Avian Species Richness and Abundance Levels in Different Habitats Along the Bad River Corridor, Northern Wisconsin

In this paper I describe the birds observed during quantitative sampling of the Bad River Corridor. A total of 210 sites were sampled in 5 main habitats and at boundaries between some of these habitats during the 1994 and 1995 breeding seasons. Of the 80 species recorded during the point counts, 47.5% were neotropical migratory bird species, representing 68.8% of the total number of individuals observed. Differences in species richness and abundance levels were tested between edge sites and interior sites, among habitat categories (open canopy, hard edge, soft edge, and mature forest), and among all habitat and boundary types. Reasons for these differences in species richness and abundance levels may be due to vegetational and structural complexity differences among the habitats and boundaries.

by Joan E. Elias

While a number of avian ecology studies have been conducted in the western Great Lakes forests (e.g. Hoffman and Mossman 1990, Temple 1990, Hawrot et al. 1995, Hoffman 1989, Mossman et al. 1990, Van Stapen and Doolittle 1993) the Bad River Indian Reservation in northern Wisconsin constitutes an important gap in our knowledge of the breeding birds of the region.

The Bad River Indian Reservation is located in Ashland County, Wisconsin (T.46–49 N., R.2–3 W; Figure 1a), and lies within the Lake Superior lowland avifauna zone of Wisconsin (Robbins 1991). The Bad River flows north through the reservation and into Lake Superior, forming an important corridor of wild lands in northern Wisconsin. The river corridor encompasses diverse forest types such as floodplain hardwoods, mixed conifers, and managed aspen forests within a forested landscape.

During the summers of 1994 and

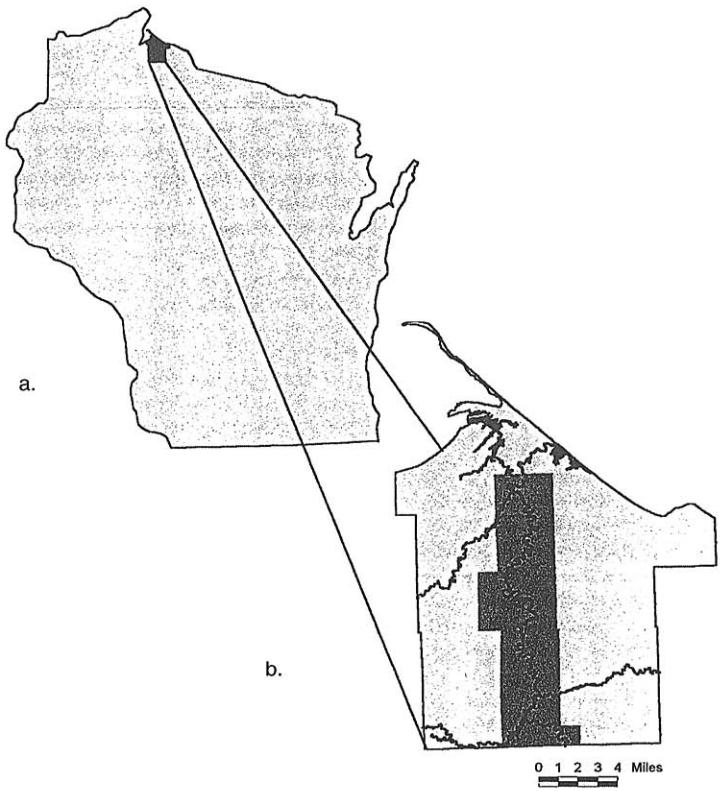

Figure 1. Location of the Bad River Indian Reservation in Wisconsin (a) and the Bad River Corridor within the Reservation (b).

1995 I conducted research on the breeding songbirds of the Bad River Corridor, an area defined by the Bad River Natural Resource Department as approximately 1 mile on either side of the river (Figure 1b). The Corridor is bounded by small gravel roads on the east and west sides. Except for US Hwy. 2 on the north and one small gravel road crossing the river, the corridor itself is roadless. However, several right-of-ways (pipelines, powerlines, railroad) do cut through the corridor.

The main objectives of this paper are, 1) to describe the avian species richness of the Bad River Corridor, and 2) to examine differences in avian species richness and abundance levels among different habitat types. Species richness and abundance levels are compared between edge sites and interior sites, among habitat categories (open canopy, hard edge, soft edge, and mature interior), and among all habitat and edge types. The importance of the Bad River Corridor to neotropical migratory birds in general and to bird species of regional management concern is discussed.

Methods

Bird Sampling—Research areas representing the 5 most common forest

types in the Bad River Corridor were chosen using aerial photographs and land cover maps constructed and ground-truthed by the Bad River Band of Lake Superior Chippewa. Breeding bird censuses were conducted within these 5 main forest types and on the boundaries, or edge habitats, between some of the forest types, for a total of 13 sampling categories (Table 1). Sites were stratified by habitat type and chosen randomly (though constrained by logistics; i.e. sites were rejected if access was not feasible). Sites within each habitat type were approximately equally distributed across time of morning and time of season and were located at least 250 meters apart to minimize double-counting of individuals. Interior habitats were sampled at least 100 meters from an edge with a differing habitat type or road. Boundaries between habitat type were located on aerial photos and boundary points were sampled on the edge between the 2 habitats.

Ten-minute, unlimited distance point counts were used to census birds during the peak of the breeding season (June 1–July 10). All birds seen and heard were recorded along with their approximate positions relative to point center. Codes were used to indicate whether a bird was calling, singing, visually observed, or flying over. Flyovers above canopy level were indicated on the data forms but not included in the analyses.

Sampling was conducted during the early morning hours from 1/2 hour before sunrise until 10:00 A.M., and not conducted when windspeed exceeded 15 mph or when there was a steady rain (light or intermittent rain was tolerable since it didn't interfere with auditory surveying of birds). These are standard procedures for the census of breeding birds (Ralph et al. 1993, Blake et al. 1991, Smith et al. 1993).

The majority of the sampling (203 points) was conducted by myself. A second observer (M. Robertsen) sampled 7 points spread among 3 habitat types.

Habitat Descriptions—MAIN HABITATS—The 5 most common cover

Table 1. Habitats and boundary types sampled via point counts in 1994 and 1995 in the Bad River Corridor, Wisconsin, and the number of points in each habitat.

	1994 # points	1995 # points	TOTAL # points
Main Habitats			
Aspen Clearcut	12	16	28
Aspen-Red Maple	13	9	22
Boreal Hardwood-Conifer	12	7	19
Bottomland Hardwoods	13	2	15
Black Ash	12	8	20
Boundary Types			
Aspen Clearcut/Aspen-Red Maple	10	15	25
Aspen Clearcut/Boreal Hardwood-Conifer	12	8	20
Aspen-Red Maple/Black Ash	8	7	15
Boreal Hardwood-Conifer/Black Ash	8	8	16
Bottomland Hardwoods/Black Ash	7	5	12
Bottomland Hardwoods/Boreal Hardwood-Conifer	7	1	8
Aspen-Red Maple/Bottomland Hardwoods	0	1	1
Aspen-Red Maple/Boreal Hardwood-Conifer	9	0	9
Total # Points	123	87	210

types within the Bad River Corridor are: 1) aspen clearcut, 2) aspen-red maple, 3) boreal hardwood-conifer, 4) bottomland hardwoods, and 5) black ash (Table 1). The cover-type classification system used by the Bad River Band (Westad et al. 1993) is based on the Minnesota Department of Natural Resources Natural Heritage Program's native vegetation community types (Minn. DNR 1993). The 5 main habitat types chosen for this study are described in detail below, and common plant species within each are listed in Table 2.

1) *Aspen Clearcut (ACC).* Twelve percent of the corridor is in recently harvested aspen (see Appendix 1 for Latin names of plants). On well-drained soils these areas are usually thick with regenerating aspens under 4 meters in height, and may also include hazelnut and dogwood species. On wet soils often the aspen is not regenerating well and is interspersed with alder thickets. Many clearcuts contain residual red maples and/or red and white pines, either as scattered individuals or in small clumps. The ground flora is extremely diverse and on drier sites is typical of a northern dry-mesic forest (sensu Curtis, 1959).

2) *Aspen-Red Maple (ARM).* Trembling aspen and red maple dominate the canopy of this cover type with some stands containing big-tooth aspen instead of trembling aspen. Minor canopy components include white birch, black ash, and red and white pines, though the conifer element is usually small. The canopy cover is not dense, usually estimated at less than 40%. The subcanopy consists of mainly red maple and has an average estimated cover of between 40% and 70%. The understory, or shrub layer (3–12 feet in height) is usually dense (greater than 70% cover with hazelnut and *Viburnum* spp. on the drier sites and alder on wet soils. The ground flora is similar to that of the aspen clearcut community type. Aspen-red maple was combined with the Bad River's aspen cover type (where red maple is not a strong canopy species) in this study. Together, these cover types comprise approximately 38% of the Bad River Corridor acreage.

2) *Boreal Hardwood-Conifer (BOR).* This cover type is a later successional stage of the ARM habitat and covers 17% of the Corridor. The canopy layer consists of trembling aspen and occasionally big-tooth aspen, red maple, white birch, balsam fir, white spruce, and red and white pines. Often the pines are found as a super-canopy. The canopy cover is generally greater than in ARM (estimated to be on average between 40% and 70%). The subcanopy cover has a percent cover similar to the ARM cover type but contains a greater percentage of conifer species. The BOR understory is less dense than that of the ARM habitat and often contains a strong conifer component (balsam fir) as well as hazelnut, alder, Juneberry, and buffalo-berry near the river bluffs. The herb layer is diverse, with a more boreal species composition than the ARM community. The BOR cover type has a stronger conifer component in all forest layers than the ARM cover type, and occasionally the presence of a coniferous super-canopy.

4) *Bottomland Hardwoods (BOT).* This is a lowland community type found along the inside bends of the Bad River where annual spring flooding has enriched the soils. It comprises 9% of the corridor. The canopy cover is relatively dense and consists of sugar maple, sil-

Table 2. Common vegetation in the 5 main habitat types within the Bad River Corridor, Wisconsin. Latin names in Appendix 1. Percentages indicate the percent of the total acreage in the corridor covered by each habitat type.

Type	Super canopy	Canopy*	Understory (shrub layer)	Ground cover
Aspen Clearcut (ACC) 12%		Residuals: Red Pine White Pine Red Maple	Trembling Aspen Red Maple Speckled Alder Hazelnut species	Bracken Fern Barren Strawberry Big-leafed Aster Canada Mayflower Wild Pea Rice Grass
Aspen-Red Maple (ARM) 38%		Trembling Aspen Red maple (White Birch) (White Pine) (Black Ash)	Speckled Alder Hazelnut species Nannyberry Downy Arrow-wood	*similar to aspen clearcut*
Boreal Hardwood-Conifer (BOR) 17%	Red Pine White Pine	Trembling Aspen Red Maple White Birch Balsam Fir White Spruce Red Pine White Pine	Juneberry Buffalo-berry Hazelnut species Speckled Alder	*some areas are similar to aspen clearcut* *other areas:* Sarsaparilla Pennsylvania Sedge Horse Gentian Bluebead Lily Starflower
Bottomland Hardwoods (BOT) 9%		Sugar Maple Silver Maple Basswood Box Elder Yellow Birch Black Ash (White Spruce) (Hemlock) (White Cedar)	Alternate-leafed Dogwood Nannyberry Downy Arrow-wood American Elm	Ostrich Fern Horsetail Wood Nettle *Rich Spring Ephemeral Community including:* Wild Leek Wild Ginger False Rue Anemone Trillium
Black Ash (BA) 7%		Black Ash Red Maple Silver Maple White Cedar Basswood (American Elm) (White Spruce) (Balsam Fir)	Downy Arrow-wood Dogwood species Speckled Alder	Marsh Marigold Marsh Saxifrage Sensitive Fern Meadow Rue Loosestrife Sedges

* Species in parentheses are minor canopy species.

ver maple, basswood, box elder, and yellow birch, with fewer numbers of white spruce, hemlock, and white cedar. The BOT cover type has an old-growth component, with some trees reaching diameters of approximately 4 feet. Snags and downed logs are common. The understory is more sparse than any of the other 4 main cover types and is limited to areas where there is a gap in the canopy. Common understory species include alternate-leaf dogwood and *Viburnum* spp. The ground layer consists of a rich spring

ephemeral community early in the season, with wood nettle and ostrich fern reaching chin-height by mid–June.

5) *Black Ash (BA).* The canopy of this cover type consists predominantly of black ash, with some red maple, and silver maple, and smaller numbers of basswood, balsam fir, white spruce, and white cedar. Generally, the canopy cover is sparse, with the average estimate slightly greater than 40% cover. Often there is no subcanopy layer. The understory layer is patchy, with dense alder thickets, *Viburnum* spp. and dogwood species in some places, while in other areas it is more open with robust sedges as a ground cover. Many black ash swamps are or had been flooded by beavers and contain many standing dead trees. The ground flora is diverse and is dominated by wetland species. For this study the black ash cover type was combined with Bad River's mixed hardwood lowland forest, which has a stronger red-maple component in the canopy, but otherwise is very similar to black ash. Together these community types cover approximately 7% of the corridor.

The ACC, ARM, and BOR communities represent different successional stages of the same basic forest type, all upland above the river bottoms. Aspen clearcut has been managed recently, within the past 10 years. Aspen-red maple forests were harvested between 25 and 50 years ago. Boreal hardwood-conifer forests have not been managed within the past approximately 60 to 80 years.

The BOT and BA communities also have not been managed in the last approximately 60 to 80 years. Some patches in these forest types appear to be old growth, i.e. they have not experienced significant management post-European settlement. In some places American elm was salvaged from the BOT habitat during the time the Dutch elm disease swept through the area (late 1960s to early 1970s). Both the BOT and BA forest types occur in lowland areas; BOT along the Bad River, and BA stands either in close proximity to BOT forests or along tributaries of the Bad River.

Habitat Descriptions—EDGE TYPES—Edges between habitats can be categorized as either "hard" or "soft." In this study, hard edges occur between aspen clearcuts (ACC) and mature upland forests (ARM and BOR); soft edges occur between upland mature forest (ARM and BOR) and lowland mature forest (BOT and BA). At hard edges a clear break in the canopy exists, while the understory (shrub layer) is continuous and dense. While soft edges may be abrupt in topography, there is little or no break in the canopy layer and relatively minor structural differences between the 2 habitat types comprising soft edges. Definitions of the terms "hard" and "soft" edges may differ among disciplines, but I am comfortable with their use in this study as defined above, based on the precedence in bird studies of using habitat structural characteristics to identify edge types (Ratti and Reese 1988, Hunter 1990, Rudnicky and Hunter 1993, Fenske 1995, Howe et al. 1996).

Bird Data Management—In order to determine whether data collected in the 2 field seasons could be pooled, 1994 and 1995 bird species abundance data were compared using Spearman rank correlations and multi-response permutation procedures (Biondini et

al. 1985, Zimmerman et al. 1985). Results of these tests (reported in Elias 1996) indicate that within each habitat and boundary type similar species were found at similar abundance levels in 1994 and 1995, allowing the data from the 2 field seasons to be pooled in further analyses.

Results

During the 2 field seasons (1994 and 1995) a total of 210 sites were sampled; 123 sites in 1994 and 87 sites in 1995 (Table 1). A total of 80 species and 3147 individuals were encountered during the point counts (Table 3). Of the 80 species 38 (47.5%) are neotropical migrants (according to Peterjohn and Sauer 1993, Sauer and Droege 1992, Terborgh 1989, Whitcomb et al. 1981, or Freemark and Collins 1992). These 38 species comprise 68.8% of the total number of individuals observed. An additional 25 species (31.2% of the total species), comprising 24.7% of the total individuals encountered, are short-distance migrants. The remaining 17 species are permanent residents (11 species) or unclassified (6 species).

The 10 most common species observed were (in decreasing order of abundance): Ovenbird, Red-eyed Vireo, Nashville Warbler, White-throated Sparrow, Veery, Chestnut-sided Warbler, Common Yellow-throat, Black-throated Green Warbler, American Redstart, and Great-crested Flycatcher. With the exception of the White-throated Sparrow, all of these most abundant species are neotropical migrants. These 10 species accounted for 52.8% of the total number of individuals recorded. By contrast, the 30 least abundant species accounted for

Table 3. Total number of individuals of all species observed during point counts in 1994 and 1995 in the Bad River Corridor, Wisconsin

Species	# Individuals
Ovenbird	370
Red-eyed Vireo	230
Nashville Warbler	176
White-throated Sparrow	152
Veery	151
Chestnut-sided Warbler	145
Common Yellowthroat	129
Black-throated Green Warbler	106
American Redstart	105
Great-crested Flycatcher	98
Song Sparrow	92
Mourning Warbler	91
Rose-breasted Grosbeak	89
Swamp Sparrow	75
Hermit Thrush	62
Blue Jay	61
Black-and-white Warbler	60
Least Flycatcher	60
Golden-winged Warbler	57
American Robin	55
Yellow-bellied Sapsucker	54
Cedar Waxwing	59
Blackburnian Warbler	47
Alder Flycatcher	46
Winter Wren	43
Brown Creeper	37
White-breasted Nuthatch	35
Northern Flicker	35
Brown-headed Cowbird	34
Canada Warbler	34
Northern Parula	29
Eastern Wood-Pewee	25
Red-winged Blackbird	25
American Goldfinch	23
Black-capped Chickadee	22
Northern Waterthrush	19
Hairy Woodpecker	17
Red-breasted Nuthatch	17
Common Raven	13
Wood Thrush	13
Pine Warbler	11
Ruffed Grouse	11
Solitary Vireo	10
Yellow-throated Vireo	10
Gray Catbird	8
Yellow-bellied Flycatcher	8
Downy Woodpecker	7
Purple Finch	7
Scarlet Tanager	7
Sedge Wren	7
Northern Oriole	6
Ruby-throated Hummingbird	6

(continued)

Table 3. Continued

Species	# Individuals
Yellow Warbler	6
House Wren	5
Yellow-rumped Warbler	5
Pileated Woodpecker	5
American Crow	4
Tree Swallow	4
Broad-winged Hawk	3
Chipping Sparrow	3
Indigo Bunting	3
Magnolia Warbler	3
Bald Eagle	2
Barred Owl	2
Common Snipe	2
Eastern Kingbird	2
Great Blue Heron	2
American Woodcock	2
Wood Duck	2
Black-billed Cuckoo	1
Belted Kingfisher	1
Eastern Phoebe	1
Evening Grosbeak	1
Killdeer	1
Mallard	1
Mourning Dove	1
Olive-sided Flycatcher	1
Red-tailed Hawk	1
Rusty Blackbird	1
Virginia Rail	1
Total # individuals	3147

only 2.5% of the total number of individuals.

Figure 2 shows the relative abundance levels of all species in the 5 main habitats. Appendix 3 lists species and their abundance levels for each habitat and boundary type.

All data in this section have been square root transformed in order to better approximate a normal distribution. This transformation is appropriate for data with Poisson distributions, as is the case with count data. In the analysis of variance (ANOVA) among specific habitats and boundaries 0.375 was added to the count data before taking the square root in order to accommodate the large number of zero counts. A significance level of $p < 0.05$ is used in the statistical comparisons below.

Edge Sites vs. Interior Sites—T-tests are used to test for differences in the number of individuals/point and the number of species/point between 8 boundary types (edge sites) and the 5 main habitats (interior sites). Interior points include those in the following habitats: aspen clearcut (ACC), aspen-red maple (ARM), boreal hardwood-conifer (BOR), bottomland hardwoods (BOT), and black ash (BA). Aspen clearcut is included as an interior habitat in this case because the object is to look at edge effects, not open vs. closed canopy effects. Edge points include those at the following boundaries: aspen clearcut/aspen-red maple (CCARM), aspen clearcut/boreal hardwood-conifer (CCBOR), aspen-red maple/black ash (ARMBA), boreal hardwood-conifer/black ash (BORBA), bottomland hardwoods/black ash (BOTBA), bottomland hardwoods/boreal hardwood-conifer (BOTBOR), aspen-red maple/boreal hardwood-conifer (ARMBOR), and aspen-red maple/bottomland hardwoods (ARMBOT).

Results of the t-tests show that edge sites contain more individuals/point than do interior sites (15.5 and 14.5, respectively) but these differences are not significant ($p = 0.056$; Figure 3a). Significant differences do exist in the number of species/point, however, with boundary sites having a greater number than interior sites (12.0 and 10.5, respectively, $p = 0.001$; Figure 3b).

Habitat Categories—To test for differences in the number of individuals/

ACC	ARM	BOR	BA	BOT	SPECIES
●			*		ALFL
				*	AMCR
•			*	*	AMGO
*	•	*	●	●	AMRE
•	*	*	•	*	AMRO
*	*				BAOR
			*		BAOW
•	•	*	•	•	BAWW
*	*	*	*		BCCH
				*	BEKI
*	*	*	*	*	BHCO
*	*	●	•	*	BLBW
*	•	•	*	•	BLJA
	*	•	•		BRCR
*	●	●	•	*	BTNW
*	*	*	*		CAWA
●	*	*	●	•	CEDW
		*		*	CHSP
	*	*	*		CORA
	*				COSN
●	•	*	●	•	COYE
●	●	*	•	•	CSWA
	*	*	*	*	DOWO
				*	EAPH
	*	*	*		EAWP
		*			EVGR
•	•	•	●	*	GCFL
*				*	GRCA
*			*		GTBH
●	*		*	*	GWWA
	*		*		HAWO
*	•	•	*	*	HETH
*	*				HOWR
*				*	INBU
ACC	ARM	BOR	BA	BOT	SPECIES

	# of individuals/point
*	<.25
•	.25-.49
●	.50-.74
●	.75-1.0
●	≥ 1.0

ACC =	Aspen clearcut
ARM =	Aspen-red maple
BOR =	Boreal hardwood-conifer
BA =	Black ash
BOT =	Bottomland hardwoods

Figure 2. Relative abundance levels for all bird species encountered in the five main habitats (excluding edge habitats) in the Bad River Corridor, Wisconsin. See text for habitat codes. Bird species codes listed in Appendix 2.

(continued)

ACC	ARM	BOR	BA	BOT	SPECIES
	*	*	•	●	LEFL
				*	MAWA
•	•	•	•	•	MOWA
		*			MYWA
●	●	●	•	*	NAWA
		*	*		NOPA
			•	*	NOWA
•	●	●	●	●	OVEN
*		*			PIWA
*	*				PIWO
*	*		*		PUFI
●	•	*	●	●	RBGR
*	*	*	*		RBNU
•	●	●	●	●	REVI
*					RTHA
*			*		RTHU
*	*	*			RUGR
*			*		RWBL
	*	*			SCTA
*					SEWR
●	*	*	●	●	SOSP
			*	*	SOVI
•	*		●		SWSP
			*		TRES
●	●	•	●	●	VEER
*	*	*	•	•	WBNU
*	*	•	*	*	WIWR
*	*				WOCO
			*	*	WOTH
●	●	•	•		WTSP
		*	*	*	YBFL
*	•	•	*	*	YBSA
			*	*	YWAR
•	*	*	*	*	YSFL
*			*		YTVI
ACC	ARM	BOR	BA	BOT	SPECIES

# of individuals/point	
*	<.25
•	.25-.49
●	.50-.74
●	.75-1.0
●	≥ 1.0

ACC =	Aspen clearcut
ARM =	Aspen-red maple
BOR =	Boreal hardwood-conifer
BA =	Black ash
BOT =	Bottomland hardwoods

Figure 2. Continued

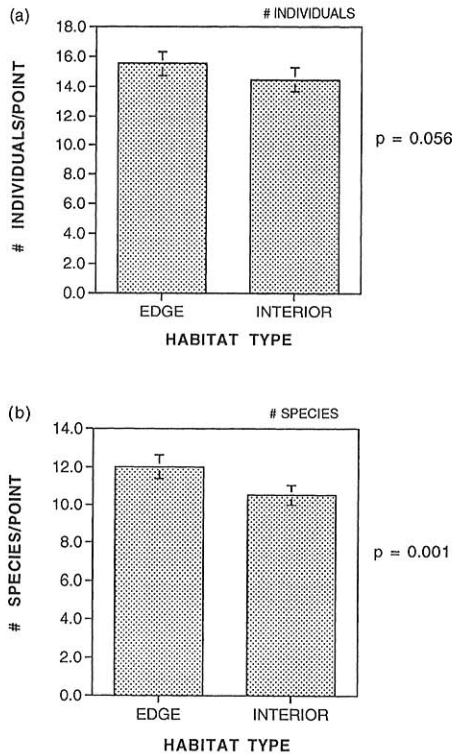

Figure 3. T-test results of the number of individuals per point (a) and number of species per point (b) at edge sites vs. interior sites in the Bad River Corridor, Wisconsin. Error bars indicate two standard errors.

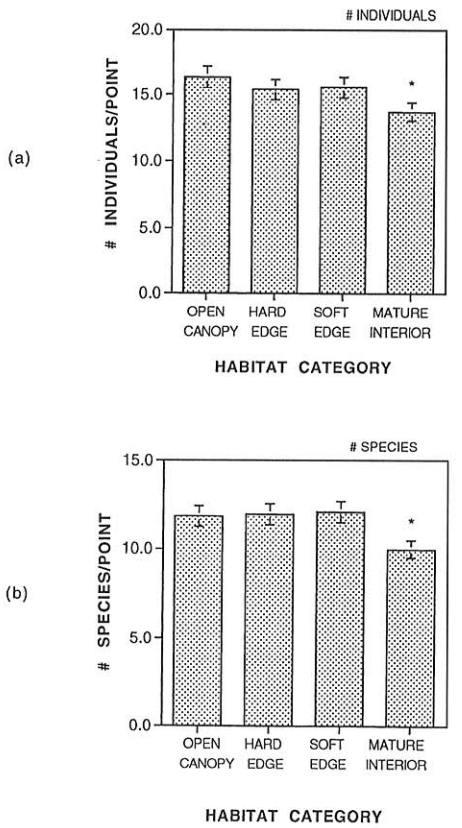

Figure 4. Analysis of variance results comparing the number of individuals/point (a) and number of species/point (b) among habitat categories in the Bad River Corridor, Wisconsin. See text for details about habitat categories. Error bars indicate two standard errors. * indicates significance at $p < 0.005$.

point and the number of species/point among habitat categories, a one-way analysis of variance (ANOVA) is used. The habitat categories tested are open canopy (ACC), hard edge (CCARM, CCBOR), soft edge (ARMBA, BORBA, BOTBA, BOTBOR, ARMBOR, and ARMBOT), and mature interior (ARM, BOR, BOT, BA).

Significant differences exist among these habitat categories in the number of individuals/point ($p = 0.007$; Figure 4a) and the number of species/point ($p = 0.000$; Figure 4b). Mature interior points contain significantly fewer numbers of individuals (13.8) and species (10.0) per point than any of the other habitat categories.

Specific Habitats and Boundaries—A one-way ANOVA is also used to test for differences in the number of individuals/point and number of species/point among the 10 habitat and boundary types with sufficiently high sample sizes (ACC, ARM, BOR, BOT, BA, CCARM, CCBOR, ARMBA, BORBA, BOTBA). Significant differ-

ences exist among the habitats and boundaries for both numbers of individuals and numbers of species per point ($p = 0.000$ in both cases; Figures 5a and 5b, respectively). A similar pattern exists for both the numbers of species/point and the numbers of individuals/point among habitats. The 4 habitats with fewest numbers of individuals/point (BOR, BOT, ARM, and CCBOR) also have the fewest numbers of species/point. The 3 habitats with the highest numbers of individuals/point (BORBA, ARMBA, CCARM) also have the highest numbers of species/point.

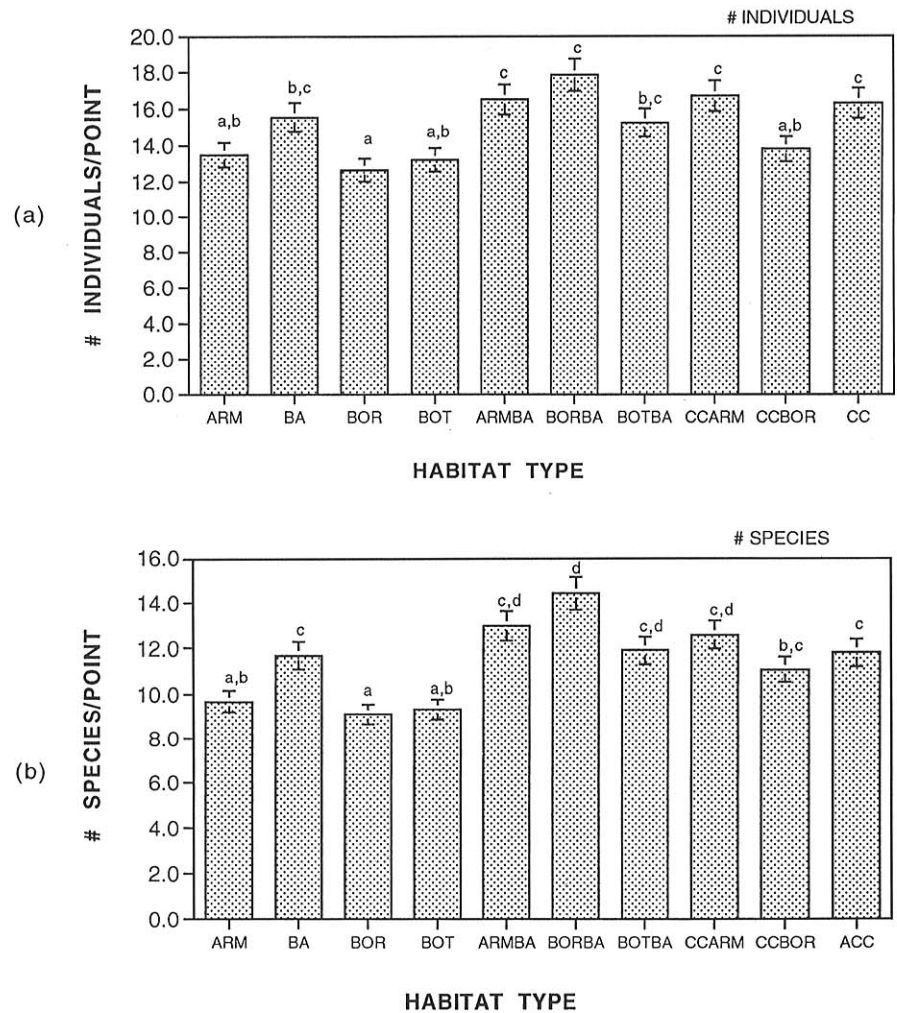

Figure 5. Analysis of variance results comparing the number of individuals/point (a) and number of species/point (b) among habitats and boundary types in the Bad River Corridor, Wisconsin. Error bars indicate two standard errors. Letters above bars indicate significant differences at $p < 0.05$ level. See text for habitat abbreviations.

Discussion

Migratory bird species accounted for the vast majority of individuals observed (93.5%) during the point count samples. Permanent residents, accounting for approximately 6% of the total number of individuals observed during sampling, may be under-represented due to the sampling method used. Point counts, primarily an auditory census technique, were conducted in June and early July when many permanent residents, such as woodpeckers, Black-capped Chickadee, Red- and White-breasted Nuthatches are no longer breeding. Under-representation of permanent residents, however, does not undermine the importance of the Bad River Corridor as breeding grounds for migratory species, especially neotropical migrants.

A large proportion (52.8%) of the total number of individuals was composed of only 10 species, a typical finding for studies of species assemblages (Preston 1962). Of these 10 most abundant species observed in the Bad River Corridor, several are listed as among the most abundant in other regional studies as well. Ovenbird and Red-eyed Vireo ranked first and second in abundance, respectively, in the Bad River Corridor. These species had the same rankings in the Apostle Island National Lakeshore in 1995 (Van Stappen and Dallman 1995) and in the Chequamegon National Forest in 1992 and 1993 (Hawrot et al. 1993), and they ranked among the most abundant in the forested areas of the Sandstone Unit of the Rice Lake National Wildlife Refuge in Minnesota (Hanowski and Niemi 1993). These 2 species alone accounted for over 19% of the total individuals observed during the Bad River Corridor point counts.

Thirteen species of neotropical migrants observed during the point counts are known to be experiencing population declines in the Midwest (Thompson et al. 1993; Table 4a). Six of these 13 species (Chestnut-sided Warbler, Nashville Warbler, Veery, Great-crested Flycatcher, American Redstart, and Common Yellow-throat)

Table 4. Neotropical migratory bird species encountered during the study in the Bad River Corridor, Wisconsin, showing population declines in the Midwest (a), and those identified as being of management concern in the Midwest (b).

a. Bird species showing population declines in the Midwest
Golden-winged Warbler
Wood Thrush
Chestnut-sided Warbler
Nashville Warbler
Canada Warbler
Eastern Wood-Pewee
Veery
Great-crested Flycatcher
Olive-sided Flycatcher
Rose-breasted Grosbeak
American Redstart
Indigo Bunting
Common Yellow-throat
b. Species of management concern in the Midwest
Golden-winged Warbler
Wood Thrush
Chestnut-sided Warbler
Nashville Warbler
Canada Warbler
Eastern Wood-Pewee
Veery
Mourning Warbler
Great-crested Flycatcher
Olive-sided Flycatcher
Ovenbird
Blackburnian Warbler
Black-billed Cuckoo
Rose-breasted Grosbeak
Scarlet Tanager
Yellow-throated Vireo
Magnolia Warbler
Yellow-bellied Flycatcher
Black-throated Green Warbler

are among the 10 most abundant species in the Bad River Corridor. Nineteen species observed during this study have been identified as neotropical migratory bird species of management concern in the Midwest (Thompson et al. 1993; Table 4b). Again, 6 of these species (Chestnut-sided Warbler, Nashville Warbler, Veery, Great-crested Flycatcher, Ovenbird, and Black-throated Green Warbler) are among the 10 most common species in the Bad River Corridor.

The fact that some declining species and some species of management concern are found abundantly in the Bad River Corridor suggests that this area may be a source habitat (Pulliam 1988, Howe et al. 1991) for these species. The importance of the Bad River Corridor in particular, and the entire western Great Lakes Region in general, as a source habitat for species listed in Tables 4a and 4b is yet to be proven. Detailed studies on nesting success, productivity, and survivorship are needed to determine whether the Bad River Corridor contains source or sink habitats.

The Brown-headed Cowbird, a nest parasite known to affect the nesting success of a variety of species (Mayfield 1964, Brittingham and Temple 1983, Robinson 1992), was observed in every habitat and boundary type in the Bad River Corridor. This species ranked 29th in abundance out of 80 species, averaging 0.16 individuals/point, which is similar to abundance levels in the Chequamegon National Forest (0.13 individuals/point, Hawrot et al. 1993). Cowbirds were found most abundantly at the boundary between boreal hardwood-conifer (BOR) and black ash (BA) forest types (0.5 individuals/point). The high number of this species at this boundary type are inexplicable since cowbirds were not found in high numbers in either BOR or BA habitats (0.11 and 0.05 individuals/point, respectively). While cowbirds did not occur in high numbers in general, the effect of this species remains unknown in the absence of research on nesting success of host species.

Edge Sites vs. Interior Sites—Wildlife managers have recognized for years that maximizing edge will maximize local species diversity (Leopold, 1933; Odum, 1971). The Bad River Corridor provides no exception to this rule, showing higher numbers of species/point at edge sites compared to interior sites. Vegetation structure is complex at the junction of 2 habitat types, a feature known to increase bird species richness (Niemi and Hanowski 1984, Probst et al. 1992). Species representing 2 different habitats may be found together at the edge between these 2 habitats, resulting in species richness greater than that which is found in either habitat alone.

Differences Among Habitats—The lower numbers of individuals/point and the lower numbers of species/point in mature interior habitat types in comparison to hard edges, soft edges, and open canopy sites may be related to vegetation and structural complexity. Hard edges, which occur where a mature forest meets an open canopy habitat (in this case ARM and BOR adjacent to ACC), have a high degree of vegetation contrast, offering a wide variety of possible nesting and feeding areas. While soft edges are not as abrupt as hard edges, changes in the percent cover of the different forest layers (canopy, subcanopy, unders-

tory) usually occur at these boundaries. Aspen clearcuts are deceivingly complex structurally and/or vegetationally in the Bad River Corridor. The presence of residual trees provides nesting sites for some species. For example I observed Pine Warblers in small patches of residual pines within aspen clearcuts. The ACC habitat has a dense understory layer consisting not only of regenerating aspen but also stump-sprouting red maples, a variety of shrub species, and patches of alders or openings of robust sedges in wet pockets. The presence of snags in the ACC habitat provides feeding and nesting sites for species such as woodpeckers and nuthatches. In comparison with edge and aspen clearcuts, the degree of structural and vegetation complexity in mature interior habitat types is usually less. The canopy cover is relatively continuous, and while the understory layer may range from nearly absent (as in BOT) to early continuous (as in ARM), the degree of contrast in these mature forests is less than that of edge or open canopy habitats.

Bird species diversity within a particular habitat type (alpha diversity, Whittaker 1972) is of limited value in itself. One must look at the species diversity of the entire landscape (gamma diversity, Whittaker 1972) in order to determine the importance of a particular habitat type. For example, species which prefer boreal hardwood-conifer habitats, but which avoid clearcuts, will be absent from the landscape if no BOR habitats exist, decreasing diversity at the landscape scale. The fact that boreal hardwood-conifer and bottomland hardwood habitats contained relatively few numbers of species in this study does not diminish the importance of these habitat types on a landscape scale, as they add to gamma diversity.

Conclusion

A total of 80 species of birds were observed at the 210 sampling points in the Bad River Corridor during 1994 and 1995. Twenty-two of these species are neotropical migrants that have shown population declines in the Midwest and/or are of management concern in this region; 8 of these 22 species are among the 10 most abundant species observed during this study. The Bad River Corridor may be a source habitat for these species and others, but further research on productivity is required in order to establish this.

Boundary sites contained a greater number of species/point than interior points. Mature interior points had fewer species/point and fewer individuals/point than hard edges, soft edges, and clearcut points. These results are not surprising and probably reflect differences in structural complexity among habitat types.

The Bad River Corridor is a complex mosaic of habitat types which enhances bird species richness at the landscape level.

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Joan E. Elias
HC 1 Box 780
Saxon, WI 54559

Appendix 1. Common and Latin names of plants mentioned in text (according to Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada, Second Edition. New York Botanical Garden).

Common name	Genus	Species
Alternate-leaf Dogwood	*Cornus*	*alternifolia*
American Elm	*Ulmus*	*americana*
Balsam Fir	*Abies*	*balsamea*
Barren Strawberry	*Waldsteinia*	*fragarioides*
Basswood	*Tilia*	*americana*
Big-leafed Aster	*Aster*	*macrophyllus*
Big-tooth Aspen	*Populus*	*grandidentata*
Black Ash	*Fraxinus*	*nigra*
Bluebead Lily	*Clintonia*	*borealis*
Box Elder	*Acer*	*negundo*
Bracken Fern	*Pteridium*	*aquilinum*
Buffalo-berry	*Shepherdia*	*canadensis*
Canada Mayflower	*Maianthemum*	*canadense*
Dogwood species	*Cornus*	species
Downy Arrow-wood	*Viburnum*	*rafinesquianum*
False Rue Anemone	*Isopyrum*	*biternatum*
Hazelnut species	*Corlyus*	species

(continued)

Appendix 1. Continued

Common name	Genus	Species
Hemlock	*Tsuga*	*canadensis*
Horse Gentian	*Triosteum*	*perfoliatum*
Horsetail	*Equisetum*	species
Juneberry	*Amelanchier*	species
Loosestrife	*Lysimachia*	species
Marsh Marigold	*Caltha*	*palustris*
Meadow Rue	*Thalictrum*	*dasycarpum*
Nannyberry	*Viburnum*	*lentago*
Ostrich Fern	*Matteuccia*	*struthiopteris*
Pensylvania Sedge	*Carex*	*pensylvanica*
Red Maple	*Acer*	*rubrum*
Red Pine	*Pinus*	*resinosa*
Rice Grass	*Oryzopsis*	species
Sarsaparilla	*Aralia*	*nudicaulis*
Sedges	*Carex*	species
Sensitive Fern	*Onoclea*	*sensibilis*
Silver Maple	*Acer*	*saccharinum*
Speckled Alder	*Alnus*	*incana*
Starflower	*Trientalis*	*borealis*
Sugar Maple	*Acer*	*saccharum*
Swamp Saxifrage	*Saxifraga*	*pensylvanica*
Trembling Aspen	*Populus*	*tremuloides*
Trillium	*Trillium*	*grandiflorum*
White Birch	*Betula*	*papyrifera*
White Cedar	*Thuja*	*occidentalis*
White Pine	*Pinus*	*strobus*
White Spruce	*Picea*	*glauca*
Wild Ginger	*Asarum*	*canadense*
Wild Leek	*Allium*	*tricoccum*
Wild Pea	*Lathyrus*	*ochroleucus*
Wood Nettle	*Laportea*	*canadensis*
Yellow Birch	*Betula*	*lutea*

Appendix 2. Common names, Latin names, and species codes for all bird species mentioned in text (according to the American Ornithologist's Union. 1983. Check-list of North American Birds. 6th Edition. American Ornithologist's Union).

Common name	Latin name	AOU code
Alder Flycatcher	*Empidonax alnorum*	ALFL
American Bittern	*Botaurus lentiginosus*	AMBI
American Black Duck	*Anas rubripes*	BLDU
American Crow	*Corvus brachyrhynchos*	AMCR
American Goldfinch	*Carduelis tristis*	AMGO
American Redstart	*Setophaga ruticilla*	AMRE
American Robin	*Turdus migratorius*	AMRO
American Woodcock	*Scolopax minor*	AMWO
Bald Eagle	*Haliaeetus leucocephalus*	BAEA
Bank Swallow	*Riparia riparia*	BANS
Barn Swallow	*Hirundo rustica*	BASW
Barred Owl	*Strix varia*	BAOW
Belted Kingfisher	*Ceryle alcyon*	BEKI
Black-and-white Warbler	*Mniotilta varia*	BAWW
Black-billed Cuckoo	*Coccyzus erythropthalmus*	BBCU
Black-capped Chickadee	*Parus atricapillus*	BCCH
Black-throated Green Warbler	*Dendroica virens*	BTNW
Blackburnian Warbler	*Dendroica fusca*	BLBW
Blue Jay	*Cyanocitta cristata*	BLJA
Blue-winged Teal	*Anas discors*	BWTE
Broad-winged Hawk	*Buteo platypterus*	BWHA
Brown Creeper	*Certhia americana*	BRCR
Brown-headed Cowbird	*Molothrus ater*	BHCO
Canada Goose	*Branta canadensis*	CAGO
Canada Warbler	*Wilsonia canadensis*	CAWA
Cedar Waxwing	*Bombycilla cedrorum*	CEDW
Chestnut-sided Warbler	*Dendroica pensylvanica*	CSWA
Chimney Swift	*Chaetura pelagica*	CHSW
Chipping Sparrow	*Spizella passerina*	CHSP
Cliff Swallow	*Hirundo pyrrhonota*	CLSW
Common Grackle	*Quiscalus quiscula*	COGR
Common Loon	*Gavia immer*	COLO
Common Merganser	*Mergus merganser*	COME
Common Raven	*Corvus corax*	CORA
Common Snipe	*Gallinago gallinago*	COSN
Common Yellowthroat	*Geothlypis trichas*	COYE
Double-crested Cormorant	*Phalacrocorax auritus*	DCCO
Downy Woodpecker	*Picoides pubescens*	DOWO
Eastern Kingbird	*Tyrannus tyrannus*	EAKI
Eastern Phoebe	*Sayornis phoebe*	EAPH
Eastern Wood-Pewee	*Contopus virens*	EAWP
Evening Grosbeak	*Coccothraustes vespertinus*	EVGR
Golden-winged Warbler	*Vermivora chrysoptera*	GWWA
Gray Catbird	*Dumetella carolinensis*	GRCA
Great Blue Heron	*Ardea herodias*	GTBH
Great-crested Flycatcher	*Myiarchus crinitus*	GCFL
Hairy Woodpecker	*Picoides villosus*	HAWO
Hermit Thrush	*Catharus guttatus*	HETH
Herring Gull	*Larus argentatus*	HEGU
Hooded Merganser	*Lophodytes cucullatus*	HOME
House Wren	*Troglodytes aedon*	HOWR
Indigo Bunting	*Passerina cyanea*	INBU

(continued)

Appendix 2. Continued

Common name	Latin name	AOU code
Killdeer	*Charadrius vociferus*	KILL
Least Flycatcher	*Empidonax minimus*	LEFL
Magnolia Warbler	*Dendroica magnolia*	MAWA
Mallard	*Anas platyrhynchos*	MALL
Marsh Wren	*Cistothorus palustris*	MAWR
Mourning Dove	*Zenaida macroura*	MODO
Mourning Warbler	*Oporornis philadelphia*	MOWA
Nashville Warbler	*Vermivora ruficapilla*	NAWA
Northern Flicker	*Colaptes auratus*	YSFL
Northern Harrier	*Circus cyaneus*	NOHA
Northern Oriole	*Icterus galbula*	BAOR
Northern Parula	*Parula americana*	NOPA
Northern Waterthrush	*Seiurus noveboracensis*	NOWA
Olive-sided Flycatcher	*Contopus borealis*	OSFL
Ovenbird	*Seiurus aurocapillus*	OVEN
Pileated Woodpecker	*Dryocopus pileatus*	PIWO
Pine Warbler	*Dendroica pinus*	PIWA
Purple Finch	*Carpodacus purpureus*	PUFI
Red-breasted Nuthatch	*Sitta canadensis*	RBNU
Red-eyed Vireo	*Vireo olivaceus*	REVI
Red-tailed Hawk	*Buteo jamaicensis*	RTHA
Red-winged Blackbird	*Agelaius phoeniceus*	RWBL
Ring-billed Gull	*Larus delawarensis*	RBGU
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	RBGR
Ruby-throated Hummingbird	*Archilochus colubris*	RTHU
Ruffed Grouse	*Bonasa umbellus*	RUGR
Rusty Blackbird	*Euphagus carolinus*	RUBL
Sandhill Crane	*Grus canadensis*	SACR
Scarlet Tanager	*Piranga olivacea*	SCTA
Sedge Wren	*Cistothorus platensis*	SEWR
Solitary Vireo	*Vireo solitarius*	SOVI
Song Sparrow	*Melospiza melodia*	SOSP
Spotted Sandpiper	*Actitis macularia*	SPSA
Swamp Sparrow	*Melospiza georgiana*	SWSP
Tree Swallow	*Tachycineta bicolor*	TRES
Turkey Vulture	*Cathartes aura*	TUVU
Veery	*Catharus fuscescens*	VEER
Virginia Rail	*Rallus limicola*	VIRA
White-breasted Nuthatch	*Sitta carolinensis*	WBNU
White-throated Sparrow	*Zonotrichia albicollis*	WTSP
Winter Wren	*Troglodytes troglodytes*	WIWR
Wood Duck	*Aix sponsa*	WODU
Wood Thrush	*Hylocichla mustelina*	WOTH
Yellow Warbler	*Dendroica petechia*	YWAR
Yellow-bellied Flycatcher	*Empidonax flaviventris*	YBFL
Yellow-bellied Sapsucker	*Sphyrapicus varius*	YBSA
Yellow-rumped Warbler	*Dendroica coronata*	MYWA
Yellow-throated Vireo	*Vireo flavifrons*	YTVI

Appendix 3. Results of points counts, listing total number of individuals and number of individuals/point in decreasing order of abundance for each habitat sampled in the Bad River Corridor, Wisconsin. Species codes according to American Ornithologist's Union, Appendix 2.

Aspen Clearcut			Aspen-Red Maple			Boreal Hardwood-Conifer			Bottomland Hardwoods		
SPP	#	#/PT	SPP	#	#/PT	SPP	#	#/PT	SPP	#	#/PT
WTSP	49	1.75	OVEN	54	2.45	OVEN	53	2.79	OVEN	33	2.06
NAWA	42	1.50	REVI	28	1.27	BTNW	26	1.37	AMRE	26	1.63
CSWA	40	1.43	CSWA	22	1.00	REVI	21	1.11	REVI	20	1.25
COYE	34	1.21	NAWA	20	0.91	NAWA	19	1.00	LEFL	15	0.94
GWWA	26	0.93	VEER	18	0.82	BLBW	10	0.53	VEER	12	0.75
VEER	26	0.93	BTNW	15	0.68	GCFL	9	0.47	RBGR	10	0.63
OVEN	25	0.89	WTSP	14	0.64	HETH	8	0.42	SOSP	8	0.50
ALFL	23	0.82	AMRE	10	0.45	VEER	7	0.37	MOWA	7	0.44
SOSP	22	0.79	BAWW	8	0.36	WIWR	7	0.37	WBNU	6	0.38
CEDW	15	0.54	COYE	8	0.36	BLJA	5	0.26	CEDW	5	0.31
RBGR	15	0.54	MOWA	8	0.36	BRCR	5	0.26	COYE	5	0.31
REVI	14	0.50	RBGR	8	0.36	MOWA	5	0.26	BAWW	4	0.25
MOWA	11	0.39	HETH	7	0.32	WTSP	5	0.26	BLJA	4	0.25
AMRO	9	0.32	BLJA	6	0.27	YBSA	5	0.26	CSWA	4	0.25
BAWW	9	0.32	GCFL	6	0.27	AMRO	4	0.21	AMRO	3	0.19
SWSP	8	0.29	YBSA	6	0.27	BAWW	4	0.21	BHCO	3	0.19
AMGO	7	0.25	GWWA	5	0.23	COYE	4	0.21	GCFL	3	0.19
GCFL	7	0.25	EAWP	4	0.18	CAWA	3	0.16	HTH	3	0.19
YSFL	7	0.25	SOSP	4	0.18	EAWP	3	0.16	YBSA	3	0.19
BHCO	6	0.21	YSFL	4	0.18	LEFL	3	0.16	BTNW	2	0.13
BLJA	6	0.21	AMRO	3	0.14	NOPA	3	0.16	NOWA	2	0.13
BCCH	5	0.18	BCCH	3	0.14	WBNU	3	0.16	WIWR	2	0.13
CAWA	5	0.18	CAWA	3	0.14	AMRE	2	0.11	WOTH	2	0.13
WBNU	5	0.18	CORA	3	0.14	BHCO	2	0.11	AMCR	1	0.06
RUGR	4	0.14	HAWO	3	0.14	CEDW	2	0.11	AMGO	1	0.06
SEWR	4	0.14	WIWR	3	0.14	CORA	2	0.11	BEKI	1	0.06
HETH	3	0.11	BHCO	2	0.09	CSWA	2	0.11	BLBW	1	0.06
RTHU	3	0.11	BLBW	2	0.09	PIWA	2	0.11	CHSP	1	0.06
RWBL	3	0.11	BRCR	2	0.09	RBGR	2	0.11	DOWO	1	0.06
YBSA	3	0.11	CEDW	2	0.09	RBNU	2	0.11	EAPH	1	0.06
AMRE	2	0.07	RBNU	2	0.09	SCTA	2	0.11	GRCA	1	0.06
GRCA	2	0.07	SCTA	2	0.09	YSFL	2	0.11	GWWA	1	0.06
HOWR	2	0.07	WBNU	2	0.09	BCCH	1	0.05	INBU	1	0.06
RBNU	2	0.07	AMWO	1	0.05	CHSP	1	0.05	MAWA	1	0.06
WIWR	2	0.07	BAOR	1	0.05	DOWO	1	0.05	NAWA	1	0.06
AMWO	1	0.04	COSN	1	0.05	EVGR	1	0.05	SOVI	1	0.06
BAOR	1	0.04	DOWO	1	0.05	MYWA	1	0.05	YBFL	1	0.06
BLBW	1	0.04	HOWR	1	0.05	RUGR	1	0.05	YWAR	1	0.06
BTNW	1	0.04	LEFL	1	0.05	SOSP	1	0.05	YSFL	1	0.06
GTBH	1	0.04	PIWO	1	0.05	YBFL	1	0.05	total	198	13.20
INBU	1	0.04	PUFI	1	0.05	total	240	12.63			
PIWA	1	0.04	RUGR	1	0.05						
PIWO	1	0.04	SWSP	1	0.05						
PUFI	1	0.04	total	297	13.50						
RTHA	1	0.04									
YTVI	1	0.04									
total	457	16.32									

(continued)

Appendix 3. Continued

Black Ash			Aspen Clearcut/Aspen-Red Maple Boundary			Aspen Clearcut/Boreal Hardwood-Conifer Boundary		
SPP	#	#/PT	SPP	#	#/PT	SPP	#	#/PT
REVI	33	1.65	OVEN	39	1.56	OVEN	35	1.75
SWSP	30	1.50	NAWA	35	1.40	NAWA	25	1.25
COYE	21	1.05	CSWA	34	1.36	WTSP	21	1.05
GCFL	20	1.00	WTSP	34	1.36	MOWA	17	0.85
OVEN	19	0.95	VEER	22	0.88	CSWA	16	0.80
VEER	13	0.65	REVI	21	0.84	REVI	15	0.75
AMRE	12	0.60	MOWA	19	0.76	COYE	12	0.60
SOSP	12	0.60	BLJA	18	0.72	SOSP	11	0.55
CEDW	10	0.50	GWWA	17	0.68	BLJA	10	0.50
RBGR	10	0.50	COYE	15	0.60	BTNW	8	0.40
BRCR	9	0.45	RBGR	15	0.60	GCFL	8	0.40
NOWA	9	0.45	AMRE	14	0.56	VEER	8	0.40
BLBW	7	0.35	ALFL	12	0.48	AMRE	7	0.35
NAWA	7	0.35	YBSA	12	0.48	BAWW	7	0.35
WBNU	7	0.35	BTNW	8	0.32	RBGR	7	0.35
AMRO	6	0.30	CAWA	8	0.32	WIWR	7	0.35
CSWA	6	0.30	CEDW	8	0.32	HETH	6	0.30
BAWW	5	0.25	GCFL	8	0.32	ALFL	5	0.25
BTNW	5	0.25	HETH	8	0.32	GWWA	5	0.25
LEFL	5	0.25	SOSP	8	0.32	BLBW	3	0.15
MOWA	5	0.25	BAWW	7	0.28	CAWA	3	0.15
WTSP	5	0.25	AMGO	6	0.24	HAWO	3	0.15
BLJA	4	0.20	EAWP	5	0.20	LEFL	3	0.15
DOWO	4	0.20	YSFL	5	0.20	NOPA	3	0.15
HETH	4	0.20	RUGR	4	0.16	PIWA	3	0.15
NOPA	4	0.20	SWSP	4	0.16	RBNU	3	0.15
EAWP	3	0.15	WIWR	4	0.15	YBSA	3	0.15
PUFI	3	0.15	AMRO	3	0.12	AMGO	2	0.10
YBSA	3	0.15	BHCO	3	0.12	AMRO	2	0.10
ALFL	2	0.10	HAWO	3	0.12	BCCH	2	0.10
BAOW	2	0.10	RBNU	3	0.12	BHCO	2	0.10
BCCH	2	0.10	BCCH	2	0.08	MYWA	2	0.10
CAWA	2	0.10	BWHA	2	0.08	YSFL	2	0.10
HAWO	2	0.10	PIWA	2	0.08	CEDW	1	0.05
SOVI	2	0.10	WBNU	2	0.08	EAWP	1	0.05
WIWR	2	0.10	AMCR	1	0.04	MODO	1	0.05
YBFL	2	0.10	BRCR	1	0.04	PIWO	1	0.05
YSFL	2	0.10	COSN	1	0.04	SCTA	1	0.05
AMGO	1	0.05	GRCA	1	0.04	SOVI	1	0.05
BHCO	1	0.05	RTHU	1	0.04	SWSP	1	0.05
CORA	1	0.05	SCTA	1	0.04	TRES	1	0.05
GTBH	1	0.05	SEWR	1	0.04	total	274	13.75
GWWA	1	0.05	SOVI	1	0.04			
RBNU	1	0.05	total	418	16.72			
RTHU	1	0.05						
RWBL	1	0.05						
TRES	1	0.05						
WOTH	1	0.05						
YWAR	1	0.05						
YTVI	1	0.05						
total	311	15.55						

(continued)

Appendix 3. Continued

Aspen-Red Maple/Black Ash Boundary		
SPP	#	#/PT
OVEN	24	1.60
REVI	16	1.07
VEER	16	1.07
COYE	14	0.93
CSWA	14	0.93
SWSP	12	0.80
BAWW	10	0.67
BTNW	10	0.67
WTSP	10	0.67
CAWA	9	0.60
HETH	9	0.60
AMRE	7	0.47
BRCR	7	0.47
MOWA	7	0.47
NAWA	7	0.47
GCFL	6	0.40
AMRO	5	0.33
ALFL	4	0.27
BCCH	4	0.27
BLJA	4	0.27
CEDW	4	0.27
RBGR	4	0.27
SOSP	4	0.27
YSFL	4	0.27
BHCO	3	0.20
EAWP	3	0.20
GRCA	3	0.20
LEFL	3	0.20
NOPA	3	0.20
NOWA	3	0.20
YBSA	3	0.20
BLBW	2	0.13
WBNU	2	0.13
WIWR	2	0.13
WOTH	2	0.13
AMGO	1	0.07
CHSP	1	0.07
GWWA	1	0.07
HAWO	1	0.07
SOVI	1	0.07
YBFL	1	0.07
YTVI	1	0.07
total	247	16.53

Boreal Hardwood-Conifer/ Black Ash Boundary		
SPP	#	#/PT
OVEN	24	1.50
REVI	18	1.13
SWSP	18	1.13
GCFL	15	0.94
SOSP	12	0.75
BTNW	11	0.69
NOPA	11	0.69
RWBL	11	0.69
COYE	10	0.63
LEFL	10	0.63
BLBW	9	0.56
WIWR	9	0.56
AMRO	8	0.50
BHCO	8	0.50
BRCR	8	0.50
RBGR	8	0.50
NAWA	7	0.44
VEER	5	0.38
WTSP	5	0.38
HETH	5	0.31
YBSA	5	0.31
YSFL	5	0.31
YTVI	4	0.25
AMRE	3	0.19
BCCH	3	0.19
CSWA	3	0.19
EAWP	3	0.19
RBNU	3	0.19
WBNU	3	0.19
AMGO	2	0.13
BAOR	2	0.13
BLJA	2	0.13
EAKI	2	0.13
HAWO	2	0.13
HOWR	2	0.13
MOWA	2	0.13
NOWA	2	0.13
PUFI	2	0.13
SEWR	2	0.13
TRES	2	0.13
WOTH	2	0.13
YWAR	2	0.13
BAWW	1	0.06
BWHA	1	0.06
CAWA	1	0.06
GRCA	1	0.06
KILL	1	0.06
MALL	1	0.06
MAWA	1	0.06
OSFL	1	0.06
PIWO	1	0.06

Boreal Hardwood-Conifer/ Black Ash Boundary (cont.)		
SPP	#	#/PT
RTHU	1	0.06
RUBL	1	0.06
SOVI	1	0.06
VIRA	1	0.06
YBFL	1	0.06
total	286	17.88

(continued)

Appendix 3. Continued

Bottomland Hardwoods/ Black Ash Boundary			Bottomland Hdwds/Boreal Hardwood-Conifer Boundary			Aspen-Red Maple/Boreal Hardwood-Conifer Boundary		
SPP	#	#/PT	SPP	#	#/PT	SPP	#	#/PT
REVI	21	1.75	OVEN	20	2.50	OVEN	24	2.67
OVEN	16	1.33	REVI	12	1.50	BTNW	11	1.22
LEFL	13	1.08	AMRE	8	1.00	NAWA	9	1.00
VEER	12	1.00	VEER	8	1.00	REVI	9	1.00
AMRE	10	0.83	BLBW	6	0.75	HETH	7	0.78
GCFL	8	0.67	BTNW	5	0.63	GCFL	6	0.67
RWBL	8	0.67	AMRO	4	0.50	YBSA	5	0.56
SOSP	8	0.67	LEFL	4	0.50	MOWA	4	0.44
AMRO	7	0.58	NAWA	3	0.38	AMRE	3	0.33
RBGR	6	0.50	RBGR	3	0.38	CSWA	3	0.33
COYE	5	0.42	WOTH	3	0.38	LEFL	3	0.33
MOWA	5	0.42	WTSP	3	0.38	VEER	3	0.33
BTNW	4	0.33	YBSA	3	0.38	WIWR	3	0.33
CORA	4	0.33	RWBL	2	0.25	BAWW	2	0.22
WBNU	4	0.33	WODU	2	0.25	BLBW	2	0.22
AMGO	3	0.25	BAWW	1	0.13	CORA	2	0.22
BLBW	3	0.25	BHCO	1	0.13	MYWA	2	0.22
BRCR	3	0.25	BLJA	1	0.13	PIWA	2	0.22
NOPA	3	0.25	BRCR	1	0.13	SOVI	2	0.22
NOWA	3	0.25	CORA	1	0.13	WTSP	2	0.22
WTSP	3	0.25	GCFL	1	0.13	AMCR	1	0.11
YTVI	3	0.25	GWWA	1	0.13	AMRO	1	0.11
BAEA	2	0.17	MOWA	1	0.13	BAOR	1	0.11
CEDW	2	0.17	NOPA	1	0.13	BBCU	1	0.11
EAWP	2	0.17	PIWA	1	0.13	BHCO	1	0.11
HAWO	2	0.17	RUGR	1	0.13	BRCR	1	0.11
HETH	2	0.17	SOSP	1	0.13	COYE	1	0.11
SWSP	2	0.17	WIWR	1	0.13	EAWP	1	0.11
WOTH	2	0.17	total	99	12.38	HAWO	1	0.11
YBSA	2	0.17				NOPA	1	0.11
YWAR	2	0.17				PIWO	1	0.11
YSFL	2	0.17				RBGR	1	0.11
AMCR	1	0.08				RBNU	1	0.11
BAOR	1	0.08				SCTA	1	0.11
BAWW	1	0.08				WBNU	1	0.11
BHCO	1	0.08				YBFL	1	0.11
BLJA	1	0.08				YSFL	1	0.11
CSWA	1	0.08				total	121	13.44
INBU	1	0.08						
NAWA	1	0.08						
SOVI	1	0.08						
WIWR	1	0.08						
YBFL	1	0.08						
total	183	15.25						