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## SEASONAL HABITAT USE AND SELECTION OF CHUKARS IN WEST CENTRAL IDAHO

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**ABSTRACT.**—We examined radio-marked Chukar (*Alectoris chukar*) habitat use and selection in west central Idaho during spring and summer of 1995 and 1996. Use of habitats also was compared with abundance and distribution of yellow starthistle (*Centaurea solstitialis*), an exotic species that is increasingly abundant in Chukar habitats. During summer Chukars used areas of southeast aspect 12% less ( $P = 0.002$ ) and areas of northwest aspect 11% more ( $P = 0.008$ ) than in spring. Chukars also used areas that averaged 9% steeper slopes ( $P < 0.001$ ) and 83 m lower elevations ( $P = 0.054$ ) in summer than in spring. Shrub cover types were used 22% more ( $P < 0.001$ ) in summer than in spring, whereas rock cover types were used 12% less ( $P < 0.009$ ). Chukars used both rock and shrub cover types more than expected in spring (26% and 11% more, respectively) and summer (14% and 33%;  $P < 0.05$ ). Grass use and forb use by Chukars were high in both seasons, ranking 1st in spring (42% of locations) and 2nd in summer (35%); however, observed use was less than expected use (76%) during both seasons ( $P < 0.05$ ). Areas with greater ground cover of yellow starthistle also were used 33% less ( $P < 0.05$ ) than expected, implicating the detrimental effects of this exotic plant on habitat use of Chukars.

*Key words:* *Alectoris chukar*, *Centaurea solstitialis*, Chukar, habitat use, selection, Idaho, yellow starthistle, radio telemetry.

Although understanding of habitat use is considered critical for management of wildlife (White and Garrott 1990), research on use and selection of habitats by Chukars (*Alectoris chukar*) is absent. Only qualitative assessments exist in the literature, with the most detailed account describing ideal Chukar habitat as about 50% sage (*Artemisia* spp.)-cheatgrass (*Bromus tectorum*)-bunchgrass, 45% talus slopes, rock outcroppings, cliffs and bluffs, and 5% brushy creek bottoms and swales (Galbreath and Moreland 1953). Characteristics of habitats used within and between seasons are even less understood, and the proportional use of habitats relative to availability has not been studied.

Impacts of invading yellow starthistle in Chukar habitats require immediate attention. Yellow starthistle is an introduced annual knapweed, 0.5 m to 1 m in height, from Eurasia. It has infested approximately 1,215,000 ha in Idaho, California, and Washington and continues to spread rapidly throughout the Chukar's range (Callihan et al. 1989).

We conducted a 2-year research project using radio telemetry to investigate habitat use and selection by Chukars. We collected descriptive data important to wildlife managers such

as slope, aspect, elevation, and plant species of habitats used by Chukars. We analyzed data collected from radioed birds to (1) compare habitats used by Chukars in spring and summer, (2) assess whether habitat use differed between males and females, (3) determine if Chukars used cover types in proportion to their availability, and (4) ascertain if Chukars used areas dominated by yellow starthistle in proportion to their availability.

### STUDY AREA

Our research was conducted in the canyon grasslands of the lower Salmon River in west central Idaho (45°55'N, 116°22'W), approximately 14 km south of Cottonwood. Boundaries of the 2036-ha study area were delineated by Chukar movements and natural physiographic barriers (Lindbloom 1998). The general climate of the lower Salmon River region is semiarid, characterized by hot, dry summers and mild winters with little snow in the valley bottoms (Tisdale 1986). Elevations range from 402 m to 1108 m with slopes of 45%–75% (Tisdale 1986). Numerous vertical cliffs and talus slopes of Columbia River basalt are present,

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and intermittent springs, creeks, and livestock watering ponds are interspersed throughout the area.

Land ownership along the canyon and plateau portions of the study area is primarily private, but most riparian habitats of the Salmon River are administered by the Bureau of Land Management. Livestock grazing is the principal land use of the study area. The plains area above the river canyons and adjacent to the study area is extensively planted to wheat.

Natural vegetation of the study area developed from flora of the Pacific Northwest and was strongly dominated by bunch grasses (Horton 1972). Tisdale (1986) reported that plant communities characterized by bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), and hood sedge (*Carex hoodii*) occupy most of the grassland area in west central Idaho. Sand dropseed (*Sporobolus cryptandrus*) and red threeawn (*Aristida longiseta*) occur at low elevations. Small inclusions of shrub-grass types are dominated by stiff sagebrush (*Artemisia rigida*), common snowberry (*Symphoricarpos albus*), smooth sumac (*Rhus glabra*), curleaf mountainmahogany (*Cercocarpus ledifolius*), and netleaf hackberry (*Celtis reticulata*; Tisdale 1986). Invasion of exotic annuals like cheatgrass and yellow starthistle has modified the historic natural vegetation composition in many areas of the lower Salmon River canyon.

## METHODS

### Data Collection

Fifty-one Chukars were captured between late January and early May with baited walk-in traps (Christensen 1970). Necklace-mounted transmitters, weighing an average 10.8 g, were attached to 22 birds (13 M, 9 F) in 1995. Because of difficulties experienced using necklace-mounted transmitters (Lindbloom 1998), we used backpack-mounted transmitters, weighing an average 14 g, on 29 birds (17 M, 12 F) captured in 1996. Radio-marked Chukars were located approximately weekly during April–August in 1995 and 1996. Locating birds weekly allowed sufficient time for Chukars to sample all cover types on the study area, given spatial heterogeneity of cover types and mobility of the birds. Unmarked birds were located with a dog during initial pretrapping surveys and while pursuing radio-marked Chukars. Covey

locations were counted as 1 habitat location. If >1 radio-marked Chukar was in a covey, data were recorded for only 1 randomly selected bird (Alldredge and Ratti 1992). To prevent bias of habitat use toward time of day, we attempted to systematically obtain an equal number of observations during 3 diurnal time periods: (1) sunrise to 1000 hours, (2) 1001–1400 hours, and (3) 1401 hours to sunset (Alldredge and Ratti 1992).

All Chukar locations from 16 February to 10 June were categorized as spring locations, when habitat was used during pair formation, breeding, and 1st nesting attempts. Summer locations were gathered between 11 June and 13 August and reflected habitat use during reneesting and brood rearing.

Habitat sampling for each location occurred within a 10-m-radius circle centered at the flush site of radio-marked birds and incidental, unmarked birds. Because Chukars are notorious for running uphill, we attempted to approach birds from the uphill side. Habitat data were not recorded if movements were detected while listening to the transmitter frequency or if birds were observed moving prior to flushing. Slope, aspect, elevation, cover type, percent of each cover type, and percent ground cover by yellow starthistle were recorded at all habitat use locations. Because of the circular nature of aspect data, we categorized measurements into 4 quadrants: (1) northeast (0°–90°), (2) southeast (91°–180°), (3) southwest (181°–270°), or (4) northwest (271°–360°). In addition, we recorded the 3 most abundant (based on estimated ground coverage) species of grass, forb, and shrub.

Four cover types were identified for analysis of habitat use and selection: (1) rock (talus, outcrop, cliff), (2) shrub, (3) grass/forb, and (4) agriculture. Because most locations contained >1 vegetative or physical characteristic or both, determination of cover type was based on the percentage of cover types present inside the 10-m-radius circle. Agricultural cover types were characterized as areas containing ≥50% agricultural crop, whereas shrub cover types contained ≥20% shrubs. Areas containing ≥20% rock cover but <20% shrub characterized rock cover types. Grass/forb cover types were characterized by areas containing <20% rock or shrub, with grass and forbs comprising the greatest percent of cover for the location.

Ground cover of yellow starthistle, grasses, forbs, and shrubs, and cover type percentages at Chukar locations were most often determined from visual estimation. To calibrate these estimates, we measured 22 bird locations using 10-m line intercepts (Canfield 1941) extended in cardinal directions from the flush site. These measurements were completed in different cover types throughout the seasons to sample plants in various phenological stages and provide checks on the accuracy of visual estimations.

To quantify cover type availability at the study-area level, all cover types were delineated on 7.5-minute-series orthophotoquads by interpreting aerial photographs. Cover type availability was measured by overlaying the orthophotoquads with 100-dot-per-square-inch grids.

Availability of areas with ground cover of yellow starthistle was determined during peak bloom (late July). Two categories of ground cover were measured: (1) starthistle  $\leq 5\%$  and (2) starthistle  $> 5\%$ . Category 1 areas contained no starthistle or only sparse densities and were easily discernible from category 2 areas as non-starthistle habitats. Category 2 areas generally contained medium to high densities. These categories were delineated on aerial photographs by walking and driving the study area and using a spotting scope. Data were later transferred to orthophotoquads and area per category of starthistle ground cover was measured using dot grids. Approximately 41% (815 ha) of the study area was classified as category 1 and 59% (1169 ha) as category 2.

#### Statistical Analyses

Habitat use data were tested to evaluate the appropriateness of pooling among (1) locations of radio-marked and unmarked birds, (2) gender, (3) years, and (4) seasons. We used a categorical data modeling procedure (PROC CATMOD; SAS Institute, Inc. 1990) to construct log-linear models that allowed for the examination of 2-, 3-, and 4-way interactions among cover type, year, season, and gender. Because gender was unknown for locations of unmarked Chukars, log-linear models were constructed without data from unmarked birds. Due to insufficient sample size, log-linear models could not be used to compare marked and unmarked birds; however, chi-square homogeneity tests provided 2-way interaction analyses. Chi-square analysis tested whether habitat

use data among years, seasons, and marked/unmarked locations were homogeneous. Because homogeneity analyses and log-linear models both indicated that habitat use differed between seasons, Z-tests for comparing 2 binomial proportions were constructed to determine which cover types were used differently.

Methods of weighting observations, assumptions, and characteristics of our data set (Allredge and Ratti 1992) were most influential in choosing the method of analyzing habitat selection (Lindbloom 1998). Chi-square goodness-of-fit tests, in conjunction with the Yates correction for continuity factor for pooled data (Zar 1996:467), were used to assess whether proportional use of cover types during spring or summer differed significantly from proportional availability in the study area (Neu et al. 1974). Bailey's confidence intervals (Bailey 1980, Cherry 1996) were constructed to detect if differences existed between observed and expected use of cover types.

Because minimum expected frequencies of agriculture cover type did not meet the requirements of Dixon and Massey (1969), and frequencies were too low to be analyzed in log-linear models, we performed tests of homogeneity without the agriculture cover type. For purposes of selection analysis, however, agriculture cover types were tested with goodness-of-fit statistics.

To address the possible avoidance of yellow starthistle, we first constructed log-linear models (PROC CATMOD; SAS Institute, Inc. 1990) to assess 2- and 3-way interactions among use of yellow starthistle ground cover, year, and gender. Because the thistle does not attain full growth until summer, we measured and analyzed use and availability for this season only. A chi-square homogeneity analysis was conducted to compare yellow starthistle use between locations of marked and unmarked birds. A goodness-of-fit test was used to test proportional use and availability of yellow starthistle ground cover categories (Neu et al. 1974). Bailey's confidence intervals (Bailey 1980, Cherry 1996) were constructed to assess differences between observed and expected use.

#### RESULTS

Grass/forb cover type was the most abundant habitat in the study area (77.5% of the study area), followed by rock (11.3%), shrub

(6.3%), and agricultural fields (4.9%). Two cover types, trees and Conservation Reserve Program (CRP) fields, accounted for <3% of the study area and were not used by Chukars. Consequently, these cover types were excluded from the statistical analyses.

Habitat use data were gathered from 346 bird locations of 51 radio-marked Chukars (30 M, 171 locations; 21 F, 113 locations) and 62 unmarked Chukar locations in 1995 (124 locations) and 1996 (222 locations). For each radio-marked Chukar, we collected data from an average of  $9.1 \pm 1.2 s_{\bar{x}}$  (range = 1–22) locations. Twenty percent of Chukar locations were from the 1st diurnal time period, 48% from the 2nd, and 33% from the 3rd.

Chukars used steeper slopes ( $t = -4.887$ ,  $P < 0.001$ ) and lower elevations ( $t = 1.936$ ,  $P = 0.054$ ) in summer than in spring. Slopes used in summer were  $60\% \pm 1.4\%$  ( $\bar{x} \pm s_{\bar{x}}$ ; range = 8–90,  $n = 156$ ), whereas slopes of locations in spring averaged  $51\% \pm 1.6\%$  (range = 0–94,  $n = 169$ ). Elevations of habitats used by Chukars averaged  $963 \pm 9$  m (range = 595–1107,  $n = 171$ ) during spring and  $880 \pm 12$  m (range = 543–1098,  $n = 158$ ) during summer.

Aspect of locations ranged from  $18^\circ$  to  $358^\circ$  and  $14^\circ$  to  $359^\circ$  in spring and summer, respectively. Four percent of Chukar locations during spring were in areas of northeast aspect, whereas 24%, 54%, and 18% were southeast, southwest, and northwest, respectively. For summer locations, 5%, 12%, 54%, and 29% were categorized as northeast, southeast, southwest, and northwest, respectively. Aspect measurements from spring locations were not homogeneous to measurements from summer locations ( $\chi^2 = 11.5$ ,  $df = 3$ ,  $P = 0.009$ ). Chukars used southeast aspects 12% less ( $Z = 2.9$ ,  $P = 0.002$ ) and northwest aspects 11% more ( $Z = -2.4$ ,  $P = 0.008$ ) in summer than in spring.

Within use locations categorized as rock cover type, the percent of talus, cliff, or outcrop averaged 39% (Table 1). Shrub cover types used by Chukars were composed of an average of 34% shrub, 19% grasses, and 26% forbs in the grass/forb cover type.

Shrubs most frequently recorded in highest abundance at Chukar locations were cudweed sagewort (*Artemisia ludoviciana*; 13% of all locations), syringa (*Philadelphus lewisii*; 7%), rose (*Rosa* spp.; 5%), common snowberry (4%), and currant (*Ribes* spp.; 3%). Grass species most frequently recorded with highest ground

coverages at use sites were *Bromus* spp. (54%), bluebunch wheatgrass (25%), bluegrass (*Poa* spp.; 15%), medusahead (*Taeniatherum asperum*; 3%), and *Festuca* spp. (2%). Common forb species were yellow starthistle (31%), arrowleaf balsamorhiza (*Balsamorhiza sagittata*; 18%), western yarrow (*Achillea millefolium*; 16%), biscuit-root (*Lomatium* spp.; 13%), and tonella (*Tonella floribunda*; 10%).

All 3- and 4-way interactions of log-linear modeling among cover type year, season, and gender were insignificant, resulting in a final model of main effects and 2-way interactions. Interaction of season and cover was significant ( $P = 0.006$ ), but there were no interactions between the dependent variables year and cover ( $P = 0.176$ ) or gender and cover ( $P = 0.097$ ).

Observations of habitat use by marked and unmarked birds during spring 1995 and 1996 were homogeneous ( $\chi^2 = 8.648$ ,  $df = 6$ ,  $P = 0.194$ ), as were observations during summer 1995 and 1996 ( $\chi^2 = 8.226$ ,  $df = 6$ ,  $P = 0.222$ ). Therefore, the data were pooled. Habitat use data collected during the spring and summer were not homogeneous ( $\chi^2 = 18.619$ ,  $df = 2$ ,  $P < 0.001$ ), consistent with results of the previous log-linear models.

Because homogeneity tests and log-linear models suggested data may be pooled between marked and unmarked birds, years, and gender but not between seasons, habitat use and selection were compared between seasons with all the data pooled. Rock cover types were used more ( $P = 0.009$ ) and shrub cover types were used less ( $P < 0.001$ ) in spring than in summer, but use of grass/forb ( $P = 0.113$ ) and agriculture did not differ between seasons (Table 2; agriculture qualitatively examined).

Degree of seasonal habitat use was examined by ranking proportional use of each cover type (Table 2). During spring grass/forb was the most used cover type, followed by rock, shrub, and agriculture. During summer shrub was the most used cover type, followed by grass/forb, rock, and agriculture.

Observed use of cover type differed from expected use, based on availability, for both spring ( $\chi^2 = 172.23$ ,  $df = 3$ ,  $P < 0.001$ ) and summer ( $\chi^2 = 329.33$ ,  $df = 3$ ,  $P < 0.001$ ). Chukars used rock and shrub more than expected and grass/forb less than expected during both spring and summer (Table 3;  $P < 0.05$  for all significant pairwise comparisons). Use of

TABLE 1. Descriptions of cover types used by Chukars in west central Idaho in 1995 and 1996.

	Cover type											
	Rock (n <sup>a</sup> = 100)			Shrub (n <sup>a</sup> = 91)			Grass/forb (n <sup>a</sup> = 123)			Agriculture (n <sup>a</sup> = 7)		
	$\bar{x}$	$s_{\bar{x}}$	Range	$\bar{x}$	$s_{\bar{x}}$	Range	$\bar{x}$	$s_{\bar{x}}$	Range	$\bar{x}$	$s_{\bar{x}}$	Range
% rock	39	1.9	18–100	20	2	0–80	9	0.8	0–40	0	0	0
% shrub	4	0.5	0–15	34	1.4	15–75	3	0.5	0–16	0	0	0
% grass	13	0.9	0–50	9	0.7	0–40	19	1.3	1–65	4	3.8	0–25
% forb	20	1.4	0–65	13	0.9	0–45	26	1.3	0–60	2	1.5	0–10
% agriculture	0	0	0	0	0	0	0	0	0	93	7.2	50–100

<sup>a</sup>Number of Chukar locations

TABLE 2. Analyses of habitat use by Chukars during spring and summer in the lower Salmon River canyon of west central Idaho, 1995 and 1996.

Cover type	Spring		Summer		Test statistic <sup>b</sup>	P value	Results <sup>c</sup>
	Proportional use (n <sup>a</sup> = 179)	Rank of use	Proportional use (n <sup>a</sup> = 158)	Rank of use			
Rock	0.374	2	0.253	3	2.384	0.009	used less*
Shrub	0.173	3	0.386	1	4.381	<0.001	used more*
Grass/forb	0.419	1	0.354	2	1.214	0.113	no difference
Agriculture	0.034	4	0.006	4	N/A <sup>d</sup>	N/A <sup>d</sup>	N/A <sup>d</sup>

\*Significant at  $P < 0.05$

<sup>a</sup>Number of Chukar locations

<sup>b</sup>Binomial proportions Z-test

<sup>c</sup>Differences of habitat use for summer compared with spring

<sup>d</sup>Use of agriculture between seasons could not be tested because of small sample sizes

TABLE 3. Confidence intervals (CI)<sup>a</sup> for spring and summer habitat selection of Chukars in the lower Salmon River Canyon of west central Idaho in 1995 and 1996.

Cover	Expected use	Spring			Summer		
		Observed use	95% CI	Results	Observed use	95% CI	Results
Rock	0.113	0.374	(0.283, 0.467)	more <sup>b</sup>	0.253	(0.169, 0.347)	more <sup>b</sup>
Shrub	0.063	0.173	(0.107, 0.253)	more <sup>b</sup>	0.386	(0.288, 0.486)	more <sup>b</sup>
Grass/forb	0.775	0.419	(0.325, 0.513)	less <sup>c</sup>	0.354	(0.259, 0.453)	less <sup>c</sup>
Agriculture	0.049	0.034	(0.008, 0.081)	no difference <sup>d</sup>	0.006	(0.010, 0.042)	less <sup>c</sup>

<sup>a</sup>Bailey (1980)

<sup>b</sup>Observed proportional use significantly greater than ( $P < 0.05$ )

<sup>c</sup>Observed proportional use significantly less than ( $P < 0.05$ )

<sup>d</sup>Observed proportional use significantly not different ( $P \geq 0.05$ ) from expected proportional use

agriculture was equal to that expected during spring and less than expected ( $P < 0.05$ ) during summer.

Log-linear modeling of yellow starthistle data revealed no 3-way interaction among use of starthistle ground cover, years, and sexes ( $P = 0.120$ ). Use of starthistle differed between years ( $P = 0.002$ ); thus, data were not pooled between years. In 1995, Chukars were located in areas of low starthistle ground cover (43%)

and in areas of higher starthistle ground cover (57%), whereas in 1996 they were located more frequently (74% of locations) in low yellow starthistle ground cover. Data from 1996 were used because of larger sample size ( $n = 125$  for 1996,  $n = 34$  for 1995). Use of starthistle did not differ between sexes ( $P = 0.264$ ); therefore, male and female data were pooled. Because use of yellow starthistle by males, females, and unmarked birds was homogeneous ( $\chi^2 = 1.025$ ,

df = 2,  $P = 0.599$ ), we also pooled data from marked and unmarked birds.

Chukars did not use yellow starthistle in proportion to availability ( $\chi^2 = 57.3$ , df = 1,  $P < 0.001$ ). Observed proportional use of habitats with  $\leq 5\%$  ground cover of yellow starthistle [Baileys CI = (0.643, 0.825)] was greater ( $P < 0.05$ ) than expected proportional use (0.411). Conversely, observed proportional use of habitats with  $> 5\%$  ground cover of starthistle (0.171, 0.352) was less ( $P < 0.05$ ) than expected proportional use (0.589).

#### DISCUSSION

Chukars in the lower Salmon River canyon showed differential use of habitats between seasons possibly as a result of diet selection, thermal cover, water availability, and anti-predator behavior. Alkon et al. (1985) suggested that Chukar diets are largely determined by forage availability, which is closely linked to meteorological and phenological events. Other studies have also demonstrated seasonal variation in Chukar food habits (Moreland 1950, Christensen 1952, Galbreath and Moreland 1953, Sandfort 1954). Galbreath and Moreland (1953) recorded increased percentages of fruits and animal matter in summer/fall over winter/spring diets. Use of shrub habitats in our study by Chukars increased 20% from spring to summer. Increased fruit consumption during summer months may have contributed to the increased proportional use of shrubs (most of which provide fruits throughout the summer) by Chukars in the lower Salmon River canyon.

Changing requirements for thermal cover may also contribute to Chukar differential use of seasonal habitats. Galbreath and Moreland (1953) noted that Chukars tolerate temperatures up to 48°C without great distress. Although summer temperatures rarely exceed 48°C in our study region, the cooler temperatures found in shrub habitats may be desirable, similar to that reported for Northern Bobwhites (*Colinus virginianus*) in Texas (Forrester et al. 1998). As proportional use of shrub cover by Chukars increased in summer, proportional use of rock habitats decreased. Undoubtedly, talus slopes and rock outcrops were hotter during summer months, while shrub habitats were cooler. In addition, Chukars used southern exposed slopes less in summer than in spring, thus providing

further evidence that Chukars were avoiding higher temperatures.

Water is believed to limit Chukar distribution and habitat use during summer (Galbreath and Moreland 1953, Harper et al. 1958, Christensen 1970). Degen et al. (1984) suggested that Chukars do not require drinking water from early winter to late spring, when succulent green forage is available, but free water is required during summer and autumn. Increases in proportional use of shrubs we observed from spring to summer, many of which were in riparian zones, may have been a result of water availability. Furthermore, Chukars used slopes of southeast aspect less and northwest aspect more in summer than in spring, perhaps in search of more succulent forage with higher moisture content.

Differential habitat use patterns could also confer advantages to Chukars by decreasing predation. In a related study (Lindbloom 1998), 41% of Chukars were preyed upon from mid-spring to late summer; 59% of these mortalities were avian caused. Local nesting raptor populations experience increased food requirements during these months, and the potential increase in predation rates from raptors may be offset by greater hiding cover found in shrub habitats.

High use and selection of shrub habitats during summer, in addition to the probable advantages of increased food resources, thermal cover, water, and hiding cover, suggest that this habitat is important to Chukars in canyon grasslands. Van Horne (1983), however, demonstrated that density of animals and habitat quality are not always positively correlated and suggested that habitat quality should be defined in terms of survival and production characteristics, as well as density, of the species occupying the habitat. Determination of habitat selection in the lower Salmon River canyon was an important 1st step in increasing our knowledge of Chukar ecology, but we recommend further research on survival and reproduction specific to cover types used by Chukars.

Although grass/forb cover types were used less than expected based on availability, these habitats were not lightly used. Grass/forb cover types ranked 1st and 2nd in use in spring and summer, respectively. Because 78% of the study area consisted of grass/forbs, it is unlikely that any moderate amount of use would be more than or equal to expected when compared with

availability. The environments within grass/forb habitats apparently provide necessary elements such as food and cover for Chukars.

The use of and impact to agricultural crops by Chukars during certain times of the year has been previously reported. Wheat, rye, and barley were reported eaten by Chukars in Washington, and potato crop damage was witnessed during dry summers when weather forced Chukars out of natural range into cultivated lands for water (Galbreath and Moreland 1953). Tomlinson (1960) reported that alfalfa, wheat, and barley are eaten by Chukars. Christensen (1970) and Harper et al. (1958), however, reported that depredation was light and of no economic significance. Results of our study are in agreement with Christensen (1970) and Harper et al. (1958); Chukars selected against agriculture habitats during summer months.

Chukars used areas heavily infested with yellow starthistle less than expected, selecting instead areas with low ground cover of starthistle. This suggests potential negative impacts of this noxious weed on Chukar habitat use. Annual helicopter surveys of Chukars in Idaho from 1993 through 1999 also found limited occurrence of Chukars in or near yellow starthistle-dominated habitats and a tendency for birds to occur more often in areas with less starthistle (C. Johnson, Bureau of Land Management, personal communication). Areas heavily infested by starthistle were most likely avoided due to the long, sharp spikes surrounding flower heads that often produce a nearly impassable field of thorns, and the near absence of other vegetation under a dense starthistle canopy.

#### MANAGEMENT IMPLICATIONS

Invasion of cheatgrass alone may not constitute suitable habitat for Chukars. Managers of canyon grasslands should encourage land practices that allow for retention of shrub communities. Horton (1972) suggested that the invasion of exotic annuals and early maturing vegetation, which create fuel conditions amenable to rapid and frequent wildfire, will adversely impact native vegetation of the lower Salmon River. Whether these events will reduce the health and distribution of shrubs in canyon grassland habitats needs to be closely monitored and will likely vary with intensity, season, and frequency of fire.

As yellow starthistle continues to expand, the availability of suitable Chukar habitat will decline. Reduction of starthistle may be necessary to increase Chukar populations to pre-infestation levels. Use of herbicides does not appear feasible, given the vastness of Chukar habitat and associated economic and ecological costs of chemical application. Biological control, such as introduction of native insects from the Mediterranean, is still in experimental stages (R. Callihan, University of Idaho, personal communication) but may be the only method possible of reducing starthistle densities. Efforts and experiments to approve the safe import of Mediterranean insects capable of controlling yellow starthistle should be continued. In addition, halting the spread of starthistle into uninvaded Chukar ranges should be addressed seriously.

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