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Breeding bird response to riparian forest management: 9 years post-harvest

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Abstract

We previously examined the 3-year response of breeding bird communities to timber harvest in riparian areas using two harvest techniques (full tree harvest (GPL) and cut-to-length (CTL)) along first- to third-order streams in northern Minnesota, USA. We revisited the same 12 sites 9 years post-harvest and compared community composition, total abundance, species richness, and the abundance of bird guilds on harvest plots randomly assigned to four treatments (three plots per treatment). Analyses revealed a significant response of the bird community to timber harvest in the riparian area. Nine years post-harvest, bird communities in the uncut riparian buffers were statistically indistinguishable from control bird communities. Differences in bird communities between CTL and GPL treatments detected 3 years post-harvest in buffers were no longer evident after 9 years. Breeding bird community composition in harvested buffers became more similar to uncut and control buffer communities in species composition. All treatment buffers continued to have more species and individuals than control buffers; these bird species had affinities for early-successional forests. No differences among forest interior species or ground-nesting birds were evident between treatments 9 years post-harvest.

Keywords: Breeding bird communities; Buffers; Cut-to-length; Forest; Harvest; Minnesota; Riparian; Principle response curves; Streams

1. Introduction

Protection of forest riparian areas for water quality and wildlife habitat during timber harvest with either fixed- or variable-width buffers has become a common management consideration in current forest practices. Most riparian management guidelines recommend set buffer widths and amounts of residual tree basal area required to protect or conserve riparian habitat function (Knopf, 1985). Buffer widths recommended to protect riparian forest function for wildlife habitat vary considerably across regions of North America and the majority of information available to suggest widths has been taken from short-term studies on response of wildlife to harvest (from 1 to 3 years post-harvest) (see Wegner, 1999). We are unaware of any forest harvest experiment study that has documented response of wildlife to riparian forest harvest for more than 3 years after the initial harvest.

We previously described breeding bird response to harvest and type of harvest technique used in riparian forests 3 years post-harvest (Hanowski et al., 2003). The harvest types used were the more traditional harvest method using whole-tree grapple skidding (GPL) and harvest with cut-to-length (CTL) harvest equipment. We examined response of breeding birds to the removal of basal area to an average of 7–10 m^2/ha. All experimental harvest sites were sampled again in 2006 and here we report on the longer time response of breeding birds to harvest equipment type and basal area remaining in riparian buffers.

2. Study area

We conducted the study along three tributary streams to Pokegama Lake (Pokegama Creek, Little Pokegama Creek, unnamed stream) in northern Minnesota (47′05″N latitude, 93′35″W longitude). More detailed description and diagram of the study area and methods can be found in Hanowski et al. (2003). Dominant tree species on plots were sugar maple (*Acer saccharum*), paper birch (*Betula papyrifera*), basswood (*Tilia americana*), and quaking aspen (*Populus tremuloides*). Streams

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were narrow (1–3 m wide), which is typical of first- to third-order streams in this region. This area was chosen because it had a forest cover at rotation age (about 80 years of age), the stream morphology was similar along all stream reaches, and the landowner was willing to harvest stands with the designated treatment. The individual study plots (12 total) were located along three separate streams within a 2-km^2 area (Hanowski et al., 2003). Study plots were 4.6 ha in size and were located along the streams such that the areas along the streams were separated from each other by at least 100 m. Biological independence, for example, assuring that the same individual was not recorded on more that one plot, was accomplished by separating the plots in space (Hanowski et al., 2003).

Study plots for the experiment were selected in the winter of 1996–1997. All experimental plots (9 total) were harvested in late-summer of 1997. Successional changes in vegetation were apparent among all treatment plots from 1997 to 2006 primarily in the adjacent upland harvest area. Edges of riparian harvest buffers were ‘‘hard’’ in 1998 but have become ‘‘softer’’ as the trees in the adjacent harvest area have grown. Upland treatment areas were open with short aspen regeneration in 1998 and in 2006, aspen trees exceeded 4 m in height. In addition, tree-fall within the riparian harvest area created pockets of downed woody material that was colonized by shrubby vegetation.

The experimental design consisted of a randomized block design. Treatment combinations consisted of one level of over-story manipulation combined with two types of harvesting operation, whole-tree harvest with grapple skidding and cut-to-length. Over-story treatments within riparian areas were designed to test best management practices (BMP) for water quality in Minnesota. This included leaving an average of 6–10 m^2/ha basal area within 30 m of either side of the stream. A block of uncut riparian control plots was retained in the experimental design as well as a total control (no harvest in the study plot). To accommodate the water quality and aquatic components of the study, treatments were assigned to plots randomly with the restriction that a riparian harvest plot was not immediately upstream of a control plot. Adjacent uplands (outside the 30 m riparian buffers) were clearcut to make them commercially operational and also representative of normal operating conditions.

2.1. Bird surveys

We conducted three breeding bird surveys on each plot in each year from 1997 to 2000 and again in 2006. Before-harvest data were collected on all plots in 1997 and post-harvest data were collected in 1998–2000 and 2006 (see Hanowski et al., 2003, for more detail). One survey was done in mid-May to document early breeding and permanent resident species (e.g., chickadees and woodpeckers), one in mid-June to capture peak singing of long-distance migrants, and one in early-July for the later breeding species (e.g., goldfinches). Because we were interested in documenting locations of birds relative to the stream, we used line-transects to conduct bird surveys. One line-transect (300 m in length) was placed through the middle of each plot perpendicular to the stream (Hanowski et al., 2003). Surveys were completed by four experienced observers who passed a bird identification test and a hearing test, and received training to standardize counts. All surveys were completed during early morning hours (within 4 h of sunrise) and with good weather conditions (no rain and winds <20 kph).

2.2. Data analyses

A sample was defined as three bird surveys on a transect in a year. For each sample ($n = 48$), we generated response (dependent) variables for individual bird species abundance and for bird community parameters. Because we were primarily interested in bird response to harvest in the buffers, we used only those birds observed within the designated riparian zone (30 m) on both sides of the stream. For each species, we used the maximum count of individuals observed on either the May, June, or July survey. We transformed all of our individual species maximum counts by $\ln(\text{count} + 0.2)$ for two reasons. First, we felt that a multiplicative model had more general utility for forest bird populations (McDonald et al., 2000), and second, to correct a violation of the normal distribution of errors assumption when the data were untransformed. For univariate community measures (species richness, total bird abundance) we used repeated-measures ANOVA models in SAS (SAS Institute, 2000). We included 1 year post-harvest (1997) and 4 years post-harvest data (1998, 1999, 2000 and 2006) in the analysis and used alpha level of 0.05 for determination of statistical significance.

We analyzed the response of riparian bird communities to harvest and harvest type using the multivariate principal response curves (PRCs) (Ter Braak and Smilauer, 1998; Kedwards et al., 1999a,b; Van den Brink and Ter Braak, 1999). We followed guidelines of Van den Brink and Ter Braak (1999), and Ter Braak and Smilauer (1998) to compute the first PRC. PRC is based upon *partial* redundancy analysis, a redundancy analysis in which explanatory variables are used to explain variation in bird species data set after first accounting for variation attributable to a third data set (covariable data). In other words, we first accounted for variation in species composition due to time, and then we attributed the remaining variation to the treatments. In our study, explanatory variables were 12 dummy variables that consisted of all combinations of the three non-control treatments and four post-treatment times. This set of explanatory variables is a subset of variables that were used in redundancy analysis (RDA) but excludes variables that denote control treatments or pre-treatment times. By excluding these variables, we ensured that treatment effects were expressed as deviations from the control (Ter Braak and Smilauer, 1998). Covariables were denoted by dummy variables indicating sampling year. The PRC was generated by plotting the first principle component of the treatment effects against time for each treatment group.

The significance of the PRC was assessed with a Monte Carlo permutation test, by permuting whole time series in the partial RDA from which the PRC was obtained. This test uses an F-type statistic based on the eigenvalue of the component (Ter Braak and Smilauer, 1998). The null hypothesis was that treatment effect was zero for all times, treatments, and guilds.

The interpretation of bird species responses in the PRC diagram is aided by a line graph of species weights. In our case, a positive weight indicates an increase in abundance following harvest, while a negative weight indicates a decline. Species with weights farther from zero have increased or decreased by greater amounts than species with weights nearer zero. The quotient $\exp(b_k \times c_{dt})$, where b_k is the species weight and c_{dt} is the canonical coefficient at time t and treatment d, can be used to quantitatively evaluate the expected increase or decrease in abundance.

3. Results

The first axis of the PRC was significant and explained 28% of the variation in the treatment regime ($P = 0.002$) (Fig. 1). Nine years after harvest, bird community composition on both GPL and CTL treatments were still similar to each other, but uncut buffer bird communities became more similar to control bird communities after 9 years (Fig. 1). The line graph of species weights indicated how individual species responded to the treatment regimes. Species with negative weights on the axis were more common on control and uncut riparian sites. More mature forest associated species and individuals such as ovenbird (*Seiurus aurocapillus*), scarlet tanager (*Piranga olivacea*), and black-throated green warbler (*Dendroica virens*) continued to distinguish control and uncut buffer bird communities from GPL and CTL bird communities. The latter two treatment communities were dominated by species that had associations with early-successional forests, including white-throated sparrow (*Zonotrichia albicollis*), chestnut-sided

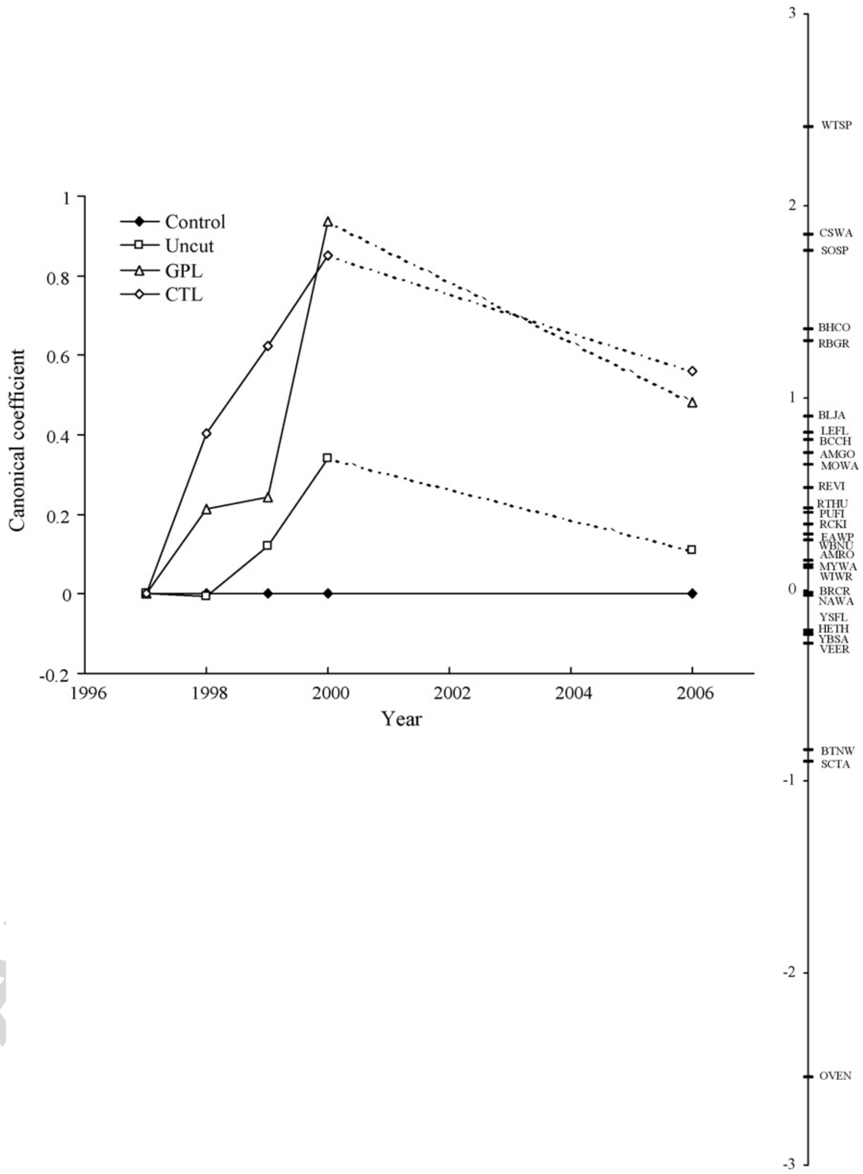

Fig. 1. First principal response curve (PRC) diagram indicating the effects of harvest technique. The vertical axis represents the first principal component of the treatment effects and explains 28% of the variation in the treatment regime ($P = 0.002$). The line graph of species weights indicates how species responded to the treatment regime (see Section 2). Appendix A lists bird codes. GPL: full tree harvest treatment; CTL: cut-to-length treatment.

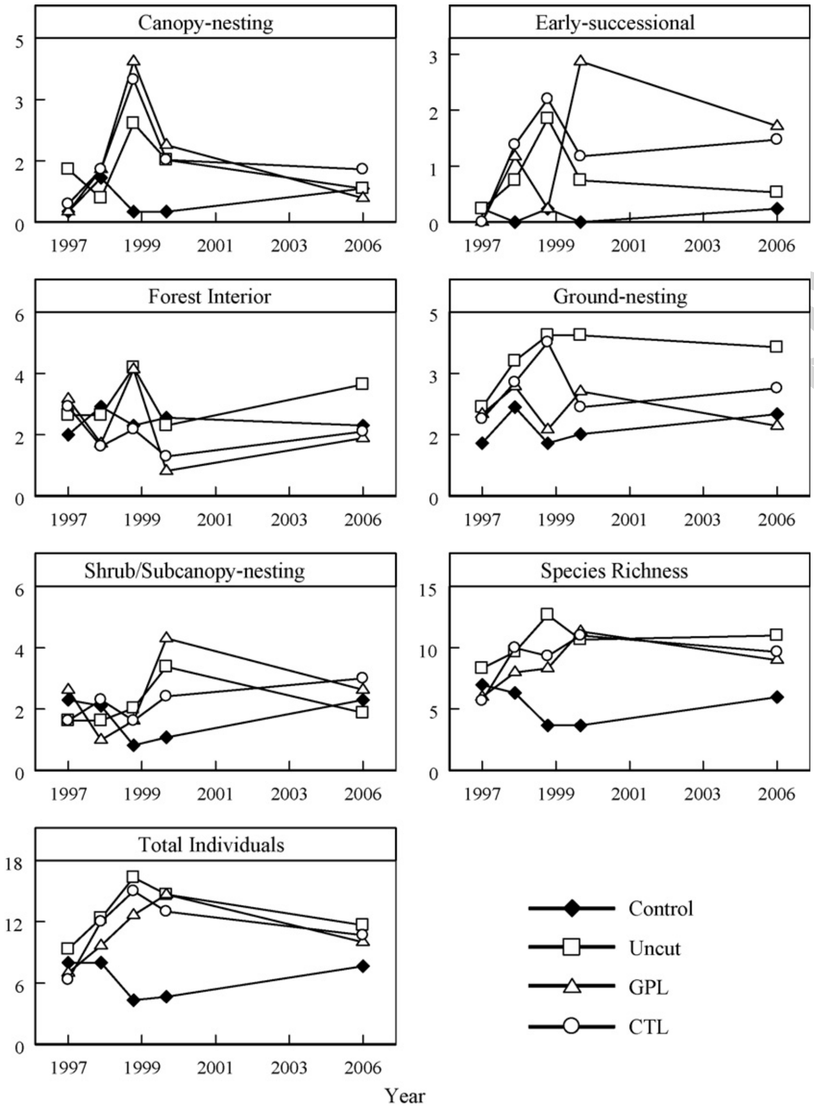

Fig. 2. Least-square mean abundance per survey for four treatments through time. 1997 was a pre-treatment year. GPL: full tree harvest treatment; CTL: cut-to-length treatment.

warbler (*Dendroica pensylvanica*), song sparrow (*Melospiza melodia*), brown-headed cowbird (*Molothrus ater*) and rose-breasted grosbeak (*Pheucticus ludovicianus*)(Fig. 1).

Numbers of bird species and individuals on transects within treatment groups were similar before treatment (1997) (Fig. 2). Up to 3 years after treatment, species richness and total numbers of individuals decreased in control plots and increased in all treatment plots (Fig. 2). Results from the repeated-measures ANOVA indicated significant differences among treatments ($P < 0.001$) in both total numbers of individuals and species. Nine years after harvest, species richness and numbers of individuals remained higher on all treatments compared to control, however the difference has become smaller over time (Fig. 2).

Of five bird guilds tested for response to riparian harvest treatment over time, three showed a significant treatment effect (Fig. 2). Number of early-successional individuals became more abundant on all treatments (compared to control) immediately after harvest, especially on the CTL and GPL sites ($P < 0.03$). However, abundance of individuals within this guild became more similar among treatments over time, especially in the uncut and control sites (Fig. 2). The shrub/sub-canopy nesting guild also exhibited a strong treatment effect ($P < 0.0001$), however, the largest difference among treatments occurred in the earlier years (up to 3 years post-harvest) (Fig. 2). Nine years after harvest, numbers of individuals within this guild were quite similar among the four treatment groups (Fig. 2). We also found a significant treatment effect ($P < 0.003$) for the canopy nesting guild (Fig. 2). The pattern of abundance over time for individual treatments was similar to that found for the shrub/sub-canopy guild: larger differences were evident in the early years after harvest but 9 years later, numbers of individuals within this guild were quite similar to each other (Fig. 2). No treatment effects were found for ground-nesting or forest interior guilds.

4. Discussion

This study provides information on longer term response of breeding bird communities to riparian forest harvest and type of harvest. Most studies to date have only documented animal response to harvest for up to 3 years post-harvest. These data are important because they provide forest managers additional information that can be used to make forest management decisions for riparian forests.

Breeding bird composition of harvested riparian plots still includes more early-successional species than both control and uncut plots 9 years post-harvest. This result was not unexpected because a large amount of basal area was removed from the treated riparian forest plots and a small amount of residual basal area was left on the upland portions of the plots (about 10 m^2/ha) (Perry et al., 1998). As expected, bird communities in the CTL and GPL treatment groups changed more relative to control plots than plots where the riparian forest was left uncut and it will take a longer period of time for these sites to reach the control group species composition. However, bird communities in all treatment groups have moved toward control bird community composition over time. The successional path observed for breeding bird communities over 9 years in harvested riparian sites is similar to what has been documented in deciduous forest communities in this region (Lind et al., 2006).

Breeding bird communities in uncut riparian buffers were similar to a mature forest bird community within 10 years after harvest and the initial increase in total number of individual birds and numbers of species that others and we have observed in the 1st year after treatment was not as evident 9 years post-harvest. The period of time that it will take for harvested buffer breeding bird communities to become the same as the adjacent upland community will likely depend on the condition of the before-harvest riparian bird community composition. In this study, pre-harvest bird communities in forest adjacent to the streams were not different than bird communities in upland forest before harvest (Hanowski et al., 2003). Bird communities in riparian buffers and adjacent upland forests next to lakes were also not different from each other in studies from northern Alberta (Macdonald et al., 2003). However, Bub et al. (2004) in the Upper Peninsula of Michigan found subtle differences in bird communities adjacent to small first-order streams, suggesting that habitat diversity in the form of native conifers even on the smaller first-order streams distinguished bird communities in riparian and upland bird forests in that area. In addition, Shirley (2004) working in British Columbia also found vegetation and bird community differences between adjacent upland and riparian forests (more deciduous trees in riparian forests).

In most regions of North America, we still lack an understanding of riparian habitat condition that were manifested under a natural disturbance regime, especially in forests associated with large rivers and lakes that provide habitat features that are used by riparian dependent species (see Hanowski et al., 2002). For example, if riparian forests had more old forest characteristics, it may be more important to manage for habitat features (large and long-lived tree species) that are used by riparian dependent bird species (eagles, osprey, cavity nesting ducks), than it is to manage principally for mature forests that may not have old forest characteristics. Results from our studies in riparian forests in northern Great Lakes forests (Hanowski et al., 2003, 2005, 2006) agree with the approach of Macdonald et al. (2003) for management of riparian forests on the landscape. They suggest, and we agree that management of riparian forests should focus on the protection of finer scale habitat features that may be important wildlife habitat feature in riparian forests (see also Macdonald et al., 2006).

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Appendix A

Common names for species depicted by their abbreviations within Fig. 1.

AMGO	American goldfinch
AMRO	American robin
BCCH	Black-capped chickadee
BHCO	Brown-headed cowbird
BLJA	Blue jay
BRCR	Brown creeper
BTNW	Black-throated green warbler
CSWA	Chestnut-sided warbler
EAWP	Eastern wood-pewee
HETH	Hermit thrush
LEFL	Least flycatcher
MAWA	Magnolia warbler
MYWA	Myrtle (yellow-rumped) Warbler
NAWA	Nashville warbler
OVEN	Ovenbird
PUFI	Purple finch
RBGR	Rose-breasted grosbeak
RCKI	Ruby-crowned kinglet
REVI	Red-eyed vireo
RUGR	Ruffed grouse
RTHU	Ruby-throated hummingbird
SCTA	Scarlet tanager
SOSP	Song sparrow
VEER	Veery
WBNU	White-breasted nuthatch
WIWR	Winter wren
WTSP	White-throated sparrow
YSFL	Yellow-shafted flicker
YBSA	Yellow-bellied sapsucker

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