10-12-1998

Use and selection of brood-rearing habitat by Sage Grouse in south central Washington

Colin M. Sveum
United States Geological Survey—Biological Resources Division, Upper Mississippi Science Center, LaCrosse, Wisconsin

John A. Crawford
Oregon State University, Corvallis

W. Daniel Edge
Oregon State University, Corvallis

Follow this and additional works at: https://scholarsarchive.byu.edu/gbn

Recommended Citation
Available at: https://scholarsarchive.byu.edu/gbn/vol58/iss4/4

This Article is brought to you for free and open access by the Western North American Naturalist Publications at BYU ScholarsArchive. It has been accepted for inclusion in Great Basin Naturalist by an authorized editor of BYU ScholarsArchive. For more information, please contact scholarsarchive@byu.edu, ellen_amatangelo@byu.edu.
USE AND SELECTION OF BROOD-REARING HABitat BY SAGE GROUSE IN SOUTH CENTRAL WASHINGTON

Colin M. Sveum¹, John A. Crawford², and W. Daniel Edge²

ABSTRACT—Sage Grouse (Centrocercus urophasianus) brood-habitat use was examined during 1992 and 1993 at the Yakima Training Center in Yakima and Kittitas counties, Washington. During the 2 yr we followed 38 broods, of which 12 persisted to 1 August (x = approximately 1.5 chicks/brood). Food forb cover was greater at all brood locations than at random locations. Hens with broods in big sagebrush/bunchgrass habitat (Artemisia tridentata/Agroppron spicatum) selected for greater food forb cover, total forb cover, and lower shrub heights; broods in altered big sagebrush/bunchgrass habitats selected greater tall grass cover and vertical cover height; broods in grassland showed no preference for any measured vegetation characteristics. During the early rearing period (post-hatching-6 wk) each year, broods selected sagebrush/bunchgrass. Broods in 1993 made greater use of grasslands than in 1992 and selected grassland during the late brood-rearing period (7-12 wk). Broods selected for sagebrush/bunchgrass during midday, but 52% of brood locations in the afternoon were in grassland. Tall grass cover was greater at morning (0500-1000 h) and afternoon (1500-2000 h) brood locations than at midday (1000-1500 h) and random locations. Midday brood locations had greater shrub cover and height than morning and afternoon locations. Selection of habitat components was similar to the results of other studies, but habitat conditions coupled with a possible lack of alternate brood-rearing cover types resulted in low survival of chicks.

Key words: broods, Centrocercus urophasianus, habitat, Sage Grouse, Washington.

Habitat use by Sage Grouse (Centrocercus urophasianus) for brood rearing was related to forb availability in previous studies (Peterson 1970, Oakleaf 1971, Autenrieth 1981, Drut, Crawford, and Gregg 1994, Drut, Pyle, and Crawford 1994). Sage Grouse chicks require protein-rich foods, including insects and forbs, for growth and development from hatching through approximately 3 mon (Savage 1969, Dunn and Braun 1986, Bergerud 1988, Drut, Pyle, and Crawford 1994). Changes in availability of these critical foods may affect Sage Grouse distribution and habitat selection (Wallestad 1971, Pyle 1993). Furthermore, in an Oregon study (Drut, Pyle, and Crawford 1994), Sage Grouse productivity was higher on an area where chicks fed on a diet of 80% forbs and insects than where chicks ate primarily (65%) sagebrush (Artemisia spp.).

Sage Grouse broods reportedly move from nesting habitats to sites where succulent and abundant forbs persist (i.e., meadows or upland sagebrush habitats) as summer temperatures increase and moisture decreases (Nelson 1955, Gill 1965, Savage 1969, Oakleaf 1971, Autenrieth 1981). Brood movements to these habitats are immediate or transitional depending on annual precipitation, temperature, and proximity from nesting habitat. Meadows and upland sagebrush habitats, however, have been grazed excessively, causing reduced food and water availability (Savage 1969, Oakleaf 1971). Disturbance in these mesic habitats has increased soil erosion, facilitated invasion by exotic plants, affected vegetative composition, and lowered water table levels (Oakleaf 1971, Hofmann 1991). Oakleaf (1971) found fewer Sage Grouse foraging in Nevada meadows as food supplies diminished because of improper grazing practices and soil erosion. In Oregon, Drut, Crawford, and Gregg (1994) noted that broods used larger home ranges where forb availability is low than where forbs are relatively abundant. This may have resulted in reduced survival. These studies reveal the importance of forbs and insects in relation to abundance, distribution, habitat selection, and productivity. Nevertheless, the effect of massive landscape changes on habitat use by broods has rarely been documented. A full understanding of...
factors affecting habitat use by broods, especially where populations are severely depleted in areas of massive habitat changes, remains incomplete.

We studied Sage Grouse in Washington where extensive habitat loss (approximately 70%) and alteration have reduced Sage Grouse to 2 separate populations totaling an estimated 630 birds by 1994 (Tirhi 1994). Our objectives were to examine selection of cover types by Sage Grouse broods and describe structure and composition of habitat components within cover types (3rd- and 4th-order selection, respectively; see Johnson 1980) used by broods.

STUDY AREA

The study was conducted on the Yakima Training Center (YTC), a 1058-km² area in Yakima and Kittitas counties, Washington, which supported approximately 330 Sage Grouse during this study (Tirhi 1994). Elevations on the YTC range from 183 to 1249 m. Hot, dry summers and cool, dry winters typify the study area. Growing season (September–August) precipitation for 1962–1993, obtained from the U.S. Department of Commerce Climatological Database, averaged 20.4 cm; growing season precipitation in 1991–92 and 1992–93 was 16.7 and 22.5 cm, respectively. Above normal precipitation accompanied by cooler than average temperatures began during winter 1992–93 and continued through summer 1993. These weather differences likely accounted for greater shrub cover and height and more tall grass and forb cover in certain cover types in 1993 (Sveum 1996).

Because the YTC serves as a military training ground, frequent off-road-vehicle use has resulted in approximately 5% of the area being covered by roads and trails (J.C. Stephan, Pacific Northwest Laboratory, personal communication). This disturbance has increased erosion and facilitated establishment of knapweed (Centauraea spp.) and cheatgrass brome (Bromus tectorum). Cattle and sheep grazing was initiated on the YTC in 1961; livestock stocking rates during 1992 and 1993 were 0.13 and 0.15 animal unit months/ha. Fires on the YTC, common during summer, burned 5.3 and 8.0 km² in 1992 and 1993, respectively (L.L. Cadwell, Pacific Northwest Laboratory, personal communication).

We identified 5 cover types available for brooding Sage Grouse on the YTC: (1) big sagebrush (A. tridentata)/bunchgrass, which is dominated by Wyoming big sagebrush (A. t. wyomingensis), rabbitbrush (Chrysothamnus spp.), bluebunch wheatgrass (Agropyron spicatum), and Sandberg’s bluegrass (Poa sandbergii); (2) stiff sagebrush (A. rigida)/Sandberg’s bluegrass; (3) altered big sagebrush/bunchgrass, which contains substantially more bare ground and lesser amounts of shrub and herbaceous cover because of repeated disturbance; (4) grassland, predominantly bunchgrasses with some rabbitbrush but virtually devoid of sagebrush because of frequent fires; and (5) riparian, with willow (Salix spp.), currant (Ribes spp.), grasses, sedges (Carex spp.), and Baltic rush (Juncus balticus).

METHODS

We captured Sage Grouse hens using spotlights and walk-in traps (Giesen et al. 1982, Schroeder and Braun 1991) and fitted the birds with numbered aluminum leg bands and necklace-attached radio transmitters during March 1992 and 1993. Each year, when radiotelemetry monitoring confirmed nesting completion, fate was determined by inspection of eggshell membranes or, in 3 instances (2 in 1992, 1 in 1993), observations of hens with young. Initial brood sizes were estimated from shells from successful nests, which were considered initial brood locations. We relocated radio-marked hens with broods >1 time/wk and attempted to obtain visual observations without flushing either hens or broods. If visual observations were not possible, we used recent sign (i.e., droppings, feathers) as an indication of habitat use. Each brood location was determined with a global positioning system in Universal Transverse Mercator (UTM) coordinates and marked with a flag to facilitate relocation for measuring vegetation. A brood was considered successful if ≥1 chicks were observed with a radio-marked hen after 1 August, the approximate date when brood integrity dissolves (Dalke et al. 1960, Oakleaf 1971). We used a t test to examine the null hypothesis that mean brood sizes were the same between years. Z tests with a continuity correction (Zar 1984:395–397) were used to test the null hypotheses that brood success rates and cover type use were the same between years.
We examined 3rd-order (selection of cover types) and 4th-order (selection of particular habitat components within cover types) habitat selection by hens with broods (Johnson 1980). Availability of cover types (3rd order) was determined within a composite minimum convex polygon home range (Odum and Kuenzler 1955) from pre-nesting movements of radio-marked hens with a geographic information system. Availability for 4th-order selection was identified by measuring randomly generated UTM coordinates within each cover type from the composite home range during the 1992-93 brood-rearing seasons.

We measured 4th-order characteristics of hens with broods at brood locations and random sites with 2 perpendicular 10-m transects at each location; the direction of the first transect was determined randomly. Canopy cover of all shrubs along each transect was estimated following Canfield (1941). Cover of grasses, forbs, and litter; residual cover; and bare ground were estimated along transects with ten 0.1-m² frames (Daubenmire 1959). Residual cover was defined as any dead upright plant material and consisted primarily of Russian thistle (Salsola kali), sagebrush, knapweed, and tumble mustard (Sisymbrium altissimum). Maximum height (cm) for shrubs and standing dead vegetation and droop height (excluding flowering parts) for grasses were measured. Grass height was classified as short (< 18 cm) or tall (≥ 18 cm) following Wakkinen (1990) and Gregg et al. (1994). Vertical vegetation cover was measured at plot centers with a modified Robel pole (Robel et al. 1970). Four readings (2 each along the 2 perpendicular 10-m transects) were taken 4 m from the pole and 1 m in height.

Separate analyses were used according to brood age class: early (post-hatching—6 wk) and late (7–12 wk). Previous research revealed changes in habitat use and diets of chicks at approximately 6 wk of age (Martin 1970, Peterson 1970, Drut, Crawford, and Gregg 1994). Both 3rd- and 4th-order data in 1993 were apportioned into 3 diurnal periods: morning (0500–1000 h), midday (1001–1500 h), and evening (1501–2000 h). Too few broods were monitored in 1992 to analyze diurnal habitat selection. Primary forbs in the diets of Sage Grouse chicks in Oregon (Drut, Pyle, and Crawford 1994) and Idaho (Autenrieth 1981) were combined and called food forbs for 4th-order analysis. These forbs included milkvetch (Astragalus spp.), clover (Trifolium spp.), hawksbeard (Crepis ssp.), microsteris (Microsteris gracilis), and species in the Cichorieae (milk-juiced composites). Riparian and stiff sagebrush/bluegrass cover types were combined for 3rd-order analysis because of infrequent brood use each year and were collectively called “other.”

We compared cover types used by radio-marked hens with broods (observed) to the availability of each cover type (expected) with chi-square analysis for 3rd-order analysis. If a significant difference between use and availability was detected, Bonferroni simultaneous confidence intervals were calculated to identify which cover types were used disproportionately (Neu et al. 1974, Byers et al. 1984). The null hypotheses for 3rd-order selection were (1) broods used cover types during both early and late brood-rearing periods in proportion to their availability and (2) brood locations by diurnal period were in cover types in proportion to their availability.

Null hypotheses for 4th-order analyses were that (1) brood and random measurements within cover types did not differ, (2) there were no differences between early and late brood-rearing periods, and (3) there were no differences among times of day and random locations. Fourth-order data were treated with analysis of variance (ANOVA) for unbalanced data and protected least significant difference mean separation tests (Proc GLM, SAS Institute, Inc. 1989). Vegetation variables with nonnormal distributions were transformed (logit transformation for proportional data and log transformation for height data); however, nontransformed means and standard errors are reported herein. All statistical tests are 2-tailed and considered significant at $\alpha = 0.10$.

**RESULTS**

We captured and fitted 85 Sage Grouse hens with radio transmitters during March of both years (45 in 1992, 40 in 1993); 11 clutches were hatched in 1992 and 27 in 1993. Eggs hatched from 22 April to 28 May in 1992 and between 2 May and 19 June in 1993. More than 80% of clutches hatched in the big sagebrush/bunchgrass type. Initial brood size

<table>
<thead>
<tr>
<th>Cover type</th>
<th>Availability (%)</th>
<th>Brood-rearing locations (%)</th>
<th>Early</th>
<th>Late</th>
<th>Early</th>
<th>Late</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1992 (n = 22/5)</td>
<td>1993 (n = 24/10)</td>
<td>1992 (n = 7/4)</td>
<td>1993 (n = 5/10)</td>
</tr>
<tr>
<td>Big sagebrush/bunchgrass</td>
<td>46</td>
<td></td>
<td>77+</td>
<td>68+</td>
<td>71</td>
<td>38</td>
</tr>
<tr>
<td>Grassland</td>
<td>34</td>
<td></td>
<td>9−</td>
<td>24</td>
<td>29</td>
<td>58+</td>
</tr>
<tr>
<td>Altered big sagebrush/bunchgrass</td>
<td>8</td>
<td></td>
<td>5</td>
<td>9</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Otherb</td>
<td>12</td>
<td></td>
<td>9−</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

a = number of locations/broods.

b = use greater than expected; no symbol = use in proportion to availability; = use less than expected (P < 0.10) by Bonferroni confidence intervals.

*Includes riparian and stiff sagebrush/bunchgrass.


<table>
<thead>
<tr>
<th>Cover type</th>
<th>Availability (%)</th>
<th>Morningc (n = 18/12)b</th>
<th>Midday (n = 49/15)</th>
<th>Afternoon (n = 25/14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big sagebrush/bunchgrass</td>
<td>46</td>
<td>67</td>
<td>65+</td>
<td>44</td>
</tr>
<tr>
<td>Grassland</td>
<td>34</td>
<td>28</td>
<td>25</td>
<td>52</td>
</tr>
<tr>
<td>Altered big sagebrush/bunchgrass</td>
<td>8</td>
<td>5</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>Otherd</td>
<td>12</td>
<td>0</td>
<td>0−</td>
<td>0</td>
</tr>
</tbody>
</table>

aMorning (0600–1000 h), midday (1001–1300 h), afternoon (1301–1700 h).
b = number of locations/broods.

b+ = use greater than expected; no symbol = use in proportion to availability; = use less than expected (P < 0.10) by Bonferroni confidence intervals.

dIncludes riparian and stiff sagebrush/bunchgrass.

was greater in 1993 ( = 7.1, sX = 0.42) than in 1992 ( = 5.7, sX = 0.50, t = -1.86, P = 0.07). In 1992 only a single hen was known to recruit young (3 chicks) into the August population, but at least 11 broods ( = 1.5 chicks) survived to 1 August in 1993. Several radio-marked hens entered a restricted area during each summer and the fate of broods that stayed in the restricted area (1 in 1992 and 4 in 1993) is unknown; consequently, they are not included in success estimates. An additional brood was removed in 1993 after contact was lost with the radio-marked hen. Brood success in 1993 was greater than in 1992 (10% in 1992 and 50% in 1993, Z = -2.56, P = 0.01).

We described 3rd-order selection by broods at 29 locations from 5 broods in 1992 and 92 locations from 19 broods in 1993. No 4th-order data were collected in 1992 because most broods perished shortly after hatching. Fourth-order data were collected from 72 locations from 17 broods and 30 random locations in 1993. Brood locations in 1992 were not analyzed by diurnal periods for 3rd-order selection because too few locations were obtained. The mean time between location of a brood and measurements for 4th-order characteristics was 4.6 d.

Sage Grouse selected big sagebrush/bunchgrass during early brood rearing of each year (Table 1) and used grasslands less than expected during the early rearing period of 1992. No cover-type selection was detected during the late rearing period in 1992, although 71% of locations were in big sagebrush/bunchgrass. During the late rearing period of 1993, broods selected grassland and used big sagebrush/bunchgrass in proportion to availability.

During the morning period in 1993, broods used all cover types in proportion to their availability (Table 2), but at midday they selected big sagebrush/bunchgrass. We found no selection during the afternoon period; however, 52% of locations were in grassland.

In 1993 brood locations in big sagebrush/bunchgrass had greater total forb and food forb cover and lower shrub heights than did random big sagebrush/bunchgrass locations (Table 3). Brood locations in altered big sagebrush/bunchgrass had greater tall grass cover.
and taller vertical cover height than random altered big sagebrush/bunchgrass locations. No differences were detected between brood and random locations in grassland. Food forb cover was greater at early and late brood locations than at random locations (Table 4).

Midday brood locations had greater shrub cover and shrub height than morning and afternoon brood locations (Table 5). Afternoon brood locations had less shrub cover and height than random locations. Morning and afternoon brood locations had greater tall grass cover than midday brood and random locations. During each diurnal period food forb cover was greater at brood locations than at random locations. Vertical cover was greater at midday brood locations than afternoon brood and random locations.

**DISCUSSION**

Broods exhibited similar patterns of cover-type use during the early rearing period each year by selecting big sagebrush/bunchgrass, which also was the primary nesting habitat. After hatching, before chicks can fly and when mortality is highest (Patterson 1952, Autenrieth 1981), broods need food in close proximity to escape cover. Random big sagebrush/bunchgrass locations had greater shrub cover and height than grassland and altered big sagebrush/bunchgrass. Short and tall grass cover also was abundant in big sagebrush/bunchgrass. The combination of shrub and grass cover in big sagebrush/bunchgrass apparently provided the best cover for nest success and early brood survival on the YTC.

Most late brood-rearing locations in 1992 were in big sagebrush/bunchgrass, but in 1993 late brood cover-type selection switched to grassland. Hens with chicks made greatest use of grasslands during the afternoon period. In Montana most early summer brood locations were in sagebrush-grassland types, but as forbs desiccated, grouse shifted to black greasewood (Sarcobatus vermiculatus) and grassland cover types in more mesic sites (Peterson 1970, Wallestad 1971). Savage (1969) found that broods left sagebrush uplands in Nevada during rapid temperature increases, which accelerated forb desiccation in sagebrush habitats. Broods may remain in sagebrush uplands when free water is available or during years when abundant precipitation increases forb availability (Oakleaf 1971, Dunn and Braun 1986).

Fourth-order analysis of 1993 data suggests that hens with broods in big sagebrush/bunchgrass (60% of all locations) selectively used sites with more total forbs (25% cover) and more food forbs (8% cover) than available randomly (8% and 2%, respectively). During early and late rearing periods, sites with greater amounts of key forbs were selected. Shrub height and residual cover were slightly less at brood locations than at random sites in big sagebrush/bunchgrass. In Oregon, Drut, Pyle, and Crawford (1994) found that total forb cover at brood sites, which ranged from 11% to
14% during early brood rearing and from 19% to 27% during late brood rearing, influenced cover-type use. Likewise, Klebnower (1969), Schoenburg (1982), and Dunn and Braun (1986) found more forb cover at Sage Grouse brood locations than at random locations. Relatively low availability of forbs in big sagebrush/bunchgrass apparently resulted in strong selection by broods for forb-rich areas within this important brood-rearing cover type. Brood locations in altered big sagebrush/bunchgrass had greater tall (>18 cm) grass cover and vertical cover than random locations within this cover type, suggesting that broods seek protective cover when using this less preferred cover type. No 4th-order vegetation selection was observed for grassland brood locations compared with random locations probably because forb cover was sufficiently abundant throughout and the abundant tall and short grass cover likely provided adequate concealment for escape.

Broods during midday selected big sagebrush/bunchgrass and were observed loafing and dust-bathing under large sagebrush. Midday brood locations had greater shrub cover, shrub height, and vertical cover than morning and afternoon locations. Midday brood locations also had greater vertical cover height than random locations. Several studies described grouse loafing during the midday after morning feeding (Nelson 1955, Gill 1965, Savage 1969, Oakleaf 1971, Autenrieth 1981). Broods used cover types in proportion to their availability during morning or afternoon periods, but 52% of afternoon locations were in grassland, which coincided with evening foraging. Morning and afternoon locations differed from midday and random locations by having greater tall (≥18 cm) grass and less shrub cover and height. Total forb cover and food forb cover at brood locations were not significantly different among diurnal periods. Daytime brood locations had greater forb and food forb cover than random locations. Dunn and Braun (1986) found that during the morning broods fed in open homogeneous areas and during the rest of the day used areas with more horizontal cover and greater variation in sagebrush canopy cover to roost and rest. Savage (1969) found that broods fed shortly after sunrise, loafed in sagebrush during midday, and moved to feeding areas in the evening. Fourth-order location measurements during the morning and afternoon suggested that broods left dense cover to feed, but total and food forbs were abundant at midday locations as well.

Late summer mean brood sizes from studies elsewhere ranged from 2.3 to 3.9 chicks/hen (Keller et al. 1941, Patterson 1952, Nelson 1955, Savage 1969, Wallestad and Watts 1973). Although brood success increased significantly on the study area in 1993, the number of chicks recruited/hen was lower than in other studies and may be insufficient to maintain population stability. Brood success was greater in 1993 than in 1992, which probably resulted from weather conditions during the 2 yr. More precipitation occurred in 1993, accompanied by cooler temperatures that lasted into the

---

### Table 4. Habitat characteristics of Sage Grouse brood locations during early and late brood-rearing periods and random locations on the Yakima Training Center, Yakima and Kittitas counties, Washington, 1993.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Early (n = 53)</th>
<th>Late (n = 19)</th>
<th>Random (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrub cover (%)</td>
<td>11(1)b</td>
<td>7(2)</td>
<td>12(2)</td>
</tr>
<tr>
<td>Shrub height (cm)</td>
<td>14(2)</td>
<td>9(3)</td>
<td>14(2)</td>
</tr>
<tr>
<td>Grass cover (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short, &lt;18 cm</td>
<td>20(1)</td>
<td>20(3)</td>
<td>21(1)</td>
</tr>
<tr>
<td>Tall, &gt;18 cm</td>
<td>19(2)</td>
<td>18(3)</td>
<td>14(2)</td>
</tr>
<tr>
<td>Forb cover (%)</td>
<td>22(2)</td>
<td>23(3)</td>
<td>15(3)</td>
</tr>
<tr>
<td>Key forb cover (%)</td>
<td>6(1)A</td>
<td>6(2)A</td>
<td>2(1)B</td>
</tr>
<tr>
<td>Residual cover (%)</td>
<td>1(0.3)A</td>
<td>0.6(0.2)A</td>
<td>2(0.4)B</td>
</tr>
<tr>
<td>Residual cover height (cm)</td>
<td>1(0.3)</td>
<td>1(0.3)</td>
<td>2(0.4)</td>
</tr>
<tr>
<td>Vertical cover height (cm)</td>
<td>14(2)</td>
<td>12(3)</td>
<td>11(1)</td>
</tr>
<tr>
<td>Bare ground (%)</td>
<td>39(3)A,B</td>
<td>39(3)A,B</td>
<td>44(3)B</td>
</tr>
<tr>
<td>Litter (%)</td>
<td>52(2)</td>
<td>50(4)</td>
<td>46(3)</td>
</tr>
</tbody>
</table>

*Means within row without letters or with the same letter are not significantly different (P > 0.10).
*Means within row with different letters are significantly different (P < 0.10).
### Table 5. Habitat characteristics of Sage Grouse brood locations by diurnal period and random locations on the Yakima Training Center, Yakima and Kittitas counties, Washington, 1993.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Morning (n = 13)</th>
<th>Midday (n = 39)</th>
<th>Afternoon (n = 20)</th>
<th>Random (n = 30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrub cover (%)</td>
<td>7(2)A,B&lt;sup&gt;c&lt;/sup&gt;</td>
<td>15(2)C</td>
<td>4(1)B</td>
<td>13(2)A,C</td>
</tr>
<tr>
<td>Shrub height (cm)</td>
<td>9(2)A,B</td>
<td>18(2)C</td>
<td>6(2)B</td>
<td>14(2)A,C</td>
</tr>
<tr>
<td>Grass cover (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short, &lt;18 cm</td>
<td>20(3)</td>
<td>19(1)</td>
<td>23(2)</td>
<td>21(1)</td>
</tr>
<tr>
<td>Tall, &gt;18 cm</td>
<td>22(2)A</td>
<td>16(2)B</td>
<td>23(3)A</td>
<td>14(2)B</td>
</tr>
<tr>
<td>Forb cover (%)</td>
<td>21(3)</td>
<td>22(2)</td>
<td>22(4)</td>
<td>13(3)</td>
</tr>
<tr>
<td>Key forb cover (%)</td>
<td>6(1)A</td>
<td>7(1)A</td>
<td>6(1)A</td>
<td>2(1)A</td>
</tr>
<tr>
<td>Residual cover (%)</td>
<td>1(0.4)</td>
<td>1(0.3)</td>
<td>1(0.4)</td>
<td>2(0.4)</td>
</tr>
<tr>
<td>Residual cover height (cm)</td>
<td>1(0.4)</td>
<td>1(0.4)</td>
<td>2(0.5)</td>
<td>20(0.4)</td>
</tr>
<tr>
<td>Vertical cover height (cm)</td>
<td>11(1)A,B</td>
<td>16(2)B</td>
<td>9(2)A</td>
<td>11(1)A</td>
</tr>
<tr>
<td>Bare ground (%)</td>
<td>36(5)</td>
<td>36(2)</td>
<td>36(3)</td>
<td>44(3)</td>
</tr>
<tr>
<td>Litter (%)</td>
<td>51(4)</td>
<td>52(3)</td>
<td>52(4)</td>
<td>46(3)</td>
</tr>
</tbody>
</table>

<sup>a</sup>Morning (0500-1000 h), midday (1001-1500 h), afternoon (1501-2000 h).
<sup>b</sup>Mean within row with different letters are significantly different (P < 0.05).
<sup>c</sup>Mean within row without letters or with the same letter are not significantly different (P > 0.10).

summer resulted in greater forb production, delayed plant desiccation, and possibly enhanced juvenile survival (Oakleaf 1971). Peterson (1970) found greater brood success during wet years in Montana when forb production was 2–3 times that of dry years. Autenrieth (1981) noted that migratory populations of Sage Grouse had high brood success because they were able to find forbs, whereas sedentary populations (like those at the YTC) had good reproductive success during moist years when forbs were abundant but did poorly during dry years. An increase in food and cover on the YTC in 1993 may have reduced brood movements, resulting in lower predator exposure and energetic costs of foraging. Nevertheless, by 1 August one-half of the broods were lost and the remainder declined from a mean of 7.1 to 1.5 chicks, approximately an 80% loss.

We concluded that nesting success (45%) was rather typical for Sage Grouse, but brood recruitment to 1 August (14%) and, especially, the number of chicks recruited (24 from 45 successful hens during the 2 yr) were far below average. We suggest that brood-rearing habitat was a strong limiting factor for this small population. Our results indicated that big sagebrush/bunchgrass and grasslands are important cover types throughout brood rearing. Within brood-rearing habitat, there was selection for sites with greater forb cover, especially forbs used as food, and shrub or grass cover (for concealment). Unlike many other Sage Grouse populations in western states, hens did not have the choice of alternative high-quality brood-rearing habitats, such as low sagebrush (A. arbusula), meadows, lakebeds, or broad, forb-rich drainages. Lack of these critical cover types at the YTC coupled with existing habitat conditions likely had an adverse effect on recruitment, which may limit populations on the YTC.

**ACKNOWLEDGMENTS**

This study was funded by Pacific Northwest Laboratory under a contract with the U.S. Department of Defense (DOD). J.A. Klabin, T.M. Kollasch, M.A. Lacroix, A.W. Leary, and K.D. Hand assisted with data collection. We thank L.L. Cadwell and the late L.E. Eberhardt for logistical support and liaisons with DOD. M.A. Gregg provided valuable comments on the manuscript. This is manuscript 11,112 of the Oregon Agricultural Experiment Station.

**LITERATURE CITED**


KELLER, R.J., H.B. SHEPERD, AND R.N. RANDALL. 1941. Survey of 1941/ North Park, Jackson County, Moffit County, including comparative data of previous seasons. Sage Grouse Survey, Colorado Game and Fish Department, Denver. 31 pp.


Received 5 February 1997
Accepted 24 November 1997