GREATER SAGE GROUSE ON THE EDGE OF THEIR RANGE: LEKS AND SURROUNDING LANDSCAPES IN THE DAKOTAS

BY

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GREATER SAGE GROUSE ON THE EDGE OF THEIR RANGE: LEKS AND SURROUNDING LANDSCAPES IN THE DAKOTAS

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department

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ABSTRACT

GREATER SAGE GROUSE ON THE EDGE OF THEIR RANGE: LEKS AND SURROUNDING LANDSCAPES IN THE DAKOTAS

Joe T. Smith

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Sage grouse (*Centrocercus spp.*) have been declining throughout their range in the United States and Canada as well as in individual states and provinces. Sage grouse, including the combined range of both the greater sage grouse (*C. urophasianus*) and the Gunnison sage grouse (*C. minimus*), once occurred in 16 states and three Canadian provinces; now they only occur in 11 states and two Canadian provinces (Connelly and Braun 1997, Schroeder et al. 1999). Excluding states suggested as part of the Gunnison sage grouse range (Young et al. 2000), greater sage grouse range has declined from 13 states and three Canadian provinces to 11 states and two Canadian provinces (Schroeder et al. 1999). Concerns are growing over the reasons for these declines. The habitat around active and historically active greater sage grouse leks in North Dakota and South Dakota was studied during 2001 and 2002 in

an attempt to find reasons for desertion of once thriving leks and for apparent population declines. I collected information on current and historic (i.e., leks with 0-<2 males on them in the last 5 years) sage grouse lek counts and distributions in western North Dakota and South Dakota. A steady decline is evident when reviewing the entire recorded period of greater sage grouse surveys in North Dakota (1951-2002) and South Dakota (1972-2002). There is also apparent eastern edge abandonment of the active breeding range over the years. Land use patterns in these areas once occupied by greater sage grouse have likely changed and are now failing to meet their needs (Connelly and Braun 1997).

I compared peripheral microhabitat and landscape characteristics to identify possible reasons for lek abandonment. For microhabitat data, I systematically selected 12 sample sites at equidistant points from each other within 1.5 km of the lek center. No differences ($P > 0.10$) were detected between sagebrush (*Artemisia spp.*) cover or sagebrush density around active leks versus that around historically active leks in North Dakota and South Dakota. Sagebrush density does appear to have a positive effect on greater sage grouse lek size in North Dakota and

South Dakota. Landscape level data were recorded and assessed using satellite imagery. Comparisons were made of 1972-1976 and 1999-2000 percent tilled and non-tilled. These land use comparisons were made between current leks versus historically active leks, active leks versus random sites, and abandoned regions versus active regions. The 1999-2000 imagery illustrated that percent tilled ground, and thus fragmentation, was greater ($P < 0.10$) within abandoned areas than within active areas in North Dakota. However, 1972-1976 imagery revealed that this relationship has been static over the last 30 years. Thus, if the decline of sage grouse is the result of tilled ground infringements it had to occur prior to 1972. Sage grouse, a landscape species, may have been slow to show the effects of this land use change.

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CHAPTER 1. GENERAL INTRODUCTION

INTRODUCTION

Sage grouse, including the combined range of the Greater and Gunnison species, once occupied portions of sixteen states in western North America as far south as New Mexico, north into three provinces of Canada (Braun 1995, Connelly and Braun 1997, Schroeder et al. 1999). Sage grouse began to decline near the onset of the twentieth century, probably due to the American westward movement, agricultural intensification, and increasing numbers of livestock (Patterson 1952, Gill 1966). Waning populations of sage grouse throughout the 1900s were attributed predominately to the decrease of sagebrush (Patterson 1952, Homer et al. 1993, Gregg et al. 1994, Connelly and Braun 1997, Connelly et al. 2000a). Sage grouse populations now occur in eleven states and two provinces in Canada (Connelly and Braun 1997, Schroeder et al. 1999).

The relationship between sagebrush and sage grouse is a partnership of necessity and has been studied by several scientists (Patterson 1952, Swenson 1987, Hupp and Braun 1989, Ellis et al. 1989, Connelly et al. 1991, Homer et al. 1993, Sveum et al. 1998a, Aldridge and Brigham 2002). Sage

grouse rely on sagebrush habitats for food, shelter, and water (Swenson 1987, Fischer et al. 1996, Schroeder et al. 1999). In the winter, sagebrush becomes the only source of food (Hupp and Braun 1989, Welch et al. 1991) with the entire diet consisting of sagebrush leaves and buds (Welch et al. 1991, Homer et al. 1993, Connelly et al. 2000a).

Unfortunately, extensive sagebrush destruction and eradication has resulted from plowing, overgrazing, improper fire management, and herbicide usage (Rickard et al. 1975, Swenson 1987, Heath et al. 1997, Nelle et al. 2000, Beck and Mitchell 2000). Fire has destroyed thousands of hectares of sagebrush and may be especially detrimental to sage grouse populations in big sagebrush (*A. tridentata*) dominated habitats because of big sagebrush's inability to re-sprout after fire (Peterson 1995, Connelly et al. 2000b, Nelle et al. 2000, Miller 2001). Overgrazing by domestic sheep (*Ovis aries*) can cause many problems in sage grouse habitat, especially in drier regions, by changing the composition of the understory from a grass/forb complex to complete domination by grasses leaving no food for the sage grouse (Patterson 1952, Beck and Mitchell 2000). Overgrazing by cattle (*Bos taurus*) on grass reduces grass cover rather than reducing forb cover

and results in low horizontal cover for nesting females (Beck and Mitchell 2000). However, with proper management, grazing can promote plant successional stages that are better as sage grouse habitat (Mosley 2001).

Sagebrush removal and disturbance in South Dakota and North Dakota appear to have occurred in the 1900s resulting in fragmentation of the sagebrush range. The extent of the big sagebrush range appears no different its historical extent in South Dakota, restricted to extreme western portion of the state (Williams 1895). However, others believe the big sagebrush range in South Dakota once touched the state's northern and southern borders, reaching east into Haakon County [South Dakota Game, Fish and Parks (SDGFP), unpublished data, 2000]. By 1914 big sagebrush in Harding County was said to be rare or absent east of Slim Buttes (Visher 1914). Big sagebrush occurred locally on silt along the lower terraces of some streams (Visher 1916). It was most abundant along the Little Missouri River in North Dakota and Sage Creek and Indian Creek in South Dakota (Visher 1916). The big sagebrush range in South Dakota currently covers large portions of Harding County, Butte County, and a small portion of Fall River County (Beetle 1960). In North Dakota, the big sagebrush range

appears to have been more fragmented over the years rather than being reduced in extent. The current range of big sagebrush in North Dakota occupies areas of Bowman, Slope, and Golden Valley Counties in the southwestern corner of the state (Beetle 1960) and is generally limited to the Badlands and areas along the Little Missouri (Stevens 1950, Stevens 1963). Big sagebrush in North Dakota and South Dakota generally attains less than half the height prevalent in more arid regions west of these states (Visher 1916).

Silver sagebrush (*A. cana*) in North Dakota and South Dakota is more widespread than big sagebrush and extends into a broader range since it appears to follow major rivers, streams, and lowlands (Beetle 1960). The silver sagebrush range in North Dakota is in the southwest section of the state bordered on the north and east by the Missouri River, but outliers were once found as far east as the 98th meridian (Stevens 1963, Cosby 1964). The 98th meridian goes through Valley City, North Dakota. Silver sagebrush in South Dakota was broadly described as found west of the Missouri River (Williams 1895, Saunders 1899) probably in scattered populations until reaching more extensive stands in the extreme western counties. Today silver sagebrush is

found in greatest abundance in counties west of the Cheyenne River Reservation with isolated patches east to the Missouri River (Beetle 1960).

Sagebrush is a very important management indicator for sage grouse and the sagebrush ecosystem as a whole in both South Dakota and North Dakota (SDGFP, unpublished data, 1992). Sagebrush in coexistence with understory forbs is especially important to female greater sage grouse during nesting and brood rearing (Drut et al. 1994a, Crawford 1997, Connelly et al 2000a).

Greater sage grouse nests are most commonly found underneath sagebrush (Patterson 1952, Gill 1966, Connelly et al. 1991, Musil et al. 1994, Sveum et al. 1998b), and female sage grouse show high nest area fidelity from year to year (Fischer et al. 1993). Nesting success was found to be higher (53%) for greater sage grouse that nested under sagebrush than those that did not (22%) (Connelly et al. 1991). Sveum et al. (1998b) found no difference between nest success under sagebrush versus nest success under other species of shrubs, indicating that if adequate cover is present, the species comprising the cover may be of minor importance as suggested by Aldridge and Brigham (2002).

The basic requirement for nesting sage grouse is areas where they can camouflage and conceal their nest from predators and where vegetation provides quality early brood rearing habitat (Klebenow 1969, Wallestad 1975a). Sage grouse nest at sites with high horizontal cover (>73%) that provide good visual barriers from predators (Musil et al. 1994, Connelly et al. 2000a). Nest concealment requirements may be met by a combination of tall residual grasses (>18 cm) and medium height shrubs (40-80 cm) (Gregg et al. 1994, Sveum et al. 1998b, Connelly et al. 2000a).

Nest sites were found to be associated with areas of <38% sagebrush cover due to the greater presence of forbs (Klebenow 1969, Connelly 2000a). Reproductive efforts by females are helped by the presence of forbs because forbs provide nutrients to the females and they help attract insects that are sought by chicks (Johnson and Boyce 1990, Barnett and Crawford 1994, Drut et al. 1994b, Crawford 1997, Sveum et al. 1998b, Gregg 2001). Insecticides applied to alfalfa (*Meticago falcata*) and crop fields used by sage grouse during the summer have a detrimental effect on survival of juveniles and adults by killing off the needed insect supply; some chemicals can even affect the

birds' brain activity and kill them directly (Blus et al. 1989, Blus and Connelly 1998).

Sagebrush habitat, as mentioned before, is very important for wintering sage grouse as it becomes the primary food source and cover (Hupp and Braun 1989, Welch et al. 1991). In Utah, Homer et al. (1993) found that sage grouse select for lower elevations and at least 20% sagebrush cover for winter habitat. Also, sagebrush height (>40.3 cm), shrub canopy (>20.4%), and bare ground (<39.6%) combined characterize choice sage grouse wintering habitat (Homer et al. 1993). Winter sagebrush cover and height, other shrub canopy, and bare ground use by sage grouse will vary by region, depending on availability (Connelly et al. 2000a).

Sagebrush supplies most of the water needs and therefore, water developments are not commonly used by sage grouse (Connelly and Doughty 1990). Sagebrush provides forage and loafing cover for males, and when located next to an open area, access to potential strutting grounds (hereafter leks)(Ellis et al. 1989, Connelly et al. 2000a).

Leks are generally in open areas that are surrounded by stands of denser sagebrush cover (Patterson 1952, Connelly et al. 2000a), but have been known to be located

next to sparse and low-in-form stands of sagebrush (Scott 1942). Strutting males selected areas surrounded by or near sagebrush with greater than 10% canopy coverage in central Montana (Wallestad 1975a). Sagebrush cover (>28%) and height (>40 cm) in proximity to the lek were important to male sage grouse lek fidelity in the Great Basin (Ellis et al. 1989).

Leks can vary in size from 0.4–16.2 ha and are typically found on open and flat terrain (Gill 1966). Factors accounting for differences in lek size may include yearly fluctuations in numbers of displaying males at lek sites, differences among population mean size, and distribution among sites used in a given year (Bradbury et al. 1989). Leks can be located on any open area from windswept ridges or exposed knolls to excavations around gravel pits and even dry lakebeds (Gill 1966, Connelly et al. 1981, Schroeder et al. 1999). Leks have also been observed on recently disturbed sites when there is a lack of suitable natural sites (Connelly et al. 1981).

Leks are usually found within winter and nesting habitat complexes (Wallestad 1975a). Leks are generally located where female grouse travel between wintering and nesting sites, and distribution of males among leks relates

to the presence of females (Gibson 1996). Male sage grouse fidelity to leks is related to the previous years' territory establishment and reproductive success (Dunn and Braun 1985, Gibson 1992). Some traditional leks have been reported to be active approximating 100 years or more (Dalke et al. 1963).

Strutting period may vary from February to May, peaking in late March to mid or late April (Pyrah 1954, Connelly et al. 1981, Bradbury et al. 1989, Gibson 1996). Males may arrive at the leks during the peak of the season around 4:00 AM and stay as late as 9:00 AM (Bradbury et al. 1989).

Greater sage grouse have abandoned some historical leks in South Dakota and North Dakota in the past 50 years, but no effort has been made to relate these abandonments to micro versus landscape level habitat changes. Greater sage grouse distribution trends and habitat selection on leks has been studied for some other states and areas (Tate et al. 1979, Connelly et al. 1981, Crawford and Lutz 1985, Dunn and Braun 1985, Ellis et al. 1989, Klott and Lindzey 1989, Gibson 1992, Gibson 1996, Johnson and Braun 1999). My study was conducted to determine if a relationship exists between occupancy and abandonment of greater sage

grouse leks and the microhabitat and landscape features associated with and peripheral to leks in western South Dakota and southwestern North Dakota.

The objectives of this study were to: 1) verify locations of known active and historically active leks in North Dakota and South Dakota; 2) estimate the number of males using active leks in North Dakota and South Dakota; 3) identify microhabitat and macrohabitat/landscape characteristics associated with active leks and compare them to historically active, but currently abandoned leks in North Dakota and South Dakota; and 4) identify and evaluate lek size in relation to surrounding landscape characteristics (e.g., tillage, sagebrush coverage, etc.) in North Dakota and South Dakota. We believe that addressing these objectives will provide information on sage grouse lek occupancy on the edge of their geographic range and provide management agencies insight to these important populations.

STUDY AREA

The study area is located in far western South Dakota, in Fall River, Butte, and Harding counties, and in southwestern North Dakota, in Bowman, Slope, and Golden

Valley counties (Fig. 1). In South Dakota the elevation in the study area ranges from 525 – 1050 m above sea level and has an overall topography of unglaciated rolling prairie with occasional buttes and intermittent streams (Johnson 1976, Kalvels 1982, Johnson 1988). Soil orders in the South Dakota study area consist mainly of Entisols, Inceptisols, Alfisols, Mollisols, and a few Aridisol patches (Johnson 1976, Kalvels 1982, Johnson 1988). Annual precipitation ranges from 37.4 cm to 41.8 cm with approximately 80% falling from April to September (Johnson 1976, Kalvels 1982, Johnson 1988). Annual snowfall ranges from 53.3 cm to 106.7 cm (Johnson 1976, Kalvels 1982, Johnson 1988). Annual temperature in the summer ranges from 14.3° C to 31.1° C and in the winter ranges from –14.6° C to –1.4° C (Johnson 1976, Kalvels 1982, Johnson 1988).

In North Dakota the elevation in the study area ranges from 640 – 1045 m above sea level and has an overall topography much like South Dakota's unglaciated rolling prairie with occasional buttes and intermittent streams, but the North Dakota study area also has pinnacles, domes, canyons, gorges, ravines, and gullies associated with the Badlands (Opdahl et al. 1975, Thompson 1978, Aziz 1989).

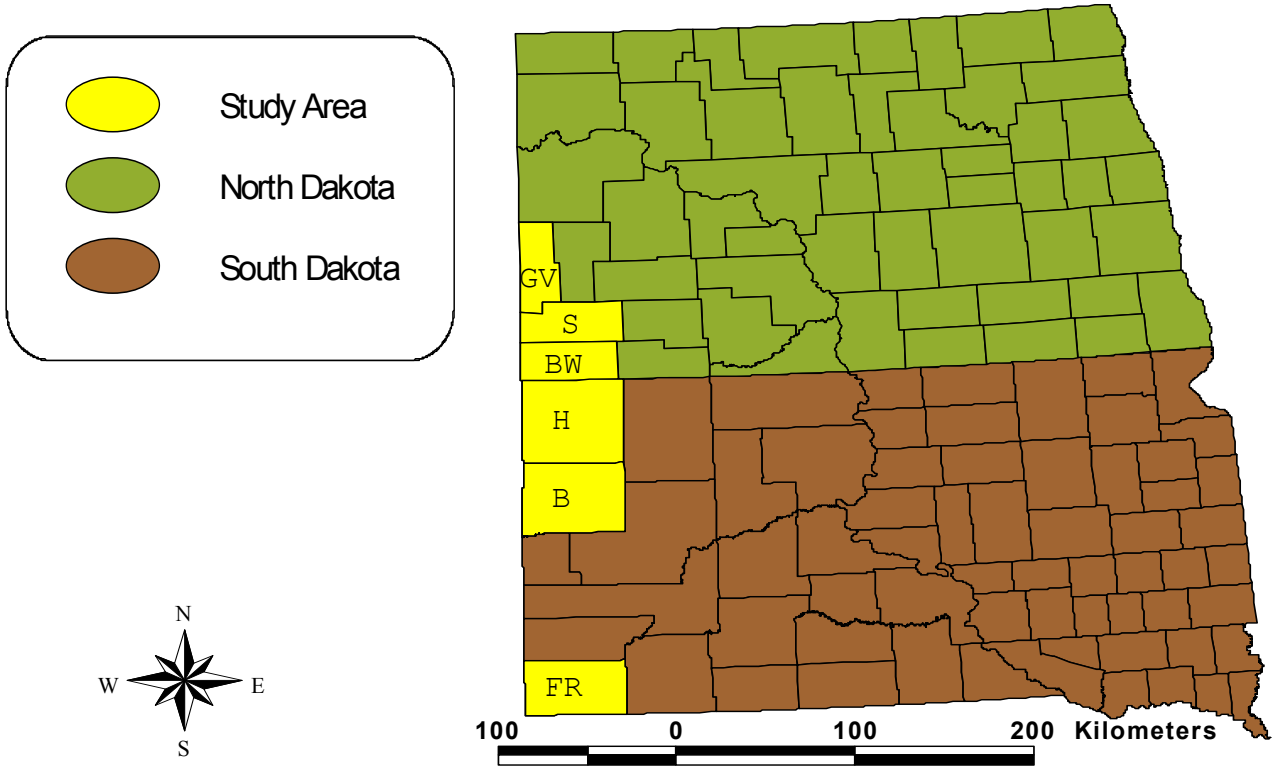


Figure 1. Location of study area in North Dakota and South Dakota. Counties are from north to south Golden Valley (GV), Slope (S), and Bowman (BW) in North Dakota and Harding (H), Butte (B), and Fall River (FR) in South Dakota.

Soil orders in the area consist of the same types that are in South Dakota. Annual precipitation ranges from 35.6 cm to 40.6 cm with approximately 80% falling from April to September (Opdahl et al. 1975, Thompson 1978, Aziz 1989). Annual snowfall ranges from 63.5 cm to 78.7 cm (Opdahl et al. 1975, Thompson 1978, Aziz 1989). Annual temperature in the Summer ranges from 9.9° C to 27.5° C and in the Winter ranges from −15.6° C to −0.2° C (Opdahl et al. 1975, Thompson 1978, Aziz 1989).

The vegetation in the study area of South and North Dakota is a mixture of shrubland, with an understory of perennial grasses and forbs, and open grassland (Johnson and Larson 1999). The most abundant shrub species are big sagebrush, silver sagebrush, western snowberry (*Symphoricarpos occidentalis*), rubber rabbitbrush (*Chrysothamnus nauseosus*), and greasewood (*Sarcobatus vermiculatus*) (Johnson and Larson 1999).

The dominant grasses in the study area includes western wheatgrass (*Pascopyrum smithii*), Kentucky bluegrass (*Poa pratensis*), Japanese brome (*Bromus japonicus*) needleandthread (*Stipa comata*), and Junegrass (*Koeleria macrantha*) (Johnson and Larson 1999). The most dominant forbs are common dandelion (*Taraxacum officinale*), common

yarrow (*Achillea millefolium*), and textile onion (*Allium textile*).

METHODS

Censusing lek attendance

Locations and past counts on active and historic leks were found through personal communication with the SDGFP, North Dakota Game and Fish (NDGF), and landowners. Extensive flights have been flown in North Dakota by the NDGF to identify new lek locations (G. D. Kobriger, pers. comm., NDGF). Flights have also been flown in South Dakota by the SDGFP, but not as extensive, systematic, or as recent as in North Dakota. After obtaining the lek locations in legal descriptions (i.e., township, range, section, and quarter section), I converted them to Universal Transverse Mercator (UTM) coordinates. Leks were then located with the help of a hand-held 12-Channel Global Positioning System (GPS) (i.e., Garmin 12 XL unit; Garmin International, Olathe, Kansas, USA). NDGF and SDGFP personnel familiar with the lek sites then verified their locations.

I surveyed leks that were within a few miles of one another on the same day to reduce the chance of counting

the same male(s) twice on two separate leks (Rogers 1964). Although adult male inter-lek movements are uncommon during the course of a breeding season, females and juvenile males have been known to move between leks (Dalke et al. 1963, Wallestad and Schladweiler 1974, Emmons and Braun 1984, Aldridge 2000). Lek observations were conducted from April 1-30 in 2001 and 2002 to coincide with the sage grouse's peak lek attendance (Connelly et al. 1981, Bradbury et al. 1989, Gibson 1996). Each lek site was surveyed three times each year during the month of April [J.W. Connelly, pers. comm., Idaho Department of Game and Fish (IDGF)]. Of the three counts, the count with the maximum number of males was used as the representative count (Rogers 1964). Counts were made from sunrise to 8:00 AM on days with low to moderate wind and no precipitation (Rogers 1964). Lek observations were made from a vehicle or on foot with at least 7 x 35 mm binoculars or a 20x spotting scope from a raised, but concealed vantage point at least 100 m away (Rogers 1964, Tate et al. 1979, Gibson 1992). At each lek site I scanned the area three times, glassing back-and-forth with the binoculars or spotting scope taking careful notice of everything in my field of view. All males on the lek and males in sagebrush adjacent to each lek were

counted (Rogers 1964). Information from these lek counts gave accurate quantitative information about activity on leks and indicated possible qualitative values of the landscape as sage grouse habitat.

Collecting microhabitat data

Microhabitat data were gathered and compared between active lek sites and historically active lek sites. The lek coordinates were then entered into a computer, referenced, and overlaid onto a map of western South Dakota and southwestern North Dakota using the geographic information system (GIS) ArcView GIS 3.2a [Environmental Systems Research Institute (ESRI), Inc. 2000]. From the center of each lek site I buffered outward 1.5 km and used this area as an indicator of habitat quality for our microhabitat analysis. A buffer of 1.5 km is used to prevent overlap with buffers of other leks and because of the extensive sampling time involved. These buffered areas were then overlaid with a 3 x 3-km regular grid (DeMers 2000), with a cell size of 0.5 km^2, and centered on the lek (Fig. 2). A total of twelve sample sites were placed systematically at equidistant points from each other around the lek. Each sample site was entered into a computer and

assigned UTM coordinates within ArcView 3.2a. These sample sites were located with the use of state maps, county maps, and the help of a hand-held 12-Channel GPS.

At the center of each sample site, four 50-m transects in each of the cardinal directions were established. Sagebrush and other shrub characteristics (e.g., cover, density, and height) were recorded for each transect (Ellis et al. 1989). Big sagebrush, silver sagebrush, and other shrub cover (e.g., total, live, and dead) were measured using the line-intercept method (Canfield 1941, Connelly et al. 1991, Musil et al. 1994, Higgins et al. 1996). Sagebrush and other shrub densities were calculated by walking along transects with a 1-m stick centered horizontally and perpendicular to the tape, counting the number of different shrub species that have $\geq$50% of their canopy or the entire area of the trunk within the area covered by the meter stick and calculating the number of each shrub species per m^2 (Higgins et al. 1996). Average sagebrush height (cm), shrub height (cm), and maximum effective height of grass (cm) were measured at 5-m intervals along the transect using a meter stick (Connelly et al. 1991, Musil et al. 1994, Nelle et al. 2000). Height measurements were performed by measuring the grass height

(cm) at the tape and the height of the closest big sagebrush, silver sagebrush, and other shrubs within a 2-m radius of the tape.

Herbaceous cover was measured using a 20 x 50-cm quadrat (Daubenmire 1959, Higgins et al. 1996) along each transect at 5-m intervals and placed with the 50-cm side perpendicular to the edge of the right side of the tape when looking from the center point of the transects. If obstructed by a shrub the quadrat was placed along the tape between the two closest sagebrush plants. At each 5-m interval a smaller 10 x 25-cm quadrat was used to measure undersory herbaceous cover. The quadrat was placed underneath the nearest sagebrush plant within a 2-m radius to the tape at a randomly selected cardinal direction from the trunk of the plant. If first direction failed to fall underneath the canopy of the sagebrush plant or was obstructed, the next counterclockwise cardinal direction was used. Using cover classes developed by Daubenmire (1959), percent grass cover, dominant grasses, percent forb cover, dominant forbs, percent bare ground, and percent litter (i.e., dead vegetation that was disconnected or not standing, dead insects, and animal feces) were recorded for both understory and herbaceous cover (Nelle et al. 2000,

J.W. Connelly, pers. comm., IDGF). Percent visual obstruction was measured using the staff-ball method (Collins and Becker 2001) in the quadrant left of each transect. Visual obstruction readings for the four transects were taken 10 m from the intersection of the four transects and at a 45° angle. Percent visual obstruction was measured at a height of 0.10 m, 0.25 m, and 0.50 m. Vegetation data collected on sample sites around each lek were used to characterize the habitat in the 1.5-km core areas around active and inactive leks.

Collecting landscape habitat data

Landscape level data were collected in order to assess the amount of tilled land versus non-tilled land sage grouse might encounter in searching potential nesting and brood rearing areas peripheral to leks. I buffered active leks, historically active leks, and randomly selected points by 4 km (DeMars 2000) and used the area within these buffers for our comparisons. Preliminary landscape level plotting indicated that buffering more than 4 km caused too much overlap between sites for significant comparisons to be made. If two buffers overlapped by more than 1 km, I ignored the one that was inactive. If both were inactive

or active I assigned one buffer area odd numbers and one buffered area even numbers and used a random number generator to choose the one to be ignored. If they overlapped less than 1 km, the buffers were treated as if they were independent. Evaluations were made by comparing current (i.e., 1999-2000) percent tilled and percent non-tilled ground between active and historically active buffered areas. I also compared historic (i.e., 1972-1976) percent tilled and percent non-tilled ground within 4-km buffers of leks that were active in 1972-1976 and not active in 1999-2000. In addition, I created random 4-km buffers by placing 18 random points within the range currently occupied by the sage grouse in North and South Dakota and then buffering these points.

Regions of activity and inactivity were created in North Dakota by using the 4-km buffers and creating a polygon around an area of inactive leks (i.e., inactive region) and another polygon around an area of predominantly active leks (i.e., active region). No regions were made in South Dakota due to the lack of historical lek location information. These regions were compared relative to the current (i.e., 1999-2000) and historic (i.e., 1972-1976) percent tilled ground within each region.

To assess region fragmentation I randomly selected 15 points within each region and then buffered these points by 2 km. I used 2-km buffers to balance the need to sample landscapes with the need for more points to better sample area. I then calculated what percentage of these random buffers had tilled ground occur within them and what percentage did not to determine tilled ground fragmentation of each region.

Landscape level data within the 4-km buffers and regions were recorded and assessed using satellite imagery [i.e., LANDSAT 7 Thematic Mapper (TM) Imagery], obtained from Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, SD, within a GIS. The GIS coverages permitted evaluation of landscape-level differences between active and historically active leks [Oklahoma Department of Wildlife Conservation (ODWC) 1998]. Satellite imagery was classified into two categories (i.e., tilled ground and non-tilled ground). Three scenes of 1972-1976 and 1999-2000 satellite imagery were classified into tilled and non-tilled ground using ERDAS Imagine Software (Imagine) 8.5 (ERDAS, Inc. 2001). I used the area of interest (AOI) tools in ERDAS to select areas believed to be tilled ground. I then used aerial photos obtained from county

Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) offices to check our interpretation of the imagery. Ground truthing of imagery was also incorporated as a way of checking our interpretation. These classified satellite images were then converted to a 60 x 60-m grid within Imagine. The grid was then brought into ArcView 3.2a (ESRI Inc. 2000) for analysis. For each category (i.e., tilled and non-tilled ground) I calculated percentage of total area within each 4-km buffer for years 1973-1976 and 1999-2000. I calculated percent of area of tilled/non-tilled ground change from 1972-1976 to 1999-2000.

I attempted to extract sagebrush from satellite imagery by using sagebrush cover measurements I collected on the ground, using the methods described in the previous section, as model training data. Sagebrush landcover determination from satellite imagery was modeled at EROS using a regression tree procedure (De'ath and Fabricius 2000, Debeljak et al. 2001). Additional visits were conducted to ground-truth imagery interpretation.

Statistical Analysis

All statistical analyses were performed using Statistical Analysis System (SAS) (SAS Institute 1999). All analyses were conducted using an α level of 0.10.

CHAPTER 2. THE HISTORY OF SAGE GROUSE IN NORTH DAKOTA AND SOUTH DAKOTA: RANGES, POPULATIONS, AND TRENDS

INTRODUCTION

Greater sage grouse of western North America once ranged in 13 states as far south as Arizona, and north into three provinces of Canada (Braun 1995, Connelly and Braun 1997, Schroeder et al. 1999). Greater sage grouse began their decline near the onset of the twentieth century probably due to the American westward movement, agricultural intensification, and increasing number of livestock (Patterson 1952, Dalke et al. 1963, Gill 1966). Declining populations of greater sage grouse continued throughout the 1900's, being mainly attributed to the decrease of sagebrush due to agriculture (i.e., cash crops), overgrazing, energy development, fire, and/or drought (Patterson 1952, Homer et al. 1993, Gregg et al. 1994, Connelly and Braun 1997, Braun 1998, Connelly et al. 2000b). Information on historic greater sage grouse ranges, trends, and population status could be of vital importance in our understanding of their population decline and in conservation efforts.

The greater sage grouse range extends into sagebrush steppe communities, primarily big sagebrush and silver sagebrush, in western North Dakota and South Dakota (Schroeder et al. 1999). Populations of the greater sage grouse in the Dakotas represent the eastern most extension of their range and they generally exist in marginal sagebrush steppe communities. My objectives were to: 1) gather historic information on greater sage grouse in North Dakota and South Dakota; 2) verify locations of known active and historically active strutting grounds (leks); and 3) discern population status and trends.

METHODS

A literature review was performed to gather information on greater sage grouse ranges, populations, and trends in North Dakota and South Dakota. Historic locations and counts of active and historic leks in North Dakota and South Dakota were found through records of lek surveys conducted by the NDGF and SDGFP. Additional verification on information was obtained from landowners and communication with state and federal natural resource personnel. Locations were plotted and overlaid on maps of

North Dakota and South Dakota within a geographic information system (GIS; i.e., ArcView 3.2a).

Greater sage grouse lek counts conducted by NDGF involved at least two counts from a vehicle or on foot on all known active leks and on historically active leks that still had adequate sagebrush cover adjacent to them. Systematic flights were flown in North Dakota to locate new greater sage grouse leks and/or identify abandoned leks that might have moved. Greater sage grouse lek counts conducted by SDGFP involve at least two counts from a vehicle, on foot, or from an airplane on all known active leks and historically active leks. Both the NDGF and the SDGFP use the maximum number of males surveyed as their count for each lek. Current active sage grouse leks were located and counted following the methods outlined in Chapter 1.

RESULTS

Yearly greater sage grouse surveys combined in North Dakota and South Dakota by county can be located in Appendices A and B; individual lek surveys can be located in Appendices C and D. Greater sage grouse harvest

information for North Dakota and South Dakota is presented in Appendices E and F.

Historical References

The historic range of the greater sage grouse in North Dakota is thought by McClanahan (1940) to have occurred throughout the western part of the state (Fig. 2). More recent depictions restrict the historical greater sage grouse range in North Dakota to the southwestern part of the state (Aldrich and Duvall 1955, Aldrich 1963, Schroder et al. 1999; NDGF, unpublished data, 2000; Fig. 2). Early accounts of the sage grouse range in North Dakota support these more recent depictions. "It is stated to be common on the plains of Western Kansas and Nebraska, as it doubtless is also in southwestern portions of Dakota" (Coues 1874:402), "none seen east of the Little Missouri" (Allen 1875:65), "not common at the village, Fort Berthold, McLean County, but reported more abundant farther west" (Hoffman 1882:403), Roosevelt shot them on the high plains about eight miles of his ranch (Roosevelt 1885), "in the Mississippi Valley district the Sage Cock is found only along the extreme western edge of Kansas, Nebraska, and

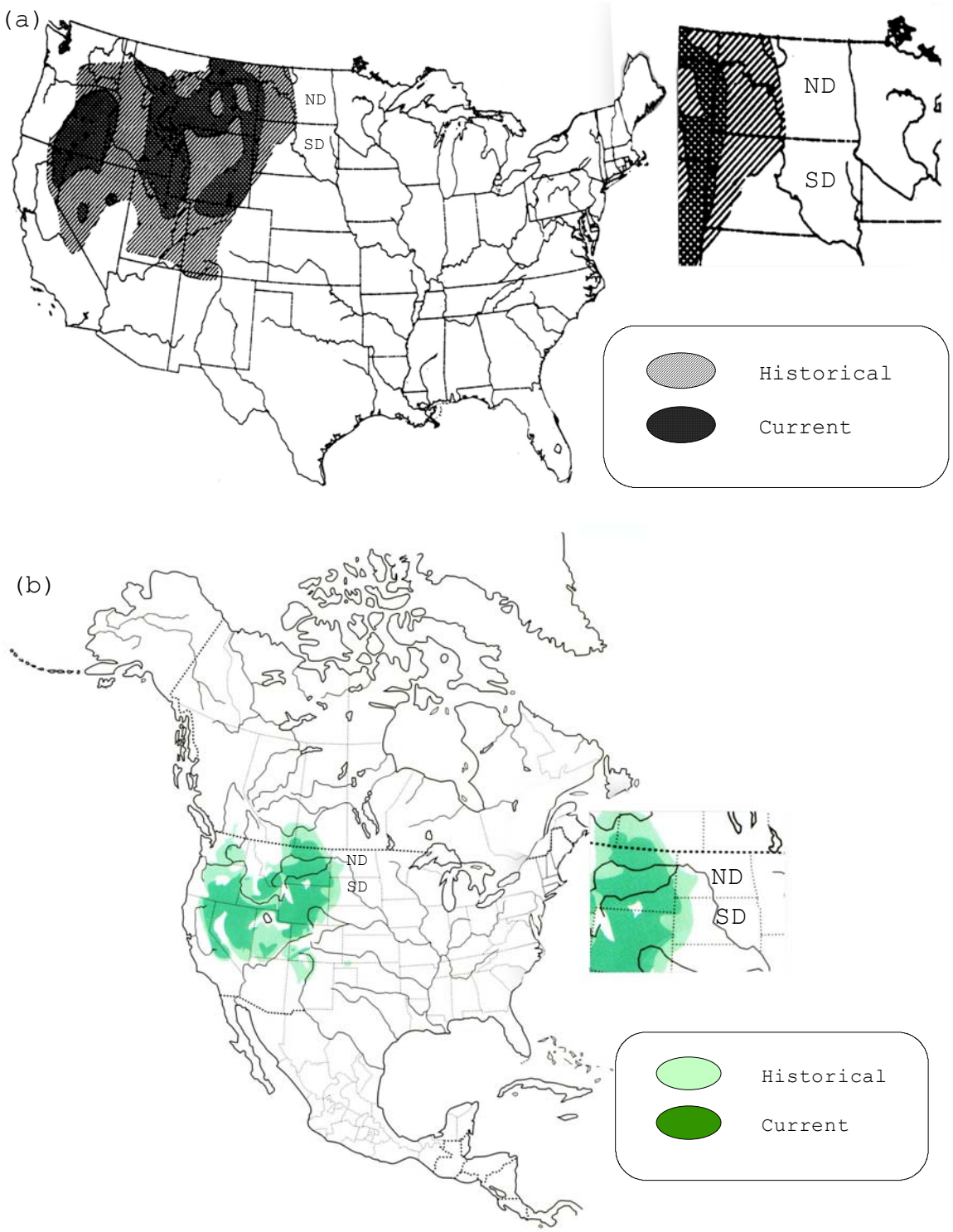
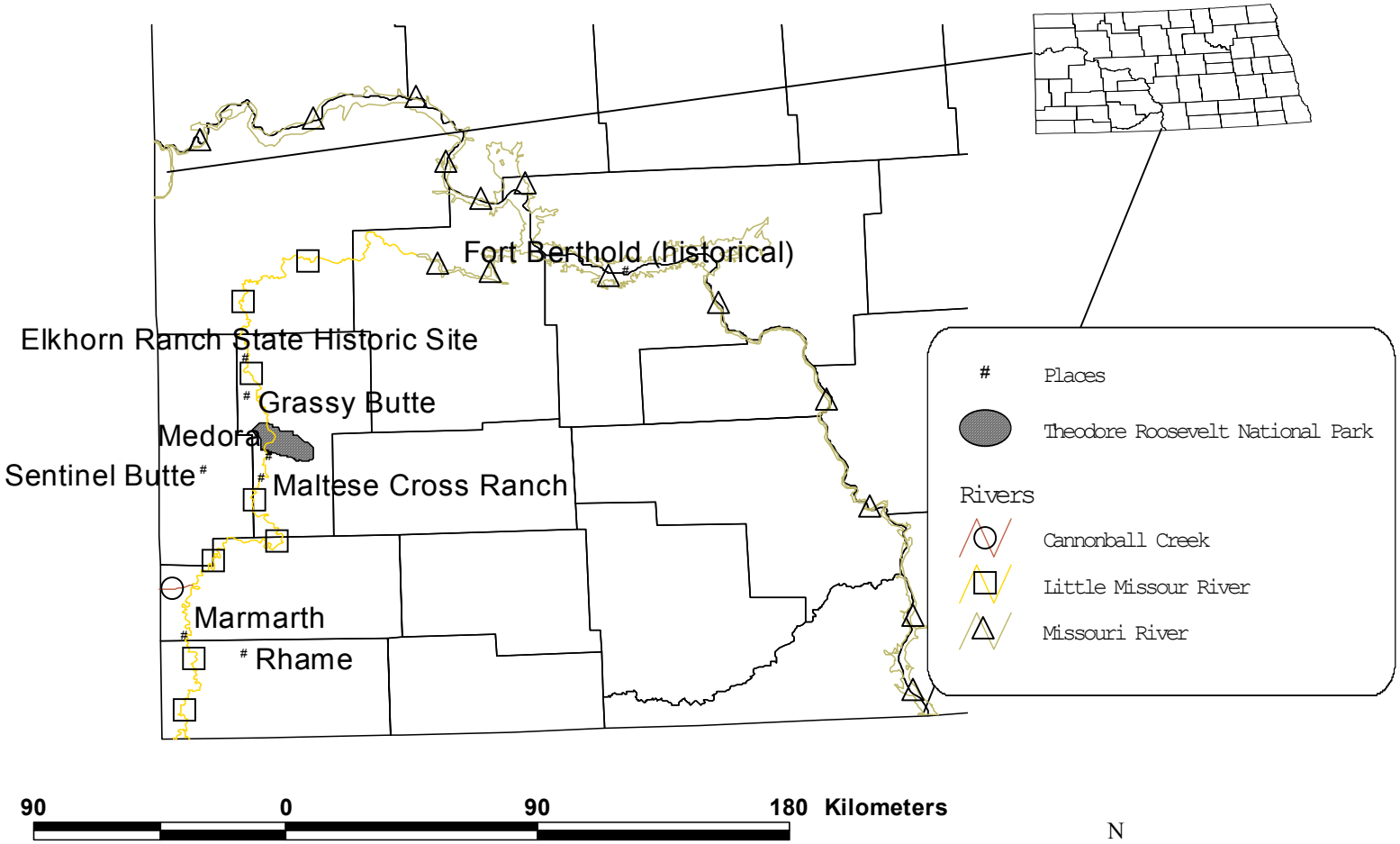


Figure 2. The historic range of greater sage grouse in North Dakota (ND) and South Dakota (SD) reproduced from McClanahan (1940; a) and Schroeder et al. (1999; b).

Dakota" (Cooke 1888:107), and Hon. Lewis Crawford in 1921 said that "the sage grouse is plentiful about 30 miles south of Sentinal Butte and at one place on the Cannonball River he has seen thousands of cocks on an old prairie dog town" (Wood 1923:36). Other early accounts of sage grouse in North Dakota state "there were lots of them in the Marmarth area in those early days" (Harv Robinson, Badlands resident in 1891), "Common in this Area and I hunted them after September 1st" (G. L. Wingstrand, resident of Rhame, ND in 1907), and "I have never seen over 20 to 30 sage hens around since I lived in this country. There are more of them south of here." (Charles Cornell, lived south of Medora on the old Collis Ranch in 1919; all quoted in Johnson and Knue 1989:59). By 1931 greater sage grouse were, as with earlier observations, prevalent in the southwestern portion of North Dakota with no noticeable decrease in numbers (Maurek 1931). During the early 1960s there were accounts of "one bird nine miles southwest of Grassy Butte in southern McKenzie County during the summer of 1962" by Wes Hardin of the U.S. Forest Service, "a small active strutting ground ten miles north of Sentinel Butte in Golden Valley County" by State Game Warden Ed Bry, and "a 'good-sized' flock at Pyramid Park" (i.e., Theodore

Roosevelt National Park) "in Billings County" seen by ranchers Willard Porter and 'Jiggs' O'Connell on several occasions (Johnson and Knue 1989:60; locations described are plotted in Fig. 3). Greater sage grouse in North Dakota are now documented in only Bowman, Slope, and Golden Valley counties in southwestern North Dakota. North Dakota reports show that greater sage grouse populations may have once numbered well over 5000 (NDGF, unpublished data, 2002).

Historic accounts of greater sage grouse in South Dakota range from the most liberal, occurring throughout the western part of the state (i.e., west of the Missouri River) excluding the area associated with the Black Hills (Over and Thoms 1921, Over and Thoms 1946) to the most conservative that depict the sage grouse range throughout the western third of the state (Aldrich and Duvall 1955, Aldrich 1963, Schroeder et al. 1999; Fig. 2). Another depiction of greater sage grouse's historic range in South Dakota falls in between these extremes (McClanahan 1940; Fig. 2). Early accounts of greater sage grouse in South Dakota describe a range resembling that of McClanahan (1940) and Schroeder et al. (1999), but a rapidly declining



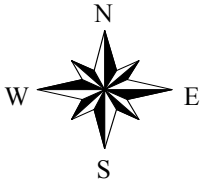


Figure 3. Locations of places in historical accounts of North Dakota. I displayed both (i.e., Elkhorn and Maltese Cross) Roosevelt Ranch locations.

one. A study completed by the United States Geological Survey (USGS) located between the 100th and 103rd meridians, bordered on the north by the North Dakota state line, and bordered on the South by the first standard parallel north of the Black Hills reported that "the sage hen is found in the west portion of the area" (Perisho 1908). Another USGS report on greater sage grouse in South Dakota states "formerly they were found in many sections of western South Dakota and westward. The last ones recorded from this state, except in the northwestern corner, were found in Sage Creek in the badlands in 1907" (Visher 1914). The USGS continues on to say "by 1910 all were gone except those in Harding and Butte Counties. Now (1913) after three more years of homesteading sage grouse are restricted in this state to the Little Missouri Valley in Harding County and the headwaters of Indian Creek in Butte" (Visher 1914). The USGS also makes the statement about sage grouse that "in a very few years they will occur in South Dakota only as a rare winter straggler from Montana" (Visher 1914; Locations of historic accounts are plotted in Fig. 4). A scary statement considering the time it was made.

In later years a report made by the South Dakota State Planning Board (1935) shows the greater sage grouse as

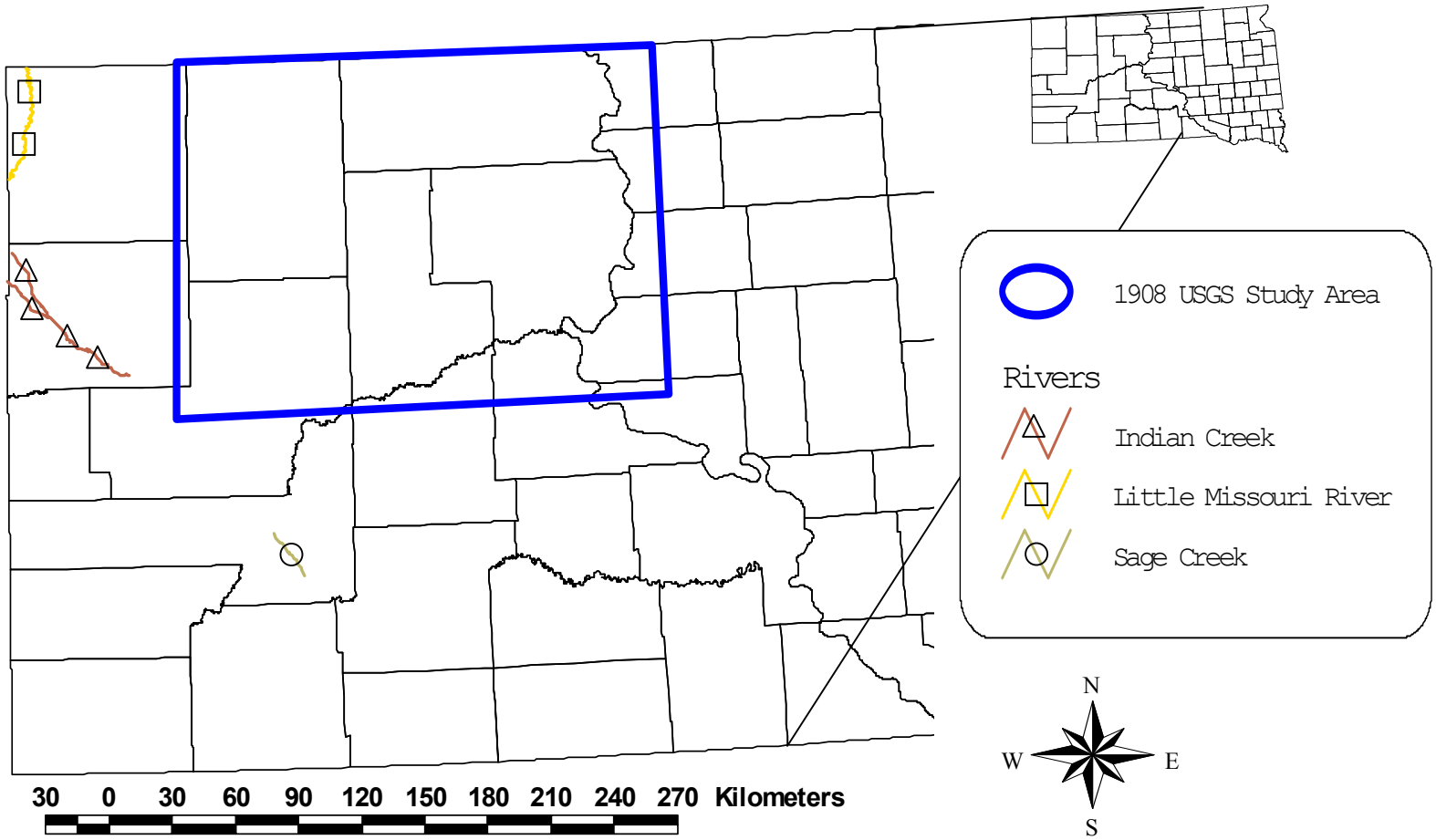


Figure 4. Locations of places in historic accounts of South Dakota.

occurring in Harding, Butte, Meade, Fall River, and even Stanley Counties. In 1952 the South Dakota sage grouse population was only documented in Harding, Butte, Perkins, and Fall River counties (Janson 1952, SDGFP 1953). SDGFP Annual Reports completed in the 1950s estimate that populations of sage grouse in South Dakota were once >10,000 (SDGFP 1952, SDGFP 1956; SDGFP, unpublished data, 2000) and provided an ample number of sage grouse for harvest (SDGFP 1952, SDGFP 1954, SDGFP 1955, SDGFP 1956). Local residents of Harding County also made reports of ample numbers of greater sage grouse; "wild game abounds in the area, including deer, antelope, sage grouse, and in certain areas pheasants and wild turkeys" (Buffalo Times-Herald 1959). However, population estimates in SDGFP (1952) and (1956) reports were gathered from an aerial census, which leads to some skepticism of the accuracy of such a large count. Presently the greater sage grouse in South Dakota has only been documented in Harding, Butte, and Fall River counties and populations are well below the 1950s' estimates.

Active and Historically Active Leks

An active sage grouse lek is a traditional communal display ground for breeding sage grouse that "has been attended by ≥2 male sage grouse in ≥2 of the previous 5 years" (Connelly et al. 2000a). Historically, there ranged between 11-22 known active leks over the past 50 years in North Dakota (Fig. 5). In South Dakota, the number of known active leks has ranged from 5-16 over approximately the last 30 years (Linde et al. 1975, Linde et al. 1976, Linde et al. 1977, Linde et al. 1978, Linde et al. 1979; SDGFP, unpublished data, 2002; Fig. 6). When compared with historic numbers of active leks, there has remained approximately the same number of known active leks located in North Dakota (Fig. 5) and South Dakota (Fig. 6). All known active and inactive lek locations of sage grouse in North Dakota (Fig. 7; UTM coordinates located in Appendix G) and South Dakota (Fig. 8; UTM coordinates located in Appendix G) show a predominance of abandonment in the eastern part of their range; this abandonment is most apparent in Bowman County, ND. Average distance between neighboring active leks was 14.43 km and the density of these was 2.25 active leks/100km^2 in North Dakota. Average distance between neighboring active leks was 24.69 km and

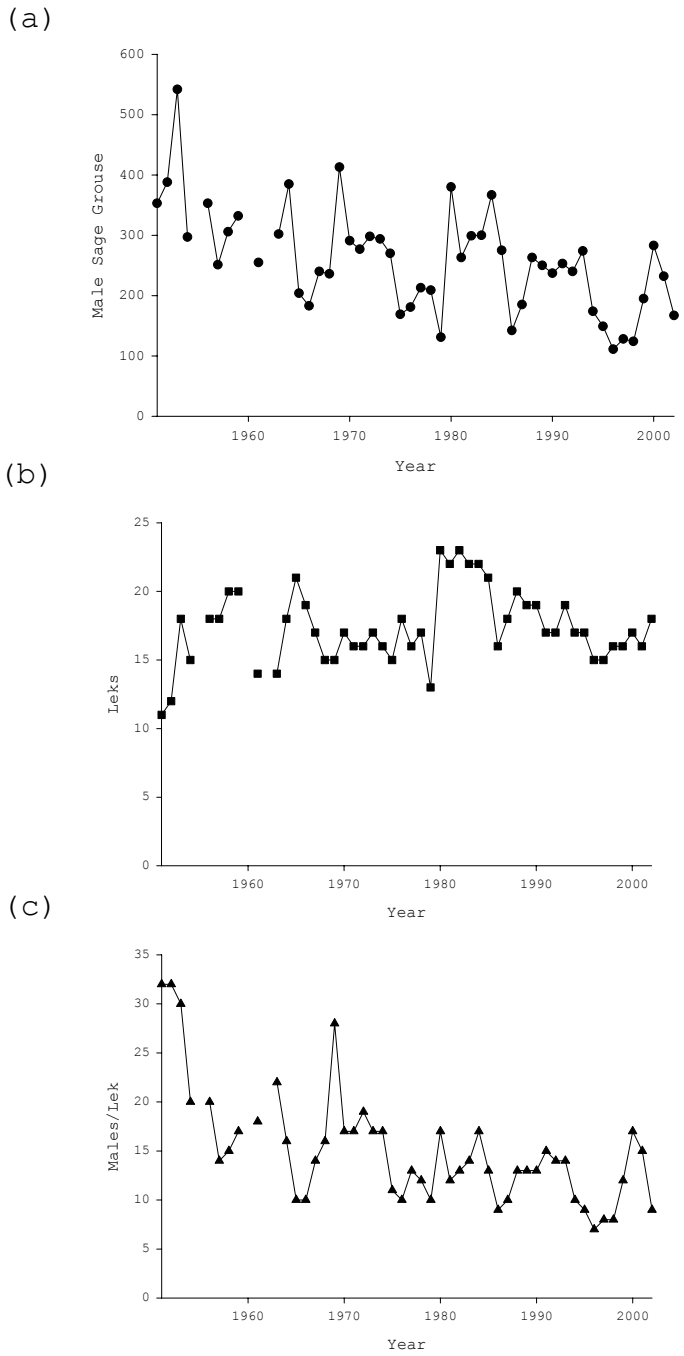


Figure 5. Male sage grouse totals for all leks combined (a), number of known active leks (b), and males/lek (c) in North Dakota over the past 50 years.

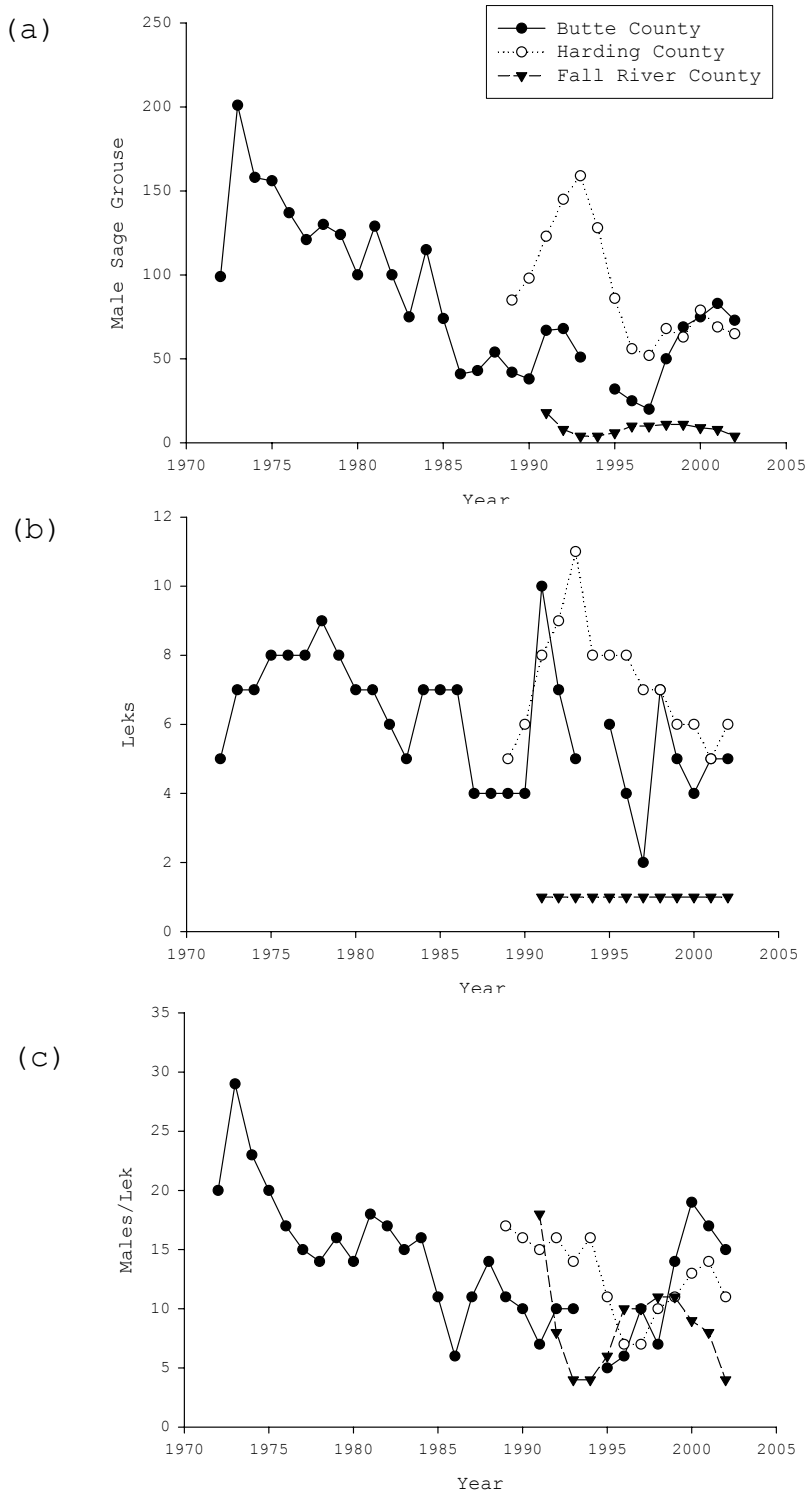


Figure 6. Male sage grouse totals for all leks combined (a), number of known active leks (b), and males/lek (c) for South Dakota counties during periods of consistent annual counts over the last 30 years.

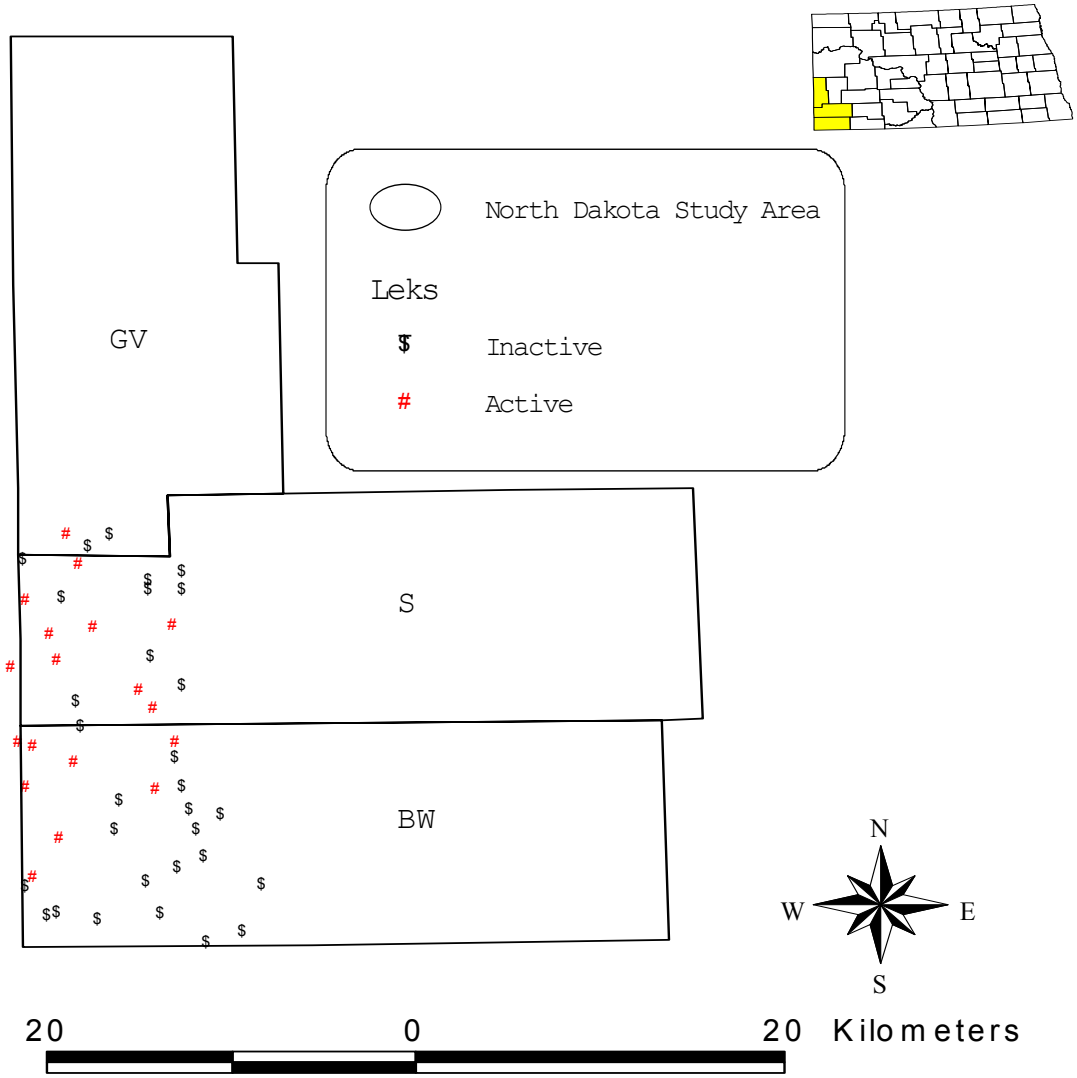


Figure 7. Active and inactive lek locations in North Dakota, 2002. [Golden Valley (GV), Slope (S), and Bowman (BW) Counties]

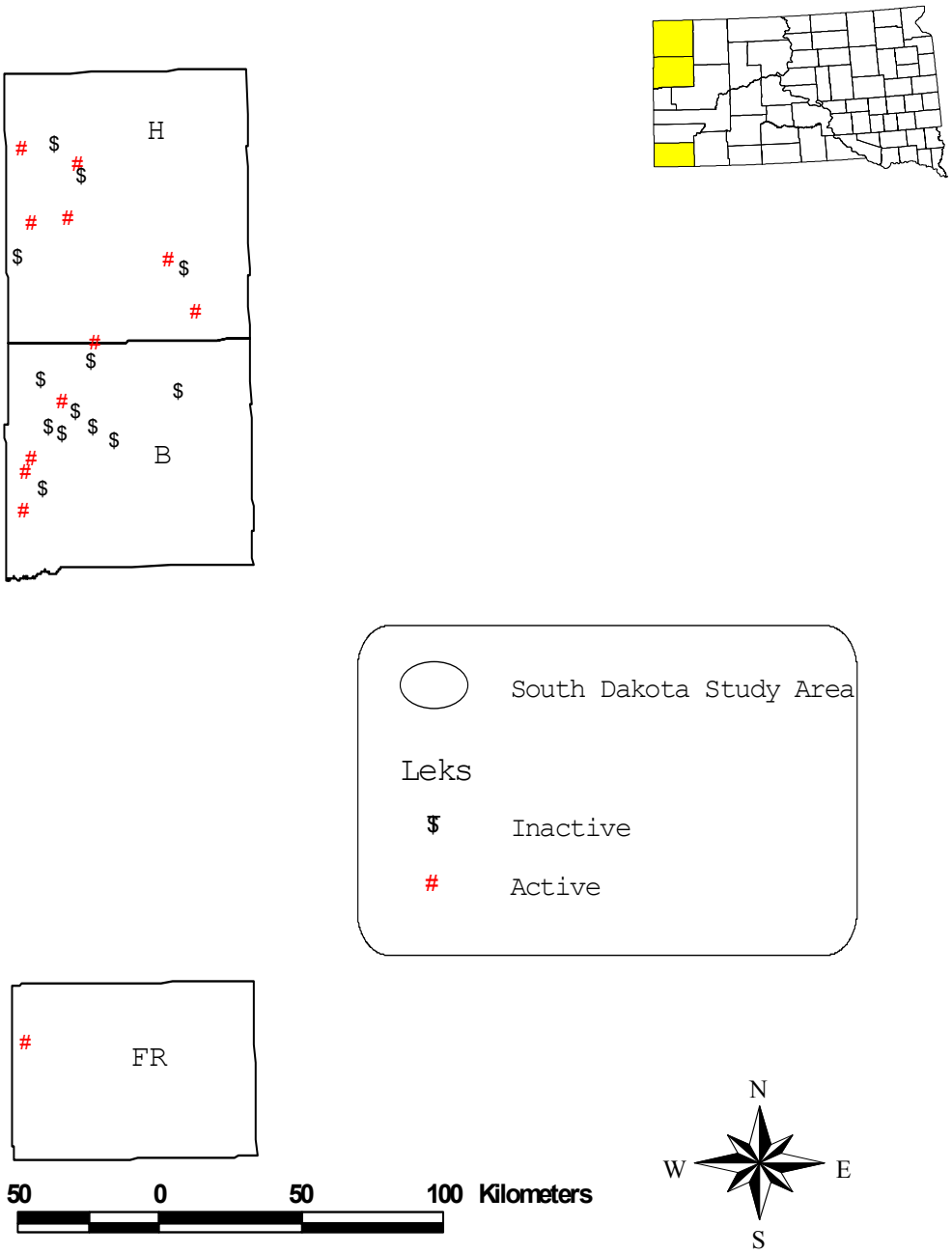


Figure 8. Active and inactive lek locations in South Dakota, 2002. [Harding (H), Butte (B), and Fall River (FR) Counties]

the density of these was 0.29 active leks/100km² in Harding and Butte Counties of South Dakota.

Long-term Lek Surveys

The survey data from the past 50 years in North Dakota show a steady decline in the number of male sage grouse (Fig. 5). The number of male sage grouse counted on North Dakota known leks ranged from 111-542, peaking in the early 1950s (NDGF, unpublished data, 2002; Fig. 5). Males per lek in North Dakota ranged from 7-32 and appeared to roughly follow a 10-year cycle suggested by Rich (1985) peaking in 1952, 1963, 1969, 1980, 1991, and 2000 (NDGF, Unpublished data, 2002; Fig. 5). However, these peaks are gradually getting lower as the years progress.

The survey data from the past 30 years in South Dakota does not show a steady decline in the numbers of male sage grouse. However, complete survey data collected before 1989 was only available for Butte County so population data for South Dakota is incomplete prior to this date and should only be used as a very rough index. Butte County, having the most consistent data, could be looked at as an indicator of greater sage grouse population status in South Dakota showing a slight decline in males (Fig. 6). Survey

information for Harding County and Fall River County has only been consistently collected since 1989 and 1991, respectively. Therefore, sage grouse lek trends in South Dakota are most reliable from 1991 to the present. Numbers of male sage grouse counted on South Dakota known leks ranged from 41-221, peaking in the early 1990s (Linde et al. 1975, Linde et al. 1976, Linde et al. 1977, Linde et al. 1978, Linde et al. 1979; SDGFP, unpublished data, 2002; Fig. 6). In South Dakota males per lek ranged from 6-29 and, using Butte County males per lek as an indicator for long-term trends, appeared to roughly follow the 10-year cycle (Rich 1985) with peaks at 1973, 1981, 1992, and 2000 (Fig. 6).

DISCUSSION

There appears to be variation in the total number of known active leks over the years in North Dakota, but no increase or decrease in these numbers over time. More leks were likely present in the past as a result of the broader range once occupied, but were not located with the extensive search methods used more recently. For example, prior to 1960 only five leks were located in Slope County and now this county is the center (# of leks) for greater

sage grouse in North Dakota. Extensive search efforts, such as the aerial searches conducted by the NDGF, have increased the number of known leks in North Dakota; from spring 1979-spring 1980 there was an increase of 10 known active greater sage grouse leks along with finding moved leks that were originally thought to be abandoned (NDGF, unpublished data, 2001). However, even with searching new areas and locating these new leks over the years a steady decline in the number of males is evident in North Dakota. I reviewed the original 11 greater sage grouse leks in the area continuously searched over the last 50 years in North Dakota, all but one are currently abandoned.

Using Butte County to represent South Dakota, long-term trends indicate a steady decline in the number of males from 1973 to 1997. However, the last three years have rivaled lek counts observed almost twenty years ago (Appendix B). Active lek numbers in Butte County have proven to be quite erratic over the past 30 years probably from inconsistent survey efforts. There are some areas in South Dakota where systematic aerial searches may help locate new leks where no leks are known to be currently present today. For instance, a lek that has been active in Fall River County for at least the last 10, and possibly

the last 30 years, is at least 38 km away from the closest known active lek in Wyoming (Gary Boyd, pers. comm., Wyoming Game and Fish) and has never had greater than 11 males observed on it in the last 10 years. Aerial searches would be of great assistance in this area to see how isolated this population actually is. However, South Dakota may not have the available man-hours or funding to put towards these extensive aerial searches that concentrate on locating new greater sage grouse leks. Regardless, leks should be visited each year noting their status (i.e., active or inactive), and with multiple counts made on the number of males in attendance (Autenrieth et al. 1982, Connelly et al. 2000a).

Counts of males on greater sage grouse leks can be traced back as far as the 1950s in North Dakota and the 1970s in South Dakota. Counts made before 1989 in South Dakota are not as reliable as North Dakota's, attributable to constant personnel changes, the use of airplane surveys, and the fact that leks in Harding and Fall River Counties were not counted consistently prior to 1989. Thus, there were likely more sage grouse present in South Dakota than recorded and state counts prior to 1989 should be viewed with caution.

It is important to census the leks at a consistent time in the spring that coincides with their peak lek attendance each year because of variations in male lek attendance (Autenrieth et al. 1982, Jenni and Hartzler 1978). Although, weather conditions may force counts to be made off of the peak season, these counts are still better than no counts. Timing of the counts, variations in male attendance, and weather condition during the count may skew the count low and provide an inadequate sage grouse population assessment (Jenni and Hartzler 1978, Beck and Braun 1980, Emmons and Braun 1984). As a result of these inconsistencies, sage grouse lek censuses should always be viewed conservatively when using them for population estimates (Connelly et al. 2000a). Lek counts are still the best method of estimating breeding populations of sage grouse and when kept consistent over the long-term are invaluable sources for population trend analysis (Connelly and Braun 1997).

Sage grouse associated with one or more occupied leks in the same geographic area and separated from other leks of the sort by >20 km represent a breeding population (Connelly et al. 2000a). Greater sage grouse associated with North Dakota and Harding and Butte Counties of South

Dakota occupy leks within 20 km of leks in Montana or Wyoming. Some leks in North Dakota are within 5 km of leks in Montana. It is likely that the populations in North Dakota and South Dakota are continuous with larger greater sage grouse populations that exist in eastern Montana and Wyoming. The other greater sage grouse breeding population in South Dakota would be associated with the single known active lek in Fall River County of South Dakota. This greater sage grouse lek in Fall River County may represent and isolated population, as the closest known neighboring lek in Wyoming is >30 km away. The extent of the movements and interchanges with Montana and Wyoming greater sage grouse breeding populations would need verification through radio telemetry studies.

A steady decline is evident when reviewing the entire recorded period of greater sage grouse surveys in North Dakota (1951-2002) and South Dakota (1972-2002). Are these current greater sage grouse populations greater or less than those of the early 1900s? With the bleak nature of the USGS reports (Perisho 1908, Visher 1914) in South Dakota, one could argue that current populations are similar to those of the early 1900s and that the 1950s data showed a rebound of the greater sage grouse to former

population highs. Greater sage grouse that occupied wider ranges described in the USGS reports (Perisho 1908, Visher 1914) apparently survived on land with marginal sagebrush cover. Settlement, with subsequent tillage and yearlong livestock grazing may have made marginal habitats less suitable for continued occupancy by greater sage grouse (Girard 1937, Yocom 1956). Overshooting may have also added to population declines and disappearances in marginal areas (Girard 1937, Patterson 1952).

With the apparent eastern edge abandonment of the active breeding range over the years, one could conjecture that land use patterns in these areas have changed and remnant habitats are now failing to meet greater sage grouse needs (Connelly and Braun 1997). With the assortment of lek sites used by greater sage grouse in the Dakotas one could assume that any enhancement of the nesting habitat in the currently occupied range could create enhanced opportunities for female sage grouse (Dalke et al. 1963). Increased nesting success may allow for lek sizes to increase and eventually the start of new leks.

The distribution of the greater sage grouse on the edge of its range will be determined by its adaptability to one or several factors important to its survival, depending

on the geographic dispersion of these factors' levels (Caughley et al. 1988). Is the adaptability interval on one factor nested geographically within the adaptability interval of another factor or do they overlap (Caughley et al. 1988)? Land-use practices more than other developments will establish the fate of the greater sage grouse (Yocom 1956) in the Dakotas and these are deeply tied in with the economics of the two states.

MANAGEMENT IMPLICATIONS

Consistency in lek surveys is a must in beginning to manage this species (Autenrieth et al. 1982, Connelly and Braun 1997). The lek count data and all identified lek locations need to be maintained in permanent records. New disturbance factors such as oil/natural gas rigs, fires, spraying, and power lines that occur near the lek area should be recorded for individual leks. Aerial searches, particularly in South Dakota, need to be added to greater sage grouse management plans. Aerial searches for new leks need to be conducted at a regular and consistent basis (Autenrieth et al. 1982) as in North Dakota (roughly every 10 years). If a lek has recently been abandoned, ground searches need to take place the very next year to determine

if lek movement has occurred. Radio telemetry studies should also be a priority for determining the movements, survival, and seasonal habitat needs of the greater sage grouse (Connelly et al. 2000a) in the Dakotas.

What to consider a new lek is a complex issue. More importantly than whether the newly located lek is classified as a new lek or a moved lek is the importance of keeping regular lek censusing routes each spring and noting the population trend on these routes. If the counts on a certain route are decreasing, it may be an indicator of harmful disturbance in that area.

During the spring lek counts, each lek site should be surveyed three times/year during the month of April (J.W. Connelly, pers. comm., IDGF). If possible the lek counts should be spread out over a three-week period (Autenrieth et al. 1982). It is understandable that due to lack of funding and person-hours available, a third visit to all leks may be difficult. Therefore, two visits may have to suffice unless the numbers of males counted on each of the two visits differed noticeably (e.g., greater than five males). In the latter case a third visit may be necessary. Counts should be made from sunrise to 8:00 AM on days with low to moderate wind (<10 km per hour) and no precipitation

(Rogers 1964, Ralph et al. 1993). Lek observations should be made from a vehicle or on foot with at least 7 x 35-mm binoculars or a 20x spotting scope from a raised, but concealed vantage point at least 100 m away (Rogers 1964, Tate et al. 1979, Gibson 1992). At each site one should scan the area at least three times during each visit, glassing back-and-forth with the binoculars or spotting scope, taking careful notice of everything in the field of view. All males on the lek and males in field of view should be counted (Rogers 1964). Of the three counts, the count with the maximum number of males should be used as the total final lek count for that year (Rogers 1964).

CHAPTER 3. SAGE GROUSE LEK ACTIVITY AND SIZE AS IT RELATES TO MICROHABITAT CHARACTERISTICS SURROUNDING THE LEK

INTRODUCTION

Declining populations of greater sage grouse during the 1900s have been attributed to the decrease of sagebrush due to agricultural conversion, overgrazing, fire, and/or drought (Patterson 1952, Rogers 1964, Homer et al. 1993, Gregg et al. 1994, Connelly and Braun 1997, Connelly et al. 2000a). Sheep have been shown to negatively affect sagebrush (Laycock 1967, Frischknecht and Harris 1973) and in South Dakota, domestic sheep grazing reduced sagebrush production by 40% in 2 years (Bever 1951). Sage grouse rely on sagebrush for food, shelter, and water (Swenson 1987, Fischer et al. 1996, Schroeder et al. 1999). In winter, sagebrush becomes the only source of food (Hupp and Braun 1989, Welch et al. 1991) with the entire diet consisting of sagebrush leaves and buds (Welch et al. 1991, Homer et al. 1993, Connelly et al. 2000a). Along with sagebrush habitat, good herbaceous cover has been shown to be important to sage grouse (Connelly et al. 1991, Gregg et al. 1994). Sagebrush and associated herbaceous plants are of critical importance to nesting and early brood rearing

(Connelly et al 2000a). In addition, since male sage grouse tend to create their displaying grounds in areas where females travel between wintering and nesting sites (Gibson 1996), it is important for good habitat to exist in proximity to the lek.

Big sagebrush communities in North Dakota are primarily restricted to the far southwestern corner; in South Dakota, big sagebrush communities occur primarily in the northwestern corner with a small region in the southwestern corner (Beetle 1960). The silver sagebrush range seems to follow major streams and tributaries located in the western half of North and South Dakota (Beetle 1960). Other than Beetle (1960) little information exists on the history or current distribution of sagebrush in the Dakotas. Nor is there any information on the quality of sagebrush canopy or herbaceous cover around leks that have been and are currently being used. The objectives of this study were to: 1) gather microhabitat information (e.g., big sagebrush height, percent sagebrush cover, herbaceous cover of grass and forbs, etc.) around currently active leks and historically active leks to see if differences arise that may be related to abandonment and 2) discern how the habitat around these leks compares to habitat

characteristics in other states shown to be preferred/usable for sage grouse nesting, brood rearing, and wintering habitat.

METHODS

Microhabitat was sampled from May 14 to June 27 during 2001 and 2002 around 27 sage grouse leks in North Dakota, 22 sage grouse leks in South Dakota, and five sage grouse leks in Montana. Microhabitat was then categorized and measured following the methods outlined in Chapter 1. All maps are displayed and UTMs given in the projection UTM Clarke 1866 NAD27 Zone 13.

Microhabitat characteristics related to lek activity

A multiple t-test with a SIDAK p-value adjustment (SAS Institute 1999) was performed to compare continuous habitat variables and a Chi-square analysis (Agresti 1996, SAS Institute 1999, Stokes 2000) was used for categorical variables. Comparisons were also made between moderately large leks (i.e., $\geq$40 males) in Montana and active leks in North Dakota and South Dakota. Variables compared were deemed to be important to sage grouse lek fidelity.

I used logistic regression procedures (Agresti 1996, SAS Institute 1999, Stokes 2000) to analyze the association of seven continuous microhabitat variables (i.e., sagebrush cover, sagebrush density, big sagebrush height, silver sagebrush height, grass height, and visual obstruction at 0.25-m and 0.50-m heights) and four categorical microhabitat variables (i.e., herbaceous forb cover, herbaceous grass cover, bare ground cover, and litter cover) with lek activity. A lek was classified as inactive if it did not have $\geq$2 male sage grouse displaying on it for $\geq$2 of the past 5 years (Connelly et al 2000a). I also considered four interaction terms (sagebrush cover x sagebrush density, sagebrush cover x big sagebrush height, sagebrush density x big sagebrush height, and sagebrush cover x forb cover) because I thought they might be important to activity. I tested: 1) North Dakota active sage grouse leks versus inactive sage grouse leks and 2) South Dakota active sage grouse leks versus inactive sage grouse leks.

A logistic regression procedure using the stepwise selection process with a significance level to enter set at P = 0.25 and a significance level to stay set at P = 0.1 (SAS Institute 1999) was used to help identify an

appropriate subset of entrant variables to use as predictors of lek activity. These variables were then entered into best subsets selection (SAS Institute 1999) to identify all models that were possibly the best (Budnik et al. 2002). All selected models were entered into the full logistic regression analysis for North Dakota and South Dakota to determine which variables had significant main effects when in the presence of other variables. I used Akaike's Information Criterion (AIC) to identify the best-fit model (Budnik et al. 2002) with inferences drawn from all models with <10 AIC units separating them because of nested characteristics (Burnham and Anderson 1998). I also followed Budnik et al. (2002) procedures and reported other goodness-of-fit measures for each model such as R^2, Hosmer and Lemeshow (1989) goodness-of-fit test, and likelihood test.

Microhabitat characteristics related to active lek size

Microhabitat characteristics were analyzed using a multiple regression procedure (Boyce 1980, Johnson 1998, SAS Institute 1999) with a significance level to enter set at P = 0.25 and a significance level to stay set at P = 0.1 to identify potential relationships between habitat

variables and lek size in North Dakota and South Dakota; these procedures were also used to analyze data from each state separately. Normality of the dependent lek size variable was confirmed using a Chi-square Probability Plot (Johnson 1998). A total of seven continuous microhabitat variables (i.e., sagebrush cover, sagebrush density, big sagebrush height, silver sagebrush height, grass height, and visual obstruction at 0.25-m and 0.50-m heights), four categorical microhabitat variables (i.e., herbaceous forb cover, herbaceous grass cover, bare ground cover, and litter cover), and four interaction terms (i.e., sagebrush cover x sagebrush density, sagebrush cover x big sagebrush height, sagebrush density x big sagebrush height, and sagebrush cover x forb cover) I thought might be important to active lek size were entered into the model. Mallows' C_p statistic (C_p) was used to select the "best" models for the dependent variable lek size (Draper and Smith 1981). Models with a minimum value of C_p, and the ratio of C_p/number of independent variables (p) close to one, were selected as "best" (Draper and Smith 1981). This method generally designates as "best" the most parsimonious model with the highest R^2 (Draper and Smith 1981). Along with

Mallows' C_p statistic, I reported C_p/p, AIC, and R^2 for each model.

RESULTS

Vegetation characteristics measured at each sample site around sampled leks can be located in Appendix H. A list of dominant plants located around each sampled lek and a list of associated scientific names can be found in Appendices I and J.

Microhabitat characteristics related to lek activity

Microhabitat comparisons in relation to lek activity in North Dakota were performed using 161 sample sites around 15 active and 138 sample sites around 12 inactive sage grouse leks. Microhabitat comparisons in relation to lek activity in South Dakota were performed using 141 sample sites around 12 active and 120 sample sites around 10 inactive sage grouse leks. I calculated descriptive statistics for variables considered in the lek activity analyses (Table 1). From the multiple t-test I found the continuous variable big sagebrush height was greater ($P < 0.10$) around active leks than around inactive leks in North

Table 1. Habitat variables [$\bar{x}$ ± SE for continuous variables and % of sample sites in each Daubenmire (1959) cover class for categorical variables] used for comparison between the area around active and inactive greater sage grouse leks [Active - North Dakota: leks = 15, sample sites (n) = 180; South Dakota: leks = 12, sample sites (n) = 144] [Inactive - North Dakota: leks = 12, sample sites (n) = 144; South Dakota: leks = 10, sample sites (n) = 120].

	North Dakota		South Dakota	
Variable[a]	Active[b]	Inactive	Active	Inactive
Sagebrush cover (%)	2.99 ± 0.26	2.24 ± 0.24	3.02 ± 0.28	3.53 ± 0.36
Sagebrush density (/m²)	0.41 ± 0.03	0.35 ± 0.03	0.62 ± 0.06	0.66 ± 0.07
Big sagebrush height (cm)	20.95 ± 1.16	15.50 ± 1.29	21.26 ± 0.90	18.10 ± 1.21
Silver sagebrush height (cm)	23.00 ± 1.41	22.26 ± 1.58	8.60 ± 1.29	10.83 ± 1.59
Grass height (cm)	10.21 ± 0.38	10.70 ± 0.57	12.22 ± 0.33	12.47 ± 0.34
Visual obstruction 0.25 m (%)	8.93 ± 1.02	12.12 ± 1.62	8.94 ± 1.12	8.46 ± 1.21
Visual obstruction 0.50 m (%)	1.72 ± 0.34	2.23 ± 0.52	0.42 ± 0.15	0.63 ± 0.28
Forb cover (%)				
1	43.33	64.58	45.14	45.00
2	56.11	34.03	54.17	55.00
3	0.56	1.39	0.69	-
Grass cover (%)				
1	11.67	17.36	2.78	3.33
2	12.22	8.33	11.81	2.50
3	40.00	33.33	42.36	42.50
4	32.22	27.78	36.81	40.00
5	3.89	11.81	5.56	10.83
6	-	1.39	0.69	0.83
Bare ground cover (%)				
1	26.11	47.92	27.78	28.33
2	40.56	29.17	40.28	41.67
3	18.89	14.58	16.67	20.83
4	11.11	5.56	14.58	9.17
5	3.33	1.39	0.69	-
6	-	1.39	-	-

Table 1. Continued.

Variable	North Dakota		South Dakota	
	Active	Inactive	Active	Inactive
Litter cover (%)				
1	16.67	25.69	2.08	6.67
2	44.44	31.94	40.28	39.17
3	22.22	27.08	40.28	44.17
4	15.00	14.58	17.36	10.00
5	1.67	0.69	-	-

[a] Daubenmire cover classes were 1 (0-5%), 2 (6-25%), 3 (26-50%), 4 (51-75%), 5 (76-95%), 6 (96-100%). Average cover reading for 40 Daubenmire frames were used to categorize cover classes for each sample site.

[b] A dash (-) indicates that Daubenmire cover class was not present at sample sites around active or inactive leks.

Dakota (Table 2). Of the categorical variables compared in North Dakota, forb cover was higher (X^2 = 15.87, 2 df, P = 0.0004) around active leks, grass cover had a general association (X^2 = 13.73, 5 df, P = 0.0174) with fewer observations around active leks at the extreme cover classes (i.e., cover classes 1 and 6), and bare ground was greater (X^2 = 21.00, 5 df, P = 0.0008) around active leks.

South Dakota comparisons showed that none of the continuous variables were different (P > 0.10) between areas around active leks and inactive leks (Table 2). Of the categorical variables, grass cover was lower (X^2 = 10.03, 5 df, P = 0.0743) around active leks in South Dakota.

The logistic regression analysis on activity in North Dakota identified two candidate models where AIC differed by <7 units and four models that differed by <10 units (Table 3). A total of two variables were in three of the models and three variables were in one to two of the models. The logistic regression analysis on activity in South Dakota identified four candidate models where the AIC differed by <2 units (Table 4). Only one variable was in all four models, one variable was in three models, and two

Table 2. Microhabitat comparisons of sample sites within 1.5 km of active versus inactive greater sage grouse leks. [North Dakota - active: leks = 15, sample sites (n) = 180; inactive: leks = 12, sample sites (n) = 144] [South Dakota - active: leks = 12, sample sites (n) = 144; inactive: leks = 10, sample sites (n) = 120].

	North Dakota				South Dakota			
Variables	Active	Inactive	Raw-P[a]	Sidak[b]	Active	Inactive	Raw-P	Sidak
Sagebrush cover (%)	2.99	2.24	0.0398	0.2474	3.02	3.53	0.2574	0.8755
Sagebrush density (%)	0.41	0.35	0.1873	0.7659	0.62	0.66	0.6392	0.9992
Big sagebrush ht. (cm)	20.95	15.50	0.0019	0.0130	21.26	18.10	0.0248	0.1614
Silver sagebrush ht. (cm)	23.00	22.26	0.7247	0.9999	8.60	10.82	0.2734	0.8931
Grass ht. (cm)	10.21	10.70	0.4611	0.9868	12.22	12.47	0.5904	0.9981
Visual obstruction 0.25 m (%)	8.93	12.11	0.0856	0.4653	8.94	8.46	0.7704	1.0000
Visual obstruction 0.50 m (%)	1.72	2.23	0.3973	0.9711	0.42	0.63	0.4962	0.9918

[a] P-value not adjusted for number of comparisons.
[b] Sidak P-value adjustment for all main effect means that takes into account the raw P-value and number of comparisons.

Table 3. The best logistic regression models explaining the effects of habitat variables on greater sage grouse lek activity in North Dakota [active: leks = 15, sample sites (n) = 180; inactive: leks = 12, sample sites (n) = 140].

	Model[a]	AIC	-2logL	Beta=0[b]	R^2	Lackfit[c]
1	0.6391 - 0.0141 voq + 0.4043 hcb*	314.784	302.784	0.0152	0.0430	0.8565
2	0.0767 + 0.0152 bsh + 0.7730 hcf* - 0.2206 hcg + 0.3358 hcb	321.181	297.181	0.0022	0.0870	0.1227
3	0.2400 + 0.0087 bsh + 0.6923 hcf* + 0.3754 hcb*	322.231	306.231	0.0024	0.0670	0.4156
4	-0.0576 + 0.0275 bsh* - 0.0195 voq*	322.786	316.786	0.0036	0.0345	0.3723

[a] bsh = big sagebrush height, voq = visual obstruction at 0.25 m, hcf = herbaceous forb cover, hcg = herbaceous grass cover, hcb = bare ground.

[b] P-value of Likelihood Ratio X^2 test that a least one variable helps predict inactivity.

[c] P-value for Hosmer and Lemeshow (1989) goodness-of-fit test; we used 0.10 as our cutoff for lack-of-fit.

* $P \leq 0.10$ for X^2 test of model parameter.

Table 4. The best logistic regression models explaining the effects of habitat variables on greater sage grouse lek activity in South Dakota [active: leks = 12, sample sites (n) = 144; inactive: leks = 10, sample sites (n) = 120].

	Model[a]	AIC	-2logL	Beta=0[b]	R^2	Lackfit[c]
1	-0.2824 - 8.7481 tsbc* + 0.0375 bsh*	262.16	256.16	0.0225	0.0285	0.1139
2	-0.2782 - 9.0944 tsbc* + 0.0367 bsh* + 0.0024 voq	262.91	254.91	0.0554	0.0285	0.3252
3	-0.5907* + 9.5626 tsbc + 0.0545 bsh* - 0.7579 tsbc x bsh*	263.88	255.88	0.0080	0.0441	0.7588
4	-0.4509 + 0.0501 bsh* - 0.4403 tsbc x bsh*	264.07	258.07	0.0041	0.0410	0.2139

[a] tsbc = sagebrush cover, bsh = big sagebrush height, voq = visual obstruction 0.25 m.

[b] P-value of Likelihood Ratio X^2 test that a least one variable helps predict inactivity.

[c] P-value for Hosmer and Lemeshow (1989) goodness-of-fit test; we used 0.10 as our cutoff for lack-of-fit.

* $P \leq 0.10$ for X^2 test of model parameter.

variables were in one to two models. The lek activity models for North Dakota and South Dakota leave a lot of variation yet to be explained with such low R^2 values and should be viewed with caution.

Microhabitat characteristics related to active lek size

Microhabitat analysis of active lek size was performed using 324 sample sites around 27 active leks of 17 different sizes. The multiple regression analysis on active lek size in North Dakota and South Dakota identified 46 models that Mallows' C_p statistic differed by less than three units. For simplicity I selected the best four models with the lowest C_p/p ratio (Table 5). These four models also had AIC values that were <3 units apart. All variables in each model were significant at $P \leq 0.10$. A total of three variables were in all four models, four variables were in two to three of the models, and two variables were in one of the models. Multiple regression results for North Dakota and South Dakota separately can be found in Appendices K and L. The multiple regression models for North Dakota and South Dakota leave a lot of variation unexplained with such low R^2 values and should be viewed with caution.

Table 5. The best multiple regression models explaining the effects of habitat variables on greater sage grouse active lek size in North Dakota and South Dakota combined [leks = 27, sample sites (n) = 324].

	Model[a]	C_p[b]	C_p/p[c]	AIC	R^2
1	7.1531* + 2.0760 tsbd* - 0.1010 voq* - 0.0513 slsh* + 1.0545 hcg* + 1.4646 hcb*	5.0022	1.0004	1391.8228	0.1014
2	7.1039* + 2.5634 tsbd* - 0.0850 voq* - 0.2903 gh* + 1.7429 hcg* + 1.5083 hcb* - 0.3459 tsbc x bsh*	5.9891	0.9982	1392.7857	0.1043
3	7.4242* + 2.3797 tsbd* - 0.0539 slsh* - 0.3400 gh* + 1.9472 hcg* + 1.4955 hcb* - 0.5480 tsbc x bsh*	5.9187	0.9865	1392.7135	0.1045
4	9.9591* + 2.4632 tsbd* - 0.1301 voq* + 0.0351 bsh* + 0.9089 hcg* - 1.2089 hcl* + 1.1109 hcb*	5.9154	0.9859	1392.7101	0.1045

[a] tsbd = sagebrush density, voq = visual obstruction 0.25 m, slsh = silver sagebrush height, gh = grass height, hcg = grass cover, hcb = bare ground cover, hcl = litter cover, tsbc = sagebrush cover.
[b] Mallows' C_p statistic.
[c] p = number of independent variable parameters.
* $P \leq 0.10$ for X^2 test of model parameter.

Montana leks compared to leks in the Dakotas

Using the multiple t-test I found the continuous variables sagebrush cover, sagebrush density, and visual obstruction at 0.25 m height to be greater ($P < 0.10$) around Montana active leks than around North Dakota active leks (Table 6). Silver sagebrush height was found to be less ($P < 0.01$) around Montana active leks than around North Dakota active leks (Table 6). Categorical variables compared between Montana and North Dakota, showed that forb cover was greater ($X^2 = 11.38$, 2 df, $P = 0.0034$), grass cover was greater ($X^2 = 38.81$, 4 df, $P = <0.0001$), bare ground was less ($X^2 = 73.17$, 4 df, $P = <0.0001$), and litter cover was greater ($X^2 = 46.98$, 4 df, $P = <0.0001$) around active leks in North Dakota.

I found continuous variables sagebrush cover, sagebrush density, visual obstruction at 0.25 m, and visual obstruction at 0.50 m were greater ($P < 0.10$) and big sagebrush height was taller ($P <0.10$) around active leks in Montana than active leks in South Dakota (Table 7). Grass height was found to be less ($P < 0.10$) around Montana active leks than around South Dakota active leks (Table 7). Categorical variables compared between Montana and South

Table 6. Microhabitat comparisons of sample sites within 1.5 km of active greater sage grouse leks with >40 males in eastern Montana and active greater sage grouse leks in North Dakota. [Montana - leks = 5, sample sites (n) = 60; North Dakota - leks = 15, sample sites (n) = 180]

Variables	Montana		North Dakota		Raw-P[a]	Sidak[b]
	$\overline{x}$	SE	$\overline{x}$	SE		
Sagebrush cover (%)	9.25	1.10	2.99	0.26	<0.0001	<0.0001
Sagebrush density (%)	1.03	0.11	0.41	0.03	<0.0001	<0.0001
Big sagebrush ht. (cm)	25.93	1.17	20.95	1.16	0.0201	0.1324
Silver sagebrush ht. (cm)	7.13	1.82	23.00	1.41	<0.0001	<0.0001
Grass ht. (cm)	9.04	0.36	10.21	0.38	0.0934	0.4968
Visual obstruction 0.25 m (%)	24.04	3.14	8.93	1.02	<0.0001	<0.0001
Visual obstruction 0.50 m (%)	1.75	0.72	1.72	0.34	0.9693	1.0000

[a] P-value not adjusted for number of comparisons.

[b] Sidak P-value adjustment for all main effect means that takes into account the raw P-value and number of comparisons.

Table 7. Microhabitat comparisons of sample sites within 1.5 km of active greater sage grouse leks with >40 males in eastern Montana and active greater sage grouse leks in South Dakota. [Montana - leks = 5, sample sites (n) = 60; South Dakota - leks = 12, sample sites (n) = 144]

Variables	Montana		South Dakota		Raw-P[a]	Sidak[b]
	$\bar{x}$	SE	$\bar{x}$	SE		
Sagebrush cover (%)	9.25	1.10	3.02	0.28	<0.0001	<0.0001
Sagebrush density (%)	1.03	0.11	0.62	0.06	0.0009	0.0060
Big sagebrush ht. (cm)	25.93	1.17	21.26	0.90	0.0037	0.0259
Silver sagebrush ht. (cm)	7.13	1.82	8.60	1.29	0.5263	0.9946
Grass ht. (cm)	9.04	0.36	12.22	0.33	<0.0001	<0.0001
Visual obstruction 0.25 m (%)	24.04	3.14	8.94	1.12	<0.0001	<0.0001
Visual obstruction 0.50 m (%)	1.75	0.72	0.42	0.15	0.0111	0.0753

[a] P-value not adjusted for number of comparisons.
[b] Sidak P-value adjustment for all main effect means that takes into account the raw P-value and number of comparisons.

Dakota, showed that forb cover was greater (X^2 = 9.311, 2 df, P = 0.0095), grass cover was greater (X^2 = 34.73, 5 df, P = <0.0001), bare ground was less (X^2 = 80.69, 4 df, P = <0.0001), and litter cover was greater (X^2 = 99.55, 3 df, P = <0.0001) around active leks in South Dakota.

DISCUSSION

Leks are key activity areas within wintering-nesting complexes and sagebrush reduction adjacent to the lek has been known to result in a decrease of strutting males or abandonment (Enyeart 1956, Peterson 1970, Wallestad and Schladweiler 1974). Previous studies have shown lek habitat is not limiting (Schroeder et al. 1999). Therefore, reasons for abandonment of leks by male sage grouse may be related to female migration from these areas to areas with more desirable nesting habitat, or due to an increase in anthropogenic disturbance in the proximate area of the lek site (Tate et al 1979, Call and Maser 1985, Braun 1998). It is important for good nesting habitat to exist around the lek in order to attract females. Male sage grouse fidelity to leks is related to the previous years' territory establishment and reproductive success (Dunn and Braun 1985, Gibson 1992). It has been suggested

that sage grouse abandon leks if an adequate food supply is not within at least 1.6 km of the lek (Call and Maser 1985). In our study, sagebrush cover did not differ around active and inactive leks within our 1.5-km buffers. Big sagebrush was taller around active leks than inactive leks in North Dakota, which may suggest that the areas around active leks provided preferred nesting sites (Wallestad and Pyrah 1974, Aldridge and Brigham 2002), hence attracting females to these areas. The retention or attraction of females would help keep males in the area and leks active (Gibson 1992). The positive effect of big sagebrush height on lek activity in the logistic models of North Dakota and South Dakota support the importance of taller big sagebrush. Sage grouse nests are usually underneath sagebrush (Patterson 1952, Gill 1966, Connelly et al. 1991, Musil et al. 1994, Sveum et al. 1998b). Nest success was found to be higher (53%) for sage grouse that nested under sagebrush than those that nested under other species of shrubs (22%) by Connelly et al. (1991). Conversely, Sveum et al. (1998b) found no difference between nest success under sagebrush versus nest success under other species of shrubs, indicating that if adequate cover is present the species comprising the cover may be of minor importance as

suggested by Aldridge and Brigham (2002). None of the continuous variables measured and compared in South Dakota appear to be playing a role in lek activity, advocating that other factors not measured may be causing abandonment. The comparisons of forb, grass, bare ground, and litter cover in North Dakota (p. 59) revealed that forb cover was greater around active leks and thus may have provided greater food availability for females and their young in these areas. Reproductive efforts by females are helped by the presence of forbs because these forbs provide nutrients to the females and help to attract insects that are heavily eaten by chicks (Barnett and Crawford 1994, Drut et al. 1994b, Crawford 1997, Sveum et al. 1998b). The positive effect of herbaceous forb cover on lek activity in the logistic models supports this need for forb cover around the leks. Bare ground in North Dakota was greater around active leks and may suggest greater shrub cover in these areas since shrubs have the tendency to shade out grasses or compete for water (Peterson 1995). The logistic models suggest a positive interaction between bare ground and lek activity. Sage grouse nesting sites in Washington have also been found to be associated with high percentages of bare ground cover (Sveum et al. 1998b). The grass cover

association found between active and inactive leks in North Dakota and South Dakota (p. 59) may suggest that if grass cover is too low there is an absence of horizontal cover, and if grass cover is too great there may be a lack of shrub cover discouraging nesting females (Wallestad and Pyrah 1974). A study in Idaho showed that grass cover at sage grouse nest sites was similar at sagebrush nest sites (7%) and non-sagebrush nest sites (9%); however, grass height was less at sagebrush sites (19 cm) than at non-sagebrush sites (23 cm) (Connelly et al. 1991).

Sagebrush cover (>28%) and height (>40 cm) in proximity to the lek are important to male sage grouse lek fidelity in the Great Basin (Ellis et al. 1989). Successful sage grouse nest areas located within big sagebrush/bunchgrass in south central Washington during 1992-1993 had sagebrush cover ranging from 19-23%, sagebrush height ranging from 23-27 cm, and bare ground ranging from 35-44% (Sveum et al. 1998b). Other studies across the country have shown that sagebrush and grass habitat characteristics around sage grouse nest sites have mean sagebrush heights ranging from 29-80cm, mean sagebrush canopy coverages ranging from 15-38%, mean grass heights

ranging from 14-30 cm, and mean grass coverages ranging from approximately 3-51% (Connelly et al. 2000a).

Comparisons of the Dakotas with Montana showed that sagebrush cover, sagebrush density, and visual obstruction at 0.25 m were greater in Montana and may be important in having large, active leks. Silver sagebrush height in North Dakota was greater and may indicate that sagebrush height is not an issue in this state. South Dakota, however, had shorter big sagebrush and taller grass height than Montana, adequate sage grouse nesting sites in South Dakota may rely upon taller grass for nesting cover to compensate for less and shorter sagebrush (Aldridge and Brigham 2002). The greater forb and grass cover in the Dakotas is not a surprise because it is the eastern edge of the sagebrush range and offers more mesic habitat compared to Montana. Herbaceous cover characteristics in the Dakotas may not be a limiting factor. Herbaceous cover characteristics located within the 1.5-km buffer around active leks appear to be adequate for female sage grouse nesting sites (Connelly et al. 2000a) and daily use areas (Musil et al. 1994); mean forb coverage fell into the range of 5-25% in North Dakota and South Dakota and mean grass coverage ranged from 26-50% in North Dakota and South

Dakota. More likely it is sagebrush characteristics that require the attention of managers. Mean sagebrush canopy coverage around active lek sites was 2.99% in North Dakota and 3.02% in South Dakota; mean sagebrush density was 0.41/m² in North Dakota and 0.62/m² in South Dakota; mean big sagebrush height was 20.95 cm in North Dakota and 21.26 cm in South Dakota; and mean silver sagebrush height was 23.00 cm in North Dakota and 8.60 cm in South Dakota. All of these sagebrush habitat characteristics are lower than those observed at successful nesting sites (Connelly et al. 2000a) and daily use areas (Musil et al. 1994), which could mean one of two things. Either sage grouse hens are traveling farther to get to the quality nesting habitats that are outside of 1.5 km of the lek site or there are patches of quality nesting habitat located within areas of the sparse sagebrush coverage measured. More than likely, female sage grouse are finding nesting sites at greater distances from the active leks than 1.5 km, since average movements from breeding to nesting sites range from 1.1–6.2 km (Connelly et al. 2000a).

Factors accounting for a difference in active lek sizes may include yearly fluctuations in numbers of displaying males at lek sites, differences among

population's mean size, and distribution among sites used in a given year (Bradbury et al. 1989). Active lek size comparisons in North Dakota and South Dakota from the multiple regression model show that high sagebrush density, grass cover, and bare ground (which may indicate more shrub cover) are important to having more males on a lek. However, there remains a lot of variation left unexplained in these models given such low R^2 values. The greater density of sagebrush and grass cover may provide better loafing cover for non-strutting males (Ellis et al. 1989) and better nesting cover for females (Connelly et al. 2000a), thus better attracting more males. The negative effects of visual obstruction at 0.25 m and grass height on lek size may have resulted because species of shrubs other than sagebrush were prevalent in these areas causing fewer females to select for these areas and as a result fewer males.

Sagebrush characteristics within the 1.5-km radius around active leks do not appear to be preferred habitat for sage grouse nesting sites when compared to other studies (Sveum et al. 1998b, Connelly et al. 2000a). However, preferred habitat may exist outside of this buffered area or the sage grouse in the Dakotas have

adapted to living in marginal sagebrush habitats using less than preferred cover as nesting sites. The adequate forb and grass cover in the Dakotas may provide the means for greater reproductive success (Crawford 1997) and the ability for sage grouse populations to exist in these marginal habitats.

MANAGEMENT IMPLICATIONS

Healthy sagebrush and herbaceous cover for greater sage grouse breeding, nesting, and early brood rearing has been proven important for their success (Dunn and Braun 1986, Connelly et al. 2000a). According to the data it does not appear that herbaceous cover characteristics are lacking in the Dakotas, but sagebrush characteristics may be the point of stress on the greater sage grouse populations. As mentioned previously, sagebrush destruction around leks may not be directly related to male sage grouse attendance, but it may be indirectly related to them due to female abandonment of the area. How large of region around the leks should managers be concerned with to prevent lek abandonment in the Dakotas? This is a question that is hard to answer due to the large movements that sage grouse have been known to make daily, monthly, and yearly

(Connelly et al. 1988). It is suggested by Connelly et al. (2000a) that the area necessary to maintain around all active leks will vary from 3.2 km to >18 km depending on the migratory status of the population and distribution of the habitat. The area to be maintained should be no less than a radius of 2.4 km from the lek (Wallestad and Schladweiler 1974). In the Dakotas sagebrush habitat is not distributed uniformly in relation to the leks, because of the patchy distribution of the sagebrush, so this suggests managing areas ≤5 km from all active leks (Connelly et al. 2000a). However, it is not known whether this population is migratory, so steps need to be taken to preserve/manage as much area as deemed possible until a radio telemetry study can be done on the Dakota sage grouse population movements. Conservation efforts of managers should key in around small/decreasing leks first because they are more likely to become abandoned due to a smaller number of birds passing through their breeding cycle (Enyeart 1956).

CHAPTER 4. USING SATELLITE IMAGERY WITHIN A GIS TO RELATE SAGE GROUSE LEK ACTIVITY TO LANDSCAPE CHARACTERISTICS

INTRODUCTION

Sage grouse generally use flat open areas for their breeding and display sites (Patterson 1952, Gill 1966) and at least sparse sagebrush cover and/or other shrubs around the lek for escape cover from predators, particularly golden eagles (*Aquila chrysaetos*)(Scott 1942, Enyeart 1956). When shrub cover near leks is removed by tillage, fire, or spraying it leaves the sage grouse at these sites vulnerable to harassment from predators and may cause abandonment (Enyeart 1956, Peterson 1970). Sagebrush cover located around lek sites is not only important for breeding activities, but nesting activities as well. Wallestad and Pyrah (1974) observed that 68% of nests were within 2.5 km of the lek site where females bred in central Montana. Wakkinen et al. (1992) discerned that 92% of nests were $\leq$ 3 km from leks where females bred in Idaho. Breeding to nesting ground movements average from 1.1 – 6.2 km, but can be as far as >20.0 km (Connelly et al. 2000a).

To identify habitat/landuse change in large areas, such as those sage grouse utilize, many studies now

incorporate satellite imagery as a valuable identification tool (Homer et al. 1993, De'ath and Fabricius 2000, Debeljak et al. 2001). It has been suggested by West (2001) that satellite imagery may be used to make landscape scale comparisons on areas of no sage grouse decline with areas of known sage grouse decline. The objective of this study was to use satellite imagery to identify sagebrush, tilled land, and non-tilled land associations within current sage grouse breeding areas and compare the same variables for abandoned breeding areas.

METHODS

Leks were buffered and satellite imagery was categorized following the methods outlined in Chapter 1. All data were analyzed and maps displayed in the projection UTM Clarke 1866 NAD27 Zone 13.

Classifying sagebrush cover in the Dakotas

Sagebrush landcover determination from satellite imagery was modeled at EROS using a regression tree procedure (De'ath and Fabricius 2000, Debeljak et al. 2001). Sagebrush cover measured at microhabitat sample sites was used as training data for the model. These

training data, along with digital elevation models (DEM) of the study area, were used as the basis for the regression tree procedure. I then used the sagebrush cover I collected on the ground to assess the model accuracy. This was done by grouping what the model perceived as sagebrush cover into categories (i.e., 0-5%, 6-10%, 11-15%, 16-20%, and ≥21%). I then randomly selected 15 sample sites I measured that fell within each category and compared what I measured with what the model predicted. The model was considered correct when its predicted sagebrush cover was within ± 5% of the measured sagebrush cover and was within 90 m or less of the correct location of measurement.

4-km buffer comparisons

The grids of 1999-2000 tilled and non-tilled grounds were overlaid with our 4-km buffers created (see Chapter 1) around active and inactive lek sites in North Dakota (Appendix M) and South Dakota (Appendix N) within ArcView 3.2a (ESRI Inc. 2000). Percent area of tilled and non-tilled ground was then calculated using the tabulate area option within the grid analyst extension of ArcView 3.2a (ESRI Inc. 2000). Percent tilled ground within active site buffers was then compared to percent tilled ground within

inactive site buffers and random point buffers (See Chapter 1, p. 20) using a paired t-test. Due to unequal variances a degrees of freedom adjustment using the Satterthwaite method was used on t-tests (SAS Institute 1999). Percent tilled ground in 1999-2000 was also compared to lek size in North Dakota and South Dakota using a linear regression procedure. Normality of the dependent size variable was confirmed using a Chi-square Probability Plot (Johnson 1998). Additionally, comparisons (paired t-test) were made between the percentage of tilled ground within the 4-km buffers around active leks in North Dakota and South Dakota to that of leks with $\geq$ 40 male sage grouse in Montana.

The grids of tilled and non-tilled ground for 1972-1976 were overlaid by 4-km buffers created around leks that were active at least two years during 1972-1976 and were inactive in 1999-2000 and leks that were active at least two years during 1972-1976 and were active in 1999-2000 in North Dakota (Appendix O) and South Dakota (Appendix P). These same leks were then overlaid onto the grid of 1999-2000 tilled ground in the North Dakota (Appendix Q) and South Dakota (Appendix R) study areas for comparison. Leks that have remained active in the comparison have not moved significantly (>0.5 km) from their location in the early

1970s. Percent area of tilled ground within the 4-km buffers was calculated using the tabulated area option in ArcView 3.2a (ESRI Inc. 2000), as previously mentioned, for both 1972-1976 and 1999-2000. A paired t-test was used to compare the percent tilled ground within 4-km buffers in 1972-1976 to the percent tilled ground within these same buffers in 1999-2000.

Region comparisons

Within ArcView 3.2a (ESRI Inc. 2000), the active and inactive regions I identified in North Dakota (see Chapter 1 p. 20; Appendix S) were overlaid onto the grid of tilled ground (Appendix T). Percent tilled and percent non-tilled areas were calculated within each region using the tabulate area method. Percent tilled and non-tilled areas within the active region and inactive region were compared using a Chi-square test. I then overlaid our two regions onto the 1976 tilled ground grid (Appendix U) and calculated the percentage of tilled ground and non-tilled ground within each region. These 1976 percentages were then compared between regions and between years using a Chi-square test.

I also used ArcView 3.2a (ESRI Inc. 2000) to compare region fragmentation in North Dakota. I overlaid our 2-km

buffers, around 15 randomly placed points within each region, onto the grid of 1999 percent tilled ground (Appendix V). The percentage of the 15 randomly placed buffers within each region containing tilled ground and percentage of the 15 randomly placed buffers containing no tilled ground within each region were then compared using a Chi-square test. I then overlaid these same 15 buffers within each region onto the 1976 tilled ground grid (Appendix W). The percentage of the 15 randomly placed buffers within each region containing tilled ground and percentage of the 15 randomly placed buffers containing no tilled ground within each region in 1976 were then compared using a Chi-square test. I also compared the proportion of these random buffers that had tilled ground occur within them in 1976 to that of 1999 within each region using a Chi-square test to see if fragmentation had changed.

RESULTS

Classifying sagebrush cover in the Dakotas

The sagebrush model (Appendix X) currently has a predictive accuracy of about 76%. The sagebrush model tends to classify non-sagebrush areas (e.g., greasewood, rock outcroppings, and even some grassy areas) as sagebrush,

particularly in Fall River County. The model was insufficient at detecting some of the denser stands of sagebrush probably due to the patchy nature of stand distribution. The model also classified areas of non-sagebrush cover as having sagebrush. The problem was compounded by the variances in topography associated with the badlands and buttes of North and South Dakota. Due to low sagebrush cover and patchy distribution we were not successful with current technologies at pulling out sagebrush coverage at the desired confidence for any management-based use.

Comparisons of 4-km buffers for 1999-2000

Comparisons of percent tilled ground within 4-km buffers around active leks and inactive leks (Table 8) in North Dakota revealed that inactive leks had a higher ($|t| = 3.03$, 12 df, $P = 0.0105$) percentage of tilled land than active leks. Percent tilled ground within 4-km buffers around random points (Table 9) was also found to be higher ($|t| = 2.47$, 25 df, $P = 0.0204$) than 4-km buffers around active sites in North Dakota.

Table 8. Comparison of 1999-2000 tilled ground and non-tilled ground within 4-km buffers of active (n = 12) and inactive (n = 10) greater sage grouse leks in North Dakota.

		Hectares (Acres)		Percent	
Lek	Active	Non-tilled	Tilled	Non-tilled	Tilled
19GV	Y	4830.84 (11932.17)	264.60 (653.56)	94.81	5.19
1S	Y	5071.68 (12527.05)	25.56 (63.13)	99.50	0.50
25BW	Y	4870.44 (12029.99)	227.52 (561.97)	95.54	4.46
28BW	Y	4821.48 (11909.06)	276.84 (683.79)	94.57	5.43
24BW	Y	4602.24 (11367.53)	496.44 (1226.21)	90.26	9.74
15BW	Y	4842.36 (11960.63)	253.44 (626.00)	95.03	4.97
16BW	Y	4770.36 (11782.79)	328.32 (810.95)	93.56	6.44
18MT	Y	5073.84 (12532.38)	23.04 (56.91)	99.55	0.45
15S	Y	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
16S	Y	5020.92 (12401.67)	74.52 (184.06)	98.54	1.46
11S	Y	4952.52 (12232.72)	144.00 (355.68)	97.17	2.83
18BW	Y	4892.04 (12083.34)	205.92 (508.62)	95.96	4.04
8BW	N	4474.08 (11050.98)	624.60 (1542.76)	87.75	12.25
7BW	N	4575.24 (11300.84)	522.36 (1290.23)	89.75	10.25
6BW	N	4964.76 (12262.96)	132.84 (328.11)	97.39	2.61
14BW	N	4307.40 (10639.28)	792.36 (1957.13)	84.46	15.54
10BW	N	4680.00 (11559.60)	417.60 (1031.47)	91.81	8.19
21BW	N	4816.44 (11896.61)	277.20 (684.68)	94.56	5.44
11BW	N	4233.96 (10457.88)	863.64 (2133.19)	83.06	16.94
9S	N	5036.76 (12440.80)	60.48 (149.39)	98.81	1.19
21S	N	3995.64 (9869.23)	1103.76 (2726.29)	78.36	21.64
17S	N	4556.88 (11255.49)	541.08 (1336.47)	89.39	10.61

Table 9. Tilled ground and non-tilled ground within 4-km buffers around random points (n = 18) in North Dakota, 1999-2000.

	Hectares (Acres)		Percent	
Random	Non-tilled	Tilled	Non-tilled	Tilled
1	4415.40 (10906.04)	586.08 (1447.62)	88.28	11.72
2	4998.60 (12346.54)	0.00 (0.00)	100.00	0.00
3	3921.84 (9686.94)	1077.48 (2661.38)	78.45	21.55
4	4175.28 (10312.94)	827.28 (2043.38)	83.46	16.54
5	4619.16 (11409.33)	380.16 (939.00)	92.40	7.60
6	4627.08 (11428.89)	374.76 (925.66)	92.51	7.49
7	4714.56 (11644.96)	285.48 (705.14)	94.29	5.71
8	4810.32 (11881.49)	189.36 (467.72)	96.21	3.79
9	5001.48 (12353.66)	0.00 (0.00)	100.00	0.00
10	4642.20 (11466.23)	360.72 (890.98)	92.79	7.21
11	4854.96 (11991.75)	148.32 (366.35)	97.04	2.96
12	4536.36 (11204.81)	464.40 (1147.07)	90.71	9.29
13	4250.16 (10497.90)	751.32 (1855.76)	84.98	15.02
14	4596.84 (11354.19)	405.72 (1002.13)	91.89	8.11
15	4876.92 (12045.99)	124.92 (308.55)	97.50	2.50
16	4067.28 (10046.18)	935.28 (2310.14)	81.30	18.70
17	4636.80 (11452.90)	365.76 (903.43)	92.69	7.31
18	5000.04 (12350.10)	0.00 (0.00)	100.00	0.00

Comparisons of percent tilled and non-tilled ground within 4-km buffers placed around active leks and inactive leks (Table 10) in South Dakota revealed no difference ($|t| = 0.35$, 17 df, $P = 0.7327$) between active and inactive leks. Also, percent tilled ground within 4-km buffers around random points (Table 11) was no different ($|t| = 1.20$, 23 df, $P = 0.2427$) than percent tilled ground within 4-km buffers around active sites in South Dakota. Comparison of 1999-2000 percent tilled and non-tilled ground in North Dakota and South Dakota versus lek size (Tables 12 & 13) within the 4-km buffers placed around active leks revealed that there was no relationship (North Dakota: $F = 2.61$, 1 df, $P = 0.1403$; South Dakota: $F = 3.26$, 1 df, $P = 0.1087$) between lek size and the percentage of tilled ground.

Comparisons of percent tilled ground within 4-km buffers placed around active leks in Montana (Table 14) versus active leks in the Dakotas showed no difference (North Dakota: $|t| = 0.24$, 12 df, $P = 0.8141$; South Dakota: $|t| = 1.36$, 11 df, $P = 0.2012$).

Table 10. Comparison of 1999-2000 tilled ground and non-tilled ground within 4-km buffers around active greater sage grouse leks (n = 11) as relates to size in North Dakota.

		Hectares (Acres)		Percent	
Lek	Size[a]	Non-tilled	Tilled	Non-tilled	Tilled
19GV	3	4830.84 (11932.17)	264.60 (653.56)	94.81	5.19
1S	9	5071.68 (12527.05)	25.56 (63.13)	99.50	0.50
25BW	3	4870.44 (12029.99)	227.52 (561.97)	95.54	4.46
11S	6	4952.52 (12232.72)	144.00 (355.68)	97.17	2.83
18BW	5	4892.04 (12083.34)	205.92 (508.62)	95.96	4.04
15BW	8	4842.36 (11960.63)	253.44 (626.00)	95.03	4.97
18MT	13	5073.84 (12532.38)	23.04 (56.91)	99.55	0.45
15S	15	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
28BW	15	4821.48 (11909.06)	276.84 (683.79)	94.57	5.43
24BW	30	4602.24 (11367.53)	496.44 (1226.21)	90.26	9.74
16BW	30	4770.36 (11782.79)	328.32 (810.95)	93.56	6.44

[a] Size is defined as the number of male sage grouse counted on lek and is the average of spring 2001 and 2002 surveys.

Table 11. Comparison of 1999-2000 tilled ground and non-tilled ground within 4-km buffers of active (n = 10) and inactive (n = 9) greater sage grouse leks in South Dakota.

		Hectares (Acres)		Percent	
Lek	Active	Non-tilled	Tilled	Non-tilled	Tilled
5B	Y	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
3H	Y	5044.32 (12459.47)	51.12 (126.27)	99.00	1.00
7H	Y	5096.88 (12589.29)	0.00 (0.00)	100.00	0.00
5H	Y	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
2H	Y	5052.24 (12479.03)	46.44 (114.71)	99.09	0.91
15B	Y	5095.08 (12584.85)	0.00 (0.00)	100.00	0.00
10H	Y	5028.12 (12419.46)	70.20 (173.39)	98.62	1.38
11B	Y	5085.72 (12561.73)	0.00 (0.00)	100.00	0.00
13B	Y	5097.24 (12590.18)	0.00 (0.00)	100.00	0.00
1FR	Y	4870.44 (12029.99)	228.60 (564.64)	95.52	4.48
9B	N	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
1B	N	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
4B	N	5097.24 (12590.18)	0.00 (0.00)	100.00	0.00
12B	N	5096.52 (12588.40)	0.00 (0.00)	100.00	0.00
8B	N	5097.60 (12591.07)	0.00 (0.00)	100.00	0.00
6B	N	5097.60 (12591.07)	0.00 (0.00)	100.00	0.00
4H	N	4838.04 (11949.96)	258.84 (639.33)	94.92	5.08
9H	N	5016.60 (12391.00)	77.76 (192.07)	98.47	1.53
8H	N	4959.00 (12248.73)	136.44 (337.01)	97.32	2.68

Table 12. Tilled ground and non-tilled ground within 4-km buffers around random points (n = 18) in South Dakota, 1999-2000.

	Hectares (Acres)		Percent	
Random	Non-tilled	Tilled	Non-tilled	Tilled
1	5001.84 (12354.54)	0.00 (0.00)	100.00	0.00
2	4815.36 (11893.94)	186.84 (461.49)	96.26	3.74
3	4999.32 (12348.32)	0.00 (0.00)	100.00	0.00
4	4997.88 (12344.76)	4.68 (11.56)	99.91	0.09
5	5001.12 (12352.77)	0.00 (0.00)	100.00	0.00
6	4718.16 (11653.86)	282.24 (697.13)	94.36	5.64
7	4960.80 (12253.18)	38.52 (95.14)	99.23	0.77
8	4930.20 (12177.59)	68.76 (169.84)	98.62	1.38
9	4987.08 (12318.09)	15.12 (37.35)	99.70	0.30
10	4848.12 (11974.86)	153.72 (379.69)	96.93	3.07
11	5001.84 (12354.54)	0.00 (0.00)	100.00	0.00
12	4846.32 (11970.41)	156.96 (387.69)	96.86	3.14
13	4998.60 (12346.54)	0.00 (0.00)	100.00	0.00
14	4998.60 (12346.54)	0.00 (0.00)	100.00	0.00
15	4914.72 (12139.36)	87.84 (216.96)	98.24	1.76
16	5002.20 (12355.43)	0.00 (0.00)	100.00	0.00
17	4153.68 (10259.59)	845.28 (2087.84)	83.09	16.91
18	5002.56 (12356.32)	0.00 (0.00)	100.00	0.00

Table 13. Comparison of 1999-2000 tilled ground and non-tilled ground within 4-km buffers around active greater sage grouse leks (n = 10) as relates to size in South Dakota.

		Hectares (Acres)		Percent	
Lek	Size[a]	Non-tilled	Tilled	Non-tilled	Tilled
1FR	6	4870.44 (12029.99)	228.60 (564.64)	95.52	4.48
3H	14	5044.32 (12459.47)	51.12 (126.27)	99.00	1.00
7H	13	5096.88 (12589.29)	0.00 (0.00)	100.00	0.00
5H	13	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
2H	11	5052.24 (12479.03)	46.44 (114.71)	99.09	0.91
10H	12	5028.12 (12419.46)	70.20 (173.39)	98.62	1.38
11B	7	5085.72 (12561.73)	0.00 (0.00)	100.00	0.00
13B	24	5097.24 (12590.18)	0.00 (0.00)	100.00	0.00
15B	25	5095.08 (12584.85)	0.00 (0.00)	100.00	0.00
5B	17	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00

[a] Size is defined as the number of male sage grouse counted on lek and is the average of spring 2001 and 2002 surveys.

Table 14. Tilled ground and non-tilled ground within 4-km buffers around active greater sage grouse leks (n = 11) in Montana, 1999-2000.

		Hectares (Acres)		Percent	
Lek	Size[a]	Non-tilled	Tilled	Non-tilled	Tilled
RO15	60*	5097.96 (12591.96)	0.00 (0.00)	100.00	0.00
CU18	42*	5097.60 (12591.07)	0.00 (0.00)	100.00	0.00
PO16B	70	5056.20 (12488.81)	41.76 (103.15)	99.18	0.82
GA6	80	5095.80 (12586.63)	0.00 (0.00)	100.00	0.00
CU43	67	5072.40 (12528.83)	25.20 (62.24)	99.51	0.49
CA7	67	5099.04 (12594.63)	0.00 (0.00)	100.00	0.00
PO32	57	5095.80 (12586.63)	0.00 (0.00)	100.00	0.00
GA74	59	4984.56 (12311.86)	111.60 (275.65)	97.81	2.19
GA52	85	4107.24 (10144.88)	992.16 (2450.64)	80.54	19.46
GA45	48	3935.88 (9721.62)	1160.64 (2866.78)	77.23	22.77
GA21	90	4942.80 (12208.72)	152.28 (376.13)	97.01	2.99

[a] An asterisk (*) indicates a survey count from spring 2000, otherwise count is from spring 2001.

Comparisons of 4-km buffers between 1972-1976 and 1999-2000

The percentage of tilled ground within 4-km buffers around leks that were active in 1972-1976 and inactive in 1999-2000 (Tables 15 and 16) showed no difference (North Dakota: $|t| = 1.14$, 4 df, $P = 0.3188$; South Dakota: $|t| = -1.00$, 5 df, $P = 0.3632$) between periods. The percentages of tilled ground within 4-km buffers around leks that were active in 1972-1976 and were still active in 1999-2000 (Tables 15 and 16) also showed no difference (North Dakota: $|t| = 0.91$, 3 df, $P = 0.4290$; South Dakota: $|t| = -1.00$, 3 df, $P = 0.3910$) between periods.

Region comparisons

Region comparisons in North Dakota revealed that the percentage of tilled grounds in 1999-2000 within the inactive region (Table 17) was greater ($X^2 = 2.9563$, 1 df, $P = 0.0855$) than the percentage of tilled ground within the active region (Table 17). The landscape in 1999-2000 within the inactive region had a greater ($X^2 = 59.2741$, 1 df, $P = <0.0001$) percentage of occurrences of tilled ground within the 15 random 2-km buffers than the 15 random 2-km buffers within the active region (Table 18).

Table 15. Comparisons of 1972-1976 and 1999-2000 tilled ground and non-tilled ground within 4-km buffers of greater sage grouse leks in North Dakota that were active at least 2 years during the period of 1972-1976 and were active (n = 4) or inactive (n = 5) in 1999-2000.

			Hectares (Acres)		Percent	
Period	Lek	Active	Non-tilled	Tilled	Non-tilled	Tilled
1972-1976	13GV	Y	5051.52 (12477.25)	46.08 (113.82)	99.10	0.90
	6S	Y	5098.68 (12593.74)	0.00 (0.00)	100.00	0.00
	11S	Y	4965.48 (12264.74)	132.12 (326.34)	97.41	2.59
	1S	Y	5065.92 (12512.82)	33.48 (82.70)	99.34	0.66
	5S	Y	5099.76 (12596.41)	0.00 (0.00)	100.00	0.00
	7BW	Y	4591.80 (11341.75)	503.28 (1243.10)	90.12	9.88
	6BW	Y	4385.52 (10832.23)	712.44 (1759.73)	86.02	13.98
	15BW	Y	4764.96 (11769.45)	331.92 (819.84)	93.49	6.51
	10BW	Y	4184.64 (10336.06)	912.60 (2254.12)	82.10	17.90
1999-2000	13GV	N	4966.56 (12267.40)	129.60 (320.11)	97.46	2.54
	6S	N	4983.84 (12310.08)	114.84 (283.65)	97.75	2.25
	11S	Y	4952.88 (12233.61)	144.00 (355.68)	97.17	2.83
	1S	Y	5071.68 (12527.05)	25.56 (63.13)	99.50	0.50
	5S	Y	5095.44 (12585.74)	0.00 (0.00)	100.00	0.00
	7BW	N	4575.24 (11300.84)	522.36 (1290.23)	89.75	10.25
	6BW	N	4964.76 (12262.96)	132.84 (328.11)	97.39	2.61
	15BW	Y	4842.36 (11960.63)	253.44 (626.00)	95.03	4.97
	10BW	N	4680.00 (11559.60)	417.60 (1031.47)	91.81	8.19

Table 16. Comparisons of 1972-1976 and 1999-2000 tilled ground and non-tilled ground within 4-km buffers of greater sage grouse leks in South Dakota that were active at least 2 years during the period of 1972-1976 and were active (n = 4) or inactive (n = 6) in 1999-2000.

			Hectares (Acres)				Percent	
Period	Lek	Active	Non-tilled		Tilled		Non-tilled	Tilled
1972-1976	6H	Y	5100.12	(12597.30)	0.00	(0.00)	100.00	0.00
	5H	Y	5098.68	(12593.74)	0.00	(0.00)	100.00	0.00
	2H	Y	5056.56	(12489.70)	39.24	(96.92)	99.23	0.77
	1H	Y	5099.04	(12594.63)	0.00	(0.00)	100.00	0.00
	9B	Y	5098.32	(12592.85)	0.00	(0.00)	100.00	0.00
	10B	Y	5097.60	(12591.07)	0.00	(0.00)	100.00	0.00
	4B	Y	5095.44	(12585.74)	0.00	(0.00)	100.00	0.00
	6B	Y	5096.88	(12589.29)	0.00	(0.00)	100.00	0.00
	5B	Y	5097.24	(12590.18)	0.00	(0.00)	100.00	0.00
	1B	Y	5096.88	(12589.29)	0.00	(0.00)	100.00	0.00
1999-2000	6H	N	5095.08	(12584.85)	0.00	(0.00)	100.00	0.00
	5H	Y	5098.68	(12593.74)	0.00	(0.00)	100.00	0.00
	2H	Y	5052.24	(12479.03)	46.44	(114.71)	99.09	0.91
	1H	N	4912.20	(12133.13)	186.48	(460.61)	96.34	3.66
	9B	N	5098.68	(12593.74)	0.00	(0.00)	100.00	0.00
	10B	Y	5099.04	(12594.63)	0.00	(0.00)	100.00	0.00
	4B	N	5097.24	(12590.18)	0.00	(0.00)	100.00	0.00
	6B	N	5097.60	(12591.07)	0.00	(0.00)	100.00	0.00
	5B	Y	5098.32	(12592.85)	0.00	(0.00)	100.00	0.00
	1B	N	5098.68	(12593.74)	0.00	(0.00)	100.00	0.00

Table 17. Comparison of 1972-1976 and 1999-2000 tilled ground and non-tilled ground within active and inactive regions in North Dakota.

		Hectares (Acres)		Percent	
Period	Region	Non-tilled	Tilled	Non-tilled	Tilled
1972-1976	Inactive	57735.72 (142607.23)	7083.00 (17495.01)	89.07	10.93
	Active	64289.16 (158794.23)	2841.12 (7017.57)	95.77	4.23
1999-2000	Inactive	58491.72 (144474.55)	6333.84 (15644.58)	90.23	9.77
	Active	64675.44 (159748.34)	2473.20 (6108.80)	96.32	3.68

Table 18. Percent of the 15 random 2-km buffers that had tilled ground occur within them in 1972-1976 and 1999-2000 within the active and inactive region in North Dakota.

Period	Region	Occurrence (%)	No Occurrence (%)
1972-1976	Inactive	80.00	20.00
	Active	40.00	60.00
1999-2000	Inactive	86.67	13.33
	Active	33.33	66.67

The proportion of tilled ground to non-tilled ground within the inactive and active region of North Dakota (Table 17) showed no difference (Inactive: $X^2 = 0.0725$, 1 df, $P = 0.7877$; Active: $X^2 = 0.0398$, 1 df, $P = 0.8418$) between 1972-1976 and 1999-2000. The proportion of tilled ground occurrence within 2-km buffers around our 15 randomly placed points within the inactive and active region of North Dakota (Table 18) likewise showed no difference (Inactive: $X^2 = 1.6017$, 1 df, $P = 0.2057$; Active: $X^2 = 0.9579$, 1 df, $P = 0.3277$) between 1972-1976 and 1999-2000.

DISCUSSION

Based on analysis of the current (i.e., 1999) satellite imagery, tilled ground appears to be playing a role in the abandonment of leks in North Dakota. However, when I looked at this relationship, using early satellite imagery (1972-1976) and more recent imagery (1999-2000), there was no increase in the amount of tilled ground associated with the inactive areas since the early to mid 1970s. If tilled ground is a factor in the abandonment of leks, its effects likely began previous to 1972. Sage grouse are influenced by landscape scale changes (Connelly

1988, Knick 2001) that may result from tillage (Peterson 1970), fire (Nelle et al. 2000) or other disturbances of sagebrush ecosystems (Haegen et al. 2002). These disturbances may affect female nesting sites (Call and Maser 1985), causing the females to shift to undisturbed areas, and thus causing a decrease in lek size or abandonment by males (Bradbury et al. 1986, Gibson 1996). Tilled ground appears to have had no effect on abandonment of leks in South Dakota; however, with the limited historical information available more leks may have been present in regions farther east where tillage has been more common. In South Dakota, plowing and spraying (i.e., herbicides and insecticides) may still be a factor in the abandonment of sage grouse leks. In North Dakota there are historic leks, but no known active leks located in areas of Bowman County where intensive cultivation practices are present. The same relationship may hold true for South Dakota. In Harding County, no known leks are documented in the northeast corner of the county, which is primarily cultivated. Similarly, in Butte County, no known leks are documented in the southeastern portion of the county, which is a primarily cultivated region. However, we lack

historical records to determine if leks were ever present in these regions of Butte and Harding County.

Other studies suggest that sage grouse movement from one lek site to another could be in response to a combination of factors. Distance may not be a factor in movements, but prior habitat alterations and topography might play an important role (Emmons and Braun 1984). Habitat alterations around the lek (e.g., plowing, spraying, burning, and overgrazing) could be related to abandonment (Wallestad and Schladweiler 1974, Call and Maser 1985). These disturbances may not directly harm the sage grouse, but when these activities cause the eradication of sagebrush and fragmentation of the habitat around strutting grounds, it has been documented to cause abandonment and an overall decrease in the population of that area (Enyeart 1956, Wallestad 1975b, Hall 2001). Other activities known to affect fidelity to displaying areas are mining, oil well development and operations, and military operations (Rogers 1964, Eng et al. 1979, Tate et al. 1979, Call and Maser 1985, Schroeder et al. 1999), mainly due to the quantity of noise produced by these activities (Rogers 1964) or creation of perching sites for raptors that prey upon sage grouse (Hall 2001).

Increased disturbance to sage grouse leks by roads and oil and natural gas wells/pumps may be playing a role in lek abandonment in North Dakota. Placements of these wells and pumps have sometimes been within 100 m, if not directly on, sage grouse lek sites. Oil well development within 200 m caused at least one lek in North Dakota to be abandoned (Jerry Kobridger, pers. comm., NDGF). However, oil/natural gas wells and power lines are located next to both currently active (six) and inactive (four) leks in the Dakotas. I have observed two leks that were within 200 m of newly constructed oil/natural gas wells in North Dakota. Whether these leks will remain active is yet to be seen. Proximity of oil/natural gas wells is also associated with other disturbances and landscape changes that could discourage lek use. To extract their product from these wells companies have been building numerous roads through areas occupied by sage grouse. The physical presence of the road itself may not daunt male and female sage grouse from using the area (Kuipers et al. 2002), but dust and noise in these areas may cause shifts as found with other sagebrush obligates (Ingelfinger 2001).

MANAGEMENT IMPLICATIONS

In the Dakotas, most of the sage grouse breeding range falls on private land, so working locally and inviting all potential stakeholders to conservation planning meetings is a must and will prove crucial in managing the habitat for this species (Hemker 2001, Sands 2001). The Conservation Reserve Program (CRP) has helped to conserve grassland birds and even sage grouse (Mazzola et al. 1998, Herkert 1998, McCoy et al. 1999); a similar program to reestablish sagebrush in areas converted to cropland might benefit sage grouse as well. Particularly, areas that have soils suited to establishing sagebrush will have the best potential for sage grouse habitat reclamation. Some ways to reestablish sagebrush communities are reseeding, transplanting sagebrush from other locations, or transplanting sagebrush from greenhouse grown stock. By translating conservation value to economic value (Olson 1996) through innovative processes and habitat restoration incentive programs we can help the rural communities meet their needs of earning a living while maintaining the sage grouse population.

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Appendix A. Historic lek count totals (i.e., leks combined), leks, and males/lek by county in North Dakota, 1951-2002[a] (NDGF, unpublished data, 2002).

	Year										
County	1951	1952	1953	1954	1955[b]	1956	1957	1958	1959	1960	1961
Bowman											
Males	337	335	504	257	-	317	201	235	246	-	197
Leks	10	11	16	12	-	16	15	17	16	-	12
Males/Lek	34	30	32	21	-	20	13	14	15	-	16
Slope											
Males	16	53	38	40	-	36	50	71	86	-	58
Leks	1	1	2	3	-	2	3	3	4	-	2
Males/Lek	16	53	19	13	-	18	17	24	22	-	29
Golden Valley											
Males	0	0	0	0	-	0	0	0	0	-	0
Leks	0	0	0	0	-	0	0	0	0	-	0
Males/Lek	0	0	0	0	-	0	0	0	0	-	0
Total											
Males	353	388	542	297	-	353	251	306	332	-	255
Leks	11	12	18	15	-	18	18	20	20	-	14
Males/Lek	32	32	30	20	-	20	14	15	17	-	18

Appendix A. Continued.

	Year										
County	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
Bowman											
Males	-	129	252	140	120	147	169	277	188	174	179
Leks	-	9	15	14	12	10	9	9	9	8	8
Males/Lek	-	14	17	10	10	15	19	31	21	22	22
Slope											
Males	-	173	33	45	53	82	61	123	95	93	111
Leks	-	5	3	6	6	6	5	5	7	7	7
Males/Lek	-	35	11	8	9	14	12	25	14	13	16
Golden Valley											
Males	-	0	0	19	10	11	6	13	8	10	8
Leks	-	0	0	1	1	1	1	1	1	1	1
Males/Lek	-	0	0	19	10	11	6	13	8	10	8
Total											
Males	-	302	285	204	183	240	236	413	291	277	298
Leks	-	14	18	21	19	17	15	15	17	16	16
Males/Lek	-	22	16	10	10	14	16	28	17	17	19

Appendix A. Continued.

County	Year										
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Bowman											
Males	133	138	74	86	110	110	66	173	131	124	137
Leks	7	7	7	9	8	8	7	10	10	10	10
Males/Lek	19	20	11	10	14	14	9	17	13	12	14
Slope											
Males	135	115	81	86	85	86	58	194	119	164	153
Leks	8	7	7	8	7	8	5	11	10	11	10
Males/Lek	17	16	12	11	12	11	12	18	12	15	15
Golden Valley											
Males	26	17	14	9	18	13	7	18	13	11	10
Leks	2	2	1	1	1	1	1	2	2	2	2
Males/Lek	13	9	14	9	18	13	7	9	7	6	5
Total											
Males	294	270	169	181	213	209	131	380	263	299	300
Leks	17	16	15	18	16	17	13	23	22	23	22
Males/Lek	17	17	11	10	13	12	10	17	12	13	14

Appendix A. Continued.

	Year										
County	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Bowman											
Males	114	157	75	96	134	100	72	56	53	75	39
Leks	9	9	7	8	8	7	7	6	7	8	5
Males/Lek	13	17	11	12	17	14	10	9	8	9	8
Slope											
Males	145	114	67	89	124	144	159	194	185	196	130
Leks	11	10	9	10	10	10	10	9	9	10	11
Males/Lek	13	11	7	9	12	14	16	22	21	20	12
Golden Valley											
Males	8	4	0	0	5	6	6	3	2	3	5
Leks	2	2	0	0	2	2	2	2	1	1	1
Males/Lek	4	2	0	0	3	3	3	2	2	3	5
Total											
Males	367	275	142	185	263	250	237	253	240	274	174
Leks	22	21	16	18	20	19	19	17	17	19	17
Males/Lek	17	13	9	10	13	13	13	15	14	14	10

Appendix A. Continued.

County	1995	1996	1997	1998	1999	2000	2001	2002
	Year							
Bowman								
Males	40	30	27	23	62	128	107	83
Leks	4	4	4	4	6	8	7	8
Males/Lek	10	8	7	6	10	16	15	10
Slope								
Males	106	76	92	96	129	150	123	79
Leks	11	10	10	10	9	8	8	7
Males/Lek	10	8	9	10	14	19	15	11
Golden Valley								
Males	3	5	9	5	4	5	2	5
Leks	2	1	1	2	1	1	1	3
Males/Lek	2	5	9	3	4	5	2	2
Total								
Males	149	111	128	124	195	283	232	167
Leks	17	15	15	16	16	17	16	18
Males/Lek	9	7	8	8	12	17	15	9

[a] Counts based on the maximum number of males surveyed during 2 visits (2001 and 2002 had 3 visits) during April from a vehicle or on foot from sunrise to 8:00 AM.
[b] A dash (-) denotes information not available.

Appendix B. Historic lek count totals (i.e., leks combined), leks, and males/lek by county in South Dakota, 1972-2002[a] (Linde et al. 1975, Linde et al. 1976, Linde et al. 1977, Linde et al. 1978, Linde et al. 1979, Crouch et al. 1981; SDGFP, unpublished data, 2002).

	Year[b]										
County	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Fall River											
Males	-	-	-	-	23	15	19	-	-	-	-
Leks	-	-	-	-	2	2	2	-	-	-	-
Males/Lek	-	-	-	-	12	8	10	-	-	-	-
Butte											
Males	99	201	158	156	164	121	130	128	100	129	100
Leks	5	7	7	8	8	8	9	8	7	7	6
Males/Lek	20	29	23	20	21	15	14	16	14	18	17
Harding											
Males	-	-	18	-	13	31	53	28	-	-	-
Leks	-	-	4	-	4	3	4	3	-	-	-
Males/Lek	-	-	5	-	3	10	13	9	-	-	-
Total											
Males	99	201	176	156	200	167	202	156	100	129	100
Leks	5	7	11	8	13	13	15	11	7	7	6
Males/Lek	20	29	16	20	15	13	13	14	14	18	17

Appendix B. Continued.

County	1983	1984	1985	1986	1987	Year 1988	1989	1990	1991	1992	1993
Fall River											
Males	-	-	-	-	-	-	-	-	18	8	4
Leks	-	-	-	-	-	-	-	-	1	1	1
Males/Lek	-	-	-	-	-	-	-	-	18	8	4
Butte											
Males	75	115	74	41	43	54	42	38	67	68	51
Leks	5	7	7	7	4	4	4	4	10	7	5
Males/Lek	15	16	11	6	11	14	11	10	7	10	10
Harding											
Males	-	-	-	-	-	-	85	98	123	145	159
Leks	-	-	-	-	-	-	5	6	8	9	11
Males/Lek	-	-	-	-	-	-	17	16	15	16	14
Total											
Males	75	115	74	41	43	54	127	136	208	221	214
Leks	5	7	7	7	4	4	9	10	19	17	17
Males/Lek	15	16	11	6	11	14	14	14	11	13	13

Appendix B. Continued.

County	1994	1995	1996	1997	Year 1998	1999	2000	2001	2002
Fall River									
Males	4	6	10	10	11	11	9	8	4
Leks	1	1	1	1	1	1	1	1	1
Males/Lek	4	6	10	10	11	11	9	8	4
Butte									
Males	-	32	25	20	50	69	75	83	73
Leks	-	6	4	2	7	5	4	5	5
Males/Lek	-	5	6	10	7	14	19	17	15
Harding									
Males	128	86	56	52	68	63	79	69	65
Leks	8	8	8	7	7	6	6	5	6
Males/Lek	16	11	7	7	10	11	13	14	11
Total									
Males	132	124	91	82	129	143	163	160	142
Leks	9	15	13	10	15	12	11	11	12
Males/Lek	15	8	7	8	9	12	15	15	12

[a] Counts based on the maximum number of males surveyed during 2 visits (2001 and 2002 had 3 visits) during April from a vehicle, airplane, or on foot from sunrise to 8:00 AM.

[b] A dash (-) indicates information not available.

Appendix C. Male sage grouse counts by lek in North Dakota during spring counts, 1951-2002[a] (NDGF, unpublished data, 2002).

		Year[b]									
County	Lek	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Bowman	1BW	25	23	36	14	-	11	11	8	14	-
	2-3BW	42	37	41	25	-	28	18	15	20	-
	4BW	14	11	15	4	-	0	0	1	0	-
	5BW	52	32	49	41	-	15	2	31	28	-
	6BW	40	60	50	33	-	34	24	8	26	-
	7BW	40	43	48	22	-	21	16	21	12	-
	8BW	34	36	36	32	-	23	16	15	12	-
	9BW	50	61	90	36	-	43	19	33	20	-
	10BW	30	26	21	22	-	25	11	13	17	-
	11BW	10	1	13	2	-	0	0	0	0	-
	12BW	-	5	2	2	-	3	0	3	1	-
	13BW	-	-	17	-	-	13	13	16	20	-
	14BW	-	-	35	-	-	10	1	9	15	-
	15BW	-	-	28	-	-	33	17	11	13	-
	16BW	-	-	14	-	-	12	8	5	6	-
	17BW	-	-	9	-	-	0	-	-	0	-
	18BW	-	-	-	24	-	20	24	25	28	-
	19BW	-	-	-	-	-	19	13	14	10	-
	20BW	-	-	-	-	-	7	0	0	0	-
	21BW	-	-	-	-	-	-	8	7	4	-
	22BW	-	-	-	-	-	-	-	-	-	-
	23BW	-	-	-	-	-	-	-	-	-	-
	24BW	-	-	-	-	-	-	-	-	-	-
	25BW	-	-	-	-	-	-	-	-	-	-
	26BW	-	-	-	-	-	-	-	-	-	-
	27BW	-	-	-	-	-	-	-	-	-	-

Appendix C. Continued.

		Year									
County	Lek	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Bowman	28BW	-	-	-	-	-	-	-	-	-	-
Slope	1S	16	53	29	29	-	34	44	41	45	-
	2S	-	-	-	9	-	2	2	0	0	-
	3S	-	-	9	2	-	-	4	5	-	-
	4S	-	-	-	-	-	-	-	25	20	-
	5S	-	-	-	-	-	-	-	-	6	-
	6S	-	-	-	-	-	-	-	-	15	-
	7S	-	-	-	-	-	-	-	-	-	-
	9S	-	-	-	-	-	-	-	-	-	-
	10S	-	-	-	-	-	-	-	-	-	-
	11S	-	-	-	-	-	-	-	-	-	-
	12S	-	-	-	-	-	-	-	-	-	-
	14S	-	-	-	-	-	-	-	-	-	-
	15S	-	-	-	-	-	-	-	-	-	-
	16S	-	-	-	-	-	-	-	-	-	-
	17S	-	-	-	-	-	-	-	-	-	-
	18MT	-	-	-	-	-	-	-	-	-	-
	20S	-	-	-	-	-	-	-	-	-	-
	21S	-	-	-	-	-	-	-	-	-	-
Golden Valley	8GV	-	-	-	-	-	-	-	-	-	-
	13GV	-	-	-	-	-	-	-	-	-	-
	19GV	-	-	-	-	-	-	-	-	-	-
Total Males		353	388	542	297	-	353	251	306	332	-
Total Leks		11	12	18	15	-	18	18	20	20	-
Males/Lek		32	32	30	20	-	20	14	15	17	-

Appendix C. Continued.

County	Lek	Year									
		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Bowman	1BW	-	-	-	-	0	0	0	0	0	0
	2-3BW	6	-	0	32	6	2	0	0	0	0
	4BW	0	-	0	0	0	0	0	0	0	0
	5BW	9	-	0	9	0	0	0	0	0	0
	6BW	13	-	4	32	22	22	18	23	26	20
	7BW	5	-	13	16	9	9	12	12	19	10
	8BW	17	-	18	8	4	0	0	0	0	0
	9BW	35	-	10	19	19	22	19	25	32	16
	10BW	17	-	0	10	5	6	17	24	36	27
	11BW	0	-	0	0	0	0	0	0	0	0
	12BW	0	-	0	0	1	0	0	0	0	0
	13BW	35	-	30	23	19	11	26	17	31	18
	14BW	16	-	0	2	4	2	0	0	0	0
	15BW	-	-	11	21	10	19	21	23	34	25
	16BW	9	-	3	13	7	5	8	10	27	20
	17BW	-	-	-	12	5	4	3	1	1	1
	18BW	28	-	35	37	24	16	22	34	71	51
	19BW	-	-	5	5	0	0	0	0	0	0
	20BW	0	-	0	0	0	0	0	0	0	0
	21BW	7	-	0	13	5	2	1	0	0	0
	22BW	-	-	-	-	-	-	-	-	-	-
	23BW	-	-	-	-	-	-	-	-	-	-
	24BW	-	-	-	-	-	-	-	-	-	-
	25BW	-	-	-	-	-	-	-	-	-	-
	26BW	-	-	-	-	-	-	-	-	-	-
	27BW	-	-	-	-	-	-	-	-	-	-
	28BW	-	-	-	-	-	-	-	-	-	-

Appendix C. Continued.

County	Lek	Year									
		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
Slope	1S	38	-	40	14	10	8	19	15	35	20
	2S	0	-	0	0	0	0	0	0	0	0
	3S	-	-	-	-	-	0	0	0	0	3
	4S	20	-	43	10	14	20	22	19	35	19
	5S	-	-	21	9	1	10	9	14	12	30
	6S	-	-	29	-	7	11	21	8	30	17
	7S	-	-	40	-	8	2	1	0	0	0
	9S	-	-	-	-	5	2	0	0	0	0
	10S	-	-	-	-	-	-	10	5	11	4
	11S	-	-	-	-	-	-	-	-	-	2
	12S	-	-	-	-	-	-	-	-	-	-
	14S	-	-	-	-	-	-	-	-	-	-
	15S	-	-	-	-	-	-	-	-	-	-
	16S	-	-	-	-	-	-	-	-	-	-
	17S	-	-	-	-	-	-	-	-	-	-
	18MT	-	-	-	-	-	-	-	-	-	-
	20S	-	-	-	-	-	-	-	-	-	-
	21S	-	-	-	-	-	-	-	-	-	-
Golden Valley	8GV	-	-	-	-	-	-	-	-	-	-
	13GV	-	-	-	-	-	-	-	-	-	-
	19GV	-	-	-	-	-	-	-	-	-	-
Total Males		255	-	302	285	204	183	240	236	413	291
Total Leks		14	-	14	18	21	19	17	15	15	17
Males/Lek		18	-	22	16	10	10	14	16	28	17

Appendix C. Continued.

County	Lek	Year 1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Bowman	1BW	0	0	0	0	0	0	0	0	0	0
	2-3BW	0	0	0	0	0	0	0	0	0	0
	4BW	0	0	0	0	0	0	0	0	0	0
	5BW	0	0	0	0	0	0	0	0	0	0
	6BW	20	20	23	26	11	6	13	7	6	8
	7BW	9	8	5	6	1	1	1	1	0	0
	8BW	0	0	0	0	0	0	0	0	0	0
	9BW	8	12	0	0	0	0	0	0	0	0
	10BW	22	33	28	25	8	8	6	9	9	24
	11BW	0	0	0	0	0	0	0	0	0	0
	12BW	0	0	0	0	0	0	0	0	0	0
	13BW	21	13	9	17	14	10	8	20	8	2
	14BW	0	0	0	0	0	0	0	0	0	0
	15BW	25	23	18	25	26	21	21	19	15	6
	16BW	20	21	9	9	3	2	0	3	0	8
	17BW	0	0	0	0	0	0	0	0	0	0
	18BW	49	49	41	30	11	14	25	19	6	16
	19BW	0	0	0	0	0	0	0	0	0	0
	20BW	0	0	0	0	0	0	0	0	0	0
	21BW	0	0	0	0	0	0	0	0	0	0
	22BW	-	-	-	-	-	10	14	0	7	38
	23BW	-	-	-	-	-	14	22	32	15	19
	24BW	-	-	-	-	-	-	-	-	-	45
	25BW	-	-	-	-	-	-	-	-	-	13
	26BW	-	-	-	-	-	-	-	-	-	-
	27BW	-	-	-	-	-	-	-	-	-	-
	28BW	-	-	-	-	-	-	-	-	-	-

Appendix C. Continued.

County	Lek	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
		Year									
Slope	1S	24	22	30	25	26	20	17	22	14	28
	2S	0	0	0	0	0	0	0	0	0	0
	3S	0	0	0	0	0	0	0	0	0	4
	4S	16	24	27	29	23	16	16	18	21	29
	5S	18	17	17	20	5	15	12	11	7	33
	6S	15	16	21	13	9	5	11	7	0	4
	7S	0	0	0	0	0	0	0	0	0	0
	9S	0	0	0	0	0	0	0	0	0	0
	10S	9	19	9	4	5	3	0	1	0	1
	11S	2	3	18	15	11	11	4	3	0	0
	12S	9	10	1	0	0	0	0	0	0	0
	14S	-	-	12	9	2	2	9	6	7	13
	15S	-	-	-	-	-	14	16	18	9	15
	16S	-	-	-	-	-	-	-	-	-	15
	17S	-	-	-	-	-	-	-	-	-	14
	18MT	-	-	-	-	-	-	-	-	-	27
	20S	-	-	-	-	-	-	-	-	-	-
	21S	-	-	-	-	-	-	-	-	-	-
Golden Valley	8GV	10	8	4	4	0	0	0	0	0	0
	13GV	-	-	22	13	14	9	18	13	7	11
	19GV	-	-	-	-	-	-	-	-	-	7
Total Males		277	298	294	270	169	181	213	209	131	380
Total Leks		16	16	17	16	15	18	16	17	13	23
Males/Lek		17	19	17	17	11	10	13	12	10	17

Appendix C. Continued.

County	Lek	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
					Year						
Bowman	1BW	0	0	0	0	0	0	0	0	0	0
	2-3BW	0	0	0	0	0	0	0	0	0	0
	4BW	0	0	0	0	0	0	0	0	0	0
	5BW	0	0	0	0	0	0	0	0	0	0
	6BW	5	2	4	5	2	0	0	0	0	0
	7BW	9	3	2	5	5	3	5	15	11	6
	8BW	0	0	0	0	0	0	0	0	0	0
	9BW	0	0	0	0	0	0	0	0	0	0
	10BW	11	11	10	10	4	0	0	0	0	0
	11BW	0	0	0	0	0	0	0	0	0	0
	12BW	0	0	0	0	0	0	0	0	0	0
	13BW	0	0	4	0	0	0	0	2	0	2
	14BW	0	0	0	0	0	0	0	0	0	0
	15BW	1	14	13	50	34	17	27	39	26	20
	16BW	7	15	18	58	39	17	23	37	17	6
	17BW	0	0	0	0	0	0	0	0	0	0
	18BW	16	20	24	28	12	4	2	1	3	3
	19BW	0	0	0	0	0	0	0	0	0	0
	20BW	0	0	0	0	0	0	0	0	0	0
	21BW	0	0	0	0	0	0	0	0	0	0
	22BW	33	20	23	6	5	1	1	0	0	0
	23BW	12	7	7	6	7	3	8	11	15	11
	24BW	30	30	32	46	49	30	28	28	26	24
	25BW	7	2	0	0	0	0	1	1	2	0
	26BW	-	-	-	-	-	-	-	-	-	-
	27BW	-	-	-	-	-	-	-	-	-	-
	28BW	-	-	-	-	-	-	-	-	-	-

Appendix C. Continued.

County	Lek	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
		Year									
Slope	1S	17	22	14	5	18	8	16	22	20	21
	2S	0	0	0	0	0	0	0	0	0	0
	3S	2	1	2	1	0	0	0	0	4	0
	4S	22	19	23	17	14	7	5	8	11	11
	5S	19	37	44	33	31	17	20	29	28	33
	6S	3	2	0	0	0	0	2	2	0	0
	7S	0	0	0	0	0	0	0	0	0	0
	9S	0	0	0	0	0	0	0	0	0	0
	10S	0	0	0	7	6	3	2	2	3	1
	11S	0	2	3	4	5	2	8	5	13	12
	12S	0	0	0	0	0	0	0	0	0	0
	14S	6	15	16	11	9	6	5	9	10	12
	15S	9	17	19	28	9	3	12	20	27	37
	16S	11	9	10	6	10	7	1	2	4	4
	17S	9	9	7	8	2	0	0	0	0	0
	18MT	21	31	15	25	10	14	18	25	24	23
	20S	-	-	-	-	-	-	-	-	-	5
	21S	-	-	-	-	-	-	-	-	-	-
Golden Valley	8GV	0	0	0	0	0	0	0	0	0	0
	13GV	8	8	5	3	3	0	-	2	3	5
	19GV	5	3	5	5	1	0	-	3	3	1
Total Males		263	299	300	367	275	142	185	263	250	237
Total Leks		22	23	22	22	21	16	18	20	19	19
Males/Lek		12	13	14	17	13	9	10	13	13	13

Appendix C. Continued.

County	Lek	Year									
		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bowman	1BW	0	0	0	0	0	0	0	0	0	0
	2-3BW	0	0	0	0	0	0	0	0	0	0
	4BW	0	0	0	0	0	0	0	0	0	0
	5BW	0	0	0	0	0	0	0	0	0	0
	6BW	0	0	0	0	0	0	0	0	0	0
	7BW	1	2	1	0	0	0	0	0	0	0
	8BW	0	0	0	0	0	0	0	0	0	0
	9BW	0	0	0	0	0	0	0	0	0	0
	10BW	0	0	0	0	0	0	0	0	0	0
	11BW	0	0	0	0	0	0	0	0	0	0
	12BW	0	0	0	0	0	0	0	0	0	4
	13BW	0	0	0	0	0	0	0	0	0	0
	14BW	0	0	0	0	0	5	1	0	3	0
	15BW	17	13	11	6	5	6	0	0	0	2
	16BW	4	2	1	2	0	0	0	1	12	20
	17BW	0	0	0	0	0	0	0	0	0	0
	18BW	5	5	9	4	7	2	1	1	4	7
	19BW	0	0	0	0	0	0	0	0	0	0
	20BW	0	0	0	0	0	0	0	0	0	0
	21BW	0	0	0	0	0	0	0	0	0	0
	22BW	0	0	0	0	0	0	0	0	0	0
	23BW	10	5	1	0	0	0	0	0	0	0
	24BW	19	21	36	18	22	17	20	17	31	43
	25BW	0	5	14	9	6	0	5	4	4	12
	26BW	-	-	2	0	0	0	0	0	0	0
	27BW	-	-	-	-	-	-	-	-	8	16
	28BW	-	-	-	-	-	-	-	-	-	24

Appendix C. Continued.

		Year									
County	Lek	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Slope	1S	27	25	26	15	13	11	16	15	20	16
	2S	0	0	0	0	0	0	0	0	0	0
	3S	0	0	0	0	0	0	1	0	0	0
	4S	14	20	16	12	8	2	9	16	13	11
	5S	46	43	38	23	29	20	16	16	31	67
	6S	0	0	0	0	0	0	0	0	0	0
	7S	0	0	0	0	0	0	0	0	0	0
	9S	0	0	0	0	0	0	0	0	0	0
	10S	0	0	0	2	1	2	0	0	0	0
	11S	16	12	12	11	6	6	8	9	10	9
	12S	0	0	9	9	14	7	10	5	12	1
	14S	17	16	8	6	3	0	0	2	0	1
	15S	43	42	49	29	16	13	15	15	28	33
	16S	4	2	5	3	2	3	5	5	2	0
	17S	0	0	0	0	0	0	0	0	0	0
	18MT	25	22	21	15	13	9	9	10	12	12
	20S	2	3	12	0	1	3	3	3	0	0
	21S	-	-	-	5	0	0	0	0	1	0
Golden Valley	8GV	0	0	0	0	1	0	0	1	0	0
	13GV	1	2	0	0	0	0	0	0	0	0
	19GV	2	0	3	5	2	5	9	4	4	5
Total Males		253	240	274	174	149	111	128	124	195	283
Total Leks		17	17	19	17	17	15	15	16	16	17
Males/Lek		15	14	14	10	9	7	9	8	12	17

Appendix C. Continued.

County	Lek	Year 2001	Year 2002
Bowman	1BW	0	0
	2-3BW	0	0
	4BW	0	0
	5BW	0	0
	6BW	0	0
	7BW	0	0
	8BW	0	0
	9BW	0	0
	10BW	0	0
	11BW	0	0
	12BW	0	2
	13BW	0	0
	14BW	0	0
	15BW	7	9
	16BW	36	23
	17BW	0	0
	18BW	4	6
	19BW	0	0
	20BW	0	0
	21BW	0	0
	22BW	0	0
	23BW	0	0
	24BW	35	24
	25BW	3	2
	26BW	0	0
	27BW	7	2
	28BW	15	15

Appendix C. Continued.

County	Lek	Year 2001	Year 2002
Slope	1S	12	5
	2S	0	0
	3S	0	0
	4S	10	6
	5S	46	30
	6S	0	0
	7S	0	0
	9S	0	0
	10S	0	0
	11S	8	4
	12S	13	10
	14S	3	0
	15S	18	12
	16S	0	0
	17S	0	0
	18MT	13	12
	20S	0	0
	21S	0	0
Golden Valley	8GV	0	1
	13GV	0	1
	19GV	2	3
Total Males		232	167
Total Leks		16	18
Males/Lek		15	9

[a] Counts based on the maximum number of males surveyed during 2 visits (2001 and 2002 had 3 visits) during April from a vehicle or on foot from sunrise to 8:00 AM.
[b] A dash (–) denotes information not available.

Appendix D. Male sage grouse counts by lek in South Dakota during spring counts, 1972-2002[a] (Linde et al. 1975, Linde et al. 1976, Linde et al. 1977; SDGFP, unpublished data, 2002)

		Year[b]										
County	Lek	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Fall River	1FR	-	-	-	-	-	-	-	-	-	-	-
Butte	1B	-	-	13	25	16	-	-	-	-	-	-
	2B	-	-	-	14	15	-	-	-	-	-	-
	3B	-	-	-	-	-	-	-	-	-	-	-
	4B	-	-	22	18	12	-	-	-	-	-	-
	5B	-	-	45	38	31	-	-	-	-	-	-
	6B	-	-	8	2	0	-	-	-	-	-	-
	8B	-	-	-	-	-	-	-	-	-	-	-
	9B	-	-	15	9	9	-	-	-	-	-	-
	10B	-	-	22	28	31	-	-	-	-	-	-
	11B	-	-	-	-	-	-	-	-	-	-	-
	12B	-	-	-	-	-	-	-	-	-	-	-
	13B	-	-	-	-	-	-	-	-	-	-	-
	14B	-	-	33	22	17	-	-	-	-	-	-
	15B	-	-	-	-	-	-	-	-	-	-	-
Harding	1H	-	-	3	-	-	-	-	-	-	-	-
	2H	-	-	8	-	-	-	-	-	-	-	-
	3H	-	-	-	-	-	-	-	-	-	-	-
	4H	-	-	-	-	-	-	-	-	-	-	-
	5H	-	-	6	-	-	-	-	-	-	-	-
	6H	-	-	1	-	-	-	-	-	-	-	-
	7H	-	-	-	-	-	-	-	-	-	-	-
	8H	-	-	-	-	-	-	-	-	-	-	-
	9H	-	-	-	-	-	-	-	-	-	-	-
	10H	-	-	-	-	-	-	-	-	-	-	-
Total Males		99	201	176	156	200	238	202	156	100	129	100
Leks		5	7	11	8	13	17	15	11	7	7	6
Males/Lek		20	29	16	20	15	14	13	14	14	18	17

Appendix D. Continued.

		Year										
County	Lek	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Fall River	1FR	-	-	-	-	-	-	-	-	17	7	4
Butte	1B	-	-	-	-	-	-	-	-	-	0	0
	2B	-	-	-	-	-	-	-	-	-	0	0
	3B	-	-	-	-	-	-	-	-	-	0	0
	4B	-	-	-	-	-	-	-	-	-	5	0
	5B	-	-	-	-	-	-	-	-	-	11	12
	6B	-	-	-	-	-	-	-	-	-	0	0
	8B	-	-	-	-	-	-	-	-	-	6	-
	9B	-	-	-	-	-	-	-	-	-	0	0
	10B	-	-	-	-	-	-	-	-	-	27	24
	11B	-	-	-	-	-	-	-	-	-	5	6
	12B	-	-	-	-	-	-	-	-	-	6	4
	13B	-	-	-	-	-	-	-	-	-	8	5
	14B	-	-	-	-	-	-	-	-	-	-	-
	15B	-	-	-	-	-	-	-	-	-	-	-
Harding	1H	-	-	-	-	-	-	14	16	-	11	7
	2H	-	-	-	-	-	-	21	28	-	17	15
	3H	-	-	-	-	-	-	16	18	-	15	16
	4H	-	-	-	-	-	-	11	8	-	4	5
	5H	-	-	-	-	-	-	23	25	-	35	29
	6H	-	-	-	-	-	-	-	3	-	1	3
	7H	-	-	-	-	-	-	-	-	-	27	22
	8H	-	-	-	-	-	-	-	-	-	27	24
	9H	-	-	-	-	-	-	-	-	-	9	11
	10H	-	-	-	-	-	-	-	-	-	-	21
Total Males		75	115	74	41	43	54	127	136	208	221	214
Leks		5	7	7	7	4	4	9	10	19	17	9
Males/Lek		15	16	11	6	11	14	14	14	11	13	24

Appendix D. Continued.

County	Lek	1994	1995	1996	1997	1998	1999	2000	2001	2002
						Year				
Fall River	1FR	2	6	7	9	11	12	9	8	4
Butte	1B	-	0	0	0	0	0	0	0	0
	2B	-	0	0	0	0	0	0	0	0
	3B	-	0	0	0	0	0	0	0	0
	4B	-	0	0	0	0	0	0	0	0
	5B	-	6	0	3	7	11	11	17	16
	6B	-	0	0	0	0	0	0	0	0
	8B	-	0	0	0	0	0	0	0	0
	9B	-	0	0	0	0	0	0	1	0
	10B	-	7	-	14	14	22	23	7	4
	11B	-	4	1	0	8	6	7	8	6
	12B	-	0	0	0	1	0	0	0	0
	13B	-	2	1	6	3	9	34	21	26
	14B	-	0	0	0	0	0	0	0	0
	15B	-	0	0	0	5	0	0	29	21
Harding	1H	4	-	-	-	-	-	-	0	0
	2H	12	-	-	-	-	-	-	12	9
	3H	18	-	-	-	-	-	-	15	12
	4H	0	-	-	-	-	-	-	0	0
	5H	16	-	-	-	-	-	-	14	12
	6H	0	-	-	-	-	-	-	0	0
	7H	23	-	-	-	-	-	-	14	11
	8H	25	-	-	-	-	-	-	0	12
	9H	4	-	-	-	-	-	-	0	0
	10H	26	-	-	-	-	-	-	14	9
Total Males		130	124	88	82	129	60	84	160	142
Leks		9	13	10	15	12	5	5	11	12
Males/Lek		14	10	9	5	11	12	17	15	12

[a] Counts based on the maximum number of males surveyed during 2 visits (2001 and 2002 had 3 visits) during April from a vehicle, airplane, or on foot from sunrise to 8:00 AM

[b] A dash (-) denotes information not available.

Appendix E. Sage grouse harvest in North Dakota, 1964-2002 (NDGF, unpublished data, 2002).

	Adult Male	Adult Female	Immature Male	Immature Female		
Year[a]	Total (%)	Total (%)	Total (%)	Total (%)	Total	Age Ratio[b]
1964	16 (62)	4 (15)	3 (12)	3 (12)	26	0.30
1965	6 (32)	6 (32)	3 (16)	4 (21)	19	0.58
1966	2 (6)	5 (15)	14 (43)	12 (36)	33	3.71
1967	12 (20)	20 (33)	11 (18)	17 (28)	60	0.88
1968	13 (21)	11 (18)	19 (31)	18 (30)	61	1.54
1969	15 (23)	22 (34)	11 (17)	16 (25)	64	0.73
1970	11 (16)	18 (27)	28 (42)	10 (15)	67	1.31
1971	20 (26)	13 (17)	20 (26)	24 (31)	77	1.33
1972	20 (17)	28 (24)	37 (32)	31 (27)	116	1.42
1973	6 (9)	27 (41)	14 (21)	19 (29)	66	1.00
1974	5 (8)	19 (32)	10 (17)	26 (43)	60	1.50
1975	21 (32)	17 (26)	14 (21)	14 (21)	66	0.74
1976	4 (10)	12 (31)	13 (33)	10 (26)	39	1.44
1977	13 (62)	3 (14)	2 (10)	3 (14)	21	0.31
1978	2 (4)	19 (41)	15 (33)	10 (22)	46	1.19
1979[c]	-	-	-	-	-	-
1980	5 (24)	15 (71)	1 (5)	0 (0)	21	0.05
1981	4 (13)	6 (20)	13 (43)	7 (23)	30	2.00
1982	5 (12)	18 (42)	9 (21)	11 (26)	43	0.87
1983	6 (9)	20 (28)	20 (28)	25 (35)	71	1.73
1984	11 (22)	15 (31)	11 (22)	12 (25)	49	0.88
1985	1 (17)	1 (17)	2 (33)	2 (33)	6	2.00
1986	4 (12)	7 (21)	10 (30)	12 (36)	33	2.00
1987	3 (17)	6 (33)	4 (22)	5 (28)	18	1.00
1988[d]	-	-	-	-	-	-

Appendix E. Continued.

	Adult Male	Adult Female	Immature Male	Immature Female		
Year	Total (%)	Total (%)	Total (%)	Total (%)	Total	Age Ratio
1989	6 (22)	11 (41)	6 (22)	4 (15)	27	0.59
1990	0 (0)	3 (23)	2 (15)	8 (62)	13	3.33
1991	5 (31)	3 (19)	7 (44)	1 (6)	16	1.00
1992	7 (32)	7 (32)	7 (32)	1 (4)	22	0.57
1993	5 (36)	5 (36)	2 (14)	2 (14)	14	0.40
1994	3 (38)	2 (25)	1 (12)	2 (25)	8	0.60
1995	3 (20)	4 (27)	6 (40)	2 (13)	15	1.14
1996	3 (11)	7 (26)	8 (30)	9 (33)	27	1.70
1997	3 (13)	6 (25)	6 (25)	9 (37)	24	1.67
1998	4 (14)	8 (28)	9 (31)	8 (28)	29	1.42
1999	1 (4)	8 (33)	8 (33)	7 (29)	24	1.67
2000	4 (7)	23 (41)	14 (25)	15 (27)	56	1.07
2001	2 (10)	14 (70)	2 (10)	2 (10)	35	0.25
2002[e]	1 (3)	16 (53)	6 (20)	7 (24)	-	0.76
Total	252 (18)	429 (29)	368 (26)	368 (26)	1402	1.08

[a] 1964 was the first season since 1922.
[b] Ratio of immature sage grouse to adult sage grouse.
[c] No season this year.
[d] Season was limited this year to a single half-day due to drought and no wings were collected.
[e] No total available at time of thesis completion.

Appendix F. Sage grouse harvest in South Dakota, 1955, 1979, and 2000-2002 (Podoll 1957, Crouch et al. 1980; SDGFP, unpublished data, 2001).

	Adult Male[d]	Adult Female	Immature Male	Immature Female		
Year[abc]	Total (%)	Total (%)	Total (%)	Total (%)	Total	Age Ratio[e]
1955	-	-	-	-	33	-
1979	-	-	-	-	13	1.75
2000	6 (23)	1 (4)	10 (42)	7 (31)	24	2.43
2001	5 (41)	2 (17)	2 (17)	3 (25)	12	0.71
2002	1 (8)	3 (25)	5 (42)	3 (25)	16	2.00
Total	12 (25)	6 (13)	17 (35)	13 (27)	98	1.67

[a] 1955 was first season since 1935.
[b] 2000 was first season since 1979.
[c] No information available on any harvest years between 1955 and 1979.
[d] A dash (-) indicates information not available.
[e] Ratio of immature sage grouse to adult sage grouse; Total age ratio was calculated from years with available sex and age data.

Appendix G. All known active and inactive greater sage grouse lek locations in North Dakota and South Dakota, 2002.

			UTM[a]	
State	County	Lek	X	Y
North Dakota	Bowman	1BW	593292	5120173
		2-3BW	594202	5115408
		4BW	595073	5111489
		5BW	595997	5108240
		6BW	596761	5103469
		7BW	589690	5099231
		8BW	604217	5098755
		9BW	601887	5090593
		10BW	597113	5088851
		11BW	599107	5110665
		12BW	593191	5122774
		13BW	578391	5094191
		14BW	583316	5092720
		15BW	575189	5099930
		16BW	578692	5106534
		17BW	585488	5108094
		18BW	590759	5114700
		19BW	591303	5093620
		20BW	593611	5101781
		21BW	586299	5112927
		22BW	574319	5098313
		23BW	576928	5093534
		24BW	574230	5115192
		25BW	580406	5119524
		26BW	581224	5125430
		27BW	575203	5122194
		28BW	573401	5122890
	Slope	1S	588683	5131731
		2S	594234	5132486
		3S	590124	5137393
		4S	590561	5128429
		5S	578208	5136816
		6S	594052	5148648
		7S	594010	5151836
		9S	589914	5150284
		10S	589956	5148648
		11S	582843	5142358
		12S	581818	5150186

Appendix G. Continued.

State	County	Lek	UTM X	UTM Y
North Dakota	Slope	14S	577232	5141126
		15S	574353	5146873
		16S	592976	5142552
		17S	580644	5129941
		18MT	572522	5135492
		20S	578757	5147628
		21S	573891	5153961
	Golden Valley	8GV	584992	5158211
		13GV	582148	5156080
		19GV	579567	5158127
South Dakota	Harding	1H	637155	5029504
		2H	583877	5043130
		3H	580533	5065648
		4H	591719	5067384
		5H	596757	5044727
		6H	601286	5057816
		7H	599666	5061000
		8H	632286	5032649
		9H	579000	5033369
		10H	641741	5016833
	Butte	1B	594736	4980169
		2B	604944	5001647
		3B	599523	4986753
		4B	612623	4977981
		5B	606336	5006862
		6B	587317	4996578
		8B	635507	4993017
		9B	587883	4963875
		10B	581423	4968646
		11B	580877	4956628
		12B	605186	4982069
		13B	594640	4989793
		14B	589581	4982216
		15B	583428	4972244
	Fall River	1FR	581630	4796587

[a] Locations are in projection UTM Clarke 1866 NAD27 Zone 13.

Appendix H. Selected microhabitat survey information from lek sites and sample sites within 1.5-km buffer of North Dakota, South Dakota, and Montana greater sage grouse leks, 2001 and 2002[a].

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek[b]	Site[c]	X	Y	Big[d]	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	ND	Bowman	2-3BW	1	593702	5116407	0.00	5.00	0.00	0.40	90.00	5.00	0.00
2001	ND	Bowman	2-3BW	2	594702	5116407	-	-	-	-	-	-	-
2001	ND	Bowman	2-3BW	3	593202	5115907	0.00	1.00	0.00	0.13	13.33	0.00	0.00
2001	ND	Bowman	2-3BW	4	594202	5115907	1.00	0.00	0.39	0.09	10.00	0.00	0.00
2001	ND	Bowman	2-3BW	5	595202	5115907	-	-	-	-	-	-	-
2001	ND	Bowman	2-3BW	6	593702	5115407	2.00	1.00	0.14	0.17	45.00	5.00	0.00
2001	ND	Bowman	2-3BW	7	594702	5115407	-	-	-	-	-	-	-
2001	ND	Bowman	2-3BW	8	593202	5114907	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	ND	Bowman	2-3BW	9	594202	5114907	-	-	-	-	-	-	-
2001	ND	Bowman	2-3BW	10	595202	5114907	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	ND	Bowman	2-3BW	11	593702	5114407	4.00	0.00	0.48	0.05	20.00	0.00	0.00
2001	ND	Bowman	2-3BW	12	594702	5114407	2.00	0.00	0.40	0.00	75.00	0.00	0.00
2001	ND	Bowman	7BW	1	589190	5100231	0.00	0.00	0.01	0.00	10.00	10.00	0.00
2001	ND	Bowman	7BW	2	590190	5100231	0.00	1.00	0.00	0.24	55.00	10.00	5.00
2001	ND	Bowman	7BW	3	588690	5099731	0.00	1.00	0.00	0.08	90.00	20.00	0.00
2001	ND	Bowman	7BW	4	589690	5099731	3.00	0.00	0.58	0.09	70.00	15.00	0.00
2001	ND	Bowman	7BW	5	590690	5099731	0.00	1.00	0.01	0.20	70.00	20.00	0.00
2001	ND	Bowman	7BW	6	589190	5099231	3.00	4.00	0.30	0.60	75.00	20.00	0.00
2001	ND	Bowman	7BW	7	590190	5099231	-	-	-	-	-	-	-
2001	ND	Bowman	7BW	8	588690	5098731	0.00	2.00	0.00	0.59	60.00	30.00	10.00
2001	ND	Bowman	7BW	9	589690	5098731	0.00	6.00	0.00	0.83	80.00	25.00	5.00
2001	ND	Bowman	7BW	10	590690	5098731	1.00	3.00	0.25	0.71	90.00	30.00	5.00
2001	ND	Bowman	7BW	11	589190	5098231	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	ND	Bowman	7BW	12	590190	5098231	-	-	-	-	-	-	-
2001	ND	Bowman	15BW	LEK	575189	5099930	4.00	0.00	0.63	0.00	50.00	0.00	0.00
2001	ND	Bowman	15BW	1	574689	5100930	0.00	0.00	0.02	0.00	15.00	0.00	0.00
2001	ND	Bowman	15BW	2	575689	5100930	3.00	0.00	0.74	0.00	45.00	0.00	0.00
2001	ND	Bowman	15BW	3	574189	5100430	0.00	0.00	0.11	0.00	90.00	0.00	0.00
2001	ND	Bowman	15BW	4	575189	5100430	-	-	-	-	-	-	-
2001	ND	Bowman	15BW	5	576189	5100430	1.00	0.00	0.05	0.00	80.00	0.00	0.00
2001	ND	Bowman	15BW	6	574689	5099930	2.00	1.00	0.24	0.21	75.00	5.00	0.00
2001	ND	Bowman	15BW	7	575689	5099930	3.00	0.00	0.67	0.00	80.00	0.00	0.00
2001	ND	Bowman	15BW	8	574189	5099430	0.00	2.00	0.00	0.23	40.00	5.00	0.00
2001	ND	Bowman	15BW	9	575189	5099430	2.00	1.00	0.62	0.30	65.00	10.00	0.00
2001	ND	Bowman	15BW	10	576189	5099430	2.00	0.00	0.58	0.01	75.00	10.00	0.00
2001	ND	Bowman	15BW	11	574689	5098930	0.00	2.00	0.00	0.38	25.00	0.00	0.00
2001	ND	Bowman	15BW	12	575689	5098930	0.00	5.00	0.00	0.59	55.00	10.00	10.00

Appendix H. Continuation of sites on page 146.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
2-3BW	1	0.00	39.26	13.35	5.93	33.18	1.83	71.50	
2-3BW	2	-	-	-	-	-	-	-	Western wheatgrass/alfalfa hayfield
2-3BW	3	0.00	35.75	10.70	2.57	40.90	41.50	19.67	
2-3BW	4	25.58	30.00	7.00	2.75	24.65	54.45	25.00	
2-3BW	5	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
2-3BW	6	25.50	31.81	11.38	7.38	32.93	11.50	64.50	
2-3BW	7	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
2-3BW	8	0.00	0.00	7.55	0.45	41.88	11.90	59.83	
2-3BW	9	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
2-3BW	10	0.00	0.00	19.00	6.00	100.00	0.00	0.00	
2-3BW	11	22.14	43.33	7.00	3.78	17.68	63.93	20.23	
2-3BW	12	21.64	32.00	11.85	3.40	46.55	4.90	57.13	
7BW	1	23.00	0.00	0.18	0.05	0.48	98.25	1.30	
7BW	2	0.00	28.80	12.78	5.00	28.85	28.65	49.43	
7BW	3	47.00	31.50	13.65	8.00	53.55	23.10	25.28	
7BW	4	24.04	21.50	10.23	2.30	33.73	15.95	57.20	
7BW	5	20.00	25.84	13.90	5.35	32.68	26.83	47.35	
7BW	6	24.00	32.87	11.48	7.00	22.43	12.70	68.18	
7BW	7	-	-	-	-	-	-	-	Wheat field
7BW	8	0.00	32.31	14.33	7.33	33.23	22.15	44.05	
7BW	9	0.00	38.94	14.23	7.45	45.15	20.38	39.63	
7BW	10	19.83	28.70	13.00	5.03	34.13	5.10	71.68	
7BW	11	0.00	0.00	0.00	0.00	0.00	99.92	0.08	
7BW	12	-	-	-	-	-	-	-	Wheat field
15BW	LEK	14.08	0.00	8.38	9.05	31.50	59.15	11.23	
15BW	1	18.67	0.00	9.60	4.90	18.40	75.68	11.15	
15BW	2	11.00	0.00	8.00	1.73	13.03	80.00	9.65	
15BW	3	18.00	0.00	16.95	15.93	40.53	33.15	29.83	
15BW	4	-	-	-	-	-	-	-	Stock dam
15BW	5	23.93	13.00	15.03	11.55	41.00	45.98	20.08	
15BW	6	30.50	33.81	22.80	11.13	58.43	5.88	44.75	
15BW	7	12.72	0.00	9.48	6.53	37.75	51.05	14.43	
15BW	8	0.00	39.92	19.18	12.60	54.05	18.60	30.00	
15BW	9	16.45	29.05	7.23	2.13	30.28	33.78	40.98	
15BW	10	18.62	0.00	8.38	6.23	29.25	51.28	24.03	
15BW	11	0.00	24.78	13.40	8.53	45.48	5.38	65.50	
15BW	12	50.00	43.13	8.68	11.25	41.95	8.60	52.70	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	ND	Bowman	22BW	1	573818	5099313	0.00	0.00	0.00	0.11	95.00	15.00	5.00
2001	ND	Bowman	22BW	2	574818	5099313	0.00	5.00	0.08	0.71	80.00	20.00	0.00
2001	ND	Bowman	22BW	3	573318	5098813	0.00	3.00	0.00	0.18	0.00	0.00	0.00
2001	ND	Bowman	22BW	4	574318	5098813	1.00	7.00	0.27	0.49	40.00	15.00	5.00
2001	ND	Bowman	22BW	5	575318	5098813	0.00	7.00	0.02	1.01	70.00	30.00	5.00
2001	ND	Bowman	22BW	6	573818	5098313	0.00	10.00	0.00	0.88	95.00	60.00	10.00
2001	ND	Bowman	22BW	7	574818	5098313	0.00	2.00	0.00	0.21	0.00	0.00	0.00
2001	ND	Bowman	22BW	8	573318	5097813	0.00	0.00	0.00	0.05	20.00	0.00	0.00
2001	ND	Bowman	22BW	9	574318	5097813	0.00	8.00	0.00	1.00	65.00	20.00	10.00
2001	ND	Bowman	22BW	10	575318	5097813	0.00	4.00	0.00	0.77	50.00	10.00	0.00
2001	ND	Bowman	22BW	11	573818	5097313	0.00	1.00	0.00	0.19	45.00	0.00	0.00
2001	ND	Bowman	22BW	12	574818	5097313	0.00	3.00	0.00	0.62	35.00	0.00	0.00
2001	ND	Bowman	24BW	LEK	574230	5115192	3.00	0.00	0.66	0.00	40.00	0.00	0.00
2001	ND	Bowman	24BW	1	573730	5116192	3.00	1.00	0.64	0.14	40.00	0.00	0.00
2001	ND	Bowman	24BW	2	574730	5116192	4.00	0.00	0.70	0.00	45.00	0.00	0.00
2001	ND	Bowman	24BW	3	573230	5115692	2.00	0.00	0.24	0.01	95.00	20.00	0.00
2001	ND	Bowman	24BW	4	574230	5115692	4.00	0.00	0.65	0.06	70.00	15.00	0.00
2001	ND	Bowman	24BW	5	575230	5115692	3.00	0.00	1.06	0.00	100.00	5.00	0.00
2001	ND	Bowman	24BW	6	573730	5115192	1.00	0.00	0.50	0.00	60.00	5.00	0.00
2001	ND	Bowman	24BW	7	574230	5115192	5.00	0.00	0.92	0.00	85.00	0.00	0.00
2001	ND	Bowman	24BW	8	573230	5114692	0.00	0.00	0.00	0.00	30.00	10.00	0.00
2001	ND	Bowman	24BW	9	574230	5114692	2.00	0.00	0.72	0.00	45.00	0.50	0.00
2001	ND	Bowman	24BW	10	575230	5114692	5.00	0.00	1.37	0.00	70.00	5.00	0.00
2001	ND	Bowman	24BW	11	573730	5114192	0.00	0.00	0.00	0.00	30.00	0.00	0.00
2001	ND	Bowman	24BW	12	574730	5114192	3.00	0.00	0.84	0.00	100.00	5.00	0.00
2001	ND	Bowman	25BW	LEK	580406	5119524	5.00	1.00	1.14	0.08	40.00	15.00	0.00
2001	ND	Bowman	25BW	1	579906	5120524	0.00	6.00	0.00	0.99	75.00	35.00	10.00
2001	ND	Bowman	25BW	2	580906	5120524	-	-	-	-	-	-	-
2001	ND	Bowman	25BW	3	579406	5120024	0.00	0.00	0.00	0.08	75.00	5.00	0.00
2001	ND	Bowman	25BW	4	580406	5120024	1.00	0.00	0.05	0.31	85.00	10.00	0.00
2001	ND	Bowman	25BW	5	581406	5120024	0.00	0.00	0.07	0.06	40.00	5.00	0.00
2001	ND	Bowman	25BW	6	579906	5119524	0.00	3.00	0.00	0.33	55.00	30.00	0.00
2001	ND	Bowman	25BW	7	580906	5119524	0.00	1.00	0.02	0.11	70.00	5.00	0.00
2001	ND	Bowman	25BW	8	579406	5119024	0.00	0.00	0.00	0.06	50.00	0.00	0.00
2001	ND	Bowman	25BW	9	580406	5119024	0.00	1.00	0.00	0.22	55.00	35.00	5.00
2001	ND	Bowman	25BW	10	581406	5119024	0.00	1.00	0.00	0.09	30.00	0.00	0.00
2001	ND	Bowman	25BW	11	579906	5118524	-	-	-	-	-	-	-
2001	ND	Bowman	25BW	12	580906	5118524	0.00	1.00	0.00	0.23	65.00	10.00	0.00

Appendix H. Continuation of sites on page 148.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
22BW	1	0.00	32.17	16.53	1.60	47.25	33.08	26.48	
22BW	2	29.09	30.85	11.83	8.23	53.65	6.88	45.88	
22BW	3	0.00	38.00	2.30	1.25	3.03	87.38	10.73	
22BW	4	22.67	29.59	8.58	7.68	27.18	5.95	83.60	
22BW	5	29.00	29.82	10.08	12.08	54.43	4.50	43.43	
22BW	6	0.00	41.28	13.88	16.20	43.30	8.60	66.95	
22BW	7	0.00	40.61	10.15	4.30	38.30	40.73	23.68	
22BW	8	0.00	32.58	5.47	1.47	15.08	80.42	7.55	
22BW	9	0.00	36.37	9.93	7.65	41.63	4.95	65.75	
22BW	10	0.00	25.73	6.40	4.48	17.13	35.40	52.03	
22BW	11	0.00	27.83	8.15	1.80	34.15	46.63	25.98	
22BW	12	0.00	33.97	12.38	7.08	44.53	9.60	59.00	
24BW	LEK	17.62	0.00	9.60	7.30	27.88	11.05	74.90	
24BW	1	24.37	26.58	9.18	9.53	22.15	5.43	81.68	
24BW	2	14.94	0.00	9.88	3.15	24.20	60.75	19.68	
24BW	3	26.64	20.00	15.60	11.95	30.00	52.78	24.50	
24BW	4	30.70	37.67	13.10	14.38	44.03	4.58	57.20	
24BW	5	21.38	0.00	14.88	8.43	48.88	32.95	33.83	
24BW	6	21.59	45.00	14.18	7.38	33.23	56.13	18.50	
24BW	7	20.32	0.00	13.43	12.60	45.23	37.00	22.98	
24BW	8	0.00	0.00	4.73	3.28	5.98	92.10	1.00	
24BW	9	16.43	0.00	8.25	3.28	46.38	21.73	41.75	
24BW	10	17.59	0.00	12.50	6.05	34.60	62.08	12.78	
24BW	11	14.00	0.00	5.50	3.25	15.78	82.00	4.55	
24BW	12	21.81	0.00	11.00	25.75	36.55	41.30	13.50	
25BW	LEK	21.03	31.50	8.18	10.83	18.83	34.28	44.55	
25BW	1	0.00	33.75	11.43	18.18	36.75	7.58	52.93	
25BW	2	-	-	-	-	-	-	-	Camp Crook road/pasture approach intersection
25BW	3	0.00	21.60	11.78	5.48	41.78	3.58	68.63	
25BW	4	28.10	19.20	10.70	7.28	32.05	32.45	54.18	
25BW	5	26.18	32.17	8.93	2.48	31.30	61.38	16.53	
25BW	6	0.00	28.35	10.30	22.70	40.18	12.30	58.75	
25BW	7	12.50	35.27	15.63	12.23	40.70	16.38	43.70	
25BW	8	0.00	28.20	15.45	9.18	51.38	9.43	47.50	
25BW	9	0.00	48.14	23.73	7.67	38.73	49.17	17.80	
25BW	10	12.00	26.61	2.50	1.15	2.50	91.95	2.35	
25BW	11	-	-	-	-	-	-	-	Steep slope (80-90°) uninhabitable territory
25BW	12	0.00	32.17	16.53	1.60	47.25	33.08	26.48	

Appendix. Continued

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	ND	Bowman	27BW	LEK	575203	5122194	-	-	-	-	-	-	-
2001	ND	Bowman	27BW	1	574703	5123194	0.00	0.00	0.06	0.01	15.00	0.00	0.00
2001	ND	Bowman	27BW	2	575703	5123194	1.00	0.00	0.16	0.04	35.00	5.00	0.00
2001	ND	Bowman	27BW	3	574203	5122694	5.00	0.00	0.86	0.01	55.00	5.00	0.00
2001	ND	Bowman	27BW	4	575203	5122694	6.00	0.00	1.31	0.00	35.00	5.00	0.00
2001	ND	Bowman	27BW	5	576203	5122694	0.00	0.00	0.02	0.00	100.00	60.00	15.00
2001	ND	Bowman	27BW	6	574703	5122194	2.00	1.00	0.36	0.06	20.00	0.00	0.00
2001	ND	Bowman	27BW	7	575703	5122194	-	-	-	-	-	-	-
2001	ND	Bowman	27BW	8	574203	5121694	1.00	5.00	0.16	0.56	65.00	15.00	0.00
2001	ND	Bowman	27BW	9	575203	5121694	8.00	10.00	1.01	0.66	75.00	45.00	25.00
2001	ND	Bowman	27BW	10	576203	5121694	1.00	0.00	0.14	0.03	100.00	15.00	0.00
2001	ND	Bowman	27BW	11	574703	5121194	0.00	0.00	0.00	0.00	55.00	0.00	0.00
2001	ND	Bowman	27BW	12	575703	5121194	3.00	0.00	1.05	0.10	35.00	0.00	0.00
2001	ND	Bowman	28BW	LEK	573401	5122890	0.00	0.00	0.34	0.00	0.00	0.00	0.00
2001	ND	Bowman	28BW	1	572901	5123890	0.00	0.00	0.07	0.00	10.00	0.00	0.00
2001	ND	Bowman	28BW	2	573901	5123890	1.00	0.00	0.39	0.00	60.00	0.00	0.00
2001	ND	Bowman	28BW	3	572401	5123390	1.00	0.00	0.36	0.00	45.00	0.00	0.00
2001	ND	Bowman	28BW	4	573401	5123390	1.00	0.00	0.24	0.04	85.00	5.00	0.00
2001	ND	Bowman	28BW	5	574401	5123390	0.00	0.00	0.02	0.00	75.00	0.00	0.00
2001	ND	Bowman	28BW	6	572901	5122890	0.00	0.00	0.05	0.00	0.00	0.00	0.00
2001	ND	Bowman	28BW	7	573901	5122890	2.00	0.00	0.46	0.00	95.00	0.00	0.00
2001	ND	Bowman	28BW	8	572401	5122390	3.00	2.00	0.32	0.13	70.00	10.00	0.00
2001	ND	Bowman	28BW	9	573401	5122390	10.00	0.00	1.40	0.00	90.00	5.00	0.00
2001	ND	Bowman	28BW	10	574401	5122390	2.00	0.00	0.28	0.03	70.00	0.00	0.00
2001	ND	Bowman	28BW	11	572901	5121890	3.00	0.00	0.83	0.00	55.00	0.00	0.00
2001	ND	Bowman	28BW	12	573901	5121890	4.00	0.00	0.31	0.07	90.00	20.00	0.00
2001	ND	Slope	1S	LEK	588683	5131731	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	ND	Slope	1S	1	588183	5132731	1.00	1.00	0.15	0.25	100.00	35.00	10.00
2001	ND	Slope	1S	2	589183	5132731	1.00	1.00	0.19	0.15	40.00	15.00	0.00
2001	ND	Slope	1S	3	587683	5132231	1.00	1.00	0.33	0.15	90.00	20.00	10.00
2001	ND	Slope	1S	4	588683	5132231	0.00	0.00	0.05	0.01	30.00	0.00	0.00
2001	ND	Slope	1S	5	589683	5132231	0.00	0.00	0.05	0.00	35.00	0.00	0.00
2001	ND	Slope	1S	6	588183	5131731	0.00	0.00	0.00	0.03	100.00	0.00	0.00
2001	ND	Slope	1S	7	589183	5131731	0.00	1.00	0.02	0.13	70.00	5.00	0.00
2001	ND	Slope	1S	8	587683	5131231	0.00	0.00	0.06	0.02	100.00	0.00	0.00
2001	ND	Slope	1S	9	588683	5131231	0.00	0.00	0.01	0.00	0.00	0.00	0.00
2001	ND	Slope	1S	10	589683	5131231	4.00	0.00	0.41	0.07	60.00	5.00	0.00
2001	ND	Slope	1S	11	588183	5130731	0.00	3.00	0.05	0.22	95.00	20.00	5.00
2001	ND	Slope	1S	12	589183	5130731	0.00	0.00	0.16	0.05	95.00	0.00	0.00

Appendix H. Continuation of sites on page 150.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
27BW	LEK	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
27BW	1	29.14	0.00	8.55	16.33	22.45	0.75	82.88	
27BW	2	27.50	27.67	13.47	16.20	60.33	13.83	30.50	
27BW	3	21.85	17.00	10.28	3.00	32.58	29.25	58.60	
27BW	4	16.59	0.00	8.78	15.55	38.73	23.45	38.55	
27BW	5	43.25	31.00	24.97	22.97	60.69	6.69	36.25	
27BW	6	24.52	27.75	8.33	6.40	56.53	12.83	32.00	
27BW	7	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
27BW	8	34.00	39.35	14.48	14.68	45.03	4.58	45.75	
27BW	9	21.14	55.10	18.58	6.67	32.83	48.81	28.11	
27BW	10	34.43	35.25	23.45	30.78	38.83	10.38	53.55	
27BW	11	22.00	0.00	14.38	7.35	29.58	10.38	73.48	
27BW	12	14.11	36.13	12.20	6.10	37.30	35.93	30.50	
28BW	LEK	7.42	0.00	8.00	7.03	9.43	86.80	2.48	
28BW	1	28.00	0.00	9.28	14.48	20.15	1.63	84.80	
28BW	2	24.69	28.00	14.50	25.48	34.80	17.48	39.58	
28BW	3	20.27	36.00	11.95	11.58	18.75	64.40	18.75	
28BW	4	24.97	19.75	11.63	6.68	43.60	19.38	47.75	
28BW	5	33.71	0.00	12.35	19.60	39.98	1.88	66.25	
28BW	6	18.70	0.00	7.63	4.05	15.80	83.50	3.65	
28BW	7	24.75	0.00	11.38	14.63	26.60	61.63	10.28	
28BW	8	27.75	46.42	11.89	23.47	23.53	8.31	67.64	
28BW	9	15.82	0.00	7.05	8.54	19.57	71.24	6.05	
28BW	10	25.19	26.80	12.23	8.38	53.88	34.00	16.85	
28BW	11	16.49	0.00	10.10	7.85	30.05	17.18	63.73	
28BW	12	39.54	33.20	22.80	22.90	50.30	7.40	39.63	
1S	LEK	0.00	0.00	7.53	4.88	26.45	9.18	75.30	
1S	1	27.50	31.81	16.53	13.03	37.73	20.05	52.00	
1S	2	24.40	35.92	11.55	4.35	46.93	3.65	61.00	
1S	3	39.07	43.83	12.35	3.85	26.25	60.85	24.50	
1S	4	17.18	19.00	10.50	3.98	58.98	4.65	46.75	
1S	5	23.63	0.00	9.33	15.90	37.98	4.13	58.05	
1S	6	0.00	25.40	17.83	8.63	63.50	0.75	49.50	
1S	7	27.21	32.27	11.23	10.85	39.03	5.18	65.43	
1S	8	29.50	27.00	13.10	4.73	37.88	11.80	63.18	
1S	9	27.83	0.00	14.50	14.63	42.50	5.38	63.55	
1S	10	31.23	36.00	12.23	13.60	35.90	2.35	65.20	
1S	11	38.67	49.72	17.55	8.38	41.13	11.18	60.63	
1S	12	20.67	51.71	15.33	8.63	40.60	28.33	41.60	

Appendix H. Contiunued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	ND	Slope	2S	1	593733	5133486	0.00	0.00	0.03	0.02	55.00	0.00	0.00
2001	ND	Slope	2S	2	594733	5133486	-	-	-	-	-	-	-
2001	ND	Slope	2S	3	593233	5132986	0.00	0.00	0.00	0.00	85.00	45.00	0.00
2001	ND	Slope	2S	4	594233	5132986	0.00	0.00	0.03	0.00	30.00	0.00	0.00
2001	ND	Slope	2S	5	595233	5132986	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	ND	Slope	2S	6	593733	5132486	-	-	-	-	-	-	-
2001	ND	Slope	2S	7	594733	5132486	0.00	0.00	0.05	0.00	40.00	0.00	0.00
2001	ND	Slope	2S	8	593233	5131986	0.00	0.00	0.01	0.05	75.00	0.00	0.00
2001	ND	Slope	2S	9	594233	5131986	1.00	0.00	0.14	0.00	65.00	0.00	0.00
2001	ND	Slope	2S	10	595233	5131986	4.00	0.00	0.95	0.00	85.00	0.00	0.00
2001	ND	Slope	2S	11	593733	5131486	0.00	0.00	0.01	0.07	40.00	5.00	0.00
2001	ND	Slope	2S	12	594733	5131486	0.00	0.00	0.05	0.00	45.00	0.00	0.00
2001	ND	Slope	14S	LEK	577232	5141126	3.00	0.00	0.30	0.00	65.00	10.00	0.00
2001	ND	Slope	14S	1	576732	5142126	-	-	-	-	-	-	-
2001	ND	Slope	14S	2	577732	5142126	0.00	0.00	0.00	0.00	5.00	0.00	0.00
2001	ND	Slope	14S	3	576232	5141626	-	-	-	-	-	-	-
2001	ND	Slope	14S	4	577232	5141626	5.00	0.00	0.60	0.09	100.00	40.00	15.00
2001	ND	Slope	14S	5	578232	5141626	0.00	2.00	0.01	0.71	70.00	10.00	0.00
2001	ND	Slope	14S	6	576732	5141126	4.00	3.00	0.18	0.38	60.00	20.00	0.00
2001	ND	Slope	14S	7	577732	5141126	9.00	1.00	0.57	0.06	95.00	55.00	30.00
2001	ND	Slope	14S	8	576232	5140626	7.00	0.00	0.36	0.01	45.00	30.00	10.00
2001	ND	Slope	14S	9	577232	5140626	3.00	5.00	0.14	0.26	0.00	0.00	0.00
2001	ND	Slope	14S	10	578232	5140626	0.00	4.00	0.01	0.44	100.00	30.00	0.00
2001	ND	Slope	14S	11	576732	5140126	4.00	0.00	0.45	0.02	80.00	45.00	10.00
2001	ND	Slope	14S	12	577732	5140126	0.00	7.00	0.05	0.52	65.00	25.00	10.00
2001	ND	Slope	20S	1	578256	5148627	0.00	2.00	0.00	0.29	75.00	0.00	0.00
2001	ND	Slope	20S	2	579256	5148627	-	-	-	-	-	-	-
2001	ND	Slope	20S	3	577756	5148127	3.00	2.00	0.16	0.54	100.00	70.00	10.00
2001	ND	Slope	20S	4	578756	5148127	0.00	3.00	0.00	0.54	90.00	30.00	10.00
2001	ND	Slope	20S	5	579756	5148127	5.00	2.00	0.34	0.06	55.00	15.00	0.00
2001	ND	Slope	20S	6	578256	5147627	5.00	0.00	0.26	0.00	45.00	25.00	0.00
2001	ND	Slope	20S	7	579256	5147627	1.00	1.00	0.04	0.08	100.00	0.00	0.00
2001	ND	Slope	20S	8	577756	5147127	3.00	4.00	0.11	0.28	85.00	25.00	10.00
2001	ND	Slope	20S	9	578756	5147127	1.00	19.00	0.11	1.41	100.00	73.33	40.00
2001	ND	Slope	20S	10	579756	5147127	4.00	1.00	0.19	0.08	95.00	30.00	15.00
2001	ND	Slope	20S	11	578256	5146627	6.00	2.00	0.53	0.12	70.00	5.00	0.00
2001	ND	Slope	20S	12	579256	5146627	-	-	-	-	-	-	-

Appendix H. Continuation of sites on page 152.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
2S	1	19.40	19.00	11.10	5.38	46.93	5.15	57.50	
2S	2	-	-	-	-	-	-	-	Wheat field
2S	3	0.00	0.00	16.03	5.08	63.73	0.73	43.83	
2S	4	31.67	0.00	6.73	6.80	24.83	28.75	42.33	
2S	5	0.00	0.00	15.78	3.28	52.08	0.05	59.63	
2S	6	-	-	-	-	-	-	-	Alfalfa field
2S	7	25.50	0.00	12.10	3.60	63.15	4.20	43.55	
2S	8	16.60	1.18	12.60	5.60	54.13	0.90	52.63	
2S	9	29.25	0.00	13.85	9.68	45.55	4.10	62.50	
2S	10	26.85	0.00	17.33	4.95	76.30	1.80	30.25	
2S	11	27.20	36.17	11.38	3.98	55.95	10.13	51.00	
2S	12	19.00	0.00	12.70	11.23	59.93	8.78	30.25	
14S	LEK	37.68	45.00	13.20	9.60	30.33	53.88	22.78	
14S	1	-	-	-	-	-	-	-	Uninhabitable territory/steep slope
14S	2	36.67	0.00	11.35	7.95	44.15	11.73	63.08	
14S	3	-	-	-	-	-	-	-	Uninhabitable territory/steep slope
14S	4	41.22	64.67	13.75	8.23	40.28	42.90	23.35	
14S	5	10.00	24.89	12.23	5.88	38.10	12.40	58.53	
14S	6	38.92	28.88	10.83	6.58	24.25	15.20	74.48	
14S	7	42.75	57.43	17.80	12.93	47.38	13.93	41.98	
14S	8	54.37	53.50	11.75	4.35	23.58	40.95	44.50	
14S	9	44.00	49.22	9.50	1.70	28.80	50.73	28.28	
14S	10	70.00	41.78	12.05	6.68	44.23	19.40	53.35	
14S	11	38.34	70.00	9.73	2.93	20.60	60.75	26.88	
14S	12	45.13	42.64	16.83	12.93	39.28	6.20	61.13	
20S	1	0.00	36.31	14.13	2.35	45.68	20.00	42.38	
20S	2	-	-	-	-	-	-	-	Steep slope/uninhabitable territory
20S	3	41.14	39.44	16.20	7.15	39.05	29.10	48.00	
20S	4	0.00	35.92	17.15	4.50	46.50	35.35	40.65	
20S	5	37.69	57.75	10.93	9.38	31.00	44.90	26.60	
20S	6	35.21	13.00	7.97	0.78	15.49	73.62	12.03	
20S	7	44.00	61.82	18.75	6.83	51.23	20.08	36.68	
20S	8	57.38	60.04	15.90	8.18	47.18	13.05	50.50	
20S	9	31.50	65.38	16.72	3.28	31.22	58.17	15.67	
20S	10	47.50	54.18	17.25	8.05	50.95	15.40	40.98	
20S	11	50.56	92.00	17.60	6.20	46.05	31.13	29.65	
20S	12	-	-	-	-	-	-	-	Steep slope/uninhabitable territory

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	ND	Slope	21S	1	573391	5154960	0.00	1.00	0.00	0.06	10.00	0.00	0.00
2001	ND	Slope	21S	2	574391	5154960	0.00	2.00	0.00	0.37	100.00	75.00	45.00
2001	ND	Slope	21S	3	572891	5154460	0.00	0.00	0.00	0.00	100.00	100.00	26.67
2001	ND	Slope	21S	4	573891	5154460	0.00	0.00	0.00	0.05	70.00	0.00	0.00
2001	ND	Slope	21S	5	574891	5154460	0.00	0.00	0.00	0.01	50.00	5.00	0.00
2001	ND	Slope	21S	6	573391	5153960	1.00	0.00	0.24	0.12	70.00	5.00	0.00
2001	ND	Slope	21S	7	574391	5153960	3.00	0.00	0.67	0.05	60.00	0.00	0.00
2001	ND	Slope	21S	8	572891	5153460	0.00	0.00	0.00	0.02	75.00	0.00	0.00
2001	ND	Slope	21S	9	573891	5153460	2.00	2.00	0.21	0.19	50.00	0.00	0.00
2001	ND	Slope	21S	10	574891	5153460	1.00	0.00	0.04	0.09	85.00	0.00	0.00
2001	ND	Slope	21S	11	573391	5153391	0.00	3.00	0.03	0.55	65.00	10.00	0.00
2001	ND	Slope	21S	12	574391	5153391	0.00	1.00	0.00	0.13	80.00	10.00	0.00
2001	SD	Butte	3B	LEK	599523	4986753	10.00	0.00	2.60	0.00	90.00	10.00	0.00
2001	SD	Butte	3B	1	599023	4987753	0.00	0.00	0.02	0.00	80.00	0.00	0.00
2001	SD	Butte	3B	2	600023	4987753	2.00	0.00	0.57	0.00	75.00	0.00	0.00
2001	SD	Butte	3B	3	598523	4987253	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	3B	4	599523	4987253	10.00	0.00	2.54	0.00	95.00	10.00	0.00
2001	SD	Butte	3B	5	600523	4987253	1.00	0.00	0.32	0.00	90.00	0.00	0.00
2001	SD	Butte	3B	6	599023	4986753	8.00	0.00	1.66	0.00	75.00	0.00	0.00
2001	SD	Butte	3B	7	600023	4986753	10.00	0.00	2.75	0.00	90.00	0.00	0.00
2001	SD	Butte	3B	8	598523	4986253	0.00	0.00	0.41	0.00	90.00	0.00	0.00
2001	SD	Butte	3B	9	599523	4986253	0.00	0.00	0.14	0.00	20.00	0.00	0.00
2001	SD	Butte	3B	10	600523	4986253	2.00	0.00	1.13	0.00	80.00	0.00	0.00
2001	SD	Butte	3B	11	599023	4985753	5.00	0.00	1.48	0.00	100.00	0.00	0.00
2001	SD	Butte	3B	12	600023	4985753	7.00	0.00	2.18	0.00	50.00	0.00	0.00
2001	SD	Butte	4B	LEK	612622	4977981	0.00	0.00	0.00	0.00	85.00	0.00	0.00
2001	SD	Butte	4B	1	612122	4978981	0.00	0.00	0.00	0.00	90.00	0.00	0.00
2001	SD	Butte	4B	2	613122	4978981	0.00	0.00	0.00	0.00	10.00	0.00	0.00
2001	SD	Butte	4B	3	611622	4978481	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	4B	4	612622	4978481	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	4B	5	613622	4978481	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	4B	6	612122	4977981	0.00	0.00	0.00	0.00	60.00	0.00	0.00
2001	SD	Butte	4B	7	613122	4977981	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	SD	Butte	4B	8	611622	4977481	3.00	0.00	1.19	0.00	45.00	0.00	0.00
2001	SD	Butte	4B	9	612622	4977481	5.00	0.00	1.65	0.00	90.00	0.00	0.00
2001	SD	Butte	4B	10	613622	4977481	0.00	0.00	0.40	0.00	85.00	5.00	0.00
2001	SD	Butte	4B	11	612122	4976981	4.00	0.00	1.93	0.00	70.00	0.00	0.00
2001	SD	Butte	4B	12	613122	4976981	6.00	0.00	2.19	0.00	80.00	0.00	0.00

Appendix H. Continuation of sites on page 154.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
21S	1	21.00	21.67	9.28	17.60	26.68	0.35	72.13	
21S	2	0.00	38.63	19.93	18.13	45.58	1.80	54.63	
21S	3	0.00	0.00	26.80	43.10	46.85	3.50	27.65	
21S	4	46.00	35.00	11.27	6.55	51.33	7.39	47.82	
21S	5	0.00	12.00	7.03	2.95	35.38	47.15	20.50	
21S	6	24.81	35.00	11.68	9.40	49.55	11.08	43.58	
21S	7	16.35	17.75	9.28	8.13	44.05	28.00	35.05	
21S	8	0.00	36.00	15.94	18.37	63.00	2.43	33.86	
21S	9	28.25	37.41	13.45	14.90	57.63	9.53	31.28	
21S	10	36.89	34.13	14.20	15.83	59.38	5.45	35.00	
21S	11	27.71	34.96	15.50	15.63	52.53	4.60	47.13	
21S	12	0.00	29.00	12.68	29.78	53.70	3.28	38.63	
3B	LEK	16.63	0.00	10.58	0.98	31.40	70.45	11.15	
3B	1	22.00	0.00	15.13	2.50	74.00	6.50	33.00	
3B	2	18.93	0.00	12.28	15.45	40.15	28.30	41.28	
3B	3	20.00	0.00	15.88	4.05	73.65	2.23	31.15	
3B	4	17.88	0.00	11.60	1.30	36.08	58.43	13.28	
3B	5	19.46	0.00	10.78	16.03	38.13	23.43	53.50	
3B	6	17.95	0.00	10.95	0.80	39.03	58.48	9.18	
3B	7	13.50	0.00	8.05	1.08	22.65	73.63	7.88	
3B	8	10.67	0.00	10.08	4.38	52.43	30.19	27.70	
3B	9	22.00	0.00	8.73	3.65	62.20	10.18	46.98	
3B	10	10.09	0.00	9.50	1.40	32.45	31.85	40.90	
3B	11	12.38	0.00	10.53	4.30	49.95	43.43	21.15	
3B	12	12.00	0.00	7.48	2.33	30.43	63.35	9.98	
4B	LEK	0.00	0.00	10.75	1.60	57.80	42.83	9.33	
4B	1	0.00	0.00	14.48	1.23	65.13	24.50	23.70	
4B	2	0.00	0.00	7.98	4.43	21.95	75.03	5.13	
4B	3	0.00	0.00	14.90	4.95	60.88	21.13	36.00	
4B	4	0.00	0.00	13.50	0.95	58.05	37.50	12.08	
4B	5	0.00	0.00	13.18	12.23	38.28	41.73	24.35	
4B	6	0.00	0.00	10.08	3.08	45.03	49.50	15.48	
4B	7	0.00	0.00	5.45	2.50	41.83	45.40	19.83	
4B	8	16.54	0.00	11.20	8.78	47.55	34.23	24.75	
4B	9	17.15	0.00	12.33	10.08	46.53	35.28	22.38	
4B	10	19.35	0.00	10.25	12.63	33.40	39.98	36.15	
4B	11	14.08	0.00	10.15	5.50	33.83	58.30	14.05	
4B	12	14.72	0.00	11.03	5.85	34.55	46.40	24.05	

Appendix H. Continued

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Butte	5B	LEK	606336	5006861	2.00	0.00	0.40	0.00	100.00	0.00	0.00
2001	SD	Butte	5B	1	605836	5007861	2.00	0.00	0.56	0.00	70.00	0.00	0.00
2001	SD	Butte	5B	2	606836	5007861	1.00	0.00	0.29	0.00	65.00	0.00	0.00
2001	SD	Butte	5B	3	605336	5007361	7.00	0.00	0.95	0.00	65.00	15.00	0.00
2001	SD	Butte	5B	4	606336	5007361	6.00	0.00	1.47	0.00	100.00	0.00	0.00
2001	SD	Butte	5B	5	607336	5007361	2.00	0.00	0.60	0.00	65.00	10.00	0.00
2001	SD	Butte	5B	6	605836	5006861	9.00	0.00	2.45	0.00	100.00	0.00	0.00
2001	SD	Butte	5B	7	606836	5006861	16.00	0.00	3.81	0.00	80.00	0.00	0.00
2001	SD	Butte	5B	8	605336	5006361	3.00	0.00	0.89	0.00	50.00	10.00	0.00
2001	SD	Butte	5B	9	606336	5006361	6.00	0.00	2.39	0.00	40.00	0.00	0.00
2001	SD	Butte	5B	10	607336	5006361	4.00	0.00	1.24	0.00	30.00	0.00	0.00
2001	SD	Butte	5B	11	605836	5005861	6.00	0.00	2.00	0.00	55.00	0.00	0.00
2001	SD	Butte	5B	12	606836	5005861	3.00	0.00	0.67	0.00	25.00	0.00	0.00
2001	SD	Butte	6B	LEK	587317	4996578	4.00	0.00	1.28	0.00	65.00	5.00	0.00
2001	SD	Butte	6B	1	586817	4997578	0.00	0.00	0.00	0.00	90.00	0.00	0.00
2001	SD	Butte	6B	2	587817	4997578	0.00	0.00	0.01	0.00	100.00	0.00	0.00
2001	SD	Butte	6B	3	586317	4997078	0.00	0.00	0.01	0.00	100.00	0.00	0.00
2001	SD	Butte	6B	4	587317	4997078	0.00	0.00	0.02	0.00	95.00	0.00	0.00
2001	SD	Butte	6B	5	588317	4997078	2.00	0.00	0.51	0.00	55.00	5.00	0.00
2001	SD	Butte	6B	6	586817	4996578	3.00	0.00	1.14	0.00	65.00	0.00	0.00
2001	SD	Butte	6B	7	587817	4996578	0.00	0.00	0.05	0.00	30.00	0.00	0.00
2001	SD	Butte	6B	8	586317	4996078	1.00	0.00	0.50	0.00	10.00	0.00	0.00
2001	SD	Butte	6B	9	587317	4996078	3.00	0.00	1.40	0.00	75.00	0.00	0.00
2001	SD	Butte	6B	10	588317	4996078	5.00	0.00	2.25	0.00	90.00	0.00	0.00
2001	SD	Butte	6B	11	586817	4995578	3.00	0.00	1.19	0.00	15.00	0.00	0.00
2001	SD	Butte	6B	12	587817	4995578	2.00	0.00	1.08	0.00	60.00	0.00	0.00
2001	SD	Butte	9B	LEK	587883	4963874	5.00	0.00	1.20	0.00	90.00	5.00	0.00
2001	SD	Butte	9B	1	587383	4964874	-	-	-	-	-	-	-
2001	SD	Butte	9B	2	588383	4964874	8.00	0.00	1.72	0.00	95.00	25.00	5.00
2001	SD	Butte	9B	3	586883	4964374	0.00	0.00	0.09	0.00	100.00	15.00	0.00
2001	SD	Butte	9B	4	587883	4964374	12.00	0.00	3.31	0.00	100.00	20.00	0.00
2001	SD	Butte	9B	5	588883	4964374	8.00	0.00	1.60	0.00	70.00	15.00	0.00
2001	SD	Butte	9B	6	587383	4963874	0.00	0.00	0.04	0.00	40.00	0.00	0.00
2001	SD	Butte	9B	7	588383	4963874	6.00	0.00	1.29	0.00	60.00	5.00	0.00
2001	SD	Butte	9B	8	586883	4963374	6.00	0.00	1.17	0.00	90.00	15.00	0.00
2001	SD	Butte	9B	9	587883	4963374	2.00	0.00	0.44	0.00	95.00	5.00	0.00
2001	SD	Butte	9B	10	588883	4963374	12.00	0.00	2.39	0.00	80.00	30.00	0.00
2001	SD	Butte	9B	11	587383	4962874	5.00	0.00	1.62	0.00	100.00	40.00	5.00
2001	SD	Butte	9B	12	588383	4962874	2.00	0.00	0.24	0.00	100.00	25.00	0.00

Appendix H. Continuation of sites on page 156.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
5B	LEK	20.30	0.00	12.63	17.30	51.95	34.98	12.50	
5B	1	17.83	0.00	12.55	8.50	53.80	23.25	21.08	
5B	2	19.68	0.00	11.95	3.83	56.50	9.15	41.33	
5B	3	26.00	0.00	11.53	13.20	33.03	45.58	14.25	
5B	4	15.67	0.00	10.35	0.90	25.98	45.40	29.90	
5B	5	22.17	0.00	13.65	5.58	54.20	12.98	50.00	
5B	6	15.08	0.00	6.98	0.50	26.20	67.90	8.68	
5B	7	11.93	0.00	4.83	0.95	6.73	67.40	17.78	
5B	8	27.33	0.00	11.30	8.68	45.63	22.90	28.93	
5B	9	12.23	0.00	7.30	3.45	20.85	73.10	8.05	
5B	10	15.23	0.00	10.00	5.65	24.05	47.75	27.63	
5B	11	12.45	0.00	7.18	3.08	17.38	61.48	20.35	
5B	12	16.64	0.00	8.93	2.40	66.75	16.43	23.10	
6B	LEK	15.26	0.00	9.85	1.68	42.90	51.63	17.43	
6B	1	0.00	0.00	14.35	6.70	46.88	23.30	34.00	
6B	2	27.00	0.00	15.80	6.48	78.48	7.10	20.35	
6B	3	29.00	0.00	13.55	9.90	182.80	7.98	44.40	
6B	4	24.00	0.00	11.80	4.38	53.00	29.75	27.43	
6B	5	20.14	0.00	10.30	6.58	51.75	15.90	45.18	
6B	6	20.93	0.00	12.08	5.88	49.70	34.40	31.80	
6B	7	14.83	0.00	10.55	7.63	43.65	37.63	30.38	
6B	8	15.80	0.00	7.53	0.60	45.00	39.78	26.35	
6B	9	12.55	0.00	7.08	2.00	51.50	33.98	19.73	
6B	10	18.38	0.00	10.58	6.15	36.75	54.68	21.13	
6B	11	13.71	0.00	8.68	2.53	39.40	53.03	20.28	
6B	12	12.93	0.00	9.60	5.30	32.23	53.63	25.53	
9B	LEK	21.59	0.00	11.50	14.53	79.38	3.90	20.95	
9B	1	-	-	-	-	-	-	-	Landowner permission (no)
9B	2	33.08	0.00	16.70	6.98	73.20	11.13	27.25	
9B	3	20.00	0.00	11.90	3.70	84.35	0.93	22.75	
9B	4	18.73	0.00	7.88	1.63	25.05	67.88	14.35	
9B	5	22.60	0.00	12.98	4.50	49.95	27.75	30.65	
9B	6	16.00	0.00	11.35	4.70	88.55	3.48	19.75	
9B	7	21.71	0.00	13.05	13.10	68.98	17.43	15.23	
9B	8	27.11	0.00	14.90	0.85	52.15	45.88	13.98	
9B	9	26.41	0.00	11.48	11.10	85.63	4.33	12.35	
9B	10	22.63	0.00	10.95	5.58	47.08	38.60	25.38	
9B	11	29.68	0.00	12.25	9.75	63.70	20.93	20.30	
9B	12	22.22	0.00	14.88	3.95	85.65	7.08	14.90	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Butte	10B	LEK	580779	4969908	0.00	0.00	0.00	0.00	30.00	0.00	0.00
2001	SD	Butte	10B	1	580279	4970908	1.00	0.00	0.21	0.00	80.00	0.00	0.00
2001	SD	Butte	10B	2	581279	4970908	1.00	6.00	0.19	1.47	100.00	60.00	5.00
2001	SD	Butte	10B	3	579779	4970408	5.00	0.00	0.86	0.00	80.00	25.00	0.00
2001	SD	Butte	10B	4	580779	4970408	11.00	0.00	0.76	0.00	100.00	55.00	5.00
2001	SD	Butte	10B	5	581779	4970408	1.00	0.00	0.04	0.00	100.00	0.00	0.00
2001	SD	Butte	10B	6	580279	4969908	6.00	0.00	0.73	0.00	100.00	25.00	0.00
2001	SD	Butte	10B	7	581279	4969908	4.00	0.00	0.72	0.00	35.00	5.00	0.00
2001	SD	Butte	10B	8	579779	4969408	1.00	0.00	0.30	0.00	90.00	0.00	0.00
2001	SD	Butte	10B	9	580779	4969408	8.00	0.00	1.03	0.00	90.00	40.00	5.00
2001	SD	Butte	10B	10	581779	4969408	7.00	0.00	0.64	0.00	100.00	40.00	0.00
2001	SD	Butte	10B	11	580279	4968908	0.00	0.00	0.04	0.00	55.00	15.00	5.00
2001	SD	Butte	10B	12	581279	4968908	1.00	0.00	0.42	0.00	5.00	0.00	0.00
2001	SD	Butte	11B	LEK	580877	4956628	1.00	0.00	0.28	0.01	35.00	2.50	0.00
2001	SD	Butte	11B	1	580377	4957628	4.00	0.00	1.54	0.00	97.50	5.00	0.00
2001	SD	Butte	11B	2	581377	4957628	3.00	0.00	1.08	0.00	92.50	2.50	0.00
2001	SD	Butte	11B	3	579877	4957128	0.00	0.00	0.04	0.00	0.00	0.00	0.00
2001	SD	Butte	11B	4	580877	4957128	4.00	0.00	1.12	0.00	90.00	15.00	0.00
2001	SD	Butte	11B	5	581877	4957128	-	-	-	-	-	-	-
2001	SD	Butte	11B	6	580377	4956628	1.00	0.00	0.19	0.28	47.50	5.00	0.00
2001	SD	Butte	11B	7	581377	4956628	4.00	0.00	1.08	0.00	60.00	22.50	0.00
2001	SD	Butte	11B	8	579877	4956128	0.00	0.00	0.03	0.00	47.50	2.50	0.00
2001	SD	Butte	11B	9	580877	4956128	1.00	1.00	0.07	0.41	97.50	32.50	0.00
2001	SD	Butte	11B	10	581877	4956128	4.00	0.00	1.32	0.00	100.00	30.00	0.00
2001	SD	Butte	11B	11	580377	4955628	4.00	0.00	0.69	0.00	75.00	15.00	0.00
2001	SD	Butte	11B	12	581377	4955628	3.00	0.00	1.12	0.00	100.00	15.00	0.00
2001	SD	Butte	12B	LEK	605185	4982068	0.00	0.00	0.03	0.00	100.00	0.00	0.00
2001	SD	Butte	12B	1	604685	4983068	6.00	0.00	2.05	0.00	95.00	0.00	0.00
2001	SD	Butte	12B	2	605685	4983068	4.00	0.00	0.69	0.00	95.00	0.00	0.00
2001	SD	Butte	12B	3	604185	4982568	4.00	0.00	1.30	0.00	100.00	30.00	0.00
2001	SD	Butte	12B	4	605185	4982568	8.00	0.00	2.12	0.00	85.00	0.00	0.00
2001	SD	Butte	12B	5	606185	4982568	0.00	0.00	0.08	0.00	100.00	5.00	0.00
2001	SD	Butte	12B	6	604685	4982068	3.00	0.00	1.08	0.00	100.00	0.00	0.00
2001	SD	Butte	12B	7	605685	4982068	4.00	0.00	0.76	0.00	95.00	5.00	0.00
2001	SD	Butte	12B	8	604185	4981568	1.00	0.00	0.23	0.00	60.00	0.00	0.00
2001	SD	Butte	12B	9	605185	4981568	4.00	0.00	0.79	0.00	100.00	10.00	0.00
2001	SD	Butte	12B	10	606185	4981568	5.00	0.00	0.93	0.00	100.00	15.00	0.00
2001	SD	Butte	12B	11	604685	4981068	4.00	0.00	1.40	0.00	80.00	0.00	0.00
2001	SD	Butte	12B	12	605685	4981068	0.00	0.00	0.05	0.00	85.00	0.00	0.00

Appendix H. Continuation of sites on page 158.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
10B	LEK	17.00	0.00	9.10	10.20	32.15	42.10	24.00	
10B	1	19.32	0.00	11.40	9.28	41.43	32.78	32.50	
10B	2	37.42	49.21	20.68	7.50	80.85	0.65	57.25	
10B	3	25.00	0.00	14.70	2.35	36.65	57.28	15.60	
10B	4	50.15	0.00	16.88	24.15	57.43	0.15	48.38	
10B	5	36.17	0.00	14.33	5.13	79.28	0.15	25.83	
10B	6	30.03	0.00	15.33	8.43	61.00	12.83	31.25	
10B	7	24.21	0.00	12.33	10.30	56.18	12.18	37.43	
10B	8	12.56	0.00	10.95	10.68	28.83	49.75	27.05	
10B	9	30.70	0.00	15.23	6.10	64.83	13.80	33.63	
10B	10	33.08	0.00	14.15	12.08	67.88	4.30	40.75	
10B	11	14.75	0.00	6.05	0.98	20.83	75.75	6.10	
10B	12	14.96	0.00	5.95	8.15	24.08	53.30	25.93	
11B	LEK	14.47	8.00	12.53	0.35	30.85	57.18	12.13	
11B	1	19.69	0.00	16.18	6.03	29.95	57.03	7.70	
11B	2	17.77	0.00	12.25	6.53	35.00	40.00	20.78	
11B	3	13.00	0.00	1.60	37.68	3.38	45.20	14.00	
11B	4	30.63	0.00	10.70	7.43	33.25	46.33	13.25	
11B	5	-	-	-	-	-	-	-	Crop Field
11B	6	21.38	8.00	12.38	2.98	35.40	44.80	24.00	
11B	7	24.84	0.00	11.78	3.43	23.55	61.55	11.85	
11B	8	14.00	0.00	6.88	10.88	27.33	43.38	21.65	
11B	9	16.00	5.29	17.78	2.40	42.48	42.15	11.38	
11B	10	27.85	0.00	13.13	2.25	21.05	60.73	16.13	
11B	11	22.23	0.00	10.85	10.18	39.18	24.48	26.83	
11B	12	20.42	0.00	13.78	2.33	31.73	42.35	23.93	
12B	LEK	26.33	0.00	13.15	10.73	59.18	8.70	36.03	
12B	1	16.56	0.00	10.98	16.25	45.03	34.30	22.80	
12B	2	22.78	0.00	13.85	5.18	66.70	4.45	35.80	
12B	3	19.45	0.00	13.53	13.35	50.25	23.48	29.88	
12B	4	15.28	0.00	10.13	7.58	28.75	65.50	5.13	
12B	5	27.36	0.00	13.15	8.40	77.33	1.00	22.43	
12B	6	18.82	0.00	12.75	11.08	53.18	20.05	35.30	
12B	7	25.03	0.00	13.53	5.50	70.18	7.45	28.35	
12B	8	13.56	0.00	10.32	9.42	42.50	13.29	52.76	
12B	9	21.19	0.00	14.30	16.35	55.63	10.75	41.13	
12B	10	18.26	0.00	12.45	9.08	43.83	18.53	42.13	
12B	11	14.29	0.00	12.95	7.98	56.25	29.93	21.50	
12B	12	17.43	0.00	10.23	8.80	39.53	41.65	24.83	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Butte	13B	LEK	594639	4989792	7.00	0.00	3.28	0.00	50.00	0.00	0.00
2001	SD	Butte	13B	1	594139	4990792	5.00	0.00	1.28	0.00	100.00	5.00	0.00
2001	SD	Butte	13B	2	595139	4990792	0.00	0.00	0.04	0.00	100.00	0.00	0.00
2001	SD	Butte	13B	3	593639	4990292	6.00	0.00	2.55	0.00	95.00	0.00	0.00
2001	SD	Butte	13B	4	594639	4990292	6.00	0.00	2.27	0.00	45.00	0.00	0.00
2001	SD	Butte	13B	5	595639	4990292	1.00	0.00	0.29	0.00	30.00	0.00	0.00
2001	SD	Butte	13B	6	594139	4989792	3.00	0.00	0.62	0.00	100.00	0.00	0.00
2001	SD	Butte	13B	7	595139	4989792	8.00	0.00	2.43	0.00	100.00	25.00	0.00
2001	SD	Butte	13B	8	593639	4989292	12.00	0.00	3.09	0.00	100.00	15.00	0.00
2001	SD	Butte	13B	9	594639	4989292	2.00	0.00	0.47	0.00	100.00	5.00	0.00
2001	SD	Butte	13B	10	595639	4989292	7.00	0.00	2.66	0.00	90.00	0.00	0.00
2001	SD	Butte	13B	11	594139	4988792	0.00	0.00	0.06	0.00	30.00	0.00	0.00
2001	SD	Butte	13B	12	595139	4988792	7.00	0.00	2.66	0.00	20.00	0.00	0.00
2001	SD	Butte	14B	LEK	591309	4982129	0.00	0.00	0.00	0.00	95.00	0.00	0.00
2001	SD	Butte	14B	1	590809	4983129	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	2	591809	4983129	0.00	0.00	0.00	0.00	95.00	0.00	0.00
2001	SD	Butte	14B	3	590309	4982629	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	4	591309	4982629	0.00	0.00	0.00	0.00	95.00	0.00	0.00
2001	SD	Butte	14B	5	592309	4982629	0.00	0.00	0.00	0.00	95.00	0.00	0.00
2001	SD	Butte	14B	6	590809	4982129	0.00	0.00	0.00	0.00	70.00	0.00	0.00
2001	SD	Butte	14B	7	591809	4982129	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	8	590309	4981629	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	9	591309	4981629	0.00	0.00	0.00	0.00	95.00	0.00	0.00
2001	SD	Butte	14B	10	592309	4981629	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	11	590809	4981129	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Butte	14B	12	591809	4981129	0.00	0.00	0.24	0.00	100.00	0.00	0.00
2001	SD	Butte	15B	LEK	583325	4972585	0.00	0.00	0.31	0.00	55.00	0.00	0.00
2001	SD	Butte	15B	1	582825	4973585	0.00	0.00	0.07	0.00	0.00	0.00	0.00
2001	SD	Butte	15B	2	583825	4973585	0.00	0.00	0.00	0.00	10.00	0.00	0.00
2001	SD	Butte	15B	3	582325	4973085	3.00	2.00	4.84	0.01	50.00	20.00	5.00
2001	SD	Butte	15B	4	583325	4973085	3.00	0.00	1.00	0.01	35.00	5.00	0.00
2001	SD	Butte	15B	5	584325	4973085	1.00	0.00	0.16	0.00	20.00	0.00	0.00
2001	SD	Butte	15B	6	582825	4972585	5.00	0.00	0.77	0.00	75.00	10.00	0.00
2001	SD	Butte	15B	7	583825	4972585	1.00	0.00	0.30	0.00	70.00	0.00	0.00
2001	SD	Butte	15B	8	582325	4972085	3.00	0.00	0.42	0.00	85.00	30.00	0.00
2001	SD	Butte	15B	9	583325	4972085	1.00	0.00	0.21	0.00	95.00	10.00	0.00
2001	SD	Butte	15B	10	584325	4972085	4.00	0.00	0.85	0.00	85.00	20.00	0.00
2001	SD	Butte	15B	11	582825	4971585	6.00	0.00	0.98	0.00	85.00	35.00	0.00
2001	SD	Butte	15B	12	583825	4971585	0.00	0.00	0.09	0.00	95.00	0.00	0.00

Appendix H. Continuation of sites on page 160.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
13B	LEK	13.23	0.00	8.65	3.65	18.93	71.60	10.73	
13B	1	20.65	0.00	12.25	5.25	37.88	48.30	22.30	
13B	2	18.78	0.00	12.03	6.80	45.25	37.58	31.43	
13B	3	13.88	0.00	11.80	6.50	25.25	65.03	15.55	
13B	4	14.50	0.00	8.85	5.53	27.78	61.90	14.68	
13B	5	19.06	0.00	11.18	4.73	35.50	55.95	13.50	
13B	6	18.50	0.00	11.20	9.10	35.50	37.00	24.00	
13B	7	16.25	0.00	14.65	3.50	45.45	41.40	22.88	
13B	8	17.13	0.00	12.93	5.93	39.40	38.93	34.00	
13B	9	21.48	0.00	16.00	14.68	51.53	14.78	45.50	
13B	10	14.43	0.00	10.13	7.05	35.38	59.50	20.48	
13B	11	16.75	0.00	9.68	15.63	36.40	11.88	58.33	
13B	12	13.38	0.00	8.70	2.83	27.18	73.95	10.80	
14B	LEK	0.00	0.00	11.73	4.40	36.58	37.75	30.25	
14B	1	0.00	0.00	13.10	12.98	52.00	19.80	23.13	
14B	2	0.00	0.00	12.63	6.85	59.83	20.90	17.88	
14B	3	0.00	0.00	15.28	7.80	93.05	0.20	7.20	
14B	4	0.00	0.00	11.60	4.15	55.53	19.25	34.73	
14B	5	0.00	0.00	11.38	15.30	49.10	21.78	28.10	
14B	6	0.00	0.00	11.90	10.55	65.00	9.20	26.50	
14B	7	0.00	0.00	12.00	14.23	66.25	3.95	34.13	
14B	8	0.00	0.00	13.20	9.10	65.00	21.48	33.38	
14B	9	0.00	0.00	14.10	21.00	58.30	25.45	19.53	
14B	10	0.00	0.00	12.88	14.45	62.75	38.95	14.93	
14B	11	0.00	0.00	16.35	5.88	83.63	1.03	43.50	
14B	12	19.17	0.00	11.35	24.85	66.38	15.40	20.50	
15B	LEK	14.48	0.00	7.40	5.18	25.18	64.28	13.55	
15B	1	18.00	0.00	4.00	5.86	5.07	84.29	9.21	
15B	2	14.00	0.00	5.03	9.68	15.90	71.40	8.33	
15B	3	34.38	30.95	14.65	7.95	61.30	17.18	34.38	
15B	4	15.90	18.00	6.48	6.13	40.78	35.60	27.50	
15B	5	20.06	0.00	9.20	2.10	37.38	52.00	18.20	
15B	6	25.74	0.00	9.43	12.30	41.55	27.13	35.63	
15B	7	22.04	0.00	11.23	3.63	53.60	23.70	29.00	
15B	8	24.68	0.00	10.15	6.95	51.38	15.05	36.38	
15B	9	25.72	0.00	12.63	12.80	56.83	12.78	29.00	
15B	10	18.32	0.00	9.78	6.00	30.85	49.08	23.80	
15B	11	28.55	0.00	13.55	10.70	53.60	24.38	29.05	
15B	12	17.69	0.00	14.33	7.43	59.05	13.25	34.38	

Appendix H. Continued

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Fall River	1FR	LEK	581629	4796587	2.00	0.00	0.27	0.26	100.00	27.50	0.00
2001	SD	Fall River	1FR	1	581129	4797587	0.00	0.00	0.00	0.00	97.50	0.00	0.00
2001	SD	Fall River	1FR	2	582129	4797587	1.00	0.00	0.03	0.00	97.50	0.00	0.00
2001	SD	Fall River	1FR	3	580629	4791087	0.00	0.00	0.05	0.00	87.50	0.00	0.00
2001	SD	Fall River	1FR	4	581629	4791087	0.00	0.00	0.02	0.15	2.50	0.00	0.00
2001	SD	Fall River	1FR	5	582629	4791087	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	SD	Fall River	1FR	6	581129	4796587	0.00	0.00	0.09	0.04	30.00	0.00	0.00
2001	SD	Fall River	1FR	7	582129	4796587	1.00	0.00	0.23	0.60	40.00	0.00	0.00
2001	SD	Fall River	1FR	8	580629	4796087	0.00	0.00	0.07	0.00	100.00	0.00	0.00
2001	SD	Fall River	1FR	9	581629	4796087	2.00	0.00	0.17	0.00	45.00	7.50	0.00
2001	SD	Fall River	1FR	10	582629	4796087	7.00	0.00	0.68	0.00	100.00	50.00	15.00
2001	SD	Fall River	1FR	11	581129	4795587	0.00	0.00	0.09	0.00	100.00	0.00	0.00
2001	SD	Fall River	1FR	12	582129	4795587	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Harding	1H	LEK	637154	5029503	2.00	0.00	0.39	0.16	60.00	0.00	0.00
2001	SD	Harding	1H	1	636654	5030503	-	-	-	-	-	-	-
2001	SD	Harding	1H	2	637654	5030503	0.00	2.00	0.00	0.46	95.00	15.00	5.00
2001	SD	Harding	1H	3	636154	5030003	12.00	0.00	1.22	0.13	80.00	65.00	10.00
2001	SD	Harding	1H	4	637154	5030003	0.00	3.00	0.03	0.94	100.00	35.00	0.00
2001	SD	Harding	1H	5	638154	5030003	14.00	0.00	1.12	0.11	100.00	25.00	0.00
2001	SD	Harding	1H	6	636654	5029503	5.00	0.00	0.85	0.02	55.00	5.00	0.00
2001	SD	Harding	1H	7	637654	5029503	1.00	2.00	0.15	0.52	100.00	30.00	0.00
2001	SD	Harding	1H	8	636154	5029003	3.00	6.00	0.17	0.62	95.00	25.00	5.00
2001	SD	Harding	1H	9	637154	5029003	0.00	2.00	0.02	0.63	55.00	25.00	0.00
2001	SD	Harding	1H	10	638154	5029003	1.00	3.00	0.01	0.69	100.00	25.00	0.00
2001	SD	Harding	1H	11	636654	5028503	3.00	3.00	0.51	0.29	90.00	30.00	0.00
2001	SD	Harding	1H	12	637654	5028503	4.00	1.00	0.82	0.20	75.00	0.00	0.00
2001	SD	Harding	2H	LEK	584376	5044130	7.00	0.00	1.81	0.00	75.00	5.00	0.00
2001	SD	Harding	2H	1	583876	5045130	0.00	0.00	0.15	0.00	20.00	0.00	0.00
2001	SD	Harding	2H	2	584876	5045130	0.00	0.00	0.01	0.00	90.00	0.00	0.00
2001	SD	Harding	2H	3	583376	5044630	2.00	0.00	0.42	0.00	70.00	20.00	0.00
2001	SD	Harding	2H	4	584376	5044630	4.00	0.00	0.70	0.00	75.00	25.00	0.00
2001	SD	Harding	2H	5	585376	5044630	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Harding	2H	6	583876	5044130	6.00	0.00	0.68	0.00	95.00	35.00	0.00
2001	SD	Harding	2H	7	584876	5044130	2.00	0.00	0.38	0.00	95.00	15.00	0.00
2001	SD	Harding	2H	8	583376	5043630	7.00	0.00	1.64	0.00	55.00	5.00	0.00
2001	SD	Harding	2H	9	584376	5043630	11.00	0.00	1.02	0.00	80.00	35.00	0.00
2001	SD	Harding	2H	10	585376	5043630	2.00	0.00	0.22	0.00	100.00	15.00	0.00
2001	SD	Harding	2H	11	583876	5043130	0.00	0.00	0.07	0.00	50.00	0.00	0.00
2001	SD	Harding	2H	12	584876	5043130	9.00	0.00	1.28	0.00	95.00	15.00	0.00

Appendix H. Continuation of sites on page 162.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
1FR	LEK	30.93	6.85	11.43	12.38	37.70	34.70	15.25	
1FR	1	0.00	0.00	11.05	2.88	90.75	0.00	11.50	
1FR	2	42.75	0.00	8.68	8.05	49.18	9.25	34.58	
1FR	3	18.56	0.00	6.68	4.48	37.88	41.35	16.88	
1FR	4	24.33	6.33	8.35	6.80	25.00	56.50	12.00	
1FR	5	23.00	0.00	3.30	3.68	45.43	8.48	43.50	
1FR	6	25.29	6.40	9.40	2.80	41.88	38.05	17.53	
1FR	7	31.46	5.31	7.80	6.23	21.80	59.55	13.05	
1FR	8	18.00	0.00	12.60	3.48	62.10	17.45	17.08	
1FR	9	34.86	0.00	7.48	5.45	45.83	17.30	38.95	
1FR	10	41.81	0.00	10.83	6.68	42.00	35.48	27.33	
1FR	11	23.50	0.00	7.65	4.13	59.75	19.50	16.50	
1FR	12	0.00	0.00	11.58	0.65	68.80	22.55	18.13	
1H	LEK	22.27	17.80	10.35	9.30	42.78	5.78	54.18	
1H	1	-	-	-	-	-	-	-	Alfalfa field
1H	2	0.00	37.33	19.08	16.18	62.58	2.60	30.53	
1H	3	33.28	37.53	15.43	11.55	48.35	13.30	38.50	
1H	4	27.33	23.85	14.13	21.80	54.15	4.20	46.75	
1H	5	35.87	27.50	20.98	5.70	55.85	10.45	44.55	
1H	6	20.57	33.00	10.80	14.75	35.83	12.13	50.65	
1H	7	32.57	32.13	17.85	13.35	51.55	5.50	45.93	
1H	8	28.79	39.09	15.48	10.90	45.33	2.10	63.33	
1H	9	30.00	30.93	13.80	9.08	48.33	7.60	44.75	
1H	10	32.50	39.03	22.03	14.58	58.75	2.25	36.00	
1H	11	27.45	28.57	15.86	12.03	38.03	14.68	47.14	
1H	12	21.64	29.13	12.35	11.18	41.00	30.53	32.53	
2H	LEK	19.65	0.00	12.18	2.05	25.75	23.73	57.43	
2H	1	28.67	0.00	7.50	7.45	24.68	16.95	62.03	
2H	2	18.00	0.00	19.38	12.83	67.95	1.43	32.55	
2H	3	27.42	0.00	10.20	4.30	25.78	7.53	72.28	
2H	4	24.40	0.00	15.13	2.03	44.95	6.15	59.60	
2H	5	0.00	0.00	17.30	3.53	75.78	2.55	25.13	
2H	6	31.53	0.00	15.78	3.20	48.68	3.43	59.00	
2H	7	34.19	0.00	17.25	3.50	72.80	4.28	27.30	
2H	8	14.25	0.00	9.63	0.28	14.50	21.13	73.08	
2H	9	30.90	0.00	13.73	2.10	40.63	24.33	41.28	
2H	10	28.88	0.00	18.43	9.68	65.65	4.65	31.13	
2H	11	29.00	0.00	11.36	8.42	56.55	8.12	40.64	
2H	12	24.13	0.00	12.15	1.25	29.20	22.90	53.95	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Harding	3H	LEK	580533	5065647	1.00	0.00	0.09	0.00	100.00	0.00	0.00
2001	SD	Harding	3H	1	580033	5066647	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Harding	3H	2	581033	5066647	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Harding	3H	3	579533	5066147	0.00	0.00	0.04	0.00	85.00	0.00	0.00
2001	SD	Harding	3H	4	580533	5066147	1.00	0.00	0.29	0.00	80.00	0.00	0.00
2001	SD	Harding	3H	5	581533	5066147	2.00	0.00	0.34	0.00	55.00	5.00	0.00
2001	SD	Harding	3H	6	580033	5065647	0.00	0.00	0.05	0.00	75.00	0.00	0.00
2001	SD	Harding	3H	7	581033	5065647	3.00	0.00	0.66	0.00	55.00	15.00	0.00
2001	SD	Harding	3H	8	579533	5065147	6.00	0.00	0.63	0.01	85.00	15.00	0.00
2001	SD	Harding	3H	9	580533	5065147	0.00	0.00	0.00	0.00	100.00	0.00	0.00
2001	SD	Harding	3H	10	581533	5065147	1.00	0.00	0.15	0.00	90.00	10.00	5.00
2001	SD	Harding	3H	11	580033	5064647	1.00	1.00	0.19	0.10	100.00	20.00	5.00
2001	SD	Harding	3H	12	581033	5064647	3.00	0.00	0.39	0.00	75.00	0.00	0.00
2001	SD	Harding	4H	LEK	591718	5067383	0.00	1.00	0.02	0.18	50.00	0.00	0.00
2001	SD	Harding	4H	1	591218	5068383	3.00	0.00	0.68	0.03	50.00	0.00	0.00
2001	SD	Harding	4H	2	592218	5068383	3.00	1.00	0.62	0.18	70.00	5.00	0.00
2001	SD	Harding	4H	3	590718	5067883	-	-	-	-	-	-	-
2001	SD	Harding	4H	4	591718	5067883	0.00	1.00	0.08	0.33	75.00	0.00	0.00
2001	SD	Harding	4H	5	592718	5067883	8.00	0.00	0.91	0.06	85.00	20.00	0.00
2001	SD	Harding	4H	6	591218	5067383	0.00	1.00	0.15	0.25	40.00	0.00	0.00
2001	SD	Harding	4H	7	592218	5067383	0.00	0.00	0.06	0.02	50.00	0.00	0.00
2001	SD	Harding	4H	8	590718	5066883	0.00	0.00	0.01	0.05	100.00	0.00	0.00
2001	SD	Harding	4H	9	591718	5066883	0.00	0.00	0.03	0.00	80.00	0.00	0.00
2001	SD	Harding	4H	10	592718	5066883	-	-	-	-	-	-	-
2001	SD	Harding	4H	11	591218	5066383	10.00	0.00	0.57	0.03	100.00	30.00	5.00
2001	SD	Harding	4H	12	592218	5066383	4.00	0.00	0.65	0.04	90.00	10.00	0.00
2001	SD	Harding	7H	LEK	599665	5061000	6.00	0.00	0.87	0.00	90.00	20.00	0.00
2001	SD	Harding	7H	1	599165	5062000	3.00	1.00	0.27	0.24	70.00	10.00	0.00
2001	SD	Harding	7H	2	600165	5062000	1.00	0.00	0.05	0.02	50.00	5.00	0.00
2001	SD	Harding	7H	3	598665	5061500	0.00	0.00	0.01	0.05	100.00	0.00	0.00
2001	SD	Harding	7H	4	599665	5061500	9.00	0.00	1.03	0.01	100.00	10.00	0.00
2001	SD	Harding	7H	5	600665	5061500	2.00	0.00	0.31	0.07	60.00	5.00	0.00
2001	SD	Harding	7H	6	599165	5061000	0.00	0.00	0.00	0.00	85.00	0.00	0.00
2001	SD	Harding	7H	7	600165	5061000	3.00	0.00	0.55	0.03	100.00	0.00	0.00
2001	SD	Harding	7H	8	598665	5060500	1.00	0.00	0.01	0.00	30.00	0.00	0.00
2001	SD	Harding	7H	9	599665	5060500	0.00	0.00	0.01	0.00	60.00	0.00	0.00
2001	SD	Harding	7H	10	600665	5060500	9.00	0.00	0.38	0.00	55.00	30.00	0.00
2001	SD	Harding	7H	11	599165	5060000	1.00	0.00	0.13	0.00	90.00	0.00	0.00
2001	SD	Harding	7H	12	600165	5060000	4.00	0.00	0.40	0.00	65.00	5.00	0.00

Appendix H. Continuation of sites on page 164.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
3H	LEK	23.79	0.00	13.28	6.58	44.28	5.98	57.00	
3H	1	0.00	0.00	14.38	9.93	77.63	5.05	22.63	
3H	2	0.00	0.00	14.28	12.20	70.50	3.78	33.13	
3H	3	24.40	0.00	12.18	8.78	52.45	1.00	54.08	
3H	4	19.10	0.00	13.18	6.10	51.00	6.38	50.38	
3H	5	19.58	0.00	11.85	2.65	39.25	11.68	62.08	
3H	6	30.67	0.00	12.93	13.05	46.70	2.30	51.93	
3H	7	18.66	0.00	9.05	3.80	30.05	23.23	60.98	
3H	8	31.29	0.00	13.63	8.95	48.75	8.58	44.75	
3H	9	0.00	0.00	12.80	21.08	48.95	6.05	40.85	
3H	10	28.61	0.00	13.93	5.53	59.33	5.20	49.75	
3H	11	28.20	40.08	15.43	7.75	66.38	2.55	45.55	
3H	12	22.33	0.00	12.23	12.58	43.10	10.65	47.18	
4H	LEK	17.40	25.50	11.98	10.45	45.70	6.80	53.50	
4H	1	16.91	32.63	11.95	4.80	38.30	24.98	45.68	
4H	2	23.62	26.27	9.81	13.97	34.83	7.03	66.33	
4H	3	-	-	-	-	-	-	-	Uninhabitable territory/steep slope/bare butte
4H	4	18.00	29.61	12.45	10.15	40.95	3.43	63.13	
4H	5	31.06	32.60	17.03	5.13	55.55	15.30	37.10	
4H	6	26.63	31.57	11.85	6.30	55.18	14.05	38.80	
4H	7	24.00	17.50	9.88	11.38	40.15	4.50	61.23	
4H	8	0.00	21.00	14.48	7.13	55.98	7.25	47.23	
4H	9	18.27	0.00	12.20	4.08	52.33	23.68	29.58	
4H	10	-	-	-	-	-	-	-	Alfalfa field
4H	11	40.51	40.00	19.40	4.80	71.15	0.93	37.80	
4H	12	25.29	42.33	11.80	10.53	50.03	9.23	49.33	
7H	LEK	24.21	0.00	13.90	6.23	40.38	12.90	56.38	
7H	1	31.18	27.63	13.98	12.23	46.28	1.78	57.50	
7H	2	28.00	27.00	12.13	15.58	46.73	1.43	54.38	
7H	3	0.00	23.00	19.83	8.43	62.75	1.00	42.00	
7H	4	27.61	0.00	13.23	8.00	30.23	22.50	56.40	
7H	5	22.61	28.50	12.30	7.58	36.45	0.60	72.73	
7H	6	27.00	21.00	11.43	5.58	46.05	10.35	57.00	
7H	7	24.22	14.00	11.50	12.73	38.60	11.83	54.70	
7H	8	34.67	0.00	9.63	2.17	46.96	41.08	15.00	
7H	9	0.00	0.00	11.78	24.75	64.50	4.25	20.78	
7H	10	38.80	53.50	15.13	5.18	60.55	2.20	46.33	
7H	11	26.67	0.00	13.50	19.98	57.33	2.00	36.70	
7H	12	24.50	0.00	13.70	7.33	44.55	10.30	52.13	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2001	SD	Harding	8H	LEK	632285	5032649	6.00	1.00	0.85	0.12	85.00	10.00	0.00
2001	SD	Harding	8H	1	631785	5033649	0.00	1.00	0.00	0.48	100.00	5.00	0.00
2001	SD	Harding	8H	2	632785	5033649	0.00	0.00	0.00	0.21	100.00	15.00	0.00
2001	SD	Harding	8H	3	631285	5033149	0.00	1.00	0.01	0.32	100.00	60.00	10.00
2001	SD	Harding	8H	4	632285	5033149	0.00	1.00	0.00	0.19	100.00	0.00	0.00
2001	SD	Harding	8H	5	633285	5033149	0.00	2.00	0.01	0.48	55.00	25.00	0.00
2001	SD	Harding	8H	6	631785	5032649	5.00	1.00	0.34	0.20	60.00	5.00	0.00
2001	SD	Harding	8H	7	632785	5032649	1.00	4.00	0.24	0.52	90.00	0.00	0.00
2001	SD	Harding	8H	8	631285	5032149	5.00	0.00	0.71	0.12	85.00	15.00	0.00
2001	SD	Harding	8H	9	632285	5032149	8.00	0.00	0.84	0.01	90.00	20.00	0.00
2001	SD	Harding	8H	10	633285	5032149	0.00	1.00	0.12	0.47	100.00	10.00	0.00
2001	SD	Harding	8H	11	631785	5031649	3.00	0.00	0.77	0.02	85.00	10.00	0.00
2001	SD	Harding	8H	12	632785	5031649	3.00	1.00	0.46	0.16	85.00	15.00	0.00
2001	SD	Harding	9H	LEK	578999	5033369	0.00	0.00	0.01	0.00	40.00	0.00	0.00
2001	SD	Harding	9H	1	578499	5034369	3.00	4.00	0.16	0.48	70.00	5.00	0.00
2001	SD	Harding	9H	2	579499	5034369	2.00	0.00	0.12	0.00	75.00	5.00	0.00
2001	SD	Harding	9H	3	577999	5033869	0.00	0.00	0.02	0.01	100.00	0.00	0.00
2001	SD	Harding	9H	4	578999	5033869	13.00	0.00	0.90	0.11	70.00	30.00	0.00
2001	SD	Harding	9H	5	579999	5033869	5.00	0.00	0.76	0.01	100.00	20.00	0.00
2001	SD	Harding	9H	6	578499	5033369	8.00	0.00	0.48	0.01	65.00	25.00	0.00
2001	SD	Harding	9H	7	579499	5033369	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2001	SD	Harding	9H	8	577999	5032869	0.00	0.00	0.00	0.00	80.00	5.00	0.00
2001	SD	Harding	9H	9	578999	5032869	5.00	0.00	0.65	0.03	80.00	15.00	0.00
2001	SD	Harding	9H	10	579999	5032869	0.00	0.00	0.00	0.00	80.00	0.00	0.00
2001	SD	Harding	9H	11	578499	5032369	0.00	0.00	0.00	0.00	40.00	0.00	0.00
2001	SD	Harding	9H	12	579499	5032369	9.00	0.00	1.00	0.00	40.00	15.00	0.00
2001	SD	Harding	10H	LEK	641740	5016832	4.00	0.00	0.52	0.06	70.00	25.00	0.00
2001	SD	Harding	10H	1	641240	5017832	1.00	1.00	0.39	0.28	65.00	0.00	0.00
2001	SD	Harding	10H	2	642240	5017832	0.00	0.00	0.02	0.00	100.00	0.00	0.00
2001	SD	Harding	10H	3	640740	5017332	0.00	2.00	0.00	0.47	100.00	0.00	0.00
2001	SD	Harding	10H	4	641740	5017332	4.00	0.00	1.24	0.01	100.00	0.00	0.00
2001	SD	Harding	10H	5	642740	5017332	0.00	1.00	0.08	0.33	100.00	0.00	0.00
2001	SD	Harding	10H	6	641240	5016832	2.00	0.00	0.48	0.12	70.00	0.00	0.00
2001	SD	Harding	10H	7	642240	5016832	2.00	0.00	0.47	0.07	100.00	0.00	0.00
2001	SD	Harding	10H	8	640740	5016332	0.00	0.00	0.00	0.07	100.00	0.00	0.00
2001	SD	Harding	10H	9	641740	5016332	0.00	2.00	0.01	0.54	100.00	10.00	0.00
2001	SD	Harding	10H	10	642740	5016332	0.00	0.00	0.02	0.00	100.00	0.00	0.00
2001	SD	Harding	10H	11	641240	5015832	-	-	-	-	-	-	-
2001	SD	Harding	10H	12	642240	5015832	1.00	0.00	0.13	0.04	70.00	0.00	0.00

Appendix H. Continuation of sites on page 166.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
8H	LEK	28.66	33.85	18.03	11.75	57.38	11.33	31.50	
8H	1	28.00	25.53	17.60	10.93	56.03	2.40	41.63	
8H	2	0.00	29.33	14.85	10.23	69.33	2.55	28.63	
8H	3	0.00	40.41	18.03	6.98	64.13	0.65	40.00	
8H	4	0.00	25.07	15.08	4.18	68.33	5.48	29.20	
8H	5	0.00	27.22	12.65	8.03	41.28	7.28	55.00	
8H	6	28.33	29.00	16.38	9.90	47.18	3.30	54.63	
8H	7	25.33	29.32	15.83	9.45	58.45	11.70	32.00	
8H	8	22.19	28.91	13.15	4.83	49.98	18.60	35.43	
8H	9	28.26	32.00	14.58	10.98	59.20	11.25	29.20	
8H	10	29.20	31.47	17.15	18.25	60.43	0.48	47.25	
8H	11	29.04	28.86	13.78	4.00	51.30	14.78	36.75	
8H	12	24.80	33.36	14.03	15.50	45.93	7.13	44.95	
9H	LEK	19.33	44.00	12.40	3.03	41.50	2.28	64.50	
9H	1	27.33	36.14	13.35	14.93	37.10	15.55	47.25	
9H	2	24.13	29.00	14.33	5.28	48.13	1.50	56.80	
9H	3	17.67	19.00	13.95	1.85	58.15	2.20	47.88	
9H	4	36.31	42.00	16.30	6.28	37.30	0.45	70.68	
9H	5	22.77	0.00	14.05	6.55	44.30	23.28	35.75	
9H	6	33.87	73.00	15.25	2.68	45.70	3.28	58.55	
9H	7	22.00	0.00	10.70	4.58	44.55	2.13	58.88	
9H	8	0.00	0.00	13.55	7.95	54.20	9.13	36.38	
9H	9	21.82	29.00	14.10	5.65	44.33	4.75	54.85	
9H	10	30.00	0.00	14.14	2.03	54.69	13.60	34.57	
9H	11	0.00	0.00	11.43	1.75	48.08	2.65	56.68	
9H	12	24.50	0.00	8.35	4.40	41.63	13.60	46.18	
10H	LEK	25.84	25.00	11.00	4.18	38.33	9.30	57.13	
10H	1	16.25	22.17	12.33	8.00	63.33	22.63	8.33	
10H	2	20.00	70.00	13.88	2.98	57.50	3.48	44.50	
10H	3	42.00	27.33	15.00	8.78	41.95	4.40	56.15	
10H	4	14.79	30.00	6.15	4.08	18.53	53.58	29.35	
10H	5	15.93	41.11	16.48	10.85	50.95	1.53	50.13	
10H	6	17.56	29.30	13.38	4.23	40.93	12.00	55.50	
10H	7	21.65	18.00	13.00	3.28	35.50	8.80	61.28	
10H	8	0.00	44.36	15.50	2.93	52.25	5.50	54.63	
10H	9	28.50	30.43	15.13	11.98	74.60	1.30	19.38	
10H	10	36.00	0.00	14.89	9.23	72.31	3.91	26.29	
10H	11	-	-	-	-	-	-	-	Landowner permission (no)
10H	12	24.29	24.40	12.03	6.13	59.98	5.75	36.20	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	MT	Custer	18CU	1	413086	5144826	4.00	0.00	0.22	0.00	85.00	10.00	0.00
2002	MT	Custer	18CU	2	414086	5144826	16.00	1.00	1.23	0.26	90.00	60.00	30.00
2002	MT	Custer	18CU	3	412586	5144326	2.00	0.00	0.57	0.03	65.00	20.00	0.00
2002	MT	Custer	18CU	4	413586	5144326	10.00	0.00	0.69	0.00	55.00	30.00	0.00
2002	MT	Custer	18CU	5	414586	5144326	5.00	3.00	0.77	0.46	70.00	15.00	0.00
2002	MT	Custer	18CU	6	413086	5143826	0.00	0.00	0.09	0.00	5.00	0.00	0.00
2002	MT	Custer	18CU	7	414086	5143826	0.00	0.00	0.00	0.00	55.00	0.00	0.00
2002	MT	Custer	18CU	8	412586	5143326	2.00	0.00	0.14	0.01	60.00	10.00	0.00
2002	MT	Custer	18CU	9	413586	5143326	1.00	0.00	0.04	0.03	60.00	0.00	0.00
2002	MT	Custer	18CU	10	414586	5143326	0.00	0.00	0.00	0.00	75.00	0.00	0.00
2002	MT	Custer	18CU	11	413086	5142826	-	-	-	-	-	-	-
2002	MT	Custer	18CU	12	414086	5142826	11.00	3.00	0.46	0.19	85.00	40.00	15.00
2002	MT	Garfield	1GA	1	291229	5198518	23.00	0.00	2.48	0.00	100.00	75.00	0.00
2002	MT	Garfield	1GA	2	292229	5198518	17.00	0.00	2.21	0.00	100.00	30.00	0.00
2002	MT	Garfield	1GA	3	290729	5198018	17.00	0.00	1.77	0.43	75.00	45.00	0.00
2002	MT	Garfield	1GA	4	291729	5198018	12.00	0.00	1.89	0.00	100.00	15.00	0.00
2002	MT	Garfield	1GA	5	292729	5198018	14.00	0.00	2.06	0.00	95.00	30.00	0.00
2002	MT	Garfield	1GA	6	291229	5197518	20.00	0.00	1.79	0.00	85.00	55.00	0.00
2002	MT	Garfield	1GA	7	292229	5197518	11.00	0.00	2.08	0.00	95.00	20.00	0.00
2002	MT	Garfield	1GA	8	290729	5197018	20.00	0.00	1.85	0.00	85.00	50.00	0.00
2002	MT	Garfield	1GA	9	291729	5197018	11.00	0.00	1.79	0.00	65.00	0.00	0.00
2002	MT	Garfield	1GA	10	292729	5197018	13.00	0.00	1.98	0.00	95.00	40.00	0.00
2002	MT	Garfield	1GA	11	291229	5196518	5.00	0.00	0.93	0.00	85.00	0.00	0.00
2002	MT	Garfield	1GA	12	292229	5196518	6.00	0.00	0.84	0.00	70.00	35.00	0.00
2002	MT	Garfield	6GA	1	294720	5198686	39.00	0.00	2.15	0.00	100.00	95.00	5.00
2002	MT	Garfield	6GA	2	295720	5198686	18.00	0.00	1.90	0.00	95.00	5.00	0.00
2002	MT	Garfield	6GA	3	294220	5198186	21.00	0.00	2.21	0.00	95.00	40.00	0.00
2002	MT	Garfield	6GA	4	295220	5198186	9.00	0.00	1.39	0.00	75.00	15.00	0.00
2002	MT	Garfield	6GA	5	296220	5198186	21.00	0.00	1.78	0.00	100.00	65.00	0.00
2002	MT	Garfield	6GA	6	294720	5197686	16.00	0.00	1.85	0.00	95.00	30.00	0.00
2002	MT	Garfield	6GA	7	295720	5197686	17.00	0.00	2.07	0.00	65.00	30.00	0.00
2002	MT	Garfield	6GA	8	294220	5197186	28.00	0.00	2.19	0.00	100.00	85.00	0.00
2002	MT	Garfield	6GA	9	295220	5197186	22.00	0.00	2.86	0.00	100.00	35.00	0.00
2002	MT	Garfield	6GA	10	296220	5197186	14.00	0.00	2.32	0.00	95.00	25.00	0.00
2002	MT	Garfield	6GA	11	294720	5196686	15.00	0.00	1.84	0.00	90.00	30.00	0.00
2002	MT	Garfield	6GA	12	295720	5196686	21.00	0.00	2.29	0.00	95.00	55.00	0.00

Appendix H. Continuation of sites on page 168.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
18CU	1	32.25	0.00	12.98	3.58	52.28	35.43	11.23	
18CU	2	32.69	29.63	10.03	4.71	41.53	49.26	7.16	
18CU	3	23.34	20.50	8.10	8.63	27.68	59.78	10.28	
18CU	4	28.97	0.00	12.78	10.45	41.60	33.00	20.23	
18CU	5	29.17	28.18	9.28	4.25	35.08	57.45	6.15	
18CU	6	13.00	0.00	5.23	11.28	22.80	54.18	17.00	
18CU	7	0.00	0.00	13.68	15.13	58.90	25.58	10.18	
18CU	8	28.47	54.00	10.83	6.43	47.45	36.73	11.03	
18CU	9	23.00	37.00	14.30	9.30	43.98	42.58	9.03	
18CU	10	20.00	0.00	11.08	2.50	71.73	18.00	10.33	
18CU	11	-	-	-	-	-	-	-	Uninhabitable terrain/steep slope/Site on butte
18CU	12	45.63	46.91	14.10	3.38	41.98	41.63	15.88	
1GA	1	22.80	0.00	11.75	8.38	27.23	64.93	4.80	
1GA	2	21.48	0.00	12.90	7.95	34.08	58.15	4.10	
1GA	3	23.90	0.00	8.60	4.55	19.23	75.43	3.68	
1GA	4	21.41	0.00	11.50	6.35	24.68	64.95	5.23	
1GA	5	22.63	0.00	10.63	5.88	21.70	69.28	5.43	
1GA	6	27.30	0.00	11.23	4.48	22.08	67.73	8.23	
1GA	7	16.48	0.00	7.73	5.93	23.13	68.68	4.80	
1GA	8	28.73	0.00	11.05	5.23	17.10	78.03	3.05	
1GA	9	17.03	0.00	7.33	5.45	13.25	81.95	1.88	
1GA	10	24.53	0.00	8.68	4.53	13.13	82.78	1.90	
1GA	11	20.11	0.00	9.48	5.85	18.10	77.58	1.85	
1GA	12	22.26	0.00	9.40	6.83	37.05	50.40	8.80	
6GA	1	34.35	0.00	6.18	5.18	10.45	82.50	5.03	
6GA	2	22.03	0.00	7.50	4.18	17.80	76.73	2.88	
6GA	3	28.03	0.00	11.13	13.70	12.60	76.48	2.65	
6GA	4	17.88	0.00	9.20	5.08	22.75	70.90	5.10	
6GA	5	25.80	0.00	9.33	3.23	20.23	77.00	3.18	
6GA	6	26.43	0.00	8.73	2.75	25.20	68.35	6.05	
6GA	7	19.95	0.00	7.68	4.35	18.58	77.15	4.13	
6GA	8	32.05	0.00	5.75	6.53	9.40	85.08	2.40	
6GA	9	23.40	0.00	9.85	3.78	28.83	66.60	4.48	
6GA	10	23.10	0.00	10.30	3.68	23.15	73.25	4.23	
6GA	11	24.83	0.00	10.73	3.73	28.05	69.38	3.75	
6GA	12	26.70	0.00	9.60	3.85	15.90	81.30	2.93	

Appendix H. Continued

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	MT	Powder River	16PO	1	441704	5044489	0.00	0.00	0.02	0.00	5.00	0.00	0.00
2002	MT	Powder River	16PO	2	442704	5044489	1.00	2.00	0.03	0.46	20.00	0.00	0.00
2002	MT	Powder River	16PO	3	441204	5043989	3.00	4.00	0.01	1.85	95.00	70.00	25.00
2002	MT	Powder River	16PO	4	442204	5043989	3.00	0.00	0.38	0.00	15.00	10.00	0.00
2002	MT	Powder River	16PO	5	443204	5043989	2.00	2.00	0.11	0.62	45.00	5.00	0.00
2002	MT	Powder River	16PO	6	441704	5043489	0.00	0.00	0.00	0.00	5.00	0.00	0.00
2002	MT	Powder River	16PO	7	442704	5043489	1.00	4.00	0.11	0.86	35.00	20.00	5.00
2002	MT	Powder River	16PO	8	441204	5042989	6.00	1.00	0.50	0.12	55.00	20.00	10.00
2002	MT	Powder River	16PO	9	442204	5042989	2.00	2.00	0.21	0.96	35.00	10.00	0.00
2002	MT	Powder River	16PO	10	443204	5042989	3.00	0.00	0.22	0.00	15.00	0.00	0.00
2002	MT	Powder River	16PO	11	441704	5042489	10.00	1.00	0.48	0.73	50.00	35.00	10.00
2002	MT	Powder River	16PO	12	442704	5042489	15.00	0.00	0.81	0.00	80.00	60.00	5.00
2002	MT	Rosebud	15RO	1	398562	5139665	5.00	1.00	0.17	0.19	80.00	42.50	0.00
2002	MT	Rosebud	15RO	2	399562	5139665	7.00	0.00	1.12	0.00	75.00	10.00	0.00
2002	MT	Rosebud	15RO	3	398062	5139165	2.00	0.00	0.27	0.00	80.00	35.00	0.00
2002	MT	Rosebud	15RO	4	399062	5139165	2.00	0.00	0.09	0.00	75.00	5.00	0.00
2002	MT	Rosebud	15RO	5	400062	5139165	2.00	0.00	0.15	0.00	100.00	20.00	0.00
2002	MT	Rosebud	15RO	6	398562	5138665	0.00	0.00	0.00	0.00	65.00	5.00	0.00
2002	MT	Rosebud	15RO	7	399562	5138665	3.00	0.00	0.19	0.00	85.00	5.00	0.00
2002	MT	Rosebud	15RO	8	398062	5138165	1.00	0.00	0.20	0.00	50.00	0.00	0.00
2002	MT	Rosebud	15RO	9	399062	5138165	3.00	0.00	0.35	0.00	65.00	0.00	0.00
2002	MT	Rosebud	15RO	10	400062	5138165	1.00	0.00	0.33	0.00	75.00	0.00	0.00
2002	MT	Rosebud	15RO	11	398562	5137665	1.00	0.00	0.15	0.00	60.00	0.00	0.00
2002	MT	Rosebud	15RO	12	399562	5137665	1.00	0.00	0.29	0.00	45.00	0.00	0.00
2002	ND	Bowman	1BW	1	592792	5121172	0.00	0.00	0.11	0.12	40.00	15.00	5.00
2002	ND	Bowman	1BW	2	593792	5121172	-	-	-	-	-	-	-
2002	ND	Bowman	1BW	3	592292	5120672	-	-	-	-	-	-	-
2002	ND	Bowman	1BW	4	593292	5120672	1.00	3.00	0.12	0.47	90.00	30.00	10.00
2002	ND	Bowman	1BW	5	594292	5120672	0.00	0.00	0.05	0.00	65.00	20.00	0.00
2002	ND	Bowman	1BW	6	592792	5120172	2.00	2.00	0.26	0.33	60.00	25.00	5.00
2002	ND	Bowman	1BW	7	593792	5120172	1.00	0.00	0.16	0.15	0.00	0.00	0.00
2002	ND	Bowman	1BW	8	592292	5119672	0.00	4.00	0.01	0.62	55.00	15.00	5.00
2002	ND	Bowman	1BW	9	593292	5119672	2.00	1.00	0.17	0.17	90.00	20.00	20.00
2002	ND	Bowman	1BW	10	594292	5119672	0.00	0.00	0.00	0.01	100.00	65.00	0.00
2002	ND	Bowman	1BW	11	592792	5119172	0.00	2.00	0.01	0.21	65.00	10.00	5.00
2002	ND	Bowman	1BW	12	593792	5119172	2.00	1.00	0.34	0.08	45.00	15.00	0.00

Appendix H. Continuation of sites on page 170.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
16PO	1	27.67	0.00	6.33	5.30	25.58	70.13	3.20	
16PO	2	38.83	26.07	6.63	6.85	29.95	63.98	2.00	
16PO	3	14.33	26.63	8.38	4.45	38.90	49.40	8.58	
16PO	4	25.14	0.00	6.43	3.85	27.78	68.03	4.73	
16PO	5	32.88	19.54	9.90	2.35	41.60	51.50	7.00	
16PO	6	0.00	0.00	4.43	2.73	11.58	84.55	3.48	
16PO	7	34.93	30.43	9.98	6.15	64.30	31.03	2.25	
16PO	8	27.24	40.25	6.55	4.75	35.15	56.18	9.15	
16PO	9	32.71	16.17	5.90	3.88	64.98	26.13	8.58	
16PO	10	35.38	0.00	8.10	6.18	44.70	42.88	10.85	
16PO	11	42.32	15.89	10.05	7.20	44.68	42.40	15.45	
16PO	12	36.90	0.00	8.38	5.03	34.58	47.48	16.38	
15RO	1	35.95	36.83	10.74	4.00	47.36	42.87	7.62	
15RO	2	24.74	0.00	6.47	3.22	10.92	81.00	6.17	
15RO	3	28.74	0.00	9.75	5.20	25.33	69.78	2.50	
15RO	4	36.82	0.00	9.18	1.05	37.65	47.85	15.03	
15RO	5	37.76	0.00	12.98	4.60	38.48	26.80	34.73	
15RO	6	40.33	0.00	4.68	5.24	32.89	58.41	2.92	
15RO	7	28.79	0.00	9.70	9.75	28.45	57.50	7.43	
15RO	8	28.83	0.00	5.27	4.59	19.45	76.14	2.45	
15RO	9	25.30	0.00	11.80	6.83	26.95	60.30	10.15	
15RO	10	21.04	0.00	9.70	4.25	34.13	55.43	9.00	
15RO	11	27.57	0.00	8.63	4.45	31.48	82.85	4.53	
15RO	12	22.07	0.00	8.15	6.08	35.38	56.33	4.90	
1BW	1	21.64	29.13	8.50	5.70	53.95	34.35	8.53	
1BW	2	-	-	-	-	-	-	-	Crop field (beets)
1BW	3	-	-	-	-	-	-	-	Uninhabitable terrain/steep slope/feedlot close
1BW	4	32.29	42.57	15.75	6.48	70.25	17.33	8.05	
1BW	5	21.33	0.00	12.33	10.40	75.08	2.33	18.45	
1BW	6	31.06	35.33	4.78	4.38	20.45	64.05	13.65	
1BW	7	18.57	25.50	5.90	5.10	31.65	61.35	6.80	Tran1&2: Uninhabitable terrain, steep slope
1BW	8	22.75	37.96	11.30	4.78	52.28	29.78	16.35	
1BW	9	36.67	38.33	9.03	10.70	45.30	36.63	10.95	
1BW	10	40.00	54.50	25.65	8.73	79.18	3.15	13.78	
1BW	11	24.00	48.86	13.98	6.80	78.48	5.85	11.58	
1BW	12	32.24	33.78	7.73	3.10	44.08	50.73	4.35	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	ND	Bowman	6BW	1	596261	5104469	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	ND	Bowman	6BW	2	597261	5104469	6.00	0.00	1.39	0.00	75.00	0.00	0.00
2002	ND	Bowman	6BW	3	595761	5103969	5.00	0.00	1.41	0.00	60.00	15.00	0.00
2002	ND	Bowman	6BW	4	596761	5103969	10.00	0.00	1.36	0.00	80.00	40.00	15.00
2002	ND	Bowman	6BW	5	597761	5103969	3.00	0.00	0.67	0.01	100.00	55.00	0.00
2002	ND	Bowman	6BW	6	596261	5103469	2.00	4.00	0.15	0.88	45.00	0.00	0.00
2002	ND	Bowman	6BW	7	597261	5103469	2.00	1.00	0.16	0.10	100.00	10.00	0.00
2002	ND	Bowman	6BW	8	595761	5102969	0.00	1.00	0.01	0.13	100.00	5.00	0.00
2002	ND	Bowman	6BW	9	596761	5102969	0.00	1.00	0.04	0.16	20.00	5.00	0.00
2002	ND	Bowman	6BW	10	597761	5102969	5.00	0.00	1.07	0.01	75.00	5.00	0.00
2002	ND	Bowman	6BW	11	596261	5102469	2.00	1.00	0.08	0.25	100.00	35.00	10.00
2002	ND	Bowman	6BW	12	597261	5102469	1.00	1.00	0.10	0.14	100.00	25.00	0.00
2002	ND	Bowman	8BW	1	603717	5099755	-	-	-	-	-	-	-
2002	ND	Bowman	8BW	2	604717	5099755	0.00	0.00	0.07	0.04	35.00	0.00	0.00
2002	ND	Bowman	8BW	3	603217	5099255	0.00	0.00	0.00	0.14	0.00	0.00	0.00
2002	ND	Bowman	8BW	4	604217	5099255	0.00	0.00	0.05	0.03	30.00	0.00	0.00
2002	ND	Bowman	8BW	5	605217	5099255	6.00	0.00	1.99	0.00	60.00	5.00	0.00
2002	ND	Bowman	8BW	6	603717	5098755	-	-	-	-	-	-	-
2002	ND	Bowman	8BW	7	604717	5098755	0.00	0.00	0.13	0.02	60.00	0.00	0.00
2002	ND	Bowman	8BW	8	603217	5098255	-	-	-	-	-	-	-
2002	ND	Bowman	8BW	9	604217	5098255	0.00	0.00	0.07	0.00	30.00	0.00	0.00
2002	ND	Bowman	8BW	10	605217	5098255	-	-	-	-	-	-	-
2002	ND	Bowman	8BW	11	603717	5097755	-	-	-	-	-	-	-
2002	ND	Bowman	8BW	12	604717	5097755	0.00	0.00	0.02	0.00	60.00	5.00	0.00
2002	ND	Bowman	9BW	1	601386	5091592	0.00	0.00	0.02	0.23	55.00	0.00	0.00
2002	ND	Bowman	9BW	2	602386	5091592	1.00	0.00	0.40	0.02	90.00	0.00	0.00
2002	ND	Bowman	9BW	3	600886	5091092	1.00	1.00	0.43	0.35	50.00	5.00	0.00
2002	ND	Bowman	9BW	4	601886	5091092	1.00	3.00	0.21	0.43	60.00	0.00	0.00
2002	ND	Bowman	9BW	5	602886	5091092	0.00	0.00	0.10	0.18	40.00	0.00	0.00
2002	ND	Bowman	9BW	6	601386	5090592	1.00	2.00	0.17	0.34	85.00	10.00	0.00
2002	ND	Bowman	9BW	7	602386	5090592	0.00	0.00	0.00	0.00	100.00	85.00	0.00
2002	ND	Bowman	9BW	8	600886	5090092	3.00	0.00	0.61	0.07	50.00	10.00	0.00
2002	ND	Bowman	9BW	9	601886	5090092	-	-	-	-	-	-	-
2002	ND	Bowman	9BW	10	602886	5090092	1.00	1.00	0.37	0.31	100.00	30.00	5.00
2002	ND	Bowman	9BW	11	601386	5089592	0.00	2.00	0.42	0.51	95.00	15.00	5.00
2002	ND	Bowman	9BW	12	602386	5089592	-	-	-	-	-	-	-

Appendix H. Continuation of sites on page 172.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
6BW	1	0.00	0.00	5.43	4.70	18.16	9.59	77.14	
6BW	2	18.41	0.00	14.15	6.10	66.10	15.05	16.98	
6BW	3	24.97	16.00	7.63	6.65	41.10	21.25	34.75	
6BW	4	24.70	0.00	13.65	6.90	50.98	17.93	31.45	
6BW	5	29.33	15.00	24.17	3.91	82.46	7.23	7.83	
6BW	6	25.08	30.00	4.63	3.50	28.55	60.08	11.30	
6BW	7	33.15	50.63	13.55	5.00	81.78	7.83	8.18	
6BW	8	38.67	26.00	9.83	3.30	43.45	49.05	6.33	
6BW	9	21.83	19.83	4.67	2.53	6.57	90.47	0.80	
6BW	10	21.70	17.50	13.28	5.28	58.53	4.20	38.55	
6BW	11	52.37	40.46	23.20	7.05	92.98	1.13	2.55	
6BW	12	29.22	36.83	17.85	3.45	76.95	7.45	15.85	
8BW	1	-	-	-	-	-	-	-	Highway
8BW	2	17.20	25.83	8.50	4.68	76.40	10.50	10.98	
8BW	3	0.00	13.00	8.57	3.71	93.00	0.86	5.00	
8BW	4	23.00	25.00	10.63	5.10	81.58	2.10	14.58	
8BW	5	15.76	0.00	9.15	7.05	46.08	13.28	38.90	
8BW	6	-	-	-	-	-	-	-	Highway
8BW	7	24.90	38.00	9.70	6.35	59.38	1.73	40.33	
8BW	8	-	-	-	-	-	-	-	Gravel Road
8BW	9	12.36	0.00	9.13	6.35	55.80	24.68	16.50	
8BW	10	-	-	-	-	-	-	-	Oil pump pad
8BW	11	-	-	-	-	-	-	-	Highway
8BW	12	25.50	29.50	13.35	6.70	86.00	0.63	10.63	
9BW	1	14.00	18.50	9.50	4.25	81.40	12.93	4.53	
9BW	2	18.19	33.33	10.78	2.90	73.90	20.38	4.48	
9BW	3	15.08	22.77	9.88	6.98	66.05	14.08	17.33	
9BW	4	18.76	23.04	12.65	4.23	78.65	14.68	4.58	
9BW	5	19.00	16.08	12.89	3.69	81.42	12.03	5.44	
9BW	6	29.17	34.57	13.88	3.83	85.45	2.23	12.55	
9BW	7	0.00	0.00	33.78	1.05	98.98	0.05	0.45	
9BW	8	23.81	31.33	10.63	6.63	80.75	1.58	14.63	
9BW	9	-	-	-	-	-	-	-	Alfalfa/crested wheatgrass hayfield
9BW	10	13.33	28.63	15.45	3.15	75.35	15.58	7.55	
9BW	11	19.00	29.65	12.23	2.48	78.65	10.13	10.78	
9BW	12	-	-	-	-	-	-	-	Wheat field

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	ND	Bowman	10BW	1	596612	5089851	0.00	0.00	0.00	0.00	35.00	0.00	0.00
2002	ND	Bowman	10BW	2	597612	5089851	6.00	0.00	1.71	0.00	30.00	5.00	0.00
2002	ND	Bowman	10BW	3	596112	5089351	0.00	0.00	0.00	0.00	20.00	0.00	0.00
2002	ND	Bowman	10BW	4	597112	5089351	0.00	0.00	0.00	0.00	15.00	0.00	0.00
2002	ND	Bowman	10BW	5	598112	5089351	0.00	0.00	0.00	0.00	50.00	50.00	0.00
2002	ND	Bowman	10BW	6	596612	5088851	2.00	0.00	0.40	0.00	55.00	0.00	0.00
2002	ND	Bowman	10BW	7	597612	5088851	3.00	0.00	0.98	0.00	5.00	0.00	0.00
2002	ND	Bowman	10BW	8	596112	5088351	3.00	0.00	0.34	0.00	50.00	15.00	0.00
2002	ND	Bowman	10BW	9	597112	5088351	9.00	0.00	1.29	0.00	60.00	5.00	0.00
2002	ND	Bowman	10BW	10	598112	5088351	0.00	0.00	0.00	0.04	100.00	75.00	0.00
2002	ND	Bowman	10BW	11	596612	5087851	-	-	-	-	-	-	-
2002	ND	Bowman	10BW	12	597612	5087851	1.00	0.00	0.19	0.03	95.00	5.00	0.00
2002	ND	Bowman	16BW	1	578192	5107534	3.00	0.00	0.97	0.00	60.00	0.00	0.00
2002	ND	Bowman	16BW	2	579192	5107534	5.00	0.00	1.69	0.00	50.00	5.00	0.00
2002	ND	Bowman	16BW	3	577692	5107034	3.00	0.00	0.40	0.00	60.00	5.00	0.00
2002	ND	Bowman	16BW	4	578692	5107034	3.00	0.00	0.62	0.00	30.00	0.00	0.00
2002	ND	Bowman	16BW	5	579652	5107034	6.00	0.00	1.18	0.00	90.00	17.00	0.00
2002	ND	Bowman	16BW	6	578192	5106534	0.00	0.00	0.02	0.00	70.00	0.00	0.00
2002	ND	Bowman	16BW	7	579192	5106534	1.00	0.00	0.41	0.00	30.00	0.00	0.00
2002	ND	Bowman	16BW	8	577692	5106034	3.00	0.00	0.52	0.01	70.00	5.00	0.00
2002	ND	Bowman	16BW	9	578692	5106034	7.00	0.00	2.11	0.00	50.00	5.00	0.00
2002	ND	Bowman	16BW	10	579652	5106034	6.00	0.00	1.32	0.00	40.00	0.00	0.00
2002	ND	Bowman	16BW	11	578192	5105534	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	ND	Bowman	16BW	12	579192	5105534	11.00	0.00	1.08	0.00	50.00	15.00	0.00
2002	ND	Bowman	18BW	1	590259	5115700	2.00	1.00	0.14	0.23	60.00	0.00	0.00
2002	ND	Bowman	18BW	2	591259	5115700	-	-	-	-	-	-	-
2002	ND	Bowman	18BW	3	589759	5115200	4.00	0.00	1.36	0.14	45.00	15.00	0.00
2002	ND	Bowman	18BW	4	590759	5115200	1.00	0.00	0.18	0.02	20.00	5.00	0.00
2002	ND	Bowman	18BW	5	591759	5115200	0.00	0.00	0.00	0.07	60.00	0.00	0.00
2002	ND	Bowman	18BW	6	590259	5114700	0.00	1.00	0.05	0.09	25.00	0.00	0.00
2002	ND	Bowman	18BW	7	591259	5114700	-	-	-	-	-	-	-
2002	ND	Bowman	18BW	8	589759	5114200	3.00	1.00	0.21	0.26	50.00	0.00	0.00
2002	ND	Bowman	18BW	9	590759	5114200	0.00	0.00	0.00	0.14	20.00	0.00	0.00
2002	ND	Bowman	18BW	10	591759	5114200	0.00	0.00	0.15	0.12	35.00	0.00	0.00
2002	ND	Bowman	18BW	11	590259	5113700	-	-	-	-	-	-	-
2002	ND	Bowman	18BW	12	591259	5113700	4.00	0.00	0.53	0.01	45.00	5.00	0.00

Appendix H. Continuation of sites on page 174.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
10BW	1	0.00	0.00	10.20	5.58	72.30	1.23	23.70	
10BW	2	15.89	0.00	7.90	3.70	46.03	9.60	44.60	
10BW	3	35.00	29.00	9.58	2.75	60.23	3.75	38.45	
10BW	4	0.00	0.00	9.80	11.23	77.55	0.60	15.55	
10BW	5	0.00	0.00	35.25	2.80	93.90	2.00	2.03	
10BW	6	22.79	0.00	10.05	4.15	58.08	10.68	30.90	
10BW	7	10.00	0.00	5.55	3.78	30.90	54.45	13.53	
10BW	8	26.09	0.00	9.38	4.55	69.75	2.15	28.23	
10BW	9	22.90	0.00	10.80	6.33	58.13	8.65	31.63	
10BW	10	0.00	70.00	29.15	3.96	93.67	1.37	3.04	
10BW	11	-	-	-	-	-	-	-	By road/uninhabitable territory
10BW	12	23.71	25.50	11.32	2.76	76.68	11.24	11.92	
16BW	1	19.78	0.00	8.28	8.13	56.90	25.10	17.00	
16BW	2	15.37	0.00	8.18	15.10	38.93	47.73	8.58	
16BW	3	24.82	0.00	9.93	10.60	40.60	47.40	9.10	
16BW	4	12.63	0.00	6.80	8.33	57.68	23.25	13.90	
16BW	5	21.05	0.00	12.25	4.23	65.43	24.55	11.40	
16BW	6	17.83	0.00	10.80	17.03	73.50	13.60	3.65	Looks like area was tilled at one point
16BW	7	17.17	0.00	7.83	11.15	23.93	62.90	7.50	
16BW	8	23.83	29.00	7.75	11.03	27.10	60.45	11.50	Next to oil road/Tran4 10 m & 15 m on road
16BW	9	17.79	0.00	8.53	11.03	63.65	22.18	10.78	
16BW	10	16.22	28.00	9.63	12.15	36.85	50.50	15.03	
16BW	11	18.50	0.00	3.08	5.28	10.98	84.65	7.45	
16BW	12	28.74	0.00	9.40	6.48	52.25	22.23	28.78	
18BW	1	23.88	17.81	9.55	5.80	65.75	19.20	12.28	
18BW	2	-	-	-	-	-	-	-	Uninhabitable terrain/steep slope
18BW	3	19.97	30.10	8.12	7.70	40.73	33.06	20.91	
18BW	4	34.56	18.71	10.23	5.60	73.30	6.53	17.33	
18BW	5	0.00	42.50	12.30	3.55	81.48	8.45	6.35	
18BW	6	38.83	22.46	8.98	9.48	68.45	4.50	22.75	Next to prairie dog town
18BW	7	-	-	-	-	-	-	-	Hayfield western wheatgrass 15-20 cm tall
18BW	8	30.23	21.80	7.89	2.27	47.62	21.73	33.22	
18BW	9	0.00	25.80	9.63	3.43	52.70	3.58	42.45	
18BW	10	23.13	30.76	4.60	1.05	21.65	73.70	3.98	
18BW	11	-	-	-	-	-	-	-	Uninhabitable/steep slope/point of butte
18BW	12	20.57	43.00	9.93	6.13	59.33	15.38	23.20	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	ND	Slope	18MT	1	572022	5136492	0.00	3.00	0.07	0.68	30.00	15.00	10.00
2002	ND	Slope	18MT	2	573022	5136492	-	-	-	-	-	-	-
2002	ND	Slope	18MT	3	571522	5135992	0.00	2.00	0.00	0.24	25.00	5.00	0.00
2002	ND	Slope	18MT	4	572522	5135992	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	ND	Slope	18MT	5	573522	5135992	2.00	1.00	0.18	0.07	15.00	5.00	0.00
2002	ND	Slope	18MT	6	572022	5135492	6.00	1.00	0.43	0.17	60.00	10.00	0.00
2002	ND	Slope	18MT	7	573022	5135492	3.00	1.00	0.27	0.19	35.00	20.00	0.00
2002	ND	Slope	18MT	8	571522	5134992	1.00	2.00	0.05	0.47	30.00	5.00	0.00
2002	ND	Slope	18MT	9	572522	5134992	9.00	0.00	1.66	0.01	65.00	0.00	0.00
2002	ND	Slope	18MT	10	573522	5134992	5.00	0.00	0.84	0.20	75.00	5.00	0.00
2002	ND	Slope	18MT	11	572022	5134992	0.00	2.00	0.00	0.39	15.00	0.00	0.00
2002	ND	Slope	18MT	12	573022	5134992	0.00	1.00	0.00	0.38	95.00	0.00	0.00
2002	ND	Slope	4S	1	590061	5129429	1.00	0.00	0.15	0.05	45.00	0.00	0.00
2002	ND	Slope	4S	2	591061	5129429	0.00	3.00	0.00	0.22	65.00	10.00	0.00
2002	ND	Slope	4S	3	589561	5128929	0.00	2.00	0.00	0.15	40.00	0.00	0.00
2002	ND	Slope	4S	4	590561	5128929	0.00	0.00	0.01	0.05	10.00	0.00	0.00
2002	ND	Slope	4S	5	591561	5128929	0.00	7.00	0.00	0.66	70.00	25.00	10.00
2002	ND	Slope	4S	6	590061	5128429	0.00	0.00	0.00	0.00	25.00	0.00	0.00
2002	ND	Slope	4S	7	591061	5128429	2.00	1.00	0.25	0.12	75.00	10.00	5.00
2002	ND	Slope	4S	8	589561	5127929	2.00	3.00	0.12	0.52	85.00	55.00	5.00
2002	ND	Slope	4S	9	590561	5127929	2.00	0.00	0.56	0.00	0.00	0.00	0.00
2002	ND	Slope	4S	10	591561	5127929	0.00	0.00	0.01	0.05	95.00	70.00	0.00
2002	ND	Slope	4S	11	590061	5127429	3.00	1.00	0.24	0.14	35.00	5.00	0.00
2002	ND	Slope	4S	12	591061	5127429	2.00	1.00	0.35	0.19	60.00	10.00	0.00
2002	ND	Slope	5S	1	577708	5137816	0.00	7.00	0.00	0.26	90.00	40.00	0.00
2002	ND	Slope	5S	2	578708	5137816	9.00	0.00	0.55	0.00	70.00	20.00	10.00
2002	ND	Slope	5S	3	577208	5137316	3.00	3.00	0.17	0.32	55.00	25.00	10.00
2002	ND	Slope	5S	4	578208	5137316	-	-	-	-	-	-	-
2002	ND	Slope	5S	5	579208	5137316	2.00	1.00	0.17	0.11	15.00	5.00	0.00
2002	ND	Slope	5S	6	577708	5136816	0.00	0.00	0.00	0.00	10.00	0.00	0.00
2002	ND	Slope	5S	7	578708	5136816	0.00	1.00	0.02	0.29	15.00	0.00	0.00
2002	ND	Slope	5S	8	577208	5136316	2.00	10.00	0.21	1.13	35.00	10.00	0.00
2002	ND	Slope	5S	9	578208	5136316	0.00	0.00	0.00	0.05	50.00	0.00	0.00
2002	ND	Slope	5S	10	579208	5136316	1.00	2.00	0.06	0.21	65.00	10.00	5.00
2002	ND	Slope	5S	11	577708	5135816	0.00	2.00	0.00	0.28	40.00	0.00	0.00
2002	ND	Slope	5S	12	578708	5135816	0.00	0.00	0.00	0.00	40.00	0.00	0.00

Appendix H. Continuation of sites on page 176.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
18MT	1	44.83	22.05	9.04	5.50	82.92	1.77	21.38	
18MT	2	-	-	-	-	-	-	-	Uninhabitable terrain
18MT	3	9.00	34.04	7.58	11.30	69.55	4.35	21.90	
18MT	4	0.00	0.00	0.00	4.30	0.80	93.30	1.60	
18MT	5	30.45	29.60	4.04	5.21	18.75	73.83	5.13	In valley of buttes/Cedar tree at 10 m 4 m tall
18MT	6	27.17	29.15	9.60	6.35	57.30	14.43	30.58	
18MT	7	33.08	34.80	10.85	5.13	65.98	16.43	16.28	
18MT	8	27.50	24.42	8.18	20.53	56.78	2.28	34.15	
18MT	9	29.18	31.50	7.90	6.18	45.75	15.43	39.18	
18MT	10	27.70	36.30	13.55	18.40	48.65	32.63	9.83	
18MT	11	0.00	34.90	7.68	14.15	64.80	6.70	28.80	
18MT	12	0.00	24.84	25.00	5.22	90.89	0.75	7.81	Tran3 Crested wheatgrass/alfalfa field
4S	1	22.06	35.44	11.20	9.93	60.18	14.28	21.83	
4S	2	0.00	34.04	13.18	9.60	58.78	4.68	39.05	
4S	3	0.00	37.76	13.35	13.85	55.95	20.65	11.65	Tran4 Steep slope
4S	4	0.00	29.75	8.63	6.93	44.18	10.43	45.80	Prairie dog town
4S	5	41.50	45.11	12.23	8.23	61.83	3.18	40.50	
4S	6	0.00	0.00	6.08	18.20	30.08	34.93	17.73	Prairie dog town
4S	7	21.45	31.29	9.73	4.00	61.55	28.20	9.33	
4S	8	25.14	46.34	13.35	6.73	61.80	17.68	13.13	
4S	9	8.59	0.00	5.18	5.23	53.20	31.18	13.95	Prairie dog town
4S	10	18.00	47.67	16.78	5.15	85.38	0.45	11.53	
4S	11	28.97	27.45	10.33	11.10	49.13	4.88	43.83	
4S	12	26.23	34.91	12.68	5.95	67.28	21.78	7.68	
5S	1	71.50	62.67	13.38	1.38	42.69	56.31	1.69	Tran2&3 Uninhabitable territory/Steep slope
5S	2	43.53	0.00	5.89	4.33	20.08	57.67	27.78	
5S	3	41.50	41.05	8.80	5.98	54.50	11.58	34.65	
5S	4	-	-	-	-	-	-	-	Uninhabitable territory/Steep slope
5S	5	27.25	37.67	4.20	0.47	14.60	74.13	32.13	Tran2 & some of 4 steep slope/1 Cedar 168 cm
5S	6	0.00	0.00	5.30	7.50	57.98	17.23	23.18	Prairie dog town
5S	7	20.00	24.06	11.70	5.20	69.15	4.78	25.85	
5S	8	49.33	54.19	15.89	3.83	49.78	41.50	2.44	Tran2&4 Uninhabitable terrain
5S	9	0.00	30.00	13.78	5.30	85.88	6.55	6.25	
5S	10	27.83	36.74	12.93	4.38	60.08	11.78	26.20	
5S	11	0.00	39.85	13.90	10.13	63.75	10.15	10.75	
5S	12	0.00	0.00	11.38	2.35	56.95	7.30	35.55	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	ND	Slope	10S	1	589455	5149648	0.00	3.00	0.00	0.87	15.00	0.00	0.00
2002	ND	Slope	10S	2	590455	5149648	0.00	0.00	0.00	0.16	100.00	15.00	0.00
2002	ND	Slope	10S	3	588955	5149148	0.00	1.00	0.00	0.25	100.00	5.00	5.00
2002	ND	Slope	10S	4	589955	5149148	0.00	0.00	0.00	0.00	45.00	25.00	0.00
2002	ND	Slope	10S	5	590955	5149148	0.00	1.00	0.00	0.16	100.00	5.00	0.00
2002	ND	Slope	10S	6	589455	5148648	0.00	3.00	0.00	0.45	45.00	15.00	5.00
2002	ND	Slope	10S	7	590455	5148648	-	-	-	-	-	-	-
2002	ND	Slope	10S	8	588955	5148148	0.00	8.00	0.04	0.91	70.00	20.00	5.00
2002	ND	Slope	10S	9	589955	5148148	0.00	1.00	0.00	0.15	25.00	0.00	0.00
2002	ND	Slope	10S	10	590955	5148148	1.00	5.00	0.04	0.53	90.00	25.00	5.00
2002	ND	Slope	10S	11	589455	5147648	1.00	1.00	0.04	0.59	45.00	5.00	0.00
2002	ND	Slope	10S	12	590455	5147648	0.00	3.00	0.00	0.34	45.00	10.00	0.00
2002	ND	Slope	11S	1	582343	5143358	0.00	4.00	0.00	0.50	90.00	15.00	0.00
2002	ND	Slope	11S	2	583343	5143358	17.00	0.00	0.98	0.00	65.00	30.00	0.00
2002	ND	Slope	11S	3	581843	5142858	-	-	-	-	-	-	-
2002	ND	Slope	11S	4	582843	5142858	3.00	19.00	0.37	1.09	70.00	30.00	10.00
2002	ND	Slope	11S	5	583843	5142858	2.00	1.00	0.26	0.10	15.00	0.00	0.00
2002	ND	Slope	11S	6	582343	5142358	8.00	0.00	0.56	0.00	80.00	30.00	15.00
2002	ND	Slope	11S	7	583343	5142358	1.00	0.00	0.00	0.37	65.00	5.00	0.00
2002	ND	Slope	11S	8	581843	5141858	-	-	-	-	-	-	-
2002	ND	Slope	11S	9	582843	5141858	0.00	9.00	0.01	0.67	45.00	10.00	0.00
2002	ND	Slope	11S	10	583843	5141858	4.00	2.00	0.44	0.15	80.00	5.00	0.00
2002	ND	Slope	11S	11	582343	5141358	-	-	-	-	-	-	-
2002	ND	Slope	11S	12	583343	5141358	3.00	0.00	0.48	0.06	25.00	5.00	0.00
2002	ND	Slope	12S	1	580628	5154058	0.00	0.00	0.13	0.06	65.00	0.00	0.00
2002	ND	Slope	12S	2	581628	5154058	-	-	-	-	-	-	-
2002	ND	Slope	12S	3	580128	5153558	1.00	0.00	0.30	0.01	75.00	0.00	0.00
2002	ND	Slope	12S	4	584428	5153558	0.00	0.00	0.02	0.01	90.00	0.00	0.00
2002	ND	Slope	12S	5	583228	5153558	0.00	1.00	0.00	0.39	80.00	5.00	0.00
2002	ND	Slope	12S	6	580628	5153058	0.00	0.00	0.02	0.06	50.00	0.00	0.00
2002	ND	Slope	12S	7	581628	5153058	0.00	0.00	0.04	0.00	80.00	0.00	0.00
2002	ND	Slope	12S	8	580128	5152558	0.00	0.00	0.01	0.15	30.00	5.00	0.00
2002	ND	Slope	12S	9	584428	5152558	3.00	0.00	0.57	0.01	45.00	0.00	0.00
2002	ND	Slope	12S	10	583228	5152558	1.00	0.00	0.10	0.00	85.00	0.00	0.00
2002	ND	Slope	12S	11	580628	5152058	0.00	3.00	0.00	0.40	90.00	50.00	0.00
2002	ND	Slope	12S	12	581628	5152058	0.00	1.00	0.07	0.13	20.00	0.00	0.00

Appendix H. Continuation of sites on page 178.

		Sagebrush Ht. (cm)			Cover (%)				
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
10S	1	0.00	29.85	10.28	3.93	36.95	6.25	58.15	
10S	2	0.00	27.17	18.93	2.23	80.00	4.95	12.50	
10S	3	0.00	32.60	19.73	3.00	73.10	0.43	25.63	
10S	4	0.00	19.00	14.65	8.10	59.95	3.20	36.15	Tran1&4: Steep slope (chokecherry, green ash, cedar, western snowberry, and golden current)
10S	5	0.00	35.19	14.65	4.58	72.48	2.85	22.28	
10S	6	0.00	35.70	9.78	7.73	39.50	0.58	59.20	
10S	7	-	-	-	-	-	-	-	Uninhabitable terrain/Steep slope (western snowberry, cedar, green ash, chokecherry, and golden current)
10S	8	47.00	37.68	13.47	2.90	69.30	1.43	30.73	
10S	9	0.00	33.85	10.94	5.10	46.97	41.74	5.42	
10S	10	42.40	38.81	17.23	9.74	65.91	6.29	24.23	
10S	11	22.80	27.64	11.80	7.75	51.30	8.85	34.30	Tran2&4: Steep slope/Uninhabitable
10S	12	0.00	40.45	16.25	3.15	61.70	6.50	30.25	Tran3&4: Uninhabitable terrain/Steep slope
11S	1	26.00	45.45	14.95	4.70	69.25	2.95	23.18	
11S	2	46.12	0.00	9.00	1.40	31.30	52.43	7.20	Tran4 Steep butte
11S	3	-	-	-	-	-	-	-	Uninhabitable terrain: side of butte
11S	4	36.65	63.77	7.35	9.38	36.13	52.25	10.23	
11S	5	17.50	33.27	5.43	2.10	66.85	22.58	11.70	
11S	6	30.29	0.00	9.39	12.47	56.17	29.08	10.19	Tran3 Steep butte
11S	7	0.00	38.29	13.34	2.81	66.88	14.16	20.34	Tran4 Water: Little Missouri
11S	8	-	-	-	-	-	-	-	Uninhabitable terrain/Steep slope/side of butte
11S	9	16.50	46.95	11.53	7.75	63.78	19.53	13.03	
11S	10	36.77	32.89	12.75	8.10	60.10	24.23	7.45	
11S	11	-	-	-	-	-	-	-	Uninhabitable terrain: Top of butte
11S	12	27.66	24.33	7.10	8.33	40.68	49.00	5.80	
12S	1	12.40	23.67	10.48	12.83	60.05	14.48	16.23	
12S	2	-	-	-	-	-	-	-	Dry creek bottom/trees prevent tape direction/ steep slope (green ash, chokecherry, and western snowberry)
12S	3	15.96	0.00	9.98	12.28	76.58	6.78	10.28	
12S	4	22.60	30.00	13.03	19.93	64.45	18.13	3.10	
12S	5	0.00	30.78	12.71	17.06	63.66	2.91	24.83	Tran3 49 m to 35 m is a windbreak (Green Ash)
12S	6	17.67	27.25	11.75	8.33	75.20	9.75	7.85	
12S	7	26.57	0.00	11.88	9.65	60.03	28.80	6.08	
12S	8	23.50	33.09	9.85	11.95	71.13	11.30	10.53	
12S	9	19.60	26.00	7.40	24.70	55.13	21.73	6.33	
12S	10	21.29	30.50	12.55	0.83	74.05	14.53	13.63	
12S	11	0.00	35.40	10.73	5.53	72.03	7.73	19.55	
12S	12	26.44	32.50	9.28	6.05	79.73	8.53	9.23	

Appendix H. Continued.

					UTM		Sagebrush Cover (%)		Sagebrush Density (/m²)		Visual Obs. (%)		
Year	State	County	Lek	Site	X	Y	Big	Silver	Big	Silver	0.10 m	0.25 m	0.50 m
2002	ND	Slope	15S	1	573853	5147873	2.00	5.00	0.19	0.29	85.00	20.00	10.00
2002	ND	Slope	15S	2	574853	5147873	0.00	9.00	0.00	0.90	85.00	30.00	5.00
2002	ND	Slope	15S	3	573353	5147373	7.00	2.00	0.35	0.16	85.00	50.00	20.00
2002	ND	Slope	15S	4	574353	5147373	3.00	2.00	0.36	0.31	85.00	15.00	5.00
2002	ND	Slope	15S	5	575353	5147373	3.00	2.00	0.30	0.22	50.00	10.00	5.00
2002	ND	Slope	15S	6	573853	5146873	2.00	0.00	0.11	0.06	80.00	5.00	0.00
2002	ND	Slope	15S	7	574853	5146873	4.00	0.00	0.32	0.02	25.00	10.00	0.00
2002	ND	Slope	15S	8	573353	5146373	-	-	-	-	-	-	-
2002	ND	Slope	15S	9	574353	5146373	11.00	0.00	0.80	0.01	35.00	10.00	5.00
2002	ND	Slope	15S	10	575353	5146373	6.00	0.00	0.48	0.12	85.00	20.00	5.00
2002	ND	Slope	15S	11	573853	5145873	-	-	-	-	-	-	-
2002	ND	Slope	15S	12	574853	5145873	1.00	4.00	0.07	0.28	65.00	25.00	10.00
2002	SD	Harding	5H	1	596256	5045727	11.00	0.00	1.53	0.00	100.00	10.00	0.00
2002	SD	Harding	5H	2	597256	5045727	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2002	SD	Harding	5H	3	595756	5045227	5.00	3.00	0.36	0.23	45.00	15.00	0.00
2002	SD	Harding	5H	4	596756	5045227	17.00	0.00	1.52	0.00	90.00	0.00	0.00
2002	SD	Harding	5H	5	597756	5045227	0.00	0.00	0.00	0.00	100.00	20.00	0.00
2002	SD	Harding	5H	6	596256	5044727	0.00	0.00	0.03	0.00	35.00	0.00	0.00
2002	SD	Harding	5H	7	597256	5044727	0.00	0.00	0.07	0.00	90.00	10.00	0.00
2002	SD	Harding	5H	8	595756	5044227	5.00	0.00	0.34	0.03	55.00	0.00	0.00
2002	SD	Harding	5H	9	596756	5044227	0.00	0.00	0.01	0.00	80.00	5.00	0.00
2002	SD	Harding	5H	10	597756	5044227	0.00	0.00	0.07	0.00	75.00	0.00	0.00
2002	SD	Harding	5H	11	596256	5043727	0.00	1.00	0.05	0.11	15.00	5.00	0.00
2002	SD	Harding	5H	12	597256	5043727	0.00	0.00	0.00	0.00	100.00	55.00	0.00
2002	SD	Harding	6H	1	600785	5058816	2.00	0.00	0.52	0.01	70.00	0.00	0.00
2002	SD	Harding	6H	2	601785	5058816	1.00	2.00	0.22	0.34	90.00	20.00	5.00
2002	SD	Harding	6H	3	600285	5058316	1.00	1.00	0.08	0.12	95.00	15.00	0.00
2002	SD	Harding	6H	4	601285	5058316	10.00	1.00	0.78	0.06	100.00	65.00	30.00
2002	SD	Harding	6H	5	602285	5058316	1.00	4.00	0.06	0.20	75.00	10.00	0.00
2002	SD	Harding	6H	6	600785	5057816	2.00	1.00	0.21	0.19	50.00	15.00	0.00
2002	SD	Harding	6H	7	601785	5057816	11.00	1.00	1.29	0.12	75.00	40.00	0.00
2002	SD	Harding	6H	8	600285	5057316	8.00	2.00	1.07	0.08	90.00	15.00	0.00
2002	SD	Harding	6H	9	601285	5057316	17.00	0.00	2.27	0.01	70.00	30.00	0.00
2002	SD	Harding	6H	10	602285	5057316	6.00	3.00	0.80	0.25	60.00	10.00	0.00
2002	SD	Harding	6H	11	600785	5056816	5.00	0.00	0.31	0.00	85.00	30.00	0.00
2002	SD	Harding	6H	12	601785	5056816	11.00	1.00	0.47	0.07	80.00	20.00	5.00

Appendix H. Continuation of sites on page 180.

		Sagebrush Ht. (cm)				Cover (%)			
Lek	Site	Big	Silver	Grass Ht. (cm)	Forb	Grass	Bare	Litter	Comments
15S	1	39.47	53.75	15.00	9.58	74.75	11.60	10.78	
15S	2	76.00	42.27	15.85	3.23	71.15	14.15	12.35	
15S	3	48.03	41.25	11.49	2.16	58.54	19.59	22.68	
15S	4	31.18	23.07	9.53	2.38	39.45	55.13	5.98	Tran4 Cedar tree at 37 m about 4m high
15S	5	39.43	39.05	12.05	3.38	61.90	29.78	9.30	
15S	6	34.22	38.33	12.53	3.25	76.20	8.43	16.15	
15S	7	24.69	61.67	6.53	3.79	25.00	56.53	15.89	Tran2&3 Uninhabitable terrain/Steep Slope
15S	8	-	-	-	-	-	-	-	Uninhabitable terrain (On top of butte)
15S	9	34.17	43.00	5.75	4.83	34.05	32.73	31.90	
15S	10	32.38	33.83	9.63	7.70	33.90	49.95	8.03	
15S	11	-	-	-	-	-	-	-	Uninhabitable terrain
15S	12	36.54	39.03	8.13	2.53	44.53	31.98	24.95	
5H	1	30.97	0.00	18.75	7.15	60.95	15.50	21.98	
5H	2	0.00	0.00	9.45	3.98	74.63	13.73	14.63	
5H	3	37.85	50.44	12.75	7.50	77.28	9.58	12.58	
5H	4	22.46	0.00	11.80	4.25	41.93	51.13	6.95	
5H	5	0.00	0.00	18.30	5.08	79.18	11.73	10.70	
5H	6	34.67	0.00	12.50	17.00	63.93	14.80	7.43	
5H	7	30.41	0.00	18.53	6.38	87.18	2.58	11.10	
5H	8	41.58	25.50	13.88	3.15	65.83	19.85	14.45	
5H	9	26.33	0.00	14.33	4.33	80.90	11.38	8.40	
5H	10	26.75	0.00	13.48	6.60	66.65	24.78	12.10	
5H	11	37.57	41.00	9.50	2.48	71.58	19.50	13.48	
5H	12	0.00	60.00	26.15	2.26	96.41	0.71	4.62	
6H	1	20.26	10.00	14.10	7.08	88.53	5.73	3.80	
6H	2	34.57	35.85	14.75	3.28	75.25	7.05	18.55	
6H	3	25.50	44.20	19.73	11.35	85.60	0.90	14.00	
6H	4	42.62	43.00	15.83	8.03	84.63	3.58	9.20	
6H	5	44.75	43.60	15.23	6.00	75.90	0.63	22.78	
6H	6	37.35	32.13	13.48	10.55	72.58	12.30	12.30	
6H	7	33.45	51.75	15.13	9.30	59.88	15.40	22.40	
6H	8	28.70	52.43	17.88	7.68	82.98	10.55	4.18	
6H	9	28.21	40.00	12.28	7.43	67.15	21.25	8.33	
6H	10	28.88	52.09	15.63	13.45	69.00	12.33	16.25	
6H	11	32.90	0.00	20.80	3.83	93.48	0.38	6.60	
6H	12	42.80	34.00	14.10	18.75	65.33	4.60	27.23	

[a] Sampling methods can be found on pages 13-19.
[b] Lek 2-3 is a designation given by the North Dakota Game and Fish.
[c] Sites entitle "Lek" were sampled on the lek itself.
[d] A dash (-) indicates sites where vegetation information was not gathered due to situations described in the comments column.

Appendix I. Shrubs, grasses, sedges, and forbs located within 1.5 km core area around greater sage grouse leks in the Dakotas, 2001-2002.

State	Lek[a]	Shrubs[b]	Grasses & Sedges	Forbs
ND	1BW	Big sagebrush	Japanese brome	Common Yarrow
		Silver sagebrush	Blue grama	Cudweed sagewort
		Saltbush	Crested wheatgrass	Common dandelion
		Rubber rabbitbrush	Kentucky bluegrass	Golden pea
		Western snowberry		Wild parsley
		Prairie rose		Yellow sweetclover
		Shadescale		Textile onion
				Alfalfa
				Plains pricklypear
	2-3BW	Big sagebrush	Western wheatgrass	Common dandelion
		Silver sagebrush	Crested wheatgrass	Common yarrow
		Western snowberry	Intermediate wheatgrass	Plains pricklypear
		Saltbush		
		Rubber rabbitbrush		
	6BW	Big sagebrush	Kentucky bluegrass	Breadroot scurfpea
		Silver sagebrush	Western wheatgrass	Common yarrow
		Saltbush	Crested wheatgrass	Common dandelion
		Rubber rabbitbrush	Blue grama	Alfalfa
		Western snowberry	Japanese brome	Small-leaf pussytoes
				Fringed sagewort
				Wild parsley
				Bastard toadflax
				American vetch
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	7BW	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Saltbush	Downy brome	Cudweed sagewort
		Skunkbrush		Breadroot scurfpea
				Northern bedstraw
				Yucca
				Plains pricklypear
	8BW	Big sagebrush	Crested wheatgrass	Textile onion
		Silver sagebrush	Blue grama	Alfalfa
		Saltbush	Kentucky bluegrass	Scarlet globemallow
		Western snowberry		Wild parsley
		Prairie rose		Fringed sagewort
				American vetch
				Common yarrow
				Common dandelion
				Plains pricklypear
	9BW	Big sagebrush	Western wheatgrass	American vetch
		Silver sagebrush	Blue grama	Bastard toadflax
		Saltbush	Kentucky bluegrass	Alfalfa
		Western snowberry	Crested wheatgrass	Common yarrow
		Prairie rose	Wheat	Clover
		Chokecherry		Fringed sagewort
		Silver buffaloberry		Breadroot scurfpea
		Golden currant		Plains pricklypear
		Poison ivy		

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	10BW	Big sagebrush	Japanese brome	Common dandelion
		Saltbush	Western wheatgrass	Alfalfa
		Western snowberry	Crested wheatgrass	Common dandelion
		Rubber rabbitbrush	Blue grama	Wild parsley
		Prairie rose	Kentucky bluegrass	Textile onion
				Common yarrow
				Pains pricklypear
	15BW	Big sagebrush	Junegrass	Common dandelion
		Silver sagebrush	Needleandthread	Common yarrow
		Saltbush	Smooth bromegrass	Wild parsley
		Prairie rose	Crested wheatgrass	Northern bedstraw
				Plains pricklypear
	16BW	Big sagebrush	Western wheatgrass	Common dandelion
		Silver sagebrush	Blue grama	Wild parsley
		Saltbush	Kentucky bluegrass	Hood’s phlox
		Broom snakeweed	Japanese brome	Common yarrow
				Plains pricklypear
	18BW	Big sagebrush	Crested wheatgrass	Bastard toadflax
		Silver sagebrush	Western wheatgrass	Desert biscuitroot
		Saltbush	Threadleaf sedge	Yucca
		Rubber rabbitbrush	Blue grama	American vetch
		Western snowberry		Textile onion
		Golden currant		Common dandelion
		Shadscale		Breadroot scurfpea
		Long-leaved sagewort		Yucca
		Prairie rose		Wild parsley
		Creeping juniper		Fringed sagewort
				Common yarrow
				Plains pricklypear

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	22BW	Big sagebrush	Blue grama	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Saltbush		Cudweed sagewort
		Rubber rabbitbrush		American vetch
				Yucca
				Northern bedstraw
				Field pussytoes
				Plains pricklypear
	24BW	Big sagebrush	Needleandthread	Common dandelion
		Silver sagebrush	Downy brome	Common yarrow
		Western snowberry	Junegrass	Breadroot scurfpea
		Saltbush	Western wheatgrass	Golden pea
		Prairie rose		Desert biscuitroot
		Long-leaved sagewort		Northern bedstraw
				Wild parsley
				Plains pricklypear
	25BW	Big sagebrush	Needleandthread	Common dandelion
		Silver sagebrush	Downy brome	Common yarrow
		Western snowberry	Junegrass	Golden pea
		Skunkbrush	Western wheatgrass	Cudweed sagewort
		Creeping juniper		Breadroot scurfpea
		Rubber rabbitbrush		American deervetch
		Silver buffaloberry		Indian wheat
		Saltbush		Yucca
		Creeping juniper		Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	27BW	Big sagebrush	Crested wheatgrass	Common dandelion
		Silver sagebrush	Western wheatgrass	Common yarrow
		Western snowberry	Junegrass	Wild parsley
		Saltbush	Downy brome	Yucca
				Alfalfa
				Plains pricklypear
	28BW	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Western wheatgrass	Common yarrow
		Saltbush	Crested wheatgrass	Breadroot scurfpea
		Prairie rose	Junegrass	Northern bedstraw
		Western snowberry	Downy brome	Wild parsley
		Skunkbrush		American deervetch
				Bastard toadflax
				Yucca
				Plains pricklypear
	1S	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Junegrass	Common yarrow
		Western snowberry		Field pussytoes
		Saltbrush		Breadroot scurfpea
		Prairie rose		Wild parsley
				Plains pricklypear
	2S	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Sandberg’s bluegrass	Common yarrow
		Western snowberry		Wild parsley
				Breadroot scurfpea
				Golden pea
				Cudweed sagewort
				Alfalfa
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	4S	Big sagebrush	Threadleaf sedge	Purple coneflower
		Silver sagebrush	Blue grama	Yucca
		Saltbush	Prairie cordgrass	Bastard toadflax
		Prairie rose	Western wheatgrass	Common yarrow
		Western snowberry		Common dandelion
		Silver buffaloberry		Fringed sagewort
		Golden currant		Yucca
		Chokecherry		Small-leaf pussytoes
		Rubber rabbitbrush		Wild parsley
		Creeping juniper		Plains pricklypear
	5S	Big sagebrush	Red threeawn	Wild parsley
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Greasewood	Japanese brome	Common dandelion
		Saltbush	Blue grama	Small-leaf pussytoes
		Shadscale	Junegrass	Cudweed sagewort
		Rubber rabbitbrush		Yucca
		Long-leaved sagewort		Purple coneflower
		Broom snakeweed		Fringed sagewort
		Creeping juniper		Plains pricklypear
	10S	Big sagebrush	Crested wheatgrass	Purple coneflower
		Silver sagebrush	Kentucky bluegrass	Yucca
		Saltbush	Japanese brome	Golden pea
		Prairie rose	Western wheatgrass	Common yarrow
		Western snowberry	Threadleaf sedge	American vetch
		Chokecherry	Blue grama	Bastard toadflax
		Golden currant		Common dandelion
		Silver buffaloberry		Fringed sagewort
		Rubber rabbitbrush		Textile onion
				Plains pricklypear

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	11S	Big sagebrush	Threadleaf sedge	Cudweed sagewort
		Silver sagebrush	Japanese brome	Common yarrow
		Western snowberry	Kentucky brome	Common dandelion
		Shadscale	Prairie cordgrass	Wild parsley
		Saltbush	Western wheatgrass	Hood's phlox
		Greasewood	Blue grama	Yucca
		Rubber rabbitbrush		Plains pricklypear
		Creeping juniper		
	12S	Big sagebrush	Crested wheatgrass	Golden pea
		Silver sagebrush	Blue grama	Fringed sagewort
		Chokecherry	Western wheatgrass	Small-leaf pussytoes
		Western snowberry		Bastard toadflax
		Golden currant		Common dandelion
		Silver buffaloberry		Common yarrow
		Prairie rose		Cudweed sagewort
		Broom snakeweed		Purple coneflower
				Wild parsley
				Plains pricklypear
	14S	Big sagebrush	Downy brome	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Greasewood	Needleandthread	Wild parsley
		Saltbush	Junegrass	Plains pricklypear
		Rubber rabbitbrush		
		Skunkbrush		
		Shadscale		

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	15S	Big sagebrush	Japanese brome	Cudweed sagewort
		Silver sagebrush	Threadleaf sedge	Fringed sagewort
		Western snowberry	Blue grama	Wild parsley
		Saltbush	Western wheatgrass	Common dandelion
		Rubber rabbbitbrush		Common yarrow
		Shadscale		Yellow sweetclover
		Skunkbrush		Bastard toadflax
		Prairie rose		Plains pricklypear
		Greasewood		Smooth beardtongue
	18MT	Big sagebrush	Junegrass	Yucca
		Silver sagebrush	Blue grama	Wild parsley
		Western snowberry	Japanese brome	Common yarrow
		Prairie rose	Threadleaf sedge	Yellow sweetclover
		Skunkbrush	Crested wheatgrass	Fringed sagewort
		Shadscale		Alfalfa
		Saltbush		Common dandelion
		Rubber rabbitbrush		Plains pricklypear
		Long-leaved sagewort		
	20S	Big sagebrush	Threadleaf sedge	Common dandelion
		Silver sagebrush	Crested wheatgrass	Common yarrow
		Shadscale	Downy brome	Wild parsley
		Skunkbrush	Kentucky bluegrass	Northern bedstraw
		Rubber rabbitbrush		Plains pricklypear
		Saltbush		

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
ND	21S	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Western snowberry	Plains reedgrass	Breadroot scurfpea
				Cudweed sagewort
				Stiff sunflower
				Plains pricklypear
SD	3B	Big sagebrush	Kentucky bluegrass	Common dandelion
			Western wheatgrass	Textile onion
				Wild parsley
				American vetch
				Plains pricklypear
	4B	Big sagebrush	Crested wheatgrass	Common dandelion
			Kentucky bluegrass	Common yarrow
				Textile onion
				American vetch
				Wild parsley
				Desert biscuitroot
				Plains pricklypear
	5B	Big sagebrush	Blue grama	Common dandelion
			Western Wheatgrass	Common yarrow
				Textile onion
				Hood’s phlox
				Lambstongue groundsel
				Wild Parsley
				American vetch
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	6B	Big sagebrush	Blue grama	Wild parsley
		Rubber rabbitbrush	Foxtail barley	Textile onion
			Western wheatgrass	Cudweed sagewort
				Hood's phlox
				Desert biscuitroot
				Plains pricklypear
	9B	Big sagebrush	Kentucky bluegrass	Common dandelion
		Rubber rabbitbrush	Blue grama	Common yarrow
				Textile onion
				Hood's phlox
				Star lily
				Lambstongue groundsel
				Fringed sagewort
				Plains pricklypear
	10B	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Blue grama	Common yarrow
		Greasewood		American vetch
		Rubber rabbitbrush		Golden pea
		Saltbush		Plains pricklypear
	11B	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Prairie cordgrass	Common yarrow
			Sandberg's bluegrass	Broom snakeweed
				Desert biscuitroot
				False dandelion
				Textile onion
				Golden pea
				American deervetch

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	12B	Big sagebrush	Kentucky bluegrass	Common dandelion American vetch Prairie violet Desert biscuitroot Plains pricklypear
	13B	Big sagebrush	Kentucky bluegrass Western wheatgrass Blue grama	Common dandelion Textile onion Hood’s phlox Wild parsley American vetch Plains pricklypear
	14B	Big sagebrush	Kentucky bluegrass Blue grama Japanese brome	Common dandelion Common yarrow Wild parsley Western wallflower Hood’s phlox Lambstongue groundsel Plains pricklypear
	15B	Big sagebrush Silver sagebrush Saltbush Greasewood	Kentucky bluegrass Blue grama	Common dandelion Common yarrow Wild parsley Stiff sunflower Textile onion American deervetch Plains pricklypear

Appendix I. Continued

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	1H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Japanese brome	Common yarrow
		Western snowberry	Crested wheatgrass	Small-leaf pussytoes
				American deervetch
				Bastard toadflax
				Cudweed sagewort
				Meadow deathcamas
				Golden pea
				Alfalfa
				Plains pricklypear
	2H	Big sagebrush	Japanese brome	Common dandelion
			Kentucky bluegrass	Common yarrow
			Threadleaf sedge	Lambstongue groundsel
				Breadroot scurfpea
				Purple coneflower
				Plains pricklypear
	3H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Japanese brome	Common yarrow
		Western snowberry	Threadleaf sedge	Cudweed sagewort
			Blue grama	Plains pricklypear
	4H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
		Western snowberry	Junegrass	Cudweed sagewort
				Breadroot scurfpea
				American vetch
				Slenderleaf collomia
				Alfalfa
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	5H	Big sagebrush	Junegrass	Common dandelion
		Silver sagebrush	Blue grama	Wild parsley
		Saltbush	Japanese brome	Cudweed sagewort
		Greasewood	Kentucky bluegrass	Gumbo evening primrose
			Prairie cordgrass	Clover
			Threadleaf sedge	Purple coneflower
			Western wheatgrass	Common Yarrow
			Red threeawn	Fringed sagewort
				Plains pricklypear
	6H	Big sagebrush	Kentucky bluegrass	Small-leaf pussytoes
		Silver sagebrush	Japanese brome	Hood’s phlox
			Threadleaf sedge	American vetch
			Western wheatgrass	Wild parsley
			Blue grama	Common dandelion
				Common Yarrow
				Cudweed sagewort
				Plains pricklypear
	7H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Threadleaf sedge	Common yarrow
				Breadroot scurfpea
				American vetch
				Field pussytoes
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	8H	Big sagebrush	Junegrass	Common dandelion
		Silver sagebrush	Sandberg's bluegrass	Common yarrow
		Western snowberry	Japanese brome	Textile onion
			Threadleaf sedge	American deervetch
				Cudweed sagewort
				Breadroot scurfpea
				Yucca
				Plains pricklypear
	9H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Junegrass	Common yarrow
		Western snowberry	Threadleaf sedge	American vetch
		Prairie rose		Cudweed sagewort
		Skunkbrush		Lambstongue groundsel
				Textile onion
				Meadow deathcamas
				Small-leaf pussytoes
				Breadroot scurfpea
				Purple coneflower
				Yucca
				Plains pricklypear
	10H	Big sagebrush	Kentucky bluegrass	Common dandelion
		Silver sagebrush	Japanese brome	Textile onion
			Threadleaf sedge	Wild parsley
			Blue grama	Desert biscuitroot
				Plains pricklypear

Appendix I. Continued.

State	Lek	Shrubs	Grasses & Sedges	Forbs
SD	1FR	Big sagebrush	Threadleaf sedge	Common dandelion
		Silver sagebrush	Western wheatgrass	Common Yarrow
		Rabbitbrush	Downy Brome	American Vetch
		Western snowberry	Japanese brome	Golden Pea
			Crested wheatgrass	Plains phlox
				Hood's phlox
				Desert buscuitroot
				Western rock jasmine
				Star lily
				Nuttall's violet
				Tufted milkvetch
				Threadleaf musineon
				Plains pricklypear

[a] For county information see lek locations.
[b] Scientific names of shrubs, grasses, sedges, and forbs can be found in Appendix J.

Appendix J. Common names and scientific names of shrubs, grasses, sedges, and forbs found within 1.5 km core area around greater sage grouse leks in the Dakotas, 2001-2002 (Johnson and Larson 1999).

Type	Common Name	Scientific Name
Shrub	Big sagebrush	*Artemisia tridentata*
	Broom snakeweed	*Gutierrezia sarothrae*
	Chokecherry	*Prunus virginiana*
	Creeping juniper	*Juniperus horizontalis*
	Golden currant	*Ribes odoratum*
	Greasewood	*Sarcobatus vermiculatus*
	Long-leaved sagewort	*Artemisia longifolia*
	Prairie rose	*Rosa arkansana*
	Rubber rabbitbrush	*Chrysothamnus nauseosus*
	Saltbush	*Atriplex spp.*
	Shadscale	*Atriplex confertifolia*
	Silver buffaloberry	*Shepherdia argentea*
	Silver sagebrush	*Artemisia cana*
	Skunkbrush	Rhus aromatica
	Western snowberry	Symphoricarpos occidentalis
Grasses	Blue grama	Bouteloua gracilis
	Crested wheatgrass	Agropyron cristatum
	Downy brome	Bromus tectorum
	Foxtail barley	Hordeum jubatum
	Intermediate wheatgrass	Elytrigia intermedia
	Japanese brome	Bromus japonicus
	Junegrass	Koeleria macrantha
	Kentucky bluegrass	Poa pratensis
	Needleandthread	Stipa comata
	Plains reedgrass	Calamagrostis montanensis
	Prairie cordgrass	Spartina pectinata

Appendix J. Continued

Type	Common Name	Scientific Name
Grasses	Red threeawn	*Aristida purpurea*
	Sandburg's bluegrass	*Poa secunda*
	Smooth bromegrass	*Bromus inermis*
	Western wheatgrass	*Pascopyrum smithii*
Sedges	Threadleaf sedge	*Carex filifolia*
Forbs	Alfalfa	*Medicago falcata*
	American deervetch	*Lotus purshianus*
	American vetch	*Vicia americana*
	Bastard toadflax	*Comandra umbellata*
	Breadroot scurfpea	*Psoralea esculenta*
	Clover	*Trifolium spp.*
	Common dandelion	*Taraxacum officinale*
	Common yarrow	*Achillea millefolium*
	Cudweed sagewort	*Artemisia ludoviciana*
	Desert biscuitroot	*Lomatium foeniculaceum*
	False dandelion	*Agoseris glauca*
	Field pussytoes	*Antennaria neglecta*
	Fringed Sagewort	*Artemisia frigida*
	Golden pea	*Thermopsis rhombifolia*
	Gumbo evening primrose	*Oenothera caespitosa*
	Hood's phlox	*Phlox hoodii*
	Indian wheat	*Plantago patagonica*
	Lambstongue groundsel	*Senecio integerrimus*
	Meadow deathcamas	*Zigadenus venenosus*
	Northern Bedstraw	*Galium boreale*
	Nuttall's violet	*Viola nuttallii*
	Plains phlox	*Phlox andicola*
	Plains pricklypear	*Opuntia polycantha*

Appendix J. Continued.

Type	Common Name	Scientific Name
Forbs	Prairie violet	*Viola pedatifida*
	Purple coneflower	*Echinacea angustifolia*
	Slenderleaf collomia	*Collomia linearis*
	Small-leafed pussytoes	*Antennaria parvifolia*
	Smooth beardstongue	*Penstemon glaber*
	Star lily	*Leucocrinum montanum*
	Stiff sunflower	*Helianthus pauciflorus*
	Textile onion	*Allium textile*
	Threadleaf musineon	*Musineon tenuifolium*
	Tufted milkvetch	*Astragalus spatulatus*
	Western rock jasmine	*Androsace occidentalis*
	Wild parsley	*Musineon divaricatum*
	Yellow sweetclover	*Melilotus officinalis*
	Yucca	*Yucca glauca*

Appendix K. The best multiple regression models explaining the effects of habitat variables on greater sage grouse active lek size in North Dakota [Leks = 15, sample sites (n) = 180].

	Model[a]	C_p[b]	C_p/p[c]	AIC	R^2
1	4.4441* + 26.5290 tsbc* - 0.1718 slsh* + 2.1585 hcg* + 2.1543 hcb*	3.9837	0.9959	832.5351	0.1357
2	6.4747* - 0.1462 slsh* + 2.2887 hcg* - 0.9191 hcl* + 2.3243 hcb*	3.9155	0.9789	832.4645	0.1360
3	4.2876* - 0.1547 slsh* + 2.1958 hcg* + 2.5183 hcb*	3.2268	1.0756	831.8167	0.1295
4	4.4647* - 0.1807 slsh* + 2.2334 hcg* + 2.3138 hcb* + 0.8599 tsbc x bsh*	3.1013	0.7753	831.6198	0.1401

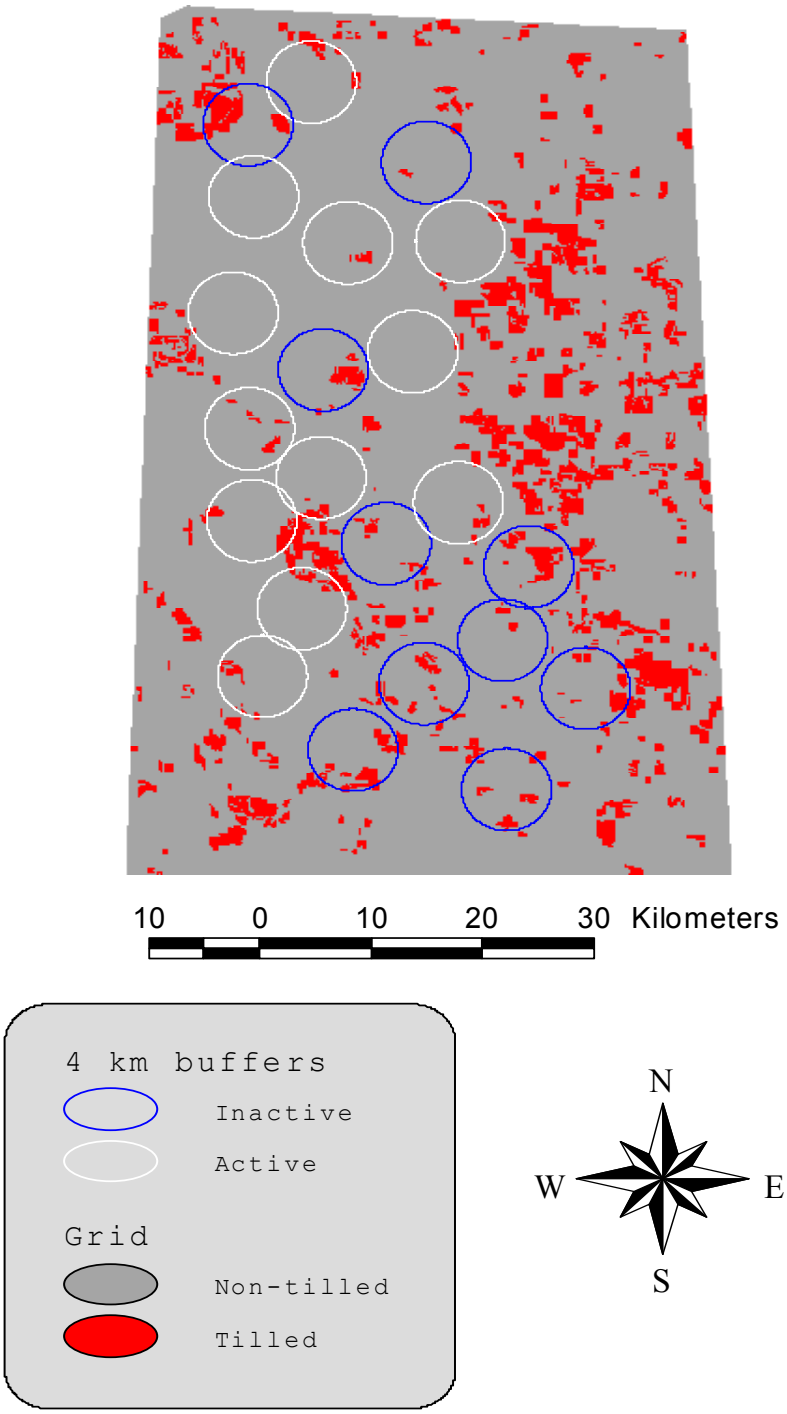
[a] slsh = silver sagebrush height, hcg = grass cover, hcb = bare ground, hcl = litter cover, tsbc = sagebrush cover.
[b] Mallows' C_p statistic.
[c] p = number of independent variable parameters.
* $P \leq 0.10$ for X^2 test of model parameter.

Appendix L. The best multiple regression models explaining the effects of habitat variables on greater sage grouse active lek size in South Dakota [Leks = 12, sample sites (n) = 144].

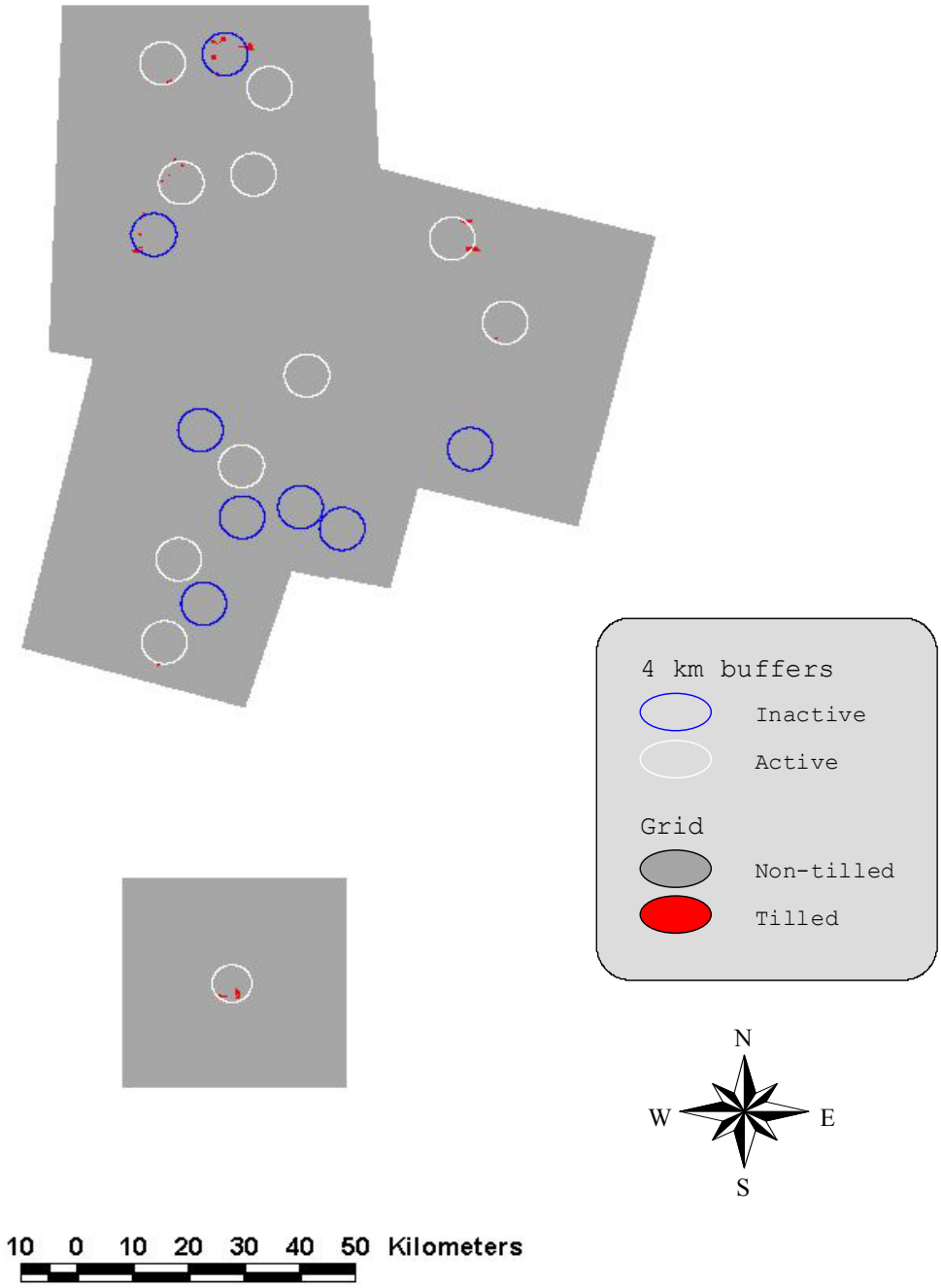
	Model[a]	C_p[b]	C_p/p[c]	AIC	R^2
1	9.7067* + 3.3241 tsbd* - 0.0841 voq* - 0.0628 slsh* + 0.8650 hcg* - 13.1167 tsbc x hcf*	5.0009	1.0002	505.9842	0.1730
2	9.9120* - 27.8685 tsbc + 3.6638 tsbd* - 0.0784 voq* - 0.2779 voh* - 0.0635 slsh + 0.7902 hcg*	6.0020	1.0003	506.9304	0.1791
3	8.2524* + 3.5939 tsbd* - 0.0784 - 0.0639 slsh* + 1.0088 hcf* + 0.8401 hcg* - 18.3712 tsbc x hcf*	6.0062	1.0010	506.9348	0.1790
4	8.6994* + 3.4566 tsbd* - 0.4205 voh* - 0.0663 slsh* + 0.8089 hcf* 0.7160 hcg* - 1.3129 tsbc x bsh*	5.9730	0.9955	506.8997	0.1792

[a] tsbd = sagebrush density, voq = visual obstruction 0.25 m, slsh = silver sagebrush height, hcg = grass cover, tsbc = sagebrush cover, hcf = forb cover, voh = visual obstruction 0.50 m.
[b] Mallows' C_p statistic.
[c] p = number of independent variable parameters.
* $P \leq 0.10$ for X^2 test of model parameter.

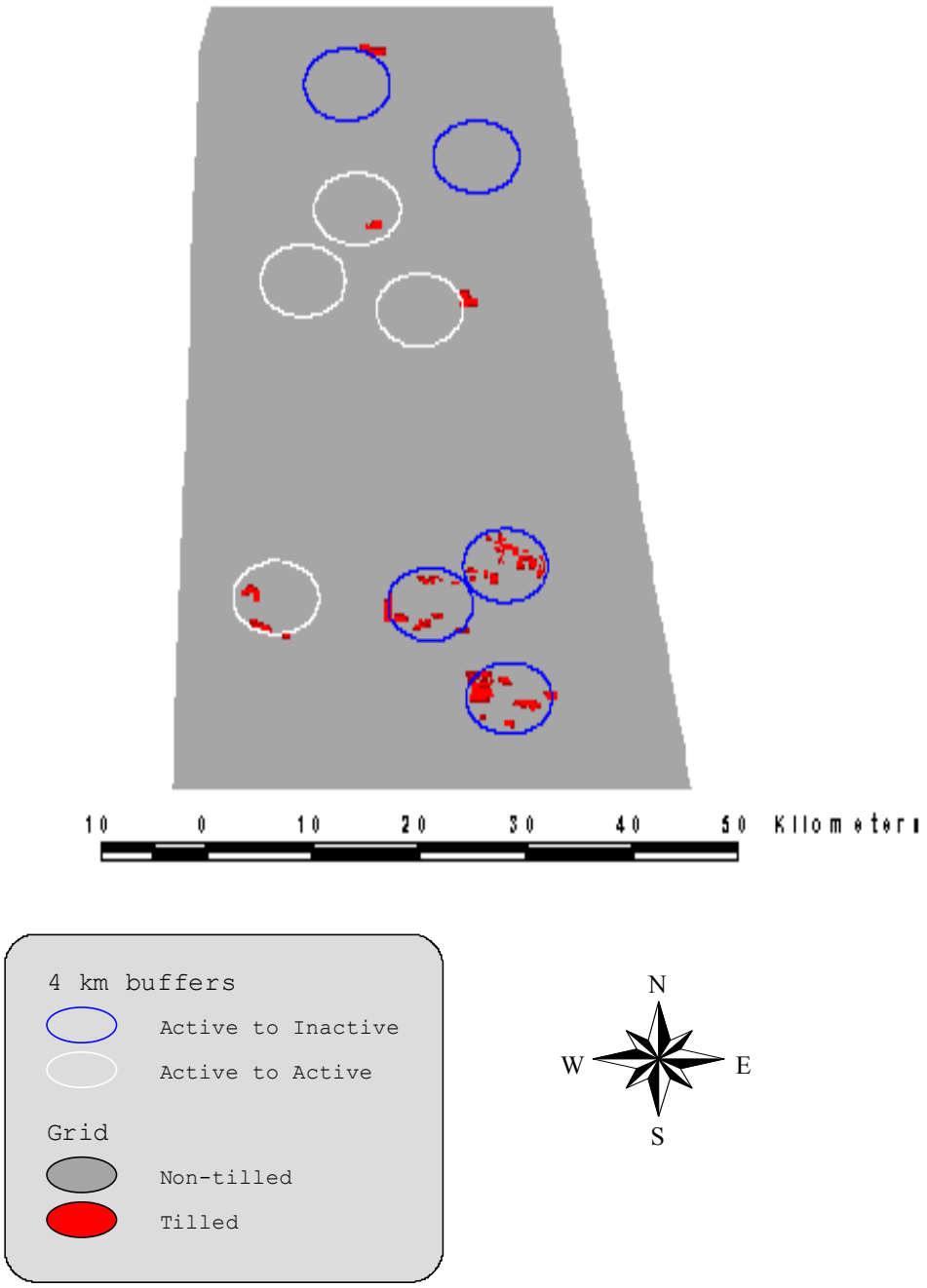
Appendix M. North Dakota 4-km buffers around active and inactive greater sage grouse leks overlaid onto 1999-2000 tilled ground grid.



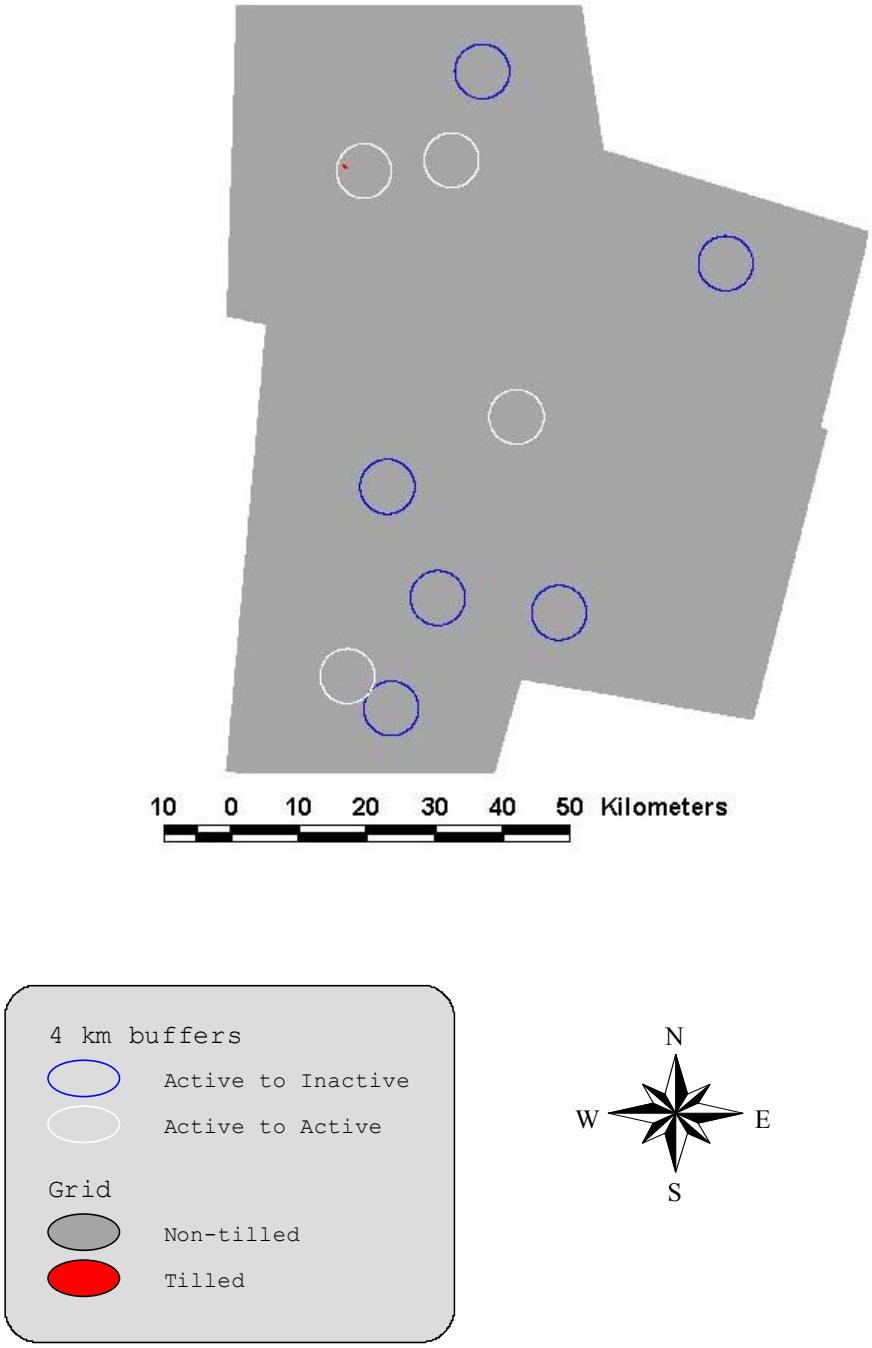
Appendix N. South Dakota 4-km buffers around active and inactive greater sage grouse leks overlaid onto 1999-2000 tilled ground grid. Only tilled ground intersecting or within buffered areas is shown.



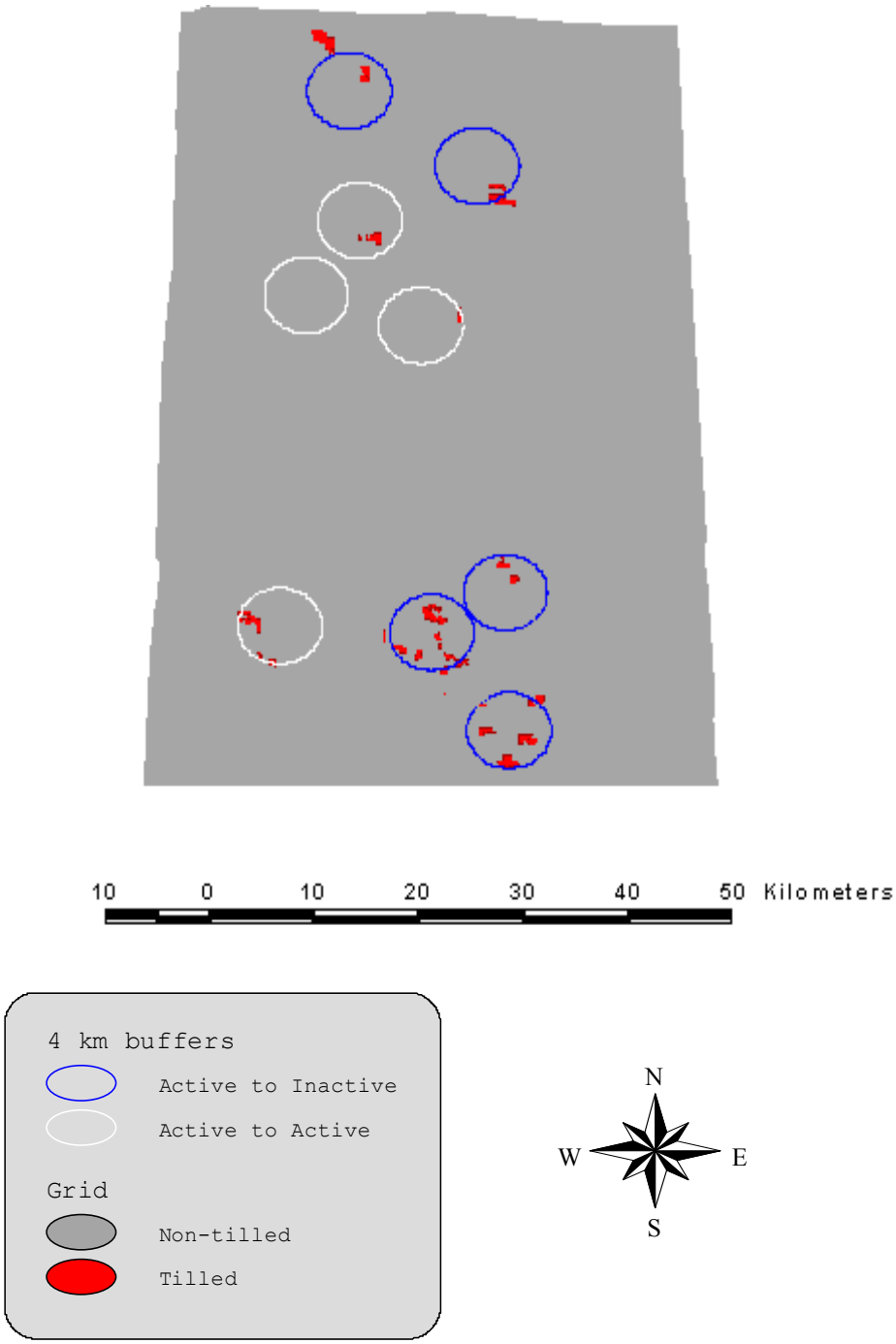
Appendix O. Grid of 1972-1976 tilled ground overlaid by 4-km buffers around greater sage grouse leks that were active at least 2 years during 1972-1976 and are either active or inactive during 1999-2000 in North Dakota. Only tilled ground intersecting or within buffered areas is shown.



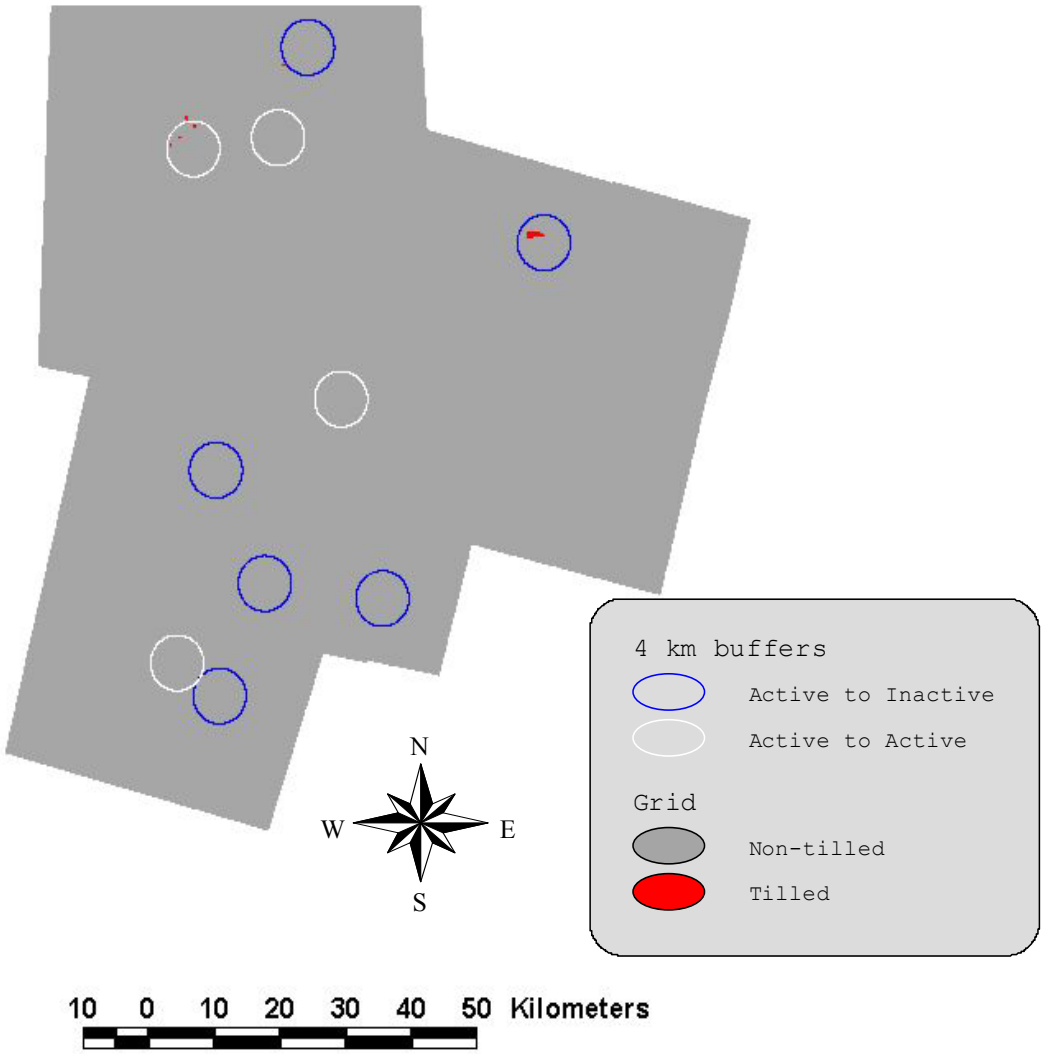
Appendix P. Grid of 1972-1976 tilled ground overlaid by 4-km buffers around greater sage grouse leks that where active at least 2 years during 1972-1976 and are either active or inactive during 1999-2000 in South Dakota. Only tilled ground intersecting or within buffered areas is shown.



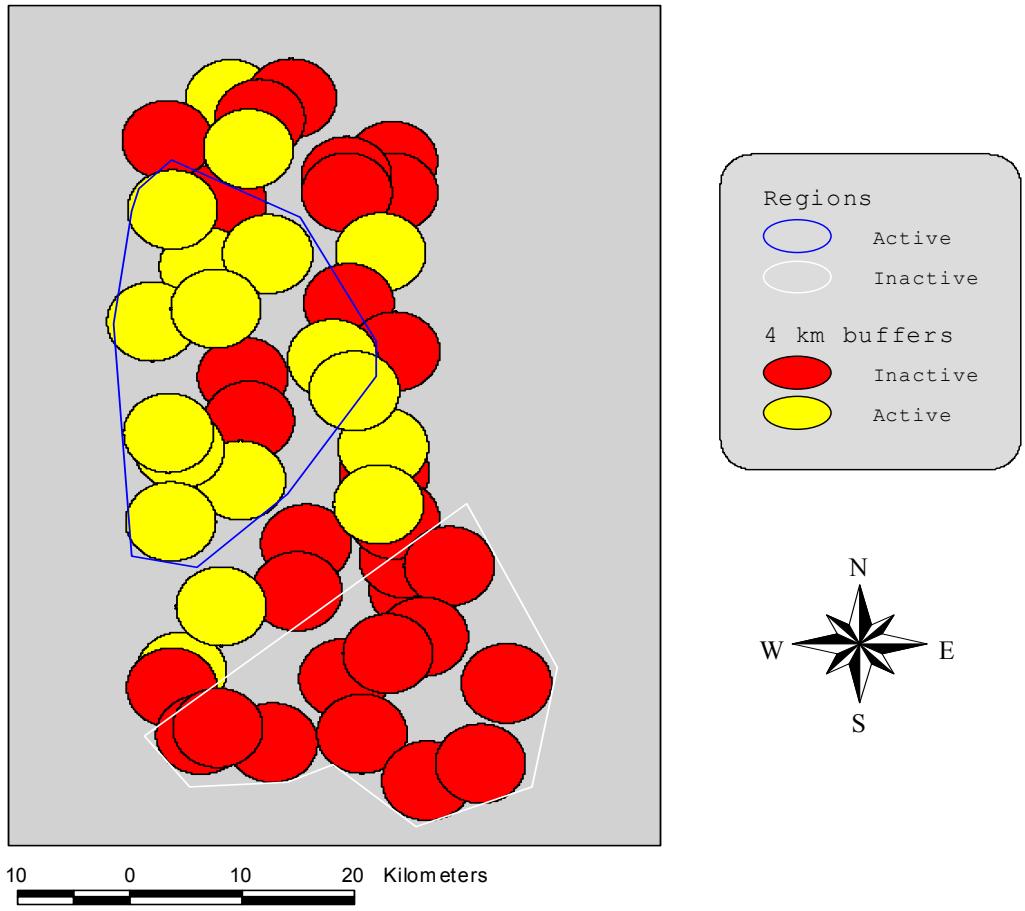
Appendix Q. Grid of 1999-2000 tilled ground overlaid by 4-km buffers around greater sage grouse leks that where active at least 2 years during 1972-1976 and are either active or inactive during 1999-2000 in North Dakota. Only tilled ground intersecting or within buffered areas is shown.



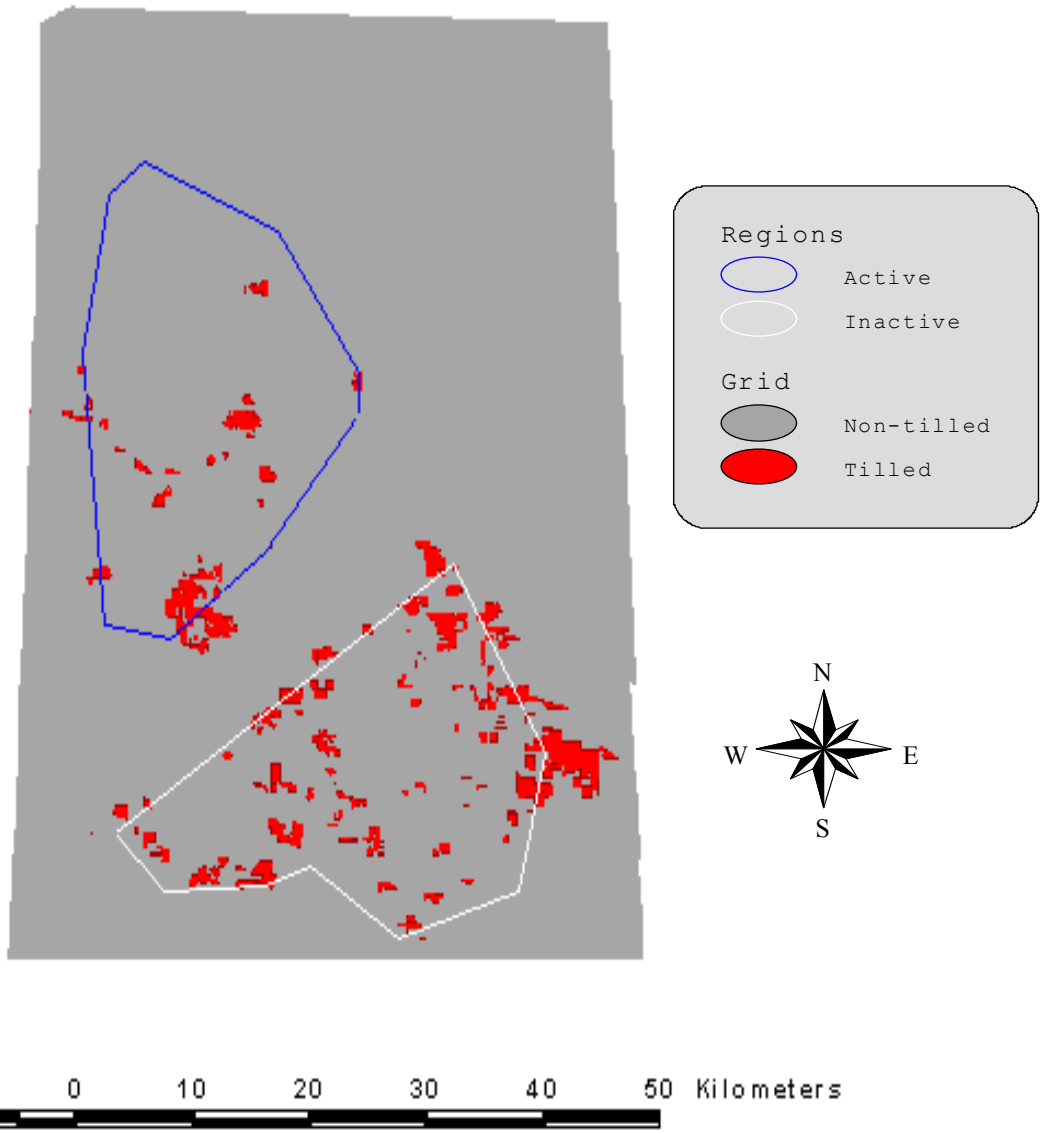
Appendix R. Grid of 1999-2000 tilled ground overlaid by 4-km buffers around greater sage grouse leks that where active at least 2 years during 1972-1976 and are either active or inactive during 1999-2000 in South Dakota. Only tilled ground intersecting or within buffered areas is shown.



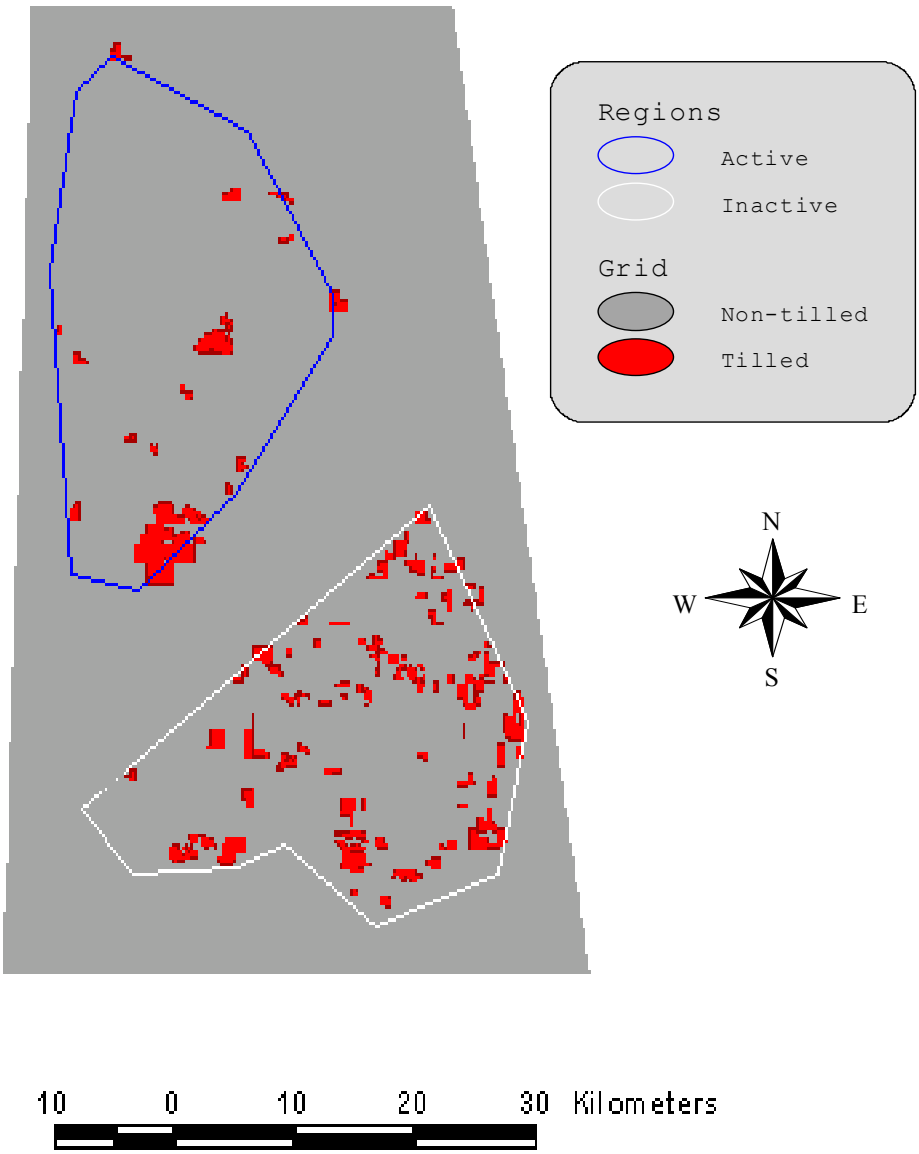
Appendix S. The Regions were created by placing polygons around 4-km buffers of predominately active greater sage grouse leks (i.e., active region) and predominately inactive greater sage grouse leks (i.e., inactive region).



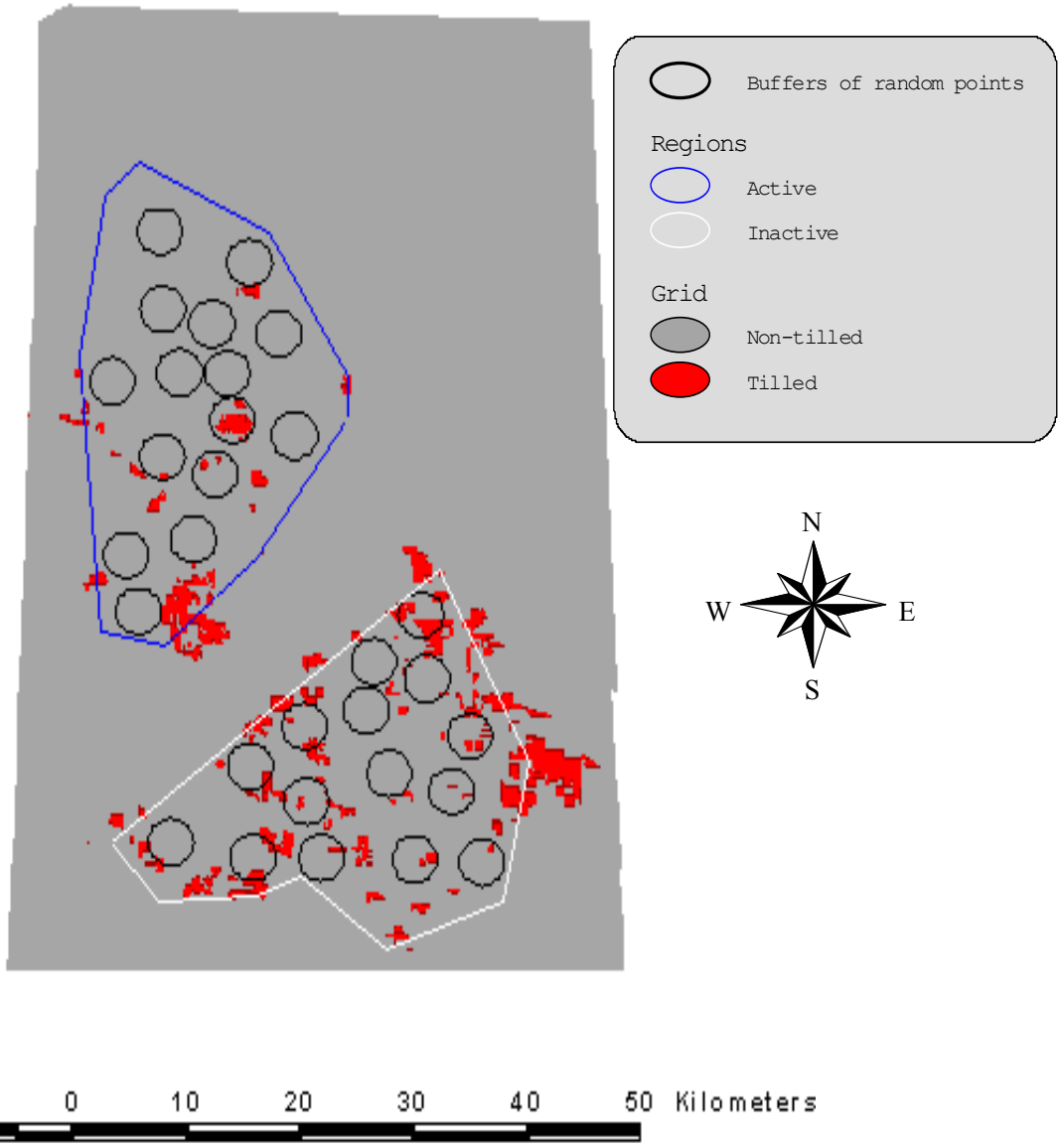
Appendix T. Active and Inactive region in North Dakota overlaid onto 1999-2000 grid of tilled ground and non-tilled ground. Only tilled ground intersecting or within regions is shown on 1972-1976 grid.



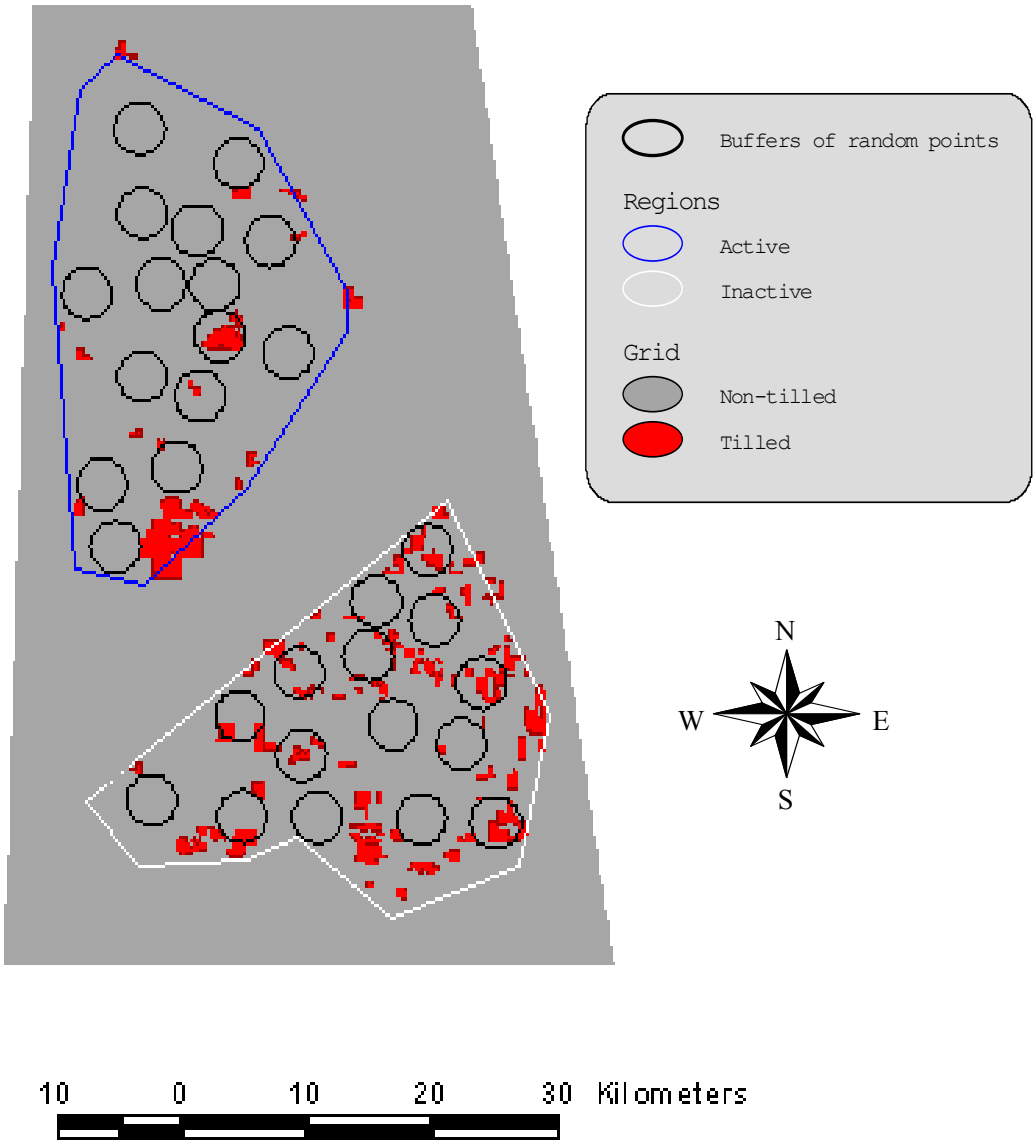
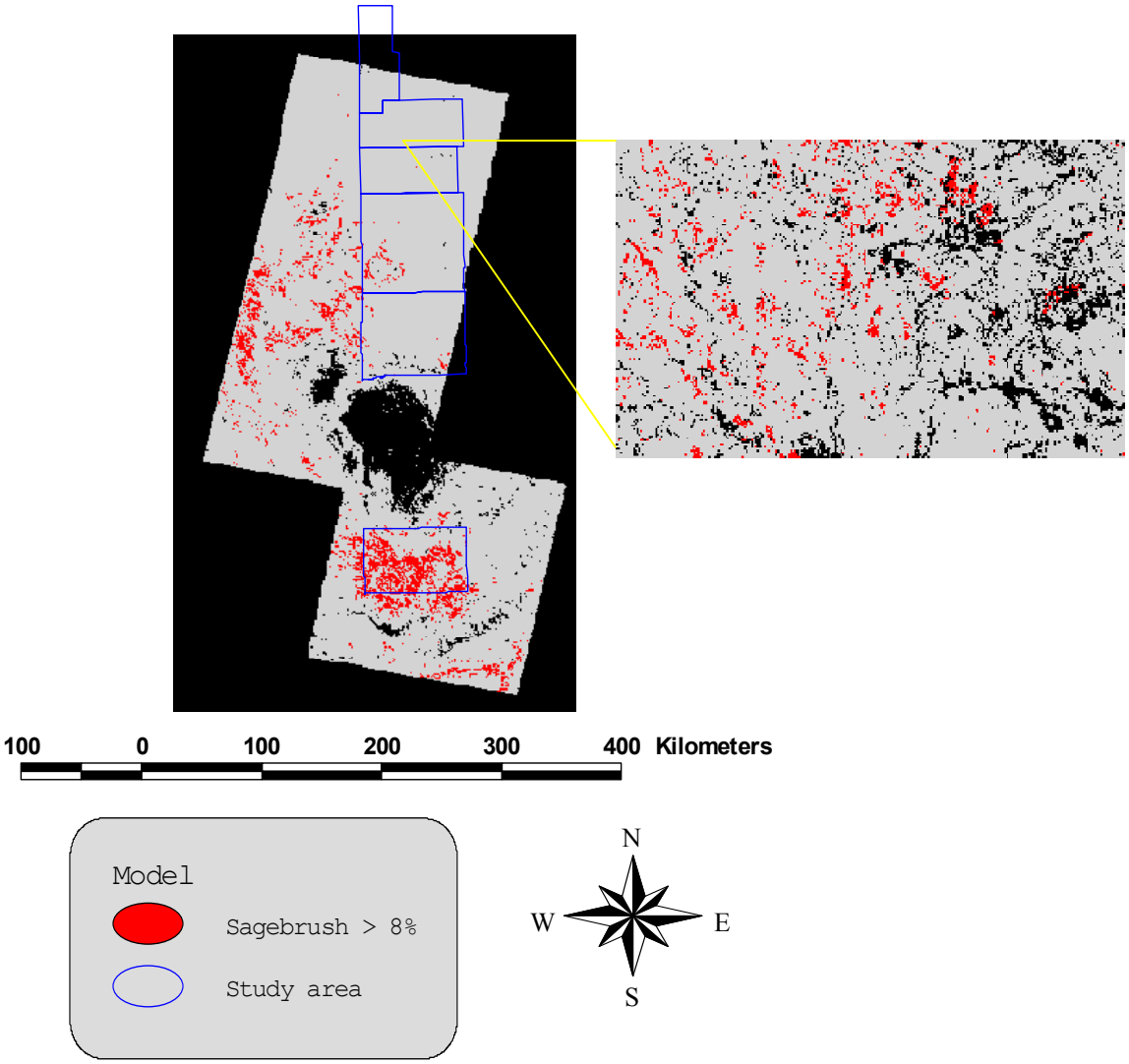
Appendix U. Active and Inactive region in North Dakota overlaid onto 1972-1976 grid of tilled ground and non-tilled ground. Only tilled ground intersecting or within regions is shown on 1972-1976 grid.



Appendix V. Random points (n = 15) that were buffered by 2 km within each region and overlaid onto 1999-2000 tilled ground grid. Only tilled ground intersecting or within regions is shown on 1972-1976 grid.



Appendix W. Random points (n = 15) that were buffered by 2 km within each region and overlaid onto 1972-1976 tilled ground grid. Only tilled ground intersecting or within regions is shown on 1972-1976 grid.



Appendix X. Model of sagebrush cover created from satellite imagery.