

AN ABSTRACT OF THE THESIS OF

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Nutrition effects productivity of grouse. Females that obtain high nutrient diets in spring produce larger clutches and larger, more viable chicks than hens on less nutritious diets. Grouse select high nutrient foods to help ensure proper nutrition. Reduced productivity accounted for the decline of sage grouse (Centrocercus urophasianus) populations in Oregon since the 1950s. Summer and fall diets of sage grouse are well described, but no information is available on foraging ecology or diet of hens during the breeding season. The objectives of this study were to determine use, availability, and nutrient content (crude protein, calcium, phosphorus) of key foods of pre-laying female sage grouse. The study was conducted on 2 areas in southeastern Oregon: Hart Mountain National Antelope Refuge and Jackass Creek.

Female sage grouse were collected for a 5-week period preceeding incubation (5 March - 8 April) 1990-91. Sagebrush (Artemisia spp.) was the primary food and composed less of the diet in 1990 (55%) than 1991 (80%). The remainder of the diet was composed of forbs. Desert parsley (Lomatium spp.), hawksbeard (Crepis spp.), long-leaf phlox (Phlox longifolia), everlasting (Antennaria spp.), mountain dandelion

(Agoseris spp.), clover (Trifolium spp.), and milkvetch (Astragalus spp.) were identified as key forbs. Forbs were used in greater proportion than available, but sagebrush was used less than available. Availability of forbs was lower in 1991 than 1990.

Samples of sagebrush from sage grouse crops were higher in crude protein than samples from foraging and random sites, and nutrient content of sagebrush was lower in 1991 than 1990. Forbs were higher in nutrient content than sagebrush. Fewer forbs were eaten in 1991 and crude protein, calcium, and phosphorus contents of the diet were lower in 1991.

Productivity of sage grouse on both areas was lower in 1991 than 1990. Results of this study indicate diet and nutrient intake of hens during the pre-laying period may influence productivity of sage grouse.

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During the Pre-laying Period

by

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# TABLE OF CONTENTS

|   | <u>PAGE</u> |
|---|-------------|
| INTRODUCTION . . . . .  | 1           |
| STUDY AREAS . . . . .   | 4           |
| Hart Mountain National Antelope Refuge . . . . .  | 4           |
| Jackass Creek . . . . .   | 5           |
| METHODS . . . . .   | 7           |
| Nutrient Content of Diet . . . . .  | 9           |
| Data Analysis . . . . .   | 10          |
| RESULTS . . . . .   | 12          |
| Diets . . . . .   | 12          |
| Area/Cover Type and Year Comparisons . . . . .  | 16          |
| Selection . . . . .   | 20          |
| DISCUSSION . . . . .  | 30          |
| LITERATURE CITED . . . . .  | 34          |
| APPENDICES  |             |
| APPENDIX 1. Foods used by pre-laying female sage grouse at<br>Hart Mountain National Antelope Refuge and<br>Jackass Creek, Oregon, March-April 1990-91 . .  | 37          |
| APPENDIX 2. Percent aggregate dry mass of foods of pre-<br>laying female sage grouse at Hart Mountain<br>National Antelope Refuge, low sagebrush cover<br>type (HMLS) and Wyoming big sagebrush cover<br>type (HMWS) and Jackass Creek, low sagebrush<br>cover type (JCLS) and mixed sagebrush cover<br>type (JCMS), Oregon, March-April 1990-91. . . | 38          |
| APPENDIX 3. Cover (%) of plants at Hart Mountain National<br>Antelope Refuge, low sagebrush cover type<br>(HMLS) and Wyoming big sagebrush cover<br>type (HMWS) and Jackass Creek, low sagebrush<br>cover type (JCLS) and mixed sagebrush cover<br>type (JCMS), Oregon, March-April 1990-91. . . .  | 41          |
| APPENDIX 4. Frequency of key foods in crops (use) and at<br>foraging sites (availability) of female sage<br>grouse at Hart Mountain National Antelope Refuge<br>and Jackass Creek, Oregon,<br>March-April 1990-91. . . . .  | 44          |

|             |   |    |
|-------------|---|----|
| APPENDIX 5. | Crude protein (cp), calcium (ca), and<br>phosphorus (p) content of some foods pre-<br>laying female sage grouse at Hart Mountain<br>National Antelope Refuge and Jackass Creek,<br>Oregon, March-April 1990-91. . . . . | 46 |
|-------------|---|----|

## LIST OF TABLES

| <u>Table</u>  | <u>Page</u> |
|---|-------------|
| 1. Productivity of sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, 1990-91.  | 13          |
| 2. Aggregate dry mass and frequency of occurrence of key foods of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990.  | 14          |
| 3. Aggregate dry mass and frequency of occurrence of key foods of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990.  | 15          |
| 4. Vegetation characteristics from randomly sampled sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April, 1990.   | 17          |
| 5. Vegetation Characteristics from randomly sampled sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April, 1991.   | 18          |
| 6. Nutrient content (%) of key foods collected from Hart Mountain National Antelope Refuge low sagebrush cover type (HMLS) and Wyoming big sagebrush cover types (HMWS), and Jackass Creek low sagebrush cover type (JCLS), Oregon, March-April 1990. | 19          |
| 7. Nutrient content (%) of key foods collected from Hart Mountain National Antelope Refuge low sagebrush cover type (HMLS), and Jackass Creek low sagebrush cover type (JCLS) and mixed sagebrush cover type (JCMS), Oregon, March-April 1990.        | 21          |
| 8. Vegetation characteristics from foraging sites of female sage grouse and random locations at Hart Mountain National Antelope Refuge, Oregon, March-April 1990-1991.  | 22          |
| 9. Vegetation characteristics at foraging sites of female sage grouse and random sites at Jackass Creek, Oregon, March-April, 1990-91.  | 23          |



|     |  |    |
|-----|--|----|
| 10. | Nutrient content (%) of sagebrush and key forbs of female sage grouse at Hart Mountain low sagebrush cover type (HMLS) and Jackass Creek low sagebrush cover type (JCLS), Oregon, March-April 1990-91.         | 24 |
| 11. | Nutrient content (%) of diets of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.   | 25 |
| 12. | Selection of key foods of female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.   | 27 |
| 13. | Nutrient content (%) of key foods collected from female sage grouse crops, sage grouse foraging sites, and random sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990. | 28 |
| 14. | Nutrient content (%) of key foods collected from female sage grouse crops, sage grouse foraging sites, and random sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1991. | 29 |

# Diet and Nutrition of Female Sage Grouse During the Pre-laying Period.

## INTRODUCTION

Reduced productivity was associated with the population decline of sage grouse (Centrocercus urophasianus) in Oregon since 1940 (Crawford and Lutz 1985). Sage grouse were once common in non-forested areas east of Oregon's Cascade Mountains (Gabrielson and Jewett 1940). From the 1950's to the 1980's, the percent of sage grouse hens in Oregon with broods decreased 78% and chicks/adult decreased 83%. From 1984 to 1986, 42% of sage grouse hens successfully hatched a clutch but only 29% of successful hens recruited chicks into the August population (G. P. Kiester, Oreg. Dep. Fish and Wildl., pers. commun.). Sage grouse populations in Oregon show a cyclic or quasi-cyclic trend and productivity fluctuates annually (Crawford and Lutz 1985). Poor productivity may be caused by a number of factors, including predation (Batterson and Morse 1948), inclement weather (Wallestad and Watts 1973), and poor nutrition of hens during the breeding season (Moss et al. 1975).

Female grouse that obtain adequate nutrition in the spring diet contribute more nutrients to their eggs (Jenkins et al. 1965) and produce larger clutches, and larger, more viable chicks compared with hens on less nutritious diets (Jenkins et al. 1963, Eastman and Jenkins 1970). Productivity of red grouse (Lagopus lagopus scoticus) and rock ptarmigan (Lagopus mutus) fluctuated annually and

fluctuations were related to availability and nutrient content of spring diets (Moss et al. 1975, Moss and Watson 1984). Nitrogen (a measure of crude protein) and phosphorus were identified as nutrients that likely limited egg production of red grouse (Moss 1967). Waibel (1977) found dietary calcium and phosphorus important for breeding success and productivity of poultry.

Selection for high nutrient foods may ensure that grouse receive adequate nutrition for reproduction and has been documented in many tetraonid species (Korschgen 1966, Moss 1972, Gurchinoff and Robinson 1972). Moss (1968, 1972) found that red grouse selected heather (Calluna vulgaris) rich in nitrogen and phosphorus during spring and rock ptarmigan selected food high in nitrogen, phosphorus, and soluble carbohydrates. Spruce grouse (Dendragapus canadensis) foraged in jackpine trees that had the greatest amounts of protein and ash in the needles (Gurchinoff and Robinson 1972).

Diet and nutrition are important for reproduction in grouse but little information is available on female sage grouse diets during the pre-laying period. Sagebrush (Artemisia spp.) composed 97% of March diets (Wallestad 1975) and 89 - 100% of April diets (Rogers 1964, Wallestad 1975) of sage grouse in Montana and Colorado; the remainder of the diets were forbs. However, diets of males and females were not separated in these studies and no information on reproductive stage of the birds or relative availability of foods was provided. Further, no information is available on food or nutrient selection by female sage grouse during the breeding season.

Reduced productivity of sage grouse in Oregon, relationships between diet, nutrition, and productivity in other grouse, and lack of information on foraging ecology of female sage grouse during the breeding season prompted this study. The goal of this study was to better understand the diet and nutritional status of pre-laying female sage grouse and how diet and nutritional status relate to productivity. The objectives were to determine use, availability, and nutrient content of key foods of pre-laying female sage grouse on 2 replicated areas in southeastern Oregon.

## STUDY AREAS

The study was conducted on 2 areas: Hart Mountain National Antelope Refuge, administered by the U.S. Fish and Wildlife Service and Jackass Creek, administered by the Bureau of Land Management. Researchers from Oregon State University (OSU) studied sage grouse nesting and brooding habitat use on both study areas from 1989 through 1991. Since 1981, Hart Mountain and Jackass Creek have supported approximately 2.5 and 1.5 birds/km<sup>2</sup>, respectively (W. H. Pyle, U.S. Fish and Wildl. Serv., unpubl. data; J. C. Lemos, Oreg. Dep. Fish and Wildl., unpubl. data). Summer productivity counts were 1.9 and 1.0 chicks/hen for Hart Mountain and Jackass Creek, respectively.

### Hart Mountain National Antelope Refuge

At Hart Mountain National Antelope Refuge, located 70 km northeast of Lakeview, Lake County, Oregon, elevation ranged from 1,500 m at the eastern portion of the refuge to 2,450 m in the west (Warner Peak). Flat sagebrush plains, interrupted by rolling hills, draws, and ridges, surrounded the area. Hart Mountain supported several lakes, springs, creeks, and meadows. Seasonally flooded lakebeds were most common in the southern portion of the study area. Mean annual precipitation was 29 cm at headquarters and maximum daily temperature averaged 21 C (March - September). Precipitation was 2.0 and 4.6 cm and temperature averaged 2.2 and -0.3 C during March 1990

and 1991, respectively (U.S. Dep. Commer., Climatological Data).

Plant phenology was delayed in 1991 compared with 1990.

During the pre-laying period, hens used low sagebrush (A. arbuscula) and Wyoming big sagebrush (A. tridentata var. wyomingensis) cover types. Principal plant types in low sagebrush cover type included low sagebrush and bluebunch wheatgrass (Agropyron spicatum). Principal plant types in Wyoming big sagebrush cover type included Wyoming big sagebrush and Thurber's needlegrass (Stipa thurberiana). Common annual and perennial forbs included desert parsley (Lomatium spp.), milkvetch (Astragalus spp.), hawksbeard (Crepis spp.), mountain-dandelion (Agoseris spp.), lupine (Lupinus spp.), and phlox (Phlox spp.). Plant nomenclature was taken from Hitchcock and Cronquist (1987).

Before 1991, livestock grazing was permitted on the refuge. A rest rotation, deferred grazing system was used. Approximately 0.13 animal unit months (AUMs)/ha were allocated from 15 April to 15 December and grazing pressure was adjusted annually according to range conditions (W. H. Pyle, U. S. Fish and Wildl. Serv., pers. commun.). The refuge was not grazed in 1991. A range fire burned approximately 4,500 ha in the center of the refuge in 1985.

### Jackass Creek

Jackass Creek, located approximately 100 km northeast of Hart Mountain in Harney County, was topographically more homogenous and approximately 300 m lower in elevation than Hart Mountain. The area consisted of flat sagebrush plains in the west leading to undulating

ridges and draws in the east, rising to Jackass Mountain (1,700 m). Jackass Creek Canyon bisected the study area east and west and the main plateau dropped into Keg Springs Valley to the south. In contrast to Hart Mountain, meadow habitats were small and widely dispersed. Water developments, lakebeds, and Jackass Creek were primary sources of water. Mean annual precipitation was 29 cm and maximum daily temperature averaged 24 C (March - September). Precipitation was 1.7 and 2.4 cm and temperature averaged 4.3 and 3.4 C during March 1990 and 1991, respectively (U.S. Dep. Commer., Climatological Data). Plant phenology was delayed in 1991 compared with 1990.

Pre-laying hens used low sagebrush, Wyoming big sagebrush, and mixed sagebrush cover types on this study area. Principal vegetative components of mixed sagebrush cover type included low sagebrush, Wyoming big sagebrush, and Sandberg's bluegrass (Poa sandbergii).

Before 1991, cattle grazing averaged 0.18 AUMs/ha from 1 April to 1 September. Jackass Creek was not grazed in 1991. From 1985 through 1990 range use by wild horses averaged 0.05 AUMs/ha (W. F. Taylor, Bur. of Land Manage., pers. commun.).

## METHODS

Johnson's (1980) hierarchical order of selection was used to evaluate selection for foraging sites (third order selection) and specific components at foraging sites (fourth order selection) within and between cover types, study areas, and years. Measures of sage grouse productivity at Hart Mountain and Jackass Creek during 1990-91 were obtained from the OSU study (J. A. Crawford, Oreg. State Univ., unpubl. data).

Sage grouse hens were collected during the 5-week period preceding incubation (4 March - 8 April) in 1990 and 1991. Forty-five hens were obtained in 4 combinations of area and cover type: Hart Mountain low sagebrush (HMLS), Hart Mountain Wyoming big sagebrush (HMWS), Jackass Creek low sagebrush (JCLS), and Jackass Creek mixed sagebrush (JCMS). In 1990, 5 and 8 hens were collected from HMLS and JCLS, respectively, and 7 hens were collected from HMWS. In addition, 2 hens found dead at Hart Mountain, 1 in HMLS and 1 in HMWS, were used for diet description. In 1991, 13 and 9 hens were collected from HMLS and JCLS, respectively, and 3 hens were collected from JCMS. Grouse were collected in the evenings to increase likelihood of obtaining a full crop. Crop contents were removed and plant species and parts (leaves, flowers, stems, etc.) identified. Contents were placed in plastic bags and frozen.

Frequency of food items in individual crops was determined by spreading the contents in a single layer in a glass tray, overlaying a dot grid, and recording the food item directly below each of 100 dots.



Crops that were too full to spread contents in a single layer were subsampled. Crop contents were identified, separated, and dried to constant mass. Percent aggregate dry mass (total mass of each food divided by total mass of all foods in all crops) was calculated for each combination of area, cover type, and year. The most common foods in the diet of sage grouse, herein called key foods, were those foods that contributed at least 1% aggregate dry mass and 25% frequency of occurrence in at least one year. Key foods were defined for each area/cover type combination.

Vegetation characteristics were evaluated at foraging sites and random sites. A foraging site was defined as a circle with a 10-m radius centered where a hen was first observed (J. W. Connelly, Id. Dep. Fish and Game, pers. commun.). For each foraging site, a random site was selected in the same cover type. Random sites were selected from cover type maps of the study areas and had the same dimensions as foraging sites. Frequency of plant species at foraging and random sites was estimated with the line-point method (Heady et al. 1959). Eight 15-m lines were randomly placed in the circle. For each line, the starting point was determined by a randomly selected distance and direction from the center of the site. Line orientation was determined by a randomly selected compass bearing. Lines that fell outside the circle were rejected and a new bearing was randomly selected. Point samples were taken at 30-cm intervals along the line. Two of the 8 lines were randomly selected for determination of shrub cover, which was estimated with the line intercept method (Canfield

1941). Percent cover of grasses and forbs was estimated in 10 randomly placed 20 x 50-cm rectangular frames (Daubenmire 1959).

#### Nutrient Content of Diet

Samples of plants selected by grouse were collected at foraging and random sites immediately after availability data were collected. If a selected plant was not found in the defined foraging or random site, plants closest to the site were collected. Plant parts may differ greatly in chemical content (W. C. Krueger, Oreg. State Univ., pers. commun.); therefore, nutrient analyses were conducted only on the plant parts consumed by grouse. Specific parts were separated from the rest of the plant, weighed wet, and dried to constant mass at 50 C. Samples were placed in paper bags and stored for latter analysis.

Analyses of plant samples for crude protein, calcium, and phosphorus were conducted after each field season. A maximum of 5 samples was analyzed for each food in each combination of area/cover type, site (crop, foraging, random), and year. If more than 5 samples were available, samples were pooled by random assignment to 1 of 5 replicates. Samples were ground in a Wiley mill with a 20 mesh screen. Crude protein was determined from analysis of samples for ammonium nitrogen and multiplication of ammonium values by 6.25. The Kjeldahl method (Association of Official Analytical Chemists 1980) was used to digest samples for crude protein and phosphorus analysis and determination for the nutrients was made colorimetrically on a

Technicon Auto Analyzer. Calcium content was determined by ashing (Association of Official Analytical Chemists 1980).

Nutrient content of the diet was calculated for each area/cover type and year. Nutrient contribution of each key food to the total diet was estimated by multiplying aggregate dry mass of each key food by the average value for each nutrient (crude protein, calcium, and phosphorus) in crop samples. Nutrient contributions of key foods were summed to estimate total dietary nutrient content.

### Data Analysis

Selection was evaluated at 3 levels: foraging sites, food items, and nutrients. Forb genera eaten but not defined as key foods were combined into an "other forb" category and forb genera available but not used were classified into a "unused forb" category. Vegetation characteristics (percent cover of shrubs, grasses, forbs, and bare ground) and forb availability (percent cover of key, other, and unused forbs) were compared (1) between areas/cover type within years at random sites; (2) between foraging and random sites within area/cover types and years; and (3) between years within area/cover types and foraging and random sites (HMLS and JCLS only). Kruskal-Wallis Test used for all comparisons and tests were considered significant at the  $p < 0.05$  level of probability for type I error (Snedecor and Cochran 1980). Least significant difference multiple comparison procedure (Snedecor and Cochran 1980) was used to separate means when the test was significant.

To evaluate food selection, frequency data from crops (use) were compared with frequency data from foraging sites (availability). Crops of 4 hens did not contain sufficient material for frequency analysis and were not used in food selection analysis. Frequency of use and availability of key, other, and unused foods was ranked for each bird. Differences between use and availability were averaged across birds and used as a measure of selection (Johnson 1980).

To evaluate selection for nutrients among crop, foraging, and random sites nutrient values of key forbs were combined and forbs were tested separately from sagebrush. Within years, factorial analysis of variance (ANOVA) (Snedecor and Cochran 1980) was used to compare nutrient content of key forbs and sagebrush by (1) sites (crop, foraging, random) and (2) by area/cover type. Site was the primary factor and area/cover type was the secondary factor. Nutrient content of sagebrush and key forbs were compared between years for HMLS and JCLS. Data were normally distributed and results considered significant at the  $p < 0.05$  level for type I error.

## RESULTS

Productivity measures of sage grouse at Hart Mountain and Jackass Creek decreased during 1991 compared with 1990 (Table 1). Percent of radio-marked hens that nested, chicks/hen, and percent hens with broods decreased on both areas in 1991. Nest success decreased in 1991 at Hart Mountain. At Jackass Creek, nest success of radio-marked hens was identical each year but no chicks were observed on brood routes in 1991 (J. A. Crawford, Oreg. State Univ., unpubl. data).

### Diets

A total of 23 taxa were eaten (Appendices 1 and 2). Sagebrush composed 44-84% of the diet; leaves, buds, and flowers of forbs composed 16-56% of the diet; and insects from 3 orders were eaten in small amounts (< 0.1%). Eight taxa were defined as key foods. Sagebrush was the primary dietary component in all area/cover types during both years (Tables 2 and 3). Hawksbeard (Crepis spp.), desert parsley (Lomatium spp.), and mountain dandelion (Agoseris spp.) were key foods in all 4 area/cover types. Everlasting (Antennaria sp.) and long-leaf phlox (Phlox longifolia) were key foods in 3 of the area/cover types. Clover (Trifolium sp.) was a key food only in HMLS and Pursh's milkvetch (Astragalus purshii) was a key food only in HMWS. Desert parsley composed 12-28% of the diet in JCMS and JCLS and was eaten by all hens collected in 1990 and 55% of the hens collected in 1991. Hawksbeard composed 7-18% of the diet at Hart Mountain.

Table 1. Productivity of sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, 1990-91<sup>a</sup>.

| Measure               | Hart Mountain |      | Jackass Creek |      |
|-----------------------|---------------|------|---------------|------|
|                       | 1990          | 1991 | 1990          | 1991 |
| Radio-tagged hens:    |               |      |               |      |
| Hens that nested (%)  | 74            | 46   | 85            | 65   |
| Nest success (%)      | 21            | 0    | 6             | 6    |
| Productivity surveys: |               |      |               |      |
| Chicks per hen        | 0.45          | 0.30 | 0.50          | 0    |
| Hens with broods (%)  | 16            | 8    | 15            | 0    |

<sup>a</sup>J. A. Crawford, Oreg. State Univ., unpubl. data.

Table 2. Aggregate dry mass and frequency of occurrence of key foods of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass-Creek, Oregon, March-April 1990.

| Food   | Aggregate Dry Mass (%)     |               |               | Frequency of Occurrence (%) |               |               |
|--|----------------------------|---------------|---------------|-----------------------------|---------------|---------------|
|  | HMLS <sup>a</sup><br>(n=6) | JCLS<br>(n=8) | HMWS<br>(n=8) | HMLS<br>(n=6)               | JCLS<br>(n=8) | HMWS<br>(n=8) |
| Sagebrush<br>( <i>Artemisia</i> spp.) <sup>b</sup> | 57                         | 44            | 59            | 100                         | 88            | 100           |
| Hawksbeard<br>( <i>Crepis</i> spp.)                | 18                         | 10            | 13            | 83                          | 88            | 62            |
| Desert parsley<br>( <i>Lomatium</i> spp.)          | 1                          | 28            | 6             | 50                          | 100           | 88            |
| Long-leaf phlox<br>( <i>Phlox longifolia</i> )     | + <sup>c</sup>             | 8             | 9             | +                           | 75            | 75            |
| Everlasting<br>( <i>Antennaria</i> sp.)            | 6                          | 0             | 6             | 33                          | 0             | 38            |
| Mountain dandelion<br>( <i>Agoseris</i> spp.)      | 2                          | 6             | 1             | 50                          | 75            | 25            |
| Clover<br>( <i>Trifolium</i> sp.)                  | 9                          | +             | +             | 33                          | +             | +             |
| Pursh's milkvetch<br>( <i>Astragalus purshii</i> ) | +                          | +             | 1             | +                           | +             | 50            |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type; HMWS = Hart Mountain Wyoming big sagebrush cover type.

<sup>b</sup>*Artemisia arbuscula* in HMLS and JCLS; *A. tridentata* var. *wyomingensis* in HMWS.

<sup>c</sup>+ = not a key food in the area/cover type.

Table 3. Aggregate dry mass and frequency of occurrence of key foods of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1991.

| Food  | Aggregate Dry Mass (%)      |               |               | Frequency of Occurrence (%) |               |               |
|---|-----------------------------|---------------|---------------|-----------------------------|---------------|---------------|
|   | HMLS <sup>a</sup><br>(n=13) | JCLS<br>(n=9) | JCMS<br>(n=3) | HMLS<br>(n=13)              | JCLS<br>(n=9) | JCMS<br>(n=3) |
| Sagebrush<br>( <i>Artemisia</i> sp.) <sup>b</sup> | 84                          | 80            | 72            | 100                         | 100           | 100           |
| Hawksbeard<br>( <i>Crepis</i> spp.)               | 7                           | 0             | 4             | 62                          | 0             | 67            |
| Desert parsley<br>( <i>Lomatium</i> spp.)         | 3                           | 12            | 20            | 85                          | 56            | 67            |
| Long-leaf phlox<br>( <i>Phlox longifolia</i> )    | + <sup>c</sup>              | 4             | 1             | +                           | 89            | 67            |
| Everlasting<br>( <i>Antennaria</i> sp.)           | 1                           | 4             | +             | 31                          | 56            | +             |
| Mountain dandelion<br>( <i>Agoseris</i> spp.)     | 2                           | 1             | 2             | 54                          | 11            | 67            |
| Clover<br>( <i>Trifolium</i> sp.)                 | 1                           | +             | +             | 31                          | +             | +             |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type; JCMS = Jackass Creek mixed sagebrush cover type.

<sup>b</sup>*Artemisia arbuscula*.

<sup>c</sup>+ = not a key food in the area/cover type.



Except for JCLS in 1991, 62-88% of hens ate hawksbeard in each area/cover type, each year. The amount of sagebrush in the diet increased in 1991 in all area/cover types (Tables 2 and 3).

#### Area/Cover Type and Year Comparisons

Vegetation characteristics and nutrient content of key foods were compared between area/cover types and between years in HMLS and JCLS. Data from random sites were used to compare vegetation characteristics between area/cover types within years. In 1990, HMWS had less grass cover than HMLS and JCLS; there were no differences in cover of shrubs, total forbs, or key forbs (Table 4). However, HMLS had greater cover of other forbs and less cover of unused forbs than JCLS and HMWS. In 1991, HMLS had greater grass cover than JCMS and greater cover of total and other forbs than JCLS and JCMS. There were no differences in cover of key forbs, unused forbs, shrubs, or bare ground cover (Table 5). Cover of individual plant genera varied between area/cover types and years (Appendix 3).

Nutrient content of sagebrush and key forbs was compared between area/cover types within years. In 1990, crude protein and phosphorus content of sagebrush was greater in HMLS and HMWS than in JCLS but calcium content of sagebrush was greater in HMWS than HMLS and JCLS (Table 6). There was no difference in crude protein and calcium content of key forbs between area/cover types. However, key forbs from JCLS were higher in phosphorus than key forbs from HMLS and HMWS. In 1991, no differences were detected in crude protein and calcium content of sagebrush between area/cover types, but phosphorus

Table 4. Vegetation characteristics from randomly sampled sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990.

| cover (%)   | HMLS <sup>a</sup><br>(n=5) |      | JCLS<br>(n=8) |      | HMWS<br>(n=7) |     |
|-------------|----------------------------|------|---------------|------|---------------|-----|
|             | $\bar{x}$                  | SD   | $\bar{x}$     | SD   | $\bar{x}$     | SD  |
| Sagebrush   | 25.6                       | 11.0 | 21.1          | 10.9 | 25.4          | 4.6 |
| Other shrub | 0.0                        | 0.0  | 0.7           | 1.5  | 1.5           | 2.6 |
| Grass       | 10.8A <sup>b</sup>         | 3.9  | 10.1A         | 3.9  | 4.0B          | 2.3 |
| Total forb  | 8.8                        | 7.3  | 6.5           | 3.5  | 3.8           | 3.9 |
| Key forb    | 6.7                        | 8.0  | 3.6           | 3.5  | 1.7           | 2.2 |
| Other forb  | 1.7A                       | 0.9  | 0.9AB         | 1.2  | 0.2B          | 0.7 |
| Unused forb | 0.4A                       | 0.7  | 2.0B          | 2.6  | 1.8AB         | 2.2 |
| Bare ground | 60.2A                      | 9.4  | 60.4A         | 9.7  | 82.3B         | 5.0 |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type; HMWS = Hart Mountain Wyoming big sagebrush cover type.

<sup>b</sup>Means with different letters are significantly different between area/cover types ( $P < 0.05$ ).

Table 5. Vegetation characteristics from randomly sampled sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1991.

| cover (%)   | HMLS <sup>a</sup><br>(n=13) |     | JCLS<br>(n=9) |     | JCMS<br>(n=3) |      |
|-------------|-----------------------------|-----|---------------|-----|---------------|------|
|             | $\bar{x}$                   | SD  | $\bar{x}$     | SD  | $\bar{x}$     | SD   |
| Sagebrush   | 19.5                        | 7.9 | 19.9          | 2.5 | 23.0          | 14.4 |
| Other shrub | 0.4                         | 1.5 | 0.1           | 0.1 | 0.4           | 0.7  |
| Grass       | 5.4A <sup>b</sup>           | 2.7 | 4.4AB         | 1.6 | 2.2B          | 0.5  |
| Total forb  | 4.6A                        | 3.7 | 1.3B          | 1.2 | 1.7B          | 2.6  |
| Key forb    | 0.8                         | 0.6 | 0.8           | 1.0 | 0.5           | 0.7  |
| Other forb  | 2.2A                        | 1.9 | 0.1B          | 0.1 | 0.1B          | 0.1  |
| Unused forb | 1.8                         | 2.4 | 0.4           | 0.4 | 1.1           | 1.8  |
| Bare ground | 76.1                        | 6.0 | 75.1          | 6.5 | 76.8          | 15.0 |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type; JCMS = Jackass Creek mixed sagebrush cover type.

<sup>b</sup>Means with different letters are significantly different between cover types ( $P < 0.05$ ).

Table 6. Nutrient content (%) of key foods collected from Hart Mountain National Antelope Refuge low sagebrush cover type (HMLS) and Wyoming big sagebrush cover type (HMWS), and Jackass Creek low sagebrush cover type (JCLS), Oregon, March-April 1990.

| Food      | Nutrient      | HMLS<br>(n=14/20) <sup>a</sup> |      | JCLS<br>(n=15/30) |      | HMWS<br>(n=15/26) |      |
|-----------|---------------|--------------------------------|------|-------------------|------|-------------------|------|
|           |               | $\bar{x}$                      | SD   | $\bar{x}$         | SD   | $\bar{x}$         | SD   |
| Sagebrush | crude protein | 17.50A <sup>b</sup>            | 3.64 | 14.73B            | 1.94 | 16.70A            | 1.70 |
|           | calcium       | 0.58A                          | 0.04 | 0.55A             | 0.03 | 0.74B             | 0.12 |
|           | phosphorus    | 0.26A                          | 0.05 | 0.22B             | 0.02 | 0.25A             | 0.02 |
| Key forbs | crude protein | 26.66                          | 6.48 | 27.24             | 3.24 | 24.33             | 4.42 |
|           | calcium       | 0.94                           | 0.38 | 1.02              | 0.45 | 0.94              | 0.29 |
|           | phosphorus    | 0.39A                          | 0.08 | 0.51B             | 0.11 | 0.44A             | 0.06 |

<sup>a</sup>n = sagebrush/key forbs.

<sup>b</sup>Means with different letters are significantly different between area/cover types ( $P < 0.05$ ).

content of sagebrush was lower in HMLS than JCLS and JCMS (Table 7). No differences in nutrient content of key forbs between areas/cover types were detected in 1991.

Vegetation characteristics differed between years. In HMLS at foraging sites, cover of total, key, and other forbs was greater in 1990 than in 1991 (Table 8). However, there was no difference in cover of unused forbs. At random sites in HMLS, only cover of key forbs was different between years. At foraging and random sites in JCLS, cover of all forb categories and grass was greater in 1990 than 1991 (Table 9).

Nutrient content of key foods and the diet differed between years. In HMLS and JCLS, nutrient content of sagebrush was lower in 1991 than 1990. Key forbs in HMLS were higher in phosphorus in 1991, but there were no differences in crude protein and calcium (Table 10). Key forbs in JCLS were lower in calcium in 1991, but there were no differences between crude protein and phosphorus. Nutrient content of the diet did not differ among area/cover types within years (Table 11). However, crude protein, calcium, and phosphorus content of the diet was higher in 1990 than 1991.

## Selection

To assess selection for foraging sites, vegetation characteristics were compared between foraging and random sites within all 4 area/cover types. No differences in vegetation characteristics

Table 7. Nutrient content (%) of key foods collected from Hart Mountain National Antelope Refuge low sagebrush cover type (HMLS) and Jackass Creek low sagebrush cover type (JCLS) and mixed sagebrush cover type (JCMS), Oregon, March-April 1991.

| Food      | Nutrient      | HMLS<br>(n=15/37) <sup>a</sup> |      | JCLS<br>(n=15/19) |      | JCMS<br>(n=8/14) |      |
|-----------|---------------|--------------------------------|------|-------------------|------|------------------|------|
|           |               | $\bar{x}$                      | SD   | $\bar{x}$         | SD   | $\bar{x}$        | SD   |
| Sagebrush | crude protein | 13.98                          | 2.26 | 13.62             | 1.72 | 14.62            | 2.20 |
|           | calcium       | 0.42                           | 0.03 | 0.42              | 0.02 | 0.45             | 0.06 |
|           | phosphorus    | 0.19A <sup>b</sup>             | 0.02 | 0.20B             | 0.02 | 0.21B            | 0.04 |
| Key forbs | crude protein | 27.01                          | 4.85 | 24.99             | 3.77 | 26.71            | 2.99 |
|           | calcium       | 0.70                           | 0.57 | 0.76              | 0.30 | 0.71             | 0.28 |
|           | phosphorus    | 0.46                           | 0.08 | 0.46              | 0.08 | 0.48             | 0.09 |

<sup>a</sup>n = sagebrush/key forbs.

<sup>b</sup>Means with different letters are significantly different between area/cover types ( $P < 0.05$ ).

Table 8. Vegetation characteristics from foraging sites of female sage grouse and random sites at Hart Mountain National Antelope Refuge, Oregon, March-April 1990-91.

| Cover (%)   | Hart Mountain low sagebrush |      |                |     |               |      |                |     | Hart Mountain<br>Wyoming big sagebrush |     |               |     |
|-------------|-----------------------------|------|----------------|-----|---------------|------|----------------|-----|--|-----|---------------|-----|
|             | Foraging                    |      |                |     | Random        |      |                |     | Foraging                               |     | Random        |     |
|             | 1990<br>(n=5)               |      | 1991<br>(n=13) |     | 1990<br>(n=5) |      | 1991<br>(n=13) |     | 1990<br>(n=7)                          |     | 1990<br>(n=7) |     |
|             | $\bar{x}$                   | SD   | $\bar{x}$      | SD  | $\bar{x}$     | SD   | $\bar{x}$      | SD  | $\bar{x}$                              | SD  | $\bar{x}$     | SD  |
| Sagebrush   | 20.7                        | 6.6  | 16.6           | 5.8 | 25.6          | 11.0 | 19.5           | 7.9 | 20.6                                   | 6.9 | 25.4          | 4.6 |
| Other shrub | 0.2                         | 0.5  | 1.1            | 1.9 | 0             | 0    | 0.4            | 1.5 | 0.3                                    | 0.5 | 1.5           | 2.6 |
| Grass       | 11.0                        | 8.1  | 6.0            | 4.5 | 10.8          | 3.9  | 5.4            | 2.7 | 6.5                                    | 3.5 | 4.0           | 2.3 |
| Total forb  | 11.6A <sup>a</sup>          | 6.4  | 4.1B           | 2.4 | 8.8           | 7.3  | 4.6            | 3.7 | 1.2                                    | 0.9 | 3.8           | 3.9 |
| Key forb    | 6.2A                        | 5.1  | 1.6B           | 1.4 | 6.7A          | 8.0  | 0.8B           | 0.6 | 0.5                                    | 0.3 | 1.7           | 2.2 |
| Other forb  | 4.4A                        | 5.7  | 1.2B           | 1.7 | 1.7           | 0.9  | 2.2            | 1.9 | 0.1                                    | 0.2 | 0.2           | 0.7 |
| Unused forb | 1.0                         | 1.0  | 1.2            | 1.0 | 0.4           | 0.7  | 1.8            | 2.4 | 1.4                                    | 2.0 | 1.8           | 2.2 |
| Bare ground | 56.7A                       | 14.6 | 73.8B          | 7.6 | 60.2          | 9.4  | 76.1           | 6.0 | 79.2                                   | 7.4 | 82.3          | 5.0 |

<sup>a</sup>Means with different letters are significantly different between years within foraging and random sites at Hart Mountain low sagebrush cover type ( $P < 0.05$ ).

Table 9. Vegetation characteristics from foraging sites of female sage grouse and random sites at Jackass Creek, Oregon, March-April 1990-91.

| Cover (%)   | Jackass Creek low sagebrush |     |               |     |               |      |               |     | Jackass Creek mixed sagebrush |     |               |      |
|-------------|-----------------------------|-----|---------------|-----|---------------|------|---------------|-----|-------------------------------|-----|---------------|------|
|             | Foraging                    |     |               |     | Random        |      |               |     | Foraging                      |     | Random        |      |
|             | 1990<br>(n=8)               |     | 1991<br>(n=9) |     | 1990<br>(n=8) |      | 1991<br>(n=9) |     | 1990<br>(n=3)                 |     | 1990<br>(n=3) |      |
|             | $\bar{x}$                   | SD  | $\bar{x}$     | SD  | $\bar{x}$     | SD   | $\bar{x}$     | SD  | $\bar{x}$                     | SD  | $\bar{x}$     | SD   |
| Sagebrush   | 31.4A <sup>a</sup>          | 8.3 | 19.9B         | 6.7 | 21.1          | 10.9 | 19.9          | 2.5 | 15.3                          | 6.7 | 23.0          | 14.4 |
| Other shrub | 1.0                         | 2.1 | 0.6           | 0.8 | 0.7           | 1.5  | 0.1           | 0.1 | 0                             | 0   | 0.4           | 0.7  |
| Grass       | 9.9A                        | 4.3 | 3.2B          | 1.5 | 10.1A         | 3.9  | 4.4B          | 1.6 | 3.0                           | 0.9 | 2.2           | 0.5  |
| Total forb  | 7.3A                        | 3.8 | 1.3B          | 0.6 | 6.5A          | 3.5  | 1.3B          | 1.2 | 2.2                           | 1.4 | 1.7           | 2.6  |
| Key forb    | 3.7A                        | 2.6 | 0.5B          | 0.4 | 3.6A          | 3.5  | 0.8B          | 1.0 | 1.2                           | 1.3 | 0.5           | 0.7  |
| Other forb  | 1.1A                        | 1.4 | 0.1B          | 0.1 | 0.9A          | 1.2  | 0.1B          | 0.1 | 0                             | 0   | 0.1           | 0.1  |
| Unused forb | 2.5A                        | 2.1 | 0.8B          | 0.6 | 2.0A          | 2.6  | 0.4B          | 0.4 | 1.0                           | 1.4 | 1.1           | 1.8  |
| Bare ground | 56.2A                       | 5.1 | 79.8B         | 7.6 | 60.4A         | 9.7  | 75.1B         | 6.5 | 83.1                          | 4.0 | 76.8          | 15.0 |

<sup>a</sup>Means with different letters are significantly different between years within foraging and random sites at Jackass Creek low sagebrush cover type ( $P < 0.05$ ).



Table 10. Nutrient content (%) of sagebrush and key forbs of female sage grouse at Hart Mountain low sagebrush cover type (HMLS) and Jackass Creek low sagebrush cover type (JCLS), Oregon, March-April 1990-91.

| Nutrient      | Sagebrush                      |      |                   |      | Key forbs         |      |                   |      |
|---------------|--------------------------------|------|-------------------|------|-------------------|------|-------------------|------|
|               | 1990<br>(n=14/15) <sup>a</sup> |      | 1991<br>(n=15/15) |      | 1990<br>(n=20/30) |      | 1991<br>(n=37/19) |      |
|               | $\bar{x}$                      | SD   | $\bar{x}$         | SD   | $\bar{x}$         | SD   | $\bar{x}$         | SD   |
| HMLS:         |                                |      |                   |      |                   |      |                   |      |
| Crude protein | 17.50A <sup>b</sup>            | 3.64 | 13.98B            | 2.26 | 26.66             | 6.48 | 27.01             | 4.85 |
| Calcium       | 0.57A                          | 0.04 | 0.42B             | 0.03 | 0.94              | 0.38 | 0.70              | 0.57 |
| Phosphorus    | 0.26A                          | 0.05 | 0.19B             | 0.02 | 0.39A             | 0.08 | 0.46B             | 0.08 |
| JCLS:         |                                |      |                   |      |                   |      |                   |      |
| Crude protein | 14.73A                         | 1.94 | 13.61B            | 1.72 | 27.24             | 3.24 | 24.99             | 3.77 |
| Calcium       | 0.55A                          | 0.03 | 0.42B             | 0.02 | 1.02A             | 0.45 | 0.76B             | 0.30 |
| Phosphorus    | 0.22A                          | 0.02 | 0.20B             | 0.02 | 0.51              | 0.11 | 0.46              | 0.08 |

<sup>a</sup>n = HMLS/JCLS.

<sup>b</sup>Means with different letters are significantly different between years within sample type and area/cover type (P < 0.05).

Table 11. Nutrient content (%) of diets of pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.

| Year | Nutrient      | HMLS <sup>a</sup> | JCLS  | HMWS  | JCMS  |
|------|---------------|-------------------|-------|-------|-------|
| 1990 | crude protein | 20.51             | 20.41 | 19.78 |       |
|      | calcium       | 0.63              | 0.68  | 0.76  |       |
|      | phosphorus    | 0.31              | 0.34  | 0.31  |       |
| 1991 | crude protein | 17.63             | 16.99 |       | 18.05 |
|      | calcium       | 0.41              | 0.45  |       | 0.52  |
|      | phosphorus    | 0.23              | 0.26  |       | 0.28  |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type; HMWS = Hart Mountain Wyoming big sagebrush cover type; JCMS = Jackass Creek mixed sagebrush cover type.

between foraging and random sites were detected in any area/cover type for either year (Tables 8 and 9).

Frequency of key foods in crops and at foraging sites were compared to determine dietary selection. Most key forbs were used selectively (Table 12) and hawksbeard and mountain dandelion ranked first or second in selection in all area/cover types except JCLS in 1991 (hawksbeard) and HMWS (mountain dandelion). Sagebrush was used less than available in all area/cover types during both years.

Foods consumed by pre-laying female sage grouse had higher nutrient content than available forage. In 1990, sagebrush samples taken from grouse crops contained significantly more crude protein than samples from foraging sites and significantly more calcium than those taken from foraging and random sites (Table 13). Crude protein content of key forbs showed a similar trend but the variance was high and the difference was not significant ( $P = 0.12$ ) (Table 13). There were no differences in phosphorus content of sagebrush or key forbs between sites. In 1991, sagebrush from crops was higher in crude protein and phosphorus than samples from foraging and random sites; there was no difference in calcium levels (Table 14). Nutrient content of key forbs did not differ among crops, foraging, and random sites during 1991.

Table 12. Selection of key foods of female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.

| Key food           | HMLS <sup>a</sup> |                | JCLS          |               | HMWS          | JCMS          |
|--------------------|-------------------|----------------|---------------|---------------|---------------|---------------|
|                    | 1990<br>(n=4)     | 1991<br>(n=11) | 1990<br>(n=7) | 1991<br>(n=9) | 1990<br>(n=7) | 1991<br>(n=3) |
| Sagebrush          | 6 <sup>b</sup>    | 5              | 5             | 5             | 7             | 5             |
| Hawksbeard         | 1* <sup>c</sup>   | 2*             | 2*            | 0             | 1*            | 1*            |
| Desert parsley     | 5                 | 6              | 3*            | 1*            | 5*            | 3*            |
| Long-leaf phlox    | + <sup>d</sup>    | +              | 4*            | 3*            | 3*            | 4             |
| Everlasting        | 3*                | 3*             | 0             | 4*            | 6*            | +             |
| Mountain dandelion | 2*                | 1*             | 1*            | 2*            | 4*            | 2*            |
| Clover             | 4*                | 4              | +             | +             | +             | +             |
| Pursh's milkvetch  | +                 | +              | +             | +             | 2*            | +             |

<sup>a</sup>HMLS = Hart Mountain low sagebrush cover type; JCLS = Jackass Creek low sagebrush cover type;

HMWS = Hart Mountain Wyoming big sagebrush cover type; JCMS = Jackass Creek mixed sagebrush cover type.

<sup>b</sup>Ranked numerically from most selected (1) to least selected (?).

<sup>c</sup>\* = used in a greater proportion than available.

<sup>d</sup>+ = not a key food in the area/cover type.

Table 13. Nutrient content (%) of key foods collected from female sage grouse crops, sage grouse foraging sites, and random sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990.

| Food      | Nutrient      | Crop<br>(n=14/19) <sup>a</sup> |      | Foraging<br>(n=15/28) |      | Random<br>(n=15/29) |      |
|-----------|---------------|--------------------------------|------|-----------------------|------|---------------------|------|
|           |               | $\bar{x}$                      | SD   | $\bar{x}$             | SD   | $\bar{x}$           | SD   |
| Sagebrush | crude protein | 17.52A <sup>b</sup>            | 1.75 | 15.18B                | 2.07 | 16.23AB             | 3.64 |
|           | calcium       | 0.67A                          | 0.15 | 0.63B                 | 0.10 | 0.58B               | 0.06 |
|           | phosphorus    | 0.25                           | 0.03 | 0.23                  | 0.04 | 0.24                | 0.03 |
| Key forbs | crude protein | 28.10                          | 5.09 | 25.82                 | 4.71 | 25.04               | 4.40 |
|           | calcium       | 0.82                           | 0.28 | 1.04                  | 0.40 | 1.00                | 0.41 |
|           | phosphorus    | 0.49                           | 0.08 | 0.46                  | 0.08 | 0.43                | 0.12 |

<sup>a</sup>n = sagebrush/key forbs.

<sup>b</sup>Means with different letters are significantly different between crop, foraging, and random sites ( $P < 0.05$ ).

Table 14. Nutrient content (%) of key foods collected from female sage grouse crops, sage grouse foraging sites, and random sites at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1991.

| Food      | Nutrient      | Crop<br>(n=12/13) <sup>a</sup> |      | Foraging<br>(n=13/33) |      | Random<br>(n=13/24) |      |
|-----------|---------------|--------------------------------|------|-----------------------|------|---------------------|------|
|           |               | $\bar{x}$                      | SD   | $\bar{x}$             | SD   | $\bar{x}$           | SD   |
| Sagebrush | crude protein | 15.82A <sup>b</sup>            | 1.51 | 13.20B                | 1.54 | 13.04B              | 1.80 |
|           | calcium       | 0.44                           | 0.04 | 0.43                  | 0.04 | 0.42                | 0.03 |
|           | phosphorus    | 0.21A                          | 0.01 | 0.19B                 | 0.02 | 0.19B               | 0.03 |
| Key forbs | crude protein | 25.93                          | 2.86 | 26.88                 | 5.08 | 26.01               | 3.81 |
|           | calcium       | 0.47                           | 0.27 | 0.72                  | 0.46 | 0.84                | 0.50 |
|           | phosphorus    | 0.44                           | 0.06 | 0.48                  | 0.08 | 0.46                | 0.09 |

<sup>a</sup>n = sagebrush/key forbs.

<sup>b</sup>Means with different letters are significantly different between crop, foraging, and random sites ( $P < 0.05$ ).

## DISCUSSION

Diet and nutrition of pre-laying female sage grouse differed between the two years of this study and sage grouse demonstrated selectivity when foraging. About 16 to 56% of the diet of pre-laying female sage grouse was composed of forbs and female sage grouse used forbs selectively. Sage grouse selected sagebrush high in crude protein. Nutrient content of the diet was lower during 1991 and may be related to lower productivity of sage grouse during 1991 compared with 1990.

Forbs may be a more important factor in diets of sage grouse hens during the pre-laying period than previously reported. I found forbs constituted twice the amount of March and early April diets of female sage grouse than reported previously. Previous authors, working in Montana, Wyoming, and Colorado, reported sagebrush composed 100% of the diet in February (Wallestad 1975), 97% in March (Wallestad 1975), 86-100% in April (Patterson 1952, Rogers 1964), and 80-86% in May (Patterson 1952, Rasmussen and Griner 1938) and general consensus among sage grouse researchers is that diets of female sage grouse during the pre-laying period are composed primarily of sagebrush. Johnson and Boyce (1991) mention that diets of sage grouse hens are composed almost exclusively of sagebrush until they nest. However, none of the authors separated the sexes, and diets of males and females may differ in spring. Female blue grouse (Dendragapus obscurus) and Icelandic ptarmigan (Lagopus mutus) switched to a diet

of forbs more rapidly and earlier in spring than males (King and Bendell 1982, Gardarsson and Moss 1969).

None of the studies of sage grouse diets in spring presented information on food availability, therefore no information is available on food selection by female sage grouse during the pre-laying period. I found that pre-laying female sage grouse exhibited selection on 2 of 3 levels investigated in this study. Female sage grouse did not select foraging areas within cover types on the basis of cover of sagebrush, grass, or forbs because no differences were detected between foraging and random sites. However, hens consistently ate a specific group of key forbs (hawksbeard, desert parsley, long-leaf phlox, everlasting, and mountain dandelion) and used forbs in a greater proportion than they were available at foraging sites. These key forbs were higher in crude protein, calcium, and phosphorus than sagebrush (Appendix 4). In addition, sage grouse selected sagebrush higher in crude protein than sagebrush that was available at foraging and random sites. However, sagebrush was not used selectively because it was widely available.

Female sage grouse may have selectively used forbs, and selected sagebrush high in crude protein, to meet nutritional demands of egg laying. Selection for high nutrient foods during the breeding season has been documented in other grouse species. Foods of rock ptarmigan were higher in nutrients than available food that was not eaten (Gardarsson and Moss 1969) and red grouse selected heather higher in nitrogen, calcium, and soluble carbohydrates from heather that was available (Moss 1972).



Nutrient selection by female sage grouse during the breeding season has not been studied. However, 3 authors investigated nutrient selection by male and female sage grouse during in winter and results were inconsistent. Sage grouse in Colorado foraged on sagebrush plants higher in crude protein than unused plants (Barber et al. 1969, Remington and Braun 1985). In Utah, sage grouse selected sagebrush based on its digestibility rather than its crude protein content (Welch et al. 1988). My results indicated sage grouse were selecting sagebrush high in crude protein, which is consistent with the results of Barber et al. (1969) and Remington and Braun (1985).

Selection for high nutrient foods by pre-laying female sage grouse occurred in both 1990 and 1991, but composition and nutrient content of the diet differed between years. Availability and use of forbs, and dietary nutrient content decreased in 1991 compared with 1990. Decreased forb availability probably led to lower forb intake and therefore, dietary nutrient content. Lower nutrient content of sagebrush further lowered dietary nutrient levels in 1991. These differences transcended area/cover types because availability of key forbs, percent forb in the diet, and nutrient content of the diet did not differ by area/cover type within year.

Differences in productivity between years may be related to differences in composition and nutrient content of the diet between years. Productivity of sage grouse at Hart Mountain and Jackass Creek was lower in 1991 than 1990. No one has investigated the relationship between diet of hens and productivity of sage grouse, but research with several European grouse suggests a relationship between diet,

nutrition of pre-laying hens, and productivity. Clutch size and weight and chick viability of captive ruffed grouse (Bonasa umbellus) increased linearly when dietary protein levels were raised incrementally from 8 to 20% (Beckerton and Middleton 1982). Likewise, clutch size and chick viability of captive willow ptarmigan were higher when diets of hens contained 20% crude protein compared with 15% protein (Hanssen et al. 1982). Breeding success of wild red grouse was positively correlated with increased nitrogen of the primary food during the pre-laying period (Moss et al. 1975). Year to year variations of brood size of rock ptarmigan were associated with number of days that newly growing plants were available to hens (Moss and Watson 1984) and annual fluctuations in autumn populations of capercaillie (Tetrao urogallus) and black grouse (I. tetrix) were associated with amounts of green material in spring diets of hens (Siivonen 1957). Although data were only available for 2 years, my results indicate a similar relationship may exist for sage grouse.

Availability of forbs during the pre-laying period may be related to reproductive success of sage grouse. Forbs have higher nutrient content than sagebrush and hens selected forbs when foraging. Because female sage grouse are near leks and nesting areas during the pre-laying period, sagebrush communities surrounding leks and nesting areas should have a healthy, diverse understory of early-season forbs.

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## APPENDICES

Appendix 1. Foods used by pre-laying female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.

| Taxa                  | Scientific name                   | Part eaten         |
|-----------------------|-----------------------------------|--------------------|
| SHRUBS:               |                                   |                    |
| Low sagebrush         | <i>Artemisia arbuscula</i>        | leaves             |
| Wyoming big sagebrush | <i>A. tridentata wyomingensis</i> | leaves             |
| FORBS AND GRASSES:    |                                   |                    |
| Desert parsley        | <i>Lomatium</i> spp.              | leaves and flowers |
| Hawksbeard            | <i>Crepis</i> spp.                | leaves             |
| Long-leaf phlox       | <i>Phlox longifolia</i>           | leaves             |
| Mountain dandelion    | <i>Agoseris</i> spp.              | leaves             |
| Clover                | <i>Trifolium</i> spp.             | leaves             |
| Everlasting           | <i>Antennaria</i> spp.            | leaves and buds    |
| Pursh's milkvetch     | <i>Astragalus purshii</i>         | leaves             |
| Buckwheat             | <i>Eriogonum</i> spp.             | leaves             |
| Obscure milkvetch     | <i>Astragalus obscurus</i>        | leaves and buds    |
| Buttercup             | <i>Ranunculus</i> spp.            | leaves and flowers |
| Phlox spp.            | <i>Phlox</i> spp.                 | leaves             |
| Blue-eyed mary        | <i>Collinsia</i> spp.             | leaves             |
| Bluebells             | <i>Mertensia</i> spp.             | leaves             |
| Larkspur              | <i>Delphinium</i> spp.            | leaves             |
| Rockcress             | <i>Arabis</i> spp.                | leaves             |
| Daisy                 | <i>Erigeron</i> spp.              | leaves             |
| Unknown forbs         |                                   | leaves             |
| Dead grass            | Gramineae                         | leaves             |
| INSECTS:              |                                   |                    |
| Ants                  | Formica                           | whole              |
| Caterpillars          | Lepidoptera                       | whole              |
| Beetles               | Coleoptera                        | whole              |

Appendix 2. Percent aggregate dry mass of foods of pre-laying female sage grouse at Hart Mountain National Antelope Refuge, low sagebrush cover type (HMLS) and Wyoming big sagebrush cover type (HMWS) and Jackass Creek, low sagebrush cover type (JCLS) and mixed sagebrush cover type (JCMS), Oregon, March-April 1990-91.

| Cover type | Common name           | Mass |      |
|------------|-----------------------|------|------|
|            |                       | 1990 | 1991 |
| HMLS       | Low sagebrush         | 56.6 | 83.8 |
|            | Hawksbeard            | 17.9 | 7.2  |
|            | Clover                | 8.6  | 1.2  |
|            | Everlasting           | 6.2  | 1.1  |
|            | Obscure milkvetch     | 4.8  | 0.1  |
|            | Mountain dandelion    | 1.6  | 1.8  |
|            | Desert parsley        | 1.0  | 3.3  |
|            | Unknown forbs         | 0.7  | 0    |
|            | Pursh's milkvetch     | 0.7  | 0    |
|            | Dead grass            | 0.4  | 0.4  |
|            | Sagebrush galls       | 0.4  | 0.9  |
|            | Buttercup             | 0.3  | 0    |
|            | Caterpillars          | 0.1  | 0    |
|            | Long-leaf phlox       | 0.1  | 0.2  |
|            | Buckwheat             | 0.1  | 0    |
|            | Ants                  | 0.1  | 0    |
|            | Phlox spp.            | 0.1  | 0.1  |
|            | Bluebells             | 0    | 0.1  |
|            | Larkspur              | 0    | 0.1  |
| HMWS       | Wyoming big sagebrush | 58.6 |      |
|            | Hawksbeard            | 12.6 |      |
|            | Long-leaf phlox       | 9.5  |      |
|            | Everlasting           | 6.0  |      |
|            | Desert parsley        | 5.7  |      |
|            | Buckwheat             | 1.6  |      |



## Appendix 2. Cont.

| Cover type | Common name        | Mass |      |
|------------|--------------------|------|------|
|            |                    | 1990 | 1991 |
| HMWS       | Mountain dandelion | 1.5  |      |
|            | Pursh's milkvetch  | 1.4  |      |
|            | Sagebrush galls    | 1.1  |      |
|            | Unknown forbs      | 0.5  |      |
|            | Dead grass         | 0.3  |      |
|            | Rockcress          | 0.2  |      |
|            | Low sagebrush      | 0.2  |      |
|            | Obscure milkvetch  | 0.1  |      |
|            | Phlox spp.         | <0.1 |      |
|            | Beetle             | <0.1 |      |
| JCLS       | Low sagebrush      | 44.3 | 79.2 |
|            | Desert parsley     | 28.4 | 12.4 |
|            | Hawksbeard         | 10.4 | 0    |
|            | Long-leaf phlox    | 7.7  | 4.0  |
|            | Mountain dandelion | 5.9  | 0.1  |
|            | Buttercup          | 0.9  | 0    |
|            | Dead grass         | 0.7  | 0.5  |
|            | Obscure milkvetch  | 0.3  | 0.1  |
|            | Unknown forbs      | 0.2  | 0    |
|            | Sagebrush galls    | 0.1  | 0.1  |
|            | Ants               | 0.1  | 0    |
|            | Daisy              | 0.1  | 0    |
|            | Pursh's milkvetch  | 0.1  | 0.1  |
|            | Blue-eyed mary     | <0.1 | <0.1 |
|            | Clover             | <0.1 | 0    |
|            | Phlox spp.         | <0.1 | <0.1 |

## Appendix 2. Cont.

| Cover type | Common name        | Mass |      |
|------------|--------------------|------|------|
|            |                    | 1990 | 1991 |
| JCMS       | Low sagebrush      |      | 72.3 |
|            | Desert parsley     |      | 19.7 |
|            | Hawksbeard         |      | 3.7  |
|            | Mountain dandelion |      | 1.8  |
|            | Long-leaf phlox    |      | 1.1  |
|            | Everlasting        |      | 0.7  |
|            | Dead grass         |      | 0.5  |
|            | Obscure milkvetch  |      | 0.1  |
|            | Phlox spp.         |      | 0.1  |
|            | Sagebrush galls    |      | <0.1 |
|            | Ants               |      | <0.1 |

Appendix 3. Cover (%) of plants at Hart Mountain National Antelope Refuge, low sagebrush cover type (HMLS) and Wyoming big sagebrush cover type (HMWS) and Jackass Creek, low sagebrush cover type (JCLS) and mixed sagebrush cover type (JCMS), Oregon, March-April 1990-91.

| Cover type | Taxa                       | Cover |      |
|------------|----------------------------|-------|------|
|            |                            | 1990  | 1991 |
| HMLS       | <i>Artemisia arbuscula</i> | 20.6  | 16.6 |
|            | <i>Poa</i> spp.            | 10.8  | 4.0  |
|            | <i>Phlox</i> spp.          | 3.0   | 0.9  |
|            | <i>Trifolium</i> spp.      | 2.8   | 0.2  |
|            | <i>Lomatium</i> spp.       | 1.7   | 1.0  |
|            | <i>Arenaria</i> spp.       | 0     | 0.6  |
|            | <i>Phlox longifolia</i>    | 1.0   | 0.2  |
|            | <i>Erigeron</i> spp.       | 0     | 0.3  |
|            | <i>Agropyron</i> spp.      | 0     | 0.3  |
|            | <i>Ranunculus</i> spp.     | 0     | 0.1  |
|            | <i>Crepis</i> spp.         | 0.8   | 0.3  |
|            | <i>Antennaria</i> spp.     | 0.7   | <0.1 |
|            | <i>Astragalus obscurus</i> | 0.4   | <0.1 |
|            | <i>Agoseris</i> spp.       | 0.3   | 0.1  |
|            | <i>Allium</i> spp.         | 0.2   | 0.2  |
|            | <i>Sitanion</i> spp.       | 0.2   | 1.6  |
|            | <i>Eriogonum</i> spp.      | 0.2   | <0.1 |
|            | <i>Tetradymia</i> spp.     | 0.2   | 0.8  |
|            | <i>Aster</i> spp.          | 0.1   | 0    |
|            | <i>Erigeron</i> spp.       | 0.1   | 0    |
|            | <i>Zygadenus</i> spp.      | 0.1   | <0.1 |
|            | <i>Astragalus</i> spp.     | 0.1   | 0    |
|            | <i>Microsteris</i> spp.    | <0.1  | 0.1  |
|            | <i>Stipa</i> spp.          | 0     | 0.2  |
|            | <i>Arabis</i> spp.         | 0     | <0.1 |
|            | <i>Delphinium</i> spp.     | 0     | <0.1 |
|            | <i>Atriplex</i> spp.       | 0     | 0.5  |

## Appendix 3. Cont.

| Cover type | Taxa                              | Cover |      |
|------------|-----------------------------------|-------|------|
|            |                                   | 1990  | 1991 |
| HMWS       | <i>A. tridentata wyomingensis</i> | 20.6  |      |
|            | <i>Poa</i> spp.                   | 4.6   |      |
|            | <i>Sitanion</i> spp.              | 1.4   |      |
|            | <i>Allium</i> spp.                | 0.6   |      |
|            | <i>Lomatium</i> spp.              | 0.4   |      |
|            | <i>Arabis</i> spp.                | 0.1   |      |
|            | <i>Phlox longifolia</i>           | 0.1   |      |
|            | <i>Spinos</i> spp.                | 0.1   |      |
|            | <i>Microsteris</i> spp.           | <0.1  |      |
|            | <i>Lewisia</i> spp.               | <0.1  |      |
|            | <i>Antennaria</i> spp.            | <0.1  |      |
|            | <i>Phlox</i> spp.                 | <0.1  |      |
| JCLS       | <i>A. Arbuscula</i>               | 31.4  | 19.8 |
|            | <i>Poa</i> spp.                   | 9.8   | 3.0  |
|            | <i>Sitanion</i> spp.              | 0.1   | 0.5  |
|            | <i>Arenaria</i> spp.              | 0.1   | 0.4  |
|            | <i>Lomatium</i> spp.              | 2.8   | 0.2  |
|            | <i>Atriplex</i> spp.              | 1.2   | 0    |
|            | <i>Erigeron</i> spp.              | 1.1   | 0.3  |
|            | <i>Phlox</i> spp.                 | 0.7   | 0    |
|            | <i>Microsteris</i> spp.           | 0.6   | <0.1 |
|            | <i>Phlox longifolia</i>           | 0.3   | 0.1  |
|            | <i>Eriogonum</i> spp.             | 0.3   | <0.1 |
|            | <i>Agoseris</i> spp.              | 0.3   | <0.1 |
|            | <i>Ranunculus</i> spp.            | 0.2   | 0    |
|            | <i>Antennaria</i> spp.            | 0.2   | 0.1  |
|            | <i>Crepis</i> spp.                | 0.2   | 0    |

## Appendix 3. Cont.

| Cover type | Taxa                              | Cover |      |
|------------|-----------------------------------|-------|------|
|            |                                   | 1990  | 1991 |
| JCLS       | <i>Frasera</i> spp.               | 0.1   | 0    |
|            | <i>Aster</i> spp.                 | 0.1   | 0    |
|            | <i>Astragalus obscurus</i>        | 0.1   | <0.1 |
|            | <i>Astragalus purshii</i>         | <0.1  | 0    |
|            | <i>Collinsia</i> spp.             | <0.1  | 0    |
|            | <i>Lithophragma</i> spp.          | <0.1  | 0    |
|            | <i>Allium</i> spp.                | 0     | <0.1 |
|            | <i>Arabis</i> spp.                | 0     | <0.1 |
| JCMS       | <i>A. arbuscula</i>               |       | 9.8  |
|            | <i>A. tridentata wyomingensis</i> |       | 5.5  |
|            | <i>Poa</i> spp.                   |       | 3.0  |
|            | <i>Lomatium</i> spp.              |       | 0.8  |
|            | <i>Arenaria</i> spp.              |       | 0.7  |
|            | <i>Phlox longifolia</i>           |       | 0.3  |
|            | <i>Erigeron</i> spp.              |       | 0.2  |
|            | <i>Microsteris</i> spp.           |       | 0.1  |
|            | <i>Crepis</i> spp.                |       | 0.1  |
|            | <i>Allium</i> spp.                |       | <0.1 |

Appendix 4. Frequency of key foods in crops (use) and at foraging sites (availability) of female sage grouse at Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.

| Cover type                                | Key food           | 1990 |        | 1991 |        |
|---|--------------------|------|--------|------|--------|
|   |                    | Use  | Avail. | Use  | Avail. |
| Hart Mountain<br>low sagebrush            | Sagebrush          | 50.5 | 24.0   | 65.4 | 20.5   |
|   | Hawksbeard         | 19.0 | 1.4    | 16.0 | 0.3    |
|   | Desert parsley     | 0.8  | 1.4    | 6.3  | 2.1    |
|   | Everlasting        | 2.8  | 0.8    | 1.8  | 0.1    |
|   | Mountain dandelion | 2.0  | 0.1    | 5.6  | 0.2    |
|   | Clover             | 11.8 | 2.6    | 0.1  | 0.4    |
| Hart Mountain<br>Wyoming big<br>sagebrush | Sagebrush          | 52.4 | 24.9   |      |        |
|   | Hawksbeard         | 12.0 | 0.1    |      |        |
|   | Desert parsley     | 10.4 | 1.0    |      |        |
|   | Long-leaf phlox    | 14.3 | 0.5    |      |        |
|   | Everlasting        | 4.1  | 0.1    |      |        |
|   | Mountain dandelion | 0.8  | 0      |      |        |
|   | Pursh's milkvetch  | 1.6  | 0      |      |        |
| Jackass Creek<br>low sagebrush            | Sagebrush          | 31.6 | 31.9   | 61.4 | 25.4   |
|   | Hawksbeard         | 7.1  | 0.2    | 0    | 0      |
|   | Desert Parsley     | 39.0 | 3.8    | 24.3 | 0.6    |
|   | Long-leaf phlox    | 3.6  | 0.9    | 6.3  | 0.6    |
|   | Everlasting        | 0    | 0      | 6.9  | 0.3    |
|   | Mountain dandelion | 17.3 | 0.1    | 0.3  | 0      |

| Cover type                          | Key food           | 1990 |        | 1991 |        |
|-------------------------------------|--------------------|------|--------|------|--------|
|                                     |                    | Use  | Avail. | Use  | Avail. |
| Jackass Creek<br>mixed<br>sagebrush | Sagebrush          |      |        | 55.3 | 13.7   |
|                                     | Hawksbeard         |      |        | 14.3 | 0      |
|                                     | Desert parsley     |      |        | 24.3 | 1.7    |
|                                     | Long-leaf phlox    |      |        | 2.3  | 0.4    |
|                                     | Mountain dandelion |      |        | 1.7  | 0      |

Appendix 5. Crude protein (cp), calcium (ca), and phosphorus (p) content of some foods of pre-laying female sage grouse, Hart Mountain National Antelope Refuge and Jackass Creek, Oregon, March-April 1990-91.

| Taxa                  | Part            | cp<br>(%) | ca<br>(%) | p<br>(%) |
|-----------------------|-----------------|-----------|-----------|----------|
| KEY FOODS:            |                 |           |           |          |
| Low sagebrush         | leaves          | 14.98     | 0.49      | 0.22     |
| Wyoming big sagebrush | leaves          | 16.70     | 0.74      | 0.25     |
| Hawksbeard            | leaves          | 29.45     | 0.74      | 0.50     |
| Desert parsley        | leaves          | 25.35     | 1.23      | 0.42     |
| Desert parsley        | flowers         | 26.38     | 0.35      | 0.63     |
| Long-leaf phlox       | leaves          | 26.80     | 0.90      | 0.49     |
| Everlasting           | leaves and buds | 17.75     | 0.49      | 0.37     |
| Mountain dandelion    | leaves          | 25.88     | 0.44      | 0.46     |
| Clover                | leaves          | 37.68     | 0.68      | 0.47     |
| Pursh's milkvetch     | leaves          | 23.75     | 0.62      | 0.30     |
| OTHER FOODS:          |                 |           |           |          |
| Obscure milkvetch     | leaves and buds | 27.33     | 0.54      | 0.30     |
| Buttercup             | leaves          | 22.32     | 0.48      | 0.42     |
| Buttercup             | flowers         | 22.62     | 0.23      | 0.70     |
| Buckwheat             | leaves          | 19.04     | 0.72      | 0.32     |