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Breeding Bird Abundance and Habitat Relationships on a Private Industrial Forest in the Western Washington Cascades

Abstract

Surveys were conducted to determine the presence, relative abundance, and habitat relationships of the breeding bird community on a private industrial forest (21,600 ha) in western Washington. A total of 284 and 299 point counts (8 min duration) were established in 1995 and 1996, respectively, along unpaved logging roads separated by a minimum distance of 240 m. The counts were performed twice, at least 10 days apart. A total of 9,491 detections of 78 species of breeding birds were detected at point count stations during the survey period with 40 species having >30 detections. A GIS analysis of forest habitat types was run for a 100-m radius circle centered on each survey point. Of 61 species tested by multiple regression analysis, significant positive regressions were revealed for the following habitat types: mature conifer habitat (>45 yr) for 32 species, pole-sized conifer habitat (27-44 yr) for 27 species, sapling-sized conifer habitat (6-26 yr) for 38 species, recent clearcut habitat (0-5 yr) for 32 species, non-forested habitat (including open water) for 20 species, and alder-hardwood habitat (all ages) for 19 species. Overall, the GIS-habitat/mutiple regression models demonstrated that all successional stages on an industrial forest were important to different groups of species within the breeding bird community. Species richness was equal or greater than observed in studies conducted on federal lands in the Pacific Northwest and suggested that industrial forests can be managed to make an important contribution to regional biodiversity of breeding birds.

Introduction

During the past 40 years, logging in Washington and Oregon has converted 80 to 90 percent of the original mature and old-growth forest into a complex mosaic of early and late-successional forest (Harris 1984, Meslow et al. 1981, Spies and Franklin 1988, Bolsinger and Waddell 1993). Previous breeding bird surveys in the southern Washington Cascades (Manuwal and Huff 1987, Manuwal 1991) and the central Oregon Coast Range (McGarigal and McComb 1992) were conducted on National Forest lands which generally receive different and less-intensive silvicultural treatments, but yet have a propensity for higher levels of forest fragmentation (Franklin and Foreman 1987, Li et al. 1993). Forest fragmentation is less of a concern for industrial forests because high harvest rates have resulted in nearly complete conversion of old forests into plantations (Spies and Franklin 1988) and the practice of clearcutting large blocks leaves few fragments (Lehmkuhl et al. 1991). Because of these fundamental differences in forest management, the characterization of breeding bird populations on private industrial forest land should be investigated to examine the potential of these lands to contribute to regional conservation and biodiversity efforts. Virtually all of the previous studies on breeding bird communities in the Pacific Northwest have been conducted on federal lands.

In this study, surveys were conducted to determine the presence, relative abundance, and habitat relationships of the breeding bird community on a private industrial forest in the western Washington Cascade range. The surveys were part of a monitoring plan which was required under a multi-species Habitat Conservation Plan (HCP) implemented by the landowner. However, the results of the study have valuable implications for monitoring populations and predicting habitat suitability on other northwestern industrial forests.

Study Area

The study area was the Mineral Tree Farm in Lewis County Washington, an industrial tree farm of about 21,600 ha in total area which is owned and operated by the Murray Pacific Corporation (Tacoma, WA). The tree farm is located along the western edge of the Southern Cascade Physiographic Province and ranges in elevation from about 300 to 1640 m. Approximately 19,600 ha of the tree farm are capable of supporting forest growth, with the remaining area containing rocky ridgetops, alpine meadows, cliff/talus slopes, roads, brush, standing water, and gravel pits. The timberlands fall within the *Tsuga heterophylla* Forest Zone (Franklin and Dyrness 1984), which is dominated by Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*). Western redcedar (*Thuja* *plicata*) is locally abundant, and Pacific silver fir (*Abies amabilis*) and noble fir (*A. procera*) are present at higher elevations. Commercial timber production is the dominant land use on the Mineral Tree Farm, which is characterized by stands of various age classes including recent clearcuts (0-5 yr; 12%), saplings (6-26 yr; 43%), pole forest (27-45 yr; 28%), and commercially mature forest (>45 yr; 15%). Isolated stands of old-growth forest (>250 yr) occurs on less than 2% of the tree farm. The area is characterized by a mild, wet maritime climate. Precipitation occurs mainly in winter and averages 180 to 360 cm annually.

Methods

We used the "extensive point count" technique to quantitatively sample the breeding bird community (Ralph et al. 1993). A total of 284 and 299 point counts were surveyed in 1995 and 1996, respectively, with 248 locations repeated in both years and a total of 330 different locations. Specifically, a fixed-distance point count was used, whereby all birds seen or heard during an 8-minute period were recorded (Manuwal and Huff 1987), if within 100 m of each observation point. Unlimited distance point counts are not recommended for most survey needs, especially where loud streams can reduce detection levels of birds (McGarigal and McComb 1992). All surveys were conducted by the author and two other qualified field biologists. During surveys, we also recorded aerial foragers that flew within 100 m above the ground (swifts, swallows, hawks, etc.) since they were probably using the point count habitat for foraging. Ralph et al. (1993) recommended that stations should only be sampled once a season for most breeding bird surveys, unless the goal is to get good estimates of small or rare habitats. We conducted two separate visits at each survey station to improve the probability of detection due to variables such as weather, nesting phenology, and time of migration. In 1995, the first visit was conducted from 15 May to 1 June. The second visit was conducted from 6 June to 29 June. In 1996, the first visit was conducted from 21 May to 31 May. The second visit was conducted from 3 June to 27 June. At least 10 days elapsed between visits during each year.

Surveys were usually conducted during fair weather, but occasionally were done during intermittent drizzle, misting, and light fog which did not decrease normal levels of bird activity and singing. Surveys were cancelled during significant rain, fog, or if winds exceeded 20 kmph. All surveys were conducted from sunrise to mid-morning hours, but did not go beyond 10:00 as recommended (Ralph et al. 1993). All field identifications, nomenclature, and taxonomy are consistent with Peterson (1990). A four-letter code (acronym) for each species was used in the field to record birds on original data forms as recommended by Ralph et al. (1993).

Point counts were established along driving routes to improve survey efficiency and were separated by a minimum distance of 240 m (0.15 mile) as recommended by Ralph et al. (1993) to avoid duplication of counting effort. The points were all located on unpaved logging roads (secondary and tertiary) as recommended by Ralph et al. (1993) and were marked with green vinyl streamers which indicated the site number for replicate visits to the site. The routes were systematically established throughout the tree farm in nearly all drainages and elevations containing driveable dirt roads.

A vector-based (ARC/INFO) Geographic Information System (GIS) was used to delineate six habitats as follows: commercially mature conifer (45+ years), pole conifer (27-44 years), sapling conifer (6-26 years), alder-hardwood (all ages), recent clearcut (0-5 years), and non-forested land (open water, rock, brush). Survey points were selected to provide an equivalent sample size from each forest habitat type as well as along wetlands, streams, and uplands. Each point was given a unique identification number and was plotted on 1:24,000 scale GIS color habitat maps of the Mineral Tree Farm.

After the surveys were completed, the data for each point count station were entered into a computer database spreadsheet (Lotus 1-2-3, Cambridge, Massachusetts). The data sets from the two years were combined and the total number of sites occupied by each species was calculated (% of 330 total stations occupied).

Due to previous timber harvesting patterns, relatively few points were placed in single forest habitat types, so sites were usually a composite of several different habitats. All point count locations from field maps were digitized into the GIS and habitat areas within a 100 m radius were calculated. A multiple regression analysis using ordinary least squares was used to determine relationships between breeding birds (dependent variable) and corresponding habitat measures as independent variables. There are no underlying assumptions on the distribution of the independent variables in multiple regression analysis (Kerlinger and Pedhazur 1973), and therefore, data transformations were not applied to the GIS habitat data. In order to avoid problems with normality among the independent variables (bird counts), abundance values were converted to a non-parametric scale (presence =1, absence = 0) as used in logistic regression analysis (Robbins et al. 1989). This also eliminated common biases in abundance counts due to differences in species-specific breeding densities and territory sizes. A separate full-model (all variables included) multiple regression analysis was run for each species so that they would be directly comparable to each other and because stepwise procedures have recently been criticized for use in ecology by many investigators (see review by James and McCulloch 1990). All statistical analyses were run on a personal computer using version 5.03 of NCSS (Number Cruncher Statistical System, Kaysville, Utah). Results are presented only for breeding birds with at least one significant habitat regression ($p < 0.05$), but species habitat models with small sample sizes should be regarded with caution. One limitation of this model is that it may not completely compensate for species which nest and forage in different habitats (see Brown 1985 for examples), and therefore, the results reported herein should also be considered in light of the current knowledge of the nesting biology of the species.

Results

A total of 9,491 detections of breeding birds occurred during the two-year survey (Table 1). A total of 78 species of breeding birds were detected at point count stations over the two years. There were a total of 70 species observed in each year, although 16 species were only recorded in one of the two survey years. During the survey period, at least 40 species had >30 detections.

Survey Replication

Point counts were highly consistent between the two visits and between years for certain species (e.g., Hammond's flycatcher, Pacific slope flycatcher, winter wren, golden-crowned kinglet, varied thrush, song sparrow). For some permanent residents and early migrants, abundance was noticeably greater on the first visit, suggesting an earlier nesting phenology (e.g., blue grouse, northern flicker, black-throated gray warbler). Abundance was noticeably greater on the second visit for some species of late migrants (e.g., willow flycatcher, Swainson's thrush, warbling vireo, black-headed grosbeak). In both 1995 and 1996, 14 species were detected on only one of the two visits, thereby showing the value of replicating counts at least twice during the breeding season (at least 10 days apart).

Relative Abundance

Of 78 species detected on the survey, 10 were detected at more than 50 percent of the survey sites, including: Pacific slope flycatcher, winter wren, dark-eyed junco, American robin, Swainson's thrush, chestnut-backed chickadee, golden-crowned kinglet, Stellar's jay, varied thrush, and hermit warbler. Another 13 species were detected at between 20 and 50 percent of survey sites and six species were detected at 10 to 20 percent of survey sites. Three candidates for state-listing in Washington were also found during the survey, including: Vaux's swift (40 detections), pileated woodpecker (34), and western bluebird (3).

Habitat Relationships

A full-model multiple regression analysis was conducted with all six independent variables (GIS forest habitat types) for each breeding bird species. A total of 61 species had at least one 1 to 6 significant regressions with the six habitats used in the analysis (Table 2). For mature conifer habitat (>45 yr), significant positive regressions were revealed among 32 bird species. For pole-sized conifer habitat (27-44 yr), significant positive regressions were revealed among 27 bird species. For sapling-sized conifer habitat (6-26 yr), significant positive regressions were revealed among 38 species. For recent clearcut habitat (0-5 yr), significant positive regressions were revealed among 32 species. For non-forested habitat (including open water), significant positive regressions were revealed among 20 species. For alder-hardwood habitat (all ages), significant positive regressions were revealed among 19 species.

Discussion

This survey documented a diverse breeding bird community of 78 species occurring on the Mineral

TABLE 1. Breeding bird survey results from an industrial tree farm in the western Washington Cascades, Lewis County (284 point counts in 1995 and 299 point counts in 1996).

Species	Species Code	1995 Total Number Visit #1	1995 Total Number Visit #2	1996 Total Number Visit #1	1996 Total Number Visit #2	Total Number of Detections	Percent of Stations Occupied
mallard *Anas platyrhynchos*	MALL	4	1	0	8	13	0.6
common merganser *Mergus merganser*	COME	0	0	0	1	1	0.3
sharp-shinned hawk *Accipiter striatus*	SSHA	1	1	0	0	2	0.6
Cooper's hawk *Accipiter cooperii*	COHA	0	0	0	1	1	0.3
red-tailed hawk *Buteo jamaicensis*	RTHA	3	11	1	3	18	4.8
American kestrel *Falco sparverius*	AMKE	2	0	0	1	3	0.9
blue grouse *Dendragapus obscurus*	BLGR	36	18	41	29	124	24.9
ruffed grouse *Bonasa umbellus*	RUGR	13	3	1	0	17	4.8
band-tailed pigeon *Columba fasciata*	BTPI	8	4	10	4	26	5.1
common snipe *Gallinago gallinago*	COSN	0	0	3	1	4	0.6
great horned owl *Bubo virginianus*	GHOW	0	0	1	2	3	0.3
northern pygmy-owl *Glaucidium gnoma*	NPOW	2	1	0	1	4	1.2
common nighthawk *Chordeiles minor*	CONI	0	3	0	2	5	1.5
Vaux's swift *Chaetura vauxi*	VASW	11	0	25	4	40	3.6
rufous hummingbird *Selasphorus rufus*	RUHU	13	8	13	27	61	15.0
red-breasted sapsucker *Sphyrapicus ruber*	RBSA	10	5	4	7	26	5.7
red-naped sapsucker *Sphyrapicus nuchalis*	RNSA	0	2	0	0	2	0.6
downy woodpecker *Picoides pubescens*	DOWO	3	0	1	2	6	1.8
hairy woodpecker *Picoides villosus*	HAWO	36	35	51	23	145	29.6
northern flicker *Colaptes auratus*	NOFL	31	18	38	17	104	22.5
pileated woodpecker *Dryocopus pileatus*	PIWO	11	13	2	8	34	7.8
olive-sided flycatcher *Contopus borealis*	OSFL	15	22	20	16	73	14.4
western wood-pewee *Contopus sordidulus*	WWPE	1	0	1	2	4	1.2
willow flycatcher *Empidonax traillii*	WIFL	13	51	28	79	171	23.4
Hammond's flycatcher *Empidonax hammondii*	HAFL	23	22	16	24	85	13.8
Pacific slope flycatcher *Empidonax difficilis*	PSFL	241	249	212	271	973	83.8
tree swallow *Tachycineta bicolor*	TRSW	5	11	11	4	31	3.6
violet-green swallow *Tachycineta thalassina*	VGSW	4	6	1	4	15	2.1
no. rough-winged swallow *Stelgidpteryx serripennis*	NRSW	1	0	0	0	1	0.3
barn swallow *Hirundo rustica*	BASW	3	2	0	0	5	1.2
gray jay *Perisoreus canadensis*	GRJA	18	31	29	31	109	20.4
Steller's jay *Cyanocitta stelleri*	STJA	91	74	109	93	367	57.5
American crow *Corvus brachyrhynchos*	AMCR	4	2	2	2	10	0.9
common raven *Corvus corax*	CORA	4	4	11	11	30	5.7
black-capped chickadee *Parus atricapillus*	BCCH	1	0	5	0	6	0.9
chestnut-backed chickadee *Parus rufescens*	CBCH	79	67	146	133	425	61.4
red-breasted nuthatch *Sitta canadensis*	RBNU	48	33	42	34	157	31.1
brown creeper *Certhia americana*	BRCR	6	11	5	9	31	8.4
Bewick's wren *Thryomanes bewickii*	BEWR	1	0	0	0	1	0.3
house wren *Troglodytes aedon*	HOWR	2	1	0	1	4	1.2
winter wren *Troglodytes troglodytes*	WIWR	241	240	222	207	910	80.8
American dipper *Cinclus mexicanus*	AMDI	0	0	4	4	8	1.8
golden-crowned kinglet *Regulus satrapa*	GCKI	115	110	94	82	401	59.6
ruby-crowned kinglet *Regulus calendula*	RCKI	2	0	0	0	2	0.6
western bluebird *Sialia mexicana*	WEBL	2	1	0	0	3	0.3
Townsend's solitaire *Myadestes townsendi*	TOSO	17	6	9	16	48	9.9
Swainson's thrush *Catharus ustulatus*	SWTH	92	192	123	172	579	69.5
hermit thrush *Catharus guttatus*	HETH	15	17	45	42	119	20.4

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Table 1, continued

Species	Species Code	1995 Total Number Visit #1	1995 Total Number Visit #2	1996 Total Number Visit #1	1996 Total Number Visit #2	Total Number of Detections	Percent of Stations Occupied
American robin *Turdus migratorius*	AMRO	89	66	74	100	329	55.7
varied thrush *Ixoreus naevius*	VATH	150	150	170	177	647	71.0
cedar waxwing *Bombycilla cedrorum*	CEWA	0	6	3	4	13	2.1
solitary vireo *Vireo solitarius*	SOVI	0	0	0	2	2	0.3
Hutton's vireo *Vireo huttoni*	HUVI	11	13	13	1	38	10.2
warbling vireo *Vireo gilvus*	WAVI	55	97	48	82	282	40.4
orange-crowned warbler *Vermivora celata*	OCWA	23	15	17	10	65	12.3
yellow warbler *Dendroica petechia*	YEWA	0	3	0	1	4	0.9
yellow-rumped warbler *Dendroica coronata*	YRWA	8	4	17	7	36	4.2
black-throated gray warbler *Dendroica nigrescens*	BGWA	67	33	45	39	184	27.2
Townsend's warbler *Dendroica townsendi*	TOWA	6	1	8	1	16	3.3
hermit warbler *Dendroica occidentalis*	HEWA	84	100	121	94	399	52.4
MacGillivray's warbler *Oporornis tolmiei*	MGWA	76	82	77	73	308	42.5
common yellowthroat *Geothlypis trichas*	COYE	0	1	0	0	1	0.3
Wilson's warbler *Wilsonia pusilla*	WIWA	87	73	72	66	298	47.0
western tanager *Piranga ludoviciana*	WETA	53	72	57	42	224	39.5
black-headed grosbeak *Pheucticus melanocephalus*	BHGR	14	28	22	29	93	18.9
rufous-sided towhee *Pipilo erythrophthalmus*	RSTO	21	20	26	24	91	17.7
fox sparrow *Passerella iliaca*	FOSP	0	0	1	0	1	0.3
song sparrow *Melospiza melodia*	SOSP	51	52	59	57	219	31.4
Lincoln's sparrow *Melospiza lincolnii*	LISP	6	1	3	0	10	1.5
white-crowned sparrow *Zonotrichia leucophrys*	WCSP	23	33	37	36	129	18.9
dark-eyed junco *Junco hyemalis*	DEJU	149	206	186	228	769	78.4
red-winged blackbird *Agelaius phoeniceus*	RWBL	3	8	4	1	16	1.5
brown-headed cowbird *Molothrus ater*	BHCO	1	0	1	0	2	0.6
red crossbill *Loxia curvirostra*	RECR	0	0	16	18	34	2.7
purple finch *Carpodacus purpureus*	PUFI	4	2	0	1	7	1.8
pine siskin *Carduelis pinus*	PISI	3	1	10	18	32	6.3
American goldfinch *Carduelis tristis*	AMGO	7	4	0	1	12	2.7
evening grosbeak *Coccothraustes vespertina*	EVGR	9	12	1	1	23	4.5
Totals		2228	2358	2414	2491	9491	

Tree Farm, with 40 species having >30 detections. Previous surveys in the southern Washington Cascades (Manuwal and Huff 1987) were on National Forest lands and detected only 46 species of breeding birds, even though young (42-75 yr), mature (105-165), and old-growth stands (250+ yr) were surveyed. That study used fewer point counts (42), but more replicates which may partially explain their lower total number of species. We also included wetlands and clearcuts in our sampling which undoubtedly helped to increase species richness for the tree farm. Surveys in Oregon (McGarigal and McComb 1992) found 55 breeding bird species at 96 point counts (only 10 species having >30 detections), but these surveys were limited to mature coniferous and hardwood forests. Surveys in Northern California/Southern Oregon (Ralph et al. 1991) found a similar number of species (71) in Douglas-fir/hardwood stands. Overall, the Mineral Tree Farm had a high species richness compared to previous Northwest investigations and contained virtually all of the breeding bird species expected for its geographic location.

The GIS-habitat/mutiple regression models demonstrated that all successional stages on an

TABLE 2. Results of multiple regression analysis of breeding bird occupancy versus GIS-habitat classes in a 100 m radius circle around point counts. Data listed under habitats are standardized beta coefficients (* indicates a probability < 0.05 that the slope of the regression is zero). R^2 is the overall adjusted r-squared value for the full-model multiple regression equation (P is the probability of the slope of the equation equalling zero).

Species Code	mature conifer >45 yr	pole conifer 27-44 yr	sapling conifer 6-26 yr	recent clearcut 0-5 yr	non-forested habitats	alder/ hardwoods	R^2	P
MALL	-0.031	-0.016	0.129*	-0.010	0.102	-0.022	0.018	0.092
RTHA	0.222*	0.018	-0.004	0.076	0.032	0.084	0.066	0.001
AMKE	-0.043	-0.018	0.064	0.167*	-0.001	-0.027	0.015	0.120
BLGR	0.276*	0.154*	0.137*	0.236*	0.027	0.043	0.254	0.001
RUGR	-0.021	0.226*	0.164*	0.020	-0.009	-0.009	0.072	0.001
BTPI	0.093	0.100	0.144*	0.086	-0.050	-0.030	0.046	0.002
VASW	0.111*	0.024	0.098	0.098	0.007	-0.038	0.031	0.018
NPOW	0.058	0.055	-0.026	0.038	-0.021	0.152*	0.021	0.062
RUHU	0.141*	0.098	0.197*	0.166*	0.059	0.020	0.142	0.001
RBSA	-0.030	0.096	0.246*	0.100	0.009	-0.052	0.075	0.001
DOWO	0.048	0.003	0.066	0.005	0.019	0.163*	0.026	0.031
HAWO	0.188*	0.096*	0.124*	0.414*	0.039	0.147*	0.359	0.001
NOFL	0.076	0.059	0.214*	0.380*	0.085	0.028	0.269	0.001
PIWO	0.184*	0.120*	0.022	0.146*	0.040	-0.017	0.083	0.001
OSFL	0.134*	0.001	0.249*	0.265*	0.028	-0.086	0.185	0.001
WIFL	0.056	0.048	0.267*	0.347*	0.078	0.073	0.272	0.001
HAFL	0.352*	-0.013	0.012	0.266*	0.017	0.005	0.237	0.001
PSFL	0.365*	0.412*	0.342*	0.294*	0.088*	0.179*	0.844	0.001
TRSW	-0.030	0.019	0.194*	0.045	0.135*	-0.026	0.059	0.001
VGSW	0.017	0.024	0.101	0.003	0.194*	-0.020	0.048	0.002
BASW	-0.012	0.095	-0.042	0.113*	0.129*	-0.033	0.023	0.049
GRJA	0.164*	0.247*	0.200*	0.134*	-0.016	0.070	0.204	0.001
STJA	0.217*	0.316*	0.400*	0.252*	0.068	0.091	0.571	0.001
AMCR	-0.042	-0.014	-0.005	-0.022	0.388*	0.058	0.142	0.001
CORA	0.110*	0.136*	0.098	0.053	-0.011	0.039	0.048	0.002
BCCH	-0.035	0.028	-0.024	0.047	0.186*	0.097	0.035	0.010
CBCH	0.373*	0.337*	0.314*	0.190*	0.104*	0.110*	0.626	0.001
RBNU	0.418*	0.128*	0.107*	0.254*	0.018	0.063	0.376	0.001
BRCR	0.314*	0.098	-0.013	0.071	0.061	0.007	0.125	0.001
HOWR	0.024	-0.022	-0.026	0.081	0.045	0.178*	0.032	0.015
WIWR	0.356*	0.435*	0.351*	0.252*	0.071*	0.177*	0.818	0.001
AMDI	0.075	0.121*	-0.034	0.032	0.004	0.087	0.019	0.076
GCKI	0.448*	0.418*	0.294*	0.102*	0.005	0.102*	0.657	0.001
TOSO	0.232*	0.053	0.032	0.253*	-0.022	-0.035	0.144	0.001
SWTH	0.276*	0.304*	0.431*	0.253*	0.116*	0.125*	0.695	0.001
HETH	0.200*	0.136*	0.297*	0.098	0.082	-0.080	0.220	0.001
AMRO	0.240*	0.222*	0.262*	0.377*	0.167*	0.132*	0.577	0.001
VATH	0.347*	0.389*	0.402*	0.184*	0.078*	0.101*	0.718	0.001
CEWA	0.087	-0.026	0.116*	0.017	0.029	0.039	0.018	0.088
HUVI	0.066	0.232*	0.145*	0.099	-0.039	0.061	0.108	0.001
WAVI	0.039	0.141*	0.397*	0.264*	0.146*	0.221*	0.465	0.001
OCWA	-0.001	0.074	0.370*	0.107*	0.067	-0.043	0.175	0.001
YRWA	0.106	-0.002	0.176*	0.055	0.032	-0.043	0.047	0.002
BGWA	0.150*	0.405*	0.144*	0.065	0.028	0.257*	0.358	0.001
TOWA	0.134*	0.229*	0.032	-0.030	-0.028	-0.027	0.060	0.001
HEWA	0.416*	0.378*	0.196*	0.182*	0.076*	0.057	0.561	0.001
MGWA	0.112*	0.034	0.417*	0.398*	0.100*	0.091*	0.504	0.001
WIWA	0.146*	0.268*	0.431*	0.186*	0.098*	0.099*	0.487	0.001

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TABLE 2, continued

Species Code	mature conifer >45 yr	pole conifer 27-44 yr	sapling conifer 6-26 yr	recent clearcut 0-5 yr	non-forested habitats	alder/ hardwoods	R^2	P
WETA	0.361*	0.145*	0.193*	0.294*	-0.044	0.177*	0.448	0.001
BHGR	0.019	0.139*	0.166*	0.298*	0.084	0.127*	0.213	0.001
RSTO	0.061	0.026	0.203*	0.318*	0.065	0.092	0.209	0.001
SOSP	0.042	0.012	0.339*	0.389*	0.187*	0.059	0.410	0.001
LISP	-0.020	-0.004	0.016	0.039	0.376*	-0.048	0.132	0.001
WCSP	0.089	0.021	0.134*	0.425*	0.079	0.025	0.261	0.001
DEJU	0.237*	0.328*	0.388*	0.424*	0.120*	0.102*	0.795	0.001
RWBL	-0.044	0.042	0.145*	0.008	0.115*	-0.032	0.030	0.019
RECR	0.132*	0.022	0.063	0.065	0.020	-0.034	0.022	0.052
PUFI	-0.048	-0.026	0.088	0.022	0.244*	0.080	0.077	0.001
PISI	0.223*	0.049	0.105	0.098	-0.055	-0.045	0.080	0.001
AMGO	0.000	0.085	-0.024	0.056	0.051	0.274*	0.085	0.001
EVGR	0.154*	0.148*	0.006	0.073	0.041	-0.042	0.051	0.001

industrial forest were important to different groups of species within the breeding bird community. Among the species that tended to be specialists (only 1 to 3 significant regressions), there were four distinct patterns that separated them from generalist species. Late successional species had their greatest affinity with mature conifer habitat (Fig. 1a). This group included two snag-dependent species: Vaux's swift and brown creeper, which require snags for nesting, roosting, or foraging (Brown 1985), as well as conifer seed-eaters that need to forage among mature mast-producing conifers (pine siskin, evening grosbeak, and red crossbill), and a large raptor which requires tall canopy trees for nest placement (red-tailed hawk).

Mature forest/edge species (Fig. 1b) differed from late-successional species by virtue of the inclusion of clearcut habitat with mature conifer habitat. This group included two snag-dependent species which typically inhabit late-successional forest: pileated woodpecker and red-breasted nuthatch (Brown 1985; Bull et al. 1986). The association of pileated woodpecker and red-breasted nuthatch with mature conifer forest and clearcuts was not due to a correlation between these two habitats (r = -0.12). Instead, it is possible that they were attracted to clearcut edges because of the higher levels of blowdowns, damaged trees, and mortality that can occur here (Norse 1990), as well as by snags, residual trees, logging slash, and stumps which were left behind in recent clearcuts. Bull et al. (1986) found that pileated woodpeckers foraged 36% of the time on downed logs and 29% in snags. Bull and Meslow (1977) also determined that 14% of feeding sites on dead wood were on stumps. In addition, Smith (1986) noted that damaged trees can produce large "distress crops" of seeds, and therefore, red-breasted nuthatches may also be attracted by local cone crop abundance along recent clearcut edges. Also in this group were three perch-hunting insectivores: olive-sided flycatcher, Hammond's flycatcher, and Townsend's solitaire, which are known to prefer forest-edge habitat (Brown 1985; Sharp 1992).

Early successional species (Fig. 1c) showed a decreasing trend of association with the successional stages, with the greatest affinity for clearcut and sapling habitats. This group included several ground foragers (white-crowned sparrow, song sparrow, and rufous-sided towhee), four shrub/sapling foragers (willow flycatcher, black-headed grosbeak, orange-crowned warbler, yellow-rumped warbler), and one open-terrain raptor (American kestrel).

As would be expected, the GIS-habitat models for alder/hardwood species (Fig. 1d) showed little association with conifer habitats, regardless of successional stage. This group included four cavity-nesters (downy woodpecker, house wren, northern pygmy-owl, and black-capped chickadee) with well-known affinities for deciduous or mixed conifer-hardwood stands (Brown 1985; Sharp 1992). American goldfinch is a seed-eater known to inhabit alder or other hardwood types

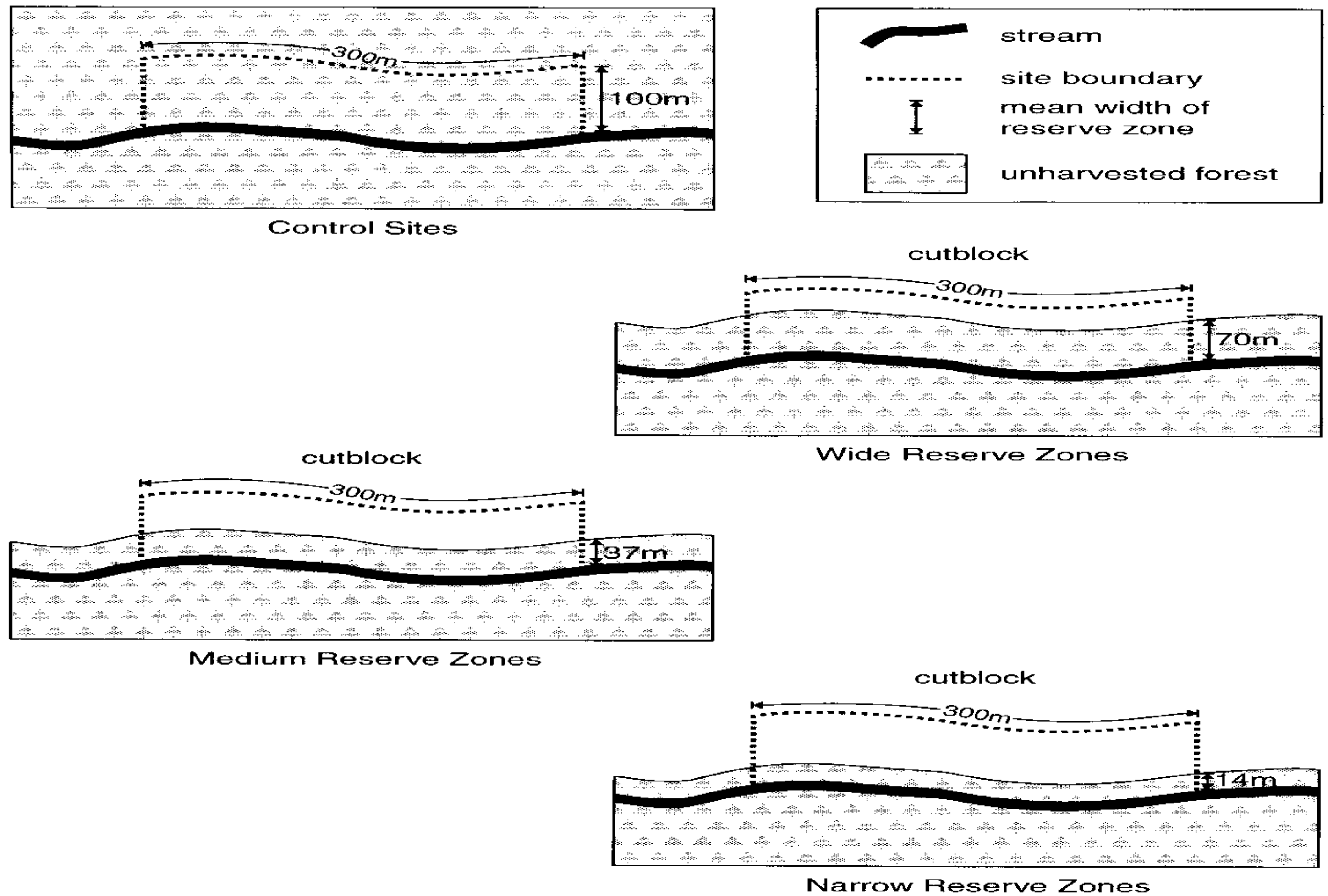

Figure 1. Groups of breeding bird species with similar habitat correlations from the GIS-habitat/multiple regression model (data represent standardized beta coefficients from Table 2). Species codes are given in Table 1.

(Brown 1985). None of these species were abundant because of the dominance of conifers on the Mineral Tree Farm.

Most of the 32 species that were significantly correlated with mature conifer in the GIS-habitat models were also observed to attain high abundance levels in mature and old-growth stands in other Northwest studies (Manuwal and Huff 1987, Manuwal 1991, Ralph et al. 1991). These strong similarities validate the utility of the GIS-habitat/multiple regression model which was developed for this study, as well as emphasize the value of maintaining mature forest habitat on private industrial forests for breeding birds. On the Mineral Tree Farm, mature conifer stands (>45 yrs) usually had higher densities of snags and remnant old-growth trees ("old-growth legacies"), than pole stands because of "sloppy clearcutting" and "high-grading" practices which were the norm before 1930 (McKelvey and Johnston 1992). Since that time, a chronic shortage of snags and large residual trees has occurred in clearcut units with the advent of "modern" intensive silviculture (Neitro et al. 1985). Intensive site preparation, concerns for worker safety, and salvage for wood chips and firewood have all contributed to a shortage of cull trees, snags, and residual trees in the Pacific Northwest (Neitro et al. 1985).

To mitigate for this predicted loss to wildlife diversity, special forest management prescriptions for the Mineral Tree Farm were developed in their HCP. These prescriptions require 30 m no-harvest buffers for wetlands and fish-bearing streams, 15 m buffers along approximately 59% of non-fish-bearing streams, and large quotas for snag/green-tree retention (i.e., 10 snags and 10 green trees must be left per ha of clearcut). No-harvest riparian buffer zones have been shown to retain most of the breeding bird species two years after clearcutting an area (Triquet et al. 1990). In addition, higher snag densities on clearcuts have been shown to produce a higher density and species richness of cavity-nesting birds (Schreiber and deCalesta 1992). The preferred use of uplands by many forest breeding birds in Oregon (McGarigal and McComb 1992) suggests that it is also important to maintain residual trees (seed trees, culls, and leave trees), snags, and no-harvest reserve areas in upland areas as well. If properly managed, industrial forests can make an important contribution to regional biodiversity and conservation of breeding birds.

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