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RELATIONSHIPS BETWEEN VEGETATIONAL STRUCTURE AND PREDATION OF ARTIFICIAL SAGE GROUSE NESTS

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Abstract: Because of high nest predation and long-term declines in sage grouse (*Centrocercus urophasianus*) productivity in Oregon, we assessed the effects of vegetational cover and height on predation of artificial sage grouse nests ($n = 330$). Artificial nest fate was positively associated with tall grass cover and medium-height shrub cover collectively ($P = 0.01$). No other vegetation, predator, temporal, or spatial variables explained any additional variation in the probability of predation. This study supports the hypothesis that greater amounts of tall grass and medium-height shrub cover at nest sites lower risk of nest predation for sage grouse. Management practices that increase cover and height of native grasses in sagebrush communities with medium-height shrubs are recommended to enhance sage grouse productivity.

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Declines in sage grouse numbers in Oregon are associated with reduced productivity (Crawford and Lutz 1985), which is in part influenced by diets of hens (Barnett and Crawford 1994) and chicks (Drut et al. 1994) and nesting success (Gregg et al. 1994). In southeastern Oregon, nesting success of radio-marked sage grouse hens was 15%, and 96% of nest failures resulted from predation (Crawford et al. 1992). Although predators were the proximate factor influencing nest loss, the ultimate cause may relate to the vegetation available to nesting sage grouse (Gregg et al. 1994). Tall, dense vegetation may provide visual, scent, and physical barriers between predators and nests of ground-nesting birds (Bowman and Harris 1980; Redmond et al. 1982; Sugden and Beyersbergen 1986, 1987; Crabtree et al. 1989).

Sage grouse nesting habitat is characterized by shrub and herbaceous cover and each may contribute to nest concealment. Wallestad and Pyrah (1974) and Gregg et al. (1994) reported that nondepredated nests had greater shrub cover than did depredated nests. Gregg et al. (1994) reported that tall (>18 cm) grass cover was greater at a small sample of nondepredated nests than at depredated nests and recommended controlled experiments on the relationship between vegetational cover and nest predation.

Artificial nests commonly have been used to test relationships between nest predation and potentially influential factors (Sugden and Beyersbergen 1986, Yahner and Voytko 1989, Reitsma et al. 1990, Esler and Grand 1993). We used artificial nests to assess effects of shrub, forb, and grass cover and height on predation of sage grouse nests.

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STUDY AREA

The study area was located at Hart Mountain National Antelope Refuge (HMNAR), Lake County, Oregon, and was described by Gregg et al. (1994). We placed artificial nests in mountain big sagebrush (*Artemisia tridentata vaseyana*) and low sagebrush (*A. arbuscula*) stands. Forbs common to the sagebrush communities included mountain-dandelion (*Agoseris glauca*), hawksbeard (*Crepis* spp.), milk-vetch (*Astragalus* spp.), lupine (*Lupinus* spp.), and phlox (*Phlox* spp.). Grasses consisted largely of bluegrass (*Poa* spp.), wheatgrass (*Agropyron* spp.), needlegrass (*Stipa* spp.), fescue (*Festuca* spp.), bottlebrush squirreltail (*Sitanion hystrix*), and giant wildrye (*Elymus cinereus*). Plant nomenclature follows Cronquist et al. (1977, 1984, 1989). Livestock grazing on HMNAR averaged 12,835 animal unit months from 1971 through 1990, but did not occur during 1991–92.

METHODS

We placed 330 artificial nests along roads within an area used by sage grouse for nesting (Gregg 1992). We set 44–60 nests during April, May, and June 1991 and 1992, which represented early, late, and renesting periods of sage grouse.

We randomly placed the first nest along each road within 1,600 m of where the road originated at a road junction. We placed subsequent nests at 320-m intervals on alternating sides of the road. When the designated site was not in low sagebrush or mountain big sagebrush community, we placed the nest on the opposite side of the road, or an additional 160 m away. We selected a sagebrush plant that was representative of a sage grouse nest site (Braun et al. 1977, Gregg et al. 1994) and 75–100 m from the road to keep any bias associated with roads consistent for all nests.

We selected nest sites during the day and marked them with a stake wrapped with reflective tape. We relocated each nest at night by casting a light on the reflective stake, placed 3 brown chicken eggs in a depression under a sagebrush, and removed the reflective stake. We left eggs uncovered and placed eggs at night to avoid avian predators associating eggs with human activity (Picozzi 1975; W. L. Wakkinen, Id. Dep. Fish and Game, Bonners Ferry, pers. commun.). When handling eggs and preparing nest sites, we used rubber gloves and boots and a scent-masking chemical. After 21 days, we relocated each nest from a small wooden stake along the roadside with a compass bearing and distance to the nest. We recorded the status of each nest as depredated (≥1 egg missing or destroyed) or nondepredated (3 undisturbed eggs).

To determine whether depredated and nondepredated nests tended to be evenly distributed in relation to geographic location, we placed a 3 × 4 grid on a map of the study area (DeLong 1994). Cells were 6 × 6 km and 9 cells contained artificial nests. Numbers of depredated and nondepredated nests were determined for each cell and arranged in a 2 × 9 contingency table. We used Chi-square analysis to determine if the probability of nest predation differed among locations. The density of artificial nests (1 nest/87 ha) was within the range of nest density estimates reported for sage grouse (Klebenow 1969, Gregg 1992).

After each 21-day test, we measured vegetation in a 3-m^2 plot (1-m radius) at the nest following Gregg et al. (1994). Percent canopy cover of shrubs was measured by line-intercept (Canfield 1941) along 2 2-m perpendicular transects intersecting at the nest center. We determined orientation of the first transect randomly. We placed each shrub intercepted into 1 of 3 height classes: short (<40 cm), medium (40–80 cm), and tall (>80 cm). Canopy cover of shrubs was recorded separately for each height class and averaged over the total transect length. We estimated percent cover of forbs and grasses in 2 20- × 50-cm plots (Daubenmire 1959), the corners of which we placed at the midpoint of each transect. We estimated forb and grass cover in short (<15 cm) and tall (≥15 cm) height classes on the basis of previous studies (Wakkinen 1990, Gregg et al. 1994). We used the average of 2 plots/nest to characterize herbaceous cover at the nest site.

We used 2 methods to index the presence of predators within the vicinity of artificial nests. We conducted weekly transects along roads that contained artificial nests. Each observation of a potential nest predator, including coyote (*Canis latrans*), common raven (*Corvus corax*), badger (*Taxidea taxus*), and ground squirrel (*Spermophilus* spp.), was assigned to the nearest nest. In addition, we walked a 314-m circular transect (50-m radius) centered at each nest site after the 21-day test to determine the presence of burrows as an indicator of potential nest predators (coyote, badger, and ground squirrel).

We used logistic regression (SAS Inst. Inc.

1989:1071) to identify variables that predicted the probability of nest predation. Variables considered in the model included 7 indicator variables (yr, month [2 variables], yr-month interaction [2 variables], and 2 indices of nest predators), 7 continuous vegetational variables (cover of short shrubs, medium shrubs, tall shrubs, short forbs, tall forbs, short grasses, and tall grasses), and all paired interaction terms of vegetational variables. We used a stepwise selection procedure with a $P \leq 0.05$ significance level for entry into the model (Neter et al. 1989: 453). We calculated an odds ratio (Hosmer and Lemeshow 1989) to compare the odds of predation for artificial nests with 5% tall grass cover and 29% medium shrub cover (averages of depredated sage grouse nests; Gregg et al. 1994) with artificial nests with 18% tall grass cover and 41% medium shrub cover (averages of nondepredated sage grouse nests).

RESULTS

Of 330 artificial nests, 233 (71%) were depredated during the 21-day tests. We did not detect a difference in the probability of nest predation among geographic locations or cells ($\chi^2 = 13.15$, 8 df, $P = 0.11$), which suggested that distributions of nondepredated and depredated nests were similar throughout the study area.

Cover of short shrubs, medium shrubs, tall shrubs, short forbs, tall forbs, short grasses, and tall grasses at artificial nest sites ranged from 0 to 87% ($\bar{x} = 27\%$), 0–83% ($\bar{x} = 25\%$), 0–38% ($\bar{x} = 1\%$), 0–42% ($\bar{x} = 5\%$), 0–22% ($\bar{x} = 1\%$), 0–53% ($\bar{x} = 10\%$), and 0–92% ($\bar{x} = 9\%$), respectively. The tall grass-medium shrub cover interaction term was the only variable that entered the logistic regression model ($P = 0.01$). No other vegetation, predator, or temporal variables helped predict nest fate with the tall grass-medium shrub cover interaction term included in the model ($P > 0.05$). The coefficient and standard error for the tall grass-medium shrub cover interaction term were -0.00049 and 0.00019, respectively. Odds of predation of artificial nests with 5% tall grass cover and 29% medium shrub cover, which were averages for depredated sage grouse nests (Gregg et al. 1994), were 1.34 times greater ($P = 0.01$) than the odds of predation of artificial nests with 18% tall grass cover and 41% medium shrub cover, averages for nondepredated sage grouse nests. The 95% confidence interval around the odds ratio was 1.07 and 1.67. Consequently, greater amounts of tall grass and medium shrub cover at artificial nest sites were associated with lower probabilities of nest predation.

DISCUSSION

Our study suggests that the influence of tall grass cover on nest fate depends on the amount of medium shrub cover present at the nest site and, likewise, the influence of medium shrub cover on nest fate depends on the amount of tall grass cover present at the nest site. Greater amounts of both tall grass cover and medium-height shrub cover were associated collectively with a lower probability of nest predation.

Previous studies examined the influence of shrub and grass cover and height, independently, and demonstrated an association between each of these variable and nest fate. Braun et al. (1977:101), in a review of sage grouse studies, noted that shrubs at nest sites ranged from 17 to 79 cm in height and typically were the tallest shrubs available within the immediate area. Connelly et al. (1991) reported that nesting success for sage grouse using sagebrush for nest sites was greater than that for grouse using plants other than sagebrush. Wallestad and Pyrah (1974) and Gregg et al. (1994) demonstrated that greater amounts of shrub cover at nest sites were associated with nondepredated sage grouse nests. In Montana, successful nests had greater shrub cover within a 9-m^2 (1.7-m radius) plot around the nest than did unsuccessful nests (33 and 21%, respectively [Wallestad and Pyrah 1974:632]). Similarly, in Oregon, nondepredated nests had more shrub cover of medium height (40–80 cm) within a 3-m^2 area (1-m radius) than did depredated nests (41 and 29%, respectively [Gregg et al. 1994:164–165]). These studies suggest that cover and height of shrubs in a relatively small area (i.e., nest site) influences nest fate. Shrub cover of nest sites often is greater than shrub cover of sagebrush stands surrounding nest sites; this is, in part, a consequence of a small sampling plot that is centered over a relatively large shrub.

Wakkinen (1990) and Gregg et al. (1994) indicated that shrub cover of sagebrush stands surrounding nest sites may not substantially influence nest predation. They reported that shrub cover within a 1,257-m (20-m radius) and 75-m^2 (5-m radius) area surrounding sage grouse nests did not differ for depredated and nondepredated sage grouse nests. Wallestad and Pyrah

(1974:63), however, reported that shrub cover of sagebrush stands surrounding sage grouse nests was greater for successful nests than unsuccessful nests (27 and 20%, respectively).

Although guidelines for managing sage grouse nesting habitat address sagebrush characteristics (Braun et al. 1977), the importance of herbaceous cover and height to nesting success was only recently identified (Gregg et al. 1994). Autenrieth (1981) reported that herbaceous cover and litter were associated with successful sage grouse nests in Idaho, but he did not present statistical results. Wakkinen (1990:20) suggested that grass height may influence nest fate, although mean grass heights at successful and unsuccessful nests (19 and 16.5 cm, respectively) within a 1,257-m^2 area were not different ($P = 0.09$). Gregg et al. (1994:164–165) reported that the percent cover of tall grass (>18 cm) within a 3-m^2 area was greater at nondepredated nests than depredated nests (18 and 5%, respectively).

Tall grass and medium-height shrub cover provided the greatest amount of canopy and lateral cover for nesting sage grouse (Gregg et al. 1994). Increased amounts of canopy cover may have reduced overhead visibility of nests and may have reduced nest predation by avian predators. Previous studies (Dwernychuk and Boag 1972, Sugden and Beyersbergen 1987) demonstrated that predation of artificial nests was inversely correlated with the amount of overhead cover. Dwernychuk and Boag (1972) suggested that the visibility of eggs was a key factor in predation by avian predators. Also, Sugden and Beyersbergen (1987) reported that tall, dense cover represented a behavioral deterrent as well as a physical barrier to American crows (*C. brachyrhynchos*) hunting on foot. Increased lateral cover possibly reduced nest predation by mammals in this study. Several studies demonstrated that nest predation by mammalian predators decreased with increased lateral cover density, understory height, and vegetational impenetrability (Schranck 1972, Bowman and Harris 1980, Crabtree et al. 1989).

MANAGEMENT IMPLICATIONS

Although suitable nest shrubs were abundant on HMNAR, tall grass cover was limited on the study area as it is throughout much of the Great Basin (Winward 1991). Our results suggest that land management practices that reduce herbaceous cover in sagebrush communities can negatively affect sage grouse nesting habitat. Livestock grazing is the principal use of Oregon rangelands that reduces herbaceous cover and height (Galbraith and Anderson 1971, Rickard et al. 1975). When sage grouse nesting habitat is an objective, managers should monitor livestock distribution and depletion of grasses to remove livestock before the minimum herbaceous cover and height needed for nesting is reached. Some rangelands may need rest from grazing to increase herbaceous cover and height to desired levels. In many situations, however, the absence of livestock grazing alone would not increase herbaceous cover because high shrub cover effectively inhibits the herbaceous understory (Sneva et al. 1984, Laycock 1991, Winward 1991).

In Wyoming big sagebrush (*A. t. wyomingensis*) stands with shrub cover >20% and mountain big sagebrush stands with shrub cover >30%, herbaceous understories are often depleted and would require sagebrush thinning to reestablish the herbaceous component (Winward 1991). Prescribed fires, herbicides, and mechanical treatments would reduce shrub cover and may increase herbaceous cover. Sagebrush reduction, however, may negatively affect sage grouse nesting habitat in the short term (Connelly et al. 1991), and therefore should be implemented only in areas where other suitable nesting habitat exists nearby. In the long term, once sagebrush reestablishes in treatment areas, sage grouse nesting habitat may be enhanced by an improved balance of shrub and grass components available to sage grouse. We recommend land management practices that increase cover and height of native grasses in sagebrush communities with medium-height shrubs as a means to enhance sage grouse nesting success and productivity.

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