REVISED PROGRESS REPORT: STRAWBERRY VALLEY SAGE GROUSE RECOVERY PROJECT
1999-2000

Presented to:
The Utah Reclamation Mitigation and Conservation Commission
Utah Division of Wildlife Resources
Uinta National Forest

by:
Kevin D. Bunnell - Graduate Research Assistant
Dustin J. Bambrough - Graduate Research Assistant
Jerran T. Flinders - Principal Investigator

BRIGHAM YOUNG UNIVERSITY

TABLE OF CONTENTS

EXECUTIVE SUMMARY

After two years of a five year project to recover the sage grouse population in Strawberry Valley, Utah, a significant effort has been made to identify factors limiting this population. All spring/summer habitat variables measured within currently occupied habitat regardless of habitat type (nest, brood, adult or random) meet the current recommended guidelines. Limiting habitat factors were identified in potential, but currently unoccupied habitat including: 1) lack of forb diversity, 2) lack of forb cover and 3) sagebrush canopy area.

Winter habitat variables measured meet the current recommended guidelines for sagebrush canopy cover and sagebrush height. The Strawberry population is both migratory and non-migratory with wintering areas located in Strawberry Valley and two areas about 18.5 and 32.2 air kilometers east of Strawberry Valley. Sage grouse occupied steeper and south facing slopes in Strawberry Valley and gentler east to southeast facing slopes in the two migratory areas.

Predation by red fox has been identified as a major factor limiting the recovery and expansion of this population. Sage grouse mortality rates in Strawberry Valley are higher then any reported. Spring red fox densities within occupied sage grouse habitat were measures at 0.77 and 1 dens/km^2 respectively for 1999 and 2000. Red fox are a non-native predator to the area that seems to be associated with the abundant food supply provided by Strawberry Reservoir and is the most immediate threat to the extirpation of the sage grouse population

A COMPREHENSIVE EVALUATION OF OCCUPIED AND UNOCCUPIED SAGE GROUSE HABITAT IN STRAWBERRY VALLEY, UTAH

(Manuscript prepared for publication in the Journal of Wildlife Management)

ABSTRACT

This study evaluated multiple aspects of spring/summer sage grouse habitat in Strawberry Valley, Utah by measuring nest, brood and adult habitat sites. In addition, three types of random habitat were measured including random habitat within core use areas, random sagebrush/grass habitat outside core use areas, and random sagebrush/grass habitat sites that had been converted to an understory of smooth brome by past range management practices. Logistic regression was used to identify those habitat variables that discriminated between site types. Variables that significantly discriminated occupied habitat from random habitat outside of core use areas included: 1) percent grass cover (p=0.009) and 2) area of sagebrush canopy (p=0.032). Variables that significantly discriminated occupied habitat from random habitat with a smooth brome understory included: 1) percent forb cover (p=0.002), 2) shrub canopy cover (p=0.017) and 3) area of sagebrush canopy (p=0.077). Variables that discriminated adult habitat from brood rearing habitat included: 1) sagebrush height (p=0.001) and 2) forb diversity (p=0.126).

INTRODUCTION

Sage grouse habitat requirements have been studied by many different researchers and revised management guidelines are currently being published (Connelly et al. in review). From this collection of research, much has been learned about the vegetative habitat requirements for sage grouse at various life stages. Great attention has been given to sage grouse nesting habitat (Klebenow 1969, Peterson 1980, Wakkinen 1990, Gregg 1991, Connelly et al. 1991, Wakkinen et al. 1992, Fischer et al. 1993, Webb 1993, Gregg et al. 1994, Nelle 1998, Sveum et al. 1998) and brood rearing habitat (Gray et al. 1967, Wallestad 1971, Klott and Lindzey 1990, Drut et al. 1994, Fischer et al. 1996, Nelle 1998, Sveum et al 1998). Less attention has been given to adult spring/summer habitat requirements (Martin 1970, Wallestad and Schladweiller 1974, Braun et al 1977, Schoenberg 1982, Hulet 1983, Martin 1990, Apa 1998). Few if any articles in professional journals have simultaneously evaluated vegetative spring/summer habitat requirements for an entire population. In addition, some important sagebrush characteristics have been neglected in relation to sage grouse habitat. For example, sagebrush stands have not been aged and only one study (Connelly et al. 1991) has measured the area within the canopy of sagebrush plants. Also, only one study (Dunn and Braun, 1986) has used multivariate statistical techniques to simultaneously analyze data. Although its true that univariate statistics will detect differences that exist between site types (use sites and random sites for example) multivariate methods are needed to identify the variables that discriminate between site types and the importance of attributes at sites. Not all variables that are significantly different between site types will necessarily contribute to the ability to distinguish one site from another. Multivariate statistics that analyze all variables simultaneously and account for correlation between variables are needed to identify these discriminating variables.

In our study of sage grouse habitat in Strawberry Valley, Utah, we simultaneously (or continuously) measured nesting, brood rearing and adult spring/summer habitats. We also measured the following three types of random sagebrush habitat: 1) random habitat sites within core use areas of sage grouse, 2) random habitat sites outside of core use areas, and 3) random habitat sites outside of core use areas that had been converted to an understory of smooth brome by past range management practices. Smooth brome areas were separated from non-use random sites because the understory composition in these areas was obviously different. Univariate statistical methods were first used to identify differences that existed between the three types of use sites and between use sites and random sites. Multivariate statistical techniques were then used to identify those variables that most significantly contributed to distinguishing between site types by accounting for correlation between variables.

Our objectives in this study were: 1) evaluate sage grouse habitat compared to the recommended guidelines and better understand how habitat was being partitioned among sage grouse at various life stages, 2) identify those variables that most contributed to this partitioning, 3) evaluate the quality of the habitat immediately surrounding the occupied habitat sites to identify limiting factors, and 4) evaluate the unoccupied habitat and identify limiting factors that might be precluding sage grouse from using these areas. We were particularly interested in evaluating the vegetative composition on sites where past range management practices replaced native forbs and bunch grasses with an aggressive sod-forming grass such as smooth brome (*Bromus inermis*) even though mountain big sagebrush (*Artemisia tridentata vaseyna*) had regrown on these sites. This particular research question may be relevant to many places other than Strawberry Valley, Utah. We believe this comprehensive approach is especially useful in identifying critical habitat characteristics as well as those vegetative factors that may limit a sage grouse population.

We thank the Utah Reclamation Mitigation and Conservation Commission, the Utah Division of Wildlife Resources, the Uintah National Forest and Brigham Young University for their financial support of this study. We also thank Dave Stricklan, Lara Peterson, Leslie Tullis Jackee Webber-Alston and Phalan Whitehair for their help in collecting data and Dr. Lara Woolfson for her statistical consultation.

STUDY AREA

This study was centered in the Strawberry Valley of north-central Utah during 1998-1999. The area is a high mountain valley (2,250 - 2,450 m) and receives approximately 58 cm of annual precipitation. Strawberry Reservoir is the dominant feature of the valley covering up to 6,950 surface hectares. Within the valley there are approx. 8,950 hectares of sagebrush/grass habitat which primarily border the reservoir (URMCC and USFS, 1997). Mountain big sagebrush dominates the area with silver sage (*Artemisia cana*) occurring within wet meadows and riparian corridors.

MATERIALS AND METHODS

Sage grouse trapping was conducted during March, April, and May 1998 and 1999 using the spotlighting method (Giesen et al. 1982). Necklace style radio telemetry tranmitters were attached to trapped sage grouse (cocks and hens).

Seasonal habitat use was identified by locating birds with transmitters attached. Once locations were identified they were classified as nest, brood, or adult habitat sites. The following habitat measurements were taken at each site: slope, aspect, G.P.S. location, percent shrub canopy cover, percent herbaceous cover, sagebrush and total shrub density, horizontal obscurity cover, and vertical cover. Percent canopy cover of shrub species was measured using the line intercept method (Bonham 1989). Shrub density was measured using the T^2 analysis for the two nearest shrubs (Ludwig and Reynolds 1988). Each of the four shrubs in the T^2 analysis was measured for height, percent decadence (defoliated or dying branches), and area within the canopy (calculated as the area of an ellipse). Percent composition of shrubs was calculated from the species occurring in the T^2 analysis. Herbaceous understory was quantified by estimating the percent cover of each species that occurred within a 1\4 m^2 plot at the nest, brood or adult site (micro-habitat) and 25 m from the site in four directions (macro-habitat). Horizontal obscurity cover was measured using a 1 m^2 cover board stratified into thirds (0-33.3 cm, 33.3 cm - 66.6 cm and 66.6 cm - 100 cm) along the vertical axis with each stratification separated into 12 equal squares. Horizontal obscurity cover measurements were taken at 2.5, 5 and 10 meters in four directions. Vertical cover was measured using an 18 cm x 18 cm cover board, separated into 36 equal squares. This board was placed directly over the nest, brood, or adult site and the number of obscured squares was recorded.

Three types of random habitat were also measured in the same manner. Random locations within core use areas (random) were located by taking a random compass bearing from a use site and going 100 m in that direction. Another random bearing and a random distance were then used to arrive at the random habitat location. Random sites within areas that had been converted to a smooth brome understory (brome) and general random points outside the core use areas (non-use random) were also located by taking random compass bearings and random distances from a random point on a road in a particular area.

During 1999 sagebrush ages were estimated at adult, random, brome, and non-use random sites by cutting the sagebrush plant nearest to the data point (sagebrush was also aged for nest and brood sites, but sample sizes were inadequate). Sagebrush cuttings were then sanded and the growth rings counted from the center to the cork cambium with the aid of a microscope. For agreement, a minimum of two counts were made of each cutting.

Statistical analyses to compare variables between site types were performed with a one-way ANOVA on each variable. In each analysis Tukey's pairwise comparisons were used to avoid inflating the experiment error rate. Non-parametric statistical procedures were used to analyze differences between individual species in the understory between site types because the data did not meet the assumptions for ANOVA (data were not normally distributed and standard deviations were not equal) . A Kruskal-Wallis analysis was used in place of the ANOVA test and a Mann-Whitney test was used to make pairwise comparisons. Binary logistic regression was used to identify variables that significantly discriminated between site types. Percent composition of shrubs was statistically analyzed for differences between site types with a chi-square test. Statistics were considered significant at alpha = 0.05.

RESULTS

Sagebrush age at adult sites and random sites was significantly greater than at non-use random sites (p = 0.04 and 0.008) respectively. Sagebrush age for brome sites was not significantly different from any other sites (Table 1).

Sagebrush canopy area was significantly greater at nest and adult sites than at all other sites (experiment error rate = 0.05 , comparison error rate = 0.00454). Also, the canopy area of all shrubs species was significantly higher for adult and nest sites when compared to all other sites (experiment error rate = 0.05 , comparison error rate = 0.00448) (Table 1).

Sagebrush plants were significantly taller at adult, nest and brome sites than at all other sites (experiment error rate = 0.05 , comparison error rate = 0.00454). Also, all shrub species were significantly taller at adult, nest and brome sites than at all other sites (experiment error rate = 0.05 , comparison error rate = 0.00448) (Table 1).

Percent decadence of sagebrush was significantly higher at adult, brome and non-use random sites than at brood and random sites (experiment error rate = 0.05 , comparison error rate = 0.00454). Also, percent decadence for all shrub species was significantly higher at adult sites than at random sites (experiment error rate = 0.05 , comparison error rate = 0.00448) (Table 1).

Percent composition of shrubs appearing in the T^2 analysis at adult sites was significantly different than at nest sites (p = 0.01), brood sites (p= 0.021) and non-use random sites (p = 0.030). Percent composition of shrubs at nest sites was significantly different than brood sites (p

= 0.001), random sites ($p < 0.001$), brome sites ($p = 0.005$) and non-use random sites ($p < 0.001$). Percent shrub composition at brood sites was significantly different from random sites ($p = 0.001$). In addition, the percent shrub composition at random sites was significantly different than at brome sites ($p = 0.015$).

Sagebrush canopy area of the closest shrub at adult sites was significantly greater than the second shrub in the T^2 analysis ($p = 0.046$). No other differences were found in the four shrubs measured at each adult site. No differences were found among the four shrubs measured at other use sites.

No statistical differences were found for sagebrush canopy cover between any site types (Table 2). Total shrub canopy cover at brome sites was significantly less (Tukey's $p = .004$) from the total shrub canopy at all other sites except nest sites which had a high standard deviation (19.21%) resulting from a small sample size ($n = 10$).

Total percent cover for grass in understory plots was significantly higher at brome sites than at all other site types (Tukey's $p = .004$). Brome sites were the only areas with timothy grass (*Phleum spp.*) in the understory. Percent cover of smooth brome was significantly higher at brome sites than at brood sites ($p < 0.0001$), adult sites ($p < 0.0001$) and random sites ($p < 0.0001$). Smooth brome was not found in the understory at nest sites or non-use random sites (Table 3).

Total percent cover of the 14 most common forb species in understory plots was significantly lower at brome sites than at all other sites except nest sites (Tukey's $p = 0.004$) and was significantly lower at non-use random sites than at brood sites and use random sites (Tukey's $p = 0.004$) (Table 4). Total forb cover was not significantly different between any other sites.

Many significant differences were found between site types in the percent cover of the 14 most common forb species (Table 4). Forb species diversity was significantly lower at brome sites (= 1.9) than at brood sites (= 3.0) (p < 0.0001) and adult sites (= 2.7) (p < 0.0001). Species diversity was also significantly lower at non-use random sites (= 2.0) than at brood (p < 0.0001) and adult sites (p = 0.0001). Forb diversity at nest sites (= 2.2) and random sites (= 2.4) was significantly lower than at brood sites (p = 0.0022 , and p= 0.0006) respectively, but did not differ significantly from adult sites.

Horizontal obscurity cover was significantly higher at brome sites than at all other sites except nest sites when measured at 2.5 m away from ground level to a height of 33.3 cm. There were no other differences in horizontal obscurity cover.

Vertical cover was significantly higher at nest sites (= 0.977) than at brood sites (= 0.622) (p = 0.0003) and adult sites (= 0.634) (p < 0.0001). There were no differences in slope between any site types, although within adult sites, males tended to select steeper slopes (= 11.31%) then females (= 4.37%).

Percent cover of forbs was significantly higher (p = 0.017) at brood micro-habitat sites than at brood macro-habitat sites (Fig 2). Species diversity was also higher (p = 0.076) at brood micro-habitat than brood macro-habitat (Fig. 3). No difference was found in percent cover of forbs or forb diversity in micro and macro habitat at adult sites (Figs. 2 & 3) There was no significant differences in percent cover of grasses in micro-habitat or macro-habitat for either brood or adult sites. Micro-habitat and macro-habitat was not analyzed for nest sites because of an insufficient sample size.

Total forb percent cover was the only variable with significant predictive value (p =

0.021) in distinguishing micro habitat from macro habitat at brood sites when a binary logistic regression was used with the 14 most common forb species and total forb cover as independent variables (concordance = 61.9%).

Binary logistic regression was used to identify the variables that significantly contributed to distinguishing adult sites from all random site types (use-random, brome, and non-use random). Adult sites were used in the analysis because they were the most general of the use habitat sites. No variables were significant in distinguishing adult sites from random sites within the core use areas. Percent grass cover ($p = 0.009$) and sagebrush canopy area ($p = 0.032$) were significant variables in distinguishing adult sites from random sites outside core use areas (concordance =70.3%). Percent forb cover ($p=0.002$), shrub canopy cover ($p = 0.017$), and area of sagebrush canopy ($p = 0.077$), were the most significant variables in distinguishing adult sites from brome sites (concordance = 79.9%). Binary logistic regression was also used to identify the variables that discriminate brood habitat from adult habitat and random habitat within core use areas. Sagebrush height ($p = .001$) and forb diversity ($p = 0.126$) were the only significant variables in discriminating brood and adult habitats (concordance = 76.1%). Forb diversity ($p = 0.008$) and forb cover ($p = 0.007$) were the only variables that contributed to discriminating brood sites from random sites (concordance = 68.4%).

DISCUSSION

One of the unique contributions of this study to the knowledge of sage grouse habitat is that many habitat types were measured simultaneously for a single population. Only one other study (Dunn and Braun, 1986) reported similar data, but with fewer site types. Our use of logistic regression to identify the vegetative habitat variables that discriminate between site types, to our knowledge, is also a unique approach although, Dunn and Braun (1986) used discriminate analysis in a similar manner.

All occupied habitat measured in this study meets the standards of the new sage grouse guidelines (Connelly et al. in review). The lack of a significant discriminator between adult sites and random sites indicates that the occupied habitat is in good condition and sage grouse are not having to search for suitable habitat within these areas. Our use of logistic regression in comparing adult habitat to non-use random sites and brome sites identified variables that discriminate the site types. In the case of non-use random sites, sagebrush height and forb diversity were the only discriminating variables identified. Sagebrush in these areas is younger (16.6 yrs.) than the sagebrush found at the adult sites (20.5 yrs.) (Table 1). This explains the difference in sagebrush height. This being the case, we expect the understory composition to change as sagebrush stands mature, which may explain the difference in forb diversity. Our recommendation in this particular case is to simply continue to monitor vegetative stands and not apply any treatments. In the case of brome sites, logistic regression identified shrub canopy cover, sagebrush canopy area and percent forb cover as discriminating variables. We believe each of these variables is a result of the competitiveness and abundance of smooth brome in the understory. Reductions in shrub canopy cover, forb cover, and forb diversity are explained by the presence of an aggressive sod forming grass such as smooth brome. The reduced canopy area of sagebrush is possibly the result of the sage being forced to grow tall rather than spreading in order to compete for light with the tall, fast growing smooth brome. In this case, the treatment prescription is to: 1) greatly reduce smooth brome in the understory, 2) maintain the sagebrush cover (possibly with a monocot-specific herbicide) and 3) reseed with a mix of forbs, native bunch grasses, and shrubs.

The discovery that sagebrush age differed significantly between use areas and non-use areas is important in understanding sage grouse habitat. Knowing that sagebrush plants are significantly older in areas occupied by sage grouse than in unoccupied areas (Table 1), we can begin to understand the disturbance regime that will most benefit sage grouse in the mountain big sagebrush habitat type. Natural disturbance cycles have been disrupted or eliminated in many sagebrush habitats by increased fire intervals, due to the introduction of cheatgrass (*Bromus tectorum),* or by decreased fire intervals, due to overgrazing or fire suppression. Knowledge of the age dynamics of sites that are occupied and unoccupied by sage grouse can help managers in their efforts to restore or mimic natural disturbance regimes to benefit sage grouse. Also, the discovery that the age of sagebrush at brome sites does not differ significantly from the age of sagebrush at use sites, and yet brome sites remain unoccupied, indicates that past range management practices, intended to decrease sagebrush and increase livestock forage in the Strawberry Valley, had negative effects on sage grouse habitat. More importantly, it indicates that the negative effects continue even though the sagebrush has had adequate time to re-establish from the past treatment. We believe this may also be true in many areas throughout the Western U.S. where similar practices occurred.

Sagebrush canopy cover is an essential part of sage grouse habitat. This cover in all occupied and unoccupied sites measured in the Strawberry Valley meet the guidelines suggested for productive breeding and brood rearing sage grouse habitat (Connelly et al. In review). Although sagebrush canopy cover in brome sites is within the guidelines, our data suggests that smooth brome may be competitively excluding the establishment of other shrub species and reducing the overall shrub cover to a level that may be insufficient for sage grouse. Sveum et al (1998) identified total shrub cover in addition to sagebrush canopy cover as an important characteristic of nesting habitat in central Washington. We suggest it may be important in all types of sage grouse habitat.

It appears that the most limiting impact of smooth brome treatments to sage grouse habitat is the reduced cover and diversity of the forb component. Many studies have documented the importance of forbs in sage grouse habitat (Dunn and Braun 1986, Klott and Lindzey, 1990, Drut et al. 1994, Apa 1998). Our data show that the competitive ability of smooth brome seriously degrades the value of treated areas for sage grouse by reducing forb cover and diversity. We believe that because the grass component was significantly higher and the forb component was significantly lower and less diverse at brome sites than at use sites these areas are not providing adequate sage grouse habitat in the Strawberry Valley. In addition we believe that even though tall sod forming grasses such as smooth brome increase horizontal obscurity cover, they may be so thick and tall as to impede ground travel by sage grouse, especially young chicks. This overrides their value as cover and further limits the potential of treated areas as sage grouse habitat. The importance of forbs in sage grouse habitat is further demonstrated by the data we collected in non-use habitat sites. Data collected at these sites show a higher and more diverse forb component than found at brome sites. However, the forb component is still significantly lower and less diverse than at brood sites and random sites in use areas.

Much as other studies have found (Oakleaf 1971 and Peterson 1970, Autenrieth 1981, Dunn and Braun 1986, Klott and Lindzey 1990, Drut et al. 1994, Apa 1998, Sveum et al. 1998) sage grouse broods in Strawberry Valley seem to prefer areas with high forb cover and diversity

We refined the forb information by documenting a higher and more diverse forb component not only when brood sites were compared to other use and random sites, but also when brood micro-habitat (exact location) was compared to brood macro-habitat (25 m from location). These findings are significant because the macro-habitat was well within the recommended guideline for percent cover of forbs in brood habitat (Connelly et al. in review) and yet sage grouse still selected areas with significantly greater forb cover (Fig. 2) and greater diversity (Fig. 3). This suggests that the guidelines may be accepting lower forb cover than is optimum for sage grouse brood rearing habitat in Strawberry Valley. In addition, the fact that logistic regression did not identify any forb species as being a significant predictor of brood micro-habitat when compared to brood macro-habitat and yet total forb cover was significant suggests that broods do not key on particular forb species when a robust suite of species are available. Rather, they selected habitat based on the overall abundance of forbs. We did not find any differences in forb cover (Fig. 2) or diversity (Fig. 3) between adult micro and macro habitat. This suggests that forb cover may not be as important as other variables in adult habitats.

Measurements of sagebrush and shrub canopy area showed that sage grouse selected shrubs having a greater canopy area for nest and adult habitat than was found at all other site types. Our measurements of shrub size at nest sites were similar to those of Connelly et al. 1991 (1.53 m^2 compared to 1.19 m^2). It is not surprising that canopy area at brood sites was lower than at nest and adult flush sites. It has been well documented that sage grouse seek areas with lower sagebrush canopy cover and greater access to succulent forbs for brood habitat (Klebenow 1969, Klott and Lindzey 1990, Drut et al 1994).

The difference in canopy area for non-use random sites is explained by the fact that these areas contained sagebrush that were significantly younger than those found at nest and adult flush sites. The significant difference in these findings is that the canopy area for sagebrush and other shrubs in brome sites was significantly lower then at nest and adult flush sites. These findings may partially explain why the treated areas have remained unoccupied by sage grouse (differences in understory composition may also contribute). It is possible that sagebrush and other shrubs growing in areas with tall aggressive grasses such as smooth brome are forced to grow tall rather than spread in order to compete for available sunlight. This competition changes the natural growth form of these shrubs and further degrades the areas potential as sage grouse habitat. This interpretation is supported by the fact that the age of the sagebrush and the height of sagebrush and other shrubs growing in brome sites did not differ from the age and height of the sagebrush at nest or adult sites.

Sagebrush and shrub height was significantly taller at adult, nest and brome sites than at other sites. These findings support other research that found sage grouse nest beneath taller sagebrush then are randomly available (Klebenow 1969 and Sveum et al. 1998). The fact that neither height nor canopy area differ between nest sites and adult flush sites suggests that hens are not choosing bigger/taller shrubs specifically for nesting activities, but are merely selecting shrubs that they would find suitable as adult birds under any circumstances. A larger sample of nest sites is needed to confirm these findings.

The finding that percent decadence of sagebrush was significantly higher at adult sites then at other sites is probably due to the older ages of the shrubs. The fact that sagebrush was significantly more decadent at adult sites then at nest sites, even though the ages of the shrubs did not differ, might be explained by the time of year that decadence estimates were made.

Sagebrush decadence at nest sites sagebrush was estimated during the spring, when the plants were presumably unstressed. Sagebrush decadence at adult flush sites was estimated throughout the spring and summer which increases the chances that the plants were stressed. The finding that sagebrush was more decadent at non-use random sites than at other sites may show that these sites are simply less productive due to soils or other edaphic factors. Further data are needed to explain this.

In our comparison of brood habitat with adult habitat, logistic regression allowed us to better understand how the available habitat was partitioned between adults and broods. Conventional wisdom would say these habitats are partitioned by sagebrush canopy cover and forb cover (Connelly et al. in review). In our analysis neither sagebrush canopy cover or forb cover were identified as discriminating variables, rather it was sagebrush height and forb diversity that most significantly discriminated between brood and adult habitat Although we found significant differences between several variables using univariate statistical methods, when all of the variables were analyzed simultaneously, only sagebrush height and forb diversity were identified as significantly contributing to the ability to discriminate between the two site types. Logistic regression was also best for our comparisons between adult sites with non-use and brome random sites. Logistic regression identified only a few variables as being significant while the univariate techniques identified several variables as being significantly different. The ability of multivariate statistics (such as logistic regression) to identify fewer discriminating variables then are significant using univariate statistics, stems from simultaneously evaluating the variables for correlation and eliminating all the but the most discriminating variables. This reduction in the number of variables identified, as a result accounting for correlation, allows managers to focus their efforts on a few identified limiting factors. If these factors are addressed correctly the correlated factors will also be corrected. Another advantage of logistic regression over univariate statistical methods is that the resulting function allows managers to calculate the probability that an area of habitat is suitable by measuring only the identified discriminating variables. For example the function describing differences between adult and brome habitat types in Strawberry Valley is: logit(Y) = -2.510 + 10.650(forb cover) + 4.754(shrub canopy cover) + 0.559(sagebrush canopy area), where logit (Y) = the probability of being classified as occupied (or suitable) habitat. Using this function a manager can calculate the probability that any sagebrush habitat in Strawberry Valley that has an understory of smooth brome will provide suitable adult sage grouse habitat by measuring the three variables in the function. A manager could also evaluate the effectiveness of a prescribed treatment designed to address limiting factors in brome habitat by measuring the same variables pre and post treatment.

CONCLUSIONS

Sage grouse are important components of big sagebrush communities. The more we understand about this dynamic biotic relationship the better are our chances to preserve and enhance sage grouse populations. Further work is needed on the age dynamics of big sagebrush stands in known sage grouse habitat. We also need to know the age dynamics of occupied and unoccupied sage grouse habitat in association with other species and subspecies of sagebrush (e.g. basin big sagebrush, Wyoming big sagebrush, three tip sagebrush and black sagebrush). Data are needed showing age differences in sagebrush stands used for different purposes (ie. nesting, brood rearing, etc.) in all sagebrush types. In addition more information is needed regarding adult sage grouse habitat, and we need to expand our knowledge of nest and brood habitat needs

Our data show the benefits of a comprehensive approach that simultaneously measures the habitat use of an entire population rather then focusing on a specific type of habitat (ie nest habitat or brood habitat). This type of approach will lead to a better understanding of habitat partitioning within populations and thus a better understanding of habitat requirements. We recommend that multivariate statistical methods be used to simultaneously evaluate differences between habitat types, so the variables that most significantly contribute to the discrimination between habitat types and elements can be identified. In addition, we suggest that in areas were sage grouse populations occupy only a portion of the available sagebrush habitat, occupied and unoccupied habitat be measured and analyzed simultaneously. This will allow treatment alternatives to be identified that will address the variables that separate occupied and unoccupied habitat and increase the habitat suitable to the local population.

LITERATURE CITED

Apa, A.D. 1998. Habitat use and movements of sympatric sage and Columbian sharp-tailed grouse in southeastern Idaho. Dissertation, University of Idaho, Moscow.

Bonham, C. D. 1989. Measurements for terrestrial vegetation. John Wiley and Sons Inc. 338pp

Braun, C.E., T. Britt and R.O. Wallstead. 1977. Guidelines for maintenance of sage grouse habitats. Wildl. Soc. Bul. 5:99-106.

Connelly, J.W., W.L. Wakkinen, A.D. Apa, K.P. Reese. 1991. Sage grouse use of nest sites in southeastern Idaho. J. Wildl. Manage. 55:521-524.

Drut, M.S., J.A. Crawford, M.A. Gregg. 1994. Brood habitat use by sage grouse in Oregon. Great Basin Nat. 54: 170-176.

Dunn, P.O., C.E. Braun. 1986. Summer habitat use by adult female and juvenile sage grouse. J. of Wildl. Manage. 50:228-235.

Fischer, R.A. K.P. Reese, and J.W. Connelly. 1996. An investigation on fire effects within xeric sage grouse brood habitat. J. Range Manage 49:194-198.

Fischer, R.A., A.D. Apa, W.L. Wakkinen, K.P. Reese, and J.W. Connelly. 1993. Nesting-area fidelity of sage grouse in southeastern Idaho. Condor 95:1038:-1041.

Gray, G.M. 1967. An ecological study of sage grouse broods with reference to nesting, movements, food habits and sagebrush strip spraying in the Medicine Lodge drainage, Clark County, Idaho. Thesis, University of Idaho, Moscow

Giesen, K.M., T.J. Schoenberg and C.E. Braun. 1982. Methods for trapping sage grouse in Colorado. Wildl. Soc. Bull. 10:224-231

Gregg, M.A., J.A. Crawford, M.S. Drut. and A.K. Delong. 1994. Vegetational cover and predation of sage grouse nests in Oregon. J. Wildl. Manage. 58:162-166

Gregg, M.A. 1991. Use and selection of nesting habitat by sage grouse in Oregon. Unpublished master's thesis, Oregon State University, Corvallis. 46pp.

Hulet, B.V. 1983. Selected response of sage grouse to prescribed fire, predation, and grazing by domestic sheep in southeastern Idaho. Thesis, Brigham Young University, Provo, Utah.

Klebenow, D.A. 1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-662.

Klott, J.H., F.G. Lindzey. 1990. Brood habitats of sympatric sage grouse and columbian sharp-tailed grouse in Wyoming. J. Wildl. Manage. 54:84-88.

Ludwig, J.A. and J.F. Reynolds. 1988. Statistical ecology a primer on methods and computing. John Wiley and Sons Inc. 337 pp

Martin, N.S. 1970. Sagebrush control related to habitat and sage grouse occurrence. J. Widl. Mange. 34:313-320.

Martin, R.C. 1990. Sage grouse responses to wildfire in spring and summer habitats. Thesis, University of Idaho, Moscow

Musil, D., K.P. Reese, and J.W. Connelly. 1994. Nesting and summer habitat use by translocated sage grouse (*Centrocercus urophasianus*) in central Idaho. Great Basin Nat. 54:228-233.

Nelle, P.G. 1998. The long term effects of fire on sage grouse nesting and brood rearing habitats on the Upper Snake River Plain. Thesis, University of Idaho, Moscow.

Peterson, B.E. 1980. Breeding and nesting ecology of female sage grouse in North Park, Colorado. Thesis. Colorado State University, Fort Collins.

Sveum, C.M., W.D. Edge, J.A. Crawford. 1998. Nesting habitat selecton by sage grouse in south-central Washington. J. Range Manage. 51:265-269.

Schoenberg, T.J. 1982. Sage grouse movements and habitat selection in North Park, Colorado. Thesis, Colorado State University, Fort Collins.

URMCC and USFS. 1997. Final draft. Strawberry valley assessment

Wakkinen, W.L., K.P. Reese and J.W. Connelly. 1992. Sage grouse nest locations in relation to leks. J Widl. Manage. 56:381-383.

Wakkinen, W.L. 1990. Net site characteristics and spring-summer movements of migratory sage grouse in southeastern Idaho. Thesis, University of Idaho, Moscow.

Wallestad, R.O. and P. Schadweiller. 1974. Breeding season movements and habitat selection of male sage grouse. J. Widl. Manage. 38:634-637.

Wallestad, R.O. 1971. Summer movement and habitat use by sage grouse broods in Montana. Journal of Wildlife Management 35: 129-136.

Webb, D.R. 1993. Sage Grouse nest site characteristics and microclimates in wyoming: final report to the Wyoming Department of Fish and Game. Laramie WY: Department of Biology, University of Wyoming. 20pp

Table 1. Mountain big Sagebrush and other shrub characteristics measured in association with sage grouse habitat in Strawberry Valley.

Site Type	Sagebrush Age (yrs.)	Sagebrush Canopy Area (m^2)	Shrub Canopy Area (m^2)	Sagebrush Height (cm)	All Shrub Height (cm)	Sagebrush Decadence (%)	All Shrub Decadence (%)
Adult	20.50[a]	1.35[a]	1.20[a]	54.07[a]	51.06[a]	30.05[a]	25.05[a]
Nest	----	1.53[a]	1.36[a]	54.32[a]	50.67[a]	21.53[a b]	20.87[a b]
Brood	----	.83[b]	.82[b]	37.60[b]	37.14[b]	16.11[b]	19.04[a b]
Random	22.80[a]	.88[b]	.69[b]	42.71[b]	37.87[b]	16.83[b]	16.62[b]
Brome	20.23[a b]	.82[b]	.73[b]	49.87[a]	48.68[a]	26.81[a]	23.31[a b]
Non-use Random	16.57[b]	.88[b]	.74[b]	40.28[b]	38.96[b]	26.22[a]	23.14[a b]

Within each column means with different letters are significantly different using Tukey's pairwise comparison (experiment error rate = 0.05)

Table 2. Percent canopy cover of mountain big sagebrush and all shrubs measured in association with sage grouse habitat in Strawberry Valley.

Site Type	Nest n=10	Brood n=28	Adult n=59	Random n=55	Brome n=30	Non-use Random n=30
Sagebrush Canopy Cover	24.8	22.9	24.7	23.2	18.5	20.2
Total Shrub Canopy Cover	36.3	33.4	33.9	35.1	23.3*	28.5

* Statistically different from all other site types except nests sites (alpha = 0.05)

Table 3 : Percent cover of grass species measured at sage grouse habitat sites in Strawberry Valley.

Site Type	Nest n =55	Brood n =150	Adult n =320	Random n =290	Brome n=150	Non-use Random n=150
Smooth Brome	0.0	0.1 Br < .0001	0.2 Br < .0001	0.2 Br < .0001	21.8	0.0
Phleum spp.	0.0	0.0	0.0	0.0	1.7	0.0
Carex spp.	0.9 BR = 0.0073 NR = 0.0015	2.1 A < .0001 R = 0.0099 BR < 0.0001 NR < 0.0001	0.3 R = 0.0067	0.7 BR = 0.0028 NR = 0.0008	0.2	0.01
Stipa spp.	0.3 B = 0.0364 A = 0.046 R = 0.019 NR = 0.0001	1.3 NR = 0.0004	1.1 NR < 0.0001	1.6 NR = 0.0002	0.0	3.7
Poa spp.	16.7	14.6 A = 0.0046	19.2	17.9 TUKEY'S p = 0.0045 FOR ALL SITES	7.7	15.9
Agropyron spp.	3.2 BR < 0.0001	1.7 BR = 0.0001	3.7 R = 0.0457 BR < 0.0001 NR = 0.0298	2.4 BR < 0.0001	0.3 NR < 0.0001	1.8
Total Grass	21.1	19.9	24.6	22.8	31.9 TUKEY'S p = 0.0045 FOR ALL SITES	21.5

Within each column p-values are reported for each site type that was significantly different for the row species. N = Nest, B = Brood, A = Adult, R = Random, BR = Brome, NR = Non-use Random

Table 4. Percent cover of forb species measured at sage grouse habitat sites in Strawberry Valley.

Site Type	Nest n = 55	Brood n = 150	Flush n = 320	Random n = 290	Brome n = 150	Non-Use Random n = 150
Pacific aster (*Aster chilensis*)	0.012 B = 0.004 BR = 0.031	1.27 F = 0.006 R = 0.013 NR = 0.013	.81	1.01	0.89	0.74
Wetern yarrow *(Achillea millefolium)*	0.19 B = .0026	1.08 R = 0.03 BR = 0.008 NR = 0.031	1.23 BR = 0.008	0.91 BR = 0.064	0.19	0.39
Pussytoes *(Antenaria spp.)*	0.07 B = 0.065	01.4 F = 0.049 R = 0.049 BR = 0.001 NR = 0.062	0.42 BR = 0.026	0.96 BR = 0.030	0.05 NR = 0.058	0.24
Looseflower milkvetch *(Astragalus tenellus)*	0	0.24 BR = 0.006	0.19 R = 0.043 BR < 0.001 NR = 0.01	1.0 BR = 0.006	0.82 NR = 0.08	0.29
Spearleaf fleabane *(Erigeron lonchophylus)*	0	0.71 F =0.001 R = 0.050	0.09	0.44	0	0
Sulfur eriogonum *(Eriogonum umbellatum)*	3.33 BR =0.032 NR = 0.052	4.47 BR = 0.067 NR = 0.084	3.54	3.89 BR = 0.029 NR = 0.045	1.45	2.70
Geranium (*Geranium spp.*)	0	0.55	0.37	1.21	0.43	0
Silky lupine (*Lupinus sericeus*)	4.49	2.86 BR = 0.007	2.86 BR = 0.072	5.96 BR = 0.034	3.36 NR = 0.004	2.52
Yellow owlclover *(Orthocarpus luteus*)	0	0.88 F = 0.011 BR < 0.001 NR<.001	0.72 R = 0.002 BR = 0.008 NR = 0.09	1.82 BR < 0.001 NR < 0.001	0.01	0.08
Penstemon *(Penstemon spp.)*	1.0 F = 0.001 R = 0.011 BR = 0.003	0.59 F = 0.032 BR = 0.072	0.29 NR = 0.063	0.49	0.09	0.62
Hoods phlox *(Phlox hoodii)*	1.28 B = 0.005 F < 0.001 R = 0.001 BR = 0.002	0.09	0.04	0.19	0.01	0

Douglas knotweed *(Polygonum douglasii)*	0	0.39 F = 0.017 BR = 0.001 NR < 0.001	0.66 R = 0.004 BR = 0.094 NR = 0.016	0.74 BR < 0.001 NR < 0.001	0.65	0.74
European strawberry *(Fragaria vesca)*	0	0.66 F = 0.005 R = 0.084	0.37	0.59	0	0
Common dandelion *(Taraxacum officinale)*	0.07 B = 0.007 F = 0.014 R = 0.048	0.85 BR < 0.001 NR = 0.010	1.15 BR < 0.001 NR = 0.021	1.42 BR < 0.001	0.07 NR = 0.024	0.23
Total Forb Cover	11.04	16.01	13.05	14.75	8.42 Tukey's (p = .0045) for B , F and R	9.39 Tukey's (p = .0045) for B and R

Within each column p-values are reported for each site type that was significantly different for the row species. N = Nest, B = Brood, A = Adult, R = Random, BR = Brome, NR = Non-use Random

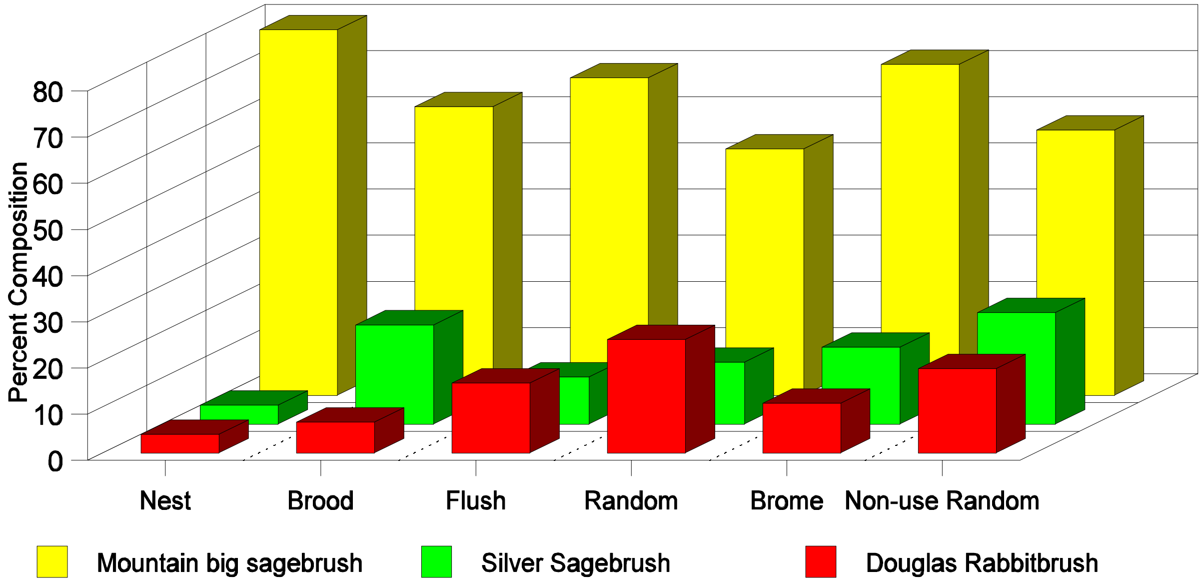

Fig. 1. Percent composition of shrub species measured in association with sage grouse habitat in Strawberry Valley.

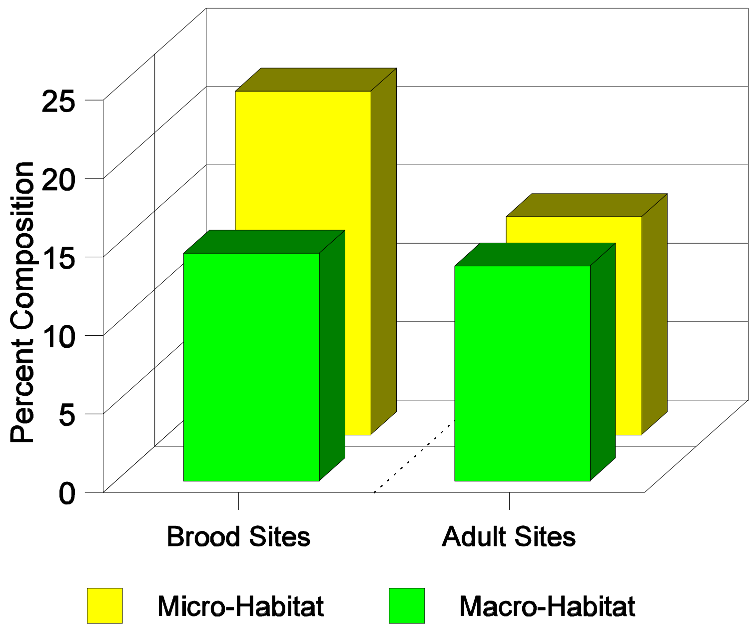

Fig. 2. Percent forb cover in micro and macro sage grouse habitat measured at brood and adult habitat sites in Strawberry Valley

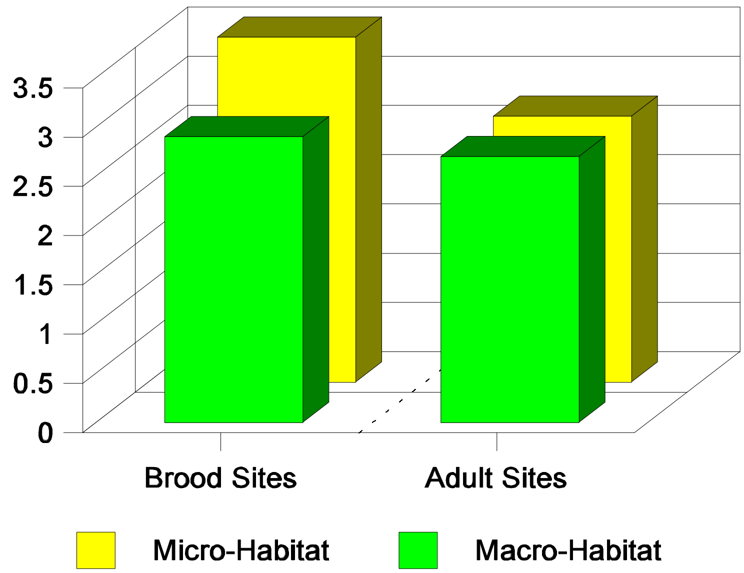

Fig. 3. Forb diversity in micro and macro sage grouse habitat measured at brood and adult habitat sites in Strawberry Valley29

SAGE GROUSE WINTER HABITAT IN STRAWBERRY VALLEY, UTAH

ABSTRACT

Sage grouse (*Centrocercus urophasianus*) winter habitat selection was examined in three areas during 1999 and 2000 for a population that is both migratory and non-migratory in Strawberry Valley, Utah. Sage grouse were captured during March through May of 1998 and 1999 using the spotlight method and fitted with necklace style radio collars. Sage grouse were monitored using telemetry and habitat data was recorded at use and random sites. Canopy cover was greater in use sites than in random sites. Canopy cover was greater in the migratory areas than in Strawberry. Sagebrush heights were taller in use sites than random sites in Strawberry but not in the migratory areas. Aspects were typically south to southeast in all areas. Sage grouse selected steeper slopes in Strawberry Valley than in migratory areas. Fluorescence tests showed Mountain big sagebrush (*Artemisia tridentata vaseyana*) to be dominant in Strawberry Valley and Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) dominant in the migratory areas. Winter habitat in Strawberry Valley and its surrounding migratory areas met the recommendations in the most recent management guidelines.

INTRODUCTION

Winter habitat is important for sage grouse (*Centorcercus urophaisianus*) because they depend almost entirely on sagebrush for forage and cover during the winter months (Griner 1939, Patterson 1952, Eng and Schladweiler 1972, Wallestad et al. 1975). Many studies have documented sage grouse winter habitat requirements. Essential above snow canopy cover has been reported ranging from 12% in Oregon (Hanf et al. 1994) to 43% in Colorado (Schoenburg 1982). Required above snow heights of sagebrush have ranged between 20 cm to 36 cm in Colorado (Beck 1977). Sage grouse in Idaho selected taller Wyoming big sagebrush (*Artemisia tridentata wyomingensis*) stands at winter use sites than at random sites. Topographic distribution of sage grouse 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. in review). Non-migratory populations are often found in low elevation habitats (Wallestad 1975) and migratory populations are often found at higher elevations (Dalke et al. 1960, Connelly 1982). The winter movements of sage grouse are not always based on the proximity of suitable winter habitat, but sometimes on tradition within a population (Connelly et al. 1988). This finding supports Welch's (1991) report that the annual movements of sage grouse in Strawberry Valley to wintering areas did not correlate with snow depth. This study is unique in that it deals with a sage grouse population that is both migratory and non-migratory.

Sage grouse have been shown to prefer both Wyoming big sagebrush (Remmington and Braun 1985, Myers 1992) and mountain big sagebrush (*Artemisia tridentata vaseyana*) (Welch et al. 1991). Remington and Braun (1985) suggested sage grouse most often select Wyoming big sagebrush because it has a higher amount of crude protein and plant vigor. In this study, we sampled different wintering areas to determine if sage grouse were selecting for a particular subspecies of big sagebrush (*Artemisia tridentata*). Our study sought to quantify the winter habitat of a population of sage grouse in Strawberry Valley, Utah and surrounding wintering areas. We focused not only on slope, aspect, percent shrub canopy cover, and shrub height, but also on individual sagebrush dimensions at the micro-site because microhabitat becomes increasingly important during the winter in Strawberry Valley, Utah as snow depth increases and suitable sagebrush habitat diminishes.

Our objective was to determine if winter habitat in both Strawberry and migratory areas is a limiting factor contributing to the decline of sage grouse in Strawberry Valley, Utah. We thank the Utah Reclamation Mitigation and Conservation Commission, Utah Division of Wildlife Resources, Uintah National Forest, and Brigham Young University for the financial support of this study. We also thank Phalan Whitehair, Brooke Chadwick, and Bill Dallmeyer for their help in collecting data and trapping sage grouse.

STUDY AREA

Sage grouse were studied during the winters of 1999 and 2000 in three areas: Strawberry Valley, and two other migratory areas referred to as Currant Creek and Lower Red Creek. Strawberry Valley is located in Wasatch County south of the Uintas and east of the Wasatch mountain ranges. The valley is characterized as a montane sagebrush steppe and has an elevation from 2280 m to 2440 m. The valley has cool summers and cold winters with an annual precipitation of 41.8 cm. Mountain big sagebrush dominates the area. Currant Creek is located about 18.5 air kilometers east of Strawberry Valley on the border of Wasatch and Duchesene Counties northwest of the town of Fruitland. Lower Red Creek is located on private land about 32.2 air kilometers east of Strawberry Valley in Duschene County east of Fruitland, north of Highway 40, and west of Highway 208 (Fig.1). Currant Creek and Lower Red Creek are similar in vegetation type and have elevations of 2134 m and 1981m respectively. The annual precipitation in these areas is 31.5 cm. An intermediate variety of mountain big sagebrush and Wyoming big sagebrush dominate these areas.

METHODS

Sage grouse were captured on or near three leks during April and May of 1998 and 1999 using the spotlight method (Giesen et al. 1982). Grouse were then fitted with a necklace style radio transmitter collar. Numbers of sage grouse captured and successfully fitted with collars were 21 (11 males and 10 females) in 1998 and 20 (14 males and 6 females) in 1999.

Winter habitat data were taken in Strawberry Valley and Currant Creek during the winters of 1999 and 2000. Data from Lower Red Creek were taken only during 1998 and 1999 because access was denied the following winter. Radio collared birds were located using a portable telemetry receiver from the ground and air and accessed by snowmobile or foot. The grouse flushed upon approach and habitat data were collected at the flush sites. Data collected included: GPS location, number of birds flushed, aspect, slope, wind speed and direction, sky condition, temperature, presence and density of snowmobile tracks, presence of predator and ungulate tracks, snow condition, snow depth, presence of rocks or cliffs, percent canopy cover by species, sagebrush and shrub density, as well as horizontal obscurity and vertical cover.

Slope was recorded in degrees using a compass clinometer. Wind speed and sky condition were recorded based on the Beufort Scale of classification. Presence of snowmobile tracks (not including ours) was recorded at the flush site, and density was described as light, medium, or heavy. Percent canopy cover was measured using the line intercept method (Bonham 1989) of above snow woody vegetation. Shrub density was calculated by measuring the closest shrub (Shrub 1) from the roost/feed site and the second closest shrub (Shrub 2) from the first shrub according to the T^2 analysis (Ludwig and Reynolds 1988). Height and canopy area were recorded for the two shrubs in the T^2 analysis. Canopy area was determined by taking two widths of the crown of the shrub and calculating the area of an ellipse. Horizontal obscurity cover was measured using a 1 m^2 cover board separated into 36 equal squares. Cover was recorded by stratifying the cover board into thirds along a vertical axis and recording the total number of obscured squares in each of the three sections. Horizontal obscurity cover was taken in four directions at 2.5, 5, and 10 meters. Vertical cover was measured using an 18 cm x 18 cm cover board separated into 36 squares. This board was placed over the roost site/feed site and the number of obscured squares was recorded.

The same data were recorded at random sites. Random sites were located from the flush site by taking a random distance and direction from a compass bearing which was limited to a distance of 100 meters. A second distance and direction was taken by the same method from the final point of the first direction.

Sagebrush leaf samples were taken from feed and non-feed sites in Strawberry Valley and Currant Creek from January through March 2000 to see if birds were selecting for a particular subspecies. The Lower Red Creek area was excluded from the sample because access to the area was denied. A fluorescence test was conducted according to the technique described by Stevens and McArthur (1974).   A score ranging from one to five was given depending on the brightness of the fluorescence of the sample (Goodrich et al. 1999).

Statistical analysis compared variables between sites using a One-Way ANOVA on each variable. A Two Sample T-Test compared differences between variables at flush and random locations.

RESULTS

Both Currant Creek and Lower Red Creek proved to be similar in canopy cover, shrub density, slope, and aspect using a One-Way ANOVA, so in this section they will be referred to collectively as the migratory areas. If an area was measured independently or a significant difference occurred between the two areas the original name will be used.

Slope and aspect measurements showed that sage grouse in Strawberry selected significantly steeper slopes (mean = 9.56 degrees SD = 5.97) than the birds in the migratory areas (mean = 3.12 degrees SD = 2.51) ($p < 0.0001$). Seventy five percent the of slopes selected in Strawberry were between 4 and 14.75 degrees and 75% of slopes selected in the migratory areas were between 1 and 4.75 degrees. Aspects selected in Strawberry were mostly south, and

aspects in the migratory areas were east or southeast (Fig. 2). Sage grouse were significantly more likely to select a south aspect in Strawberry than in the migratory areas ($p = 0.003$).
Use sites in both Strawberry and the migratory areas had greater canopy cover than random sites ($p = 0.013$ and $p = 0.0023$ respectively). Percent canopy cover at Strawberry was 50% greater at use sites than at random sites ($p = 0.013$). Canopy cover at both the use and random sites in the migratory areas was greater than use and random sites in Strawberry ($p = 0.033$ and $p < 0.0001$ respectively) (Table 1). Sagebrush canopy area of the closest shrub to the roost/feed site showed no significant difference between the migratory areas and Strawberry. The second closest shrub however, was larger at the migratory areas than at Strawberry ($p = 0.039$). The canopy area of Shrub 1 and Shrub 2 was not significantly different in the migratory areas, but Shrub 1 was significantly larger than Shrub 2 at Strawberry ($p = 0.039$) (Table 2).

Sagebrush heights at the use sites in the migratory areas were not significantly different than the random sites. However, sagebrush in Strawberry was taller at use sites than at random sites ($p = 0.0041$). Shrub 1 was also taller than Shrub 2 in Strawberry ($p = 0.034$) (Table 3).

Horizontal obscurity cover at use sites in Strawberry was greater ($p < 0.05$) than random sites at all three levels of the cover board, in all four directions, and at all three distances except level three at 2.5 m and level three at 10 m. Horizontal obscurity at the migratory areas was greater at use-sites than random sites at all three levels of the cover board in all four directions for distances of 2.5 m and 5 m ($p < 0.05$). However, no levels at a distance of 10 m were significant in the migratory areas (Table 4). Vertical cover was not significant between Strawberry and the migratory areas, however, it was greater at the use sites of all three areas than at the random sites of these areas.

Average temperature ranged from –5 to 10^{o} C with an average of .67 ^{o} C for Strawberry and –7 to 12^{o} C with an average of 1.86^{o} C for the migratory areas. The temperature difference was not significant between the two areas. Flock size was about 8 birds for both Strawberry and the migratory areas. Snow depth was significantly greater at Strawberry (mean = 31.7 cm) than at migratory areas (mean = 9.3 cm) ($p > 0.0001$).

Results from the fluorescence test showed a significant difference between Strawberry (mean = 4.4) Currant Creek (mean = 2.6) ($p > 0.0001$), but not between Strawberry and Currant Creek feed sites versus non-feed sites (Table 5). Mountain big sagebrush is the dominant species in Strawberry. The dominant species in Currant Creek is an intermediate variety of Mountain big sagebrush crossed with Wyoming big sagebrush.

Canid tracks were identified at 45.7% of use sites in Strawberry, 15.4% of use sites in Currant Creek, and 33.3% of use sites in Lower Red Creek. The total for all three areas was 36.5%. All but one of the predator tracks identified was either coyote (*Canis lantrans*) or red fox (*Vulpes vulpes*). Although no mortalities of collared birds occurred during the winter, numerous canid tracks and fox dens were found throughout the Strawberry area. A total of 13 fox dens were documented this winter.

No snowmobile tracks were recorded in the migratory areas. Strawberry had five out of 35 (14.2%) use sites where tracks were found. All five were classified as "heavy" use.

DISCUSSION

The topographic distribution of sage grouse on steeper south facing slopes in Strawberry compared to east or southeast facing slopes in the migratory areas can be attributed to the amount of snow Strawberry receives compared to migratory areas. In Strawberry, patches of above snow sagebrush could only be found on steeper south facing slopes at maximum snow depth, thus attracting sage grouse to congregate in these areas. The snow depth in the migratory areas was significantly less and didn't limit the exposure of above snow sagebrush throughout the winter allowing sage grouse to select a greater variety of use sites. The winters of 1999 and 2000 were generally mild, so it is not known if the population would completely abandon the Strawberry Valley during a heavy snow year.

Percent canopy cover and horizontal obscurity measurements in the migratory areas were greater at use sites than at random sites, yet height was similar at both use and random sites. These results suggest that sage grouse are selecting for stands with denser canopy cover rather than simply the stands with the tallest shrubs in the migratory areas. This finding is somewhat different from a study done in southeastern Idaho where stands of both higher canopy cover and taller shrubs of Wyoming big sagebrush were selected (Robertson 1991). The fact that there was no significant difference between Shrub 1 and Shrub 2 at the migratory areas indicates that favorable microhabitat is easier to find in the migratory areas than in Strawberry.

Sagebrush percent canopy cover fell within the guidelines outlined by Connelly et al. (in review). Sagebrush height was taller than the recommended guidelines (Connelly et al. in review) in both the migratory areas and Strawberry. This is not surprising considering the mild winters in both 1999 and 2000. Percent canopy cover, horizontal obscurity, and shrub height in Strawberry were greater in use sites than in non-use sites indicating there is stronger selection for adequate habitat in Strawberry than in the migratory areas. Field observations suggested that as snow depth increased, sage grouse were forced into smaller patches of sagebrush usually on the steeper south facing slopes.

Snowmobile tracks were expected to occur more often than found in Strawberry because of the large amount of winter recreation in the area. The five sites that were recorded as “heavy” were frequently traveled snowmobile roads or trails, which were probably present before the grouse selected these sites. Snowmobilers did not appear to disturb sage grouse in other use or random sites because most of the activity occurred in fishing areas on the lake.

We anticipated some sort of correlation between sagebrush that had been fed on by sage grouse versus those that were not selected for feeding through the use of the fluorescence test. Although the test showed nothing significant between feed and non-feed shrubs, it did show that sage grouse moving from Strawberry to the Currant Creek are not discriminating between mountain big sagebrush and intermediate varieties. A protein analysis between feed and non-feed sagebrush shrubs in Strawberry and Currant Creek is pending.

The conclusion of this study is that current winter habitat for this sage grouse population is adequate under prevailing conditions. In a high snow year sage grouse may be forced to abandon the Strawberry Valley for lower elevation wintering areas. Routes traveled and destinations selected may depend on the migrational experience of these native sage grouse.

Literature Cited

Beck, T. D. I. 1977. Sage grouse flock characteristics and habitat selection during winter. Journal of Wildlife Management 41:18-26.

Bonham, C. D. 1989. Measurements for terrestrial vegetation. John Wiley and Sons Inc. 338pp.

Connelly, J. W. , M. A. Schroeder, A.R. Sands, and C.E. Braun. 2000. Guidelines for management of sage grouse populations and habitats. Unpublished document.

Connelly, J. W. , H. W. Browers, and R. J. Gates. 1988. Seasonal movements of sage grouse in southeastern Idaho. Journal of Wildlife Management 52:116-122.

Eng, R. L. , and P. Schladweiler. 1972. Sage grouse winter movements and habitat use in central Montana. Journal of Wildlife Management 36:141-146.

Giesen, K. M. , T. J. Schoenburg, C.E. Braun. 1982. Methods for trapping sage grouse in Colorado. Wildlife Society Bulletin 10:224-231.

Goodrich, S. , E .D. McArthur, and A. T. Winward. 1999. Sagebrush ecotones and average annual precipitation. Pages 88-94 *in* E. D. McArthur, W. K. Ostler, and C. L. Wamboldt, compilers. Proceedings: shrubland ecotones. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. RMRS-P-11.

Griner, L. A. 1939. A study of sage grouse (Centrocercus urophasianus), with special reference to life history, habitat requirements, and numbers of distribution. Thesis, Utah State Agricultural College, Logan.

Hanf, J. M. , P. A. Schimdt, and E. B. Groshens. 1994. Sage grouse in the high desert of central Oregon: results of a study, 1988-1993. U.S. Department of Interior, Bureau of Land Management Series P-SG-01, Prineville, Oregon.

Hulet, B. 1983. Selected responses of sage grouse to prescribed fire, predation, and grazing by domestic sheep in southeastern Idaho. Thesis, Brigham Young University, Provo.

Hupp, J. W. , and C. E. Braun. 1989. Topographic distribution of sage grouse foraging in winter. Journal of Wildlife Management 53:823-829.

Ludwig, J. A. , and J. F. Reynolds. 1988. Statistical ecology primer on methods and Computing. John Wiley and Sons Inc. 337pp.

Patterson, R. L. 1952. The sage grouse in Wyoming. Sage Books, Inc., Denver, Colo. 341pp.

Remmington, T. E., and C. E. Braun. 1985. Sage grouse food selection in winter, North Park, Colorado. Journal of Wildlife Management 49:1055-1061.

Robertson, M. D. 1991. Winter ecology of migratory sage grouse and associated effects of prescribed fire in southeastern Idaho. Thesis, University of Idaho, Moscow.

Schoenburg, T. J. 1982. Sage grouse movements and habitat selection in North Park, Colorado. Thesis, Colorado State University, Fort Collins.

Spomer, G. G., Henderson, D. M. 1988. Use of UV absorption for identifying subspecies of *Artemisia tridentata*. Journal of Range Management 41:395-398.

Stevens, R., and E. D. McArthur. 1974. A simple field technique for identification of Some sagebrush taxa. Journal of Range Management 27:325-326.

Wallestad, R., J. G. Peterson, and R. L. Eng. 1975. Foods of adult sage grouse in central Montana. Journal of Wildlife Management 39:628-630.

Table 1. A comparison of shrub canopy cover at use sites and random locations.

	Canopy Cover (%)	N
Strawberry		
Use sites	13.22	32
Random	7.07	26
Migratory Areas		
Use sites	17.14	28
Random	11.45	30

Table 2. Mean crown cover of shrub 1 and shrub 2 at use sites in each wintering area.

	Average Crown Cover (m^2)	N
Strawberry		
Shrub 1	1.03[a]	57
Shrub 2	.571[b]	57
Currant Creek		
Shrub 1	0.768	33
Shrub 2	0.752	33
Lower Red Creek		
Shrub 1	1.02	29
Shrub 2	1.23	18

[a] Value differed significantly ($p < 0.05$) between shrub 2 in the same area.
[b] Value differed significantly ($p < 0.05$) between shrub 2 in the migratory areas.

Table 3. A comparison of mean sagebrush height of shrub 1 and shrub 2 in use and random sites in each wintering area.

	Height (cm)	N
Strawberry		
Shrub 1	39.8[a]	57
Shrub 2	33.4	57
Random	24.4	58
Currant Creek		
Shrub 1	56.9	20
Shrub 2	63.5	20
Random	52.1	22
Lower Red Creek		
Shrub 1	47.2	33
Shrub 2	46.9	33
Random	39.3	30

[a] Value differed significantly ($p < 0.05$) between random site in the respective area.

Table 4. A comparison of horizontal obscurity cover at Strawberry and Migratory Areas use sites. Corresponding random sites are in the column to the right of use sites.

	Horizontal Obscurity Cover (%)			
	Strawberry	Random	Migratory Areas	Random
Level 1				
2.5 m	78	44	86	55
5 m	86	53	94	80
10 m	89	62	98[a]	98
Level 2				
2.5 m	47	21	67	34
5 m	55	29	83	54
10 m	63	40	90[a]	85
Level 3				
2.5 m	24[a]	13	44	14
5 m	31	15	69	35
10 m	39[a]	24	74[a]	65

[a] Value did not differ significantly ($p > 0.05$) from random sites in the respective area.

Table 5. Fluorescence test scores of sagebrush samples that were fed on versus those that were not fed on. Higher scores are associated with Mountain big sagebrush.

	Mean Fluorescence Score	N
Strawberry		
Feed	4.31	29
Non-feed	4.48	27
Currant Creek		
Feed	2.62	21
Non-feed	2.50	28

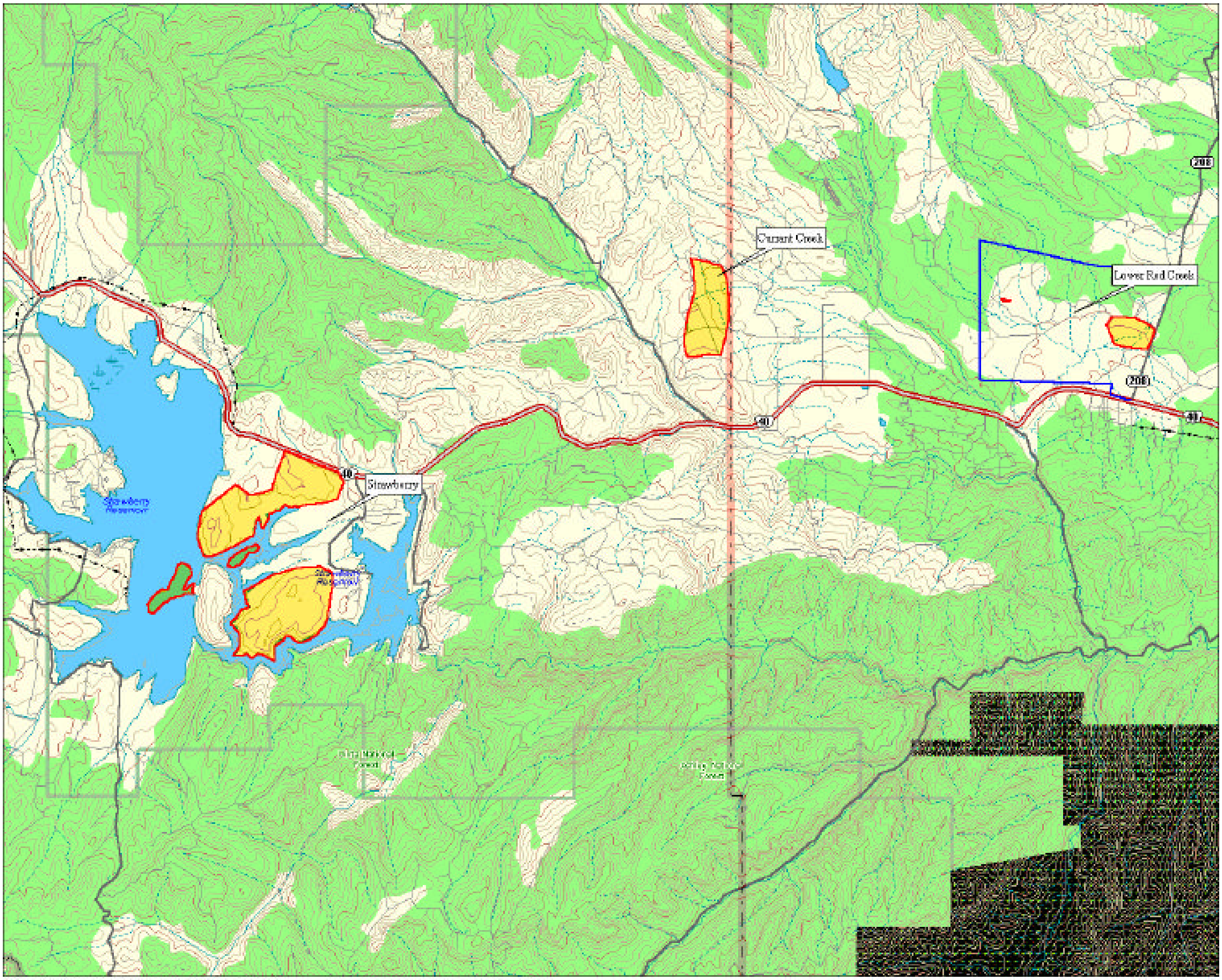

Fig. 1. Winter habitat study area. Areas marked in yellow are the wintering areas for the Strawberry Valley sage grouse population during the winters of 1999 through 2000. Private land associated with wintering habitat is outlined in blue.

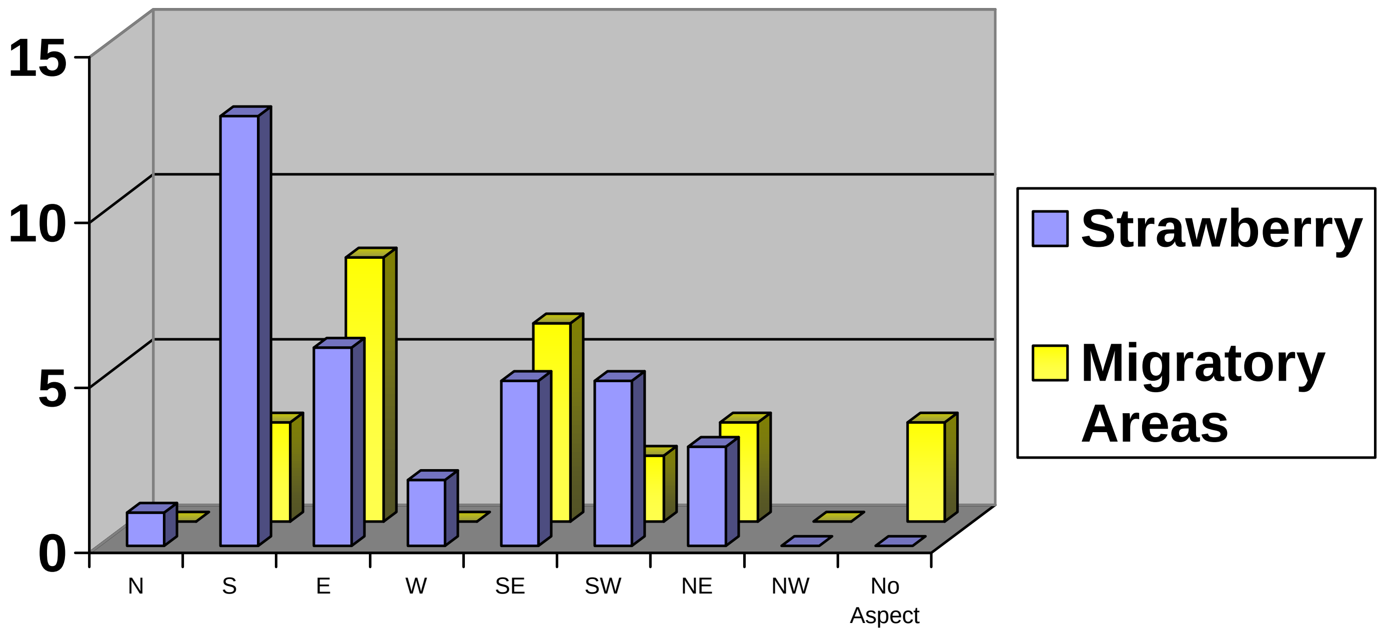

Fig. 2. Number of preferred aspects at use sites in Strawberry and Migratory wintering areas.

RED FOX PREDATION ON SAGE GROUSE IN STRAWBERRY VALLEY, UTAH

(Manuscript prepared for publication in the Journal of Wildlife Management)

Under Construction