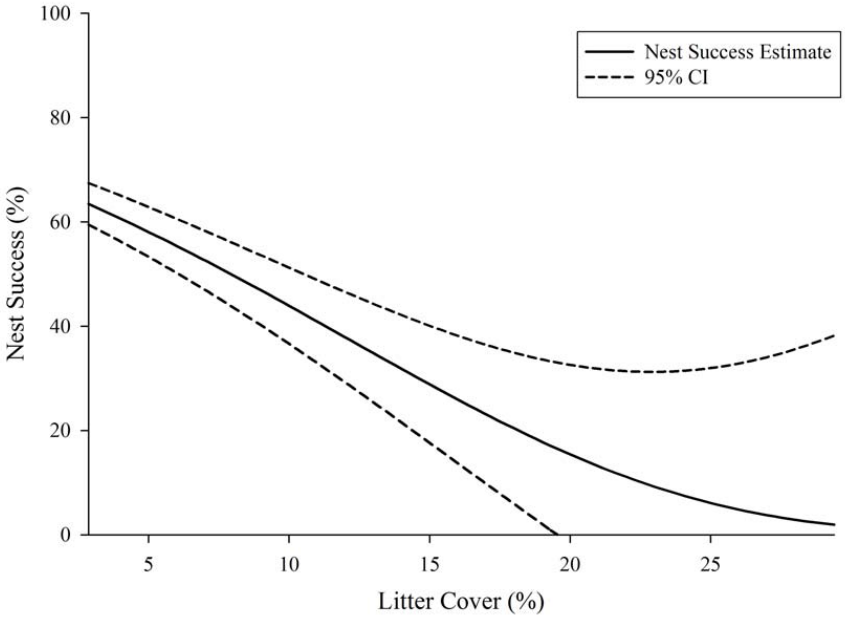
	Brood			**Random**			**Both Years**		
	2006	2007		2006	2007		Brood	Random	
Variable	(n=59)	(n=60)	P-value	(n=56)	(n=60)	P-value	(n=119)	(n=116)	P-value
Sagebrush Density (plants/m^2)	0.3	0.5	<0.01	0.7	0.4	<0.01	0.4	0.5	0.08
Sagebrush Cover (%)	4.6	4.7	0.94	4.5	2.8	0.03	4.6	3.6	0.04
Visual Obstruction (cm)	5.4	7.1	0.12	2.3	4.7	<0.01	6.2	3.5	<0.01
Grass Height (cm)	23.3	37.5	<0.01	19.2	31.9	<0.01	30.5	25.7	<0.01
Total Cover (%)	61.3	55.6	<0.01	51.0	51.0	1.00	58.4	51.0	<0.01
Grass Cover (%)	34.4	28.3	<0.01	28.6	24.8	0.26	31.3	26.6	<0.01
Japanese Brome Cover (%)	10.4	9.9	0.66	4.9	11.4	<0.01	10.1	8.3	0.04
Bluegrass Cover (%)	5.9	2.3	<0.01	3.8	2.2	<0.01	4.0	3.0	0.08

Effect of Grass Height on Nest Success



APPENDIX J Figure 5. Effect of grass height on greater sage-grouse nest success in northwestern South Dakota, USA, 2006-2007. Nest success estimate derived from back-transformed beta estimates included in top model. Confidence intervals estimated from the delta method (Seber 1982). (Kaczor 2008)

Effect of Litter Canopy Coverage on Nest Success



APPENDIX J Figure 7. Effect of litter canopy coverage on greater sage-grouse nest success in northwestern South Dakota, USA, 2006-2007. Nest success estimate derived from backtransformed beta estimates included in top model. Confidence intervals estimated from the delta method (Seber 1982). (Kaczor 2008)

APPENDIX J Appendix 3. Demographic information for all greater sage-grouse captured in northwestern South Dakota, USA, 2006-2007. (Kaczor 2008)

Band #	Capture Date	X[a]	Y[a]	Nearest Lek	Sex[b]	Age[c]	Weight (g)	Radio Freq.
1001	28-Mar-06	583058	4972413	Crago	F	A	1654	150.064
1002	31-Mar-06	583874	4972344	Crago	F	A	1552	150.073
1003	1-Apr-06	605131	4983015	Two Top	F	A	1618	150.083
1004	1-Apr-06	604838	4982844	Two Top	F	Y	1612	150.094
1005	1-Apr-06	604840	4983075	Two Top	F	A	1602	150.103
1006	1-Apr-06	605197	4983537	Two Top	F	A	1732	150.114
1007	1-Apr-06	605399	4982814	Two Top	F	A	1648	151.074
1008	3-Apr-06	594044	4989246	Widdoss	F	A	1586	150.133
1009	3-Apr-06	595437	4988647	Widdoss	F	Y	1734	150.145
1010	3-Apr-06	595437	4988647	Widdoss	F	Y	1464	150.155
1011	3-Apr-06	595437	4988647	Widdoss	F	Y	1482	151.085
1012	3-Apr-06	595594	4988735	Widdoss	F	A	1594	150.173
1013	3-Apr-06	595758	4988629	Widdoss	F	Y	1482	150.183
1014	3-Apr-06	595619	4988954	Widdoss	F	Y	1520	150.193
1015	4-Apr-06	623696	4994653	McFarland	F	A	1758	150.204
1016	4-Apr-06	623922	4994453	McFarland	F	Y	1556	150.214
1017	5-Apr-06	583265	4972042	Crago	F	A	1650	150.353
1018	5-Apr-06	581965	4969635	Rumph	F	Y	1520	150.363
1019	7-Apr-06	606987	5006247	County Line	F	Y	1610	150.373
1020	7-Apr-06	606596	5006738	County Line	F	A	1704	150.383
1021	7-Apr-06	606596	5006738	County Line	F	A	1626	151.014
1022	7-Apr-06	606490	5006922	County Line	F	A	1610	151.022
1023	7-Apr-06	606616	5007299	County Line	F	A	1806	151.033
1024	7-Apr-06	606053	5006751	County Line	F	A	1590	150.503
1025	7-Apr-06	605932	5006832	County Line	F	A	1642	150.703
1026	7-Apr-06	605849	5006714	County Line	F	A	1634	150.714
1027	8-Apr-06	623462	4994283	McFarland	F	A	1756	150.732
1028	8-Apr-06	623243	4995268	McFarland	F	A	1738	150.973
1029	8-Apr-06	623243	4995268	McFarland	F	Y	1470	150.764
1030	8-Apr-06	623494	4994808	McFarland	F	A	1606	150.772
1031	9-Apr-06	583034	4972327	Crago	F	Y	1472	150.785
1032	9-Apr-06	581219	4969831	Rumph	F	Y	1628	150.804
1033	9-Apr-06	581315	4969863	Rumph	F	Y	1613	150.812
1034	9-Apr-06	581512	4969966	Rumph	F	A	1636	151.333
1035	9-Apr-06	581403	4970033	Rumph	F	A	1782	151.343
1036	9-Apr-06	583487	4972092	Crago	F	Y	1544	151.353
1037	9-Apr-06	594466	4990149	Widdoss	F	A	1690	151.362
1038	10-Apr-06	605130	4983164	Two Top	F	Y	1658	151.375
1039	10-Apr-06	604967	4983102	Two Top	F	Y	1594	151.382
1040	10-Apr-06	604946	4983024	Two Top	F	Y	1480	151.393
1041	17-Jul-06	626931	4986394	Quad 7	unk	C	558	150.024
1042	17-Jul-06	626931	4986394	Quad 7	unk	C	422	151.553
1043	17-Jul-06	626931	4986394	Quad 7	unk	C	468	151.533
1044	17-Jul-06	617726	4993470	McFarland	unk	C	466	150.993
1045	17-Jul-06	617726	4993470	McFarland	unk	C	664	151.442
1046	17-Jul-06	617726	4993470	McFarland	unk	C	476	151.422
1047	18-Jul-06	602067	4986019	Widdoss	unk	C	490	150.573
1048	18-Jul-06	600432	4986227	Widdoss	unk	C	576	150.654

Band #	Capture Date	X[a]	Y[a]	Nearest Lek	Sex[b]	Age[c]	Weight (g)	Radio Freq.
1049	18-Jul-06	600432	4986227	Widdoss	unk	C	698	151.503
1050	18-Jul-06	600512	4987086	Widdoss	unk	C	338	151.151
1051	18-Jul-06	600512	4987086	Widdoss	unk	C	432	151.524
1052	18-Jul-06	600512	4987086	Widdoss	unk	C	600	151.245
1053	18-Jul-06	600512	4987086	Widdoss	unk	C	466	151.524
1054	18-Jul-06	596981	4987357	Widdoss	unk	C	646	151.562
1055	18-Jul-06	596981	4987357	Widdoss	unk	C	838	151.483
1056	17-Jul-06	617726	4993470	McFarland	F	A	1362	151.413
1057	18-Jul-06	596981	4987357	Widdoss	unk	C	812	151.543
1058	18-Jul-06	596981	4987357	Widdoss	unk	C	816	151.094
1059	18-Jul-06	596981	4987357	Widdoss	unk	C	644	151.533
1060	19-Jul-06	606966	4983857	Two Top	unk	C	642	151.713
1061	19-Jul-06	606966	4983857	Two Top	unk	C	628	151.453
1062	20-Jul-06	600796	4987123	Widdoss	unk	C	552	151.733
1063	31-Jul-06	599438	4991214	Widdoss	unk	C	430	150.284
1064	31-Jul-06	599438	4991214	Widdoss	unk	C	396	150.303
1065	2-Aug-06	606586	5004830	County Line	unk	C	566	151.043
1066	10-Aug-06	600069	5012561	Split Lek	unk	C	602	150.443
1067	10-Aug-06	600069	5012561	Split Lek	unk	C	494	150.524
1069	19-Jul-07	600206	4986435	Two Top	M	C	612	151.942
1070	19-Jul-07	600206	4986435	Two Top	unk	C	486	151.803
1071	19-Jul-07	600206	4986435	Two Top	unk	C	552	151.755
1072	19-Jul-07	600206	4986435	Two Top	unk	C	656	151.763
1073	19-Jul-07	600206	4986435	Two Top	unk	C	510	151.783
1074	19-Jul-07	600206	4986435	Two Top	M	C	552	151.934
1077	19-Jul-06	569728	4980943	State Line	unk	C	630	150.402
1078	19-Jul-06	569728	4980943	State Line	unk	C	500	150.127
1079	19-Jul-06	569728	4980943	State Line	unk	C	662	150.022
1080	31-Jul-06	570999	4978754	State Line	unk	C	420	150.163
1081	31-Jul-06	570999	4978754	State Line	unk	C	460	150.742
1082	20-Jul-06	600777	4987058	Widdoss	unk	C	632	N/A
1083	20-Jul-06	600777	4987058	Widdoss	unk	C	520	N/A
1084	20-Jul-06	600777	4987058	Widdoss	unk	C	584	N/A
1085	20-Jul-06	600234	4986337	Widdoss	unk	C	568	N/A
1086	20-Jul-06	600234	4986337	Widdoss	unk	C	626	N/A
1087	20-Jul-06	600234	4986337	Widdoss	unk	C	642	N/A
1088	20-Jul-06	600234	4986337	Widdoss	unk	C	640	N/A
1090	22-Aug-06	603221	4985402	Widdoss	unk	C	N/A	N/A
1092	22-Aug-06	603221	4985402	Widdoss	unk	C	N/A	N/A
1093	22-Aug-06	603221	4985402	Widdoss	unk	C	N/A	N/A
1094	22-Aug-06	603221	4985402	Widdoss	F	Y	N/A	N/A
1095	22-Aug-06	603221	4985402	Widdoss	F	C	N/A	151.123
1096	22-Aug-06	603221	4985402	Widdoss	unk	C	N/A	N/A
1097	20-Mar-07	624299	4994777	McFarland	F	Y	1566	150.984
1098	21-Mar-07	585688	4972089	Crago	F	Y	1474	150.954
1099	20-Mar-07	628371	4995961	Quad 7	F	A	N/A	N/A
1100	21-Mar-07	624274	4994608	McFarland	F	A	N/A	N/A
1101	22-Mar-07	603438	5007080	County Line	F	Y	1492	151.002
1102	22-Mar-07	585462	4970879	Crago	F	A	N/A	N/A
1103	26-Mar-07	594427	4989883	Widdoss	F	Y	1396	151.053

Band #	Capture Date	X[a]	Y[a]	Nearest Lek	Sex[b]	Age[c]	Weight (g)	Radio Freq.
1104	26-Mar-07	594408	4989863	Widdoss	F	A	1684	151.064
1105	1-Apr-07	unk	unk	unk	F	unk	unk	N/A
1106	1-Apr-07	unk	unk	unk	F	unk	unk	N/A
1107	1-Apr-07	unk	unk	unk	F	unk	unk	N/A
1108	1-Apr-07	unk	unk	unk	F	unk	unk	N/A
1109	23-Mar-07	605528	4982812	Two Top	F	A	N/A	N/A
1110	26-Mar-07	594255	5990427	Widdoss	F	Y	1498	151.103
1111	26-Mar-07	593709	4990683	Widdoss	F	A	1634	151.115
1112	26-Mar-07	593709	4990683	Widdoss	F	Y	1552	151.133
1119	19-Jul-07	603730	4988165	Two Top	unk	C	560	151.133
1120	19-Jul-07	603730	4988165	Two Top	unk	C	380	150.624
1121	19-Jul-07	603730	4988165	Two Top	unk	C	422	150.064
1122	19-Jul-07	606678	4984369	Two Top	unk	C	798	150.643
1123	19-Jul-07	606678	4984369	Two Top	unk	C	774	150.673
1124	19-Jul-07	606678	4984369	Two Top	unk	C	772	150.683
1125	19-Jul-07	606678	4984369	Two Top	unk	C	812	151.824
1126	23-Jul-07	580091	4970734	South Owl	unk	C	590	150.722
1127	23-Jul-07	589059	4991119	Widdoss	unk	C	532	150.793
1128	23-Jul-07	589059	4991119	Widdoss	unk	C	506	150.824
1129	23-Jul-07	589059	4991119	Widdoss	unk	C	682	150.833
1130	23-Jul-07	589059	4991119	Widdoss	unk	C	562	150.764
1131	24-Jul-07	606022	5009500	County Line	unk	C	602	150.373
1132	24-Jul-07	592056	4990220	Widdoss	unk	C	914	151.895
1133	24-Jul-07	600496	4985607	Two Top	unk	C	874	150.873
1134	2-Aug-07	608346	5002699	County Line	unk	C	966	150.883
1135	2-Aug-07	606150	5009419	County Line	unk	C	554	150.914
1136	7-Aug-07	594637	4987901	Widdoss	unk	C	566	150.923
1151	24-Oct-07	605829	5006655	County Line	M	C	2252	151.583
1152	24-Oct-07	595309	4988513	Widdoss	F	A	1500	151.393
1153	24-Oct-07	595420	4988559	Widdoss	F	A	1544	150.094
1154	24-Oct-07	605921	5006498	County Line	F	A	1496	151.363
1155	24-Oct-07	605844	5006720	County Line	F	A	1476	150.973
1501	31-Mar-06	583997	4972302	Crago	M	A	3040	151.036
1502	4-Apr-06	623572	4994708	McFarland	M	A	2920	151.194
1503	10-Apr-06	604849	4982804	Two Top	M	A	3320	151.574
1504	10-Apr-06	604701	4983175	Two Top	M	A	3216	151.585
1505	10-Apr-06	604879	4982796	Two Top	M	A	3304	151.594
1506	4-May-06	606663	5006951	County Line	M	A	3058	151.604
1507	4-May-06	606476	5006526	County Line	M	A	3048	151.614
1508	4-May-06	606663	5006951	McFarland	M	A	3022	151.962
1509	4-May-06	624042	4994699	McFarland	M	A	3094	151.973
1510	4-May-06	606508	5007060	County Line	M	A	2962	151.645
1511	5-May-06	583496	4972516	Crago	M	A	3040	151.655
1512	5-May-06	583783	4972382	Crago	M	A	3254	151.664
1513	5-May-06	581257	4969846	Rumph	M	A	2954	151.675
1514	5-May-06	594613	4989913	Widdoss	M	A	3078	151.983
1515	5-May-06	594548	4989957	Widdoss	M	A	3206	151.994
1516	5-May-06	594573	4989618	Widdoss	M	A	3044	151.036
1517	5-May-06	594437	4989670	Widdoss	M	A	3066	N/A
1518	5-May-06	594393	4989788	Widdoss	M	A	3010	N/A

Band #	Capture Date	X[a]	Y[a]	Nearest Lek	Sex[b]	Age[c]	Weight (g)	Radio Freq.
1519	5-May-06	594605	4989797	Widdoss	M	A	3030	N/A
1520	20-Mar-07	624060	4994448	McFarland	M	A	3344	151.982
1522	26-Mar-07	594402	4989990	Widdoss	M	A	3140	151.803
1523	26-Mar-07	593674	4989252	Widdoss	M	Y	2378	151.813
1524	26-Mar-07	594499	4989909	Widdoss	M	A	3124	151.824
1525	26-Mar-07	594409	4989727	Widdoss	M	A	3206	151.834
1526	8-May-07	606576	5006401	County Line	M	A	2932	151.843
1527	8-May-07	606581	5006401	County Line	M	Y	2302	151.854
1528	8-May-07	606648	5006757	County Line	M	A	2762	151.883
1529	8-May-07	606649	5006756	County Line	M	Y	2174	151.903
1530	10-Apr-07	583326	4972901	Crago	M	A	3234	151.914
1531	10-Apr-07	583278	4972599	Crago	M	Y	2752	151.923
1532	10-Apr-07	583280	4972594	Crago	M	Y	2550	151.934
1533	6-Apr-07	623766	4994869	McFarland	M	A	3138	151.942
1534	6-Apr-07	623813	4994912	McFarland	M	A	3046	151.956
1535	10-Apr-07	583324	4972905	Crago	M	A	2958	151.895
1536	8-May-07	632577	5029924	Squaw Creek	M	A	3230	N/A
1537	8-May-07	632419	5029864	Squaw Creek	M	A	2804	N/A
1538	8-May-07	632427	5029824	Squaw Creek	M	A	3146	N/A
1539	8-May-07	632308	5029856	Squaw Creek	M	A	3051	N/A
1540	8-May-07	632283	5029860	Squaw Creek	M	A	3190	N/A
1541	8-May-07	632251	5029908	Squaw Creek	M	A	2962	N/A
1542	8-May-07	632296	5029969	Squaw Creek	M	A	2500	N/A
1543	8-May-07	632281	5029958	Squaw Creek	M	A	2900	N/A
1544	8-May-07	632356	5029936	Squaw Creek	M	A	3190	N/A
1545	8-May-07	632099	5029946	Squaw Creek	M	A	2806	N/A
1546	8-May-07	594446	4989880	Widdoss	M	Y	2316	151.175
1547	9-May-07	605043	4982559	Two Top	M	A	2926	151.824
1548	9-May-07	583447	4972548	Crago	M	A	2828	151.895
1549	9-May-07	583149	4972598	Crago	M	Y	2310	151.914
1550	9-May-07	583115	4972531	Crago	M	A	3134	151.923
1601	16-May-06	586803	5042787	Valley Creek	M	Y	2352	N/A
1604	16-May-06	586476	5042810	Valley Creek	M	A	2874	N/A
1606	16-May-06	586717	5042928	Valley Creek	M	Y	2414	N/A
1607	16-May-06	586319	5042651	Valley Creek	M	A	2868	N/A
1608	16-May-06	586522	5042693	Valley Creek	M	A	3170	N/A
1609	16-May-06	586685	5042726	Valley Creek	M	A	3002	N/A
1610	16-May-06	586528	5042756	Valley Creek	M	A	2922	N/A
1611	16-May-06	586794	5042842	Valley Creek	M	Y	2298	N/A
1612	16-May-06	586799	5042754	Valley Creek	M	A	2864	N/A
1613	16-May-06	586671	5042868	Valley Creek	M	A	2918	N/A
1614	16-May-06	586660	5042780	Valley Creek	M	A	2738	N/A
1615	16-May-06	586597	5042715	Valley Creek	M	A	2852	N/A
1616	16-May-06	586509	5042708	Valley Creek	M	A	2990	N/A
1617	16-May-06	586433	5042659	Valley Creek	M	A	2920	N/A
1618	16-May-06	586317	5042837	Valley Creek	M	A	3034	N/A
1619	16-May-06	586459	5042861	Valley Creek	M	A	2896	N/A

[a] UTM coordinates in NAD27, zone 13.
[b] Sex classification are: F-female, M-male, and unk-unknown.
[c] Age classification are: A-adult, Y-yearling, and C-hatch year chick.

APPENDIX K
Smith 2003

APPENDIX K Appendix H. Selected microhabitat survey information form lek sites and sample sites within 1.5 km buffer of North Dakota, South Dakota, and Montana greater sage grouse leks, 2001 and 2002. (Smith 2003)

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Butte	3B	LEK	599523	4986753	10	0	0.98	31.4	70.45	11.15
2001	SD	Butte	3B	1	599023	4987753	0	0	2.5	74	6.5	33
2001	SD	Butte	3B	2	600023	4987753	2	0	15.45	40.15	28.3	41.28
2001	SD	Butte	3B	3	598523	4987253	0	0	4.05	73.65	2.23	31.15
2001	SD	Butte	3B	4	599523	4987253	10	0	1.3	36.08	58.43	13.28
2001	SD	Butte	3B	5	600523	4987253	1	0	16.03	38.13	23.43	53.5
2001	SD	Butte	3B	6	599023	4986753	8	0	0.8	39.03	58.48	9.18
2001	SD	Butte	3B	7	600023	4986753	10	0	1.08	22.65	73.63	7.88
2001	SD	Butte	3B	8	598523	4986253	0	0	4.38	52.43	30.19	27.7
2001	SD	Butte	3B	9	599523	4986253	0	0	3.65	62.2	10.18	46.98
2001	SD	Butte	3B	10	600523	4986253	2	0	1.4	32.45	31.85	40.9
2001	SD	Butte	3B	11	599023	4985753	5	0	4.3	49.95	43.43	21.15
2001	SD	Butte	3B	12	600023	4985753	7	0	2.33	30.43	63.35	9.98
2001	SD	Butte	4B	LEK	612622	4977981	0	0	1.6	57.8	42.83	9.33
2001	SD	Butte	4B	1	612122	4978981	0	0	1.23	65.13	24.5	23.7
2001	SD	Butte	4B	2	613122	4978981	0	0	4.43	21.95	75.03	5.13
2001	SD	Butte	4B	3	611622	4978481	0	0	4.95	60.88	21.13	36
2001	SD	Butte	4B	4	612622	4978481	0	0	0.95	58.05	37.5	12.08
2001	SD	Butte	4B	5	613622	4978481	0	0	12.23	38.28	41.73	24.35
2001	SD	Butte	4B	6	612122	4977981	0	0	3.08	45.03	49.5	15.48
2001	SD	Butte	4B	7	613122	4977981	0	0	2.5	41.83	45.4	19.83
2001	SD	Butte	4B	8	611622	4977481	3	0	8.78	47.55	34.23	24.75
2001	SD	Butte	4B	9	612622	4977481	5	0	10.08	46.53	35.28	22.38
2001	SD	Butte	4B	10	613622	4977481	0	0	12.63	33.4	39.98	36.15
2001	SD	Butte	4B	11	612122	4976981	4	0	5.5	33.83	58.3	14.05
2001	SD	Butte	4B	12	613122	4976981	6	0	5.85	34.55	46.4	24.05
2001	SD	Butte	5B	LEK	606336	5006861	2	0	17.3	51.95	34.98	12.5
2001	SD	Butte	5B	1	605836	5007861	2	0	8.5	53.8	23.25	21.08
2001	SD	Butte	5B	2	606836	5007861	1	0	3.83	56.5	9.15	41.23
2001	SD	Butte	5B	3	605336	5007361	7	0	13.2	33.03	45.58	14.25
2001	SD	Butte	5B	4	606336	5007361	6	0	0.9	25.98	45.4	29.9
2001	SD	Butte	5B	5	607336	5007361	2	0	5.58	54.2	12.98	50
2001	SD	Butte	5B	6	605836	5006861	9	0	0.5	26.2	67.9	8.68
2001	SD	Butte	5B	7	606836	5006861	16	0	0.95	6.73	67.4	17.78
2001	SD	Butte	5B	8	605336	5006361	3	0	8.68	45.63	22.9	28.93
2001	SD	Butte	5B	9	606336	5006361	6	0	3.45	20.85	73.1	8.05
2001	SD	Butte	5B	10	607336	5006361	4	0	5.65	24.05	47.75	27.63
2001	SD	Butte	5B	11	605836	5005861	6	0	3.08	17.38	61.48	20.35

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Butte	5B	12	606836	5005861	3	0	2.4	66.75	16.43	23.1
2001	SD	Butte	6B	LEK	587317	4996578	4	0	1.68	42.9	51.63	17.43
2001	SD	Butte	6B	1	586817	4997578	0	0	6.7	46.88	23.3	34
2001	SD	Butte	6B	2	587817	4997578	0	0	6.48	78.48	7.1	20.35
2001	SD	Butte	6B	3	586317	4997078	0	0	9.9	82.8	7.98	44.4
2001	SD	Butte	6B	4	587317	4997078	0	0	4.38	53	29.75	27.43
2001	SD	Butte	6B	5	588317	4997078	2	0	6.58	51.75	15.9	45.18
2001	SD	Butte	6B	6	586817	4996578	3	0	5.88	49.7	34.4	31.8
2001	SD	Butte	6B	7	587817	4996578	0	0	7.63	43.65	37.63	30.38
2001	SD	Butte	6B	8	586317	4996078	1	0	0.6	45	39.78	26.35
2001	SD	Butte	6B	9	587317	4996078	3	0	2	51.5	33.98	19.73
2001	SD	Butte	6B	10	588317	4996078	5	0	6.15	36.75	54.68	21.13
2001	SD	Butte	6B	11	586817	4995578	3	0	2.53	39.4	53.03	20.28
2001	SD	Butte	6B	12	587817	4995578	2	0	5.3	32.23	53.63	25.53
2001	SD	Butte	9B	LEK	587883	4963874	5	0	14.53	79.38	3.9	20.95
2001	SD	Butte	9B	1	587383	4964874	.	.	.	.	.	.
2001	SD	Butte	9B	2	588383	4964874	8	0	6.98	73.2	11.13	27.75
2001	SD	Butte	9B	3	586883	4964374	0	0	3.7	84.35	0.93	22.75
2001	SD	Butte	9B	4	587883	4964374	12	0	1.63	25.05	67.88	14.35
2001	SD	Butte	9B	5	588883	4964374	8	0	4.5	49.95	27.75	30.65
2001	SD	Butte	9B	6	587383	4963874	0	0	4.7	88.55	3.48	19.75
2001	SD	Butte	9B	7	588383	4963874	6	0	13.1	68.98	17.43	15.23
2001	SD	Butte	9B	8	586883	4963374	6	0	0.85	52.15	45.88	13.98
2001	SD	Butte	9B	9	587883	4963374	2	0	11.1	85.63	4.33	12.35
2001	SD	Butte	9B	10	588883	4963374	12	0	5.58	47.08	38.6	25.35
2001	SD	Butte	9B	11	587383	4932874	5	0	9.75	63.7	20.93	20.3
2001	SD	Butte	9B	12	588383	4932874	2	0	3.95	85.65	7.08	14.9
2001	SD	Butte	10B	LEK	580779	4969908	0	0	10.2	32.15	42.1	24
2001	SD	Butte	10B	1	580279	4970908	1	0	9.28	41.43	32.78	32.5
2001	SD	Butte	10B	2	581279	4970908	5	6	7.5	80.85	0.65	57.25
2001	SD	Butte	10B	3	579779	4970408	1	0	2.35	36.65	57.28	15.6
2001	SD	Butte	10B	4	580779	4970408	11	0	24.15	57.43	0.15	48.38
2001	SD	Butte	10B	5	581779	4970408	1	0	5.13	79.28	0.15	25.83
2001	SD	Butte	10B	6	580279	4969908	6	0	8.43	61	12.83	31.25
2001	SD	Butte	10B	7	581279	4969908	4	0	10.3	56.18	12.18	37.43
2001	SD	Butte	10B	8	579779	4969408	1	0	10.68	28.83	49.75	27.05
2001	SD	Butte	10B	9	580779	4969408	8	0	6.1	64.83	13.8	33.63
2001	SD	Butte	10B	10	581779	4969408	7	0	12.08	67.88	4.3	40.75
2001	SD	Butte	10B	11	580279	4968908	0	0	0.98	20.83	75.75	6.1
2001	SD	Butte	10B	12	581279	4968908	1	0	8.15	24.08	53.3	25.93

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Butte	11B	LEK	580877	4956628	1	0	0.35	30.85	57.18	12.13
2001	SD	Butte	11B	1	580377	4957628	4	0	6.03	29.95	57.03	7.7
2001	SD	Butte	11B	2	581377	4957628	3	0	6.53	35	40	20.78
2001	SD	Butte	11B	3	579877	4957128	0	0	37.68	3.38	45.2	14
2001	SD	Butte	11B	4	580877	4957128	4	0	7.43	33.25	46.33	13.25
2001	SD	Butte	11B	5	581877	4957128	.	.	.	.	.	.
2001	SD	Butte	11B	6	580377	4956628	1	0	2.98	35.4	44.8	24
2001	SD	Butte	11B	7	581377	4956628	4	0	3.43	23.55	61.55	11.85
2001	SD	Butte	11B	8	579877	4956128	0	0	10.88	27.33	43.38	21.65
2001	SD	Butte	11B	9	580877	4956128	1	1	2.4	42.48	42.15	11.38
2001	SD	Butte	11B	10	581877	4956128	4	0	2.25	21.05	60.73	16.13
2001	SD	Butte	11B	11	580377	4955628	4	0	10.18	39.18	24.48	26.83
2001	SD	Butte	11B	12	581377	4955628	3	0	2.33	31.73	42.35	23.93
2001	SD	Butte	12B	LEK	605185	4982068	0	0	10.73	59.18	8.7	36.03
2001	SD	Butte	12B	1	604685	4983068	6	0	16.25	45.03	34.3	22.8
2001	SD	Butte	12B	2	605685	4983068	4	0	5.18	66.7	4.45	35.8
2001	SD	Butte	12B	3	604185	4982569	4	0	13.35	50.25	23.48	29.88
2001	SD	Butte	12B	4	605185	4982569	8	0	7.58	28.75	65.5	5.13
2001	SD	Butte	12B	5	606185	4982569	0	0	8.4	77.33	1	22.43
2001	SD	Butte	12B	6	604685	4982068	3	0	11.08	53.18	20.05	35.3
2001	SD	Butte	12B	7	605685	4982068	4	0	5.5	70.18	7.45	28.35
2001	SD	Butte	12B	8	604185	4981568	1	0	9.42	42.5	13.29	52.76
2001	SD	Butte	12B	9	605185	4981568	4	0	16.35	55.63	10.75	41.13
2001	SD	Butte	12B	10	606185	4981568	5	0	9.08	43.83	18.53	42.13
2001	SD	Butte	12B	11	604685	4981068	4	0	7.98	56.25	29.93	21.5
2001	SD	Butte	12B	12	605685	4981068	0	0	8.8	39.53	41.65	24.83
2001	SD	Butte	13B	LEK	594639	4989792	7	0	3.65	18.93	71.6	10.73
2001	SD	Butte	13B	1	594139	4990792	5	0	5.25	37.88	48.3	22.3
2001	SD	Butte	13B	2	595139	4990792	0	0	6.8	45.25	37.58	31.43
2001	SD	Butte	13B	3	593639	4990292	6	0	6.5	25.25	65.03	15.55
2001	SD	Butte	13B	4	494639	4990292	6	0	5.53	27.78	61.9	14.68
2001	SD	Butte	13B	5	595639	4990292	1	0	4.73	35.5	55.95	13.5
2001	SD	Butte	13B	6	594139	4989792	3	0	9.1	35.5	37	24
2001	SD	Butte	13B	7	595139	4989792	8	0	3.5	45.45	41.4	22.88
2001	SD	Butte	13B	8	593639	4989292	12	0	5.93	39.4	38.93	34
2001	SD	Butte	13B	9	594639	4989292	2	0	14.68	51.53	14.78	45.5
2001	SD	Butte	13B	10	595639	4989292	7	0	7.05	35.38	59.5	20.48
2001	SD	Butte	13B	11	595139	4988792	0	0	15.63	36.4	11.88	58.33
2001	SD	Butte	13B	12	595139	4988792	7	0	2.83	27.18	73.95	10.8
2001	SD	Butte	14B	LEK	591209	4982129	0	0	4.4	36.58	37.75	30.25

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Butte	14B	1	590809	4983129	0	0	12.98	52	19.8	23.13
2001	SD	Butte	14B	2	591809	4983129	0	0	6.85	59.83	20.9	17.88
2001	SD	Butte	14B	3	590309	4982629	0	0	7.8	93.05	0.2	7.2
2001	SD	Butte	14B	4	591309	4982629	0	0	4.15	55.53	19.25	34.73
2001	SD	Butte	14B	5	592309	4982629	0	0	15.3	49.1	21.78	28.1
2001	SD	Butte	14B	6	590809	4982129	0	0	10.55	65	9.2	26.5
2001	SD	Butte	14B	7	591809	4982129	0	0	14.23	66.25	3.95	34.13
2001	SD	Butte	14B	8	590309	4981629	0	0	9.1	65	21.48	33.38
2001	SD	Butte	14B	9	591309	4981629	0	0	21	58.3	25.45	19.53
2001	SD	Butte	14B	10	592309	4981629	0	0	14.45	62.75	38.95	14.93
2001	SD	Butte	14B	11	590809	4981129	0	0	5.88	83.63	1.03	43.5
2001	SD	Butte	14B	12	591809	4981129	0	0	24.85	66.38	15.4	20.5
2001	SD	Butte	15B	LEK	583325	4972585	0	0	5.18	25.18	64.28	13.55
2001	SD	Butte	15B	1	582825	4973585	0	0	5.86	5.07	84.29	9.21
2001	SD	Butte	15B	2	583825	4973585	0	0	9.68	15.9	71.4	8.33
2001	SD	Butte	15B	3	582325	4973085	3	2	7.95	61.3	17.18	34.38
2001	SD	Butte	15B	4	583325	4973085	3	0	6.13	40.78	35.6	27.5
2001	SD	Butte	15B	5	584325	4973085	1	0	2.1	37.78	52	18.2
2001	SD	Butte	15B	6	582825	4972585	5	0	12.3	41.55	27.13	35.63
2001	SD	Butte	15B	7	583825	4972585	1	0	3.63	53.6	23.7	29
2001	SD	Butte	15B	8	582325	4972085	3	0	6.95	51.38	15.05	36.38
2001	SD	Butte	15B	9	583325	4972085	1	0	12.8	56.83	12.78	29
2001	SD	Butte	15B	10	584325	4972085	4	0	6	30.85	40.08	23.8
2001	SD	Butte	15B	11	582825	4971585	6	0	10.7	53.6	24.38	29.05
2001	SD	Butte	15B	12	583825	4971585	0	0	7.43	59.05	13.25	34.38
2001	SD	Fall River	1FR	LEK	581629	4796587	2	0	12.38	37.7	34.7	15.25
2001	SD	Fall River	1FR	1	581129	4797587	0	0	2.88	90.75	0	11.5
2001	SD	Fall River	1FR	2	582129	4797587	1	0	8.05	49.18	9.25	34.58
2001	SD	Fall River	1FR	3	580629	4791087	0	0	4.48	37.88	41.35	16.88
2001	SD	Fall River	1FR	4	581629	4791087	0	0	6.8	25	56.5	12
2001	SD	Fall River	1FR	5	582629	4791087	0	0	3.68	45.43	8.48	43.5
2001	SD	Fall River	1FR	6	581129	4796587	0	0	2.8	41.88	38.05	17.53
2001	SD	Fall River	1FR	7	582129	4796587	1	0	6.23	21.8	59.55	13.05
2001	SD	Fall River	1FR	8	580629	4796087	0	0	3.48	62.1	17.45	17.08
2001	SD	Fall River	1FR	9	581629	4796087	2	0	5.45	45.83	17.3	38.95
2001	SD	Fall River	1FR	10	582629	4796087	7	0	6.68	42	35.48	27.33
2001	SD	Fall River	1FR	11	581129	4795587	0	0	4.13	59.75	19.5	16.5
2001	SD	Fall River	1FR	12	582129	4795587	0	0	0.65	68.8	22.55	18.13
2001	SD	Harding	1H	LEK	637154	5029503	2	0	9.3	42.78	5.78	54.18
2001	SD	Harding	1H	1	636654	5030503	.	.	.	.	.	.

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Harding	1H	2	637654	5030503	0	2	16.18	62.58	2.6	30.53
2001	SD	Harding	1H	3	636154	5030003	12	0	11.55	48.35	13.3	38.5
2001	SD	Harding	1H	4	637154	5030003	0	3	21.8	54.15	4.2	46.75
2001	SD	Harding	1H	5	638154	5030003	14	0	5.7	55.85	10.45	44.55
2001	SD	Harding	1H	6	636654	5029503	5	0	14.75	35.83	12.13	50.65
2001	SD	Harding	1H	7	637654	5029503	1	2	13.35	51.55	5.5	45.93
2001	SD	Harding	1H	8	636154	5029003	3	6	10.9	45.33	2.1	63.33
2001	SD	Harding	1H	9	637154	5029003	0	2	9.08	48.33	7.6	44.75
2001	SD	Harding	1H	10	638154	5029003	1	3	14.58	58.75	2.25	36
2001	SD	Harding	1H	11	636654	5028503	3	3	12.03	38.03	14.68	47.14
2001	SD	Harding	1H	12	637654	5028503	4	1	11.18	41	30.53	32.53
2001	SD	Harding	2H	LEK	584376	5044130	7	0	2.05	25.75	23.73	57.43
2001	SD	Harding	2H	1	583876	5045130	0	0	7.45	24.68	16.95	62.03
2001	SD	Harding	2H	2	584876	5045130	0	0	12.83	67.95	1.43	32.55
2001	SD	Harding	2H	3	583376	5044630	2	0	4.3	25.78	7.53	72.28
2001	SD	Harding	2H	4	584376	5044630	4	0	2.03	44.95	6.15	59.6
2001	SD	Harding	2H	5	585376	5044630	0	0	3.53	75.78	2.55	25.13
2001	SD	Harding	2H	6	583876	5044130	6	0	3.2	48.68	3.43	59
2001	SD	Harding	2H	7	584876	5044130	2	0	3.5	72.8	4.28	27.3
2001	SD	Harding	2H	8	583376	5943630	7	0	0.28	14.5	21.13	73.08
2001	SD	Harding	2H	9	584376	5043630	11	0	2.1	40.63	24.33	41.28
2001	SD	Harding	2H	10	585376	5043630	2	0	9.68	65.65	4.65	31.13
2001	SD	Harding	2H	11	583876	5043130	0	0	8.42	56.55	8.12	40.64
2001	SD	Harding	2H	12	584876	5043130	9	0	1.25	29.2	22.9	53.95
2001	SD	Harding	3H	LEK	580533	5065647	1	0	6.58	44.28	5.98	57
2001	SD	Harding	3H	1	580033	5066647	0	0	9.93	77.63	5.05	22.63
2001	SD	Harding	3H	2	581033	5066647	0	0	12.2	70.5	3.78	33.13
2001	SD	Harding	3H	3	579533	5066147	0	0	8.78	52.45	1	54.08
2001	SD	Harding	3H	4	580533	5066147	1	0	6.1	51	6.38	50.38
2001	SD	Harding	3H	5	581533	5066147	2	0	2.65	39.25	11.68	62.08
2001	SD	Harding	3H	6	580033	5065647	0	0	13.05	46.7	2.3	51.93
2001	SD	Harding	3H	7	581033	5065647	3	0	3.8	30.05	23.23	60.98
2001	SD	Harding	3H	8	579533	5065147	6	0	8.95	48.75	8.58	44.75
2001	SD	Harding	3H	9	580533	5065147	0	0	21.08	48.95	6.05	40.85
2001	SD	Harding	3H	10	581533	5065147	1	0	5.53	59.33	5.2	49.75
2001	SD	Harding	3H	11	580033	5064647	1	1	7.75	66.38	2.55	45.55
2001	SD	Harding	3H	12	581033	5064647	3	0	12.58	43.1	10.65	47.18
2001	SD	Harding	4H	LEK	591718	5067383	0	1	10.45	45.7	6.8	53.5
2001	SD	Harding	4H	1	591218	5068383	3	0	4.8	38.3	24.98	45.68
2001	SD	Harding	4H	2	592218	5068383	3	1	13.97	34.83	7.03	66.33

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Harding	4H	3	590718	5067883	.	.	.	.	.	.
2001	SD	Harding	4H	4	591718	5067883	0	1	10.15	40.95	3.43	63.13
2001	SD	Harding	4H	5	592718	5067883	8	0	5.13	55.55	15.3	37.1
2001	SD	Harding	4H	6	591218	5067383	0	1	6.3	55.18	14.05	38.8
2001	SD	Harding	4H	7	592218	5067383	0	0	11.38	40.15	4.5	61.23
2001	SD	Harding	4H	8	509718	5066883	0	0	7.13	55.98	7.25	47.23
2001	SD	Harding	4H	9	591718	5066883	0	0	4.08	52.33	23.68	29.58
2001	SD	Harding	4H	10	592718	5066883	.	.	.	.	.	.
2001	SD	Harding	4H	11	591218	5066383	10	0	4.8	71.15	0.93	37.8
2001	SD	Harding	4H	12	592218	5066383	4	0	10.53	50.03	9.23	49.33
2001	SD	Harding	7H	LEK	599665	5061000	6	0	6.23	40.38	12.9	56.38
2001	SD	Harding	7H	1	599165	5062000	3	1	12.23	46.28	1.78	57.5
2001	SD	Harding	7H	2	600165	5062000	1	0	15.58	46.73	1.43	54.38
2001	SD	Harding	7H	3	598665	5061500	0	0	8.43	62.75	1	42
2001	SD	Harding	7H	4	599665	5061500	9	0	8	30.23	22.5	56.4
2001	SD	Harding	7H	5	600665	5061500	2	0	7.58	36.45	0.6	72.73
2001	SD	Harding	7H	6	599165	5061000	0	0	5.58	46.05	10.35	57
2001	SD	Harding	7H	7	600165	5061000	3	0	12.73	38.6	11.83	54.7
2001	SD	Harding	7H	8	598665	5060500	1	0	2.17	46.96	41.08	15
2001	SD	Harding	7H	9	599665	5060500	0	0	24.75	64.5	4.25	20.78
2001	SD	Harding	7H	10	600665	5060500	9	0	5.18	60.55	2.2	46.33
2001	SD	Harding	7H	11	599165	5060000	1	0	19.98	57.33	2	36.7
2001	SD	Harding	7H	12	600165	5060000	4	0	7.33	44.55	10.3	52.13
2001	SD	Harding	8H	LEK	632285	5032649	6	1	11.75	57.38	11.33	31.5
2001	SD	Harding	8H	1	631785	5033649	0	1	10.93	56.03	2.4	41.63
2001	SD	Harding	8H	2	632785	5033649	0	0	10.23	69.33	2.55	28.63
2001	SD	Harding	8H	3	631285	5033149	0	1	6.98	64.13	0.65	40
2001	SD	Harding	8H	4	632285	5033149	0	1	4.18	68.33	5.48	29.2
2001	SD	Harding	8H	5	633285	5033149	0	2	8.03	41.28	7.28	55
2001	SD	Harding	8H	6	631785	5032649	5	1	9.9	47.18	3.3	54.63
2001	SD	Harding	8H	7	632785	5032649	1	4	9.45	58.45	11.7	32
2001	SD	Harding	8H	8	631285	5032149	5	0	4.83	49.98	18.6	35.4
2001	SD	Harding	8H	9	632285	5032149	8	0	10.98	59.2	11.25	29.2
2001	SD	Harding	8H	10	633285	5032149	0	1	18.25	60.43	0.48	47.25
2001	SD	Harding	8H	11	631785	5031649	3	0	4	51.3	14.78	36.75
2001	SD	Harding	8H	12	632785	5031649	3	1	15.5	45.93	7.13	44.95
2001	SD	Harding	9H	LEK	578999	5033369	0	0	3.03	41.5	2.28	64.5
2001	SD	Harding	9H	1	578499	5034369	3	4	14.93	37.1	15.55	47.25
2001	SD	Harding	9H	2	579499	5034369	2	0	5.28	48.13	1.5	56.8
2001	SD	Harding	9H	3	577999	5033869	0	0	1.85	58.15	2.2	47.88

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2001	SD	Harding	9H	4	578999	5033869	13	0	6.28	37.3	0.45	70.68
2001	SD	Harding	9H	5	578499	5033869	5	0	6.55	44.3	23.28	35.75
2001	SD	Harding	9H	6	578499	5033369	8	0	2.68	45.7	3.28	58.55
2001	SD	Harding	9H	7	579499	5033369	0	0	4.58	44.55	2.13	58.88
2001	SD	Harding	9H	8	577999	5032869	0	0	7.95	54.2	9.13	36.38
2001	SD	Harding	9H	9	578999	5032869	5	0	5.65	44.33	4.75	54.85
2001	SD	Harding	9H	10	579999	5032869	0	0	2.03	54.69	13.6	34.57
2001	SD	Harding	9H	11	578499	5032369	0	0	1.75	48.08	2.65	56.68
2001	SD	Harding	9H	12	579499	5032369	9	0	4.4	41.63	13.6	46.18
2001	SD	Harding	10H	LEK	641740	5016832	4	0	4.18	38.33	9.3	57.13
2001	SD	Harding	10H	1	641240	5017832	1	1	8	63.33	22.63	8.33
2001	SD	Harding	10H	2	642240	5017832	0	0	2.98	57.5	3.48	44.5
2001	SD	Harding	10H	3	640740	5017332	0	2	8.78	41.95	4.4	56.15
2001	SD	Harding	10H	4	641740	5017332	4	0	4.08	18.53	53.58	29.35
2001	SD	Harding	10H	5	642740	5017332	0	1	10.85	50.95	1.53	50.13
2001	SD	Harding	10H	6	641240	5016832	2	0	4.23	40.93	12	55.5
2001	SD	Harding	10H	7	642240	5016832	2	0	3.28	35.5	8.8	61.28
2001	SD	Harding	10H	8	640740	5016332	0	0	2.93	52.25	5.5	54.63
2001	SD	Harding	10H	9	641740	5016332	0	2	11.98	74.6	1.3	19.38
2001	SD	Harding	10H	10	642740	5016332	0	0	9.23	72.31	3.91	26.29
2001	SD	Harding	10H	11	641240	5015832	.	.	.	.	.	.
2001	SD	Harding	10H	12	642240	5015832	1	0	6.13	59.98	5.75	36.2
2002	SD	Harding	5H	1	596256	5045727	11	0	7.15	60.95	15.5	21.98
2002	SD	Harding	5H	2	597256	5045727	0	0	3.98	74.63	13.73	14.63
2002	SD	Harding	5H	3	595756	5045227	5	3	7.5	77.28	9.58	12.58
2002	SD	Harding	5H	4	596756	5045227	17	0	4.25	41.93	51.13	6.95
2002	SD	Harding	5H	5	597756	5045227	0	0	5.08	79.18	11.73	10.7
2002	SD	Harding	5H	6	596256	5044727	0	0	17	63.93	14.8	7.43
2002	SD	Harding	5H	7	597256	5044727	0	0	6.38	87.18	2.58	11.1
2002	SD	Harding	5H	8	595756	5044227	5	0	3.15	65.83	19.85	14.45
2002	SD	Harding	5H	9	596756	5044227	0	0	4.33	80.9	11.38	8.4
2002	SD	Harding	5H	10	597756	5044227	0	0	6.6	66.65	24.78	12.1
2002	SD	Harding	5H	11	596256	5043727	0	1	2.48	71.58	19.5	13.48
2002	SD	Harding	5H	12	597256	5043727	0	0	2.26	96.41	0.71	4.62
2002	SD	Harding	6H	1	600785	5058816	2	0	7.08	88.53	5.73	3.8
2002	SD	Harding	6H	2	601785	5058816	1	2	3.28	75.25	7.05	18.55
2002	SD	Harding	6H	3	600285	5058316	1	1	11.35	85.6	0.9	14
2002	SD	Harding	6H	4	601285	5058316	10	1	8.03	84.63	3.58	9.2
2002	SD	Harding	6H	5	602285	5058315	1	4	6	75.9	0.63	22.78
2002	SD	Harding	6H	6	600785	5057816	2	1	10.55	72.58	12.3	12.3

Year	State	County	Lek	Site	Easting	Northing	Cover % ARTR2	Cover % ARCA13	Cover % Forb	Cover % Grass	Cover % Bare	Cover % Litter
2002	SD	Harding	6H	7	601785	5057816	11	1	9.3	59.88	15.4	22.4
2002	SD	Harding	6H	8	600285	5057316	8	2	7.68	82.98	10.55	4.18
2002	SD	Harding	6H	9	601285	5057316	17	0	7.43	67.15	21.25	8.33
2002	SD	Harding	6H	10	602285	5057316	6	3	13.45	69	12.33	16.25
2002	SD	Harding	6H	11	600785	5056816	5	0	3.83	93.48	0.38	6.6
2002	SD	Harding	6H	12	601785	5056816	11	1	18.75	65.33	4.6	27.23

"." missing data.

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Butte	3B	LEK	599523	4986753	2.6	0	90	10	0	16.63	0	10.58
2001	SD	Butte	3B	1	599023	4987753	0.02	0	80	0	0	22	0	15.13
2001	SD	Butte	3B	2	600023	4987753	0.57	0	75	0	0	18.93	0	12.28
2001	SD	Butte	3B	3	598523	4987253	0	0	100	0	0	20	0	15.88
2001	SD	Butte	3B	4	599523	4987253	2.54	0	95	10	0	17.88	0	11.6
2001	SD	Butte	3B	5	600523	4987253	0.32	0	90	0	0	19.46	0	10.78
2001	SD	Butte	3B	6	599023	4986753	1.66	0	75	0	0	17.95	0	10.95
2001	SD	Butte	3B	7	600023	4986753	2.75	0	90	0	0	13.5	0	8.05
2001	SD	Butte	3B	8	598523	4986253	0.41	0	90	0	0	10.67	0	10.08
2001	SD	Butte	3B	9	599523	4986253	0.14	0	20	0	0	22	0	8.73
2001	SD	Butte	3B	10	600523	4986253	1.13	0	80	0	0	10.09	0	9.5
2001	SD	Butte	3B	11	599023	4985753	1.48	0	100	0	0	12.38	0	10.53
2001	SD	Butte	3B	12	600023	4985753	2.18	0	50	0	0	12	0	7.48
2001	SD	Butte	4B	LEK	612622	4977981	0	0	85	0	0	0	0	10.75
2001	SD	Butte	4B	1	612122	4978981	0	0	90	0	0	0	0	14.48
2001	SD	Butte	4B	2	613122	4978981	0	0	10	0	0	0	0	7.98
2001	SD	Butte	4B	3	611622	4978481	0	0	100	0	0	0	0	14.9
2001	SD	Butte	4B	4	612622	4978481	0	0	100	0	0	0	0	13.5
2001	SD	Butte	4B	5	613622	4978481	0	0	100	0	0	0	0	13.18
2001	SD	Butte	4B	6	612122	4977981	0	0	60	0	0	0	0	10.08
2001	SD	Butte	4B	7	613122	4977981	0	0	0	0	0	0	0	5.45
2001	SD	Butte	4B	8	611622	4977481	1.19	0	45	0	0	16.54	0	11.2
2001	SD	Butte	4B	9	612622	4977481	1.65	0	90	0	0	17.15	0	12.33
2001	SD	Butte	4B	10	613622	4977481	0.4	0	85	5	0	19.35	0	10.25
2001	SD	Butte	4B	11	612122	4976981	1.93	0	70	0	0	14.08	0	10.15
2001	SD	Butte	4B	12	613122	4976981	2.19	0	80	0	0	14.72	0	11.03
2001	SD	Butte	5B	LEK	606336	5006861	0.4	0	100	0	0	20.3	0	12.63
2001	SD	Butte	5B	1	605836	5007861	0.56	0	70	0	0	17.83	0	12.55
2001	SD	Butte	5B	2	606836	5007861	0.29	0	65	0	0	19.68	0	11.95
2001	SD	Butte	5B	3	605336	5007361	0.95	0	65	15	0	26	0	11.53
2001	SD	Butte	5B	4	606336	5007361	1.47	0	100	0	0	15.67	0	10.35
2001	SD	Butte	5B	5	607336	5007361	0.6	0	65	10	0	22.17	0	13.65
2001	SD	Butte	5B	6	605836	5006861	2.45	0	100	0	0	15.08	0	6.98
2001	SD	Butte	5B	7	606836	5006861	3.38	0	80	0	0	11.93	0	4.83
2001	SD	Butte	5B	8	605336	5006361	0.89	0	50	10	0	27.33	0	11.3
2001	SD	Butte	5B	9	606336	5006361	2.39	0	40	0	0	12.23	0	7.3
2001	SD	Butte	5B	10	607336	5006361	1.24	0	30	0	0	15.23	0	10
2001	SD	Butte	5B	11	605836	5005861	2	0	55	0	0	12.45	0	7.18
2001	SD	Butte	5B	12	606836	5005861	0.67	0	25	0	0	16.64	0	8.93

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Butte	6B	LEK	587317	4996578	1.28	0	65	5	0	15.26	0	9.85
2001	SD	Butte	6B	1	586817	4997578	0	0	90	0	0	0	0	14.35
2001	SD	Butte	6B	2	587817	4997578	0.01	0	100	0	0	27	0	15.8
2001	SD	Butte	6B	3	586317	4997078	0.01	0	100	0	0	29	0	13.55
2001	SD	Butte	6B	4	587317	4997078	0.02	0	95	0	0	24	0	11.8
2001	SD	Butte	6B	5	588317	4997078	0.51	0	55	0	0	20.14	0	10.3
2001	SD	Butte	6B	6	586817	4996578	1.14	0	65	5	0	20.93	0	12.08
2001	SD	Butte	6B	7	587817	4996578	0.05	0	30	0	0	14.83	0	10.55
2001	SD	Butte	6B	8	586317	4996078	0.5	0	10	0	0	15.8	0	7.53
2001	SD	Butte	6B	9	587317	4996078	1.4	0	75	0	0	12.55	0	7.08
2001	SD	Butte	6B	10	588317	4996078	2.25	0	90	0	0	18.38	0	10.58
2001	SD	Butte	6B	11	586817	4995578	1.19	0	15	0	0	13.71	0	8.68
2001	SD	Butte	6B	12	587817	4995578	1.08	0	60	0	0	12.93	0	9.6
2001	SD	Butte	9B	LEK	587883	4963874	1.2	0	90	5	0	21.59	0	11.5
2001	SD	Butte	9B	1	587383	4964874	.	.	.	.	.	.	.	.
2001	SD	Butte	9B	2	588383	4964874	1.72	0	95	25	5	33.08	0	16.7
2001	SD	Butte	9B	3	586883	4964374	0.09	0	100	15	0	20	0	11.9
2001	SD	Butte	9B	4	587883	4964374	3.31	0	100	20	0	18.73	0	7.88
2001	SD	Butte	9B	5	588883	4964374	1.6	0	70	15	0	22.6	0	12.98
2001	SD	Butte	9B	6	587383	4963874	0.04	0	40	0	0	16	0	11.35
2001	SD	Butte	9B	7	588383	4963874	1.29	0	60	5	0	21.71	0	13.05
2001	SD	Butte	9B	8	586883	4963374	1.17	0	90	15	0	27.11	0	14.9
2001	SD	Butte	9B	9	587883	4963374	0.44	0	95	5	0	26.41	0	11.48
2001	SD	Butte	9B	10	588883	4963374	2.39	0	80	30	0	22.63	0	10.95
2001	SD	Butte	9B	11	587383	4932874	1.62	0	100	40	5	29.68	0	12.25
2001	SD	Butte	9B	12	588383	4932874	0.24	0	100	25	0	22.22	0	14.88
2001	SD	Butte	10B	LEK	580779	4969908	0	0	30	0	0	17	0	9.1
2001	SD	Butte	10B	1	580279	4970908	0.21	0	80	0	0	19.32	0	11.4
2001	SD	Butte	10B	2	581279	4970908	0.19	1.47	100	60	5	37.42	49.21	20.68
2001	SD	Butte	10B	3	579779	4970408	0.86	0	80	25	0	25	0	14.7
2001	SD	Butte	10B	4	580779	4970408	0.76	0	100	55	5	50.15	0	16.88
2001	SD	Butte	10B	5	581779	4970408	0.04	0	100	0	0	36.17	0	14.33
2001	SD	Butte	10B	6	580279	4969908	0.73	0	100	25	0	30.03	0	15.33
2001	SD	Butte	10B	7	581279	4969908	0.72	0	35	5	0	24.21	0	12.33
2001	SD	Butte	10B	8	579779	4969408	0.3	0	90	0	0	12.56	0	10.95
2001	SD	Butte	10B	9	580779	4969408	1.03	0	90	40	5	30.7	0	15.23
2001	SD	Butte	10B	10	581779	4969408	0.64	0	100	40	0	33.08	0	14.15
2001	SD	Butte	10B	11	580279	4968908	0.04	0	55	15	5	14.75	0	6.05
2001	SD	Butte	10B	12	581279	4968908	0.42	0	5	0	0	14.96	0	5.95
2001	SD	Butte	11B	LEK	580877	4956628	0.28	0.01	35	2.5	0	14.47	8	12.53

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Butte	11B	1	580377	4957628	1.54	0	97.5	5	0	19.69	0	16.18
2001	SD	Butte	11B	2	581377	4957628	1.08	0	92.5	2.5	0	17.77	0	12.25
2001	SD	Butte	11B	3	579877	4957128	0.04	0	0	0	0	13	0	1.6
2001	SD	Butte	11B	4	580877	4957128	1.12	0	90	15	0	30.63	0	10.7
2001	SD	Butte	11B	5	581877	4957128	.	.	.	.	.	.	.	.
2001	SD	Butte	11B	6	580377	4956628	0.19	0.28	47.5	5	0	21.38	8	12.38
2001	SD	Butte	11B	7	581377	4956628	1.08	0	60	22.5	0	24.84	0	11.78
2001	SD	Butte	11B	8	579877	4956128	0.03	0	47.5	2.5	0	14	0	6.88
2001	SD	Butte	11B	9	580877	4956128	0.07	0.41	97.5	32.5	0	16	5.29	17.78
2001	SD	Butte	11B	10	581877	4956128	1.32	0	100	30	0	27.85	0	13.13
2001	SD	Butte	11B	11	580377	4955628	0.69	0	75	15	0	22.23	0	10.85
2001	SD	Butte	11B	12	581377	4955628	1.12	0	100	15	0	20.42	0	13.78
2001	SD	Butte	12B	LEK	605185	4982068	0.03	0	100	0	0	26.33	0	13.15
2001	SD	Butte	12B	1	604685	4983068	2.05	0	95	0	0	16.56	0	10.98
2001	SD	Butte	12B	2	605685	4983068	0.69	0	95	0	0	22.78	0	13.85
2001	SD	Butte	12B	3	604185	4982569	1.3	0	100	30	0	19.45	0	13.53
2001	SD	Butte	12B	4	605185	4982569	2.12	0	85	0	0	15.28	0	10.13
2001	SD	Butte	12B	5	606185	4982569	0.08	0	100	5	0	27.36	0	13.15
2001	SD	Butte	12B	6	604685	4982068	1.08	0	100	0	0	18.82	0	12.75
2001	SD	Butte	12B	7	605685	4982068	0.76	0	95	5	0	25.03	0	13.53
2001	SD	Butte	12B	8	604185	4981568	0.23	0	60	0	0	13.56	0	10.32
2001	SD	Butte	12B	9	605185	4981568	0.79	0	100	10	0	21.19	0	14.3
2001	SD	Butte	12B	10	606185	4981568	0.93	0	100	15	0	18.26	0	12.45
2001	SD	Butte	12B	11	604685	4981068	1.4	0	80	0	0	14.29	0	12.95
2001	SD	Butte	12B	12	605685	4981068	0.05	0	85	0	0	17.43	0	10.23
2001	SD	Butte	13B	LEK	594639	4989792	3.28	0	50	0	0	13.23	0	8.75
2001	SD	Butte	13B	1	594139	4990792	1.28	0	100	5	0	20.65	0	12.25
2001	SD	Butte	13B	2	595139	4990792	0.04	0	100	0	0	18.78	0	12.03
2001	SD	Butte	13B	3	593639	4990292	2.55	0	95	0	0	13.88	0	11.8
2001	SD	Butte	13B	4	494639	4990292	2.27	0	45	0	0	14.5	0	8.85
2001	SD	Butte	13B	5	595639	4990292	0.29	0	30	0	0	19.06	0	11.18
2001	SD	Butte	13B	6	594139	4989792	0.62	0	100	0	0	18.5	0	11.2
2001	SD	Butte	13B	7	595139	4989792	2.43	0	100	25	0	16.25	0	14.65
2001	SD	Butte	13B	8	593639	4989292	3.09	0	100	15	0	17.13	0	12.93
2001	SD	Butte	13B	9	594639	4989292	0.47	0	100	5	0	21.48	0	16
2001	SD	Butte	13B	10	595639	4989292	2.66	0	90	0	0	14.43	0	10.13
2001	SD	Butte	13B	11	595139	4988792	0.06	0	30	0	0	16.75	0	9.68
2001	SD	Butte	13B	12	595139	4988792	2.66	0	20	0	0	13.38	0	8.7
2001	SD	Butte	14B	LEK	591209	4982129	0	0	95	0	0	0	0	11.73
2001	SD	Butte	14B	1	590809	4983129	0	0	100	0	0	0	0	13.1

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Butte	14B	2	591809	4983129	0	0	95	0	0	0	0	12.63
2001	SD	Butte	14B	3	590309	4982629	0	0	95	0	0	0	0	15.28
2001	SD	Butte	14B	4	591309	4982629	0	0	70	0	0	0	0	11.6
2001	SD	Butte	14B	5	592309	4982629	0	0	100	0	0	0	0	11.38
2001	SD	Butte	14B	6	590809	4982129	0	0	100	0	0	0	0	11.9
2001	SD	Butte	14B	7	591809	4982129	0	0	100	0	0	0	0	12
2001	SD	Butte	14B	8	590309	4981629	0	0	100	0	0	0	0	13.2
2001	SD	Butte	14B	9	591309	4981629	0	0	95	0	0	0	0	14.1
2001	SD	Butte	14B	10	592309	4981629	0	0	100	0	0	0	0	12.88
2001	SD	Butte	14B	11	590809	4981129	0	0	100	0	0	0	0	16.35
2001	SD	Butte	14B	12	591809	4981129	0.24	0	100	0	0	19.17	0	11.35
2001	SD	Butte	15B	LEK	583325	4972585	0.31	0	55	0	0	4.48	0	7.4
2001	SD	Butte	15B	1	582825	4973585	0.07	0	0	0	0	18	0	4
2001	SD	Butte	15B	2	583825	4973585	0	0	10	0	0	14	0	5.03
2001	SD	Butte	15B	3	582325	4973085	4.84	0.01	50	20	5	34.38	30.95	14.65
2001	SD	Butte	15B	4	583325	4973085	1	0	35	5	0	15.9	18	6.48
2001	SD	Butte	15B	5	584325	4973085	0.16	0	20	0	0	20.06	0	9.2
2001	SD	Butte	15B	6	582825	4972585	0.77	0	75	10	0	25.74	0	9.43
2001	SD	Butte	15B	7	583825	4972585	0.3	0	70	0	0	22.04	0	11.23
2001	SD	Butte	15B	8	582325	4972085	0.42	0	85	30	0	24.68	0	10.15
2001	SD	Butte	15B	9	583325	4972085	0.21	0	95	10	0	25.72	0	12.63
2001	SD	Butte	15B	10	584325	4972085	0.85	0	85	20	0	18.32	0	9.78
2001	SD	Butte	15B	11	582825	4971585	0.98	0	85	35	0	28.55	0	13.55
2001	SD	Butte	15B	12	583825	4971585	0.09	0	95	0	0	17.69	0	14.33
2001	SD	Fall River	1FR	LEK	581629	4796587	0.27	0.26	100	27.5	0	30.93	6.85	11.43
2001	SD	Fall River	1FR	1	581129	4797587	0	0	97.5	0	0	0	0	11.05
2001	SD	Fall River	1FR	2	582129	4797587	0.03	0	97.5	0	0	42.75	0	8.68
2001	SD	Fall River	1FR	3	580629	4791087	0.05	0	87.5	0	0	18.56	0	6.68
2001	SD	Fall River	1FR	4	581629	4791087	0.02	0.15	2.5	0	0	24.33	6.33	8.35
2001	SD	Fall River	1FR	5	582629	4791087	0	0	0	0	0	23	0	3.3
2001	SD	Fall River	1FR	6	581129	4796587	0.09	0.04	30	0	0	25.29	6.4	9.4
2001	SD	Fall River	1FR	7	582129	4796587	0.23	0.6	40	0	0	31.46	5.31	7.8
2001	SD	Fall River	1FR	8	580629	4796087	0.07	0	100	0	0	18	0	12.6
2001	SD	Fall River	1FR	9	581629	4796087	0.17	0	45	4.5	0	34.86	0	7.48
2001	SD	Fall River	1FR	10	582629	4796087	0.68	0	100	50	15	41.81	0	10.83
2001	SD	Fall River	1FR	11	581129	4795587	0.09	0	100	0	0	23.5	0	7.65
2001	SD	Fall River	1FR	12	582129	4795587	0	0	100	0	0	0	0	11.58
2001	SD	Harding	1H	LEK	637154	5029503	0.39	0.16	60	0	0	22.27	17.8	10.35
2001	SD	Harding	1H	1	636654	5030503	.		.	.	.	.	.	.
2001	SD	Harding	1H	2	637654	5030503	0	0.46	95	15	5	0	37.33	19.08

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Harding	1H	3	636154	5030003	1.22	0.13	80	65	10	33.28	37.53	15.43
2001	SD	Harding	1H	4	637154	5030003	0.03	0.94	100	35	0	27.33	23.85	14.13
2001	SD	Harding	1H	5	638154	5030003	1.12	0.11	100	25	0	35.87	27.5	20.98
2001	SD	Harding	1H	6	636654	5029503	0.85	0.02	55	5	0	20.57	33	10.8
2001	SD	Harding	1H	7	637654	5029503	0.15	0.52	100	30	5	32.57	32.13	17.85
2001	SD	Harding	1H	8	636154	5029003	0.17	0.62	95	25	0	28.79	39.09	15.48
2001	SD	Harding	1H	9	637154	5029003	0.02	0.63	55	25	0	30	30.93	13.8
2001	SD	Harding	1H	10	638154	5029003	0.01	0.69	100	25	0	32.5	39.03	22.03
2001	SD	Harding	1H	11	636654	5028503	0.51	0.29	90	30	0	27.45	28.57	15.86
2001	SD	Harding	1H	12	637654	5028503	0.82	0.2	75	0	0	21.64	29.13	12.35
2001	SD	Harding	2H	LEK	584376	5044130	1.81	0	75	5	0	19.65	0	12.18
2001	SD	Harding	2H	1	583876	5045130	0.15	0	20	0	0	28.67	0	7.5
2001	SD	Harding	2H	2	584876	5045130	0.01	0	90	0	0	18	0	19.38
2001	SD	Harding	2H	3	583376	5044630	0.42	0	70	20	0	27.42	0	10.2
2001	SD	Harding	2H	4	584376	5044630	0.7	0	75	25	0	24.4	0	15.13
2001	SD	Harding	2H	5	585376	5044630	0	0	100	0	0	0	0	17.3
2001	SD	Harding	2H	6	583876	5044130	0.68	0	95	35	0	31.53	0	15.78
2001	SD	Harding	2H	7	584876	5044130	0.38	0	95	15	0	34.19	0	17.25
2001	SD	Harding	2H	8	583376	5943630	1.64	0	55	5	0	14.25	0	9.63
2001	SD	Harding	2H	9	584376	5043630	1.02	0	80	35	0	30.9	0	13.73
2001	SD	Harding	2H	10	585376	5043630	0.22	0	100	15	0	28.88	0	18.43
2001	SD	Harding	2H	11	583876	5043130	0.07	0	50	0	0	29	0	11.36
2001	SD	Harding	2H	12	584876	5043130	1.28	0	95	15	0	24.13	0	12.15
2001	SD	Harding	3H	LEK	580533	5065647	0.09	0	100	0	0	23.79	0	13.28
2001	SD	Harding	3H	1	580033	5066647	0	0	100	0	0	0	0	14.38
2001	SD	Harding	3H	2	581033	5066647	0	0	100	0	0	0	0	14.28
2001	SD	Harding	3H	3	579533	5066147	0.04	0	85	0	0	24.4	0	12.18
2001	SD	Harding	3H	4	580533	5066147	0.29	0	80	0	0	19.1	0	13.18
2001	SD	Harding	3H	5	581533	5066147	0.34	0	55	5	0	19.58	0	11.85
2001	SD	Harding	3H	6	580033	5065647	0.05	0	75	0	0	30.67	0	12.93
2001	SD	Harding	3H	7	581033	5065647	0.66	0	55	15	0	18.66	0	9.05
2001	SD	Harding	3H	8	579533	5065147	0.63	0.01	85	15	0	31.29	0	13.63
2001	SD	Harding	3H	9	580533	5065147	0	0	100	0	0	0	0	12.8
2001	SD	Harding	3H	10	581533	5065147	0.15	0	90	10	5	28.61	0	13.93
2001	SD	Harding	3H	11	580033	5064647	0.19	0.1	100	20	5	28.2	40.08	15.43
2001	SD	Harding	3H	12	581033	5064647	0.39	0	75	0	0	22.33	0	12.23
2001	SD	Harding	4H	LEK	591718	5067383	0.02	0.18	50	0	0	17.4	25.5	11.98
2001	SD	Harding	4H	1	591218	5068383	0.68	0.03	50	0	0	16.91	32.63	11.95
2001	SD	Harding	4H	2	592218	5068383	0.62	0.18	70	5	0	23.62	26.27	9.81
2001	SD	Harding	4H	3	590718	5067883	.		.	.	.	.	.	.

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Harding	4H	4	591718	5067883	0.08	0.33	75	0	0	18	29.61	12.45
2001	SD	Harding	4H	5	592718	5067883	0.91	0.06	85	20	0	31.06	32.6	17.03
2001	SD	Harding	4H	6	591218	5067383	0.15	0.25	40	0	0	26.63	31.57	11.85
2001	SD	Harding	4H	7	592218	5067383	0.06	0.02	50	0	0	24	17.5	9.88
2001	SD	Harding	4H	8	509718	5066883	0.01	0.05	100	0	0	0	21	14.48
2001	SD	Harding	4H	9	591718	5066883	0.03	0	80	0	0	18.27	0	12.2
2001	SD	Harding	4H	10	592718	5066883	.		.	.	.	.	.	.
2001	SD	Harding	4H	11	591218	5066383	0.57	0.03	100	30	5	40.51	40	19.4
2001	SD	Harding	4H	12	592218	5066383	0.65	0.04	90	10	0	25.29	42.33	11.8
2001	SD	Harding	7H	LEK	599665	5061000	0.87	0	90	20	0	24.21	0	13.9
2001	SD	Harding	7H	1	599165	5062000	0.27	0.24	70	10	0	31.18	27.63	13.98
2001	SD	Harding	7H	2	600165	5062000	0.05	0.02	50	5	0	28	27	12.13
2001	SD	Harding	7H	3	598665	5061500	0.01	0.05	100	0	0	0	23	19.83
2001	SD	Harding	7H	4	599665	5061500	1.03	0.01	100	10	0	27.61	0	13.23
2001	SD	Harding	7H	5	600665	5061500	0.31	0.07	60	5	0	22.61	28.5	12.3
2001	SD	Harding	7H	6	599165	5061000	0	0	85	0	0	27	21	11.43
2001	SD	Harding	7H	7	600165	5061000	0.55	0.03	100	0	0	24.22	14	11.5
2001	SD	Harding	7H	8	598665	5060500	0.01	0	30	0	0	34.67	0	9.63
2001	SD	Harding	7H	9	599665	5060500	0.01	0	60	0	0	0	0	11.78
2001	SD	Harding	7H	10	600665	5060500	0.38	0	55	30	0	38.8	53.5	15.13
2001	SD	Harding	7H	11	599165	5060000	0.13	0	90	0	0	26.67	0	13.5
2001	SD	Harding	7H	12	600165	5060000	0.4	0	65	5	0	24.5	0	13.7
2001	SD	Harding	8H	LEK	632285	5032649	0.85	0.12	85	10	0	28.66	33.85	18.03
2001	SD	Harding	8H	1	631785	5033649	0	0.48	100	5	0	28	25.53	17.6
2001	SD	Harding	8H	2	632785	5033649	0	0.21	100	15	0	0	29.33	14.85
2001	SD	Harding	8H	3	631285	5033149	0.01	0.32	100	60	10	0	40.41	18.03
2001	SD	Harding	8H	4	632285	5033149	0	0.19	100	0	0	0	25.07	15.08
2001	SD	Harding	8H	5	633285	5033149	0.01	0.48	55	25	0	0	27.22	12.65
2001	SD	Harding	8H	6	631785	5032649	0.34	0.2	60	5	0	28.33	29	16.38
2001	SD	Harding	8H	7	632785	5032649	0.24	0.52	90	0	0	25.33	29.32	15.83
2001	SD	Harding	8H	8	631285	5032149	0.71	0.12	85	15	0	22.19	28.91	13.15
2001	SD	Harding	8H	9	632285	5032149	0.84	0.01	90	20	0	28.26	32	14.58
2001	SD	Harding	8H	10	633285	5032149	0.12	0.47	100	10	0	29.2	31.47	17.15
2001	SD	Harding	8H	11	631785	5031649	0.77	0.02	85	10	0	29.04	28.86	13.78
2001	SD	Harding	8H	12	632785	5031649	0.46	0.16	85	15	0	24.8	33.36	14.03
2001	SD	Harding	9H	LEK	578999	5033369	0.01	0	40	0	0	19.33	44	12.4
2001	SD	Harding	9H	1	578499	5034369	0.16	0.48	70	5	0	27.33	36.14	13.25
2001	SD	Harding	9H	2	579499	5034369	0.12	0	75	5	0	24.13	29	14.33
2001	SD	Harding	9H	3	577999	5033869	0.02	0.01	100	0	0	17.67	19	13.95
2001	SD	Harding	9H	4	578999	5033869	0.9	0.11	70	30	0	36.31	42	16.3

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2001	SD	Harding	9H	5	578499	5033869	0.76	0.01	100	20	0	22.77	0	14.05
2001	SD	Harding	9H	6	578499	5033369	0.48	0.01	65	25	0	33.87	73	15.25
2001	SD	Harding	9H	7	579499	5033369	0	0	0	0	0	22	0	10.7
2001	SD	Harding	9H	8	577999	5032869	0	0	80	5	0	0	0	13.55
2001	SD	Harding	9H	9	578999	5032869	0.65	0.03	80	15	0	21.82	29	14.1
2001	SD	Harding	9H	10	579999	5032869	0	0	80	0	0	30	0	14.14
2001	SD	Harding	9H	11	578499	5032369	0	0	40	0	0	0	0	11.43
2001	SD	Harding	9H	12	579499	5032369	1	0	40	15	0	24.5	0	8.35
2001	SD	Harding	10H	LEK	641740	5016832	0.52	0.06	70	25	0	25.84	25	11
2001	SD	Harding	10H	1	641240	5017832	0.39	0.28	65	0	0	16.25	22.17	12.33
2001	SD	Harding	10H	2	642240	5017832	0.02	0	100	0	0	20	70	13.88
2001	SD	Harding	10H	3	640740	5017332	0	0.47	100	0	0	42	27.33	15
2001	SD	Harding	10H	4	641740	5017332	1.24	0.01	100	0	0	14.79	30	6.15
2001	SD	Harding	10H	5	642740	5017332	0.08	0.33	100	0	0	15.93	41.11	16.48
2001	SD	Harding	10H	6	641240	5016832	0.48	0.12	70	0	0	17.56	29.3	13.38
2001	SD	Harding	10H	7	642240	5016832	0.47	0.07	100	0	0	21.65	18	13
2001	SD	Harding	10H	8	640740	5016332	0	0.07	100	0	0	0	44.36	15.5
2001	SD	Harding	10H	9	641740	5016332	0.01	0.54	100	10	0	28.5	30.43	15.13
2001	SD	Harding	10H	10	642740	5016332	0.02	0	100	0	0	36	0	14.89
2001	SD	Harding	10H	11	641240	5015832	.		.	.	.	.	.	.
2001	SD	Harding	10H	12	642240	5015832	0.13	0.04	70	0	0	24.29	24.4	12.03
2002	SD	Harding	5H	1	596256	5045727	1.53	0	100	10	0	30.97	0	18.75
2002	SD	Harding	5H	2	597256	5045727	0	0	0	0	0	0	0	9.45
2002	SD	Harding	5H	3	595756	5045227	0.36	0.23	45	15	0	37.85	50.44	12.75
2002	SD	Harding	5H	4	596756	5045227	1.52	0	90	0	0	22.46	0	11.8
2002	SD	Harding	5H	5	597756	5045227	0	0	100	20	0	0	0	18.3
2002	SD	Harding	5H	6	596256	5044727	0.03	0	35	0	0	34.67	0	12.5
2002	SD	Harding	5H	7	597256	5044727	0.07	0	90	10	0	30.41	0	18.53
2002	SD	Harding	5H	8	595756	5044227	0.34	0.03	55	0	0	41.58	25.5	13.88
2002	SD	Harding	5H	9	596756	5044227	0.01	0	80	5	0	26.33	0	14.33
2002	SD	Harding	5H	10	597756	5044227	0.07	0	75	0	0	26.75	0	13.48
2002	SD	Harding	5H	11	596256	5043727	0.05	0.11	15	5	0	37.57	41	9.5
2002	SD	Harding	5H	12	597256	5043727	0	0	100	55	0	0	60	26.15
2002	SD	Harding	6H	1	600785	5058816	0.52	0.01	70	0	0	20.26	10	14.1
2002	SD	Harding	6H	2	601785	5058816	0.22	0.34	90	20	5	34.57	35.85	14.75
2002	SD	Harding	6H	3	600285	5058316	0.08	0.12	95	15	0	25.5	44.2	19.73
2002	SD	Harding	6H	4	601285	5058316	0.78	0.06	100	65	30	42.62	43	15.83
2002	SD	Harding	6H	5	602285	5058315	0.06	0.2	75	10	0	44.75	43.6	15.23
2002	SD	Harding	6H	6	600785	5057816	0.21	0.19	50	15	0	37.35	32.13	13.48
2002	SD	Harding	6H	7	601785	5057816	1.29	0.12	75	49	0	33.45	51.75	15.13

Year	State	County	Lek	Site	Easting	Northing	Density ARTR2	Density ARCA13	Visual obs % 0.10m	Visual obs % 0.25m	Visual obs % 0.50m	Ht. (cm) ARTR2	Ht. (cm) ARCA13	Ht. (cm) Grass
2002	SD	Harding	6H	8	600285	5057316	1.07	0.08	90	15	0	28.7	52.43	17.88
2002	SD	Harding	6H	9	601285	5057316	2.27	0.1	70	30	0	28.21	40	12.28
2002	SD	Harding	6H	10	602285	5057316	0.8	0.25	60	10	0	28.88	52.09	15.63
2002	SD	Harding	6H	11	600785	5056816	0.31	0	85	30	0	32.9	0	20.8
2002	SD	Harding	6H	12	601785	5056816	0.47	0.07	80	20	5	42.8	34	14.1

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