GREATER SAGE-GROUSE WINTER AND MALE AND FEMALE SUMMER HABITAT SELECTION IN STRAWBERRY VALLEY, UTAH

by

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As chair of the candidate's graduate committee, I have read the thesis of Dustin J. Bambrough in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

GREATER SAGE-GROUSE WINTER AND MALE AND FEMALE
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VALLEY, UTAH

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Master of Science

Manuscript No. 1

Greater Sage-Grouse (*Centrocercus urophasianus*) winter habitat selection was examined during the winters of 1999 through 2001 in Strawberry Valley, Utah and proximate migratory destinations. Habitat data were recorded at use and random sites to determine if winter habitat is a limiting factor contributing to the decline of this population. Significant habitat components distinguishing use from random sites at Strawberry using logistic regression were: big sagebrush (*Artemisia tridentata*) canopy cover, distance to the nearest sagebrush from the roost/feed site, crown area of nearest sagebrush from the roost/feed site, and snow depth at the roost/feed site. Univariate statistics showed sagebrush canopy cover was greater in the migratory areas than at Strawberry. Sagebrush height and crown area at the micro-habitat level were greater in

use sites than random sites at Strawberry. Vertical obscurity cover was greater in use sites than random sites in all winter habitat study areas. Aspects were typically south in use sites at Strawberry and east or no aspect in use sites within the migratory areas. Greater sage-grouse selected steeper slopes in use sites at Strawberry than use sites at the migratory areas. Winter sagebrush characteristics in Strawberry Valley and migratory destinations were adequate during the winters of 1999 through 2001, however preservation of migratory destinations of this native greater sage-grouse population is essential when snow depth eliminates sagebrush from Strawberry Valley.

Manuscript No. 2

Male and non-reproductive female Greater Sage-Grouse (*Centrocercus urophasianus*) habitat selection was compared for a population in Strawberry Valley, Utah during 4 summers (i.e. May through August). Non-reproductive females were located in brood habitat throughout the summer and were not grouped with males. Logistic regression showed the following six habitat components affected the tendency of habitat selection to be male or female: 1) Vertical obscurity cover 2) Slope 3) Shrub height 4) Shrub canopy cover 5) Grass cover (micro-habitat) 6) Forb cover (micro-habitat). Univariate statistics showed these females selected more gradual slopes, more vertical obscurity cover, shorter shrubs, and greater forb cover at the macro-habitat level than males. Non-reproductive female greater sage-grouse should be considered as an integral part of comprehensive habitat management plans for smaller greater sage-grouse populations.

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Introduction

Greater Sage-Grouse (*Centrocercus urophasianus*) (Young et al. 2000), here after referred to as sage-grouse or grouse, are limited to use of sagebrush above the snow for forage and cover during winter (Griner 1939, Patterson 1952, Eng and Schladweiller 1972). Rowland and Wisdom (2002) reported that winter studies are less common than studies of sage-grouse during lekking, nesting, and brood rearing periods. Some studies have described sage-grouse winter habitat. Sagebrush canopy cover has been reported ranging from 12% in Oregon (Hanf et al. 1994) to 43% in Colorado (Schoenburg 1982). Height of sagebrush in winter use areas ranged between 20 cm to 36 cm in Colorado (Beck 1977). Topographic distribution of sage-grouse in winter varies depending on snow depth, slope, and aspect (Beck 1977, Hupp and Braun 1989).

Sage-grouse populations can be migratory or non-migratory (Hulet 1983, Connelly et al. 2000). Non-migratory populations are often found in lower elevation habitats (Wallestad 1975) while migratory populations are often found at higher elevations (Dalke et al. 1960, Connelly 1982). Winter movements are not always based on the proximity of suitable winter habitat but apparently on successful traditions within a population (Connelly et al. 1988).

Sage-grouse have been shown to prefer both Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) (Remington and Braun 1985, Myers 1992) and mountain big sagebrush (*Artemisia tridentata vaseyana*) (Welch et al. 1991). Remington and Braun (1985) suggested sage-grouse often select Wyoming big sagebrush because leaves contain a higher amount of crude protein and lower amounts of plant secondary compounds such as monoterpenes.

In an effort to understand the decline of sage-grouse in Strawberry Valley, Utah (Griner 1939, Welch 1990, Bunnell 2000), this study quantified and compared winter habitat use sites to random sites to determine if winter habitat in Strawberry and/or winter migratory destinations is a limiting factor contributing to decline of this population. This study also determined which habitat variables were most influential in winter habitat selection, through multivariate analysis.

Materials and Methods

Strawberry Valley is located in Wasatch County south of the Uinta and east of the Wasatch mountain ranges. Topography consists of mountain ridges and valleys with Strawberry reservoir occupying about 6,946 ha. The valley is characterized as a montane sagebrush steppe with an elevation from 2,280 m to 2,440 m. The valley has cool summers and cold winters with an annual precipitation of 58 cm. Mountain big sagebrush dominates the area interspersed with bitterbrush (*Purshia tridentata*), green rabbitbrush (*Chrysothamnus viscidiflorus*), mountain snowberry (*Symphoricarpus oreophilus*), squaw currant (*Ribes cereum*), chokecherry (*Prunus virginiana*), and silver sage (*Artemisia cana*) and shrubby cinquefoil (*Potentilla fruticosa*) occurring in the more mesic meadows.

The Currant Creek winter habitat study area is located on state and private land about 18.5 km east of Strawberry Valley on the border of Wasatch and Duchesne Counties northwest of the town of Fruitland. Elevation is about 2,134 m and topography is characterized by rolling hills and benches with an intermediate variety of mountain and Wyoming big sagebrush as the dominant shrub species (Goodrich et al. 1999).

The Lower Red Creek winter habitat study area is located on private land about 32.2 km east of Strawberry Valley in Duchesne County. The site is located east of Fruitland, north of U.S. Highway 40, and west of State Highway 208. Eroded washes and benches characterize the topography. Elevation is about 1,981 m with an annual average precipitation of 31.5 cm. Wyoming big sagebrush dominates the area intermixed with greasewood (*Sarcobatus vermiculatus*) and rubber rabbitbrush (*Chrysothamnus nauseosus*).

Winter field work was conducted in 1999 through 2001 in three areas: Strawberry Valley, and two winter migratory destinations referred to as Currant Creek and Lower Red Creek. Data from Lower Red Creek were collected only during the winter of 1999 because access was denied the subsequent winters. Sage-grouse were captured on or near three leks during March, April, and May of 1998, 1999, and 2000 using long-handled poles with nylon nets and hand-held spotlights (Giesen et al. 1982, Wakkinen et al. 1992). Individuals were fitted with a necklace style radio transmitter collar.

Each radio-collared grouse was located and flushed at least once in each study area, during winter, following the spring when it was captured. Radio-collared grouse were located using a portable telemetry receiver and antennae, and telemetry locations were accessed by snowmobile and/or on foot. Periodic fixed wing flights were used to locate sage-grouse that had not been found within a two-week period.

The grouse flushed upon approach and habitat data were collected at the third roost/feed site encountered. The third roost/feed site was chosen as a method to randomize the roost/feed site sample when several individuals flushed in close proximity. Roost/feed sites were identified by tracks, fresh fecal droppings, and marks indicating browsing on sagebrush leaves. Both macro and micro-habitat data were collected at the use site. Macro-habitat data were defined as data collected within a 2,500 m^2 habitat sample area and included UTM coordinates, aspect, slope, distance to habitat edge, temperature, snow depth, and sagebrush and total shrub canopy cover (Fig. 1). Micro-habitat data were taken in the immediate area (i.e. about 0.25 m^2) where the grouse was roosting or feeding and habitat measurements included snow depth, shrub height and crown area above snow, distance to the nearest sagebrush from the roost/feed site, and vertical and horizontal obscurity cover. If a large group (i.e. >10) of grouse flushed, micro-habitat data were collected at a roost/feed site for every fifth grouse flushed.

Slope was recorded in degrees using a clinometer. Canopy cover of live woody vegetation was measured and recorded by species according to the line intercept method (Bonham 1989) using four 25 m transects intersecting at the roost/feed site and extending in the four cardinal directions. Two shrubs were chosen by measuring the nearest shrub (shrub 1) from the roost/feed site and the second nearest shrub (shrub 2) from the first shrub according to the T^2 analysis (Ludwig and Reynolds 1988). Above snow height and shrub crown area were recorded for the two shrubs in the T^2 analysis. Shrub crown area was determined by taking two measurements of crown diameter at right angles to each other and calculating area of an ellipse formed by the measurements. Horizontal obscurity cover was measured in the four cardinal directions on each of the 25 m canopy cover transect lines using a 1 m^2 cover board separated into 36 equal size squares. Cover was determined by identifying percent of obscured squares. Obscurity was defined as any vegetation or object penetrating the perimeter of an individual square. Horizontal obscurity cover was read from a height of 36 cm (i.e. average sage-grouse height) from the snow surface in the four cardinal directions at 2.5, 5, and 10 m. Vertical cover was measured using an 18 cm^2 cover board separated into 36 equal size squares. The board was placed on the ground at the use site and the number of obscured squares directly above the board was recorded. The same definition used for assessing horizontal obscurity was used to determine vertical obscurity.

The same data were recorded at a random site. A random site was located by twisting a graduated compass dial at least three times and then walking in the direction of the compass-orienting arrow for a distance of 100 m. From this point, a random distance from 0 to 100 m and a second direction was taken from the graduated compass dial following the same procedure to locate the random site. If the compass-orienting arrow for the second direction was greater than 90 or less than 270 degrees from the first direction the procedure was repeated until a direction of less than 90 and greater than 270 was selected to prevent repeat sampling in the use site (Fig. 2).

Leaf samples from sage-grouse browsed and non-browsed sagebrush were collected in Strawberry Valley and Currant Creek use sites from January through March 2000 to determine if individuals were selecting for particular characteristics of mountain big sagebrush. Browsed samples were collected by removing the leaves of sagebrush plants that had recently been browsed, and sealing them in a bag. Browsed samples were identified by the sharp cuttings in the leaves typical of sage-grouse (Remington and

Braun 1985). Non-browsed samples were taken from sagebrush plants located in use areas but showing no use by sage-grouse. The Lower Red Creek winter migratory study area was excluded from the sample because access to the area by the landowner was denied. A fluorescence test was conducted according to Stevens and McArthur (1974). This technique determines the subspecies of big sagebrush based on the degree of fluorescence produced by samples from sagebrush leaves crushed in water and evaluated under an ultraviolet light. A score from zero (basin big sagebrush) (*Artemisia tridentata tridentata*) to five (mountain big sagebrush) was given depending on brightness of the fluorescence. Brigham Young University's Soils and Plant Analysis Laboratory conducted a crude protein analysis on browsed and non-browsed samples.

Logistic regression was used to identify the relationship between use and random sites in Strawberry Valley for the following quantitative habitat components: slope, temperature, sagebrush and total species canopy cover, distance to habitat edge, snow depth at the macro-site, distance to the nearest sagebrush (shrub 1) from the roost/feed site, above snow height and crown area of the nearest shrub (shrub 1) from the roost/feed site, snow depth at the roost/feed site, vertical obscurity cover, and horizontal obscurity cover at 2.5, 5, and 10 m. Aspect was also included in the model by coding each aspect (i.e. north, south, east, west, northeast, northwest, southeast, southwest, and no aspect) into a binary format. Logistic regression was then used to determine the best fitting model using the habitat variables listed above. Variables were considered significant at alpha = 0.15 (Hatcher and Stepanski 1994). Sample size was 71 for use sites and 62 for random sites. Univariate statistical analyses compared the same habitat components included in the multivariate analysis except for aspect. ANOVA tests compared variables between habitat study areas and T-Tests compared differences between habitat components at flush and random sites. Since multiple habitat variables were analyzed for each site, the alpha level was adjusted according to the Bonferroni correction (Bonferroni 1936 and Miller 1981) making the *P*-value significant at 0.004.

Results

Numbers of sage-grouse captured and successfully fitted with collars were 21 (11 males and 10 females) in 1998, 20 (14 males and 6 females) in 1999, and 14 (13 males and 1 female) in 2000.

While the purpose of this study was to quantify habitat measurements of all shrub species, only 36 out of 456 samples measured at the micro-site were species other than big sagebrush, so canopy cover, height, and shrub crown area will be reported for big sagebrush only. Migratory areas refer to Currant Creek and Lower Red Creek collectively unless mentioned specifically.

The following habitat components or variables most distinguished sage-grouse use sites from random sites at Strawberry using logistic regression: sagebrush canopy cover ($P = 0.158$), distance to the nearest sagebrush (shrub 1) from the roost/feed site ($P < 0.001$), crown area of the nearest sagebrush (shrub 1) from the roost/feed site ($P = 0.029$), and snow depth at the roost/feed site ($P = 0.134$) (concordance = 88.9%).

At Strawberry, shrubs 1 and 2 were taller at use sites than shrubs 1 and 2 at random sites ($P < 0.001$ and $P = 0.001$). Sagebrush crown area of shrub 1 was larger in use sites than shrub 1 at random sites at Strawberry ($P = 0.003$). Sagebrush crown area of shrub 1 was also larger than shrub 2 in use sites at Strawberry ($P = 0.002$) (Table 1). Results comparing Strawberry with the migratory areas were varied. Sagebrush canopy cover at Currant Creek use sites was greater than Strawberry use sites ($P < 0.001$) (Table 2). Shrub 1 was taller at Currant Creek than shrub 1 at Strawberry use sites ($P < 0.001$). Crown area of shrub 1 was larger in use sites at Strawberry than use sites at Lower Red Creek ($P < 0.001$). Distance from the roost/feed site to shrub 1 was less in use sites than random sites at Strawberry and Currant Creek ($P < 0.001$).

Horizontal obscurity cover at use sites in Strawberry was greater than random sites at each distance (i.e. 2.5, 5, and 10 m) ($P < 0.001$). In Currant Creek, horizontal obscurity cover was greater than random sites ($P < 0.001$) at each distance except for the 10 m distance. There was no difference between use and random sites for any distance in Lower Red Creek (Table 3). Vertical obscurity cover was significantly greater in use than random sites at each winter habitat study area ($P < 0.001$) (Table 3).

Slopes were steeper at Strawberry use sites than in use sites at the winter habitat migratory study areas ($P < 0.001$). Slopes were steeper at Currant Creek than Lower Red Creek ($P = 0.002$). Sage-grouse selected south, southeast, or southwest aspects at 75% of the use sites in Strawberry, east-facing aspects at 40% of the uses sites in Currant Creek, and no aspect at 50% of the use sites in Lower Red Creek (Fig. 3).

Snow depth was greater at Strawberry random sites ($\bar{x} = 37$ cm) than use sites ($\bar{x} = 26$ cm) ($P < 0.001$). Average snow depth was greater at Strawberry ($\bar{x} = 31$ cm) than at the migratory areas (Currant Creek $\bar{x} = 12$ cm and Lower Red Creek $\bar{x} = 3$ cm) ($P < 0.001$). Snow depth at use sites was not significantly different ($P \leq 0.004$) than random sites in the migratory areas. Temperatures ranged from –12 to 10 °C ($\bar{x} = 0.0$ °C) at Strawberry, –5 to 9 °C ($\bar{x} = 0.87$ °C) at Currant Creek and, -7 to 12 °C ($\bar{x} = 3.9$ °C) at

Lower Red Creek. Temperature was not significantly different ($P \leq 0.004$) during the winter at each habitat study area.

Browsed and non-browsed leaf samples collected from Strawberry had a higher mean fluorescence score ($\bar{x} = 4.4$) indicating they were mountain big sagebrush. Samples taken from Currant Creek had a lower mean fluorescence score ($\bar{x} = 2.6$) suggesting Wyoming big sagebrush. Mean fluorescence scores from sagebrush leaf samples collected at Strawberry were greater than samples collected at Currant Creek ($P < 0.001$). Fluorescence scores of browsed samples were not significantly different than non-browsed samples in both the Strawberry and Currant Creek study areas (Table 4). Leaves taken from sagebrush browsed by sage-grouse in Strawberry were slightly but not significantly lower in percent crude protein than the non-browsed samples ($P = 0.036$) (Table 4).

Discussion

The winter habitat model revealed that sage-grouse use sites could be distinguished from random sites during winter in Strawberry Valley. Univariate statistical results showed sage-grouse associate with certain winter habitat components more than others.

The habitat components or variables discriminating between use and random sites in the winter habitat model suggest that sage-grouse in Strawberry are selecting areas where sagebrush canopy cover is greater and where sagebrush with large crown areas persist. Sagebrush crown area of the closest sagebrush plant (shrub 1) to the roost/feed site in our model is of note since sagebrush crown area is not specifically emphasized in the literature as a characteristic influencing sage-grouse winter habitat selection.

Distance to the nearest sagebrush (shrub 1) from the roost/feed site suggests that proximity to sagebrush at the micro-habitat level is important because grouse are actively foraging during the day, and proximity to sagebrush provides both food and cover. Univariate statistics also confirmed the significance of this habitat component. Mean distance to the nearest sagebrush (shrub 1) from the roost/feed site for the three winter habitat areas was 40 cm. This distance did not vary by more than 4 cm in each of the three winter habitat study areas. Snow depth at the roost/feed site was probably related to crown area of the nearest sagebrush (shrub 1) since a larger crown area would prevent snow accumulation directly under or near the individual sagebrush shrub.

Aspect was included in the model because it was anticipated that a particular aspect or aspects would discriminate between use and random sites since sage-grouse were located on south, southwest, or southeast facing slopes at 75% of the use sites. However, when using regression, significant variables may drop out of the model if they are highly correlated with another variable (Hatcher and Stepanski 1994). In this case, aspect was highly correlated with slope, which wasn't a discriminatory variable between sage-grouse use and random sites. The reason for this was that habitat data were gathered in sage-grouse occupied areas not in unoccupied or non-use areas, therefore, because random sites did not exceed 200 m from use sites, slope and aspect were often similar between use and random sites. However, the high number of sage-grouse flushed on south facing slopes indicates that aspect would be a discriminating variable in respect to sage-grouse winter habitat selection in Strawberry Valley.

A multivariate analysis between the migratory areas and Strawberry use sites was not attempted because sample size in the migratory areas was too small to draw inferences. Morrison et al. (1992) warn that inadequate sample size will produce inaccurate interpretations of the data using multivariate methods.

Sagebrush canopy cover was lower in Strawberry than reported in other winter habitat studies (Autenrieth et al. 1981, Beck 1977, Schoenburg 1982). Sagebrush canopy cover in Strawberry use sites barely met the most recent sage-grouse management guidelines (Connelly et al. 2000), and sagebrush canopy cover in random sites fell below the recommended minimum requirement. These results emphasize the importance of maintaining suitable winter habitat in the migratory destinations (i.e. Currant and Lower Red Creek) and indicate that this small population of sage-grouse is utilizing a majority of the available winter habitat in Strawberry Valley. Figure 4 shows GIS summer sagebrush canopy cover data in relation to winter sage-grouse locations in Strawberry Valley.

Sagebrush height and shrub crown area of shrub 1 were greater in Strawberry use sites than random sites, however, these sagebrush characteristics were not significantly different between use sites and random sites in the winter migratory areas. This finding suggests that these grouse select winter migratory destinations based on the homogeneity of suitable sagebrush characteristics at the micro-habitat level.

Vertical obscurity cover was a habitat component that was on average 35% greater in use sites than random sites at all winter habitat study areas. In comparison, horizontal cover varied among Strawberry and migratory areas revealing no apparent relationship except in Strawberry use versus random sites. These results indicate that this population uses sagebrush stands or individual shrubs during winter that will provide cover from aerial rather than terrestrial predators.

The topographic distribution of grouse on steeper south facing slopes in Strawberry compared to east facing slopes or no aspect in the migratory areas can be attributed to the amount of snow Strawberry receives compared to the migratory areas. In Strawberry, visible patches of sagebrush could only be found on steeper south facing slopes at maximum snow depth, thus attracting grouse to congregate in these areas. These results are different from winter habitat studies conducted by Beck (1977) and Hupp and Braun (1989) who reported that sage-grouse selected gradual slopes or drainages. This may be due to the inundation of drainages at lower elevations in Strawberry Valley by the Strawberry Reservoir. Griner (1939), however, documented sage-grouse in Strawberry Valley using wind swept ridges and exposed rock outcroppings during winter before the expansion of the reservoir. Snow depth in the migratory areas was significantly less and didn't limit the exposure of sagebrush throughout the winter, allowing sage-grouse to select use sites on a variety of slopes. The winters of 1999 through 2001 were generally mild, thus we anticipate that this sage-grouse population will completely abandon the Strawberry Valley during a heavy snow year, increasing the value of suitable habitat in the winter migratory areas.

The Currant Creek winter habitat study area is located in an area where an intermediate variety of mountain and Wyoming big sagebrush exists (Goodrich et al. 1999), therefore we anticipated a correlation between individual sagebrush shrubs browsed by sage-grouse, versus those that were not, using the fluorescence test. A positive result would have provided evidence that both mountain and Wyoming big sagebrush occur in this area and sage-grouse were selecting for one or the other or both. Although the test showed no significant difference of selection between browsed and non-browsed sagebrush plants, it did show that sage-grouse migrating from Strawberry to the Currant Creek are not discriminating between big sagebrush subspecies or accessions.

The protein analysis revealed that sage-grouse in the Strawberry Valley study area selected mountain big sagebrush shrubs with lower percent crude protein content, suggesting that sage-grouse in this area may be selecting for palatability rather than slightly higher crude protein. The difference was so slight that no further tests were done to assess palatability as related to plant secondary compounds such as phenolics. Of this diverse group of compounds, condensed tannins may reduce the digestible availability of proteins by chemical complexing. Analyses of secondary compounds would be completed to verify this hypothesis.

In 1999 sagebrush in portions of the winter migratory study areas, owned by private individuals, were treated with tebuthiron, also known as "spike", at 2 lbs per acre. This treatment subsequently caused 100% mortality (i.e. decadent stands with no leaves) of sagebrush by 2001. In the Currant Creek winter migratory study area about 2,000 acres were treated with tebuthiron in the autumn of 1999. During the winter of 2000 some of the radio-collared grouse, including 2 hens, migrated from the Strawberry winter habitat study area to the Currant Creek migratory study area and were flushed in the treated area with as many as 18 other sage-grouse that were not radio-collared. In 2001 no radio-collared grouse were located in this area. Although the tebuthiron treatment was not planned or included in a study design, this treatment serendipitously allowed us to observe the adverse effects of a tebuthiron treatment in sage-grouse winter habitat. This observation illustrates the importance of documenting winter habitat for both migratory and non-migratory sage-grouse populations and effective communication between private, state, federal, and academic entities concerning preservation of sage-grouse winter habitat.

The conclusion of this study is that current winter habitat for this sage-grouse population is adequate under prevailing conditions in Strawberry Valley. However, in a high snow year, sage-grouse will be forced to abandon Strawberry Valley for lower elevation wintering areas. The described herbicide treatment in the Currant Creek winter migratory study area appears to have eliminated a portion of this critical resource. Preservation of these migratory areas is essential. Routes traveled and destinations selected may depend on the migratory experience of these native sage-grouse. Future research should document whether this sage-grouse population can behaviorally change and utilize other wintering habitats with acceptable sagebrush habitat.

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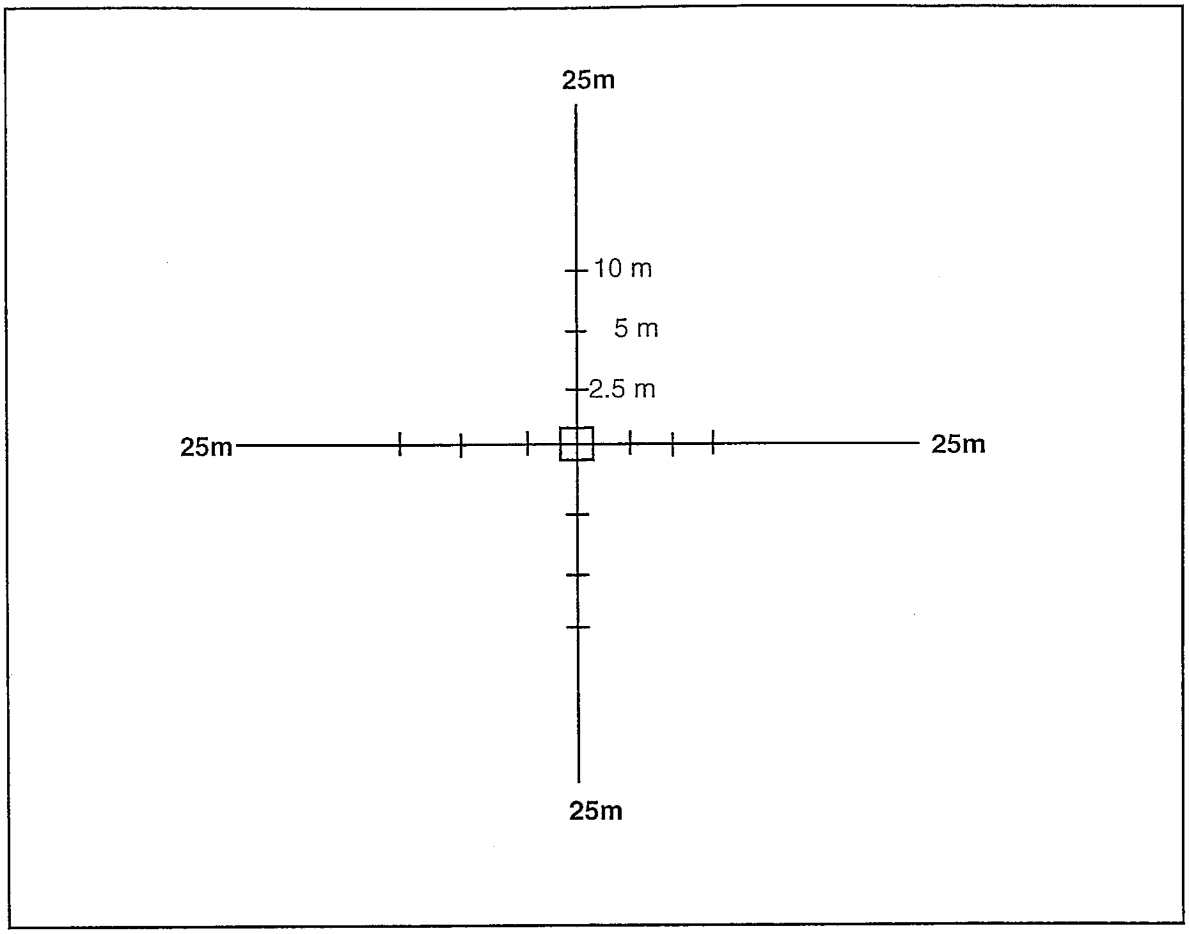

Fig 1. This diagram illustrates the habitat sample area study design. Horizontal obscurity distances were measured at distances represented by tick marks on the 25 m transect lines The roost/feed site is represented by the square in the middle. Diagram is not to scale.

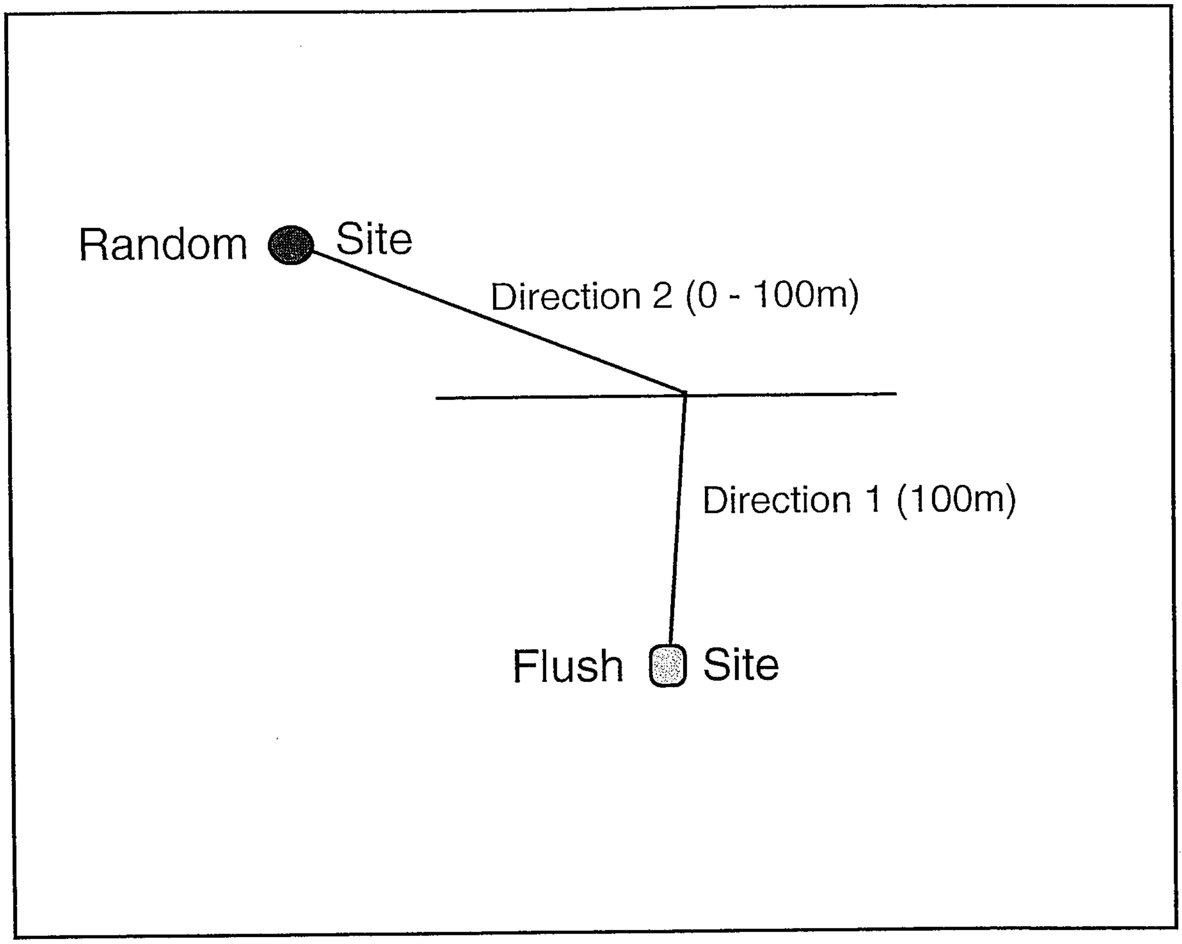

Fig. 2. This diagram describes how a random site was selected. Distances for each direction are shown in parentheses and the horizontal line between direction 1 and 2 represents the boundary of a half plane in which a second direction below this line was excluded.

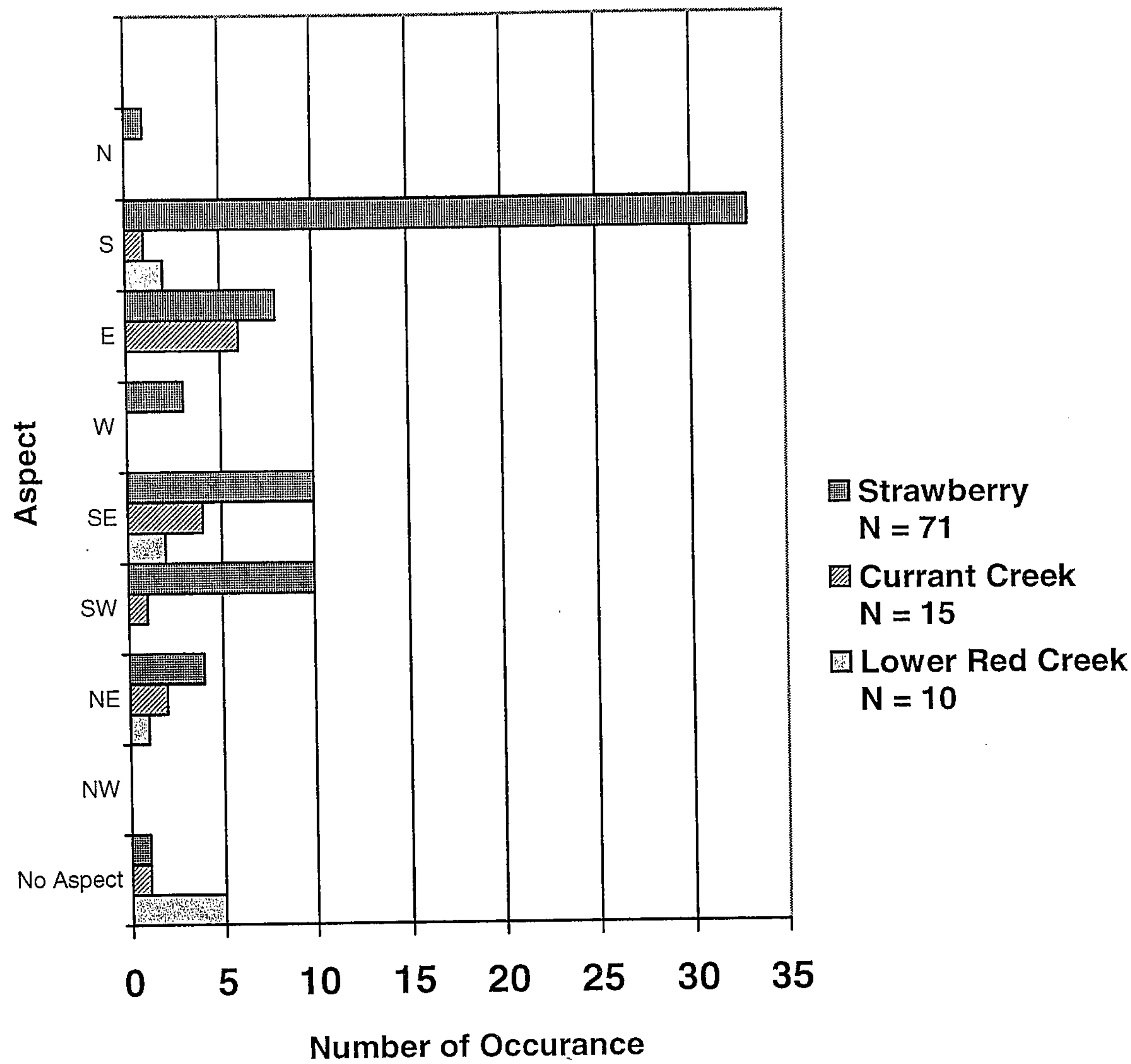

Fig. 3. Compared here are aspects at use sites in the three winter habitat study areas.

Fig 4. This map shows sage-grouse winter locations in Strawberry Valley overalaid on a broad scale sagebrush canopy cover GIS coverage. Data from this coverage was developed from range inventories and didgital orthophotos with an accuracy estimate of 82-84%.

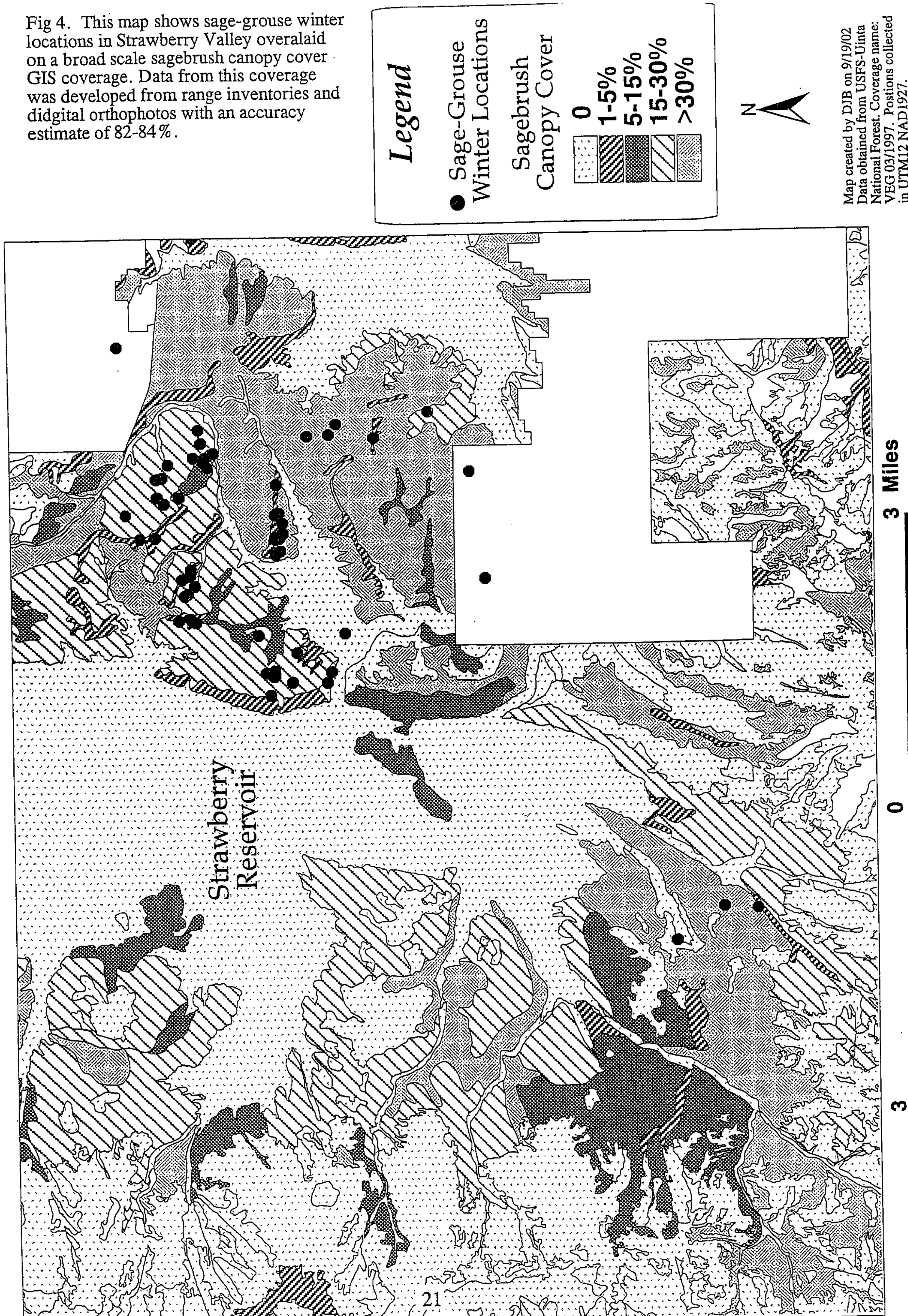

Table 1. These data contrast sagebrush height and crown area of shrub 1 and shrub 2 in use and random sites of all winter habitat study areas.

	Height (cm)	SE	Crown Area (m^2)	SE	N
Strawberry					
Shrub 1	38.9[a]	1.7	0.4403[ab]	0.411	94[c+]
Shrub 2	31.9[a]	1.8	0.2839	0.291	90[c+]
Random (S1)	24.8	3.0	0.2599	0.435	50[+]
Random (S2)	23.4	2.4	0.2425	0.446	52[+]
Currant Creek					
Shrub 1	58.1	4.2	0.3823	0.752	23[c+]
Shrub 2	65.8	4.8	0.4748	0.109	24[c+]
Random (S1)	49.6	5.6	0.3183	0.854	13
Random (S2)	48.7	7.3	0.3512	0.725	12[+]
Lower Red Creek					
Shrub 1	44.3	4.6	0.2308	0.424	21[c+]
Shrub 2	41.6	3.8	0.1923	0.450	21[c+]
Random (S1)	41.2	6.1	0.2576	0.120	10
Random (S2)	33.6	9.1	0.1941	0.813	10

[a] Value was significantly ($P < 0.004$) greater than respective shrub at random sites.
[b] Value was significantly ($P < 0.004$) greater than shrub 2.
[c] Difference in sample size explained by micro-habitat data collected on every fifth grouse flushed at each use site.
[+] Difference in sample size due to measurements analyzed for sagebrush only.

Table 2. These data describe mean sagebrush canopy cover in winter habitat study areas and sites. *P*-values are reported for comparisons between use and random sites in each habitat study area.

	Canopy Cover (%)	*P*-value	SE	N
Strawberry				
Use sites	10.94	0.011	1.0	71
Random Sites	6.82		1.3	62[c]
Currant Creek				
Use sites	20.41[a]	0.017	1.9	15
Random Sites	14.00		1.6	13[c]
Lower Red Creek				
Use sites	12.82	0.008[b]	1.4	10
Random Sites	9.71		2.0	10

[a] Value was significantly ($P < 0.004$) greater than Strawberry.
[b] *P*-value result based on Log *e* transformation on data.
[c] Fewer random sites were completed due to time and weather constraints.

Table 3. Visual habitat factors are shown by mean horizontal obscurity cover of all four cardinal directions and at three distances at Strawberry and migratory area use sites. Corresponding random sites are in the second column to the right of use sites and sample size (N) is in parentheses to the right of the respective area in the same column. Vertical cover is reported on the bottom row for each respective area and site.

	Horizontal Obscurity Cover (%)											
	S[*](97)	SE	R[*](62)	SE	CC[*](25)	SE	R[*](13)	SE	LRC[*](21)	SE	R[*](10)	SE
Distance												
2.5 m	44[a]	2.4	19	3.2	65[a]	4.8	40	4.5	63	3.8	48	5.4
5 m	52[a]	2.4	25	3.4	83[a]	2.9	56	5.9	74	4.1	62	4.3
10 m	61[a]	2.2	37	4.0	90	3.1	80	6.1	85	3.0	68	7.6
	Vertical Cover (%)											
	36[a]	3.8	2.6	1.7	33[a]	8	0	0	42[a]	6.5	1.9	1.9

[*]S = Strawberry, CC = Current Creek, LRC = Lower Red Creek, R = Random site of respective area

[a] Value differed significantly ($P < 0.004$) from random sites in the respective winter habitat study area.

Table 4. These unique data show the mean fluorescence scores and percent crude protein in leaves from browsed and non-browsed sagebrush from January to March 2000 in the Strawberry Valley and Currant Creek winter habitat study areas.

	Fluorescence Score	Standard Error	% Crude Protein	Standard Error	N
Strawberry					
Browsed	4.31	0.19	11.06[a]	0.24	32
Non-browsed	4.48	0.12	11.84	0.27	27
Currant Creek					
Browsed	2.62[b]	0.26	12.28[b]	0.26	23
Non-browsed	2.50[b]	0.17	12.43[b]	0.19	28

[a] Slight difference ($P = 0.036$) between non-browsed leaf samples.
[b] Significant difference ($P < 0.001$) between browsed samples in Strawberry Valley.

A Comparison of Male and Non-Reproductive Female Greater Sage-Grouse Summer Habitat Selection in Strawberry Valley, Utah

Introduction

Greater Sage-Grouse (*Centrocercus urophasianus*) (Young et al. 2000), here after referred to as sage-grouse or grouse, summer habitat has been described for adult males (Wallestad and Schladweiller 1974, Ellis et al. 1989), adult females and juveniles (Dunn and Braun 1986), nesting (Klebenow 1969, Wallestad and Pyrah 1974, Wakkinen 1990), brood rearing (Wallestad 1971, Drut et al. 1994, Sveum et al. 1998), and breeding (Patterson 1952, Gill 1965, Barnett and Crawford 1994). Studies have compared sage-grouse occupied to un-occupied habitat (Bunnell 2000), use sites to non use sites (Ellis et al. 1989), use sites to random sites (Dunn and Braun 1986), use in vegetation treated and non-treated areas (Martin 1970, Carr 1967), and the effects of burning on sage-grouse habitat (Hulet 1983, Fischer 1994, Pyle and Crawford 1996). Here we report the first comparison of male and non-reproductive female summer habitat selection.

Throughout a four-year study conducted to assess the decline of sage-grouse in Strawberry Valley Utah, (Griner 1939, Welch 1990, Bunnell 2000) males and non-reproductive females (i.e. females that did not initiate a nest or lost their nest or brood) were rarely located in the same areas during the summer season. Non-reproductive females also appeared to select different habitat components than males. The purposes of this study were to quantify male and non-reproductive female habitat selection for a small (i.e. < 100) sage-grouse population in Strawberry Valley, Utah, to determine if habitat selection differences exist and then to create a statistical model to predict gender based on selection in relation to these habitat measurements.

Materials and Methods

Strawberry Valley is located in Wasatch County south of the Uinta and east of the Wasatch mountain ranges. Topography consists of mountain ridges and valleys with Strawberry reservoir occupying about 6,946 ha. The valley is characterized as a montane sagebrush steppe with an elevation from 2,280 to 2,440 m. The valley has cool summers and cold winters with an annual precipitation of 58 cm (USDA Forest Service 1997). Mountain big sagebrush (*Artemisia tridentata vaseyana*) dominates the area interspersed with bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), mountain snowberry (*Symphoricarpus oreophilus*), wax currant (*Ribes cereum*), chokecherry (*Prunus virginiana*), and silver sage (*Artemisia cana*) and shrubby cinquefoil (*Potentilla fruticosa*) occurring in the more mesic meadows.

Sage-grouse were captured on or near three leks during March, April, and May of 1998, 1999, 2000, and 2001 using long-handled poles with nylon nets and hand-held spotlights (Giesen et al. 1982, Wakkinen et al. 1992). Individuals were fitted with a necklace style radio transmitter collar.

Habitat data were collected in Strawberry Valley during the summers (i.e. May through August) of 1998 through 2001. Each radio-collared grouse was located and flushed at least once during the summer following the spring it was captured. Radio-collared grouse were located using a portable telemetry receiver and antennae and telemetry locations were accessed by foot. Periodic fixed wing flights were used to find sage-grouse that had not been located within a two-week period. A German shorthair pointer dog was used to locate un-collared females.

Grouse flushed when approached and habitat data were collected at the third use site encountered. The third use site was chosen as a method to randomize the sample chosen at use sites when several individuals flushed in close proximity. Presence of fresh fecal droppings was also used to precisely locate use sites. The dog was used to scout the flush site and general area for chicks for about 20 minutes. If no chicks were found the site was identified as that of a non-reproductive female. If a non-reproductive radio-collared female flushed with a female with a brood, the site was identified as a brood site rather than a non-reproductive female site. Hen behavior was also monitored to determine if a brood was present. Radio-collared hens would return to the area from where they flushed within 20 minutes if the hen had a brood. Radio-collared females were also monitored through the nesting season to determine nest and/or hatching success.

Both macro and micro-habitat data were collected at the use site. Macro-habitat data were data collected within a 2,500 m^2 habitat sample area and included UTM location, aspect, slope, distance to habitat edge, shrub canopy cover by species, average shrub height and crown area, and average (i.e. 5 quadrats) herbaceous understory cover and diversity. Micro-habitat data were collected in the immediate area (i.e. about 0.5 m^2) where the grouse was roosting or feeding and vegetation measured included shrub height and crown area, distance and species of the closest shrub to the use site, herbaceous understory cover and diversity (i.e. 1 quadrat), and vertical and horizontal obscurity cover (Fig. 1).

Slope was recorded in degrees using a clinometer. Canopy cover of live woody vegetation was measured and recorded by species according to the line intercept method

(Bonham 1989) using four 25 m transects intersecting at the use site and extending in the four cardinal directions. Two shrubs were chosen by measuring the distance of the closest shrub (shrub 1) from the use site and the second closest from the first shrub according to the T^2 analysis (Ludwig and Reynolds 1988). The T^2 analysis was then repeated to find the second closest shrub from the use site and the next closest shrub from this shrub. Shrub height and crown area were recorded for the four shrubs in the two T^2 analyses. Shrub crown area was determined by taking two measurements of shrub crown diameter at right angles to each other and calculating area of an ellipse formed by the measurements. Horizontal obscurity cover was measured using a 1 m^2 cover board separated into 36 equal size squares. Cover was recorded by identifying percent of obscured squares. Obscurity was defined as any vegetation or object penetrating the perimeter of an individual square. Horizontal obscurity cover was read from a height of 36 cm (i.e. average sage-grouse height) from the ground in the four cardinal directions at 2.5, 5, and 10 m. Vertical cover was measured using an 18 cm^2 cover board separated into 36 equal size squares. The board was placed on the ground at the use site and percent of obscured squares directly above the board was recorded. The same definition used for assessing horizontal obscurity was used to determine vertical obscurity.

Cover of herbaceous understory was an ocular estimate by genus or species using a ¼ m^2 understory quadrat placed at the use site (micro-site) and at the end of each 25 m transect. Frequency was defined as the presence of a forb species in a ¼ m^2 quadrat. Species diversity was recorded as the total number of species found within a ¼ m^2 quadrat.

Kulcynski's similarity index (Oosting 1956) was used to determine the similarity of cover of 19 of the most common forb species found in the ¼ m^2 quadrats at male and non-reproductive female use sites. The most common forb species were determined by frequency as defined above. Kulcynski's similarity index is expressed in the following formula:

$$SI = \frac{2C}{A+B} \times 100$$

where

SI = similarity index
C = the least amount plant species common to both diets
A = the total amount of plant species in diet A
B = the total amount of plant species in diet B

Logistic regression was used to identify male and non-reproductive female use sites for the following quantitative habitat components: slope, aspect, distance to habitat edge, distance to shrub 1, total species shrub height and crown area of shrub 1 (micro-site), average total species shrub height and crown area, sagebrush height and crown area of shrub 1 (micro-site), average sagebrush height and crown area, total shrub species canopy cover, sagebrush canopy cover, vertical obscurity cover, horizontal obscurity cover at 2.5, 5, and 10 m, and understory cover of grass, forbs, and shrubs at micro and macro-sites. These habitat components were fit to a logistic regression model with gender as the response variable using a stepwise algorithm. Each habitat component was also compared between male and non-reproductive female use sites using univariate statistical analyses. Since multiple habitat components were analyzed for each site, the alpha level was adjusted according to the Bonferroni correction (Bonferroni 1936, Miller 1981) making the *P*-value significant, for univariate results, at 0.002.

Results

Numbers of sage-grouse captured and successfully fitted with collars were 21 (11 males and 10 females) in 1998, 20 (14 males and 6 females) in 1999, 14 (13 males and 1 female) in 2000, and 24 (22 males and 2 females) in 2001. Un-collared females were located using the pointer dog at 18 different flush sites. Habitat selection was analyzed at 61 male and 54 non-reproductive female use sites.

A factor analysis was performed on the horizontal obscurity measurements to assess multicolinearity. Results from this analysis showed the 36 horizontal obscurity variables could be represented by 4 factors. These 4 factors were included in the logistic regression.

The multivariate analysis included six habitat components or variables in the model. The variables that most affected the tendency of habitat selection to be male or non-reproductive female were 1) Vertical obscurity cover 2) Slope 3) Total species height (macro-level) 4) Total species canopy cover 5) Understory grass cover (micro-level) 6) Understory forb cover (micro-level) (Table 1).

Univariate results showed that males selected steeper slopes than non-reproductive females ($P < 0.001$) with 16.4% of aspects being west for males and 22.2% being no aspect for non-reproductive females. Males selected taller shrubs at the use site than non-reproductive females ($P = 0.002$). Mountain big sagebrush was the closest shrub at 71% of male and 65% of female use sites. Non-reproductive females selected greater vertical cover than males ($P < 0.001$) (Table 2). Horizontal Obscurity cover was not significantly different between male and non-reproductive female use sites, however horizontal obscurity cover was less at 2.5 m than at 5 and 10 m at both male and non-reproductive female use sites ($P < 0.001$).

Non-reproductive females selected greater understory cover of forbs than males at the macro-habitat level ($P < 0.001$) (Table 3). Understory cover of 7 of the 19 most common forbs species found in the ¼ m^2 understory quadrats was significantly different between male and non-reproductive female use sites and understory cover of 12 of the 19 most common forb species had a Kulcynski's similarity index score greater than 50% (Table 4).

Discussion

Male and non-reproductive female sage-grouse in Strawberry Valley, Utah, selected habitats with different ecological components. We thought there would be differences since non-reproductive females were located in noticeably different areas than males throughout the four year study (Fig. 3).

Vertical cover was a habitat component that discriminated between male and female use sites in the gender model. One could speculate that females with broods would select greater vertical cover to protect broods, however these data concern habitat selection of females without broods. Perhaps non-reproductive females during this season demonstrate behaviors similar to females with broods instinctively, which would explain why non-reproductive females stayed throughout the summer in the same area as females with broods.

Preference of steeper slopes by males in this study may simply be related to the topography of Strawberry Valley. Males were often located on steeper slopes rising immediately from the edge of the reservoir. These steep slopes allowed males accessibility to water and served as good escape terrain. Non-reproductive females were located on gradual slopes, associated with mesic meadows where moving water persists and there is a higher concentration of forbs. Beck (1977) found that gradual slopes were a selection factor for sage-grouse during the winter in North Park, Colorado, but selection in his study was related to aspect and snow drifting over sagebrush.

The mean value of 55 cm for mountain big sagebrush height at male use sites in Strawberry Valley was similar to sagebrush height reported by Ellis et al. (1989) (53.2 cm) for a breeding male population in a Wyoming big sagebrush habitat type near Duchesne, Utah. Average canopy cover for mountain big sagebrush at male use sites in Strawberry (18%) was similar to that reported by Barber (1991) (23%) also in a mountain big sagebrush type on Diamond Mountain, Utah, but much less than documented in other studies. Ellis et al. (1989) reported 31% sagebrush canopy cover for males and Wallestad and Schladweiller (1974) found most of the breeding males in their study in Montana within sagebrush canopy cover ranging from 20 - 50% with a mean of 32%. Perhaps these differences can be attributed to differences in the structural dimensions of sagebrush in mountain and Wyoming big sagebrush habitat types.

Sagebrush height and canopy cover measurements for non-reproductive females more closely associated with studies reporting vegetation characteristics of nest sites (Wallestad 1975, Autenrieth 1981) than the more open canopy cover of brood habitats (Martin 1970, Wallestad 1971), although, height and canopy cover in our study did fall within the range of productive brood-rearing habitat as described in the most recent sage-grouse management guidelines (Connelly et al. 2000). The gender model for this study did not show sagebrush height or canopy cover as discriminating variables. Canopy cover and average height of all shrubs species were discriminating variables. This was likely due to the higher percent of taller and wider canopies of rabbitbrush and bitterbrush shrubs found at male use sites compared to the shorter and smaller canopies of silver sage and shrubby cinquefoil occurring at female use sites.

Grass and forb understory cover in the ¼ m^2 understory quadrats at non-reproductive female use sites were similar to studies reported for brood habitat (Apa 1998, Fischer 1994, Gregg 1991) and discriminated between male and non-reproductive female use sites. We found about 19 - 22% forb cover at non-reproductive female use sites while Drut et al. (1994) reported forb cover in Oregon ranging from 11 - 14% during early brood rearing and 19 - 27% during late brood rearing. Grass understory at the micro-habitat level was not significantly different, but its relation to the other habitat variables in the model seems to indicate that it does contribute to differences in habitat selection between males and non-reproductive females.

Grass and forb cover in the gender model were associated with higher averages for non-reproductive females and are both vegetative components important for nesting and brood habitats. These habitat components also indicate a similarity in habitat selection among reproductive females and non-reproductive females. This relationship was observed in Strawberry Valley. Non-reproductive females were located in the same general area as females with broods (Fig. 3). Non-reproductive females were sometimes flushed at the same time and location as a female with a brood throughout the summer.

Female nesting success varies among sage-grouse populations (Gregg 1991, Connelly et al. 1993, Schroeder 1997, Coggins 1998). In Idaho, Connelly et al. (1993) found 45% of yearlings and 22% of adults did not nest during the breeding season and about 47% of both yearlings and adults were unsuccessful nesters. Other studies have shown that nest success ranges from as low as 12% to as high as 86% (Trueblood 1954, Gregg 1991, Schroeder et al. 1999). These data indicate that at least half of the females in some populations are non-reproductive. In small populations like the one found in Strawberry Valley, the survival of yearling or adult non-reproductive females is important since these individuals will hopefully be the source of future recruitment.

This study has shown that non-reproductive female sage-grouse in Strawberry Valley spent the summer season in nest and brood habitat. We need to know if this occurs in other populations or is just a phenomenon associated with sage-grouse in Strawberry Valley. If unsuccessful females stay in the same habitat as females with broods this increases the importance of these areas. Brood habitat may thus be important for increased nutritional status for non-reproductive yearling and adult females as Barnett and Crawford (1994) have suggested for pre-laying hens.

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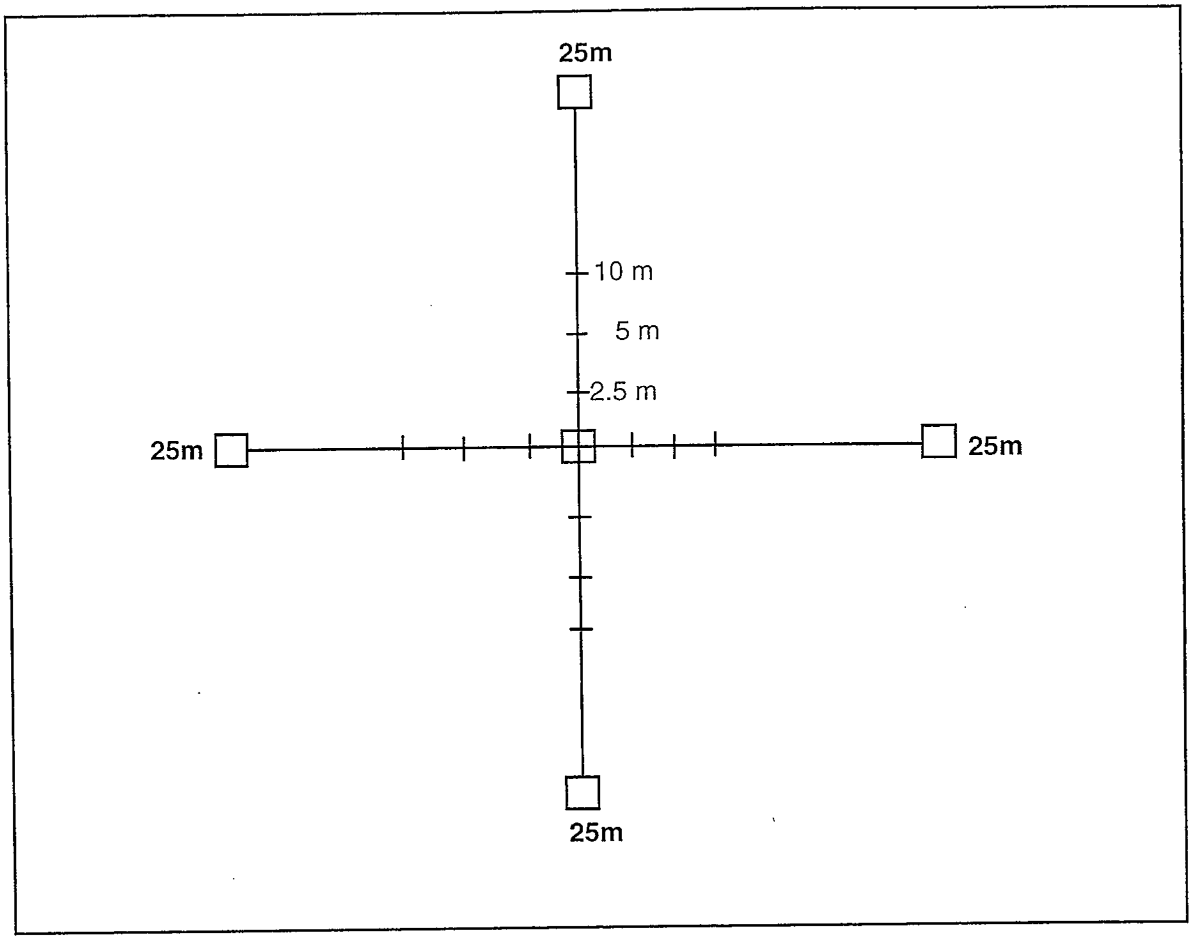

Fig 1. This diagram illustrates the habitat sample area study design established at male and female use sites. Horizontal obscurity distances were measured at distances represented by tick marks on the 25 m transect lines and the ¼ m^2 understory quadrats are represented by squares. Diagram is not to scale.

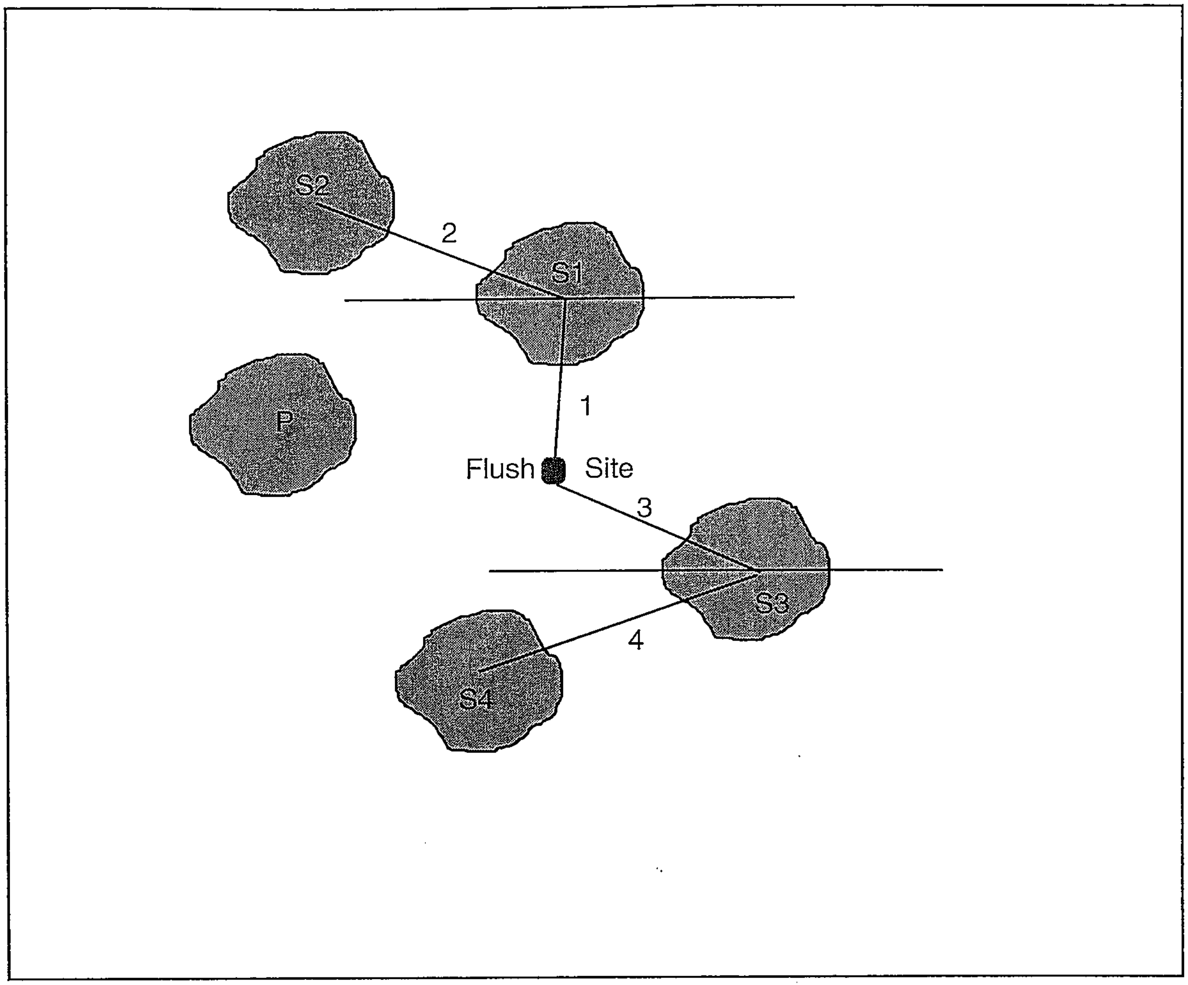

Fig. 2. This diagram is an example of the T^2 analyses conducted at each use site. S1 and S2 represent shrubs selected in the first T^2 analysis, and S3 and S4 represent shrubs selected in the second T^2 analysis. Black lines denote distances associated with numbers describing the order in which distances were measured. Shrubs rooted below the black lines (i.e. P) drawn through S1 and S3 were excluded when selecting S2 and S4.

Fig 3. This map shows sage-grouse locations in Strawberry Valley by sex and/or reproductive status.

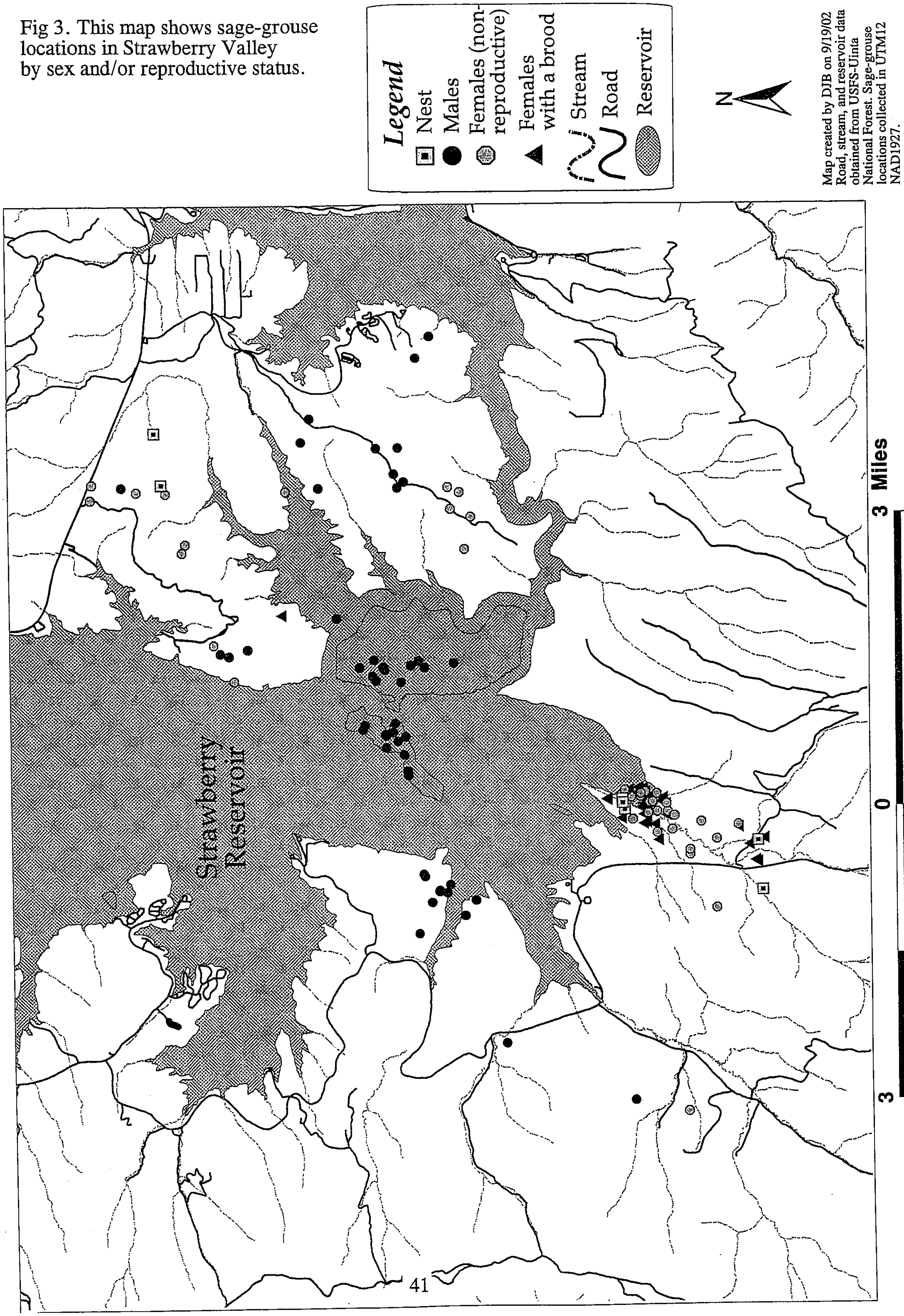

Table 1. Compiled here are the logistic regression results using gender as the response variable. Negative beta estimates indicate that smaller values of the variable are associated with males and higher values associated with females, and positive beta estimates indicate the inverse.

Variable	Beta Estimate	SD	*P*-value
Vertical Obscurity	-3.58	1.09	0.001
Slope	0.36	0.11	0.001
Height (macro)[1]	0.12	0.03	<0.001
Canopy Cover[1]	-9.41	3.07	0.002
Understory Grass (micro)[2]	-6.25	2.39	0.010
Understory Forbs (micro)[2]	-7.71	2.77	0.005

[1] Average of all shrub species.
[2] Ocular estimate of percent cover using a ¼ m^2 quadrat at the use site.

Table 2. These data are a univariate statistical summary of habitat components measured for males and non-reproductive females. Abbreviations are: Dist=Distance, s1=Shrub 1, avg =Average, Hght=Shrub height, S=Mountain big sagebrush, CA=Shrub crown area, Tot=Total, CC=Canopy cover, HOC=Horizontal obscurity cover, VOC=Vertical obscurity cover.

	Male			Female			
Variable	N	$\bar{x}$	SE	N	$\bar{x}$	SE	*P*
Slope	61	9.6°	1	51[a]	3.4°	0.5	<0.001
Edge	61	59cm	7.5	54	55cm	6.3	0.708
Dist-s1	61	39cm	3.4	54	33cm	2.0	0.188
Tot-Hght-s1	61	54cm	3.6	54	45cm	2.6	0.036
Tot-Hght-avg	61	52cm	2.7	54	42cm	1.7	0.002
S-Hght-s1	43[b]	57cm	3.1	35[b]	49cm	3.4	0.111
S-Hght-avg	53[b]	55cm	2.4	46[b]	47cm	2.2	0.027
Tot-CA-s1	61	$0.400m^2$	0.074	54	$0.281m^2$	0.036	0.150
Tot-CA-avg	61	$0.349m^2$	0.036	54	$0.234m^2$	0.021	0.007
S-CA-s1	43[b]	$0.325m^2$	0.041	45[b]	$0.289m^2$	0.040	0.063
S-CA-avg	53[b]	$0.398m^2$	0.046	46[b]	$0.314m^2$	0.039	0.164
Tot-% CC	61	26%	1.8%	54	32%	2.6%	0.078
S-% CC	61	18%	1.4%	54	22%	2.0%	0.105
HOC-2.5	61	80%	2.4%	54	83%	1.9%	0.248
HOC-5	61	91%	1.7%	54	94%	1.1%	0.134
HOC-10	61	94%	1.4%	54	96%	1.2%	0.269
VOC	61	50%	4.5%	52[a]	73%	4.6%	<0.001

[a] Difference in sample size due to missing data.
[b] Difference in sample size due to measurements analyzed for sagebrush only.

Table 3. This table compares percent forb cover and average forb diversity occurring in ¼ m^2 understory plots for micro and macro-habitat levels at male and non-reproductive female use sites.

	Micro					Macro				
	Male		Female			Male		Female		
Cover (%)	$\bar{x}$	SE	$\bar{x}$	SE	*P*	$\bar{x}$	SE	$\bar{x}$	SE	*P*
grasses	21%	2.6	20%	1.9	0.839	22%	1.8	22%	1.8	0.885
forbs	13%	1.5	22%	2.6	0.004	14%	1.0	20%	1.3	<0.001
shrubs	29%	3.3	29%	3.9	0.899	32%	2.1	29%	2.6	0.232
Diversity										
grasses	1.4	0.09	1.4	0.09	0.901	1.5	0.07	1.5	0.08	0.765
forbs	2.6	0.23	2.5	0.19	0.710	2.6	0.17	2.5	0.11	0.539
shrubs	1.5	0.11	1.2	0.11	0.065	1.5	0.07	1.2	0.08	0.007
N	61		54			61		54		

Table 4. Compiled here are mean percent cover, frequency, and Kulcynski's similarity index (SI)[1] of the nineteen most common forb species occurring in ¼ m^2 understory plots at male and non-reproductive female use sites.

	Females		Males		
	N = 54	N = 270[2]	N = 61	N = 305[2]	
Genus / species	Cover %	Frequency %	Cover %	Frequency %	SI %
Sulfur buckwheat (*Eriogonum umbelllatum*)	4.1	32.1	2.6	40.3	76.8
Silvery lupine (*Lupinus argenteus*)	2.2	21.3	2.5	28.9	93.7
Sedge spp.[3] (*Carex spp.*)	2.0*	12.8	0.6	16.1	44.8
Common dandelion (*Taraxacum officinale*)	1.4	15.4	0.7	7.2	65.0
Milfoil yarrow (*Achillea millefolium*)	0.9*	16.4	0.5	7.2	70.3
Yellow owl-clover (*Orthocarpus luteus*)	0.9*	11.8	0.5	8.9	65.4
Douglas knotweed (*Polygonum douglasii*)	0.8*	10.8	0.1	3.6	21.5
Slender cinquefoil (*Potentilla gracilis*)	0.7*	7.2	0.1	2.3	22.4
Pacific aster (*Aster chilensis*)	0.7	6.2	0.3	3.6	63.5
Penstemon spp. (*Penstemon spp.*)	0.6	7.9	0.6	11.8	98.3
Mountain strawberry (*Fragaria virginiana*)	0.5*	6.2	0.0	0.3	1.3
Thistle spp. (*Cirsium spp.*)	0.4	5.6	0.2	4.6	55.8
Geranium spp. (*Geranium spp.*)	0.4	3.0	0.2	4.9	75.1
Milkvetch spp. (*Astragalus spp.*)	0.3	3.6	0.6	10.2	64.3
Pussytoes spp. (*Antenaria spp.*)	0.3	3.0	0.5	6.6	63.9
Blue-eyed Mary (*Collinsia parviflora*)	0.2	4.6	0.4	10.8	65.9
Head sandwort (*Arenaria congesta*)	0.1	1.3	0.4	3.9	42.8
Utah bladderpod (*Lesquerella utahensis*)	0.01*	0.3	0.1	4.6	15.4
Yellow salsify (*Tragopogon dubius*)	0.0	0.3	0.1	4.6	6.1

[1] Kulcynski's similarity index compared overlap of percent cover.
[2] Sample size represents each of the five ¼ m^2 quadrats at each use site.
[3] Not a forb, but included in this table because of its high percent cover and frequency.
* Significant at the 0.05 level (log*e* data transformation) between male and non-reproductive female use sites.