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Relationship of Riparian Reserve Zone Width to Bird Density and Diversity in Southeastern British Columbia

Abstract

British Columbia forestry guidelines require riparian management areas of 20 to 50 m width between small streams and cutblocks, composed of reserve zones (no timber harvest) and/or management zones (limited timber harvest). Guidelines in Kootenai National Forest, Montana, limit forest harvesting for 30 m adjacent to permanent streams. As one step in providing a basis to assess such guidelines, we compared (1) habitat structure between spruce-dominated riparian forest and pine-dominated upland forest, (2) breeding bird characterisitics (density of detections, species richness, species diversity and species equitability) between riparian and upland forest, and (3) breeding bird characterisitics between riparian reserve zones of various widths (averaging 70, 37, or 14 m wide). The study occurred in the Montane Spruce biogeoclimatic zone of southeastern British Columbia. In relation to upland forest, riparian forest had greater tall shrub and canopy cover, but fewer live trees. Snag density, low shrub cover, and coarse woody debris did not differ at $P<0.05$. The two habitat types did not differ in mean bird species richness per site, but riparian forest had greater species diversity and species equitability, greater density of all species combined, and greater density of three individual species. The density of all birds combined, all riparian-associated birds combined, and three of the four riparian-associated species increased with increasing reserve zone width. Species diversity and species equitability did not differ significantly among treatments.

The widths of riparian management areas required under current British Columbia and Kootenai National Forest guidelines are considerably narrower than the widest category of reserves investigated in this study (70 m). Our data indicate that prescribed riparian management areas under current guidelines will have lower densities of total birds and of riparian-associated birds than if reserves were required to average 70 m in width.

Introduction

Riparian habitats are considered essential for many wildlife species because of high plant and animal productivity, complex habitat structure, proximity to water, and role as movement corridors (Thomas et al. 1979b, Morgan and Wetmore 1986, Bunnell et al. 1992, Bunnell and Dupuis 1993, Naiman et al. 1993, Stevens et al. 1995). In the Montane Spruce biogeoclimatic zone of British Columbia, where this study occurred, approximately 65% of vertebrate species are associated with riparian areas (Bunnell and Dupuis 1993).

The Forest Practices Code of British Columbia requires that forest managers maintain riparian management areas (RMAs) between cutblocks and streams, consisting of riparian reserve zones (RRZs) with no forest harvest and riparian management zones (RMZs) with limited harvest. The width of these zones is variable, depending on a stream's channel width and its value for fisheries or as a domestic water supply. For streams less than 20 m wide, reserve zones vary from 0 to 30 m and management zones vary from 20 to 30 m, for a total of 20 to 50 m (BC Ministry of Forests and BC Environment 1995). The national forest nearest to the study area is Kootenai, in northern Montana. Guidelines for Kootenai National Forest require that permanent streams be buffered by streamside management zones (SMZs) that are generally 30 m wide and in which only limited timber harvesting is permitted (Kootenai National Forest 1994).

In western North America, little riparian research has been specific to conifer-dominated riparian habitats of dry to mesic inland montane regions. However, it is well established that the creation of edge and the ratio of edge to interior forest habitat have significant effects on faunal characteristics (Thomas et al. 1979a, Strelke and Dickson 1980, Kroodsma 1982, Hansson 1983, Kroodsma 1984, Wilcove 1985, Thompson et al. 1992, Faaborg et al. 1993). Recently, several studies have specifically addressed the effects of the width of riparian reserve zones or management zones on bird community characteristics. Narrow reserves generally fail to provide habitat for the complete range of naturally-occurring bird species (Stauffer and Best 1980, Croonquist and Brooks 1993, Spackman and Hughes 1994, Darveau et al. 1995, Gyug 1995), but results differ between landscapes. In some situations, no major differences are apparent even over a broad range of riparian reserve zone widths (Smith and Schaefer 1992). Furthermore, McGarigal and McComb (1992) report a case where riparian zones exhibit lower species diversity and density than upland sites. Therefore, it is not clear to what extent current forestry guidelines will maintain the ecological values of riparian habitats of the inland Northwest.

As one step in providing an empirical basis to assess guidelines, we compared (1) habitat structure between riparian and upland forest, (2) breeding bird characterisitics between riparian and upland forest, and (3) breeding bird characteristics between riparian reserve zones of various widths in the Montane Spruce biogeoclimatic zone of southeastern British Columbia.

Methods

This study occurred in the "Dry, Cool Montane Spruce" (MSdk) biogeoclimatic subzone of the Invermere Forest District in southeastern British Columbia (Figure 1) at elevations of 1100 to 1300 m. Mean annual precipitation for the MSdk is 590 mm, with a mean summer temperature of about 8.5°C and a mean winter temperature of about −3.0°C (Braumandl and Curran 1992). Fifteen study sites were established adjacent to streams with channels 1 to 10 m wide, paralleling one side of the stream for 300 m and extending upslope for 100 m. Sites were a minimum of 500 m apart at the closest points. The forested area in each site included riparian forest on historic floodplains and upland forest farther upslope, and was 80 to 140 years old. Sites exhibited complex vegetational patterns, but based on the MSdk classification (Braumandl and Curran 1992), riparian forest corresponded most closely to the "hybrid white spruce - dogwood - horsetail" (*Picea glauca x engelmanni - Cornus stolonifera - Equisetum arvense*) series, and upland forest was most similar to the "lodgepole pine - Oregon grape - pinegrass" (*Pinus contorta - Mahonia aquifolium - Calamogrostis rubescens*) series. Control sites contained only riparian and upland forest, while treatments included recent clearcuts (<1 to 5 years old) at the upslope end. The three treatments were classed as narrow, medium or wide reserve zones, according to the width of forest remaining between the cutblock and the stream (Table 1 and Figure 2). These strips of forest corresponded to RRZs of Forest Practices Code nomenclature, and included both riparian and upland vegetation. Forest on the opposite side of the stream from each site was in a mature, uncut state and was vegetationally similar to the study site. Habitat types in all sites were mapped at 1:1000 scale, based on transects run perpendicular to the stream at 25-m intervals. The forested area of each site was determined using a digital planimeter, then divided by 300 m to yield the mean width of each reserve zone.

Coarse woody debris (CWD) volumes were assessed using the method of Lofroth (1992), and included all pieces ≥10 cm diameter on one 200-m transect per habitat type at 15 sites. Sampling methods for vegetative characteristics were modified from provincial standards (Habitat Monitoring Committee 1990) because the linear nature of our riparian sites and the habitat units within

TABLE 1. Characteristics of 15 riparian study sites in the Montane Spruce zone, Invermere Forest District, B.C., 19939-1994.

Characteristic		Control	Treatment		
			Wide Reserve Zone	Medium Reserve Zone	Narrow Reserve Zone
Sample Size		5	3	5	2
Width of Riparian Forest (m)	Mean (Range)	27 (9-45)	25 (11-44)	21 (13-31)	14 (13-14)
Width of Upland Forest (m)	Mean (Range)	73 (55-91)	45 (29-54)	16 (10-23)	0
Total Width of RRZ (m)	Mean (Range)	—	70 (64-73)	37 (33-43)	14 (13-14)
Width of Cutblock (m)	Mean (Range)	—	30 (27-36)	63 (57-67)	86 (86-87)
Total Site Width (m)		100	100	100	100
Length Parallel to Stream (m)		300	300	300	300
Aspect		2N,2S,1W	1N,2E	3N,2S	1N,1E
Slope (L=<10%; H=>10%)		1L,4H	3H	2L,3H	2L

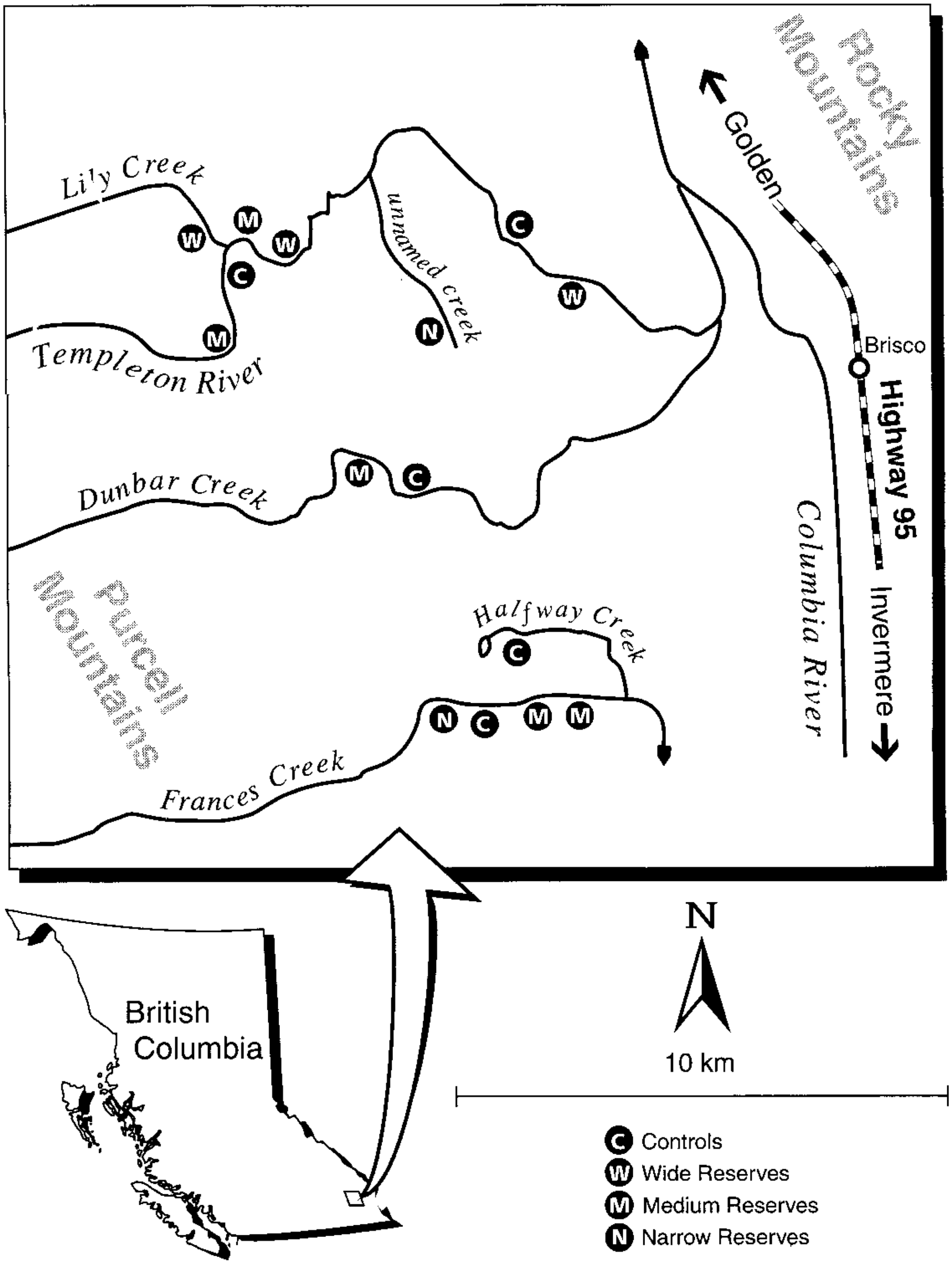

Figure 1. Study area and study site locations.

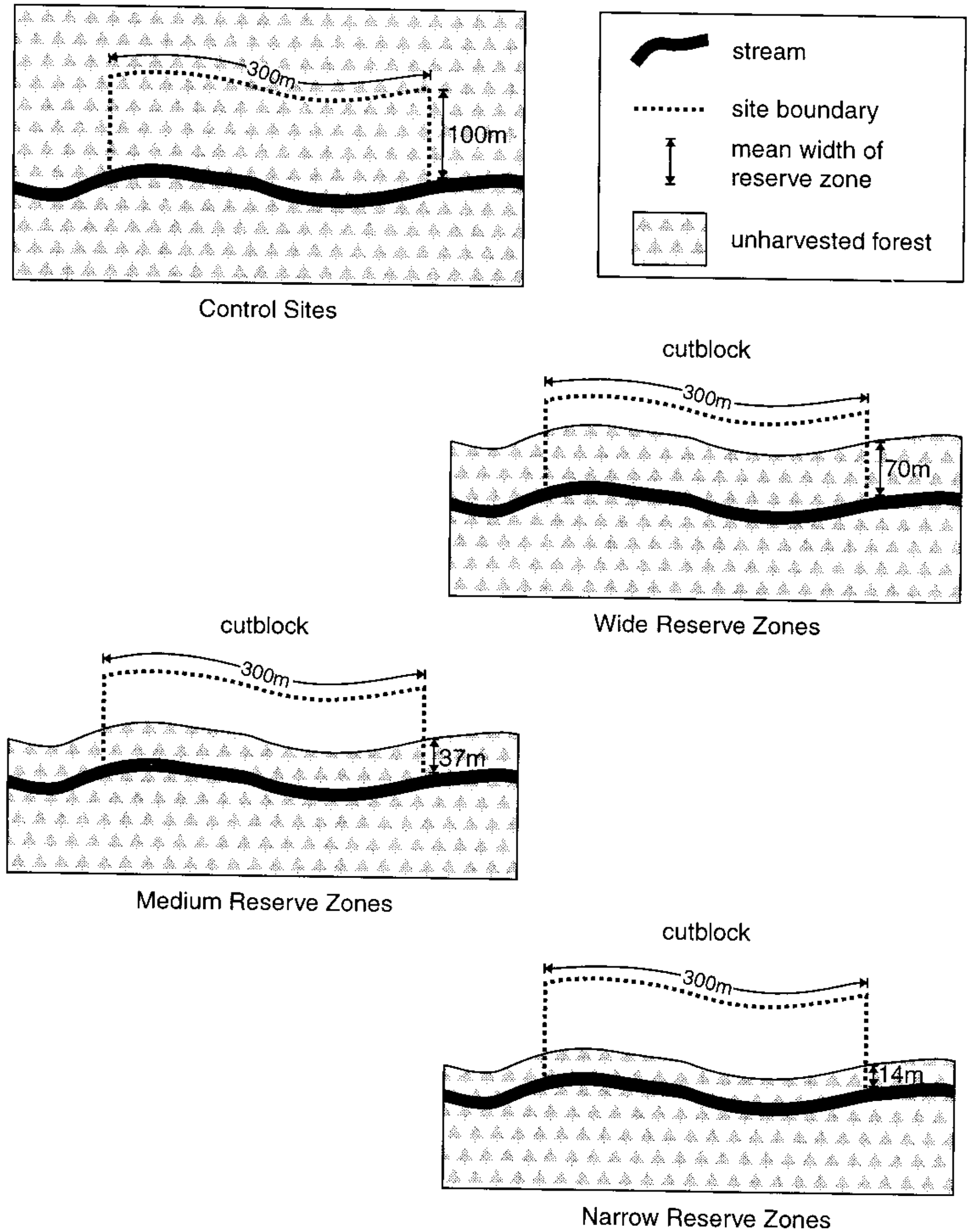

Figure 2. Control and treatment types.

them precluded the use of randomly-oriented transects, and made it necessary to sample from smaller plots (4 m radius) than recommended for forested habitats. For each habitat type at each site, four circular plots were drawn on habitat maps using random X and Y coordinates, then transferred to the field. Within each plot, the following data were recorded: number of snags, number of trees (>10 m tall), percent canopy cover (using a spherical densiometer), percent cover of the tall shrub stratum (2 to 10 m), and percent cover of the low shrub stratum (<2 m). Two-tailed t-tests were used to determine whether values differed among habitats. Because the study was intended to be exploratory rather than comprehensive, sample sizes were low and P values were not adjusted for multiple comparisons.

Each site was divided into a bird survey grid of twelve 50 m x 50 m plots, arranged in an array of six squares aligned parallel to the stream by two squares deep. The grid covered the entire 300 m x 100 m site. Thus, in all but controls it included both the cutblock and the reserve zone. Plot boundaries were marked on 1:1000 habitat maps. Each site was visited three times during May and June, once in each of early, mid and late morning. On each occasion, an observer spent five minutes at the center of each plot, marking locations on habitat maps of all birds seen or heard within the plot.

Species richness (number of bird species) was tallied for each site, and also for each habitat type in controls. Bird density (number of detections/ha) was calculated for each species and for all species combined. In control sites, density was calculated separately for riparian forest and upland forest. Riparian-associated species were defined by determining which species' populations were significantly more abundant in riparian forest than upland forest in control sites. This was accomplished using one-tailed t-tests for species which general references or other studies indicated were riparian-associated in similar ecosystems (Farrand 1983a, 1983b, 1983c, Godfrey 1986, Gyug 1995, Scott 1987, Campbell et al. 1990a, 1990b, Peterson 1990, Semenchuk 1992), and using two-tailed t-tests for other species. Densities of each riparian-associated species, all riparian-associated species combined, and all species combined were each compared (ANOVA) among treatments (narrow, medium or wide reserve zone). Controls were used to define riparian-associated species, as described above, but were not compared to reserve-zone treatments because bird use of streamside areas may be qualitatively different in reserve zones than in intact forest, as a result of temporary "packing" into reserve zones of birds that formerly occurred in adjacent logged land (Lehmkuhl et al. 1991, Gyug 1995). Thus, the presence of a bird in a reserve zone may not reflect the same level of use or habitat value that it would in a forest stand widely separated from cutting. A regression equation was calculated for reserve zone width (m) versus density of riparian-associated birds. Riparian-associated species were determined based on two years of data but other comparisons were based on one year, as the full range of treatments was only studied in one year. Species diversity and species equitability were also compared among habitat types for controls and among treatments using the following equations (Krebs 1989):

$$H = -\sum_{i=1}^{s} (p_i)(\log_{10} p_i)$$

where:

H = Shannon-Wiener index of species diversity

s = number of species at site

p_i = proportion of sample belonging to i^{th} species

$$J = H/\log_{10} S$$

where:

J = species equitability

S = number of species in all sites (as an approximation of the number in the community)

Results

In comparison to upland forest, riparian forest had greater canopy cover, a lower density of live trees, and greater tall shrub cover (Table 2). CWD volume, snag density and low shrub cover did not differ significantly between the two habitat types, although the calculated P value for CWD (0.19) suggests the possibility that CWD values were greater in riparian forest.

Within controls, species richness was similar between riparian forest and upland forest: mean richness per site was 7.3 for both riparian and upland, while total richness for all five sites was 22 for riparian and 19 for upland. Bird density was higher in riparian forest than in upland forest

TABLE 2. Riparian forest and upland forest habitat attributes in 15 mature stands of the Montane Spruce zone, Invermere Forest District, B.C., 1993-1994.

Habitat Attributes	Riparian Forest		Upland Forest		t-Test
	mean	SE	mean	SE	P
CWD (m^3/ha)	103	13	79	13	0.19
Canopy cover (%)	74	2	61	3	<0.01
Live trees (stems/ha)	666	56	82	85	0.04
Snags (stems/ha)	169	40	176	41	0.91
Tall shrubs (% cover)	15	2	10	1	0.05
Low shrubs (% cover)	23	3	21	2	0.59

for all species combined (12.2 versus 6.5 detections/ha, p=0.03) and for three individual species: golden-crowned kinglets (*Regulus satrapa*; 3.8 versus 2.3, p=0.04), Hammond's flycatcher (*Empidonax hammondii*; 1.7 versus 0.5, p=0.03) and winter wren (*Troglodytes troglodytes*; 0.5 versus 0.0, p=0.01). Species diversity and species equitability were also higher in the riparian (H_{RIP}=0.96, H_{UPL}=0.86; J_{RIP}=0.62, J_{UPL}=0.55). Species densities by habitat type are summarized in Table 3.

Riparian-associated birds were considered to be the three having greater densities in the riparian than upland, plus the Townsend's warbler (*Dendroica townsendi*)[1]. Densities of these four species combined differed between treatments (ANOVA, P<0.01; Table 4). This was also true for each of the riparian-associated species individually (P<0.01), except Hammond's flycatcher (P=0.26). The regression of reserve zone width versus density of riparian-associated birds (Figure 3) had a correlation coefficient (R^2) of 0.803 and the regression equation:

$$y = 0.093x - 0.303, \text{ where}$$

y = density of riparian-associated birds (detections/ha)

x = reserve zone width (m)

In addition, the density of all species combined differed significantly among treatments, with higher densities in wider sites (Table 4). However, species diversity and species equitability per site did not differ significantly between treatments (P=0.15), with mean values of H_{NAR}=0.84, H_{MED}=0.71, H_{WID}=0.89 and J_{NAR}=0.54, J_{MED}=0.46, J_{WID}=0.58. Densities by treatment for each species are summarized in Table 3.

Discussion

The differences between riparian forest and upland forest for several of the habitat attributes indicate that these forest types provided different environments. For example, riparian forest provided greater canopy cover with fewer trees, greater tall shrub cover and possibly more CWD than upland forest. These differences emphasize the importance of maintaining the riparian forest's structural attributes to provide landscape-scale habitat variability, particularly because species can be strongly associated with particular structural patterns (Marzluff and Lyon 1983, Sharpe 1996), and riparian forest composes a relatively small part of the landscape.

We found bird density, species diversity and species equitability to be higher and species richness to be similar in riparian forest compared to adjacent upland forest. This was true despite the riparian forest portion of control sites being considerably smaller than the upland portion (recall Table 1). These results suggest that, at least at the stand level, riparian areas have a disproportionately high value in maintaining diverse avifaunas in conifer-dominated forests of the Montane Spruce zone. Therefore, guidelines intended to maintain riparian forest are justifiable from an avian perspective. Our results are consistent with the findings of many other authors who reported greater abundance or diversity of birds in riparian areas compared to upland areas (Thomas et al. 1979a, Stauffer and Best 1980, Emmerich and Vohs 1982, Knopf 1985, Bunnell et al. 1991, Croonquist and Brooks 1993, Leung and Simpson 1994). However, the results of several studies indicated patterns opposite to this. McGarigal and McComb (1992) found that upland forest in the wet coastal region of Oregon had more diverse avifaunas and higher populations than adjacent riparian forest. The authors of the Oregon study suggested that their study area, relative to more arid regions, showed less contrast between riparian and upland habitats in terms of water availability, microclimate, and structural complexity. In fact, overstory cover, low shrub cover, snag density and conifer basal area were all greater in upland than riparian areas in their study. Habitat use by some individual species also differed greatly between our study and the Oregon study. We found golden-crowned kinglets and Hammond's flycatchers to be more abundant in riparian forest, and

TABLE 3. Mean density (detections/ha) of birds in 3-ha sites adjacent to streams in the Montane Spruce zone, Invermere Forest District, B.C. Comparisons of forest type are pooled for 1993 and 1994, and those of reserve zone width are from 1994.

	Forest Type					Reserve Zone Type						
	Riparian (n=5)		Upland (n=5)		t-Test	Wide (n=3)		Medium (n=5)		Narrow (n=2)		ANOVA
Species	mean	SE	mean	SE	P[a]	mean	SE	mean	SE	mean	SE	P
American Robin (*Turdus migratorius*)						0.04	0.04	0.03	0.03	0.00	0.00	0.78
Black-capped Chickadee (*Parus atricapillus*)	0.09	0.06	0.02	0.02	0.35	0.05	0.05	0.00	0.00	0.00	0.00	0.35
Brown Creeper (*Certhia americana*)	0.03	0.03	0.05	0.05	0.80							
Brown-headed Cowbird (*Molothrus ater*)						0.04	0.04	0.00	0.00	0.06	0.06	0.35
Calliope Hummingbird (*Stellula calliope*)	0.00	0.00	0.02	0.02	0.33							
Cedar Waxwing (*Bombycilia cedrorum*)	0.03	0.03	0.02	0.02	0.87	0.00	0.00	0.00	0.00	0.06	0.06	0.13
Chipping Sparrow (*Spizella passerina*)						0.09	0.09	0.09	0.09	0.06	0.06	0.96
Dark-eyed Junco (*Junco hyemalis*)	0.14	0.11	0.49	0.13	0.06	0.84	0.25	0.73	0.45	0.18	0.18	0.80
Golden-crowned Kinglet (*Regulus satrapa*)	3.76	0.66	2.31	0.35	*0.04	2.97	0.22	1.44	0.22	0.62	0.39	0.01
Gray Jay (*Perisoreus canadensis*)	0.15	0.15	0.00	0.00	0.33	0.18	0.04	0.00	0.00	0.00	0.00	0.01
Great Gray Owl (*Strix nebulosa*)	0.06	0.06	0.00	0.00	0.33							
Hairy Woodpecker (*Picoides villosus*)						0.04	0.04	0.00	0.00	0.00	0.00	0.35
Hammond's Flycatcher (*Empidonax hammondii*)	1.73	0.56	0.47	0.24	*0.03	2.02	0.71	1.19	0.30	0.62	0.51	0.26
MacGillivray's Warbler (*Oporonis tolmiei*)	0.06	0.06	0.00	0.00	0.33							
Mountain Chickadee (*Parus gambeli*)	0.00	0.00	0.02	0.02	0.33	0.00	0.00	0.00	0.00	0.06	0.06	0.13
Olive-sided Flycatcher (*Contopus borealis*)						0.09	0.09	0.00	0.00	0.00	0.00	0.35
Pileated Woodpecker (*Drycopus pileatus*)	0.04	0.04	0.00	0.00	0.33							
Pine Grosbeak (*Pinicola enucleator*)						0.04	0.04	0.00	0.00	0.00	0.00	0.35
Pine Siskin (*Carduelis pinus*)	0.59	0.38	0.68	0.27	0.84	1.08	0.76	0.54	0.20	0.76	0.38	0.67
Purple Finch (*Carpodacus purpureus*)						0.04	0.04	0.00	0.0	0.00	0.00	0.35
Red Crossbill (*Loxia curvirostra*)	0.91	0.91	0.62	0.50	0.78	2.30	2.17	0.09	0.09	0.06	0.06	0.34
Red-breasted Nuthatch (*Sitta canadensis*)	0.03	0.03	0.09	0.06	0.39	0.04	0.04	0.03	0.03	0.13	0.13	0.50
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	0.54	0.54	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.17	0.17	0.13
Ruby-crowned Kinglet (*Regulus calendula*)	0.03	0.03	0.06	0.05	0.58	0.04	0.104	0.31	0.28	0106	0.06	0.70

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TABLE 3, continued

Species	Forest Type Riparian (n=5)		Upland (n=5)		t-Test	Reserve Zone Type Wide (n=3)		Medium (n=5)		Narrow (n=2)		ANOVA
	mean	SE	mean	SE	P[a]	mean	SE	mean	SE	mean	SE	P
Rufous Hummingbird (*Selasphorus rufus*)	0.00	0.0	0.02	0.02	0.33	0.09	0.05	0.03	0.03	0.00	0.00	0.25
Solitary Vireo (*Vireo solitarius*)	0.00	0.00	0.15	0.09	0.12	0.44	0.37	0.00	0.00	0.00	0.00	0.24
Spruce Grouse (*Dendragapus candadensis*)	0.11	0.07	0.00	0.00	0.15							
Swainson's Thrush (*Catharus ustulatus*)	0.30	0.11	0.36	0.16	0.76	0.98	0.55	0.20	0.08	0.11	0.11	0.16
Townsend's Warbler (*Dendroica towsendii*)	1.26	0.47	0.67	0.33	*0.16	1.0	0.27	0.17	0.12	0.06	0.06	0.01
Varied Thrush (*Ixoreus naevius*)	0.20	0.12	0.05	0.05	*0.13	0.09	0.05	0.00	0.00	0.00	0.00	0.05
Warbling Vireo (*Vireo gilvus*)						0.23	0.22	0.00	0.00	0.00	0.00	0.07
Western Tanager (*Prinaga ludoviciana*)	0.00	0.00	0.08	0.08	0.33	0.25	0.25	0.00	0.00	0.00	0.00	0.35
White-winged Crossbill (*Loxia leucoptera*)	0.17	0.12	0.00	0.00	0.17							
Winter Wren (*Troglodytes troglodytes*)	0.49	0.17	0.00	0.00	*0.01	0.43	0.15	0.00	0.00	0.06	0.06	0.01
Yellow-rumped Warbler (*Dendroica coronata*)	0.25	0.13	0.30	0.11	0.79	0.21	0.11	0.48	0.35	0.24	0.01	0.79

[a] P values are based on one-tailed t-tests for species which other literature indicated were riparian-associated in similar ecosystems, and on two-tailed t-tests for other species (see methods). Species for which one-tailed tests were done are indicated with an *.

TABLE 4. Mean density (detections/ha*) of all bird species combined and of riparian-associated birds in ten 3-ha sites that included riparian reserve zones in the Montane Spruce zone, Invermere Forest District, B.C., 1994.

Species	Wide Res. Zone mean	SE	Medium Res. Zone mean	SE	Narrow Res. Zone mean	SE	ANOVA P
All species	13.7	0.9	5.3	0.7	4.3	0.1	<0.01
All riparian-associated spp.	6.5	0.7	2.8	0.3	1.4	1.0	<0.01
Golden-crowned Kinglet	3.0	0.2	1.4	0.2	0.6	0.4	<0.01
Hammond's Flycatcher	2.0	0.7	1.2	0.3	0.6	0.5	0.26
Townsend's Warbler	1.1	0.3	0.2	0.1	0.1	0.1	<0.01
Winter Wren	0.4	0.1	0.0	0.0	0.1	0.1	0.01

* based on total area in each site, which included riparian and upland forest plus cutblock

winter wrens to occur only in riparian forest, whereas in coastal Oregon, Hammond's flycatchers occurred only in upland sites, golden-crowned kinglets were more abundant in upland sites, and winter wrens were less abundant but present in upland sites. In Vermont, Spackman and Hughes (1994) found the greatest bird abundance on transects that were the greatest distance from the high water mark of streams (>150 m). Murray and Stauffer (1995) found in Virginia that some species were positively and some were negatively associated with the riparian, with no significant overall trends in relative abundance or species richness. The results of these latter three studies

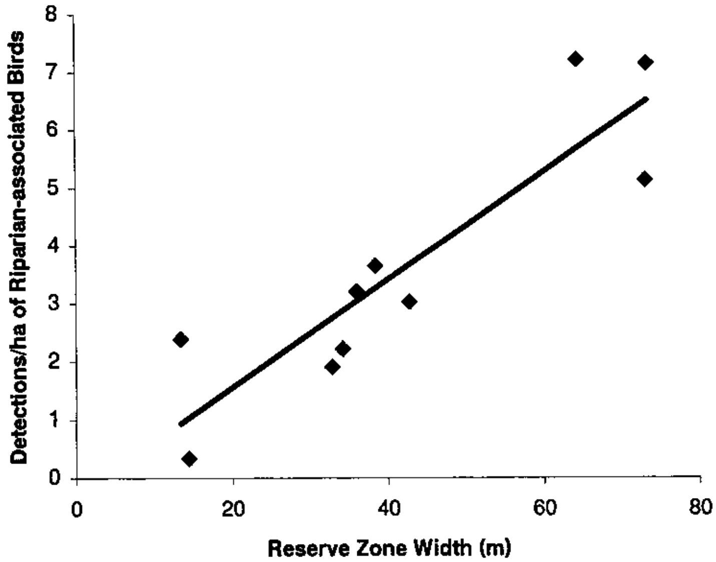

Figure 3. Density of riparian-associated birds in 10 100-m wide sites that included riparian reserve zones in the Montane Spruce zone, Invermere Forest District, B.C., 1994.

indicate that the value of riparian habitat to a given species, guild or community may differ widely between regions. Similarly, Knopf (1985) found that the relative significance of riparian areas varied along an elevational gradient. Our research and much of the literature generally support the theory that riparian areas are disproporionately important in maintaining diverse, abundant avifaunas, but their value cannot be generalized between regions or elevations. Management must therefore be based upon a local understanding of the distinctiveness of riparian habitat relative to upland habitat.

We found densities of riparian-associated birds and of all bird species combined to increase with width for riparian reserve zones averaging 14, 37 and 70 m. It is not known how far this trend would continue for even wider reserve zones. Controls were not compared to this trend because they had no definable width (there was no adjacent cutblock) and because habitat use by birds was probably qualitatively different in the contiguous forest of the controls, compared to the strips of forest and edge that made up the treatments. The observed pattern of increasing bird density with increasing reserve zone width occurred despite our census areas being the same width (100 m) for all reserve zone widths, the true riparian vegetation being intact in all sites, and the opposite bank providing a continuous block of intact forest. Given these facts, our results suggest that for narrower reserves 1) bird populations did not fully compensate for lost habitat by "packing" into a smaller forested area, as occurs in some fragmented forests (Lehmkuhl et al. 1991), or by making use of the adjacent cutblock, 2) riparian habitat value may be affected when adjacent upland forest is cut, even if the riparian itself is not cut, and 3) narrower riparian reserve zones are of less value than wider reserve zones, even if forest on the opposite side of the stream is intact. The low habitat value of narrow and medium reserve zones relative to wide reserve zones is consistent with most other studies. Three of the four species that we considered to be riparian associates and were sensitive to reserve zone width (Townsend's warbler, winter wren and golden-crowned kinglet) were also found to be sensitive to forested riparian corridor width by Gyug (1995) in habitats very similar to those we studied. Gyug found far fewer individuals of these species in reserve zones less than 50 m compared to those greater than 100 m, based on sites having reserve zones and cutblocks on both sides of the stream. In Quebec, Darveau et al. (1995) found that riparian reserve strips 60 m wide supported forest-dwelling birds in a pattern similar to controls, but that strips 20 or 40 m wide did not. In Iowa, Stauffer and Best (1980) found a positive correlation between reserve width and bird species richness for sites ranging from 10 to 250 m wide. Croonquist and Brooks (1993) noted that sensitive species were absent from riparian reserves <25 m wide, and that reserves >125 m wide were needed to support a near-natural avifauna in Pennsylvania. Spackman and Hughes (1994) found that riparian corridors of about 175 m were needed to maintain 95% of the bird species found in control sites in Vermont. In contrast, Smith and Schaefer (1992) found very little difference in bird community characteristics between riparian reserves 20 to 60 m wide and those 75 to 150 m wide on urban streams in Florida, but felt this may have reflected an inadequate range of widths studied.

Differences in habitat characteristics and bird communities between riparian and upland forests support the practice of maintaining reserves in streamside forest. There are undoubtedly some species that are less abundant or less active in spruce-dominated riparian forest than in lodgepole pine-dominated upland forest. However, given the rarity of riparian forest relative to upland forest, differences in habitat attributes between riparian and upland, and the high species diversity and abundance in the riparian, it is prudent to preferentially provide protective management to riparian habitats in the Montane Spruce zone. Where partial cutting occurs in riparian forest, the differences in forest attributes that make riparian habitat unique from upland habitat should be maintained. Riparian wildlife might benefit if prescribed volumes of timber were removed in patches rather than uniformly, to ensure that at least part of the riparian habitat maintains its uniqueness and high habitat suitability. This hypothesis requires investigation, as it might also result in greater habitat fragmentation per volume of timber removed.

Depending on channel width, British Columbia guidelines require RMAs of 20 to 50 m on small streams, with only a portion of this being an RRZ and thereby being free from forest harvesting (BC Ministry of Forests and BC Environment 1995). Based on those guidelines, RMAs in the Montane Spruce zone may have considerably lower bird densities, including those of riparian associates, than they would if they were 70 m wide. A similar situation is likely to occur in Kootenai National Forest, where timber harvesting is restricted only in SMZs 30 m wide (Kootenai National Forest 1994). Furthermore, even the widest reserve zones studied, if isolated from contiguous mature forest, would probably be several orders of magnitude too small to maintain all species of neotropical migrants because of the small amount of habitat and expected high rates of nest predation and brood parasitism (Faaborg et al. 1993). Thus, if one goal of riparian management is to support near-natural densities of riparian-associated birds and maintain diverse avifaunas at the stand level, it appears that RMAs or SMZs should be wider than currently required under British Columbia or Kootenai National Forest guidelines, and should not be isolated from larger stands of mature forest.

Current riparian management guidelines in B.C. are not based on vegetational characteristics. A "riparian" management area will consist almost entirely of upland forest when the band of riparian vegetation is narrow, or alternatively, w maintain only a portion of the riparian forest whe that vegetation type extends a great distance fron the stream. This is likely because guidelines wer developed to maintain recreational, aesthetic, fisheries and hydrological values, not just wildlife values. However, wildlife values and many other values could more adequately be maintained if prescribed widths of reserve zones, management zones and RMAs as a whole were seen as minimums, with provisions to enlarge them where riparian habitat extended greater distances from the stream, regardless of channel width, fisheries value, or use of a stream as a domestic water supply.

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Notes

1. The t-test for whether the Townsend's warbler occurs at greater density in the riparian than the upland yielded a P value of 0.16, which is generally beyond acceptable significance. However, a more extensive study in very similar habitat (Gyug 1995) found this species to be more common in the riparian (P=0.01), so it is included with other riparian associates in analyses of their response to treatments.

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