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Title: Habitat Use and Selection by Sage Grouse Broods in Southeastern Oregon

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In Oregon, sage grouse (Centrocercus urophasianus) were common in the eastern portion of the state. Since 1940 populations declined because of decreased productivity. The western subspecies (C. u. phaios) was listed as a candidate for threatened and endangered status in 1985 because of declines in Oregon and Washington and extirpation from British Columbia. Habitat availability and habitat condition were factors associated with impaired productivity. Stand structure and forb availability were characteristics most associated with habitat selection by hens with broods. The objectives of this study were to determine habitat use and selection by hens with broods and the relationship between food availability, habitat use by hens, and diets of juvenile sage grouse. Of the 2 study areas used, Hart Mountain had greater long term productivity and abundance than Jackass Creek. Use of cover types and habitat components were compared within and between study areas.

In this study, sage grouse hens selected low sagebrush (Artemisia sp.) cover types during early brood-rearing then switched to use of big sagebrush cover types during late brood-rearing. In general, cover types used selectively had greater availability of forbs, and changes in forb availability within cover types from early to late brood-rearing corresponded to changes in cover type use. Differences in forb availability between study

areas may have affected productivity. Hens at Jackass Creek selected sites with forb cover similar to that available to broods at Hart Mountain and home ranges were larger at Jackass Creek. Furthermore, diets of juvenile sage grouse were higher in forbs and insects at Hart Mountain. Larger home ranges and less nutritious diets were potentially responsible for lower productivity at Jackass Creek. Results indicated that management to improve brood habitat should focus on maintenance of cover type diversity and availability of forbs.

Habitat Use and Selection by Sage Grouse Broods in Southeastern Oregon

by

Martin S. Drut

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Head of department of Fisheries and Wildlife

Redacted for Privacy

Dean of Graduate School

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Typed by researcher for Martin S. Drut

I dedicate this thesis to my grandmother

Minna Ginzler,

who inspired me without a word

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TABLE OF CONTENTS

Page

LIST OF TABLES

Table

Page

Habitat Use and Selection by Sage Grouse Broods in Southeastern Oregon

INTRODUCTION

Sage grouse (Centrocercus urophasianus) distribution contracted since 1900 throughout much of their range because of land-use practices, such as livestock grazing and sagebrush (Artemisia spp.) removal for agricultural purposes, that negatively affected shrub-steppe habitats (Patterson 1952:260, Martin 1970, Wallestad 1971, Klebenow 1982). In Oregon, sage grouse were common in sagebrush-dominated areas east of the Cascade Mountain Range before 1940 (Gabrielson and Jewett 1940). Since 1940, sage grouse populations declined approximately 60% and during the same period, productivity (chicks/adult, chicks/brood, and percent adults with broods) declined as much as 68%, resulting in changes in sage grouse abundance (Crawford and Lutz 1985). As a consequence of declines in Oregon and Washington and extirpation from British Columbia, the western subspecies (C. u. phaios) was listed as a candidate for threatened and endangered status by the Department of Interior (Federal Register, 18 September 1985).

Habitat availability and condition were factors that limited sage grouse populations through impaired productivity of hens (Klebenow 1969, Blake 1970, Wallestad 1975, Martin 1976, Autenrieth 1981). Stand structure and forb availability were characteristics most associated with habitat selection by hens with broods (Klebenow 1969, Peterson 1970, Wallestad 1971, Autenrieth 1981, Dunn and Braun 1986). Forbs and insects formed the primary forage of sage grouse chicks and shrubs provided escape and thermal cover (Klebenow and Gray 1968, Peterson

1970). A relationship may exist between availability of forage and escape cover and success of hens to recruit broods into the fall population.

The objectives of this study were to determine use and selection of cover types and habitat components by sage grouse hens with broods on 2 study areas in southeastern Oregon and to determine the relationship between food availability, habitat use by hens with broods, and diets of sage grouse chicks. Null hypotheses of no selection by hens with broods and no relationship to diets of chicks were tested.

STUDY AREAS

The study was conducted on 2 areas: Jackass Creek, administered by the Bureau of Land Management (BLM), and Hart Mountain National Antelope Refuge, administered by the U.S. Fish and Wildlife Service (USFWS) (Figure 1). Historical information about sage grouse populations, from 1950 to 1991, was available from surveys conducted by Oregon Department of Fish and Wildlife (ODFW) at Jackass Creek and by the USFWS at Hart Mountain, and from 2 research studies. Hart Mountain served as a location for study of habitat use and diet of sage grouse hens (Nelson 1955) and Jackass Creek was used by ODFW for an investigation of habitat selection for nesting and brood-rearing by sage grouse from 1984 to 1986 (G. P. Keister, Oreg. Dep. Fish and Wildl., unpubl. data). Hart Mountain represented some of the best remaining sage grouse habitat in Oregon and supported greater abundance and had higher productivity of sage grouse than Jackass Creek. Estimates of sage grouse abundance since 1980 were approximately 2.5 birds/km^2 and 1.5 birds/km^2 at Hart Mountain and Jackass Creek, respectively (J. Lemos, Oreg. Dep. Fish and Wildl., unpubl. data; W. H. Pyle, U. S. Fish and Wildl. Serv., unpubl. data). Abundance estimates were based on number of males/lek and a sex ratio of 40 males:60 females (Rogers 1964). Summer productivity counts from 1981 through 1990, the only period for which comparable data were available, were 1.9 and 1.0 chicks/hen for Hart Mountain and Jackass Creek, respectively. At Jackass Creek, cover types available to sage grouse hens and land management practices were typical of much of the remaining sage grouse range in the state.

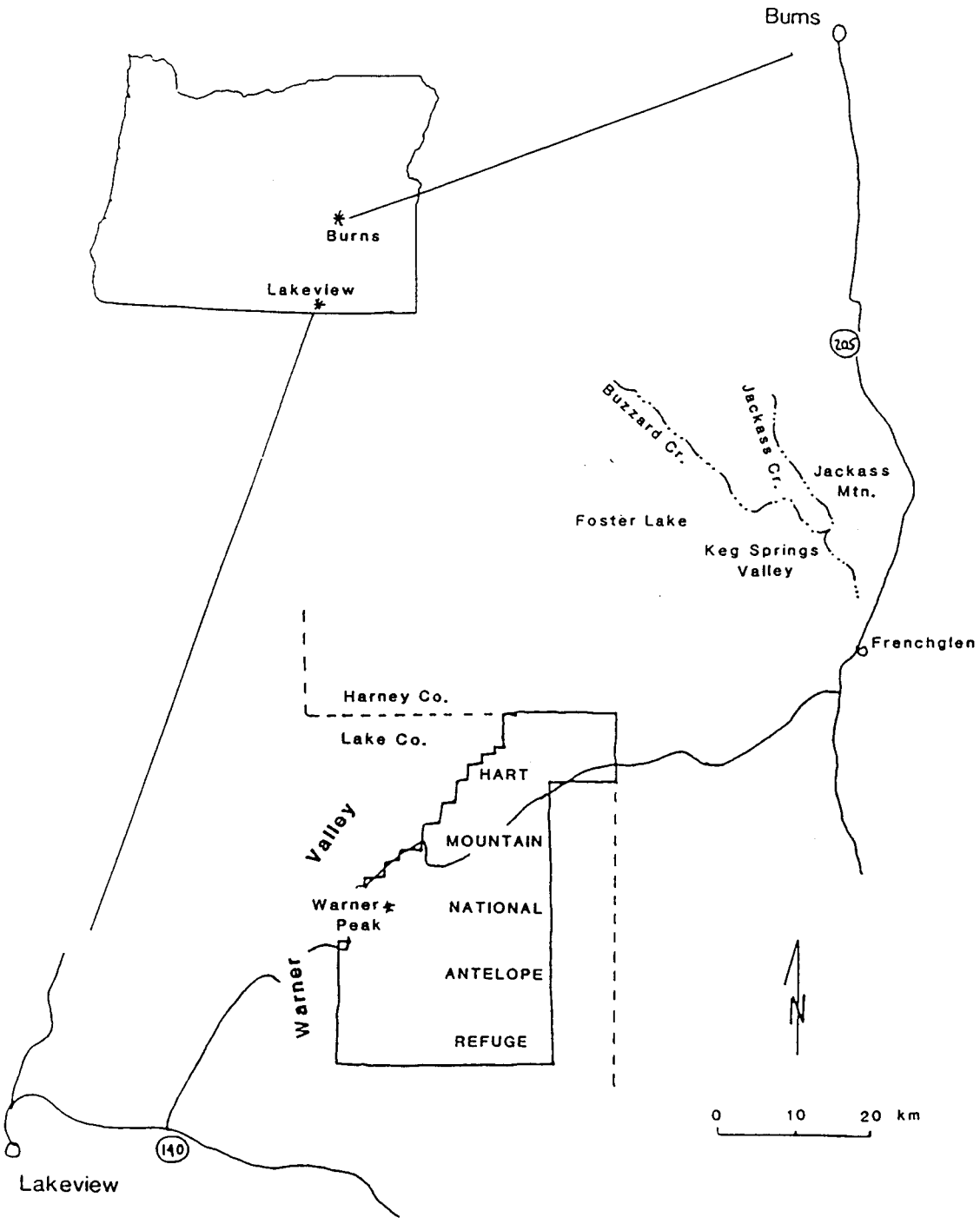

Figure 1. Location of the study areas in Lake and Harney Counties, Oregon.

Jackass Creek

The Jackass Creek study area, located approximately 70 km southwest of Burns, Harney County, Oregon, comprised nearly 39,000 ha. The area ranged from sagebrush covered plains in the west to undulating ridges and draws to the east, eventually rising to Jackass Mountain (1700 m). The main plateau descended into Keg Springs Valley to the south and Jackass Creek canyon bisected the study area east and west. Buzzard Creek formed a second major drainage that joined Jackass Creek in the southeast and Foster Lake formed a large, seasonal lakebed at the western end of the study area. Major sources of water were Jackass Creek, Buzzard Creek, lakebeds, and water developments (distributed throughout the study area). In contrast to Hart Mountain, meadow habitats were few and widely dispersed. Annual temperature averaged 10° C and mean precipitation was 28.5 cm. Precipitation was 13 and 21 cm during 1990 and 1991, respectively (U. S. Natl. Weather Serv., Burns, Oreg.).

Prominent vegetation consisted of low sagebrush (A. arbuscula) and big sagebrush (A. tridentata). Western junipers (Juniperus occidentalis) were present on the eastern portion of the study area. Common annual and perennial forbs included mountain dandelion (Agoseris spp.), hawksbeard (Crepis spp.), lupine (Lupinus spp.), and phlox (Phlox spp.). Grasses consisted largely of bluegrass (Poa spp.), wheatgrass (Agropyron spp.), needle-and-thread grass (Stipa spp.), and fescue (Festuca spp.). Plant nomenclature followed Hitchcock and Cronquist (1987).

Livestock grazing averaged 7000 animal unit months (AUMs) and range use by wild horses averaged 2000 AUMs from 1985 through 1990 (F. Taylor, Bur. of Land Manage., pers. commun.). Livestock grazing occurred from 1 April to 1 September.

Hart Mountain National Antelope Refuge

The Hart Mountain National Antelope Refuge study area, located approximately 100 km southwest of Jackass Creek in Lake County, Oregon, comprised nearly 89,000 ha. Elevation ranged from 1500 m at the eastern portion of the refuge to 2450 m in the west (Warner Peak). Surrounding desert consisted of flat sagebrush plains interrupted by rolling hills, ridges, and draws. Hart Mountain supported several springs, lakes, creeks, and meadow habitats. Seasonally flooded lakebeds, some of which held water throughout the summer, were most common in the southern portion of the study area. At refuge headquarters (elevation 1700 m), annual temperature averaged 6° C and mean precipitation was 29 cm and at higher elevations (> 1800 m) temperatures were lower and precipitation greater than at headquarters.

Dominant cover consisted of low sagebrush, big sagebrush, and bitterbrush (Purshia tridentata). High elevation stands included juniper, mountain mahogany (Cercocarpus ledifolius), and aspen (Populus tremuloides). Forb and grass genera were similar to those at Jackass Creek but species differed with elevation (e.g., presence of rough fescue (F. scabrella) above 2000 m).

Livestock grazing was permitted on the refuge until 1991. Approximately 12,000 AUMs were allocated from 15 April to 15 December;

a rest rotation, deferred grazing system was used (W. H. Pyle, U. S. Fish and Wildl. Serv., pers. commun.). The number of AUMs differed annually in relation to range conditions (W. H. Pyle, U. S. Fish and Wildl. Serv., pers. commun.). Wild horses occurred on the area, but numbers were reduced from 225 in 1987 to 25 by 1988 (W. H. Pyle, U. S. Fish and Wildl. Serv., pers. commun.). In 1985, a wild fire burned approximately 4,500 ha in the center of the refuge.

METHODS

Habitat selection by sage grouse hens with broods was evaluated on a hierarchical order of selection (Johnson 1980). Selection for cover types (third order selection) and for habitat components within cover types (fourth order selection) was evaluated within and between study areas from radio-marked hens.

Trapping and Radio-marking of Hens

The study was conducted during the breeding seasons (March through August) from 1989 to 1991. A total of 278 hens (139 on each study area) was trapped and equipped with radio transmitters. At the conclusion of each field season, marked hens were recaptured, radio transmitters removed, and a sample of previously unmarked hens was equipped with radios to maintain independence of samples among years. Approximately 46 unmarked hens were trapped on each study area in 1990 and 1991. Spotlights, rocket nets, and net guns were used to capture grouse. Sex and age of grouse were determined by plumage characteristics, wing molt, and primary length (Beck et al. 1975). Solar-powered radio transmitters with nickel-cadmium batteries attached to herculite ponchos (Amstrup 1980) that weighed 20 g and numbered aluminum leg bands were fitted to each hen. Locations of radio-marked hens were obtained with portable receivers and 2-element hand-held antennae.

Monitoring Radio-marked Hens

Cover types and habitat components used for rearing broods were determined from locations of radio-marked hens. Marked hens were located initially in April of each year to determine nesting chronology. When monitoring revealed that a hen initiated a nest, the location was marked on a map. Hatching dates were estimated for all nests by projection from the onset of incubation. Radio locations were taken remotely to avoid disturbance of the hen. When monitoring revealed the hen moved from the nest and incubation ceased, the fate of the nest was determined. A brood was considered successfully hatched if the nest contained at least 1 egg with a detached shell membrane and unsuccessful if all eggs present had firmly attached shell membranes or were unhatched. Monitoring of hens without broods continued through the nesting period to determine if renesting occurred. Radio-marked hens that hatched a brood were monitored 4 times weekly to determine habitats used for rearing broods. Each location was marked and served as a site for habitat sampling. Monitoring of broods continued until a hen lost her brood or brood integrity disintegrated (approximately 1 August of each year).

Selection of Cover Types (Third Order Selection)

Eleven cover types were described from Soil Conservation Service information (J. Kinzle, U. S. Dep. Agric., Soil Conserv. Serv., unpubl. data) and previous descriptions at Jackass Creek by Trainer et al. (1983) and Gregg (1992) (Appendix A). Cover at brood sites was classified into 1 of the 11 cover types for each hen; 2 cover types

were not available at Jackass Creek (mountain shrub and low sagebrush/fescue). Cover type maps were prepared from color infrared photographs.

Study area boundaries, based on locations of radio-marked hens with broods, were determined each year with the minimum convex polygon method (Mohr 1947, Odum and Kuenzler 1955). All cover types within study area boundaries were classified as available to hens for rearing broods (see Whiteside and Guthery 1983). Proportions of cover types within the area available for rearing broods were determined with a dot grid system (Avery 1977).

Selection of Habitat Components (Fourth Order Selection)

Habitat sampling was conducted at brood sites within 2 days after location of a brood. The following habitat components were measured to characterize habitat structure of each location: percent cover of forbs, grasses, and shrubs; and height of shrubs. Two 10-m perpendicular transects intersecting at the brood location were arranged. The position of the first transect was determined from a randomly selected compass bearing. The intercept distance (cm) of all species of shrubs along each transect was recorded to determine canopy coverage (Canfield 1941). Height of each shrub intercepted was measured from the ground to the top of the shrub canopy and placed into 1 of 3 classes: short (<40 cm), medium (40-80 cm), or tall (>80 cm). Shrubs were classified to species and forbs and grasses were identified to genus. Percent cover of forbs and grasses was estimated from 5 uniformly spaced rectangular plots (20 x 50 cm) on each transect

(Daubenmire 1959). Sampling intensity was determined by constructing a species area curve with data collected from initial vegetation sampling (Pieper 1978:12).

Diets of juvenile sage grouse were obtained as part of a concurrent study (M. S. Drut, Oreg. State Univ., unpubl. data; W. H. Pyle, U. S. Fish and Wildl. Serv., unpubl. data) and comprised forbs, sagebrush, and arthropods. Key foods were defined by aggregate mass (≥1%) or frequency (≥10%) in crops of collected chicks. The following plants were key foods common to both study areas: mountain-dandelion, milk-vetch (Astragalus spp.), hawksbeard, fleabane (Erigeron spp.), biscuit-root (Lomatium spp.), microsteris (Microsteris gracilis), broomrape (Orobanche spp.), common dandelion (Taraxacum officinale), and clover (Trifolium spp.). Additional key genera identified at Jackass Creek were blepharipappus (Blepharipappus scaber) and woolly-heads (Psilocarphus brevissimus) and at Hart Mountain were yarrow (Achillea sp.), aster (Aster spp.), monkey-flower (Mimulus spp.), and yellow salsify (Tragopogon dubius). Key arthropods were identified as June beetles (Scarabaeidae), darkling beetles (Tenebrionidae), and ants (Formicidae).

Habitat structure was characterized at randomly selected locations within cover types used on each study area during the brood-rearing period (May-August) (Appendices B-E). Random sites were located with a random numbers table, which was used to determine starting point, compass bearing, and distance to start of transect. Number of random locations sampled in each cover type was based on

canopy cover of sagebrush and was determined with the "n-test" (Snedecor and Cochran 1980:221).

Data Analysis

Home ranges for hens with broods were determined with the McPaal home range program (Stuwe and Blohowiak 1983). Home ranges were compared for 2 brood-rearing periods (early: hatching to 6 weeks, and late: 7 to 12 weeks after hatching) within and between study areas with Chi-square analysis (Snedecor and Cochran 1980:20). Six-week intervals were based on data from Martin (1970) that indicated hens with broods changed habitat use at this time and from Peterson (1970) that revealed differences in foods taken by juveniles beginning at approximately 6 weeks after hatching.

Within study areas, cover types used by sage grouse for rearing broods were compared with availability of cover types. Between study areas, cover type availability and use were compared. Data were arranged in contingency tables and analyzed with Chi-square analysis. Cover types with less than 5 observations were combined and analyzed collectively. If there were differences, confidence interval testing (Neu et al. 1974, Byers et al. 1984) was used to determine cover types used selectively. Use of cover types by hens with broods of different ages was compared with Chi-square to assess possible changes in habitat use associated with age of broods. Furthermore, cover types used by hens that nested successfully and by hens with broods during the first 6 weeks after hatching were compared.

Within each age class, habitat components (percent cover of shrubs, all forbs and key forbs, and grasses) measured at random sites on each study area were compared for cover types selectively used (used greater than available), proportionately used (used in proportion to availability), used less than available, and unused by radio-marked sage grouse hens with broods to determine vegetative features associated with use of cover types. Habitat components measured at brood sites were compared to random sites within cover types where broods were observed to determine vegetative components used selectively. Similar comparisons were made for brood sites and random sites between study areas to assess differences in use and availability of habitat attributes. Key forbs were analyzed separately from other habitat components because multiple analysis of variance (MANOVA) was used for all comparisons. If a significant MANOVA was found, a factorial analysis of variance was used to determine which habitat components contributed to the difference (Snedecor and Cochran 1980:339). The least significant difference test was used to separate means (Snedecor and Cochran 1980:272). Results were considered significant at the 95% confidence level.

RESULTS

For the 2 study areas, 130 nests were located from radio-marked hens but only 18 broods were produced (Table 1). At Hart Mountain, 11 hens hatched broods; 4 broods survived 6 weeks, from which 6 chicks were recruited into the August population. At Jackass Creek, 7 hens produced broods, 3 broods survived past 6 weeks, and 3 chicks were recruited into the August population.

Most successful nests were located in cover types with medium height shrubs (40-80 cm) but after broods hatched hens moved to low sagebrush cover types during the early brood-rearing period (Table 2). The proportion of brood sites in low sagebrush was significantly greater than successful nests in low sagebrush.

Three cover types were used selectively during early brood-rearing: low sagebrush-bunchgrass (LSB) and mixed sagebrush at Jackass Creek and low sagebrush-fescue (LSF) at Hart Mountain (Table 2). Mountain big sagebrush (MBS) was used in proportion to availability at Hart Mountain. Wyoming big sagebrush (WBS), at both study areas, and LSB, at Hart Mountain, were used in lesser proportions than available. None of the other 6 cover types was used during the early brood-rearing period.

During the late brood-rearing period, hens increased use of medium height sagebrush cover types on both study areas (Table 2). WBS at Jackass Creek and MBS at Hart Mountain were used significantly more during the late period than during the early period. LSF at Hart Mountain was the only cover type used in greater proportions than available during the late period (Table 2). No cover types at Jackass

Table 1. Reproductive success of sage grouse hens equipped with radio transmitters at Jackass Creek and Hart Mountain National Antelope Refuge study areas, Harney and Lake Counties, Oregon, 1989-1991.

Status	Jackass Creek	Hart Mountain
Nests	69	61
Successful broods at:	7	11
hatching	7	11
6 weeks	3	4
12 weeks	3	4
Chicks/Hen	1.0	1.5

Table 2. Cover types used (%) by successfully nesting radio-marked sage grouse hens and available (%) and used (%) by radio-marked sage grouse hens with broods during the hatching to 6 weeks (early) and 7 to 12 weeks after hatching (late) periods at Jackass Creek (N = 7 nests and 84 and 40 brood observations, respectively) and Hart Mountain National Antelope Refuge (N = 11 nests and 89 and 40 brood observations, respectively) study areas, Harney and Lake counties, Oregon, 1989-1991.

	Jackass Creek					Hart Mountain				
		Early		Late			Early		Late	
Cover type	Nests	Available	Used	Available	Used	Nests	Available	Used	Available	Used
Wyoming big sagebrush[ab]	42[c]	53	17[d]	30	45[f]	0	8	2[d]	0	0
Low sagebrush-bunchgrass[b]	29[c]	32	54[e]	30[a]	17[df]	8[c]	43	20[d]	0	0
Mixed sagebrush[ab]	29	9	29[e]	15	20	0	<1	0	<1	0
Lakebed	0	2	0	22[a]	15[b]	0	<1	0	0	0
Basin big sagebrush	0	1	0	2	3	0	<1	0	0	0
Mountain big sagebrush[ab]	0	1	0	0	0	92[c]	21	30	57	52[f]
Low sagebrush-fescue[ab]	0	0	0	0	0	0	5	47[e]	16	38[be]
Mountain shrub[a]	0	0	0	0	0	0	6	0	2	0
Meadow[a]	0	1	0	1	0	0	3	0	5	8
Grassland	0	0	0	0	0	0	8[a]	0	<1	3
Juniper/Aspen[a]	0	1	0	0	0	0	5	0	19	0

[a]Availability different between study areas ($P < 0.05$)
[b]Use different between study areas ($P < 0.05$)
[c]Use different between successful nests and early broods ($P < 0.05$)
[d]Use less than expected ($P < 0.05$)
[e]Use greater than expected ($P < 0.05$)
[f]Use different between age periods ($P < 0.05$)

Creek were used selectively. MBS and grassland, at Hart Mountain, and WBS, mixed sagebrush, and basin big sagebrush, at Jackass Creek, were used in proportion to availability. LSB, at Jackass Creek, was the only cover type used significantly less than available. Use of riparian cover types (lakebeds at Jackass Creek and meadows at Hart Mountain), in proportion to availability, also occurred during the late brood-rearing period.

Availability of cover types differed between study areas for both brood-rearing periods (Table 2). LSF and MBS, highly used cover types at Hart Mountain, had $\leq$1% availability at Jackass Creek. Meadows were also low in availability (1%) at Jackass Creek. Mixed sagebrush and WBS had limited availability ($\leq$8%) at Hart Mountain.

Percent cover of key forbs measured at random locations was greater in cover types used selectively than in cover types used less than available during early brood-rearing (Tables 3 and 4). During late brood-rearing, forb cover (all forbs and key forbs) and grass cover were greater within cover types that were unused by broods than within cover types used by broods at Jackass Creek. Conversely, at Hart Mountain, % cover of all forbs and grasses was greater in cover types used selectively and used in proportion to availability than unused cover types; no differences were evident for key forbs.

At Hart Mountain, no pattern of selection for habitat components was evident within cover types with sufficient brood observations for analysis during both brood-rearing periods (Table 5). At Jackass Creek, forb cover was greater at brood sites than random sites in LSB and mixed sagebrush during the early period (Table 6). During late

Table 3. Structural characteristics at random sites in cover types used selectively (greater than available), used proportionately (in proportion to availability), used less than available, and unused during the hatching to 6 weeks (early) and 7 to 12 weeks after hatching (late) periods by radio-marked sage grouse hens with broods at Jackass Creek, Harney County, Oregon, 1989-1991. Means with same letter or no letter within each category are not different ($P > 0.05$).

	Early			Late		
Characteristic	Used selectively (N=125) $\bar{x}$(SD)	Used less than available (N=51) $\bar{x}$(SD)	Unused (N=78) $\bar{x}$(SD)	Used Proportionately (N=109) $\bar{x}$(SD)	Used less than available (N=50) $\bar{x}$(SD)	Unused (N=26) $\bar{x}$(SD)
Forb cover (%)						
All forbs	8(6)	9(6)	8(9)	8(10)A	6(4)A	19(13)B
Key forbs[a]	4(4)A	1(1)B	3(4)A	3(2)A	2(2)A	6(8)B
Grass cover (%)	8(6)A	10(6)AB	14(10)B	7(5)A	6(3)A	30(19)B
Shrub cover (%)						
Short (0-40 cm)	24(13)A	5(4)B	5(4)B	11(9)A	28(10)B	3(5)C
Medium (41-80 cm)	7(14)	12(6)	11(10)	10(7)A	1(1)B	2(3)B
Tall (>80 cm)	1(5)A	5(6)B	11(8)C	7(10)A	0B	1(1)B

[a]Key forbs were analyzed separately from cover of all forbs

Table 4. Structural characteristics at random sites in cover types used selectively (greater than available), used proportionately (in proportion to availability), used less than available, and unused during the hatching to 6 weeks (early) and 7 to 12 weeks after hatching (late) periods by radio-marked sage grouse hens with broods at Hart Mountain National Antelope Refuge, Lake County, Oregon, 1989-1991. Means with same letter or no letter within each category are not different ($P > 0.05$).

	Early				Late		
Characteristic	Used selectively (N=46) $\bar{x}$(SD)	Used proportionately (N=88) $\bar{x}$(SD)	Used less than available (N=54) $\bar{x}$(SD)	Unused (N=117) $\bar{x}$(SD)	Used selectively (N=26) $\bar{x}$(SD)	Used proportionately (N=80) $\bar{x}$(SD)	Unused (N=134) $\bar{x}$(SD)
Forb cover (%)							
All forbs	12(4)A	11(6)A	8(6)B	7(5)B	13(4)A	13(13)A	6(5)B
Key forbs[a]	4(2)A	2(2)B	2(2)B	2(4)B	2(2)	1(2)	2(2)
Grass cover (%)	14(7)A	11(10)B	8(8)C	18(12)A	16(6)A	16(10)A	12(11)B
Shrub cover (%)							
Short (0-40 cm)	15(8)A	17(11)A	7(11)B	9(8)B	20(10)A	13(10)B	8(9)B
Medium (41-80 cm)	0A	16(17)B	19(10)B	13(13)B	0A	6(10)B	11(10)B
Tall (>80 cm)	0A	1(2)A	1(1)A	5(8)B	0A	1(2)A	4(7)B

[a]Key forbs were analyzed separately from cover of all forbs

Table 5. Structural characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the hatching to 6 weeks (early) and 7 to 12 weeks after hatching (late) periods at Hart Mountain National Antelope Refuge, Lake County, Oregon, 1989-1991. Means with same letter or no letter within cover types for each habitat characteristic are not different ($P > 0.05$).

	Cover type										
	Low sagebrush-bunchgrass			Low sagebrush-fescue				Mountain big sagebrush			
Characteristic	Random (N=40) $\bar{x}$(SD)	Early (N=14)[a] $\bar{x}$(SD)	Random (N=30) $\bar{x}$(SD)	Early (N=46)[a] $\bar{x}$(SD)	Random (N=40) $\bar{x}$(SD)	Late (N=15)[a] $\bar{x}$(SD)	Random (N=26) $\bar{x}$(SD)	Early (N=27)[a] $\bar{x}$(SD)	Random (N=72) $\bar{x}$(SD)	Late (N=21)[a] $\bar{x}$(SD)	Random (N=30) $\bar{x}$(SD)
Forb cover (%)											
All forbs	8(5)	7(2)	5(2)	12(3)A	12(4)A	19(5)B	13(4)AB	14(5)	13(6)	19(4)	* 14(5)
Key forbs[b]	3(2)	2(2)	1(2)	3(2)	4(2)	4(4)	2(2)	3(3)	2(1)	4(3)	2(2)
Grass cover (%)	8(4)A	10(3)B	9(8)AB	16(6)	14(7)	17(6)	16(6)	15(7)	12(6)	16(8)	13(7)
Shrub cover (%)											
Short (0-40 cm)	21(8)	21(9)	22(8)	22(8)A	15(8)B	19(9)A	20(10)A	18(9)	17(11)	17(9)	17(9)
Medium (41-80 cm)	0	0	0	0	0	0	0	9(10)A	17(12)B	14(71)B	16(11)B
Tall (>80 cm)	0	0	0	0	0	0	0	0	1(2)	0	1(4)

[a]Brood observations for that time period
[b]Key forbs were analyzed separately from cover of all forbs

Table 6. Structural characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the hatching to 6 weeks (early) and 7 to 12 weeks after hatching (late) periods at Jackass Creek, Harney County, Oregon, 1989-1991. Means with same letter or no letter within cover types for each habitat characteristic are not different ($P > 0.05$).

	Cover type											
	Low sagebrush-bunchgrass				Mixed sagebrush				Wyoming big sagebrush			
Characteristic	Early (N=44)[a] $\bar{x}$(SD)	Random (N=74) $\bar{x}$(SD)	Late (N=7)[a] $\bar{x}$(SD)	Random (N=50) $\bar{x}$(SD)	Early (N=23)[a] $\bar{x}$(SD)	Random (N=51) $\bar{x}$(SD)	Late (N=7)[a] $\bar{x}$(SD)	Random (N=30) $\bar{x}$(SD)	Early (N=16)[a] $\bar{x}$(SD)	Random (N=51) $\bar{x}$(SD)	Late (N=18) $\bar{x}$(SD)	Random (N=27) $\bar{x}$(SD)
Forb cover (%)												
All forbs	14(5)A	9(5)B	3(1)C	6(2)B	14(4)A	6(4)B	12(4)A	3(2)B	10(4)	9(6)	9(3)	6(2)
Key forbs[b]	7(4)A	5(4)B	1(1)C	2(2)C	5(4)A	3(2)A	5(5)A	1(1)B	1(1)A	1(1)A	3(3)B	2(2)B
Grass cover (%)	8(4)A	6(3)A	3(1)B	6(3)A	9(6)	7(5)	9(5)	6(4)	10(4)	10(6)	11(8)	8(3)
Shrub cover (%)												
Short (0-40 cm)	25(7)A	24(8)A	36(9)B	28(10)AB	21(8)A	18(10)A	13(8)B	21(8)A	5(3)	5(4)	5(3)	8(6)
Medium (41-80 cm)	1(1)	1(1)	0	0	6(6)A	5(5)A	12(7)B	9(6)AB	15(7)	12(6)	14(7)	13(7)
Tall (>80 cm)	0	0	0	0	1(1)	3(7)	4(11)	2(3)	2(4)A	5(6)A	4(5)A	9(10)B

[a]Brood observations for that time period
[b]Key forbs were analyzed separately from cover of all forbs

brood-rearing, forb cover was greater at brood sites in mixed sagebrush. Percent cover of key forbs in LSB was significantly less during late brood-rearing than during early brood-rearing whereas % cover of key forbs was significantly greater in WBS during the late period. Availability of forbs in LSB at Hart Mountain exhibited a trend similar to LSB at Jackass Creek. No clear pattern emerged for grass cover or among the 3 height classes of shrub cover. Analyses for selection of habitat components were also conducted for lakebed and meadow habitats (Appendices F and G).

Hart Mountain had greater total forb cover and grass cover at random sites during both brood-rearing periods than did Jackass Creek; no differences were evident for key forbs (Tables 7 and 8). No differences in forb cover occurred at sites used by broods during the early period. However, % cover of all forbs was greater at brood sites at Hart Mountain during late brood-rearing. Hart Mountain had less shrub cover of tall height than Jackass Creek.

At Hart Mountain, mean home range size was 8.2 and 1.4 km^2 for the early and late periods, respectively, whereas at Jackass Creek, mean home range was 20.7 and 50.5 km^2, respectively. Home range size was significantly smaller in the late period than the early period at Hart Mountain (X^2=4.8, df=1, P=0.02) whereas home range size increased significantly during the late period at Jackass Creek (X^2=12, df=1, $P < 0.001$). Home range size was smaller at Hart Mountain than at Jackass Creek during both age periods (X^2=1741, df=1, $P < 0.001$).

Table 7. Structural characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the hatching to 6 weeks period, Jackass Creek and Hart Mountain National Antelope Refuge study areas, Harney and Lake Counties, Oregon, 1989-1991.

	Brood		Random	
Characteristic	Jackass Creek (N=84) $\bar{x}$(SD)	Hart Mountain (N=87) $\bar{x}$(SD)	Jackass Creek (N=224) $\bar{x}$(SD)	Hart Mountain (N=188) $\bar{x}$(SD)
Forb cover (%)				
All forbs	13(6)	11(7)	8(7)[a]	12(8)
Key forbs[b]	3(4)	3(2)	2(2)	2(2)
Grass cover (%)	9(5)[a]	15(7)	9(3)[a]	13(8)
Shrub cover (%)				
Short (0-40 cm)	21(10)	20(9)	21(12)[a]	16(9)
Medium (41-80 cm)	4(6)	3(7)	17(10)	13(10)
Tall (>80 cm)	1(2)[a]	0	3(7)[a]	1(2)

[a]Value different between study areas ($P < 0.05$)
[b]Key forbs were analyzed separately from cover of all forbs

Table 8. Structural characteristics at brood sites and random sites in cover types used by radio-marked sage grouse hens with broods during the 7 to 12 weeks after hatching period, Jackass Creek and Hart Mountain National Antelope Refuge study areas, Harney and Lake Counties, Oregon, 1989-1991.

	Brood		Random	
Characteristic	Jackass Creek (N=38) $\bar{x}$(SD)	Hart Mountain (N=38) $\bar{x}$(SD)	Jackass Creek (N=132) $\bar{x}$(SD)	Hart Mountain (N=106) $\bar{x}$(SD)
Forb cover (%)				
All forbs	8(6)[a]	20(8)	7(9)[a]	13(12)
Key forbs[b]	2(3)	3(3)	2(2)	3(2)
Grass cover (%)	8(5)[a]	16(7)	7(5)[a]	16(10)
Shrub cover (%)				
Short (0-40 cm)	14(14)	16(9)	17(12)	15(11)
Medium (41-80 cm)	12(10)	8(10)	7(8)	5(9)
Tall (>80 cm)	3(6)[a]	0	5(9)[a]	1(2)

[a]Value different between study areas ($P < 0.05$)
[b]Key forbs were analyzed separately from cover of all forbs

DISCUSSION

Results from this study indicated habitat selection by broods was influenced primarily by availability of forbs. At Hart Mountain, broods used cover types (LSF and MBS) that had greater availability of forbs than cover types that were unused or used less than available. LSF and MBS were available at higher elevations (>1800 m) where precipitation potentially increased forb production and delayed phenology. Cover types used by broods at Jackass Creek were not used or were used less than available at Hart Mountain because of lower forb availability although those cover types were structurally similar (e.g. LSB was used selectively at Jackass Creek but was used less than available at Hart Mountain). Because forb availability was relatively high in LSF and MBS, hens were not selective for forb cover within cover types at Hart Mountain. Forb cover remained high in LSF through the late brood-rearing period and selective use of LSF continued. Also, broods that used cover types at higher elevations were not as dependent on riparian areas and stayed in upland habitats.

At Jackass Creek, broods also selected cover types based on forb availability. Forb cover was greater in cover types used selectively (LSB and mixed sagebrush) during the early period. Within selected cover types, sites with forb cover similar to Hart Mountain were sought by broods. Availability of forbs changed into the late period and use of cover types also changed. WBS had increased use because key forbs were more available in this cover type and less available in LSB. Forbs also were associated with brood habitat use in other studies (Klebenow 1969, Peterson 1970, Pyrah 1971, Wallestad 1971, Martin

1976). In Idaho, broods moved to higher elevations as forbs desiccated at lower elevations (Klebenow 1969). At Hart Mountain, 1 radio-marked hen exhibited this type of movement whereas other hens nested at relatively high elevations closer to mesic cover types. As forb availability decreased in upland sites, bottomlands (greasewood sites and alfalfa fields) were noted as important in Montana (Wallestad 1971, Martin 1976). At Jackass Creek, high-elevation cover types and bottomland sites were not readily available, which heightened the importance of riparian areas, such as lakebeds.

Importance of riparian areas to broods was documented by increased use of lakebeds and meadows during the late brood-rearing period. At Jackass Creek, lakebeds were more numerous within the study area defined from late brood use and were the only riparian areas available to large numbers of birds. During drought conditions experienced in 1990 and 1991, lakebeds were devoid of forbs. Meadows had greater forb cover than all cover types used during the late period on both study areas and forbs remained available under drought conditions; however, meadows represented only 1% of the available habitat at Jackass Creek. Lack of meadow habitat at Jackass Creek may have negative effects on chick survival. In Colorado, forb cover ranged from 7% in upland sites to 41% in meadows (Schoenberg 1982). Meadows were important habitats in Nevada (Oakleaf 1971, Evans 1986) and at Hart Mountain. Riparian areas were not used selectively by radio-marked hens with broods at Hart Mountain, presumably because forbs remained available in the cover type (LSF) used selectively during the late period.

Differences of availability in cover types and forb cover may relate to productivity differences between areas. Hens with broods were able to locate structural characteristics within cover types that were similar between areas. Hens selected for forb cover amounts that were similar between areas during the early period. However, broods at Jackass Creek seemingly had difficulty locating sites with high forb cover, which was reflected by relatively large home ranges. At Hart Mountain, forb availability was higher and home ranges were smaller. During the late period, difficulty in location of sites with high forb cover increased at Jackass Creek and home range size increased. Drought conditions exacerbated this situation and potentially were responsible for the large movements by broods. At Hart Mountain, home range size decreased during the late period because forbs remained available at upland sites and meadows. Other studies indicated a decrease in the size of areas used by broods over time. In Montana, home range decreased from 85 ha in June to 51 ha by August (Wallestad 1971) and no movements away from hay meadows were detected once broods reached these areas in Colorado (May and Poley 1969). Larger home ranges at Jackass Creek may indicate chicks were more exposed to predators and expended more energy, which influenced survival. Relatively low survival of chicks at Hart Mountain may have been associated with abiotic factors such as weather. Four of 12 broods were lost just after hatching because of severe weather at high elevations where those hens had nested.

Larger home range sizes, low forb availability, and lack of meadow habitats at Jackass Creek emphasized the potential importance of

forbs to broods. Diets of juveniles were affected by the differences in availability between areas. Forbs and insects were a smaller proportion in diets of chicks at Jackass Creek (23 and 12%, respectively) than at Hart Mountain (50 and 22%, respectively). Conversely, sagebrush was a larger proportion of the diet at Jackass Creek than at Hart Mountain (65 and 28%, respectively) (M.S. Drut, Oreg. State Univ, unpubl. data). Forbs and insects provide critical nutrients and are more easily digested by chicks than are grasses or shrubs and lack of these items in diets may influence survival (Klebenow and Gray 1968, Peterson 1970).

Sagebrush height may be an additional factor involved with habitat selection. Broods selected cover types with a short shrub component during the early brood rearing period. Increased use of LSB at Jackass Creek and LSB and LSF at Hart Mountain from nesting cover to early brood rearing habitat and selective use of LSB at Jackass Creek and LSF at Hart Mountain reflected use of short shrub cover. Cover types with taller sagebrush (WBS) were used less than available on both study areas during the early period. As broods matured beyond 6 weeks of age, use of medium height shrub cover types increased.

Other studies reflected changes in use of sagebrush height and stand density over time. In Montana, broods used sagebrush with canopy cover of 6% and height that ranged from 15-30 cm in June but use changed to areas with an average of 12% canopy cover and sagebrush height that ranged from 30-45 cm by August (Peterson 1970). Pyrah (1971) and Wallestad (1971) also noted sagebrush height was greater in cover types used by broods during late summer. In this study, broods

also used taller sagebrush in August than in June. In Idaho, broods used stands with <31% shrub cover and, in Montana, broods used stands with <25% shrub cover; canopy cover was less than typically found in available habitat (Klebenow 1969, Wallestad 1971). Canopy cover of shrubs did not appear as important as shrub height in habitat selection in this study. Overall shrub cover at random sites and brood sites was <35% and no differences were detected.

Mixed sagebrush at Jackass Creek was the most structurally diverse cover type available. Selective use by nesting hens and during the early brood-rearing period, and continued use into the late brood period, indicated mixed sagebrush had characteristics desirable to broods and nesting hens. In Colorado, however, sage grouse broods were reported to select homogeneous stands (Dunn and Braun 1986); mixed sagebrush at Jackass Creek was characteristically heterogeneous. Mixed sagebrush potentially maintained a consistent availability of forbs because of the low sagebrush/big sagebrush mixture.

MANAGEMENT IMPLICATIONS

Hens with broods, in this study, selected a diverse number of cover types based primarily on availability of forbs for food and sagebrush for structural cover. Therefore, management of brood habitat should focus on maintenance of cover type diversity and availability of forbs. Hens at Jackass Creek selected forb cover of 12 to 14% and key forbs from 4 to 7%, which approximated forb availability at Hart Mountain, and may represent minimum forb cover needed for brood habitat. Grazing, fire suppression, and sagebrush control are land-use practices that influence shrub and understory cover throughout sage grouse range. Since the arrival of European settlers, these practices had primarily negative impacts on sage grouse habitat. Long-term effects of overgrazing on upland habitats were loss of herbaceous understory vegetation and changes in habitat structure (Patterson 1952:274; Autenrieth et al. 1982; Klebenow 1982, 1985). Changes associated with overgrazing created habitat unsuitable to sage grouse in some areas (Autenrieth 1981). When large tracts of sagebrush were removed through chemical spraying, these areas were unused by sage grouse (Pyrah 1971, Wallestad 1971, Martin 1976). Fire suppression leads to dense sagebrush stands unsuitable as brood habitat. However, fire increased the spread of exotics such as knapweed (Centaurea spp.) and cheatgrass (Bromus tectorum) that negatively affect forb cover (Hoffman 1991). Positive effects on sage grouse brood habitat were obtained when land-use practices were used under in limited or controlled circumstances. Moderate grazing enhanced forb availability in upland meadows during late summer; however, meadows with dense shrub

cover and steep stream banks associated with overgrazing were avoided by broods (Klebenow 1985, Evans 1986). Both fire and sagebrush removal open dense stands of sagebrush to brood use, create habitat mosaics, and increase availability of some forbs (Klebenow 1970, 1972). Enhancement of forb availability may be dependent on seral stages associated with specific forbs. Because broods used a variety of cover types and forb genera, management on a landscape scale will be necessary to rehabilitate sage grouse brood habitat.

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APPENDICES

Appendix A. Description of cover types at Hart Mountain National Antelope Refuge and Jackass Creek study areas, Lake and Harney Counties, Oregon.

Cover type	Cover type description
Low sagebrush/bunchgrass	Found on alluvial fans and table lands with <30% slope. Principal plant species are low sagebrush (Artemesia arbuscula), bluebunch wheatgrass (Agropyron spicatum), and bluegrass (Poa spp.). Also may be associated with spiny hopsage (Atriplex spinosa).
Low sagebrush/fescue	Found on exposed ridges and side slopes at higher elevations (2000 to 2800m) at Hart Mountain. Primary plant species are low sagebrush and Idaho fescue (Festuca idahoensis).
Wyoming big sagebrush	Occurs on rolling uplands and lake basin terraces with slopes <30%. Primary plant species include Wyoming big sagebrush (A. tridentata wyomingensis) and bottlebrush squirrel tail (Sitanion hystrix). Also may be associated with spiny hopsage.
Mountain big sagebrush	Occurs at higher elevations (1800 to 2600m) on ridges and mountain shoulders. Primary plant species is Mountain big sagebrush (A. t. vaseyana) and Idaho fescue (F. idahoensis) or rough fescue (F. scabrella).
Mixed sagebrush	Characteristic of scabrock areas (15 to 75% rock fragments) associated with ridge tops, sloping tablelands, and alluvial plans. Primary plant species are low sagebrush, big sagebrush (A. t. spp.), and Sandberg's bluegrass (P. sandbergii).
Mountain shrub	Common at Hart Mountain at elevations between 1800 and 2300m. Primary plant species are mountain big sagebrush, antelope bitterbrush (Purshia tridentata), blue grass, and needle grass (Stipa spp.)
Basin big sagebrush	Occurs on low terraces associated with drainages and lake basins. Primary plant species are basin big sagebrush (A. t. tridentata) and basin wild rye (Elymus cinereus)

Appendix A. (continued)

Cover type	Cover type description
Grassland	Natural grasslands or areas disturbed by fire. Primary plant species are cheat grass (Bromus tectorum), bluegrass, and bottle brush squirrel tail.
Meadow	Associated with stream valleys that have poorly drained soils and subsurface water in summer. Primary plant species are bluegrass, sedge (Carex spp.), and baltic rush (Juncus balticus).
Lakebed	Found on depressions covered with water in spring. Primary plant species are silver sagebrush (A. cana) and bluegrass.
Juniper/aspen/mahogany	Associated with low ridges or footslopes. Primary plant species are western juniper (Juniperus occidentalis), aspen (Populus tremuloides), and mountain mahogany (Cercocarpus lepifolius). May be found interspersed with big sagebrush.

Appendix B. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during the hatching to 6 weeks period at Hart Mountain National Antelope Refuge, Lake County, Oregon, 1989-1991.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	40	Collinsia	0.8	50
		Sitanion	1.3	27
		Poa	5.0	88
		Phlox	2.5	43
Low sagebrush/fescue	40	Agoseris	0.5	32
		Arenaria	0.8	25
		Astragalus	1.6	43
		Crepis	0.8	30
		Festuca	9.6	87
		Phlox	3.8	72
		Poa	3.6	86
		Sitanion	0.9	28
Mountain shrub	41	Agoseris	0.5	25
		Agropyron	1.3	18
		Bromus	3.2	48
		Collinsia	1.2	65
		Festuca	1.5	8
		Poa	6.2	61
		Sitanion	3.0	36
		Stipa	2.6	24
Mountain big sagebrush	72	Agoseris	0.7	36
		Agropyron	1.5	33
		Balsamorhiza	1.3	6
		Collinsia	1.0	54
		Eriogonum	1.2	15
		Festuca	3.4	26
		Lupinus	2.4	52
		Poa	3.0	47
		Sitanion	1.4	30
		Senecio	1.0	29
Wyoming big sagebrush	34	Collinsia	0.7	45
		Musci	3.4	13
		Poa	1.5	42
		Sitanion	0.9	30
Grassland	30	Agropyron	1.8	8
		Bromus	8.5	58
		Carex	1.6	10
		Microsteris	1.1	46
		Poa	5.1	51
		Sitanion	3.0	34
Lakebed	20	Juncus	1.3	52

Appendix B. (continued)

Cover type	n	Genus	Cover	Frequency
Meadow	20	Achillea	4.1	44
		Agropyron	2.7	35
		Aster	1.3	18
		Carex	5.8	41
		Haplopappus	2.0	19
		Iris	1.1	14
		Juncas	4.5	64
		Koeleria	1.2	14
		Poa	10.6	81
		Potentilla	4.7	38
Basin big sagebrush	30	Bromus	1.4	17
		Collinsia	0.7	42
		Elymus	1.3	6
		Festuca	2.4	14
		Microsteris	1.2	49
		Musci	2.3	9
		Phlox	1.7	23
		Poa	3.7	32
		Sitanion	2.9	29
		Stipa	2.5	14

Appendix C. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during the hatching to 6 weeks period at Jackass Creek study area, Harney County, Oregon, 1989-1991.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	69	Collinsia	1.5	63
		Lomatium	1.2	29
		Microsteris	0.7	31
		Musci	1.4	16
		Poa	5.7	92
		Phlox	0.9	25
Wyoming big sagebrush	46	Bromus	1.2	21
		Collinsia	1.0	38
		Lomatium	1.4	30
		Microsteris	1.0	37
		Musci	1.6	8
		Poa	7.2	70
		Sitanion	1.4	26
		Stipa	2.3	16
Mixed sagebrush	46	Collinsia	0.6	36
		Lomatium	1.3	33
		Microsteris	0.7	36
		Musci	1.2	10
		Phlox	0.7	24
		Poa	5.6	74
		Sitanion	1.6	31
		Stipa	1.2	19
Basin big sagebrush	36	Bromus	2.8	35
		Collinsia	1.4	34
		Microsteris	1.0	28
		Poa	11.5	72
		Polemonium	1.3	22
		Sitanion	3.1	38
Lakebed	22	Musci	1.0	5

Appendix D. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during the 7 to 12 weeks after hatching period at Hart Mountain National Antelope Refuge, Lake County, Oregon, 1989-1990.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	30	Collinsia	0.5	41
		Musci	1.0	15
		Phlox	0.8	28
		Poa	5.0	86
		Sitanion	1.3	27
Low sagebrush/fescue	26	Arenaria	0.5	12
		Collinsia	0.3	11
		Festuca	9.4	81
		Phlox	4.3	59
		Poa	4.4	82
		Sitanion	0.9	20
Mountain big sagebrush	30	Antennaria	1.1	8
		Collinsia	0.3	27
		Festuca	4.7	38
		Lupinus	5.0	61
		Poa	3.8	62
		Senecio	1.0	26
		Sitanion	2.2	43
Basin big sagebrush	27	Bromus	1.6	28
		Carex	1.9	17
		Collinsia	0.9	56
		Gayophytum	0.3	16
		Lupinus	2.1	24
		Microsteris	1.2	52
		Poa	6.2	51
		Polemonium	1.0	25
		Sitanion	4.4	54
Lakebed	25	Cryptantha	0.5	16
		Downingia	0.6	16
		Juncus	2.1	30
		Musci	1.9	7
		Myosurus	5.0	19
		Navarretia	2.0	31
		Oenothera	1.3	7
		Polygonum	1.9	38
		Psilocarphus	1.2	30
Grassland	30	Bromus	8.1	71
		Epilobium	0.5	19
		Lupinus	0.7	18
		Microsteris	0.4	27
		Poa	2.8	38
		Sitanion	3.1	34

Appendix D. (continued)

Cover type	n	Genus	Cover	Frequency
Mountain shrub	30	Bromus	6.2	39
		Collinsia	0.5	35
		Festuca	2.8	15
		Microsteris	0.4	21
		Poa	7.2	65
		Sitanion	3.6	37
		Stipa	3.5	28
Wyoming big sagebrush	23	Bromus	0.6	23
		Collinsia	0.3	19
		Musci	0.9	14
		Phlox	0.3	11
		Poa	0.7	28
		Sitanion	1.0	30
Meadow	20	Achillea	0.9	20
		Agropyron	2.8	33
		Aster	0.5	13
		Carex	8.9	36
		Haplopappus	1.3	15
		Iris	1.9	20
		Juncus	0.8	50
		Lomatium	0.4	15
		Penstemon	0.4	13
		Poa	12.1	86
		Potentilla	3.1	38

Appendix E. Cover (%) and frequency (%) of dominant taxa from randomly sampled locations during the 7 to 12 weeks after hatching period at Jackass Creek study area, Harney County, Oregon, 1989-1990.

Cover type	n	Genus	Cover	Frequency
Low sagebrush/bunchgrass	50	Collinsia	0.7	49
		Poa	4.0	88
		Sitanion	1.2	30
Mixed sagebrush	30	Collinsia	0.4	23
		Phlox	0.5	14
		Poa	4.2	86
		Sitanion	0.7	12
Wyoming big sagebrush	27	Collinsia	0.6	60
		Musci	0.8	10
		Poa	5.3	78
		Sitanion	1.4	37
Basin big sagebrush	27	Bromus	1.6	28
		Carex	1.9	17
		Collinsia	0.9	56
		Gayophytum	0.3	16
		Lupinus	2.1	24
		Microsteris	1.2	52
		Poa	6.2	51
		Polemonium	1.0	25
		Sitanion	4.4	54
Lakebed	25	Cryptantha	0.5	16
		Downingia	0.6	16
		Juncus	2.1	30
		Musci	1.9	7
		Myosurus	5.0	19
		Navarretia	2.0	31
		Oenothera	1.3	7
		Polygonum	1.9	38
		Psilocarphus	1.2	30
Meadow	26	Achillea	0.7	14
		Carex	4.5	23
		Juncus	12.6	41
		Microsteris	0.5	13
		Poa	12.8	64
		Taraxacum	1.4	21
		Trifolium	3.1	22

Appendix F. Structural characteristics at brood sites (N=6) and random sites (N=25) on lakebeds during the 7 to 12 weeks after hatching period at Jackass Creek, Harney County, Oregon, 1989-1990. Means with same letter or no letter for each habitat characteristic are not different ($P > 0.05$).

Characteristic	Brood $\bar{x}$(SD)	Random $\bar{x}$(SD)
Forb cover (%)		
All forbs	2(3)A	14(14)B
Key forbs[a]	2(2)	1(2)
Grass cover (%)	6(4)	4(5)
Shrub cover (%)		
Short (0-40 cm)	23(13)A	11(10)B
Medium (41-80 cm)	20(13)A	10(10)B
Tall (>80 cm)	0	<1

[a]Key forbs were analyzed separately from cover of all forbs

Appendix G. Structural characteristics at brood sites (N=3) and random sites (N=20) on meadows during the 7 to 12 weeks after hatching period at Hart Mountain National Antelope Refuge, Lake County, Oregon, 1989-1990. Means with same letter or no letter for each habitat characteristic are not different ($P > 0.05$).

Characteristic	Brood $\bar{x}$(SD)	Random $\bar{x}$(SD)
Forb cover (%)		
All forbs	27(9)	21(17)
Key forbs[a]	16(3)	21(15)
Grass cover (%)	4(3)A	1(1)B
Shrub cover (%)		
Short (0-40 cm)	<1	<1
Medium (41-80 cm)	0	0
Tall (>80 cm)	0	0

[a]Key forbs were analyzed separately from cover of all forbs