Research Report

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Effects of Cattle Grazing on Birds in Interior Douglas-fir (*Pseudotsuga menziesii*) Forests of British Columbia

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Abstract

Livestock grazing is a dominant land use across North America and although the effects of grazing on birds have been studied in grassland, shrubland, and riparian habitats, studies of the effects in forests are rare. We investigated the effects of cattle grazing in forests on vegetation, the relationships between vegetation characteristics and the abundance of foraging and nesting guilds of birds, and the overall effects of grazing on the bird community in the Interior Douglas-fir (*Pseudotsuga menziesii*) biogeoclimatic zone of British Columbia. Cattle grazing was associated with reduction in ground vegetation height and grass cover, and increases in the number of shrubs and saplings. Bark insectivores, foliage insectivores, cavity nesters, and shrub/tree nesters all responded positively to sapling density. However, this translated into few overall effects of cattle grazing on birds, with only bark insectivores exhibiting greater abundance on grazed areas. Grazed areas also had fewer aerial insectivores but the mechanism driving this remains unclear. Current forest grazing practices at our study sites appear to have few negative effects on bird abundance and diversity, with the possible exception of aerial insectivores. Study of additional sites is required to assess if forest grazing exerts similar effects throughout the Interior Douglas-fir forest. Furthermore, study of the effects of forest grazing on productivity and survival of birds is needed.

KEYWORDS: *aerial insectivore; bark insectivore; birds; Cariboo-Chilcotin; interior Douglas-fir biogeoclimatic zone*

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Introduction

Livestock grazing is one of the principal land uses in North America, occurring on 317 million ha in the USA and 26 million ha in Canada (Horton 1996; Lubowski et al. 2006). Grazing can have widespread impacts on vegetation structure and composition. Grazing has direct impacts on vegetation via compaction of soil and trampling and defoliation of plants (Kauffman and Krueger 1984). As some plant species respond positively to grazing pressure while others respond negatively, grazing can alter species composition (Kutt and Woinarski 2007) and facilitate invasions of exotic species (Kimball and Schiffman 2003). These grazing-induced changes in species composition can result in conversion of grassland to shrubland (Skarpe 1990), hasten the regeneration of cleared pasture to forest (Posada et al. 2000; Zimmermann et al. 2009) and facilitate forest expansion (Richardson et al. 2007). Such vegetation changes can in turn impact bird communities. For instance, grazing can reduce the suitability of an area for species that rely on characteristics such as tall grass and greater cover (e.g., Lesser Prairie-Chicken [*Tympanuchus pallidicinctus*] and Upland Sandpiper [*Bartramia longicauda*]) (Derner et al. 2009), while potentially benefiting those that prefer low cover and bare ground (e.g., Mountain Plover [*Charadrius montanus*] and Long-billed Curlew [*Numenius americanus*]) (Derner et al. 2009). Birds may suffer increased nest predation rates due to reduced cover and altered suitability of nesting sites (Ammon and Stacey 1997; Fondell and Ball 2004). In addition, cattle may directly impact birds by exposing, trampling, or otherwise destroying ground nests (Nack and Ribic 2005; Walsberg 2005).

While both the direct and indirect effects of cattle on vegetation and birds have been relatively well studied in western grasslands, shrublands, and riparian areas (reviewed in Kauffman and Krueger 1984; Bock et al. 1993; Fleischner 1994; Saab et al. 1995; Tewksbury et al. 2002), there is less known about the impacts of cattle grazing in forests, particularly on birds (Bock et al.1993; Saab et al. 1995). Studies investigating the effects of grazing on forest vegetation have revealed that light, controlled grazing can facilitate tree recruitment by removing vegetation that otherwise outcompetes seedlings. However, with more intense or uncontrolled grazing, cattle can reduce shrub understorey and trample and browse seedlings, potentially impacting forest recruitment (reviewed in Adams 1975; see also Harrington and Kathol 2009; Van Uytvanck and Hoffmann 2009). Despite early observations that heavy grazing can dramatically alter forest structure and avifauna (Dambach 1944) few studies have directly assessed the effects of cattle on birds in non-riparian forested areas. Bird species are expected to have differing susceptibilities to cattle grazing depending on the degree to which they use different strata of vegetation. Cattle are predicted to have the greatest effect on birds that primarily use ground or understorey vegetation, and minimal effects on those using the forest canopy. Martin and Possingham (2005) found that the amount of time spent foraging in particular vegetation strata was a significant predictor of the response of individual bird species to grazing in a grassy eucalypt forest. The few studies that have investigated the impact of cattle grazing on birds in non-riparian forest have typically found that more bird species respond negatively to grazing than positively. However, the degree of response of the bird community varies widely, ranging from most species exhibiting a response to cattle (Martin and Possingham 2005; Martin and McIntyre 2007) to almost none (Goguen and Mathews 1998; Kutt and Woinarski 2007). Effects of cattle grazing may also vary with forest type. For example, Alexander et al. (2008) found cattle grazing reduced abundances of shrub-nesting and foliage-gleaning birds in oak woodlands but not in mixed conifer forest. In contrast, they found that grazing increased species richness in the mixed conifer forest but not in the oak woodland.

> *Cattle are predicted to have the greatest effect on birds that primarily use ground or understorey vegetation, and minimal effects on those using the forest canopy.*

Ranching in forestland is a widespread practice in the interior of British Columbia, Canada. Cattle ranchers have been using forested areas since the 1890s, and by 1950, 2.8 million ha of forestland were grazed (Tisdale 1950). Currently, at least 70% of all rangeland in the province is in forest (Wikeem et al. 1993). This region has experienced considerable forest ingrowth and encroachment in the last century, altering the structure of the forest-grassland matrix (Ross 2000, Bai et. al. 2004). To date, no studies have examined the effects of cattle grazing on birds in the Interior Douglas-fir (*Pseudotsuga menziesii*) biogeoclimatic (BEC) zone, which is the most important zone for grazing in the southern interior of British Columbia (Wikeem et al. 1993). We therefore set out to examine the effects of current grazing practices on both vegetation and birds in the Douglas-fir forest of the Cariboo-Chilcotin region. We first investigated the effects of grazing on ground vegetation and forest structure, and then assessed relationships between particular vegetation characteristics and the abundance of different foraging and nesting guilds of birds. Finally, we assessed if changes in vegetation associated with cattle grazing and guild-level responses to vegetation led to differences in the bird community composition, overall abundance, and diversity between grazed and ungrazed areas.

Methods

Study Area

We conducted this study in the Cariboo-Chilcotin region of the Interior Douglas-fir biogeoclimatic zone (IDF) in British Columbia, Canada, where the lower elevations of the Fraser and Chilcotin River valleys are grassland, grading into the dry, open forest at higher elevations. At our study sites, forest canopy is dominated by Douglas-fir (97% of trees). Understorey consists primarily of Douglas-fir saplings (80% of saplings) and a mixture of Common Snowberry (*Symphoricarpos albus*), rose (*Rosa* spp.), and juniper (*Juniperus* spp.). Dominant ground cover includes Bluebunch Wheatgrass (*Agropyron spicatum*), Pine Grass (*Calamagrostis rubescens*), Kentucky Bluegrass (*Poa pratensis*), and Rosy Pussytoes (*Antennaria microphylla*). Soils of the Douglas-fir/pinegrass subzone of the IDF are primarily Orthic Grey Luvisols, while the higher elevations of the grassland subzone are Dark Grey Chernozems (Annas and Coupé 1979). Ranching is an important land use of the area. Current stocking rates in the region for grassland and forest range are estimated to average 1.2 AUM (animal unit month)/ha and do not exceed 3.3 AUM/ha (C. Mumford and W. Heyes-van Vliet, personal communication July 2009), and pastures extend across the grassland-forest ecotone and into the forest. The study was conducted at three sites located within 70 km of each other: Churn Creek Protected Area (CCPA; average aspect 100°; average elevation 834 m; BEC variant IDFxm) on the western plateau above the Fraser River; the OK Ranch (OKR; average aspect 200°; average elevation 1176 m; BEC variants IDFxm and IDFxw) on the eastern plateau above the Fraser River; and Junction Sheep Range Provincial Park (JSR; average aspect 83°; average elevation 912 m; BEC variant IDFxm) which lies above the junction of the Chilcotin and Fraser Rivers. We categorized sites as either: 1. currently grazed (OKR and CCPA) or 2. ungrazed (JSR) but were unable to further categorize the intensity of grazing due to local variability in the timing, duration and intensity of grazing, both temporally and geographically. During the study we attempted to get cattle counts and length of times on sites from the ranchers involved but were unable to obtain this information. However, field crews who spent considerable time at the sites noted that grazed plots were being actively grazed during the study. JSR has not been grazed by cattle in over 30 years. We established 116 point count stations in forest (>30% tree cover; assessed visually) across the three different sites in a grid pattern, with each station 250 m apart.

Bird Abundance

Each station was surveyed for birds three times between mid-May and mid-July in 2007 and again in 2008. All birds seen or heard within a 50 m radius during a six minute point-count were identified to species and recorded. As woodpeckers are not well recorded with passive point count surveys, surveys were followed by an eight minute playback of local woodpecker calls. Any woodpeckers seen or heard at any distance during the point count or playback were noted. Woodpeckers not successfully identified to species were recorded as "unknown woodpecker." Surveys were conducted between 0500 and 1000 hours or occasionally until 1100 hours if the day was cool and birds were still singing. Counts were not conducted during high winds or rain. We defined species abundance as the maximum number of individuals of each species seen at a given station during the year, to reflect the peak in local breeding density. As the species-level abundance data contained many zeros, abundances were combined into nesting (cavity, ground, shrub/tree) and foraging guilds (aerial insectivore, bark insectivore, foliage insectivore, and ground insectivore); omnivores and raptors were omitted from guild-level analyses due to low abundances (Appendix A). Species were classified to guilds based on their primary feeding habitats during the nesting period, following Poole (2010). Red Crossbills (*Loxia curvirostra*) were omitted from all analyses because they were encountered in large foraging flocks (up to 35 individuals) that did not reflect local breeding abundance.

Vegetation

We collected two sets of vegetation data at point count stations: *ground vegetation* and *forest structure. Ground vegetation* was assessed as the percent cover of bare ground, biocrust, forbs, grass, and litter within a 5 m radius circle centred on the point count station, and on its maximum height, which was recorded at the centre of the station and at one, three, five, and ten metres in each of the cardinal directions and then averaged. Because this was a measure of ground cover and vegetation was often sparse and the categories included bare ground, the method we used summed categories to 100%. The class "litter," which had the highest correlations with the other categories, was omitted from analyses. While we acknowledge that different species of forbs and grasses respond differently to grazing, the lumping of different species in these categories was necessary because many species occurred too rarely to be analyzed separately. As well, cattle grazing can also shift communities from grass dominated to forb dominated so using these broader categories was appropriate.

Forest structure measures included the number of shrubs (including saplings < 1 m tall), saplings (> 1 m tall and ≤ 12.5 cm diameter at breast height [dbh]) and trees (> 12.5cm dbh) within an 11.3 m radius circle (0.04 ha) centred on the point count station. We attempted to collect each type of vegetation data once per station over the two years of the study, but were unable to measure both at all point count stations due to logistical constraints. Ground vegetation data was collected at 113 of the 116 stations, and forest structure data was collected at 63 stations.

Statistical Analysis

As we were primarily interested in the effects of grazing on avifauna rather than year-to-year variation, and found no evidence for year effects or year by grazing interactions on overall avian abundance or diversity (see below), we did not include year in analyses of effects of grazing on vegetation, guild-level responses to vegetation characteristics, or differences in bird community composition with grazing category.

Effects of grazing on vegetation

We first used discriminant function analysis (DFA) to assess differences between grazed and ungrazed stations in ground vegetation and forest structure (Table 1). DFA is used to determine which variables discriminate between groups, in this case, grazed or ungrazed sites, and are therefore, the best predictors of whether a station is grazed or ungrazed.

Percent ground cover values were arcsine transformed and numbers of shrubs, saplings, and trees were $\log_{10}(x+1)$ transformed. For ease of interpretation, back-transformed values (mean + 95% confidence intervals [CI]) are presented in figures. As we were using DFAs not to predict group membership but instead to highlight vegetation differences between grazing categories, we used Wilks' λ, a measure of the variation in the data not explained by the grouping (grazing category), to assess the overall utility of the DFA. Standardized canonical discriminant function coefficients (which indicate the direction and relative contribution of each variable to the discriminant function) and means + 95% confidence intervals for each grazing category were used to assess the relative importance of each variable in differentiating grazed and ungrazed stations. DFAs were conducted in the statistical package SPSS 17.0 (SPSS Inc, Chicago, IL).

TABLE 1. Sets of vegetation characteristics used in discriminant function analyses to assess vegetation differences between grazed and ungrazed forest sites

Discriminant function set	Vegetation characteristics included
Ground vegetation	Height of ground vegetation
	Cover of bare ground
	Cover of biocrust
	Cover of forbs
	Cover of grass
Forest structure	Number of shrubs
	Number of saplings
	Number of trees

Guild-level responses to vegetation

We used an information theoretic approach to assess the fine-scale response of each guild of birds to individual characteristics of the vegetation. This is a model selection method which uses AIC, or Akaike Information Criteria, to determine which model (among series of plausible models specified before conducting the analyses) best fits the data collected. Only bird count data collected in the same year as the appropriate vegetation set at each station were used ($n = 113$ for analysis of guild-level responses to ground vegetation; $n = 63$ for forest structure). We predicted that birds foraging and nesting on the ground are most likely to respond to changes in ground vegetation, while those that forage and nest in the understorey and canopy layers are most likely to respond to changes in forest structure (Martin and Possingham 2005). Aerial insectivores may forage on flying insects that originate on ground, shrub or canopy vegetation, and thus may respond to changes in both ground vegetation and forest structure, depending on the source of their invertebrate prey. We therefore tested only biologically relevant model sets relating to these hypotheses (Table 2).

The candidate model set for ground vegetation contained eight models, consisting of a "null" and "all combinations" of ground vegetation variables (vegetation height, bare ground, biocrust cover, forb cover, and grass cover), though bare ground + biocrust cover and forb cover + grass cover were grouped, rather than being used independently, to keep the number of candidate models from approaching the sample size. The forest structure set contained eight candidate models, consisting of a null model and all combinations forest structure variables (number of shrubs, saplings, and trees). Because none of the variables included within a single analysis were correlated ($r < 0.4$) each combination represented a biologically realistic hypothesis. Generalized linear models (GENMOD, a procedure in the statistical software SAS, version 9.2 SAS Institute Inc, Cary, NC) with Poisson distributions and log links were used to generate estimates for models predicting guild abundance from vegetation. QAIC (quasi-AIC) values corrected for small sample sizes (QAIC_c) were used in all analyses (Burnham and Anderson 2002). QAIC_c weights (w_i) were used to assess the relative support for each of the models. Summed w_is ($\sum w_i$) and AIC weighted parameter estimates (PE) and their associated unconditional standard errors ($\mathrm{SE_u}$) were also computed to assess the support for and relative effects of the parameters present in the best-supported models (Burnham and Anderson 2002).

Effects of grazing on bird community composition

We used DFAs to assess if the grazing-associated changes in vegetation and guild-level responses to vegetation characteristics led to differences in bird community composition between grazed and ungrazed areas. Community composition was expressed as abundance of three nesting or four foraging guilds (Table 3).

Guild-level abundances were $\log_{10}(x+1)$ transformed, and the full set of abundance data ($n = 116$ stations $\times$ 2 years of observation = 232) were used. For ease of interpretation, back-transformed values (mean + 95% CI) are presented in figures. The overall utility of the DFAs and relative contribution of each guild to the discriminant function were assessed as above.

Response of bird community to grazing

Finally, we used an information theoretic approach to investigate if the grazing-associated changes in vegetation and guild-level responses to vegetation characteristics led to overall differences in bird abundance and diversity (calculated using the Shannon-Weiner diversity index) between grazed and ungrazed areas, while accounting for potential year effects and year by grazing interactions. Each model set consisted of five models (null, year, grazing, year + grazing, and year + grazing + year*grazing). Generalized linear models (proc GENMOD, SAS 9.2) were used to generate AIC_c estimates corresponding to each hypothesis. AIC values corrected for small sample sizes (AIC_c) were used in all analyses (Burnham and Anderson 2002). Relative support for models and individual terms was assessed as above.

TABLE 2. Sets of vegetation characteristics tested for potential effects on guild-level bird abundance

	Vegetation sets tested
Foraging guild	
Aerial insectivore	Ground vegetation, forest structure
Bark insectivore	Forest structure
Foliage insectivore	Forest structure
Ground insectivore	Ground vegetation
Nesting guild	
Cavity	Forest structure
Ground	Ground vegetation
Shrub/tree	Forest structure

TABLE 3. Sets of guild-level bird abundance used in discriminant function analyses to assess differences in bird community composition between grazed and ungrazed forest sites

Discriminant function set	Guild-level abundances included
Nesting guild	Cavity
	Ground
	Shrub/tree
Foraging guild	Aerial insectivores
	Bark insectivores
	Foliage insectivores
	Ground insectivores

Results

Effects of Grazing on Vegetation

Vegetation differed between grazed and ungrazed areas, with grazing category explaining 9.4% of the variation in ground vegetation (Wilks' $\lambda = 0.906$) and 12.2% of variation in the forest structure (Wilks' $\lambda = 0.878$). Grazed stations had less grass cover, shorter ground vegetation, and more forb cover, although the latter two effects were weaker (standardized discriminant function coefficients: grass = -0.731, vegetation height = -0.466, forb = 0.414, biocrust = -0.236, bare ground = 0.153; Figure 1). Grazed stations also had more shrubs, and to a lesser degree, more saplings (shrubs = 0.798, saplings = 0.556, trees = -0.435; Figure 2).

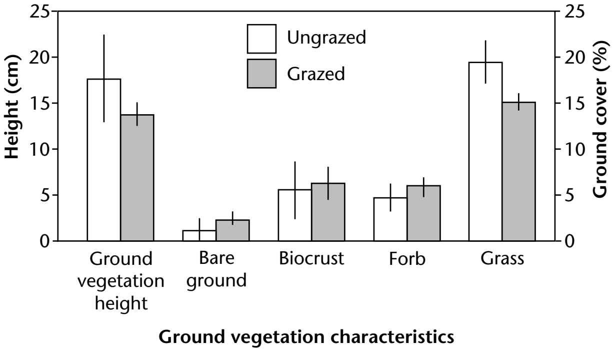

FIGURE 1. Ground vegetation characteristics at grazed ($n = 16$) and ungrazed ($n = 97$) stations. Error bars represent 95% CI.

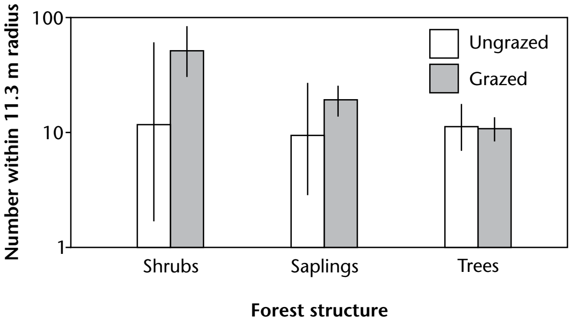

FIGURE 2. Forest structure characteristics at grazed ($n = 13$) and ungrazed ($n = 50$) stations. Error bars represent 95% CI.

Guild-level Responses to Vegetation

Foraging guilds

Bark insectivores responded to forest structure, being more abundant where there were more saplings ($\Sigma w_i = 0.64$, PE ± $SE_u = 0.003 \pm 0.003$, Table 4, where PE is Parameter Estimate and SE is Standard Error). Foliage insectivores were also more common where there was a greater density of saplings ($\Sigma w_i = 0.96$, PE ± $SE_u = 0.004 \pm 0.001$). In contrast, ground insectivores did not appear to respond to any aspect of ground vegetation, and aerial insectivores did not respond to either ground vegetation or forest structure. For these two guilds, the null models received the most support and SE_us for all terms bounded zero (Table 4).

Nesting guilds

Cavity nesters, a very similar suite of species to bark insectivores (Appendix A), exhibited similar responses to vegetation. Cavity nesters were more common where there were more saplings ($\Sigma w_i = 0.61$, PE ± $SE_u = 0.002 \pm 0.002$; Table 5). Shrub/tree nesters were also more common at stations with more saplings ($\Sigma w_i = 0.94$, PE ± $SE_u = 0.003 \pm 0.001$). Ground nester abundance, however, did not appear to be affected by ground vegetation as the null model received the most support and the model-averaged parameter estimates and associated SE_us bounded zero (Table 5).

Effects of Grazing on Bird Community Composition

Grazed and ungrazed stations differed in the relative abundance of the different foraging guilds, with 12.7% of the variation explained by grazing category (Wilks' $\lambda = 0.873$). Grazed stations had fewer aerial insectivores and a more bark insectivores (standardized discriminant function coefficients: aerial = -0.979, bark = 0.369, foliage = -0.024, ground = 0.140; Figure 3). In contrast, grazing category did not affect the relative abundance of the different nesting guilds, with only 2.9% of the variation in abundance explained by grazing category (Wilks' $\lambda = 0.971$; Figure 4).

TABLE 4. Strongly supported ($\Delta QAIC_c < 2$) and null models relating abundance by foraging guild to forest structure and ground vegetation. All candidate sets contained 8 models.

Guild	Model	n	K^1	$QAIC_c{}^2$	$\Delta QAIC_c{}^3$	$w_i{}^4$
Aerial insectivore	Forest structure					
	1. (null)	63	2	159.64	0.00	0.33
	2. Number of saplings	63	3	160.63	0.99	0.20
	3. Number of shrubs	63	3	161.43	1.78	0.13
	Ground vegetation					
	1. (null)	113	2	219.21	0.00	0.44
	2. Height of ground vegetation	113	3	220.46	1.25	0.23
Bark insectivore	Forest structure					
	1. Number of saplings	63	3	145.49	0.00	0.28
	2. Number of saplings + number of trees	63	4	146.11	0.62	0.20
	3. (null)	63	2	146.83	1.34	0.14
	4. Number of trees	63	3	146.99	1.50	0.13
Foliage insectivore	Forest structure					
	1. Number of saplings	63	3	193.60	0.00	0.44
	2. Number of saplings + number of trees	63	4	194.82	1.22	0.24
	3. Number of shrubs + number of saplings	63	4	195.36	1.76	0.18
	5. (null)	63	2	200.12	6.52	0.02
Ground insectivore	Ground vegetation					
	1. (null)	113	2	512.18	0.00	0.39
	2. Forb cover + grass cover	113	4	514.00	1.82	0.16
	3. Height of ground vegetation	113	3	514.10	1.93	0.15
	4. Bare ground + biocrust cover	113	4	514.16	1.98	0.15

1 The number of estimated parameters in the model including the variance.

2 A measure of the level of fit of the data to the model weighted by the number of variables in the model, corrected for small sample sizes.

3 The difference between the $QAIC_c$ of each model and that of the most parsimonious model.

4 The likelihood of the model given the data, relative to the other models in the candidate set.

TABLE 5. Strongly supported ($\Delta QAIC_c < 2$) and null models relating abundance by nesting guild to forest structure and ground vegetation. All candidate sets contained 8 models. See Table 4 for definitions of column headings.

Guild	*Model*	*n*	*K*	*QAICc*	*ΔQAICc*	*wi*
Cavity nester	Forest structure					
	1. Number of saplings	63	3	196.81	0.00	0.31
	2. (null)	63	2	197.91	1.10	0.18
	3. Number of saplings + number of trees	63	4	198.13	1.32	0.16
Ground nester	Ground vegetation					
	1. (null)	113	2	341.72	0.00	0.35
	2. Height of ground vegetation	113	3	342.74	1.01	0.21
	3. Bare ground + biocrust cover + height of ground vegetation	113	5	342.84	1.11	0.20
Shrub/tree nester	Forest structure					
	1. Number of saplings	63	3	288.32	0.00	0.48
	2. Number of shrubs + number of saplings	63	4	289.75	1.43	0.23
	5. (null)	63	2	293.94	5.62	0.03

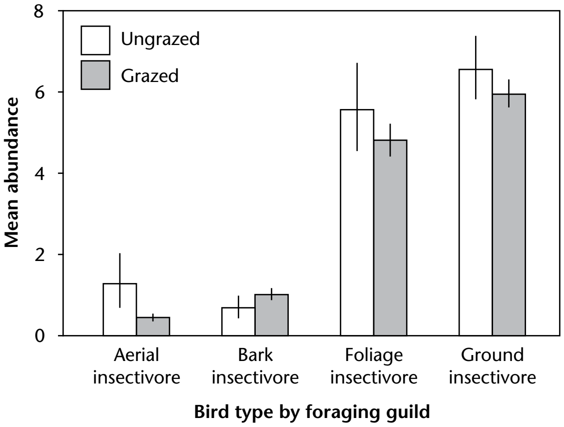

FIGURE 3. Mean bird abundance by foraging guild at grazed ($n = 32$) and ungrazed ($n = 200$) point-count stations. Error bars represent 95% CI.

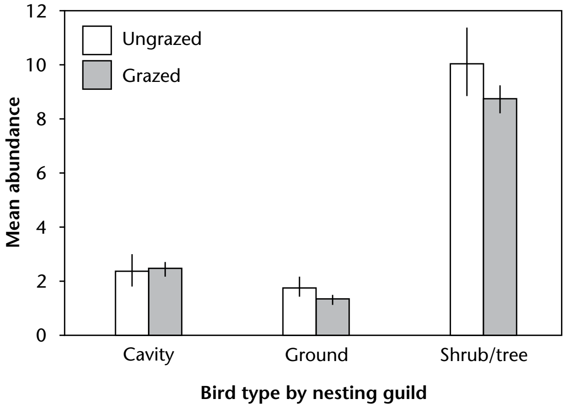

FIGURE 4. Mean bird abundance by nesting guild at grazed ($n = 32$) and ungrazed ($n = 200$) point-count stations. Error bars represent 95% CI.

Response of Bird Community to Grazing

We found no evidence that grazing affected bird abundance or diversity. While the top-ranked models for both abundance and diversity consisted of a grazing term, in both cases the null model ranked second and also received substantial support (Table 6).

In addition, unconditional parameter estimates for the effects of grazing bounded zero (abundance: $\sum w_i$ = 0.56, PE ± SE_u = 0.761 ± 0.946; diversity: $\sum w_i$ = 0.63, PE ± SE_u = 0.070 ± 0.077; Figs. 5 and 6). There was no evidence for an effect of year on either total abundance or diversity (abundance: $\sum w_i$ = 0.33, PE ± SE_u = -0.112 ± 0.293; diversity: $\sum w_i$ = 0.16, PE ± SE_u = -0.006 ± 0.020), nor were there any grazing by year interactions (abundance: $\sum w_i$ = 0.05, PE ± SE_u = -0.017 ± -0.111; diversity: $\sum w_i$ = 0.16, PE ± SE_u = 0.002 ± 0.010; Figures 5 and 6).

TABLE 6. Strongly supported (ΔAIC < 2.0) models from candidate model sets that predict plot-level bird abundance and diversity as a function of grazing category, year, and grazing*year. Both candidate sets included five models. See Table 4 for definitions of column headings.

Model		n	K	AIC_c	ΔAIC_c	w_i
Bird abundance						
	1. Grazing	222	3	1373.72	0.00	0.36
	2. (null)	222	2	1374.01	0.28	0.31
	3. Grazing + year	222	4	1375.74	1.75	0.15
	4. Year	222	3	1375.74	2.01	0.13
Bird diversity						
	1. Grazing	222	3	179.96	0.00	0.41
	2. (null)	222	2	180.79	0.83	0.27
	3. Grazing + year	222	4	181.88	1.92	0.16

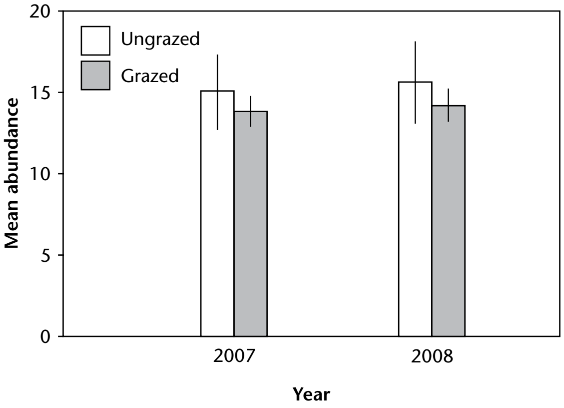

FIGURE 5. Mean bird abundance (all guilds) at grazed and ungrazed point-count stations in 2007 and 2008. *n* = 16 ungrazed and 100 grazed stations per year. Error bars represent 95% CI.

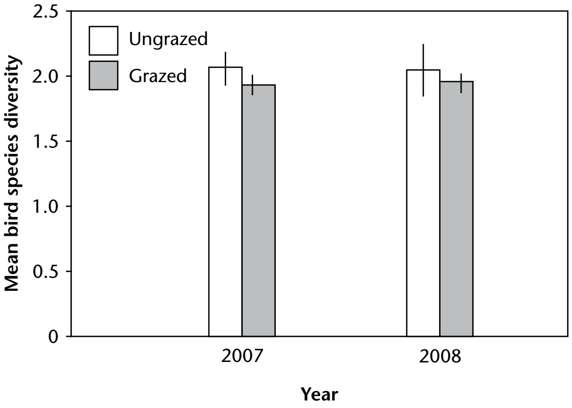

FIGURE 6. Mean bird species diversity (Shannon-Weiner index) at grazed and ungrazed point-count stations in 2007 and 2008. *n* = 16 ungrazed and 100 grazed stations per year. Error bars represent 95% CI.

Discussion

Studies examining how grazing impacts vegetation structure and bird communities have primarily been conducted in grassland, shrubland and riparian areas, while studies examining the effects of grazing on birds in forest are rare (Bock et al. 1993; Saab et al. 1995). Our study is the first to examine the influence of cattle grazing in forests on bird community composition, abundance, and diversity in the Interior Douglas-fir biogeoclimatic zone of British Columbia, Canada, despite forest grazing being a widespread practice in the area (Tisdale 1950; Wikeem et al. 1993). We observed vegetation structure to differ between grazed and ungrazed sites, and several bird guilds responded to vegetation characteristics that were potentially altered by grazing. However these effects generally did not scale up to overall differences in bird community composition, abundance, or diversity between grazed and ungrazed sites.

Grazed sites differed from a long-term ungrazed site in terms of both ground vegetation and forest structure, having less grass cover, shorter ground vegetation and somewhat greater forb cover, as well as greater density of saplings and shrubs. The shorter ground vegetation and increased sapling density we observed are likely attributable to cattle grazing. Cattle have been well documented to reduce the average height of ground vegetation, and in British Columbia, sward height is used to monitor and assess range condition in both forest and grassland pasture (Fraser 2003; Range Branch 2006). While cattle grazing can exert negative impacts on shrubs and saplings via trampling and browsing (Mayer et al. 2006; Marquardt et al. 2009), grazing can also enhance shrub and sapling growth by removing competing ground vegetation (Skarpe 1990; Darabant et al. 2007). Forest grazing has been associated with increases in density of young conifers in the northwestern United States, and these increases have been attributed to removal of competing vegetation by cattle (Rummell 1951; Zimmerman and Neuenschwander 1984). The majority of trees (97%) and saplings (80%) at our sites are Douglas-fir, and removal of ground vegetation has been demonstrated to enhance the growth and survival of Douglas-fir seedlings, including in the Interior Douglas-fir biogeoclimatic zone (Harper et al. 2005; Dinger and Rose 2009). However, as we had only one ungrazed site, we cannot rule out the possibility that the vegetation differences we observed are site effects rather than a direct result of cattle grazing. Additional work is required to verify if forest grazing has similar effects on vegetation throughout the region.

We tested the degree to which cavity nesters, shrub/tree nesters, bark insectivores, and foliage insectivores responded to different aspects of forest structure and the responses of ground nesters and ground insectivores to characteristics of ground vegetation. Bark insectivores, foliage insectivores, cavity nesters and shrub/tree nesters all exhibited increased abundance with greater density of saplings. These guilds may have responded positively to sapling density because saplings (defined as > 1 m tall and ≤ 12.5 cm dbh, this category includes reasonably-sized young trees) may provide foraging opportunities or nesting substrates. Sapling density may also be correlated to some other unmeasured characteristic to which the birds were responding (e.g., presence of large old trees or dead snags, which provide substrate for nesting cavities). In contrast, neither ground nester nor ground insectivore abundance was related to any of the ground vegetation variables measured. The changes in ground vegetation associated with grazing (22% reduction in vegetation height, 22% reduction in grass cover, 29% increase in forb cover) may not have been great enough to have pronounced effects on ground nesters or ground insectivores. However, in studies of grasslands and shrublands, grazing-induced changes in vegetation height and grass cover of similar magnitude have been associated with decreases in density and species richness of ground-foraging granivorous birds (Gonnet 2001) and reductions in breeding success of ground-nesting Grasshopper Sparrows (*Ammodramus savannarum)* (Sutter and Ritchison 2005). Mixed responses at the species level may have masked expected effects. For example, a decrease in abundance of ground-nesting or ground-foraging species that prefer tall, extensive grass cover could be negated by an increase in species that prefer less cover. However, most species were present at only a low proportion of stations, preventing us from assessing species-specific responses to grazing and vegetation characteristics.

The effects of cattle grazing on birds are generally indirect, with birds responding to grazing-induced changes in vegetation and associated characteristics such as nest-site suitability and food supply, rather than the presence of cattle per se (Ammon and Stacey 1997; Fondell and Ball 2004; Dennis et al. 2008). In our study areas, cattle grazing was associated with some differences in bird community composition, with grazed sites having more bark insectivores and fewer aerial insectivores. The increased abundance of bark insectivores on grazed sites is likely due to their positive association with sapling density, as sapling density was higher on grazed sites. However, foliage insectivores, cavity nesters, and shrub/tree nesters also exhibited positive associations with sapling density, but this did not translate into increased abundance on grazed sites. The increase in sapling density associated with cattle grazing may have been too small to affect abundance of these guilds. Aerial insectivores exhibited much lower abundance at the grazed sites, even though they did not respond to any measured vegetation characteristic of either ground vegetation or forest structure. Aerial insectivores may be responding to aspects of the vegetation that we did not measure, such as species composition, or they may be responding to factors such as predation risk, nest site suitability, and food availability, which may not exhibit close correlations with the vegetation characteristics we measured. In addition, as we only had one ungrazed site, we cannot rule out the possibility of site effects.

Despite altering bird community composition, cattle grazing did not affect overall bird abundance or diversity at our sites. Mixed effects between guilds may have negated overall abundance trends, with decreases in aerial insectivores on grazed areas being offset by increases in bark insectivores. Grazing may not have affected bird diversity because current levels of grazing in the region are relatively low. Low intensity grazing often results in heterogeneous use of the vegetation, with some preferred areas being heavily utilized while others are relatively untouched (DelCurto et al. 2005; Kohler et al. 2006; Willcox et al. 2010). Habitat may therefore remain available to a broad suite of species, from those that prefer characteristics of heavily grazed vegetation to those that are relatively grazing-intolerant (Derner et al. 2009).

While current levels of grazing appear to have little negative impact on the bird community (other than potentially reducing aerial insectivore abundance), these results need to be treated with caution as they are based on relative abundance data only and we have no information on demography. Information on survival and productivity is required to accurately assess habitat quality and predict population trajectories (Van Horne 1983). The presence of cattle and cattle-induced vegetation changes can lead to increases in predation and parasitism, which reduce nesting success (Ammon and Stacey 1997; Goguen and Matthews 2000). The effects of forest grazing on reproduction of birds in the Douglas-fir forest of the Cariboo-Chilcotin area remain to be determined.

Management Implications

Current forest grazing practices at our study sites in the Cariboo-Chilcotin area appear to exert few negative effects on bird abundance. The only group to exhibit a negative effect of grazing was aerial insectivores, and the mechanism underlying the effect is unclear as aerial insectivores did not respond to any of the vegetation characteristics we measured. This result is cause for some concern, as many aerial insectivores are declining across North America (35% of species; Sauer et al. 2008), and three of the eight aerial insectivores in this study are declining in British Columbia (average annual population change 1966-2007: Dusky Flycatcher -1.77%, Olive-sided flycatcher -4.14%, Townsend's Solitaire -2.52%; Sauer et al. 2008. See Appendix A for scientific names). Study of additional long-term ungrazed sites is required to confirm these findings and assess if forest grazing of cattle exerts similar effects (particularly on aerial insectivores) throughout the Interior Douglas-fir forest.

British Columbia's cattle population has dropped by 21% in recent years, from a peak of 950 000 head in July 2004 to 656 000 in July 2008 (Statistics Canada 2011), so there is potential for the use of the forest as rangeland to increase in the future should cattle numbers return to previous levels. Higher intensity grazing may produce more pronounced changes to ground vegetation which could negatively affect ground-nesting and ground-foraging guilds. Additionally, at higher intensity, forest grazing may instead exert negative effects on Douglas-fir reproduction by cattle trampling or browsing seedlings. Such inhibited forest regeneration would have the potential to negatively impact several bird guilds which exhibit positive relationships with sapling density.

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References

Adams, S. N. 1975. Sheep and cattle grazing in forests: a review. Journal of Applied Ecology 12:143–152.

Alexander, J. D., J. L. Stephens, and N. E. Seavy. 2008. Livestock utilization and bird community composition in mixed-conifer forest and oak woodland in southern Oregon. Northwest Science 82:7–17.

Ammon, E. M., and P. B. Stacey. 1997. Avian nest success in relation to past grazing regimes in a montane riparian system. Condor 99:7-13.

Annas, R. M., and R. Coupé [EDS]. 1979. Biogeoclimatic zones and subzones of the Cariboo forest region. B.C. Ministry of Forests. Victoria, BC, Canada.

Bai, Y., K. Broersma, D. Thompson and T. J. Ross. 2004. Landscape-level dynamics of grassland-forest transitions in British Columbia. Rangeland Ecology & Management 57:66–75.

Bock, C. E., V. A. Saab, T. D. Rich, and D. S. Dobkin. 1993. Effects of livestock grazing on neotropical migratory landbirds in western North America. In: D. M. Finch and P. W. Stangel [EDS]. Status and management of neotropical migratory landbirds. Fort Collins, CO, USA: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, RM-GTR–229.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach, 2nd ed. Springer-Verlag, New York, NY.

Dambach, C. A. 1944. A ten-year ecological study of adjoining grazed and ungrazed woodlands in northeastern Ohio. Ecological Monographs 14:255–270.

Darabant, A., P. B. Rai, K. Tenzin, W. Roder, and G. Gratzer. 2007. Cattle grazing facilitates tree regeneration in a conifer forest with palatable bamboo understory. Forest Ecology and Management 252:73–83.

DelCurto, T., M. Porath, C. T. Parsons, and J. A. Morrison. 2005. Management strategies for sustainable beef cattle grazing on forested rangelands in the Pacific northwest. Rangeland Ecology and Management 58:119–127.

Dennis, P., J. Skartvelt, D. I. McCracken, R. J. Pakeman, K. Beaton, A. Kunaver and D. M. Evans. 2008. The effects of livestock grazing on foliar arthropods associated with bird diet in upland grasslands of Scotland. Journal of Applied Ecology 45:279–287.

Derner, J. D., W. K. Lauenroth, P. Stapp, and D. J. Augustine. 2009. Livestock as ecosystem engineers for grassland bird habitat in the western great plains of North America. Rangeland Ecology and Management 62:111–118.

Dinger, E. J., and R. Rose. 2009. Integration of soil moisture, xylem water potential, and fall-spring herbicide treatments to achieve the maximum growth response in newly planted Douglas-fir seedlings. Canadian Journal of Forest Research 39:1401–1414.

Fleischner, T. L. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629–644.

Fondell, T. F., and I. J. Ball. 2004. Density and success of bird nests relative to grazing on western Montana grasslands. Biological Conservation 117:203–213.

Fraser, D. A. 2003. Applying best stubble heights on rangelands. Rangeland Health Brochure 6. Victoria, B.C., Canada: B.C. Ministry of Forests, Forest Practices Branch. ***http://www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro77.htm*** (Accessed 30 March 2010.)

Goguen, C. B., and N. E. Mathews. 1998. Songbird community composition and nesting success in grazed and ungrazed pinyon-juniper woodlands. Journal of Wildlife Management 62:474–484.

Goguen, C. B., and N. E. Mathews. 2000. Local gradients of cowbird abundance and parasitism relative to livestock grazing in a western landscape. Conservation Biology 14:1862–1869.

Gonnet, J. M. 2001. Influence of cattle grazing on population density and species richness of granivorous birds (Emberizidae) in the arid plain of the Monte, Argentina. Journal of Arid Environments 48:569–579.

Harper, G. J., P. G. Comeau, and B. S. Biring. 2005. A comparison of herbicide and mulch mat treatments for reducing grass, herb, and shrub competition in the B.C. interior Douglas-fir zone—ten-year results. Western Journal of Applied Forestry 20:167–176.

Harrington, J. A., and E. Kathol. 2009. Responses of shrub midstory and herbaceous layers to managed grazing and fire in a North American savanna (oak woodland) and prairie landscape. Restoration Ecology 17:234–244.

Horton, P. R. 1996. The rangelands of British Columbia. Kamloops, B.C., Canada: B.C. Ministry of Forests, Range Branch. ***http://www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro46.htm*** (Accessed 30 March 2010.)

Kauffman, J. B., and W. C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications . . . a review. Journal of Range Management 37:430–438.

Kimball, S., and P. M. Schiffman. 2003. Differing effects of cattle grazing on native and alien plants. Conservation Biology 17:1681–1693.

Kohler, F., F. Gillet, S. Reust, H. H. Wagner, F. Gadallah, J-M. Gobat, and A. Buttler. 2006. Spatial and seasonal patterns of cattle habitat use in a mountain wooded pasture. Landscape Ecology 21:281–295.

Kutt, A. S., and J. C. Z. Woinarski. 2007. The effects of grazing and fire on vegetation and the vertebrate assemblage in a tropical savanna woodland in north-eastern Australia. Journal of Tropical Ecology 23:95–106.

Lubowski, R. N., M. Vesterby, S. Bucholtz, A. Baez, and M. J. Roberts. 2006. Major uses of land in the United States, 2002. Economic Information Bulletin No. EIB–14. Washington, DC, USA. US Department of Agriculture, Economic Research Service. ***http://www.ers.usda.gov/Publications/EIB14/*** (Accessed 20 March 2010.)

Marquardt, S., A. Marquez, H. Bouillot, S. G. Beck, A. C. Mayer, M. Kreuzer, and H. A. Alzérreca. 2009. Intensity of browsing on trees and shrubs under experimental variation of cattle stocking densities in southern Bolivia. Forest Ecology and Management 258:1422–1428.

Martin, T. G., and S. McIntyre. 2007. Impacts of livestock grazing and tree clearing on birds of woodland and riparian habitats. Conservation Biology 21:504–514.

Martin, T. G., and H. P. Possingham. 2005. Predicting the impact of livestock grazing on birds using foraging height data. Journal of Applied Ecology 42:400–408.

Mayer, A. C., V. Stöckli, W. Konold, and M. Kreuzer. 2006. Influence of cattle stocking rate on browsing of Norway Spruce in subalpine wood pastures. Agroforestry Systems 66:143–149.

Nack, J. L., and C. A. Ribic. 2005. Apparent predation by cattle at grassland bird nests. Wilson Bulletin 117:56–62.

Poole, A. [ED.] 2010. The birds of North America online. Cornell Lab of Ornithology and American Ornithologists' Union. ***http://bna.birds.cornell.edu/bna (***Accessed 10 January 2010.)

Posada, J. M., T. M. Aide, and J. Cavelier. 2000. Cattle and weedy shrubs as restoration tools of tropical montane rainforest. Restoration Ecology 8:370–379.

Range Branch. 2006. A methodology for monitoring Crown range. Rangeland Health Brochure 10 (draft). Kamloops, B.C., Canada: B.C. Ministry of Forests, Range Branch. ***http://www.for.gov.bc.ca/hfd/pubs/Docs/Bro/Bro82.htm*** (Accessed 30 March 2010.)

Richardson, D. M., P. W. Rundel, S. T. Jackson, R. O. Teskey, J. Aronson, A. Bytnerowicz, M. J. Wingfield, and Ş. Procheş. 2007. Human impacts in pine forests: past, present and future. Annual Reviews in Ecology, Evolution and Systematics 38:275–297.

Ross, T.J. 2000. Forest Ingrowth and Encroachment in the Cariboo Forest Region Between 1961 and 1997. Prepared for B.C. Ministry of Agriculture, Food and Fisheries and Cariboo-Chilcotin Grazing Enhancement Fund, Williams Lake, BC.

Rummell, R. S. 1951. Some effects of livestock grazing on ponderosa pine forest and range in central Washington. Ecology 32:594–607.

Saab, V. A., C. E. Bock, T. D. Rich, and D. S. Dobkin. 1995. Livestock grazing effects in western North America. In: T. E. Martin and D. M. Finch [EDS.]. Ecology and management of neotropical migratory birds. Oxford University Press, Oxford, UK.

Sauer, R. J., J. E. Hines, and J. Fallon. 2008. The North American breeding bird survey, results and analysis 1966-2007. Version 5.15.2008. Laurel, MD, USA: US Geological Survey, Patuxent Wildlife Research Center. ***http://www.mbr-pwrc.usgs.gov/bbs/bbs.html*** (Accessed 9 April 2010.)

Skarpe, C. 1990. Shrub layer dynamics under different herbivore densities in an arid savanna, Botswana. Journal of Applied Ecology 27:873–885.

Statistics Canada. 2011. Cattle statistics, vol. 10, no. 1. Catalogue no. 23-012-X. Ottawa, ON, Canada: Statistics Canada, Agriculture Division. ***http://www.statcan.gc.ca/pub/23-012-x/2010002/t089-eng.htm*** (Accessed 14 July 2011.)

Sutter, B., and G. Ritchison. 2005. Effects of grazing on vegetation structure, prey availability, and reproductive success of grasshopper sparrows. Journal of Field Ornithology 76:345–351.

Tewksbury, J. J., A. E. Black, N. Nur, V. A. Saab, B. D. Logan, and D. S. Dobkin. 2002. Effects of anthropogenic fragmentation and livestock grazing on western riparian bird communities. Studies in Avian Biology 25:158–202.

Tisdale, E. W. 1950. Grazing of forest lands in interior British Columbia. Journal of Forestry 48:856–860.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893–901.

Van Uytvanck, J., and M. Hoffmann. 2009. Impact of grazing management with large herbivores on forest ground flora and bramble understorey. Acta Oecologica 35:523–532.

Walsberg, G. E. 2005. Cattle grazing in a national forest greatly reduced nesting success in a ground-nesting sparrow. Condor 107:714–716.

Wikeem, B. M., A. Mclean, A. Bawtree, and D. Quinton. 1993. An overview of the forage resource and beef production on Crown land in British Columbia. Canadian Journal of Animal Science 73:779–794.

Willcox, E. V., G. W. Tanner, W. M. Giuliano, and R. McSorley. 2010. Avian community response to grazing intensity on monoculture and mixed Florida pastures. Rangeland Ecology and Management 63:203–222.

Zimmerman, G. T., and L. F. Neuenschwander. 1984. Livestock grazing influences on community structure, fire intensity, and fire frequency within the Douglas-fir/Ninebark habitat type. Journal of Range Management 37:104–110.

Zimmermann, H., D. Renison, I. Leyer, and I. Hensen. 2009. Do we need livestock grazing to promote *Polylepis australis* tree recruitment in the Central Argentinean Mountains? Ecological Research 24:1075–1081.

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APPENDIX A. Foraging and nesting guild assignments for the 56 bird species observed at forested (>30% tree cover) point count stations in the Interior Douglas-fir biogeoclimatic zone, British Columbia, Canada. Foraging guild: AI = aerial insectivore, BI = bark insectivore, FI = foliage insectivore, GI = ground insectivore, O = omnivore, R = raptor. Nesting guild: C = cavity, G = ground, ST = shrub/tree, OT = other.

Common Name	Scientific Name	Foraging Guild	Nesting Guild
American Crow	*Corvus brachyrhynchos*	O	ST
American Kestrel	*Falco sparverius*	R	C
American Robin	*Turdus migratorius*	GI	ST
Black-backed Woodpecker	*Picoides arcticus*	BI	C
Black-capped Chickadee	*Poecile atricapilla*	FI	C
Brown-headed Cowbird	*Molothrus ater*	GI	OT
Blue Grouse	*Dendragapus obscurus*	O	G
Brown Creeper	*Certhia americana*	BI	C
Cassin's Finch	*Carpodacus cassinii*	FI	ST
Cassin's Vireo	*Vireo cassinii*	FI	ST
Cedar Waxwing	*Bombycilla cedrorum*	FI	ST
Chipping Sparrow	*Spizella passerina*	GI	ST
Clark's Nutcracker	*Nucifraga columbiana*	O	ST
Common Raven	*Corvus corax*	O	ST
Dark-eyed Junco	*Junco hyemalis*	GI	G
Downy Woodpecker	*Picoides pubescens*	BI	C
Dusky Flycatcher	*Empidonax oberholseri*	AI	ST
European Starling	*Sturnus vulgaris*	GI	C
Evening Grosbeak	*Coccothraustes vespertinus*	FI	ST
Gray Jay	*Perisoreus canadensis*	O	ST
Hammond's Flycatcher	*Empidonax hammondii*	AI	ST
Hairy Woodpecker	*Picoides villosus*	BI	C
Hermit Thrush	*Catharus guttatus*	GI	ST
Lazuli Bunting	*Passerina amoena*	FI	ST
Least Flycatcher	*Empidonax minimus*	AI	ST
Merlin	*Falco columbarius*	R	ST
Mountain Bluebird	*Sialia currucoides*	GI	C
Mountain Chickadee	*Poecile gambeli*	FI	C
Northern Flicker	*Colaptes auratus*	GI	C
Orange-crowned Warbler	*Vermivora celata*	FI	G
Olive-sided Flycatcher	*Contopus cooperi*	AI	ST
Pine Siskin	*Carduelis pinus*	FI	ST
Pileated Woodpecker	*Dryocopus pileatus*	BI	C
Pacific-slope Flycatcher	*Empidonax difficilis*	AI	ST
Red-breasted Nuthatch	*Sitta canadensis*	BI	C
Ruby-crowned Kinglet	*Regulus calendula*	FI	ST
Red Crossbill[1]	*Loxia curvirostra*	-	-
Red-naped Sapsucker	*Sphyrapicus nuchalis*	BI	C
Red-tailed Hawk	*Buteo jamaicensis*	R	ST
Ruffed Grouse	*Bonasa umbellus*	O	G

Rufous Hummingbird[2]	*Selasphorus rufus*	-	ST
Red-winged Blackbird	*Agelaius phoeniceus*	GI	ST
Spotted Towhee	*Pipilo maculatus*	O	G
Swainson's Thrush	*Catharus ustulatus*	GI	ST
Townsend's Solitaire	*Myadetes townsendi*	AI	OT
Townsend's Warbler	*Dendroica townsendi*	FI	ST
Tree Swallow	*Tachycineta bicolor*	AI	C
Three-toed Woodpecker	*Picoides tridactylus*	BI	C
Vesper Sparrow	*Pooecetes gramineus*	GI	G
Warbling Vireo	*Vireo gilvus*	FI	ST
Western Meadowlark	*Sturnella neglecta*	GI	G
Western Tanager	*Piranga ludoviciana*	FI	ST
Wilson's Warbler	*Wilsonia pusilla*	FI	ST
Western Wood-Pewee	*Contopus sordidulus*	AI	ST
Yellow Warbler	*Dendroica petechia*	FI	ST
Yellow-rumped Warbler	*Dendroica coronata*	FI	ST
Unknown woodpecker species	-	BI	C

[1] Omitted from all analyses due to the presence of large (up to 35 individuals) foraging flocks, which do not reflect local breeding density.

[2] Nectarivore. Omitted from analyses of bird abundance by foraging guild.

Test Your Knowledge . . .

*Effects of Cattle Grazing on Birds in Interior Douglas-fir (*Pseudotsuga menziesii*) Forests of British Columbia*

How well can you recall some of the main messages in the preceding Research Report? Test your knowledge by answering the following questions. Answers are at the bottom of the page.

1. Cattle grazing was associated with which changes in vegetation?
   - A) Reduction in ground vegetation height
   - B) Reduction in grass cover
   - C) Reduction in the number of shrubs and saplings
   - D) A+B

2. Which guild of forest birds were less common in grazed vs. ungrazed areas?
   - A) Bark insectivores
   - B) Aerial Insectivores
   - C) Cavity nesters

3. Grazing can alter plant community composition by:
   - A) Differential responses of different plant species to grazing
   - B) Facilitation of the establishment of exotic invasive species
   - C) Compaction of soil and trampling and defoliation of plants
   - D) All of the above

Answers

1. D   2. B   3. D