White-Tailed Deer Habitat and Winter Diets in the Black Hills, South Dakota

Daniel W. Uresk, USDA-Forest Service, Rapid City, South Dakota 57701

Donald R. Dietz (Deceased), USDA-Forest Service, Rapid City, South Dakota 57701

Abstract

The purpose of this study was to determine available plant production, gain a better understanding of white-tailed deer (*Odocoileus virginianus*) diets from rumen contents and to determine the relationship between availability of plants and diets during winter months. This study was conducted in the Black Hills of South Dakota in two areas, Experimental Forest and McVey Burn. Available plant production was collected on the McVey burn during 1972-1973 and one year in the Experimental Forest in 1981, on 14 m^2/ ha basal area, representative of Forest Management. Microhistological analysis of white tailed deer rumens was used to identify and quantify diets by plant species and life forms. Deer diets on the Experimental Forest consisted of 63 percent shrubs, 22 percent graminoids and 6 percent forbs. Diets of deer on the McVey Burn were similar with 59 percent shrubs, 14 percent graminoids, and 12 percent forbs. For both study areas, five common species comprised the greatest portion of deer diets. Key forage species were prairie sagewort (*Artemisia frigida*), willow (*Salix species*), kinnikinnick (*Arctostaphylos uva-ursi*), ponderosa pine (*Pinus ponderosa*), and bluegrasses (*Poa species*). Shrubs were the most important food items in deer diets. Future habitat management efforts should be directed toward improving shrub production for white-tailed deer winter consumption. Similarity indices ranged from 0 to 88 percent, an indication that some plants were highly selected or avoided by deer (low similarities) and other plants were consumed in similar proportions as available on both areas. Rank order correlations were low and ranged from r = -0.22 on the Experimental Forest to r = 0.11 indicating white-tailed deer were not selecting plants in the same proportions as their availability.

Key words: habitat, forest, burn, grazing, herbage, forage, white-tailed deer

Introduction

White-tailed deer (*Odocoileus virginianus*) represent a valuable resource in the Black Hills of South Dakota. Total annual harvest approximates 4,000 to 5,000 animals and has generated millions of dollars in revenue in license fees in South Dakota (Petersen 1984). Total harvests of white-tailed deer from 2005 through 2014 ranged from 2,410 in 2014 to a high of 5,397 animals in 2007 with a mean 3,085 over a 10 year period (SDGFP 2017). It is estimated that the Black Hills white-tailed deer hunting season generates over $2 million dollars annually to the economy (Deperno et al. 2002).

In the Black Hills area white-tailed deer populations have been in steady decline during the past few decades (Petersen 1984: Deperno et al. 2002). Several theories have been advanced as explanations of this downward trend in recent years including degradation of habitat primarily from heavy livestock grazing, interspecific competition with elk (Wydeven and Dhlgren 1983; Uresk et al. 2007; Uresk et al. 2009a; Uresk et al 2009b; Mergen 2013), and habitat loss due to land development. Average cattle diets in the Black Hills for both shrub and tree consumption combined ranged from 20 percent to 37 percent in the northern Black Hills and and from 8 percent to 35 percent in the central Black Hills (Uresk and Lowery 1984; Uresk and Paintner 1985; Uresk 1987). Livestock grazing management has remained essentially static since 1982 through 2005 with Forest Plans (USDA Forest Service 1983; USDA Forest

Service 1997; USDA Forest Service 2005) based on standards and guidelines, although some allotment management plans changed yearly. Elk diets in Wind Cave National Park focused primarily on graminoids with forbs the most important forage class for the fall and winter periods (Wydeven and Dhlgren 1983). Browse species (e.g., shrubs) were minor components of the elk diets. However, elk were not present in the area when this study was conducted, only in later years.

Forage, water and cover are the primary habitat components that limit deer populations and loss and degradation of habitat is the most important single factor in decline of deer populations (Deperno et al. 2002). As habitat is lost and/or degraded, deer forage and cover is quantitatively and qualitatively decreased, resulting in malnutrition, starvation, and poor reproductive success.

White-tailed deer in the Black Hills, especially those from the McVey Burn area, are more migratory than those found in other areas and have distinct winter, spring and summer-fall ranges (Thilenius 1972; Deperno et al 2002). Although summer range is important and in some cases critical, winter habitat and forage is the key factor limiting deer populations in the West (Wallmo et al. 1977; Deperno et al. 2002). Tall-growing palatable shrubs, which provide forage when other short statured forages are unavailable due to snow cover or of poor nutritional quality, are one of the most important components on winter range and are in many cases lacking or seriously depleted in the Black Hills. A further ecological review of the white-tailed deer in the Black Hills is presented by Sieg and Severson (1996).

The objective of this study is to compare early, mid and late winter white-tailed deer diets and forage production on two different study areas within the Black Hills (McVey Burn and Experiment Forest). Results from this research will hopefully aid in future monitoring and management for white-tailed deer in the Black Hills.

Study Area

The Black Hills encompasses about 5001 km^2 (USDA-Forest Service 1983) and is approximately 193 km from north to south, beginning in the northeastern portion of Wyoming and following the western most border of South Dakota. The elevation within the study areas ranges from 1600 m to 1800 m. Precipitation during the study period compared to recent precipitation data show no significant changes. During the study period, average annual precipitation on this area was about 51 cm and 80% falls from April to September (Dietz et al 1980). Current average annual precipitation at Hill City, SD is 53 cm, of which 79 percent falls from April to September (CLIMOD 2 2016). The growing season is approximately 89 days and average annual temperatures range from -6.2^0 C to 35.5^0 C.

This study was conducted on two sites within the Black Hills: 1) the Black Hills Experimental Forest, which has an overstory of mature trees, and 2) the McVey Burn Area which was dominated with ponderosa pine (*Pinus ponderosa*) with few open meadows prior to a forest fire in 1939 and subsequently was dominated with immature ponderosa pine during the study period (Dietz et al. 1980). The Experimental Forest is located approximately 32 km (20 miles) west of Rapid City and is dominated by ponderosa pine. Understory shrubs for the Experimental Forest include kinnikinnick (*Arctostaphylos uva-ursi*), chokecherry (*Prunus virginiana*), creeping barberry (*Mahonia repens*), Saskatoon serviceberry (*Amelanchier alnifolia*) and common snowberry (*Symphoricarpos albus*). Common graminoids include roughleaf ricegrass (*Oryzopsis asperfolia*), timber oatgrass (*Danthonia intermedia*), sedges (*Carex species*), Kentucky bluegrass (*Poa pratensis*), cream pea (*Lathyrus ochroleucous*) and bluebell bellflower (*Campanula rotundifolia*). Hoffman and Alexander (1987) describe habitat types and plant species throughout the Black Hills.

The McVey Burn located northwest of Hill City in the central Black Hills, South

Dakota comprises about 8903 ha that burned from a wildfire in 1939 (Dietz et al. 1980). Prior to the fire, the area was dominated by mature ponderosa pine with a few small meadows. Over 60 percent of the area was burned. This area was utilized by white-tailed deer primarily during the winter and was one of the most important winter deer ranges in the Black Hills. Native vegetation consists of Saskatoon serviceberry Woods' rose (*Rosa woodsii*), little bluestem (*Schizachyrium scoparium*), prairie sagewort (*Artemisia frigida*), common snowberry, and Kentucky bluegrass.

Methodology

Vegetation Production

Herbage production was determined on the Experimental Forest site within sapling stands (14 m^2/ha basal area) on three replicated plots during August, 1974 (Uresk and Severson, 1998). Six randomly placed transects 15 m in length were placed within each of the three plots. Twelve 30 x 60 cm quadrats were randomly placed along each transect. The current annual herbage growth was harvested at ground level for each herbaceous species. All leaves, and the terminal portions of twigs to the first node, were clipped on each shrub. Plant material was oven dried at 60^0 C for 48 hours and oven dry weights obtained. Weights were averaged and expressed as means per plot for data analyses.

On the McVey Burn, visual estimates and clipped standing herbage were sampled by species at peak production from July - August during 1972 and1973 from two randomly selected plots each year. Using the weight-estimated method described by Pechanec and Pickford (1937), herbage yields were obtained by species using a ratio estimator. Each plot was 30.5 m by 30.5 m. Ten circular hoops (0.89m^2) were placed on each of four transects spaced 3 m apart for a total of 40 clipped hoops. Visual estimates by plant species (green weight by ounces) were obtained within all 10 circular hoops for each transect. One circular hoop on each transect was randomly selected for clipping herbage at ground level by species. All leaves and terminal portions of twigs to first node were clipped on shrubs and visually estimated. All plant material by species was oven dried at 60^0 C for 48 hours and corrected to oven dry weights. The ratio estimator by species = mean of actual clipped weights (oven dried) / mean of estimated weights was used for a correction factor. The correction factors by species were multiplied for each visually estimated species within all hoops per plot. Mean weights per plot (replicate) were used for analyses.

Deer Diets

Data on deer diets were compiled by microhistological examination of rumen contents from 17 deer harvested directly on the Experimental Forest over five winters, and from 40 deer harvested on the McVey Burn Area during five winters (December-May). McVey burn was a wintering area for many deer while in the experimental forest few deer remained in the area during winter months. With fewer deer in the experimental forest, harvesting deer was much more difficult, resulting in different numbers of deer harvested in the two areas. Deer were collected in 1967, 1969, 1970, 1971 and 1972 for both areas. Rumen samples from each deer were kept frozen prior to examination. Individual samples were then thawed, dried, and ground through a Wiley mill fitted with a 1 mm screen. All rumen material was washed over a 0.1-mm screen (Sparks and Malechek 1968). Rumen material was cleared of chlorophyll and other composites with Hertwig's solution. Microhistological examinations of the samples were conducted using standard procedure with 5 slides per rumen sample and 20 fields per slide under a binocular microscope at 100 power for identifiable plant fragments (Sparks and Malechek 1968; Rogers and Uresk 1974; Johnson et al 1983). Hand compounded test mixtures of plants were used periodically to check accuracy of reading slides for plant identification and to maintain quality control. A similarity of 90 percent was maintained between actual test

mixtures of plants and estimated values of plants read from slides (Rogers and Uresk 1974).

Statistics

Data from microhistological examination of rumen contents were reported as percentages of dietary density. Changes by forage categories in monthly diets of white tailed deer were analyzed using one-factor analysis of variance (SPSS 2003). The F-protected Tukey's Multiple Range Test ($p \leq 0.10$) was used to perform comparisons among months.

Vegetation production data for each species and category (shrub, forb, grass, and tree) were averaged across years on the McVey Burn site (n=4). Vegetation production collected in 1974 comprised the data for the Experimental Forest site (n =3).

Kulczyuski's similarity index (Oosting 1956) was used to compare deer diets with herbage production to determine degree of association. Spearman's rank order correlation (SPSS 2003) was used to compare the relationship of herbage production with deer diets.

Results

Vegetation Production - Experimental Forest

Total plant production on the Experimental Forest averaged 557 kg/ha (Table 1). Shrubs accounted for the greatest amount (55%) of production with 308 kg/ha and more specifically, kinnikinnick provided 293 kg/ha. Others shrubs included American red raspberry (*Rubus idaeus*) with 5 kg/ha, Woods' rose (4 kg/ha) and common snowberry with 4 kg/ha.

Graminoid phytomass was 212 kg/ha (Table 1), 38 percent of the total production. Roughleaf ricegrass provided 124 kg/ha, followed by timber oatgrass at 47 kg/ha, sedges at 25 kg/ha, and bearded wheatgrass (*Elymus caninus*) with 7 kg/ha. Other minor grass species were mountain ricegrass (*Piptatheropsis pungens*) at 3 kg/ha and bluegrasses at 5 kg/ha.

Forbs were the least productive (7%) with 37 kg/ha. Milk vetch (*Astragalus species*) yielded 13 kg/ha followed by cream pea with 12 kg/ha (Table 1). Other forbs included common yarrow (*Achillea millefolium*), field pussytoes (*Antennaria neglecta*) and woodland strawberry (*Fragaria vesca*) (1-4 kg/ha).

Vegetation Production - McVey Burn

Vegetative production on the McVey Burn area averaged 684 kg/ha (Table 1). Shrubs accounted for the majority of vegetation (60%) with 408 kg/ha. Among shrub species, mountain ninebark (*Physocarpus monogynus*) yielded 151 kg/ha, russet buffaloberry (Shepherdia canadensis) at 105 kg/ha, Woods'rose at 64 kg/ha, common snowberry at 31 kg/ha, and white spirea (*Spiraea betulifolia*) at 29 kg/ha were the most abundant. Minor species accounted for an additional 26 kg/ha of production. Woody species present in the area but not sampled included quaking aspen (*Populus tremuloides*), prairie sagewort, creeping barberry, common juniper (*Juniperus communis*) and chokecherry.

Grasses and forbs accounted for approximately 20 percent of the production each. Grasses provided 143 kg/ha, of vegetative production (Table 1). Canada wildrye (*Elymus canadensis*) produced 106 kg/ha, followed by bluegrasses (*Poa species*) at 21 kg/ha, and sedges at 5 kg/ha. Forbs averaged 135 kg/ha (Table 1). Important forbs included asters at 37 kg/ha, American licorice (*Glycyrrhiza lepidota*) at 21 kg/ha, northern bedstraw (*Galium boreale*) at 19 kg/ha, spreading dogbane (*Apocynum androsaemifolum*) with 18 kg/ha, and cinquefoils (Potentilla species) at 12 kg/ha.

Deer Diet - Experimental Forest

Shrubs were the most important component in diets of deer collected on the Experimental Forest throughout the three sampling periods- early winter (December-January), mid-winter (February-March) and late winter-spring (April-May) (Table 2, Fig. 1). Shrubs were common in white-tailed deer diets during the winter (December-May) comprising 63 percent of the diet (Table 3). Kinnikinnick was the most

Table 1. Average plant production (Kg/ha ± SE) on the Experimental Forest (14 m2/ha basal area, Uresk and Severson (1998))[1] and McVey Burn in the Black Hills, South Dakota.

Category	Experimental Forest[1] (n = 3) 1974	McVey Burn (n = 4) 1972-1973
Forbs		
Actaea rubra	0	3 ± 2
Achillea millefolium	2 ± 1	4 ± <1
Antennaria neglecta	1 ± 1	<1
Apocynum androsaemifolium	0	18 ± 7
Symphyotrichum ciliolatum	0	17 ± 4
Aster spp.	0	8 ± 7
Astragalus spp.	13 ± 6	0
Fragaria vesca	4 ± 3	3 ± 2
Galium boreale	0	19 ± 3
Glycyrrhiza lepidota	0	21 ± 13
Lathyrus ochroleucus	12 ± 7	12 ± 5
Potentilla spp.	0	12 ± 7
Solidago spp.	0	3 ± <1
Taraxacum officinale	0	5 ± 1
Vicia americana	0	10 ± 4
Other species	5	1
Total Forbs	**37 ± 14**	**135 ± 23**
Graminoids		
Agropyron caninum	7 ± 4	0
Bromus spp.	0	4 ± 2
Carex spp.	25 ± 5	5 ± 1
Danthonia intermedia	47 ± 2	0
Elymus canadensis	0	106 ± 18
Oryzopsis asperifolia	124 ± 88	0
Piptatheropsis pungens	3 ± 3	0
Poa spp.	5 ± 5	21 ± 9
Other species	1	7
Total Graminoids	**212 ± 91**	**143 ± 51**
Shrubs		
Arctostaphylos uva-ursi	293 ± 78	1 ± 1
Physocarpus monogynus	0	151 ± 36
Rosa woodsii	4 ± 3	64 ± 7
Rubus idaeus	5 ± 4	1 ± 1
Shepherdia canadensis	0	105 ± 21
Spiraea betulifolia	0	29 ± 8
Symphoricarpos albus	4 ± 3	31 ± 6
Other species	2	26
Total Shrubs	**308 ± 76**	**408 ± 89**
GRAND TOTAL	**557 ± 138**	**684 ± 113**

important shrub utilized. Consumption of kinnikinnick increased to a high of 59 percent in late winter with an overall winter average of 41 percent. Willow (*Salix species*) made up 13 percent of the winter deer diet (Table 3). Common juniper (*Juniperus communis*) was 5 percent of the overall diet. Other shrubs were minor components in deer diets.

Grass presence within the overall deer diets ranged from 17 to 36 percent (average of 22 percent) (Table 2 Fig. 1). Bluegrasses (*Poa species*) were the most common graminoid utilized. (Table 3). Needle-and-thread (*Hesperostipa comata*) including green needlegrass (*Nassella viridula*) provided 3 percent of the winter diet (Table 3).

Forbs were less commonly found in diets throughout winter, ranging from 2 to 7 percent (Table 2). Field pussytoes and cinquefoils were common forbs in the diets (Table 3). Lichen comprised 2 percent during the winter months. Trees were of limited importance with 4 percent.

Table 2. White-tailed Deer Diets (% ± SE) by Plant Category for the Experimental Forest and McVey Burn in the Black Hills, South Dakota.

	Forest			Burn		
Category	**Early Winter Dec-Jan n=5[1]**	**Mid-Winter Feb-Mar n=8**	**Late Winter Apr-May n=4**	**Early Winter Dec-Jan n=6**	**Mid-Winter Feb-Mar n=19**	**Late Winte Apr-May n=15**
Forbs	7.2 ± 0.7bd[2]	2.4 ± 0.3cd	5.6 ± 1.2d	13.5 ± 1.0a	8.0 ± 0.2b	13.9 ± 0.2a
Graminoids	17.4 ± 2.0c	17.6 ± 2.8bc	36.3 ± 3.0a	17.0 ± 3.7c	5.5 ± 0.1d	23.4 ± 0.7b
Lichen	3.6 ± 1.1a	1.4 ± 1.1b	1.5 ± 1.5b	0.2 ± 0.2b	0.2 ± 0.2b	0.2 ± 0.1b
Shrub	65.2 ± 2.5b	75.0 ± 3.0a	32.5 ± 3.1d	50.7 ± 3.0c	69.9 ± 1.4ab	49.1 ± 1.2c
Trees	6.8 ± 3.1abc	3.3 ± 2.0bc	2.0 ± 0.9c	18.8 ± 15.8a	17.1 ± 5.6a	3.5 ± 4.5ab

[1] Rumen sample size

[2] According to Tukey's Test, means in a row followed by a similar letter are not significantly different at p ≤ 0.10.

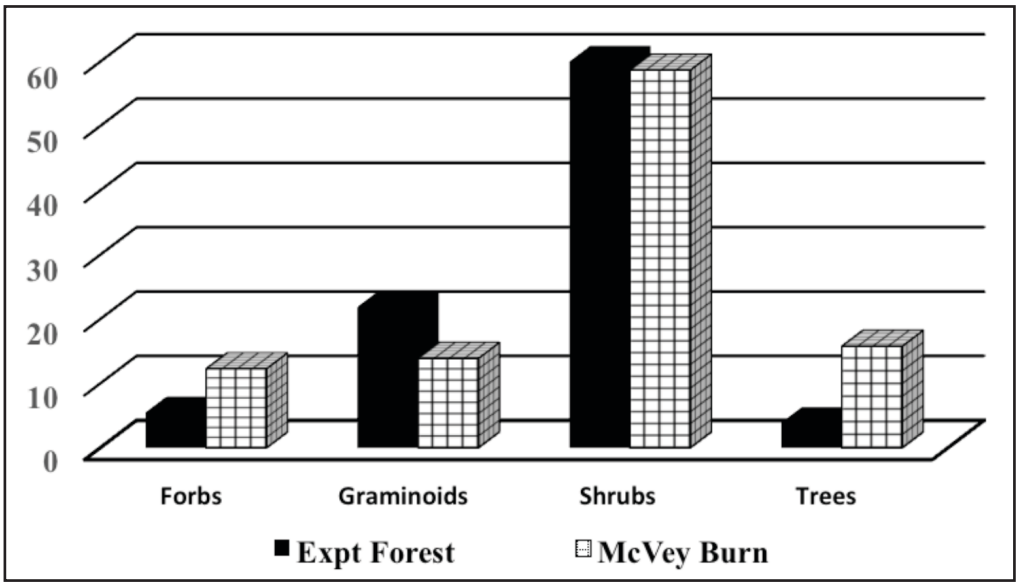

Figure 1. White-tailed deer diets (%) during winter months (December – May) by plant category on the Experimental Forest and McVey Burn.

Table 3. Mean winter deer diets (%) by plant species on the Experimental Forest and McVey Burn in the Black Hills, South Dakota.

Winter White-tailed Deer Diets (December-May)		
Plant Species	**Experimental Forest (n = 17)[1]**	**McVey Burn (n = 40)**
Forbs		
Antennaria neglecta	3.3	2.9
Astragalus spp.	0.2	2.7
Potentilla spp.	1.8	2.5
Solidago spp.	0.2	4.2
Total Forbs	**5.5**	**12.3**
Graminoids		
Carex spp.	1.8	2.5
Danthonia intermedia	0.1	1.8
Poa spp.	7.2	9.4
Hesperostipa comata+Nassella viridula	2.8	0.2
Total Graminoids	**21.9**	**13.9**
Unknown lichen	**2.1**	**0.5**
Shrubs		
Arctostaphylos uva-ursi	40.5	1.6
Artemisia frigida	0	35.9
Mahonia repens	3.7	0
Juniperus communis	4.6	0.5
Rosa woodsii	0.3	1.0
Rubus idaeus	0.5	2.2
Salix spp.	12.6	14.8
Shepherdia canadensis	1.2	2.7
Total Shrubs	**63.4**	**58.7**
Trees		
Pinus ponderosa	**3.9**	**15.8**

[1] Rumen sample size

Deer Diet - McVey Burn

Shrubs were the most abundant among all deer diet categories on the McVey Burn (Table 2, Fig. 1). Shrubs in deer diets ranged from 49 percent to 70 percent and were highly important throughout December-May. Prairie sagewort was common constituting 36 percent of the diet (Table 3). Willows comprised 15 percent of the diet. Other shrubs included kinnikinnick and American red raspberry with 2 percent and russet buffaloberry with 3 percent of the diet.

Graminoids were more dominant in deer diets during early winter (17%) and early spring (23%) (Table 2). Bluegrasses comprised 9 percent of the diet (Table 3). Other graminoids (2-3%) included timber oatgrass and sedges.

Forbs were significant during early winter and late winter with 14 percent of the deer diet, decreasing to 8 percent mid-winter (Table 2). Goldenrod (*Solidago species*) provided 4 percent of the diet (Table 3). Field pussytoes, milk vetch and cinquefoils were minor (2-3%) components in the

diet. Lichens were insignificant in diets. Ponderosa pine needles provided 16 percent of the deer diet (Table 3). Other tree species in the diets were not observed.

Deer Diet - Experimental Forest vs McVey Burn

Shrubs in deer diets on the Experimental Forest and McVey Burn were similar during the winter season (December through May) with each comprising approximately 60 percent of the total diet (Table 3, Fig. 1). Major shrubs in diets included kinnikinnick and willow on the Experimental Forest with fringed sage and willow on the McVey Burn (Table 3). Graminoids were the second most abundant forage plants in deer diets with 22 percent and 14 percent of the total diets on the Experimental Forest and McVey Burn areas, respectively (Table 3, Fig. 1). Forbs were the least abundant forage plants in the deer diets with 6 percent on the Forest and 12 percent on the Burn (Table 3, Fig 1).

Ponderosa pine needles made up approximately 16 percent of the total deer diet on McVey Burn (Table 3, Fig 1). Trees were small in stature on this site (Dietz et al. 1980). White-tailed deer diets on the Experimental Forest consisted of fewer pine needles within the diet with 4 percent. The area had larger and more mature pine trees. Both areas had a decreasing trend in trees observed in the diet from early to late winter (Table 2).

Relationships between Available Forage Species and Deer Diets

Percent similarity between available herbage and white-tailed deer diets ranged from 0 to 88 percent. High similarities indicate that deer are selecting specific plant species or groups in the same proportions as available in the areas. Low similarities show that deer are avoiding plants for food. Similarity indices for forbs, graminoids and shrubs were greater on McVey Burn than for deer associated in the Experimental Forest area. Spearman's rank order correlations were low for both study areas. These relationships of available herbage vs deer diets on the Experimental Forest were, r = -0.22 and McVey Burn, r = 0. 11. Correlations of each area were not significant at $p \leq 0.10$. This indicates that white-tailed deer were not selecting plants for their diet in the same proportions as their availability on both areas.

Discussion

The Black Hills are dominated with widely distributed ponderosa pine. It is the major climax species in 7 of the 12 habitat types described by Hoffman and Alexander (1987). The study areas were in a *Pinus ponderosa/Arctostaphylos uva ursi* habitat type. During late fall and early winter months white-tailed deer would migrate to the McVey Burn primarily for forage availability. White-tailed deer on the Experimental Forest were yearlong residents. Plant production on the Experimental Forest with ponderosa pine at 14 m^2/ha basal area (saplings) was used to compare with the McVey Burn area (Uresk and Severson 1998). Plant species richness was greatest on the Burn area, however the number of plant species in white-tailed deer food items were similar with 17 species for each area during the months December through May. Shrubs were the most important food items in white-tailed deer diets during the winter months for both areas. Hill and Harris (1943) reported 65 percent of white-tailed deer diets in the Black Hills consisted of 23 shrub and tree species during October- December and 21 shrub and tree species from January- April from rumen contents. In comparison, this study identified 9 shrubs and trees in white-tailed deer diets pooled for both sites, a significant decrease in shrub species. This may be due to a reduction in shrub species over a 29 year period due to management of the resources or differences in areas surveyed.

Kinnikinnick was by far the most important shrub species in the diet of white-tailed deer on the Experimental Forest site, comprising as much as 59 percent of the diet in winter. Hill and Harris (1943) reported that kinnikinnick made up 24 percent of

the white-tailed deer diet during the winter months. This species is one of the most important browse species during winter on ponderosa pine sites in the Black Hills (Hill and Harris 1943) and is the most productive shrub on many sites (Pase 1958; Uresk and Severson 1998). It is highly digestible and has a high intra-cellular carbohydrate and mineral content (Uresk et al. 1975). The importance of kinnikinnick, and its high preference value in winter has been demonstrated in other studies of white-tailed deer (Schneeweis et al. 1972; Hill and Harris1943). Conversely, kinnikinnick was a conspicuously minor element in the diets of deer collected on the McVey Burn Area with a high of 8 percent in early winter. Production for kinnikinnick on the McVey Burn was low, however, this species has a high association with the ponderosa pine forest.

Prairie sagewort was important in deer diets on the McVey Burn. This species will maintain a high digestibility of 60 percent throughout the winter while other woody species decrease markedly through winter months (Dietz 1972). Prairie sagewort is high in energy, partially due to the presence of large amounts of essential oils (Dietz 1972).

Ponderosa pine needles comprised a high proportion of the winter diets of deer on the McVey Burn Area. Pine needles are a palatable deer food and there has been some concern about pine needle abortion with deer but no supportive information. The predominance of pine needles in winter diets of deer on the McVey Burn Area may have been influenced by snow cover and temperature, although the high percentage of short statured prairie sagewort in diets, suggests there was little or no snow cover in some areas of the burn.

Willows were important in deer diets on both areas for the winter months. On the Experimental Forest willow comprised 30 percent of the diet during early winter (Uresk, unpublished data), a time of high utilization. Willow was consistently found in deer diets throughout the winter season at approximately 13 percent in the Forest and 15 percent on the McVey Burn. Willow is considered a relatively high protein forage (Dietz 1965). Willows are important browse plants throughout the Black Hills and for stabilizing stream banks, and providing shade to lower stream temperatures. However, over-browsing and trampling of the riparian systems and loss of willows has been primarily attributed to livestock, although disease and insects are some causative factors (Froiland 1962). Current willow surveys are not available but observations of willows in the Black Hills indicate heavy use and trampling by livestock.

Graminoids were commonly used by deer in both study areas, during early winter and spring. Hill and Harris (1943) reported similar results. Cook (1972) reported that bluegrasses are high in nutritive value early in the spring, but lose their nutritive value rapidly during active growth. Cool season grasses (needle grasses) start growth later but retain their nutrients with maturity.

While forbs were common components of deer diets throughout the winter months, they were more important in the diets of deer on the McVey Burn. Forbs are low in nutritional qualities during the winter and generally do not furnish adequate nutrients after fruiting stage (Cook 1972). However, forbs are a common component of deer diets in the Black Hills, but are not considered high nutritional value food items (Hill and Harris 1943; Dietz 1972).

Several forage species with high similarity indices include Solidago species, bluegrass, kinnikinnick, sedges and American red raspberry in the McVey Burn. High similarities in the Experimental Forest included field pussytoes, while other plant species exhibited low similarities. White-tailed deer consuming forage plants in approximately the same proportions as available are considered high similarities. Overall, the rank order correlations relating availability of plants to deer diets, indicated that deer were not selecting food items in the same proportions as availability.

These selective differences are attributed to digestibility and nutrients of the various forage species (Dietz 1972).

Winter use of forage categories by white-tailed deer on both sites followed similar trends found in other studies, with grasses and forbs most important in late winter and spring, shrubs and forbs most important in fall, and shrubs most important in winter (Schneeweis et al. 1972; Hill and Harris1943). In this study, shrubs were an important food component in white-tailed deer diets on both sites. Fewer shrub species occurred in deer diets from the Experimental Forest and McVey burn than reported by Schneeweis et al. (1972). More recently, the reduction in shrub and tree species in deer diets has been attributed to heavy utilization of shrubs by livestock and wildlife (Uresk and Lowry 1984; Uresk and Painter 1985; Hoffman and Alexander 1987; Deperno et al. 2000; Deperno et al. 2002).

Management Implications And Summary

Although these data were collected over 35 years ago, the data provided on forage production and winter diets of white-tailed deer diets provides new and additional information that has not been published. This study is helpful and informative to managers with respect to white-tailed deer habitat needs. Winter deer diets on the Experimental Forest and McVey Burn were similar. Important forage species were prairie sagewort, willows, kinnikinnick, ponderosa pine and bluegrasses. Shrubs were the most preferred food items consumed by white-tailed deer during winter months. Methods to improve shrub production and other plant diversity and/or quantity are available (Sieg and Severson 1995; Dietz et al. 1980; Uresk and Severson 1998) and include optimizing tree density for shrub production by controlled burning geared to stimulation of shrub enhancement in the forest and planting of shrubs in key deer wintering areas. In addition, management of livestock grazing at acceptable levels leaving 60% of herbage left ungrazed (based on modified Robel pole and visual obstruction of herbage (0.5-inch bands) at average peak herbage) will provide increased benefits for improvement of plant resources for quantity and diversity (Beetle et al. 1961; Severson and Urness 1994: Uresk and Benzon 2007; Uresk et al. 2009a, 2009b; Juntti 2012; Mergen 2013). The benefits of leaving adequate residual herbage, approximately 60 percent of average peak herbage left ungrazed are: 1) increase plant diversity and production, 2) decrease soil temperature and increase soil moisture, 3) reduce runoff of water, and 4) plants mature later and are healthier. Leaving adequate levels of residual vegetation throughout the rangelands including dry years in the Black Hills will provide for increased shrub diversity and availability, improving the resources for livestock and wildlife. Such measures would greatly enhance winter deer range and lend support to a declining deer population ((Deperno et al. 2000; Deperno et al. 2002, SDGFP 2017).

Acknowledgments

We thank Harold Messner who was instrumental for assistance in collecting field data, summaries and white-tailed deer collections throughout the study. Thanks are extended to Roger Kerbs for providing valuable assistance throughout all phases of the study. Appreciation is extended to Terrie Foppe at Colorado State University for microhistological analyses of fecal samples and to Maggie Voorhees for analyses and summaries. Kieth Severson and Daryl Mergen provided helpful comments on the manuscript.

Literature Cited

Beetle, A.A, W.M. Johnson, R.L. Lang, M. May and D.R. Smith DR. 1961. Effect of grazing intensity on cattle weights and vegetation on the Bighorn Experimental Pastures. Wyoming Agricultural Experiment Station Bulletin 373: 1–22.

CLIMOD 2. 2016. Climate Information to management and operational decisions. Field Test Version. Ithaca Cornell University, NY. Available at: http://climodtest.nrcc.cornell.edu/ [Cited 9 September 2016].

Cook, C.W. 1972. Comparative nutritive values of forbs, grasses and shrubs. Pp. 289-302. *in* Wildland shrubs-their biology and utilization. 1971 July; Logan, UT. USDA-Forest Service. GTR INT-1. Ogden, UT: Intermountain Forest and Range Experiment Station.

Deperno, C.S., J.A. Jenks, S.L. Griffin and L.A. Rice. 2000. Female survival rates in a declining white-tailed deer population. Wildlife Society Bulletin 28:1030-1037.

Deperno, C.S., J.A. Jenks, S.L. Griffin, L.A. Rice and K.F. Higgens. 2002. White-tailed deer habitats in the Black Hills. Journal of Range Management 55:242-252.

Dietz, D.R. 1972. Nutritive value of shrubs. Pp. 289-302. *in* Proceedings of symposium: Wildland shrubs-their biology and utilization. 1971 July; Logan, UT. USDA-Forest Service. GTR INT-1. Ogden, UT: Intermountain Forest and Range Experiment Station.

Dietz, D. R. 1965. Deer nutrition research in range management. Pp. 274-285. *in* Transactions of the thirtieth North American wildlife and natural resources conference. 1965 March 8-10; Washington, D.C.

Dietz, D. R., D.W. Uresk, H.E. Messner and L.C. McEwen, 1980. Establishment, survival and growth of selected browse species in a ponderosa pine forest. USDA-Forest Service. Research Paper RM-219. Fort Collins, CO. Rocky Mountain Forest and Range Experiment Station.

Froiland, S.G. 1962. The genus salix (willows) in the Black Hills of South Dakota. USDA-Forest Service. Technical Bulletin No. 1269. Rocky Mountain Forest and Range Experiment Station. Ft. Collins CO.

Hill, R.R. and D. Harris. 1943. Food preferences of Black Hills deer. Journal of Wildlife Management. 7: 233-235.

Hoffman, G.R. and R.R. Alexander. 1987. Forest vegetation of the Black Hills National Forest of South Dakota and Wyoming: a habitat type classification. USDA-Forest Service. Research Paper RM-276. Fort Collins CO. Rocky Mountain Forest and Range Experiment Station.

Johnson, M.K., H. Wofford and H.A. Pearson. 1983. Microhistological techniques for food habits analyses. USDA-Forest Service. Southern Forest Experiment Station Research Paper. SO-199.

Juntti, T.M. 2012. Monitoring livestock forage use in the Black Hills. Proceedings of South Dakota Academy of Science. 91:238

Mergen, D.E. 2013. 2012 summary report of Robel pole data collected on the northern Black Hills SD. Mergen Ecological Delineations, Inc. 45 pp.

Oosting, H.J. 1956. The study of plant communities. W. H. Freeman and Co., San Francisco. 440 pp.

Pase, C.P. 1958. Herbage production and composition under immature ponderosa pine stands in the Black Hills. Journal of Range Management 11: 238-243.

Petersen, L. E. 1984. Northern Plains. Pp. 441-448. *in* L.K. Hall, ed. White-tailed deer: Ecology and management. Wildlife Management Institute. Harrisburg, PA: Stack pole Books.

Pechanec, J.F., and G.D. Pickford. 1937. A weight-estimate method for the determination of range or pasture production. Journal of American Society of Agronomy 29:894-904.

Rogers, L.E. and D.W. Uresk. 1974. Food plant selection by the migratory grasshopper (*Melanoplus sanquinipes*) within a cheatgrass community. Northwest Science 45:230234.

Schneeweis, J. C., K.E. Severson, L.E. Petersen, T.E. Schenck, R.L. Linder and A.H. Richardson. 1972. Food habits of deer in the Black Hills. Bulletin 606. Agricultural Experiment Station, Brookings, South Dakota.

SDGFP 2017. SD Game and Fish: Black Hills Deer. Available at: https://gfp.sd.gov/hunting/harvest/reports/BLACK%20HILLS%20DEER.PDF. [Cited 27 January 2017].

Sieg, C.H. and K.E. Severson. 1996. Managing habitats for white-tailed deer in the Black Hills and Bear Lodge Mountains of South Dakota and Wyoming. USDA-Forest Service. RM GTR-274. Fort Collins, CO. Rocky Mountain Forest and Range Experiment Station.

Sparks, D.R. and J.C. Malechek. 1968. Estimating percentage dry weight diets using a microscopic technique. Journal of Range Management 21:264-265.

SPSS. 2003. Statistical procedures for social science. SPSS Base 12.0 for Windows User Guide. SPSS Inc., Chicago, IL, 667 pp.

Severson, K. E. and P.J. Urness 1994. Livestock grazing: A tool to improve wildlife habitat Pp.232-249. in M.Vavra, W.A. Laycock and R.D. Pieper, eds., Ecological implications of livestock herbivory in the west. Society for Range Management. Denver, Colorado. 297 pp.

Thilenius, J.F. 1972. Classification of deer habitat in the ponderosa pine forest of the Black Hills, South Dakota. USDA-Forest Service. Research Paper RM-91. Fort Collins, CO. Rocky Mountain Forest and Range Experiment Station.

Uresk, D.W. 1987. Diets of cattle in the Black Hills of South Dakota. Pp. 33-35. *in* H.G. Fisser, ed. Proceedings: 16th Wyoming shrub ecology workshop; 1987 May 26-27; Sundance, WY. Laramie, WY: University of Wyoming, Department of Range Management.

Uresk, D.W. and D.G. Lowrey. 1984. Cattle diets in the central Black Hills of South Dakota. pp. 50-52 *in* D.L Noble and R.P. Winokur, Editors. Wooded Draws: Characteristics and values for the northern Great Plains. Symposium Proceedings. South Dakota School of Mines and Technology, Rapid City South Dakota.

Uresk, D.W. and W.W. Paintner. 1985. Cattle diets in a ponderosa pine forest in the northern Black Hills. Journal of Range Management 38:440-442.

Uresk, D. W. and K.E. Severson. 1998. Response of understory species to changes in ponderosa pine stocking levels in the Black Hills. Great Basin Naturalist 58:312-327.

Uresk, D.W., D.R. Dietz and H.E. Messner. 1975. Constituents of in vitro solution contribute differently to dry matter digestibility of deer food species. Journal of Range Management. 28: 419-421.

Uresk, D.W. and T.A. Benzon. 2007. Monitoring with a modified Robel pole on meadows in the central Black Hills of South Dakota. Western North American Naturalist 67:46-50.

Uresk, D.W., D.E. Mergen and T.A. Benzon. 2009a. Monitoring meadows with a modified Robel pole in the Northern Black Hills, South Dakota. Prairie Naturalist 41:121-125.

Uresk, D. W., D.E. Mergen and T.A. Benzon. 2009b. Estimating standing vegetation with a modified Robel pole on meadows and grasslands in southern Black Hills of South Dakota. Proceedings of the South Dakota Academy of Science 88:91-97.

USDA-Forest Service. 1983. Land and resource management plan: Black Hills National Forest. Custer, South Dakota.

USDA-Forest Service 1997. Black Hills National Forest Revised Land and Resource Management Plan. Black Hills National Forest, Rocky Mountain Region, Custer, South Dakota.

USDA Forest Service. 2005. Black Hills National Forest Revised 1997 Land and Resource Management Plan, Phase II Amendment. Final Environmental Impact Statement. Black Hills National Forest, Rocky Mountain Region, Custer, South Dakota. Available at: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsm9_011678.pdf. [Cited 27 January 2017].

Wallmo, O.C, L.H. Carpenter, W.L. Regelin, R.B. Gill and D.L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. Journal of Range Management 30: 122-127.

Wydeven, A.P. and R.B. Dahlgren. 1983. Food habits of elk in the Northern Great Plains. Journal of Wildlife Management 47: 916-923.

Received 16 December 2016
Accepted 02 February 2017