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# The Role of Riparian Buffers in Forest Bird Conservation

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## Executive Summary

In 2005-2006, study sites were selected, transects were established, preliminary data were collected to estimate bird densities, and vegetation and site data were collected. This report summarizes the data collected and preliminary trends. Maps show locations of the study areas. Many partnerships were forged and considerable matching funds supported this study.

Matching suitable sites across the 3 treatments in a given area was a considerable challenge and took more time than anticipated. A total of 64 study sites were selected; 45 were surveyed for birds between early May and early July 2005, and 41 were surveyed for vegetation between mid-July and September. Eight have not yet been matched with nearby sites of another treatment and 2 have been matched with only one other treatment. A few sites that had been surveyed will have to be dropped in 2006 because of harvesting of the site or nearby stands.

Data for 12 matched sets of 3 treatments (randomized block design) were compared for bird abundance and biophysical characteristics of the sites. Stream width and most measurements of vegetation structure did not differ among the 3 treatments, indicating sites within blocks were well-matched. Three measurements of forest structure, however, did differ significantly among treatments: (1) canopy cover was significantly lower in riparian buffers compared to upland references, (2) total basal area was significantly lower in riparian buffers compared to riparian reference sites, and (3) density of hardwood stems in the 25-40cm diameter size class was significantly lower in riparian buffers compared to riparian and upland references. Although matched as closely as possible, riparian reference sites contained about 10% more hardwood than buffers and upland sites. Riparian reference sites also had more white ash, large red maple, and large hemlocks; riparian buffers tended to have more balsam fir; and upland sites had more red oak. Pines were larger and more abundant in the reference sites than in buffers. Biophysical characteristics measured did not vary significantly with buffer width.

A total of 54 bird species were observed in the 36 matched transects. Only 23 were mature forest species of conservation concern; overall, these represented only 28% of the birds in riparian buffers. More birds of conservation concern were found in reference sites (48% in riparian reference sites and 64% in upland reference sites). Estimated total densities were highest for riparian buffers, intermediate for riparian references, and lowest for upland references. At the guild level, both ground foragers and ground nesters were more abundant in riparian buffers. Guild abundance was not related to width of riparian buffers. Some species of conservation concern were more abundant in reference sites (Least Flycatcher, Bay-breasted Warbler, Black-throated Green Warbler, Ovenbird), two were more characteristic of upland sites (Blackburnian Warbler, Golden-crowned Kinglet), two were more abundant in riparian sites (Northern Parula, Yellow-bellied Flycatcher), and two were more often detected in riparian buffers (Swainson's Thrush, Yellow-bellied Sapsucker).

Tentative results are consistent with the two hypotheses of interest: (1) buffers currently on the landscape may not be maintaining several birds of conservation concern, and (2) riparian forest has greater conservation value to certain bird species than does upland habitat. Additional surveys are needed to determine more accurate bird densities. In May-July 2006, transects will be surveyed for birds at least 3 times to obtain sufficient data to estimate densities with confidence. In addition, sites added late in 2005 will be surveyed for vegetation.

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# Introduction

Riparian zones are linear habitats where terrestrial ecosystems meet the aquatic ecosystems of rivers, streams, and lakes. Riparian zones may contain unique habitats that support different or larger numbers of species than surrounding terrestrial habitats. As such, riparian zones may be considered sensitive habitats that have special qualities for wildlife, especially vertebrates. Overall, research suggests that riparian forest may provide higher quality habitat than upland sites. Studies conducted elsewhere suggest that several species of birds found in the forest of Nova Scotia may prefer riparian habitat. For a comprehensive literature review, see the 2005 final report for this project.

Much recent interest has focused on forestry practices in the riparian zone as they affect terrestrial ecosystems and vertebrate species. Several studies in other areas have reported an effect of buffer width on bird abundances. Riparian remnants may serve as movement corridors for birds, especially those that are dispersing or migrating. Thus, as landscapes become less forested through habitat loss or fragmentation, riparian forest increases in importance in working landscapes. Prior to the present study, no research had been conducted on forest birds in riparian buffers in Nova Scotia.

## Purpose

This project is investigating the conservation value of riparian buffers to forest birds in mainland Nova Scotia. The objectives are to determine the effects of buffer width and the importance of riparian *versus* upland forest to birds of conservation concern. The study will determine how buffer width and other riparian habitat characteristics affect habitat suitability for species of interest. The benefits will be an increased understanding of the value of riparian buffer habitat to wildlife. Ultimately, this may lead to more flexible guidelines for buffer width in Nova Scotia. For example, in certain situations, buffers larger than the 20 m provincial guideline may be warranted if land managers are interested in conserving populations of the more sensitive bird species.

Results of the project will enhance the ability of industry and woodlot owners to make forest management decisions that take into account avian biodiversity along forested watercourses and water bodies.

(1) More ecologically-relevant and flexible guidelines for buffer widths is possible if we understand the effects of buffer width on wildlife under different contexts, such as forest type, stream width, and landscape configuration.

(2) If riparian forest has greater value for wildlife than upland forest, it may be of greater conservation benefit to leave more trees along streams than to leave the same number of trees in isolated upland patches of forest.

Ultimately, the findings of the study may result in better quality riparian habitat. At least the value of riparian buffer habitat will be clarified and used to inform management decisions.

### Research Questions

This study will examine two interconnected hypotheses. One addresses provincial regulations and the other is broader. The first hypothesis is that the 20-m buffer required for watercourses in Nova Scotia may be inadequate to provide breeding habitat for bird species of conservation concern. The second is that forested riparian areas may be especially important to wildlife and may provide more value than a forest plot of similar age, forest type, and size in upland sites.

The two main objectives of this study are to determine:

(1) under what conditions a riparian buffer wider than the regulation 20 m is expected to make a difference for breeding birds, especially those of conservation concern, and

(2) whether riparian forest has greater value to these birds than does upland forest of the same type.

These objectives will be achieved by comparing bird abundance and breeding evidence in these three different habitats at a wide range of locations across the province.

Different species of birds respond differently to forest harvesting. Some species tend to increase because they respond positively to the increase in more open and/or edge habitats, whereas some decrease because they respond negatively to the break-up of the canopy and/or loss of mature trees. Bird data will be examined in light of the conservation concern about each species.

## Methods

To account for the effects of local forest type, soil, and climate, riparian buffers are being compared to mature, unharvested riparian and upland forest of similar types nearby. The study design is based on a randomized block design Analysis of Variance (ANOVA). Forest type in a given study area is the block. Sites are located primarily in conifer or conifer-dominated stands, mostly spruce, but some include mixed forest with hardwoods or hemlock.

Three treatments are included: (1) buffer with forest harvested on both sides of the stream, (2) riparian forest unharvested within 200 m of stream, and (3) upland forest, more than 200 m from stream. Treatments are replicated in 20 blocks across mainland Nova Scotia for a total of 60 transects, each $\geq$200 m in length.

### Site selection

Fig. 1 shows the spatial arrangement of study sites across mainland NS. The detailed locations are shown in smaller scale maps in Figs. 2-7. All sites are listed in Table 1, along with county, land ownership, transect length, whether surveyed for birds an/or vegetation, and transects that are match within a block of three. Sites are mainly distributed across Bowater and J.D. Irving lands but a few sites are in lands held by Stora/Enso, lands of small woodlot owners, and in protected areas (e.g., reference sites in Kejimkujik). By working with forest companies that use different buffer widths, a range of buffer widths, stream types, and regions of Nova Scotia were included. The amount and type of harvesting within the buffers also varied.

Riparian buffers, averaging 47 m in width from stream edge to cut edge, and ranging from 11m-140m, were selected along 1st–3rd order streams (0.6–44.3m wide). Forest adjacent to buffers was in the regeneration phase, having been clear cut harvested on both sides of the stream between the years 1995 and 2001. This was done to avoid the crowding effect, a common phenomenon exhibited by forest birds for 2-3 years following harvest.

Field work for site selection began 2 May 2005 and continued into Nov 2005. Only sites selected before early July could be surveyed for birds. Most of these were also surveyed for vegetation. Several sites were added after the end of the vegetation measuring season, i.e. after August. Sites not yet surveyed will be surveyed in 2006.

At each site surveyed, a transect 200-300 m in length was established (see examples in Fig. 8). Start and end locations were at least 100 m from the edges of the stand that included the buffer. Each transect was marked, according to landowner instructions, to enable relocation, surveys, and mapping. For buffer sites, transects were situated near the outer edge of narrow buffers and in the middle of wide buffers. Upland forest transects were straight lines located in forests that had similar physical characteristics and forest types to paired riparian sites. In this report, preliminary data are compared for 12 matched blocks. Although transect lengths vary, the length of transects within any one block are the same and directly comparable.

**Bird surveys**

Birds were surveyed by the distance transect method, where each bird detected by sight or sound was mapped in terms of distance along the transect as well as distance from the transect line (see examples in Fig. 9). Upon first detection, individual birds were mapped on a grid for use later in determining distance from transect and location within the buffer or clear-cut. Students and field assistants conducting the surveys and identifying birds were Anna Dorey, Gareth Akerman, and Jesse McLean. All surveys were recorded on mini-disc for later verification.

Transects were surveyed once for birds between late May and early July 2005, between the hours of 5:00AM to 10:00AM. Transects were walked deliberately at a pace of 6 min/25 m. If a 25-m stretch was completed before the 6-min mark then the observer waited at the end of the segment and continued to detect birds. Surveys were only conducted during periods of fair weather, excluding rain and high winds which may influence avian activity and/or detection.

To date, bird detections have been tallied and summarized in terms of birds per transect and estimates of birds per hectare. Estimating density from single surveys is problematic, more so when the forested areas of interest differ in size and distribution among the three treatments. Furthermore these estimated densities may reflect true densities of breeding birds. Firstly, in poorer quality habitat, which may be the case for mature forest species in riparian buffers, more of the males attempting to breed are likely to be unsuccessful than are males in better quality habitats. Secondly, these unpaired males sing more and are thus more often detected.

Additional surveys in 2006 will be required before enough data have been accumulated to have confidence in density estimates. Surveys will be repeated several times over the breeding season. Surveys will begin in May and will be repeated every 3 weeks through mid-July to collect breeding (or lack of breeding) evidence for all species. It will be important to identify birds who have been unsuccessful in attracting a mate yet continued to sing and be detected in surveys.

While all bird species were surveyed, the focus was on forest bird species that are less common, declining, or more sensitive to current forestry practices in NS: those identified in last year's final report (Staicer 2005). The main response variable is the number and per cent of birds of conservation concern. Predictions are that birds of conservation concern, which are primarily species of mature forest interiors, will be less abundant in buffers than in unharvested riparian forest or upland forest. Also predicted are lower densities and species diversity for birds of conservation concern in upland forest than in unharvested riparian forest, which is expected to have higher within-site habitat diversity.

**Vegetation surveys**

Vegetation composition and structure was quantified in July-August 2005. All vegetation surveys were undertaken by Jesse McLean and Gareth Akerman. Vegetation was surveyed within transects perpendicular to the transect (and stream when present). Physical characteristics quantified included slope, distance of transect from watercourse, fringe (non-treed) vegetation width, and watercourse width

Four rectangular plots of 30m x 5m were delineated at equidistance points along each transect, at both ends and towards the centre. Each plot was 150 $m^2$ in area for a total of 600$m^2$ sample area per transect. Tree condition, species and diameter at breast height were recorded for every tree greater than 7 cm dbh within each plot. Trees less than 7 cm dbh were tallied. Snags were also recorded for dbh, and decay class. Three circular subplots, located at 5, 15, and 25 m perpendicular distance from the line transect, were delineated. Within each circular subplot, percent cover was estimated for canopy cover and vertical forest structure. A spherical densiometer was used to estimate percent canopy cover. Percent cover of vertical strata was visually estimated at vertical levels of 0.5m, 2.5m, and 10m.

**Data analysis**

Data were entered into excel spreadsheets in flat file format and a data dictionary was developed for each data file. UTMs for each site were obtained in order to map study sites (Figs. 1-8). Anna Dorey, the Science Horizons Intern working on this project, learned to use ArcView for the purpose of mapping our sites and establishing a geodatabase in the Staicer research lab. This geodatabase will enable landscape analyses in 2006-2007, after all field data have been collected for the project. UTMs for the start and end of each transect were also obtained for more detailed mapping in the future. Forest cover data and topography will be added to these future maps.

Data summaries are presented for 12 blocks of matched sites. Analysis of Variance (ANOVA) was used to determine whether there is a significant treatment effect. Some ANOVAs have been done for vegetation data. Analyses will be done at the species level for the more common birds. Non-parametric statistics were used to test differences in foraging and nesting guilds between treatments. Regression is being used to examine whether abundances of particular bird species, percentage of birds of conservation concern, and nesting and foraging guilds vary with vegetation and site features, such as buffer width, stream width, tree basal area, canopy cover, and per cent hardwood. Regression was also used to test whether site or vegetation characteristics differ with buffer width.

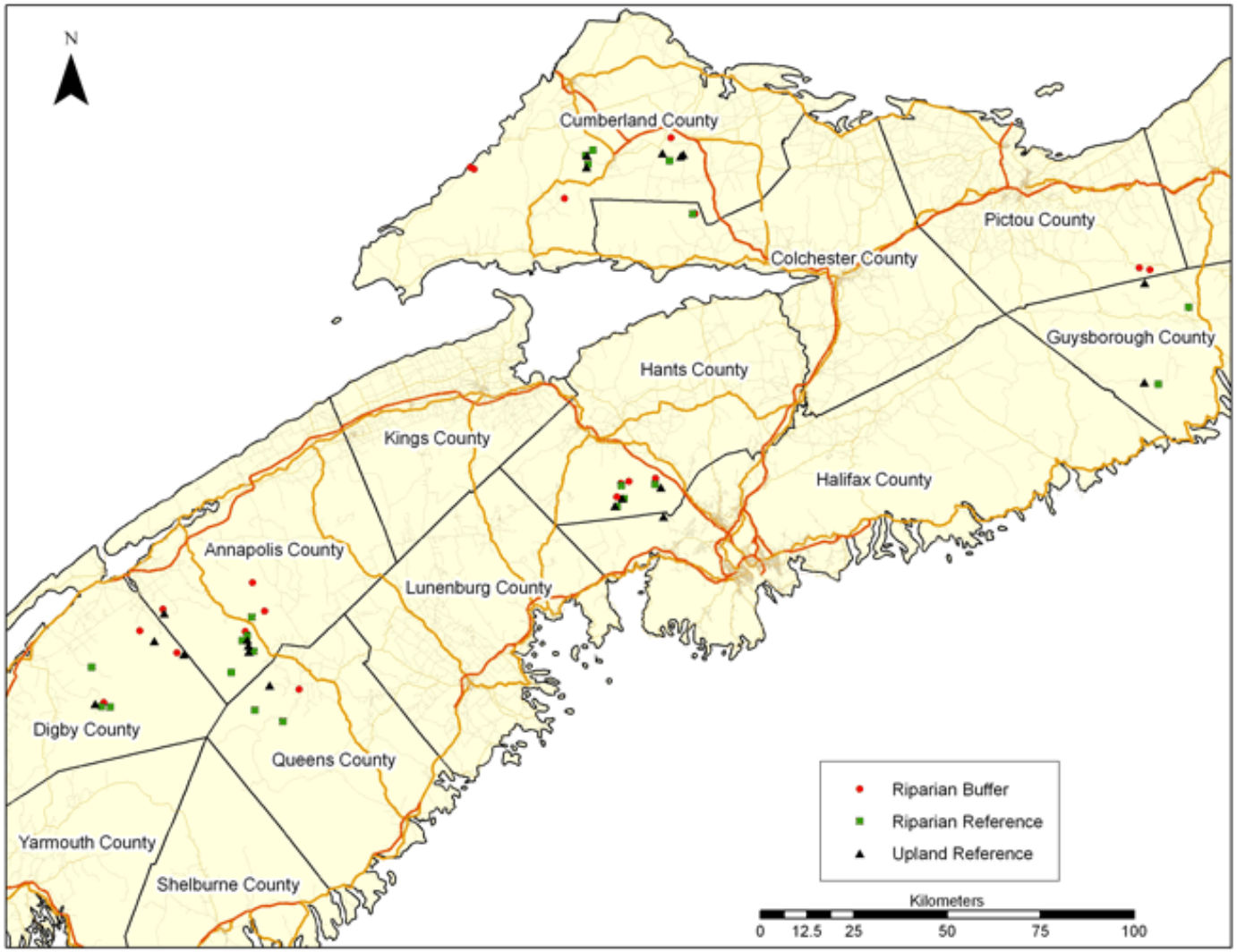



**Fig. 1. Map of mainland Nova Scotia showing the spatial distribution of study sites in the riparian buffer project. See Table 1 for site information and Figs. 2-7 for more detailed maps of the different areas within mainland Nova Scotia.**

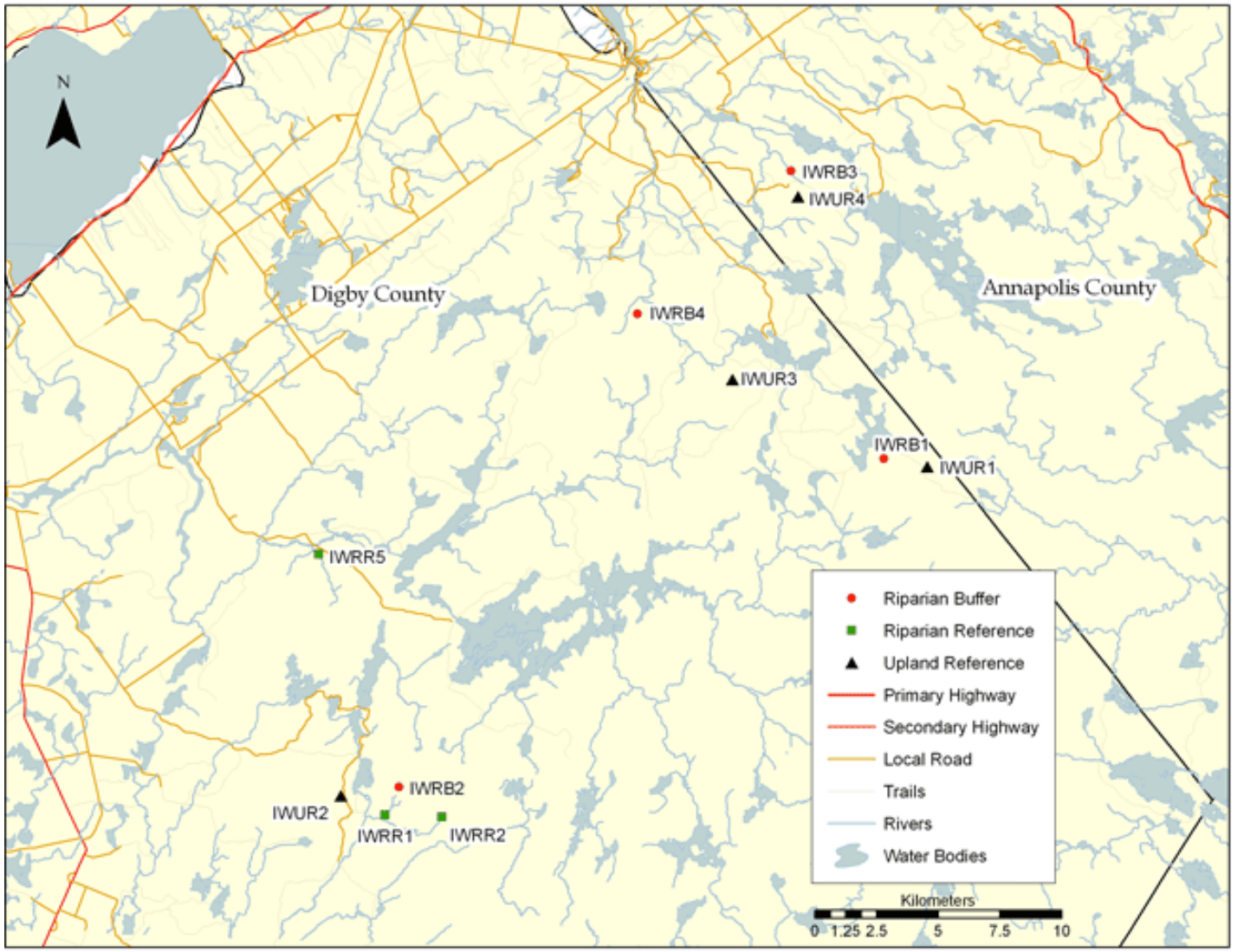



**Fig. 2. Map showing the study sites in J.D. Irving lands in the Weymouth area.**

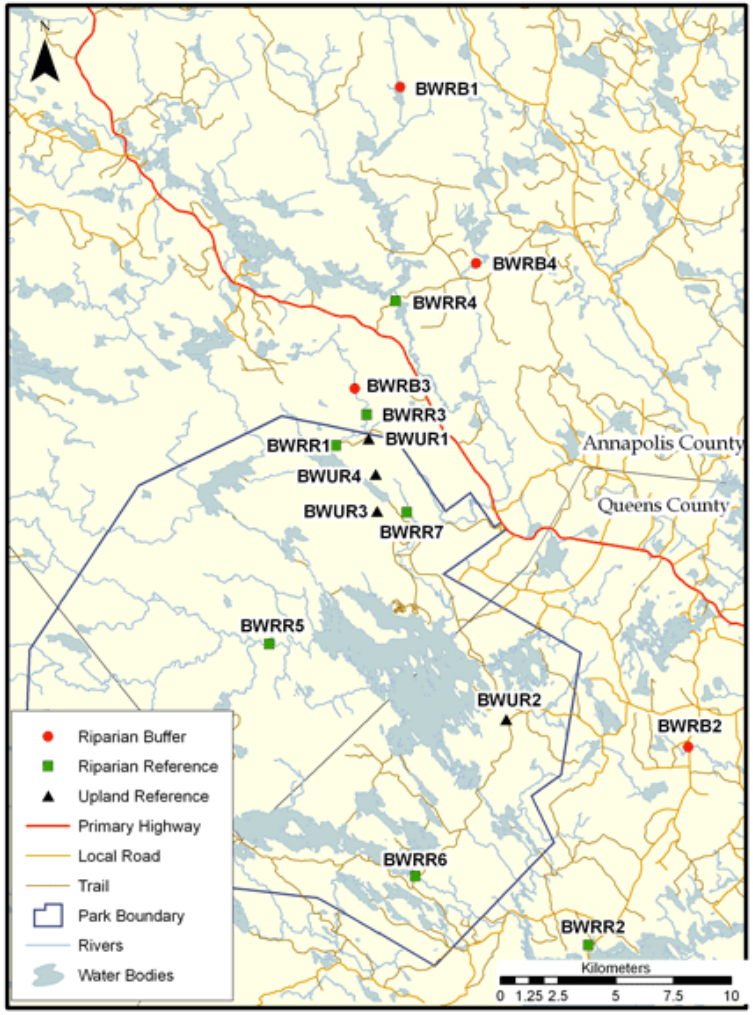



**Fig. 3. Map of study sites in the Mersey River Watershed, lands primarily owned by Bowater or Parks Canada. Park shown is Kejimkujik NPNHS.**

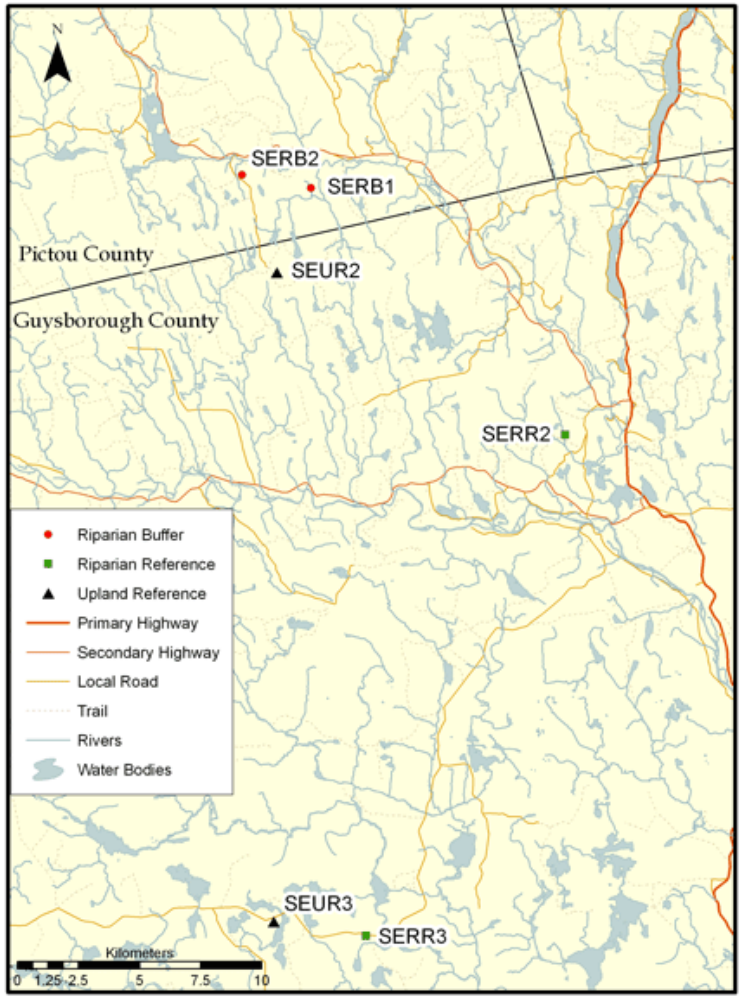



**Fig. 4. Map of study sites in the Pictou area, on Stora-Enso lands.**

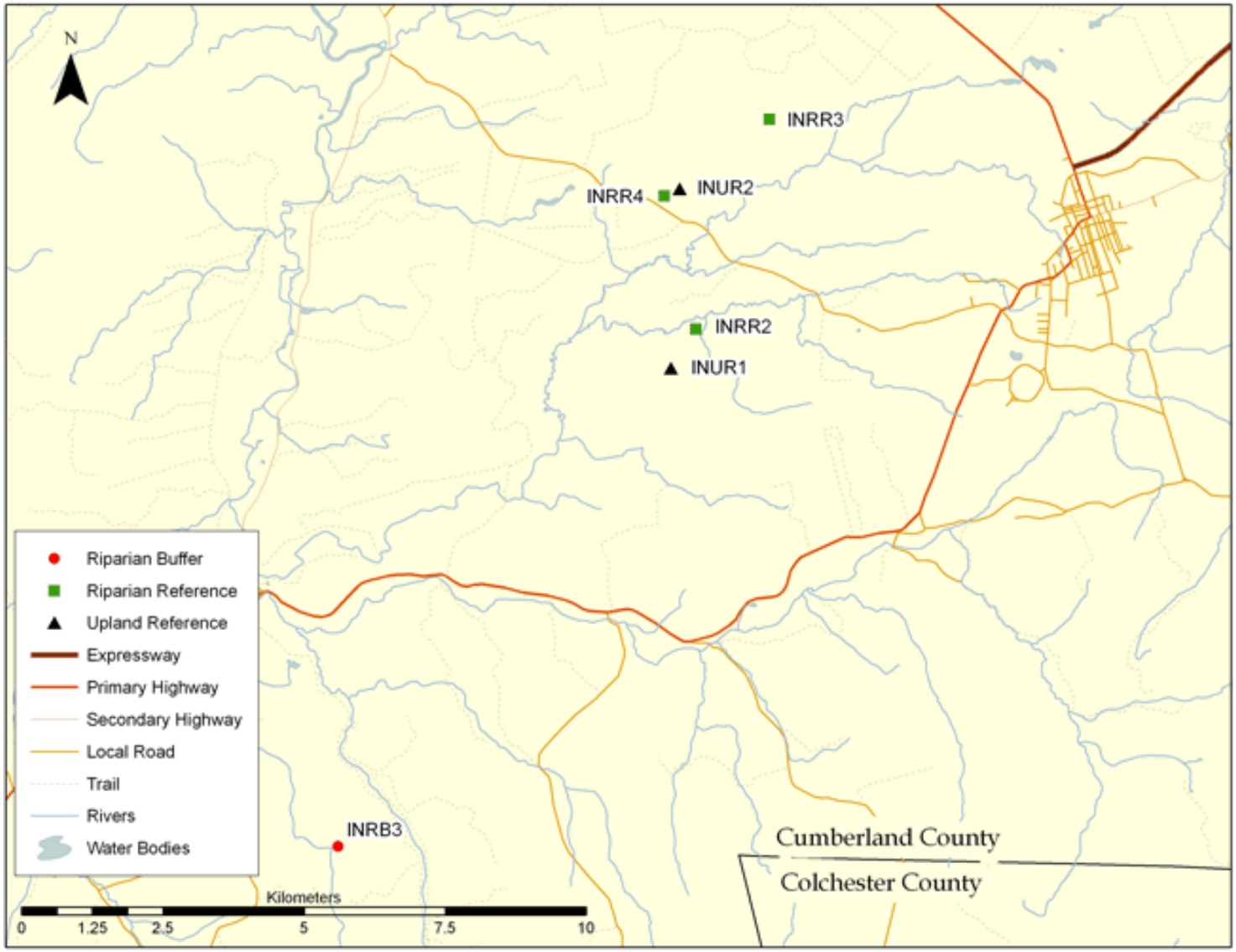



**Fig. 5. Map of study areas west of Amherst, NS. These are mostly within lands operated by J.D. Irving.**

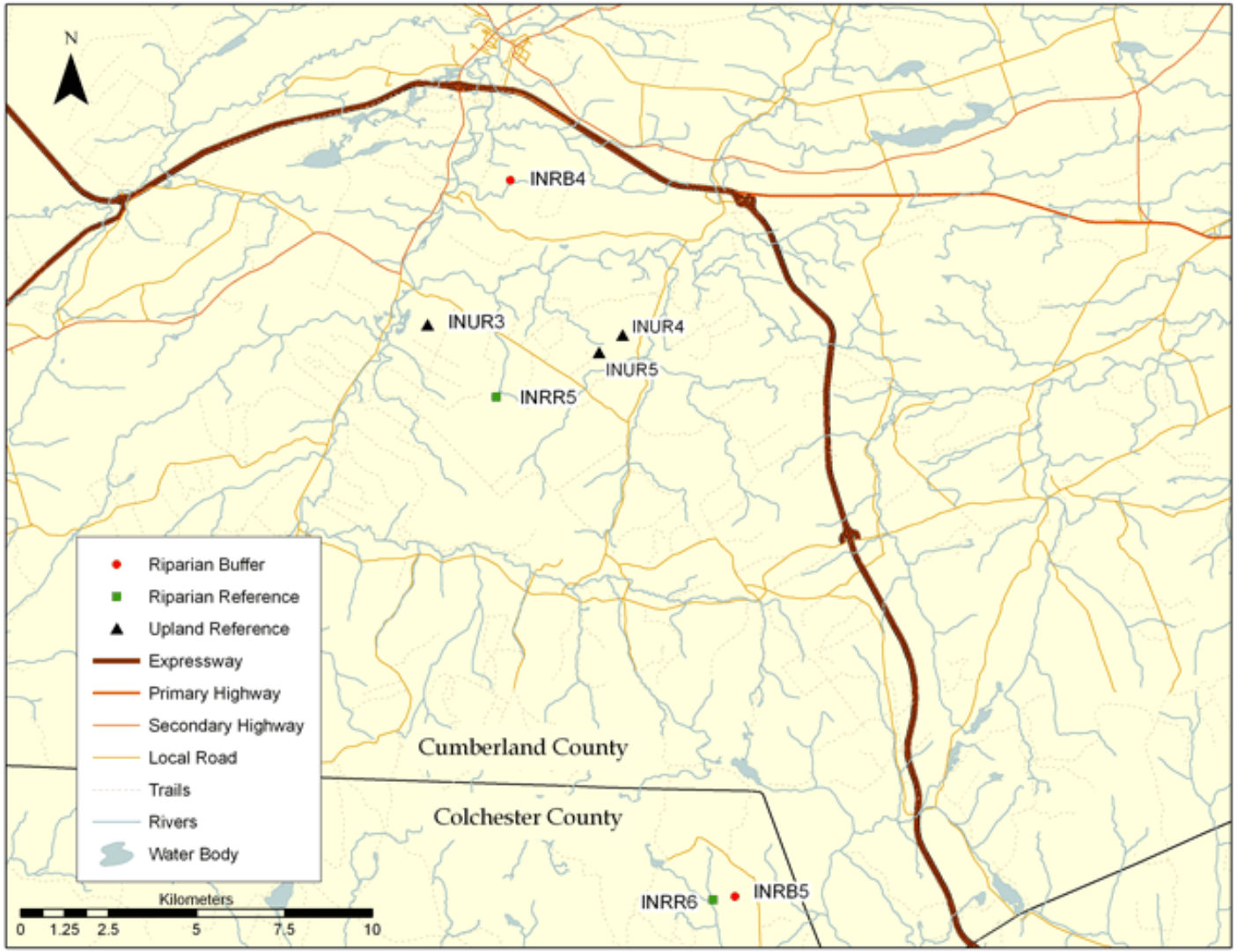



**Fig. 6. Map of additional study areas in Cumberland County. These are mostly within lands operated by J.D. Irving.**

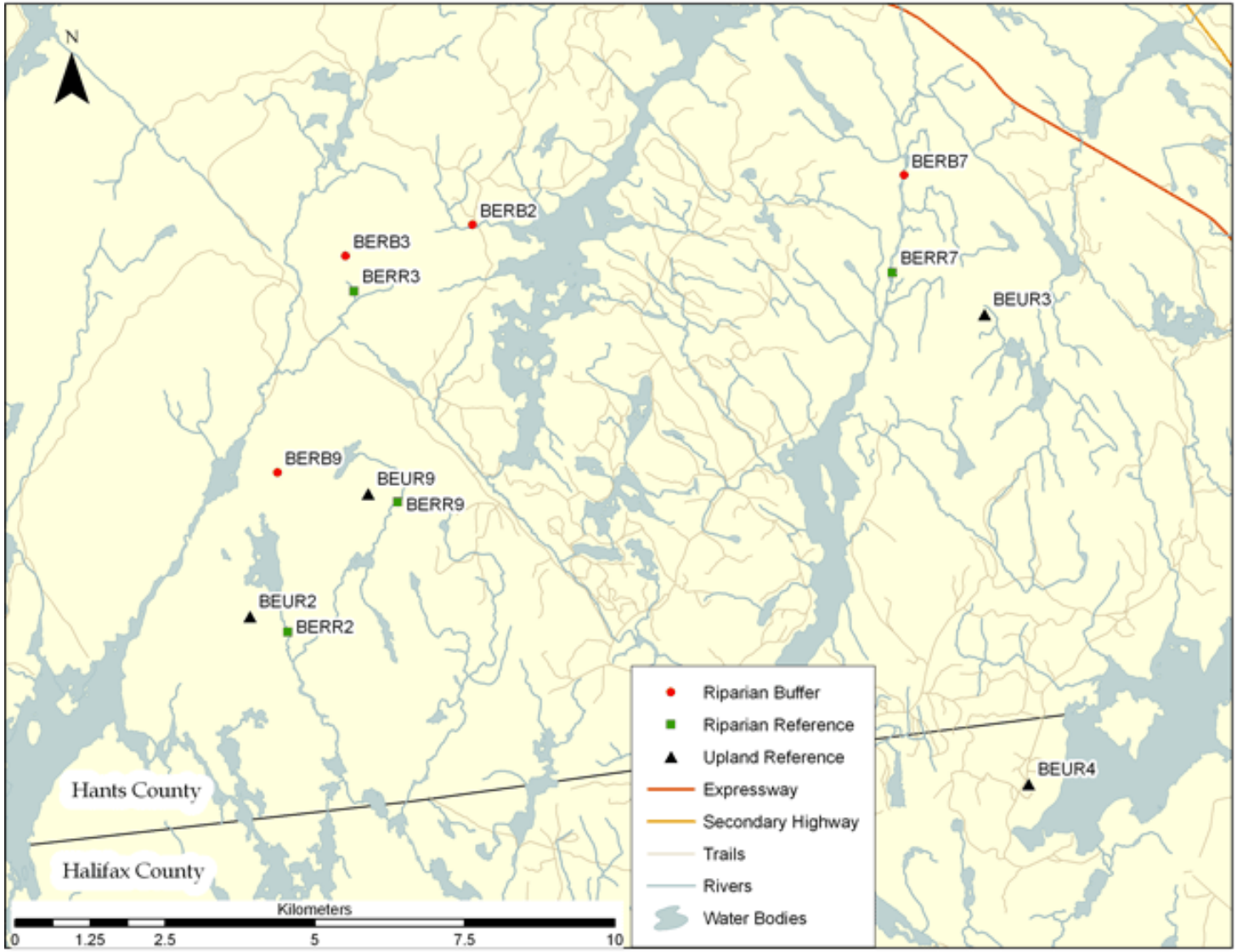



**Fig. 7. Map of study sites in Hants and Halifax Counties, primarily in Bowater's eastern region. Expressway is Hwy 101.**


**Fig. 8. Aerial photographs of the landscape in which one matched set of transects were located (indicated by white lines).**
**Left: Riparian buffer BERB2 transect, across stream from buffer used in the Bowater-Pockwock study.**
**Right: Matching upland reference (BEUR2) and riparian reference (BERR2) transects.**


**Riparian Buffer (BERB2)** **Riparian Reference (BERR2)** **Upland Reference (BEUR2)**

**Fig. 9. Example of bird survey data for matched transects, mapped onto aerial photographs of the study sites. Transects are marked in blue, birds in white. Circles indicate singing males, arrows show movement of birds, house symbol indicates pair. Species are denoted by standard 4-letter AOU codes.**

**Table 1. Site information for transects, labeled as on maps; whether surveys for birds or vegetation were done in 2005 (Y=yes, N=no); and matches to transects in the same block.**

| Transect ID code | Treatment | Length (m) | NS County | Land owner | Birds | Veg. | Matches |
|---|---|---|---|---|---|---|---|
| BERB1 | Riparian Buffer | 200 | Hants | Bowater | Y | N | none yet |
| BERB2 | Riparian Buffer | 300 | Hants | Bowater | Y | Y | BEUR2, BERR2 |
| BERB3 | Riparian Buffer | 200 | Hants | Bowater | Y | Y | BEUR4, BERR3 |
| BERB5 | Riparian Buffer | 250 | Hants | Bowater | N | N | none yet |
| BERB7 | Riparian Buffer | 250 | Hants | Bowater | Y | Y | BEUR3, BERR7 |
| BERB8 | Riparian Buffer | 200 | Hants | Bowater | Y | N | none yet |
| BERB9 | Riparian Buffer | 250 | Hants | Bowater | N | N | BEUR9, BERR9 |
| BERR2 | Riparian Reference | 300 | Hants | Bowater | Y | Y | BEUR2, BERB2 |
| BERR3 | Riparian Reference | 200 | Hants | Bowater | Y | Y | BEUR4, BERB3 |
| BERR4 | Riparian Reference | 200 | Hants | Bowater | N | N | none yet |
| BERR7 | Riparian Reference | 250 | Hants | Bowater | Y | Y | BEUR3, BERB7 |
| BERR9 | Riparian Reference | 200 | Hants | Bowater | N | N | BEUR9, BERB9 |
| BEUR2 | Upland Reference | 300 | Hants | Bowater | Y | Y | BERB2, BERR2 |
| BEUR3 | Upland Reference | 200 | Hants | Bowater | Y | Y | BERB7, BERR7 |
| BEUR4 | Upland Reference | 250 | Halifax | HRM Water | Y | Y | BERB3, BERR3 |
| BEUR9 | Upland Reference | 250 | Hants | Bowater | N | N | BERR9, BERB9 |
| BWRB1 | Riparian Buffer | 300 | Annapolis | Bowater | Y | Y | BWUR1, BWRR1 |

| Transect ID code | Treatment | Length (m) | NS County | Land owner | Birds | Veg. | Matches |
|---|---|---|---|---|---|---|---|
| BWRB2 | Riparian Buffer | 300 | Queens | private woodlot | Y | Y | BWUR2, BWRR2 |
| BWRB3 | Riparian Buffer | 300 | Annapolis | private woodlot | Y | Y | BWUR3, BWRR3 |
| BWRB4 | Riparian Buffer | 300 | Annapolis | Bowater | Y | Y | BWUR4, BW444 |
| BWRR1 | Riparian Reference | 300 | Annapolis | Parks Canada | Y | Y | BWUR1, BWRB1 |
| BWRR2 | Riparian Reference | 300 | Queens | Bowater | Y | Y | BWUR2, BWRB2 |
| BWRR3 | Riparian Reference | 300 | Annapolis | private woodlot | Y | Y | BWUR3, BWRB3 |
| BWRR4 | Riparian Reference | 300 | Annapolis | Bowater | Y | Y | BWUR4, BWRB4 |
| BWRR5 | Riparian Reference | 300 | Annapolis | Parks Canada | Y | Y | none yet |
| BWRR6 | Riparian Reference | 300 | Queens | Parks Canada | Y | Y | none yet |
| BWRR7 | Riparian Reference | 300 | Annapolis | Parks Canada | Y | Y | none yet |
| BWUR1 | Upland Reference | 300 | Annapolis | Parks Canada | Y | Y | BWRB1, BWRR1 |
| BWUR2 | Upland Reference | 300 | Queens | Parks Canada | Y | Y | BWRB2, BWRR2 |
| BWUR3 | Upland Reference | 300 | Annapolis | Parks Canada | Y | Y | BWRB3, BWRR3 |
| BWUR4 | Upland Reference | 300 | Annapolis | Parks Canada | Y | Y | BWRB4, BWRR4 |
| INRB1 | Riparian Buffer | 200 | Cumberland | T.W M. & Associates | Y | Y | INUR1, INRR2 |
| INRB2 | Riparian Buffer | 200 | Cumberland | Irving | Y | Y | INUR3, INRR3 |
| INRB3 | Riparian Buffer | 200 | Cumberland | Irving | Y | Y | INUR2, INRR4 |
| INRB4 | Riparian Buffer | 300 | Cumberland | Irving | N | N | INUR4, INRR5 |

| Transect ID code | Treatment | Length (m) | NS County | Land owner | Birds | Veg. | Matches |
|---|---|---|---|---|---|---|---|
| INRB5 | Riparian Buffer | 250 | Colchester | Irving | N | N | INUR5, INRR6 |
| INRR2 | Riparian Reference | 200 | Cumberland | Irving | Y | Y | INUR1, INRB1 |
| INRR3 | Riparian Reference | 200 | Cumberland | Irving | Y | Y | INUR3, INRB2 |
| INRR4 | Riparian Reference | 200 | Cumberland | Irving | Y | Y | INUR2, INRB3 |
| INRR5 | Riparian Reference | 200 | Cumberland | Irving | N | N | INUR4, INRB4 |
| INRR6 | Riparian Reference | 250 | Colchester | Irving | N | N | INUR5, INRB5 |
| INUR1 | Upland Reference | 200 | Cumberland | Irving | Y | Y | INRB1, INRR2 |
| INUR2 | Upland Reference | 200 | Cumberland | Irving | Y | Y | INRB3, INRR4 |
| INUR3 | Upland Reference | 300 | Cumberland | Irving | Y | Y | INRB2, INRR3 |
| INUR4 | Upland Reference | 200 | Cumberland | Irving | N | N | INRB4, INRR5 |
| INUR5 | Upland Reference | 200 | Cumberland | Irving | N | N | INRR6, INRB5 |
| IWRB1 | Riparian Buffer | 300 | Digby | Irving | Y | Y | IWUR1, IWRR1 |
| IWRB2 | Riparian Buffer | 200 | Digby | Irving | Y | Y | IWUR2, IWRR2 |
| IWRB3 | Riparian Buffer | 200 | Annapolis | Irving | N | N | IWUR4 |
| IWRB4 | Riparian Buffer | 200 | Digby | Irving | N | N | IWUR3, IWRR5 |
| IWRR1 | Riparian Reference | 200 | Digby | Irving | Y | Y | IWUR1, IWRB1 |
| IWRR2 | Riparian Reference | 200 | Digby | Irving | Y | Y | IWUR2, IWRB2 |
| IWRR5 | Riparian Reference | 200 | Digby | Irving | N | N | IWUR3, IWRB4 |

| Transect ID code | Treatment | Length (m) | NS County | Land owner | Birds | Veg. | Matches |
|---|---|---|---|---|---|---|---|
| IWUR1 | Upland Reference | 200 | Digby | Irving | Y | Y | IWRR1, IWRB1 |
| IWUR2 | Upland Reference | 200 | Digby | Irving | Y | Y | IWRB2, IWRR2 |
| IWUR3 | Upland Reference | 200 | Digby | Irving | Y | Y | IWRB4, IWRR5 |
| IWUR4 | Upland Reference | 200 | Annapolis | Irving | N | N | IWRB3 |
| SERB1 | Riparian Buffer | 200 | Pictou | Stora-Enso | Y | N | SEUR3, SERR3 |
| SERB2 | Riparian Buffer | 200 | Pictou | Stora-Enso | Y | N | SEUR2, SERR2 |
| SEUR2 | Upland Reference | 200 | Guysborough | Stora-Enso | N | N | SERB2, SERR2 |
| SERR1 | Riparian Reference | 200 | Guysborough | Stora-Enso | Y | Y | none yet |
| SERR2 | Riparian Reference | 200 | Guysborough | Stora-Enso | N | N | SEUR2, SERB2 |
| SERR3 | Riparian Reference | 200 | Guysborough | Stora-Enso | N | N | SEUR3, SERB1 |
| SEUR3 | Upland Reference | 200 | Guysborough | Stora-Enso | N | N | SERB1, SEUR3 |

## Results & Discussion

Matching suitable transects across the 3 treatments in a given area was a challenge partly because of stringent criteria for buffer site selection (e.g. length of $\geq$200 m, vegetation relatively homogeneous, and harvested on both sites of the stream within 5-10 years ago). Our study is sampling essentially all buffers that fit these criteria in the working landscapes of our industry partners. Site selection was also challenging because suitable reference sites were rare or inaccessible. Both unharvested riparian forest and upland forest were often difficult to find in the same general area where a suitable riparian buffer could be located.

The efficiency of site selection was also hampered by lack of quick access to GIS data. Our industry partners were extremely helpful and spent significant time helping us locate sites by producing various iterations of maps. Nonetheless it took considerable time to get maps created for us, visit potential sites identified on the maps, and request additional maps as needed. In some cases it was also necessary to consult aerial photographs and satellite imagery.

To date, a total of 64 study sites have been selected (Table 1). Of these, 45 transects were surveyed for birds and 41 for vegetation. Eight have not yet been matched with nearby sites of another treatment and 2 have been matched with only one other treatment. A few transects that had been established and surveyed will have to be dropped because of harvesting of the stand or nearby stands. For 12 of the blocks (12 transects for each of the three treatments or 36 matched transects), data were obtained for both birds (Table 2) and vegetation (Tables 4-5). Stream width and most stand measurements did not differ among the three treatments, indicating sites within blocks were well-matched.

**Vegetation**

Three measurements of forest structure differed significantly among treatments (Table 4). Canopy cover was significantly lower for riparian buffers (80%) than for the two kinds of reference sites (85-88%; Fig. 10 and Table 4). Total basal area was highest for riparian reference sites (56 $m^2$/ha) and significantly lower for riparian buffers (38 $m^2$/ha; Fig. 10 and Table 4). Number of hardwood stems/ha in the ≥25<40 cm diameter size class was significantly lower in riparian buffers (53.2/ha) compared to riparian (65.3/ha) and upland references (69.4/ha; Table 4).

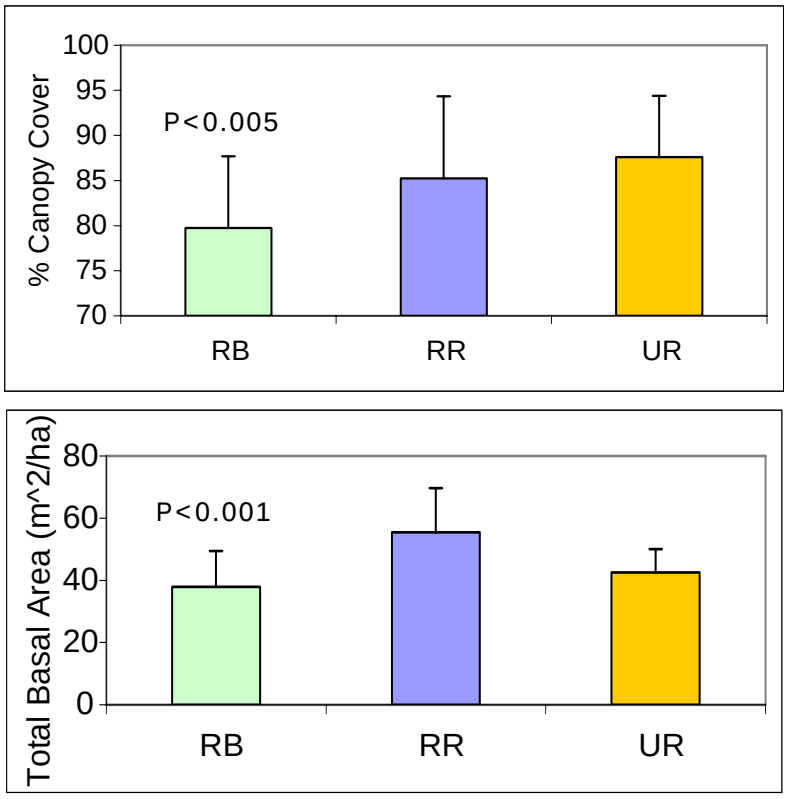



**Fig. 10. Comparison of percent canopy cover (Top) and total basal area (Bottom) for the 12 matched sets of transects. See Table 4 for other habitat measurements.**

**Table 2. Comparison of mean values for vegetation and site characteristics for the three treatments. Significant differences among treatments are indicated in boldface.**

| Variable | Riparian Buffer (n =12) | Riparian Reference (n = 12) | Upland Reference (n = 12) | ANOVA results F | ANOVA results P |
|---|---|---|---|---|---|
| Stream width (m) | 10.0 | 8.1 | --- | 0.214 | 0.648 |
| **Canopy cover (%)** | **79.8** | **85.3** | **87.6** | **3.028** | **0.062*** |
| CWD ($m^2$/ha) | 8.1 | 6.3 | 7.5 | 0.826 | 0.447 |
| **Basal Area ($m^2$/ha)** | **37.9** | **55.5** | **42.5** | **7.697** | **0.002**** |
| Softwood | 24.8 | 33.6 | 29.0 | 1.493 | 0.239 |
| Hardwood | 7.1 | 16.5 | 9.5 | 2.102 | 0.146 |
| Snags | 6.0 | 5.4 | 4.0 | 0.654 | 0.530 |
| Decay Class 1-2 | 2.0 | 1.3 | 1.3 | 0.993 | 0.387 |
| Decay Class 3-4 | 3.9 | 3.3 | 3.1 | 0.535 | 0.594 |
| Softwood stems/ha | | | | | |
| 2-7 cm | 442.3 | 647.2 | 627.8 | 1.611 | 0.222 |
| 7-15 cm | 496.9 | 469.4 | 562.5 | 0.015 | 0.985 |
| 15-25 cm | 282.5 | 312.5 | 312.5 | 0.301 | 0.742 |
| 25-40 cm | 100.3 | 126.4 | 125 | 0.345 | 0.712 |
| 40-60 cm | 18.3 | 22.2 | 19.4 | --- | --- |
| >60 cm | 1.4 | 2.8 | 5.6 | --- | --- |
| **Hardwood stems/ha** | | | | | |
| 2-7 cm | 16.0 | 29.2 | 23.6 | --- | --- |
| 7-15 cm | 73.1 | 59.7 | 63.9 | 0.398 | 0.677 |
| 15-25 cm | 63.5 | 91.7 | 109.7 | 0.804 | 0.460 |
| **25-40 cm** | **53.2** | **65.3** | **69.4** | **3.416** | **0.051**$^+$ |
| 40-60 cm | 2.8 | 15.3 | 5.6 | --- | --- |
| >60 cm | 2.8 | 9.7 | 0.0 | --- | --- |

Note: Where possible, variables were log-transformed for normality. Pairs of means were compared using Tukey's test. Blank (---) means too few trees to test.

* riparian buffers were significantly different from upland references.

** riparian buffers were significantly different from riparian references.

$^+$ riparian buffers were significantly different from upland and riparian references.

**Table 3. Mean densities of trees (stems/hectare) for the 3 treatments in 12 blocks.**

| Stems/ha* | Riparian Buffer (n=12) | Riparian Reference (n=12) | Upland Reference (n=12) |
|---|---|---|---|
| **Balsam Fir** | | | |
| 2-7 cm | 288.7 | 495.8 | 352.8 |
| 7-15 cm | 287.2 | 231.9 | 211.1 |
| 15-25 cm | 120.6 | 100.0 | 52.8 |
| 25-40 cm | 16.3 | 11.1 | 1.4 |
| **Red/black Spruce** | | | |
| 2-7 cm | 120.1 | 129.2 | 234.7 |
| 7-15 cm | 175.4 | 179.2 | 293.1 |
| 15-25 cm | 137.8 | 186.1 | 240.3 |
| 25-40 cm | 71.6 | 69.4 | 94.4 |
| 40-60 cm | 11.3 | 5.6 | 4.2 |
| **White Spruce** | | | |
| 7-15 cm | 0.0 | 0.0 | 1.4 |
| 15-25 cm | 1.4 | 0.0 | 1.4 |
| 25-40 cm | 4.2 | 0.0 | 2.8 |
| 40-60 cm | 1.4 | 0.0 | 1.4 |
| **White Pine** | | | |
| 2-7 cm | 5.7 | 2.8 | 8.3 |
| 7-15 cm | 5.2 | 18.1 | 34.7 |
| 15-25 cm | 3.3 | 13.9 | 9.7 |
| 25-40 cm | 1.4 | 16.7 | 13.9 |
| 40-60 cm | 2.8 | 6.9 | 1.4 |
| >60 cm | 1.4 | 2.8 | 2.8 |
| **Red Pine** | | | |
| 2-7 cm | 0.0 | 0.0 | 2.8 |
| 7-15 cm | 0.0 | 0.0 | 1.4 |
| 25-40 cm | 0.0 | 1.4 | 2.8 |
| 40-60 cm | 0.0 | 0.0 | 2.8 |
| **Jack Pine** | | | |
| 15-25 cm | 0.0 | 1.4 | 0.0 |
| 25-40 cm | 0.0 | 8.3 | 0.0 |
| **Eastern Hemlock** | | | |
| 2-7 cm | 26.4 | 19.4 | 29.2 |
| 7-15 cm | 29.2 | 30.6 | 11.1 |
| 15-25 cm | 18.1 | 11.1 | 5.6 |
| 25-40 cm | 6.9 | 19.4 | 9.7 |
| 40-60 cm | 2.8 | 9.7 | 9.7 |
| >60 cm | 0.0 | 0.0 | 2.8 |
| **Eastern Larch** | | | |
| 2-7 cm | 1.4 | 0.0 | 0.0 |
| 7-15 cm | 0.0 | 2.8 | 9.7 |
| 15-25 cm | 1.4 | 0.0 | 2.8 |

| Stems/ha* | Riparian Buffer (n=12) | Riparian Reference (n=12) | Upland Reference (n=12) |
|---|---|---|---|
| **Red Maple** | | | |
| 2-7 cm | 15.4 | 27.8 | 19.4 |
| 7-15 cm | 60.0 | 48.6 | 45.8 |
| 15-25 cm | 48.7 | 73.6 | 65.3 |
| 25-40 cm | 34.3 | 52.8 | 40.3 |
| 40-60 cm | 2.8 | 11.1 | 1.4 |
| >60 | 2.8 | 9.7 | 0.0 |
| **Sugar Maple** | | | |
| 2-7 cm | 0.0 | 1.4 | 0.0 |
| 7-15 cm | 2.8 | 0.0 | 0.0 |
| **White Birch** | | | |
| 2-7 cm | 1.9 | 0.0 | 1.4 |
| 7-15 cm | 5.2 | 5.6 | 8.3 |
| 15-25 cm | 9.7 | 11.1 | 11.1 |
| 25-40 cm | 11.0 | 2.8 | 9.7 |
| 40-60 cm | 0.0 | 0.0 | 4.2 |
| **Yellow Birch** | | | |
| 2-7 cm | 0.0 | 0.0 | 2.8 |
| 7-15 cm | 1.4 | 0.0 | 2.8 |
| 25-40 cm | 0.0 | 1.4 | 0.0 |
| 40-60 cm | 0.0 | 1.4 | 0.0 |
| **Grey Birch** | | | |
| 7-15 cm | 0.0 | 2.8 | 0.0 |
| 15-25 cm | 0.0 | 1.4 | 0.0 |
| **Red Oak** | | | |
| 7-15 cm | 0.0 | 0.0 | 2.8 |
| 15-25 cm | 0.0 | 0.0 | 15.3 |
| 25-40 cm | 0.0 | 2.8 | 8.3 |
| **White Ash** | | | |
| 7-15 cm | 0.0 | 0.0 | 1.4 |
| 15-25 cm | 0.0 | 5.6 | 0.0 |
| 25-40 cm | 0.0 | 5.6 | 0.0 |
| 40-60 cm | 0.0 | 2.8 | 0.0 |
| **Trembling Aspen** | | | |
| 15-25 cm | 0.0 | 0.0 | 2.8 |
| 25-40 cm | 0.0 | 0.0 | 2.8 |
| **Ironwood** | | | |
| 7-15 cm | 0.0 | 2.8 | 0.0 |

*only size classes containing stems for a given species are shown (rows with zeros for all 3 treatments are not included in this table)

Although matched as closely as possible, riparian reference sites contained about 10% more hardwood than buffers and upland sites (Table 2). They also had more white ash, more large red maple, and more large hemlocks than buffers or upland sites (Table 3). Buffers tended to have more balsam fir and black spruce. Upland sites had more red oak and trembling aspen. Pines tended to be larger and more abundant in reference sites. Site and vegetation characteristics were not related to width in riparian buffers.

**Birds**

A total of 54 bird species were observed in the 36 matched transects during the survey period (Table 4). This list would be longer if all transects were included and if observations made outside of the survey periods were included. Only 23 of the 54 were species of conservation concern (SCC, Table 4). Of these, 7 were wood-warblers, 4 were flycatchers, 3 were thrushes, and 2 were raptors. Overall, only 28% of the birds observed in riparian buffers were on the list of mature forest species of conservation concern. The percentage of birds in reference sites was higher, 48% of the riparian reference sites and 64% of the upland reference sites.

If all transects sampled for birds and vegetation are included, the patterns are very similar (Fig. 11). Species of conservation concern were less abundant in riparian buffers than in reference sites. Interestingly, upland reference sites had a larger percentage of species of conservation concern than did riparian references, although the difference was not statistically significant. Perhaps the natural edge along the water course in unharvested riparian forest is not attractive to some closed-canopy species. Further study is needed to assess this possibility.

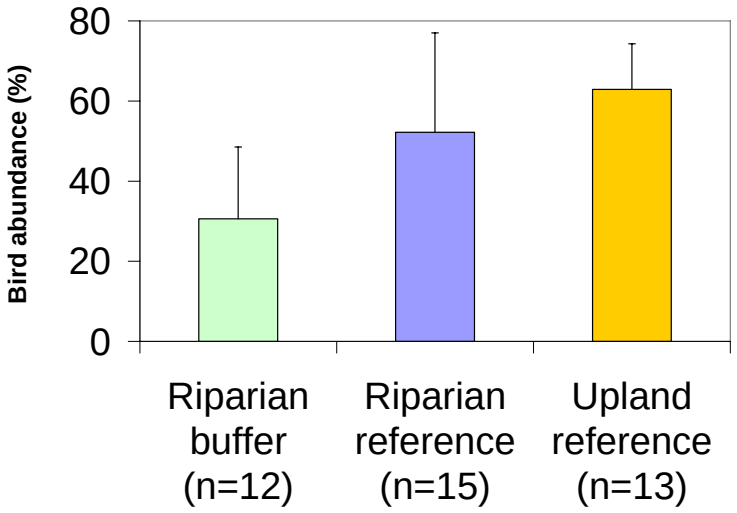



**Fig. 11. Percentage of individuals that belonged to Species of Conservation Concern (see Table 4) along transects of the three treatments.**

**Table 4. Mean detections per hectare of the various bird species for the three treatments (n = 12 matched blocks). SCC indicates whether bird is a Species of Conservation Concern (boldface; Y= yes, N=no).**

| Common name | Latin name | SCC | Riparian Buffer (n=12) | Riparian Reference (n=12) | Upland Reference (n=12) |
|---|---|---|---|---|---|
| American Redstart | *Setophaga ruticilla* | N | 0.483 | 0.465 | 0.222 |
| American Robin | *Turdus migratorius* | N | 0.505 | 0.024 | 0.056 |
| **Barred Owl** | ***Strix varia*** | **Y** | **0.035** | **0.000** | **0.000** |
| **Bay-breasted Warbler** | ***Dendroica castanea*** | **Y** | **0.000** | **0.893** | **0.965** |
| Black-and-white Warbler | *Mniotilta varia* | N | 0.981 | 0.103 | 0.122 |
| **Blackburnian Warbler** | ***Dendroica fusca*** | **Y** | **0.000** | **0.089** | **0.528** |
| Black-capped Chickadee | *Parus atricapillus* | N | 0.627 | 0.748 | 0.373 |
| Blackpoll Warbler | *Dendroica striata* | N | 0.027 | 0.000 | 0.014 |
| **Black-throated Blue Warbler** | ***Dendroica caerulescens*** | **Y** | **0.000** | **0.022** | **0.056** |
| **Black-throated Green Warbler** | ***Dendroica virens*** | **Y** | **0.178** | **0.501** | **0.667** |
| Blue Jay | *Cyanocitta cristata* | N | 0.000 | 0.024 | 0.031 |
| **Blue-headed Vireo** | ***Vireo solitarius*** | **Y** | **0.545** | **0.445** | **0.399** |
| **Brown Creeper** | ***Certhia americana*** | **Y** | **0.053** | **0.048** | **0.090** |
| **Cape May Warbler** | ***Dendroica tigrina*** | **Y** | **0.000** | **0.000** | **0.042** |
| Cedar Waxwing | *Bombycillia cedrorum* | N | 0.035 | 0.000 | 0.000 |
| Chimney Swift | *Chaetura pelagica* | N | 0.000 | 0.047 | 0.000 |
| Chipping Sparrow | *Spizella passerina* | N | 0.000 | 0.021 | 0.056 |
| Common Grackle | *Quiscalus quiscula* | N | 0.121 | 0.000 | 0.000 |
| Common Raven | *Corvus corax* | N | 0.035 | 0.022 | 0.000 |
| Common Yellowthroat | *Geothlypis trichas* | N | 1.316 | 0.480 | 0.000 |
| Dark-eyed Junco | *Junco hyemalis* | N | 0.679 | 0.442 | 0.361 |
| Downy Woodpecker | *Picoides pubescens* | N | 0.000 | 0.079 | 0.035 |
| **Eastern Wood Pewee** | ***Contopus sordidulus*** | **Y** | **0.000** | **0.071** | **0.049** |

| Common name | Latin name | SCC | Riparian Buffer (n=12) | Riparian Reference (n=12) | Upland Reference (n=12) |
|---|---|---|---|---|---|
| Evening Grosbeak | *Hesperiphona vespertina* | N | 0.000 | 0.024 | 0.000 |
| **Golden-crowned Kinglet** | ***Regulus satrapa*** | **Y** | **0.379** | **0.431** | **0.625** |
| **Gray Jay** | ***Perisoreus canadensis*** | **Y** | **0.063** | **0.042** | **0.069** |
| Hairy Woodpecker | *Picoides villosus* | N | 0.621 | 0.044 | 0.042 |
| **Hermit Thrush** | ***Catharus guttatus*** | **Y** | **0.324** | **0.206** | **0.274** |
| **Least Flycatcher** | ***Empidonax minimus*** | **Y** | **0.104** | **1.096** | **0.632** |
| Magnolia Warbler | *Dendroica magnolia* | N | 1.694 | 0.764 | 0.319 |
| Nashville Warbler | *Vermivora ruficapilla* | N | 0.000 | 0.278 | 0.083 |
| Northern Flicker | *Colaptes auratus* | N | 0.056 | 0.000 | 0.014 |
| **Northern Goshawk** | ***Accipiter gentilis*** | **Y** | **0.070** | **0.000** | **0.000** |
| **Northern Parula** | ***Parula americana*** | **Y** | **0.722** | **0.415** | **0.063** |
| **Olive-sided Flycatcher** | ***Nuttallornis borealis*** | **Y** | **0.333** | **0.049** | **0.000** |
| **Ovenbird** | ***Seiurus aurocapillus*** | **Y** | **0.174** | **0.400** | **0.292** |
| Palm Warbler | *Dendroica palmarum* | N | 0.508 | 0.243 | 0.174 |
| **Purple Finch** | ***Carpodacus purpureus*** | **Y** | **0.000** | **0.000** | **0.017** |
| **Red-breasted Nuthatch** | ***Sitta canadensis*** | **Y** | **0.241** | **0.273** | **0.264** |
| Red-eyed Vireo | *Vireo olivaceus* | N | 0.073 | 0.000 | 0.014 |
| Red-winged Blackbird | *Agelaius phoeniceus* | N | 0.237 | 0.232 | 0.132 |
| Ruby-crowned Kinglet | *Regulus calendula* | N | 0.178 | 0.453 | 0.174 |
| Savannah Sparrow | *Passerculus sandwichensis* | N | 0.035 | 0.000 | 0.000 |
| **Swainson's Thrush** | ***Catharus ustulatus*** | **Y** | **0.273** | **0.057** | **0.069** |
| Swamp Sparrow | *Melospiza georgiana* | N | 0.000 | 0.091 | 0.000 |
| Tennessee Warbler | *Vermivora peregrina* | N | 0.070 | 0.000 | 0.014 |
| Tree Swallow | *Tachycineta bicolor* | N | 0.027 | 0.000 | 0.000 |
| **Veery** | ***Catharus fuscescens*** | **Y** | **0.000** | **0.021** | **0.000** |
| White-breasted Nuthatch | *Sitta carolinensis* | N | 0.081 | 0.021 | 0.000 |

| Common name | Latin name | SCC | Riparian Buffer (n=12) | Riparian Reference (n=12) | Upland Reference (n=12) |
|---|---|---|---|---|---|
| White-throated Sparrow | *Zonotrichia albicollis* | N | 1.399 | 0.021 | 0.000 |
| Winter Wren | *Troglodytes troglodytes* | N | 0.223 | 0.130 | 0.052 |
| **Yellow-bellied Flycatcher** | ***Epidonax flaviventris*** | **Y** | **0.100** | **0.042** | **0.000** |
| **Yellow-bellied Sapsucker** | ***Sphyrapicus varius*** | **Y** | **0.626** | **0.047** | **0.083** |
| Yellow-rumped Warbler | *Dendroica coronata* | N | 0.840 | 0.933 | 0.597 |

Species more abundant in reference sites included the Least Flycatcher, Bay-breasted Warbler, Black-throated Green Warbler, and Ovenbird (Table 4). Blackburnian Warblers, which breed and feed in tall conifers, were largely restricted to upland sites and Golden-crowned Kinglets were more common there as well. The Northern Parula, a warbler that builds its nests in hanging clumps of *Usnea* spp. lichens, and the Yellow-bellied Flycatcher were more common in riparian sites (both buffer and reference) than in upland sites. Swainson's Thrushes and Yellow-bellied Sapsuckers were more common in riparian buffers, although these species have large territories making density calculations in buffers more problematic.

Estimated total bird densities were highest for riparian buffers (15 birds/ha), intermediate for riparian references (11 birds/ha), and lowest for upland references (8 birds/ha; Fig. 12). Additional surveys are needed to determine if these trends are real. More birds could be detected in buffers for several reasons: some of the birds could be making temporary use of buffers but actually breeding in the harvested area outside of the buffer; territories may be more elongate (parallel to the buffer) making it more likely to encounter the birds on a transect; or territories could actually be denser in the buffer because of greater food resources.

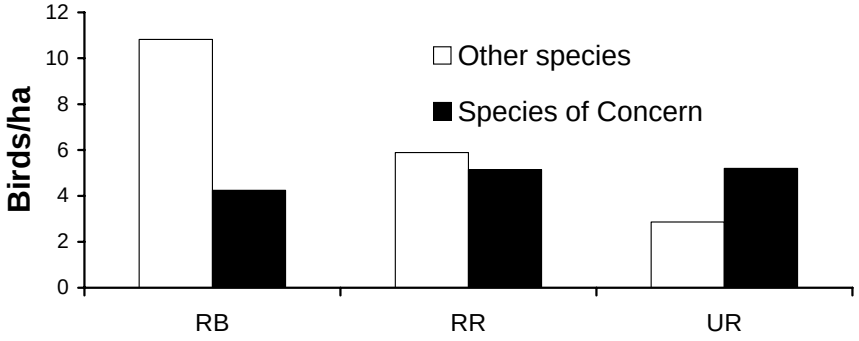
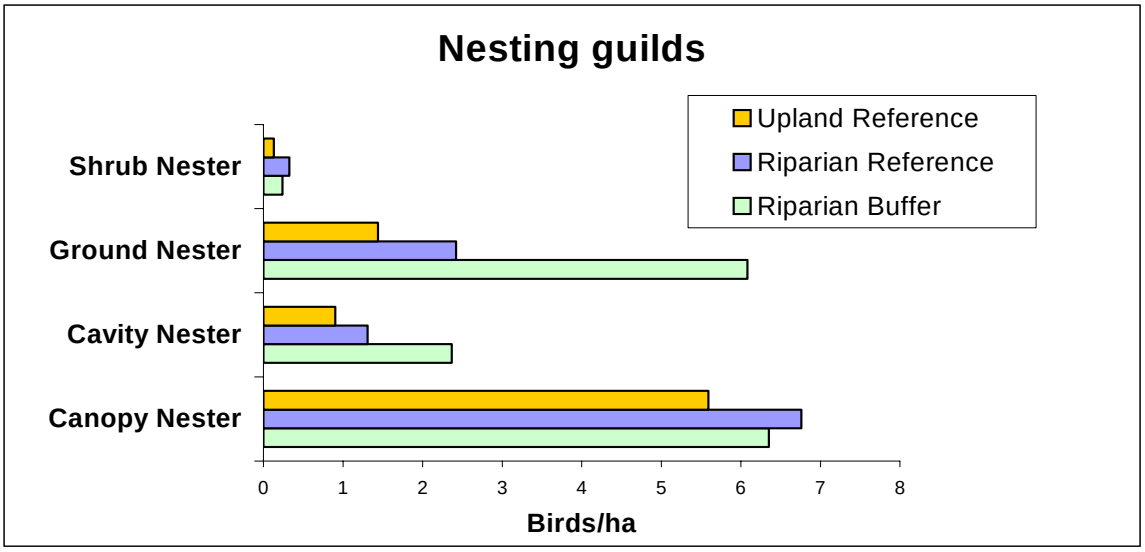



**Fig. 12. Estimated densities of all birds in the three treatments. Other species includes forest species that are not on the list of conservation concern as well as species typical of open/edge and early-successional habitats.**

At the guild level, both ground foragers and ground nesters were significantly more abundant in riparian buffers (Table 5, Fig. 13), which may include more ground vegetation. Guild abundance was not related to width of riparian buffers.



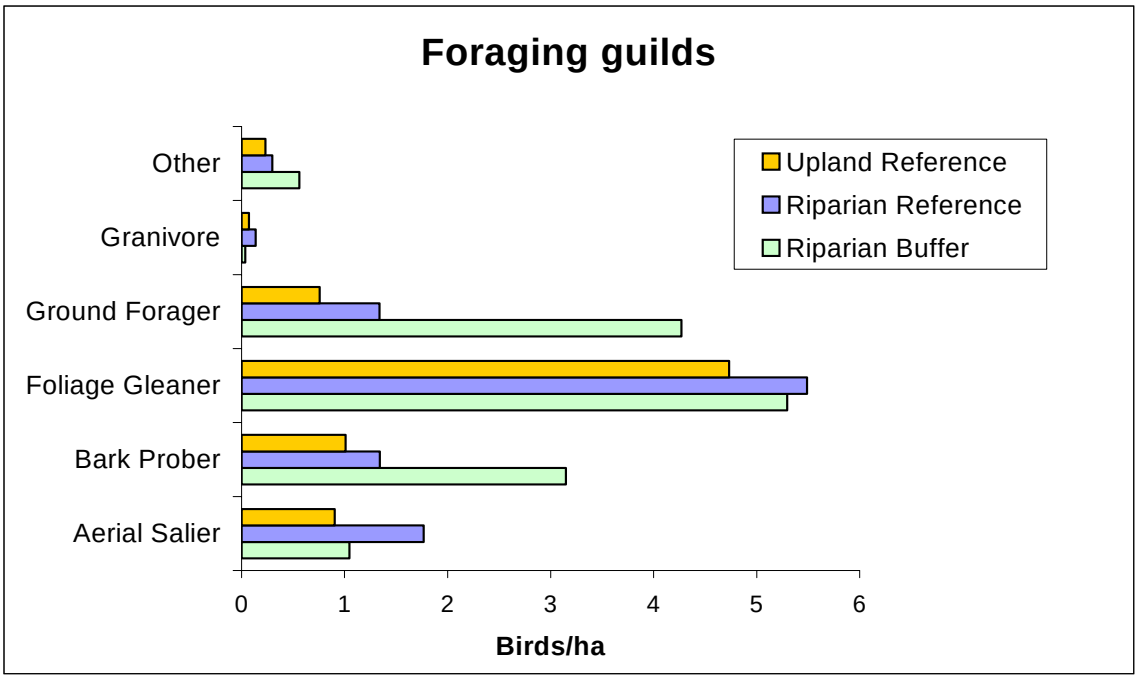




**Fig. 13. Estimated densities of birds when combined into ecological guilds. Nesting guilds (Top) included birds that nest in shrubs or low vegetation, on the ground, in cavities, or in the canopy. Foraging guilds (Bottom) included birds that mainly eat seeds (granivores), forage for insects and other invertebrates on the ground, glean insects from leaves in the canopy, probe bark on tree trunks, and catch flying insects (aerial sallier). Other includes generalists and birds of prey.**

**Table 3. Mean detections per hectare of foraging and nesting guilds compared among treatments.**

| Guild | Riparian Buffer | Riparian Reference | Upland Reference | K-W test statistic | P-value |
|---|---|---|---|---|---|
| *Foraging Guild* | | | | | |
| Aerial Sallier | 1.047 | 1.768 | 0.903 | 2.372 | 0.305 |
| Bark Prober | 3.148 | 1.343 | 1.009 | 2.936 | 0.230 |
| Foliage Gleaner | 5.295 | 5.489 | 4.733 | 0.425 | 0.809 |
| **Ground Forager** | **4.270** | **1.338** | **0.756** | **10.031** | **0.007 *** |
| Granivore | 0.035 | 0.135 | 0.072 | 1.639 | 0.441 |
| Other | 0.562 | 0.298 | 0.232 | 0.317 | 0.853 |
| *Nesting Guild* | | | | | |
| Canopy Nester | 6.352 | 6.761 | 5.592 | 1.581 | 0.454 |
| Cavity Nester | 2.365 | 1.308 | 0.901 | 2.808 | 0.246 |
| **Ground Nester** | **6.082** | **2.421** | **1.440** | **12.006** | **0.002*** |
| Shrub Nester | 0.237 | 0.323 | 0.132 | 1.471 | 0.479 |

* significant at P<0.01, Kruskal Wallis test statistic with a Chi-square distribution, df=2.

## Conclusions

Among the mature-forest associated Species of Conservation Concern identified in the 2004-2005 pilot study, some were more abundant in riparian forest and others were more abundant in upland forest. Some species were notably absent from riparian buffers. On the other hand, buffers had many species and individuals typical of open, edge, or early-successional habitats.

Survey results indicate that the vegetation characteristics of riparian buffers differed from those of reference sites along streams and in upland areas. Buffers had lower tree basal area and canopy cover than reference sites. How much of this difference is due to harvesting within buffers or blow down is presently unclear. Results also suggest that NS conifer-dominated riparian forest tends to have more hardwood than upland sites. These habitat differences may explain some of the differences found in bird communities. The larger abundances of ground foragers and ground nesters in buffers may be linked to greater development of low vegetation and the greater opportunity for feeding and nesting sites it provides.

Preliminary results are consistent with the two hypotheses of interest: (1) buffers currently on the landscape may not be maintaining several birds of conservation concern, and (2) riparian forest has greater conservation value to certain species than does upland habitat. Another field season is required to obtain a larger data set for more accurate calculation of bird densities and to determine which species are successfully breeding in buffers.