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Conservation value of agricultural riparian strips in the Boyer River watershed, Québec (Canada)

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Abstract

Riparian habitats play a major role in biodiversity conservation in intensive agricultural landscapes because they represent remnants of both wetland and woody habitats available for wildlife. The importance of herbaceous, shrubby and wooded riparian habitats for the conservation of biodiversity (plants, amphibians, reptiles, birds, small mammals) is well documented for the Boyer River watershed (southern Québec, Canada). This paper examines their conservation value for these different taxonomic groups at the watershed level and the possible effects on wildlife of various landscape modification scenarios. The overall species richness and insectivorous bird abundance in the watershed would increase markedly if there were more wooded strips in the landscape mainly due to additional plant and bird species. A scenario where all three types of riparian strips would be well-represented in the watershed is most likely to be implemented. This scenario would be the most beneficial to wildlife communities because of high native species diversity within wooded strips combined with the presence of unique species associated with each of the three types of strips. Encouraging landowners to protect existing wooded riparian habitats would be the most effective and cost-beneficial method to maintain current level of habitats distribution in the landscape, and to favour the establishment of new shrubby and wooded strips in the Boyer River watershed.

Keywords: Farmland; Landscape modification; Québec; Riparian habitat; Streambank

1. Introduction

In North America, over 90% of riparian habitats have been lost during the past 200 years (Popotnik and Giuliano, 2000) mostly due to agricultural intensification, which has also contributed to the degradation of the originally forested landscape (O'Neill et al., 1988; Medley et al., 1995; Bélanger and Grenier, 2002). Most small-sized family owned farms have been converted into specialized monoculture production, largely dominated by corn and soybean (Statistics Canada, 1997). These changes have been associated with increased use of agrochemicals (pesticides, fertilizers) and destruction of marginal habitats (hedgerows, riparian habitats, ponds) (Rodenhouse et al., 1995; Ribic et al., 1998). More than 20,000 km

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of original watercourses have been straightened in the St. Lawrence valley of southern Québec (Canada) (Beaulieu, 2001) with significant loss of riparian habitats. Those remaining are submitted to chemical drift (Freemark and Boutin, 1995; Kleijn and Snoeijing, 1997; de Snoo and de Wit, 1998) and physical impacts because the farming community believes that hedgerows, fencerows, and riparian habitats are refuges for pest species (weeds, insects, birds, rodents) (Marshall and Smith, 1987; Jobin et al., 2001; Oreszczyn and Lane, 2001) and are reducing the area of valuable cultivated land.

The originally forested landscape of the Boyer River watershed in southern Québec, Canada, has been converted to an agroforested landscape dominated by cropland, and it is estimated that 70% of its waterbodies have been modified for agricultural purposes (Maisonneuve et al., 2000a). The role of agricultural riparian strips for the conservation of biodiversity is well recognized (Naiman et al., 1993; Iverson et al., 2001; Paine and Ribic, 2002), and communities and species distribution were analysed for plants (Boutin et al., 2003), birds (Deschênes et al., 2003), amphibians, reptiles, and small mammals (Maisonneuve and Rioux, 2001) in the Boyer River watershed. Several species of wetland affinity as well as species typical of forest habitats were found in the studied habitats. However, the role of riparian strips for the conservation of biodiversity as a whole in agricultural landscapes still has to be examined at the watershed level.

This paper aims to evaluate the ecological roles that remaining riparian strips may play in the landscape with an emphasis on conservation of native species. Data on land-use, riparian strip distribution, and wildlife use of these habitats have been tallied for the Boyer River watershed to allow predictions to be made on how biodiversity may vary with different levels of change in riparian strip distribution. The objectives of this paper were to (1) analyse the value of different types of riparian strips for the conservation of several taxonomic groups, (2) illustrate how different landscape modification scenarios for riparian habitats (status quo, intensification or reduction in agricultural activities, restoration programs) may affect the distribution of species (or groups of species) and (3) recommend riparian habitat management practices which benefit both wildlife and farmers.

2. Methods

The Boyer River watershed (46°46′N, 70°57′W), a major tributary of the St. Lawrence River, is located at about 30 km southeast of Québec city, southern Québec, Canada (Fig. 1). It covers 217 km^2 and supports 345 km of watercourses. Over 60% of the land is cultivated with forage and pasture dominating the landscape, with increasing corn and cereal crops over the last decades. Hog farms are widespread in the region and runoffs from these farms have contributed to make the Boyer River one of Québec's most polluted rivers. The original forests were dominated by sugar maple (*Acer saccharum*), beech (*Fagus grandifolia*), and birch (*Betula alleghaniensis*) with associated herbaceous species such as *Trilium erectum*, *Smilacina racemosa*, *Erythronium americanum*, and *Dryopteris spinulosa*, among others (Grandtner, 1966). Today, forests and woodlots cover only 28% of the watershed, the rest being built-up areas, peatlands, abandoned farmland, riparian strips, and hedgerows. Besides rivers and streams, remaining wetlands now largely consists of farm ponds and peatland pools (Maisonneuve et al., 2000a).

Riparian habitats were identified on topographic maps (1:20,000) and on aerial photographs (1:15,000, taken in 1990). Thirty-five 600 m long, homogeneous sections of riparian habitats were selected, e.g. (a) six grazed strips with livestock access to the watercourse, (b) 11 herbaceous strips dominated by grasses or forbs and devoid of woody species, (c) 12 strips with shrubs <10 m and (d) six strips with trees >10 m. Shrubs and trees growing along riverbanks were of natural origin (unplanted). Grazed strips were only surveyed for bird communities due to logistical constraints and were excluded from the analysis.

Habitat description (width, plant cover) and adjacent land-use of each section were recorded in April 1996. Every section was divided in 100 m intervals and cover (%) of bare soil, grasses, forbs, low and tall shrubs, and trees were visually estimated, along with cover of adjacent crops (see Boutin et al. (2003) and Deschênes et al. (2003) for details). These measures were averaged for each section and compared among strip types with the non-parametric Kruskal–Wallis test.

The vegetation of all selected strips was surveyed during summer 1996 and spring 1997 using two com-

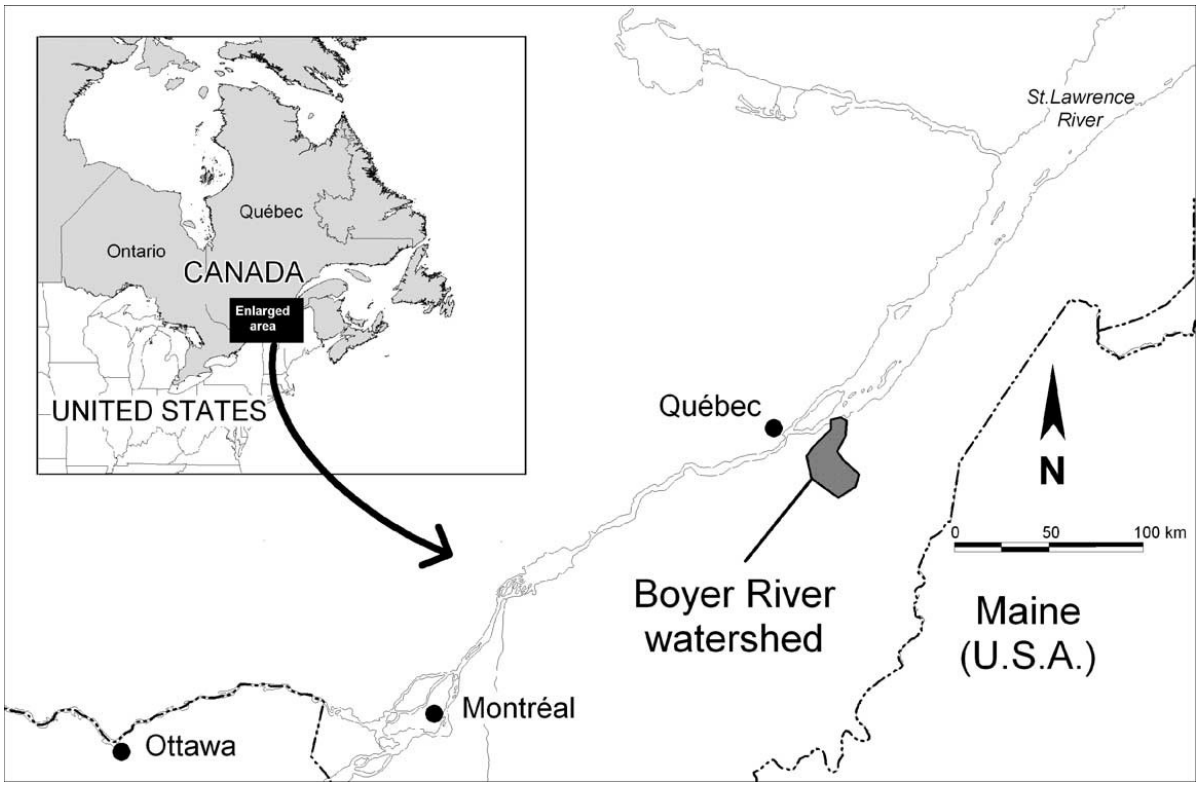

Fig. 1. Map of the study area showing the Boyer River watershed, southern Québec (Canada).

plementary methods (Boutin et al., 2003). The first performed during summer 1996 consisted of a quantitative assessment of 1 m^2 quadrats positioned along three transects at both ends and in the middle of each section. Each transect had at least two quadrats, one adjacent to the crop, one to the waterbody, and a third in the centre of wide strips with shrubs and trees. The vegetation present in the herbaceous layer was inventoried and cover assessed per species in each quadrat. The second method performed in summer 1996 and spring 1997 consisted of walking several times through each selected strip and list all the plant species present, regardless of abundance. This second method was better suited for recording the patchy and ephemeral spring vegetation. Species were divided into several categories including lifespan (annual, biennial, perennial), native or introduced, wetland affinity (upland, facultative or obligate wetland species; following Gauthier, 1997), and weediness. For this latter category, plants were classified as (1) noxious weeds if listed in the Québec's Noxious Weed Act (*Lythrum salicaria* was included in this list), (2) other unwanted plants in pastures (other weeds) and (3) non-weed species.

Amphibians, reptiles and small mammals were surveyed in six herbaceous, six shrubby and six wooded strips (Maisonneuve and Rioux, 2001). Snap traps, Sherman live traps and pitfall traps were placed alternatively every 10 m along transects parallel to the water and were operated for five consecutive nights in September 1995 and 1996. Drift fences were used in spring, summer and fall of 1996 and 1997 to record amphibians, reptiles and additional small mammals. They consisted of jute fences installed parallel to streams with pitfall traps flush to the ground level placed every 10 m. Funnel traps were also placed along the fences.

Birds were surveyed in May/June 1996 along each selected strip (Deschênes et al., 2003) using the transect method (Bibby et al., 1992). Seven bird counts were conducted and any bird heard or seen every 100 m in the riparian strip, within 25 m from the strip in the adjacent fields, and on the watercourse was recorded. Species were classified according to their

(1) potential to cause damage to crops in southern Québec, (2) migratory status and (3) population trends (see Deschênes et al., 2003).

2.1. Landscape modification scenarios

Every riparian strip visible on the aerial photographs and located in agricultural settings (excluding forested areas) was delineated and adjacent land-use identified. Strips located on each side of watercourses (rivers, streams, drainage ditches) were counted as separate habitats and were categorized as (1) herbaceous-dominated, (2) shrub-dominated, or (3) tree-dominated. Each strip was drawn on 1:20,000 maps, and the length of each segment was calculated with a curvimeter, and summed for each category.

To assess how each taxonomic group might be impacted by large-scale changes in riparian habitat distribution, the following landscape modification scenarios were considered: (1) all riparian strips transformed into either herbaceous, shrubby or wooded strips; (2) only two types of strips equally represented in the landscape; (3) all three types with similar relative importance over the whole watershed. Considering no other change in the landscape matrix, the scenarios were compared to the current strip distribution in terms of species richness of each taxonomic group within each type of riparian strip. The mean species richness of each group for each scenario was estimated by multiplying the mean species richness within a given strip type with the strip's relative importance in the watershed. Quantitative changes in insectivorous birds (following De Graaf et al., 1985) and in birds potentially detrimental to crops and foraging in the first 25 m in adjacent crops (Jobin et al., 2001; Deschênes et al., 2003) were also estimated.

2.2. Data analysis

Species richness and abundance were tallied for each taxonomic group and for each section. Species found in only one type of riparian strip (thereafter "unique species") were described according to set categories (migratory status, weediness, etc.). Sørenson similarity indices (Jongman et al., 1995) were calculated for each taxonomic group and for each pair of strip within each strip type to evaluate homogeneity with respect to species composition. Mean indices were compared among strip types using analysis of variances followed by the Tukey–Kramer test for pairwise comparisons.

3. Results

Hayfields and pastures were the dominant (>75%) cropfields abutting shrubby and wooded strip whereas hayfields (46%), cereals/corn (22%) and oldfields (18%) were adjacent to herbaceous strips (Table 1). Wooded strips were generally wider than herbaceous or shrubby strips, and adjacent watercourses were also wider along wooded strips. Cover of the different vegetation types followed the a priori classification of riparian habitats. Dominant plant species in herbaceous strips included several obligate (obl) and facultative (fac) wetland species such as *Phalaris arundinacea* (fac), *Bromus inermis*, *Galium palustre* (obl), *Calamagrostis canadensis* (fac), *Impatiens capensis* (fac), *Eupatorium maculatum* (fac), *Polygonum hydropiper* (obl) and *P. sagittatum* (obl), *Poa* spp., *Aster* spp., and *Solidago* spp. *Prunus virginiana*, *Spiraea latifolia*, *Rubus idaeus*, *Cornus stolonifera* (fac), and *Alnus rugosa* (fac) were commonly found in shrubby strips whereas the most abundant tree species growing in the selected strips were *Acer negundo*, *Salix* sp. (fac), *Fraxinus* sp., *A. saccharum*, *Prunus virginiana*, and *Populus tremuloides*.

Species richness and abundance increased from herbaceous strips to highly structured wooded strips, and this pattern was observed for plants (both herbaceous and woody species; Boutin et al., 2003), birds (Deschênes et al., 2003) and small mammals (Maisonneuve and Rioux, 2001). The abundance of amphibians and reptiles increased with vegetation complexity, but more species were observed in shrubby strips (Maisonneuve and Rioux, 2001). Average pairwise Sørenson similarity indices for every taxonomic group were higher in wooded strips suggesting that communities were generally more homogeneous than in shrubby and herbaceous strips (Table 2).[1]

Some species were observed in only one type of riparian habitats, 65 in wooded, 28 in shrubby and 19

[1] The list of all recorded species is available by request to the first author.

Table 1
Habitat characteristics of three types of riparian habitats studied in the Boyer River watershed, southern Québec (Canada), 1995–1997[a]

	Herbaceous ($n = 11$)		Shrubby ($n = 12$)		Wooded ($n = 6$)		Kruskal–Wallis	
	Mean	S.E.	Mean	S.E.	Mean	S.E.	H	P
Width (m)								
Riparian habitat	3.4 a	0.2	3.7 a	0.4	19.2 b	3.2	13.8	0.0010
Adjacent watercourse	2.8 a	0.6	1.9 a	0.2	15.3 b	3.7	13.3	0.0013
Cover (%)								
Bare soil	0.2 a	0.2	0.0 a	0.0	0.3 b	0.3	1.8	0.4068
Grass species	58.4 a	7.4	20.4 b	2.6	14.9 b	5.1	16.8	0.0002
Forbs	33.6 a	6.3	14.5 bc	1.4	16.4 ac	1.9	6.1	0.0473
Shrub < 2 m	7.4 a	2.2	39.0 b	5.2	15.4 c	3.3	17.9	0.0001
Shrub > 2 m	0.3 a	0.2	25.6 b	7.0	15.7 b	3.1	17.3	0.0002
Trees > 10 m	0.1 a	0.1	1.1 b	0.3	37.4 c	5.2	20.8	<0.0001
Adjacent crop (%)								
Hay	46.2 a	13.0	59.7 a	13.2	68.1 a	15.6	1.3	0.5344
Corn	6.8 a	6.8	6.3 a	4.2	0.0 a	0.0	1.1	0.5822
Cereals	15.2 a	6.6	3.5 a	2.8	4.2 a	4.2	2.1	0.3560
Pasture	13.6 a	9.7	18.1 a	10.6	19.4 a	16.3	0.6	0.7563
Ploughed	0.0 a	0.0	1.4 a	1.4	0.0 a	0.0	1.4	0.4925
Oldfield	18.2 a	12.2	11.1 a	7.8	8.3 a	8.3	0.1	0.9529

[a] Different letters following means in the same row indicate significant differences, pairwise comparisons with Mann–Whitney test.

in herbaceous strips. Six woody plant species were only observed in shrubby strips, 14 tree and shrub species in wooded strips and none in herbaceous strips. A total of 15 herb species were unique to herbaceous strips, 16 to shrubby and 34 to wooded strips (Fig. 2). Species unique to herbaceous strips were mainly weeds, annuals and introduced species, most unique species observed in shrub or tree-dominated strips were non-weeds, perennial and native species. Unique wetland-associated species were marginally better represented in wooded strips. One amphibian species (yellow-spotted salamanders, *Ambystoma maculatum*) only occurred in a shrubby strip, and one species of small mammal (eastern chipmunk, *Tamias striatus*) was only observed in a wooded strip. Fifteen species of birds were observed in only one type of habitat, 2 in herbaceous, 2 in shrubby, and 11 in wooded strips. Most species only observed in

Table 2
Mean (S.E.) Sørenson similarity indices calculated for each pair of strip among the various riparian strips and for each group considered in the Boyer River watershed, southern Québec (Canada), 1995–1997[a]

Taxonomic group	Herbaceous ($n = 11$ strips)	Shrubby ($n = 12$ strips)	Wooded ($n = 6$ strips)	ANOVA	
				F	P
Herbs + woody spp.	0.53 (0.01) a	0.57 (0.01) b	0.60 (0.01) b	9.23	0.0002
Herbs only	0.55 (0.01) a	0.57 (0.01) ab	0.60 (0.01) b	5.24	0.0065
Woody spp. only	0.38 (0.03) a	0.57 (0.01) b	0.59 (0.02) b	27.15	<0.0001
Birds	0.41 (0.03) a	0.51 (0.01) b	0.69 (0.02) c	19.47	<0.0001
Amphibians/reptiles[b]	0.40 (0.07) a[c]	0.45 (0.03) a	0.59 (0.04) b	4.83	0.0145
Small mammals[b]	0.69 (0.03) a	0.76 (0.02) ab	0.77 (0.01) b	3.58	0.0367

Number of pairwise comparisons for 12 strips: 66; 11 strips: 55; 6 strips: 15; 4 strips: 6.

[a] Different letters following means in the same row indicate significant differences, ANOVA and Tukey–Kramer honestly significant difference (HSD) test for pairwise comparisons.

[b] Only 6 strips of each type surveyed for this group.

[c] Only 4 strips because 2 strips had 0 species.

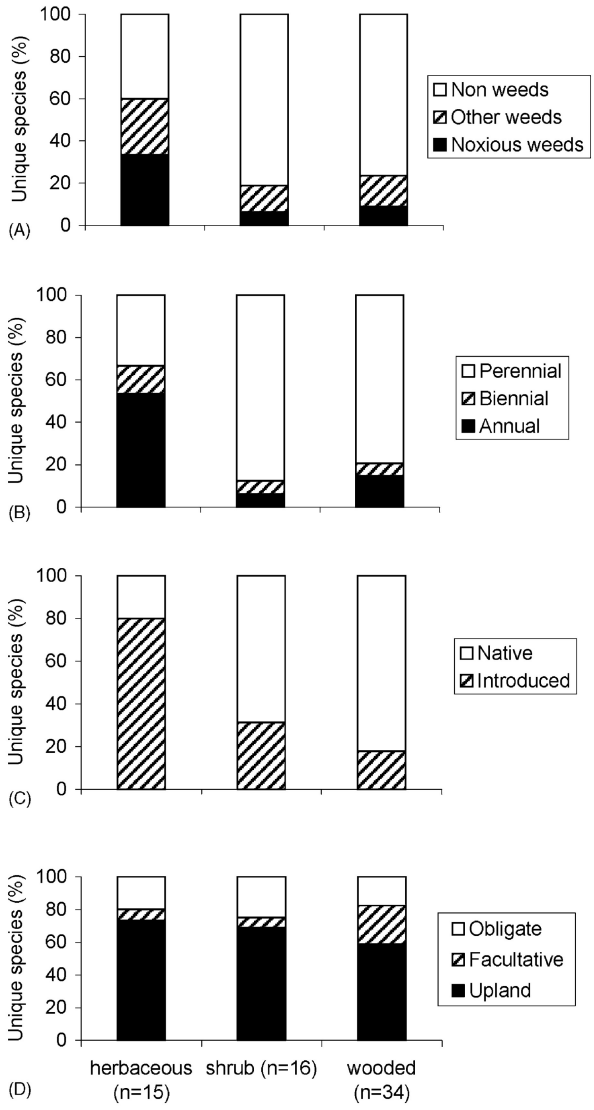

Fig. 2. Relative importance of herbaceous species observed only in herbaceous, shrubby or wooded riparian strips in the Boyer River watershed in southern Québec according to their (A) weediness status, (B) lifespan, (C) origin and (D) wetland affinity.

the latter were insectivores (e.g. black-capped chickadee, *Parus atricapillus*, least flycatcher, *Empidonax minimus*). An additional 14 species were observed both in tall shrubby and wooded strips, most being also insectivores (e.g. chesnut-sided warbler, *Dendroica pensylvanica*, downy woodpecker, *Picoides pubescens*, red-eyed vireo, *Vireo olivaceus*). Finally, a suite of wetland-associated species were present in the strips (spotted sandpiper, *Actitis macularia*, belted kingfisher, *Ceryle alcion*, alder flycatcher, *Empidonax alnorum*, northern waterthrush, *Seiurus noveboracensis*, common yellowthroat, *Geothlypis trichas*) and these were mostly observed in wooded strips.

Over 86% (385 km) of all riparian habitats situated within farmlands in the Boyer River watershed were categorized as herbaceous-dominated. Only 4% were bordered by shrubby vegetation, and tree-dominated strips represented 10% of all riparian habitats. Based on the current distribution and extent of riparian habitats in the watershed, the estimated mean species richness in each taxonomic group varied according to the scenarios of varying proportions of herbaceous, shrubby and wooded strips over the watershed (Fig. 3). More shrubby strips in the landscape would slightly increase the total number of species, mostly due to an increased number of woody species. The total species richness of the strips would increase markedly if more wooded strips were encountered in the landscape because plant and bird species would be more numerous. Mean species richness in all strips of the watershed would be nearly doubled if all strips were wooded as compared to the current situation.

Compared to the current situation, the total number of insectivorous birds using riparian strips would increase eight-fold (up to approximately 30,000 individuals) if all riparian habitats were converted into wooded strips (Fig. 4a). Fewer insectivores would be present in the strips if they were all grass-dominated. Insectivore abundance would increase three-fold if all three types of strips were equally distributed in the watershed. Birds potentially detrimental to crops would be slightly more abundant (3900 individuals) in the first 25 m of adjacent crops if all strips were converted into herbaceous strips than in the current situation (3500 birds) (Fig. 4b). The estimated abundance of these species would be reduced if the three types of strips had equal distribution in the landscape (2750 birds) or if all were wooded strips (1700 birds). According to the scenario where all habitats would be converted into herbaceous strips, pasture weeds and crop-damaging rodents would most likely increase in abundance because of their prevalence in grassy habitats (Maisonneuve and Rioux, 2001; Boutin et al., 2003).

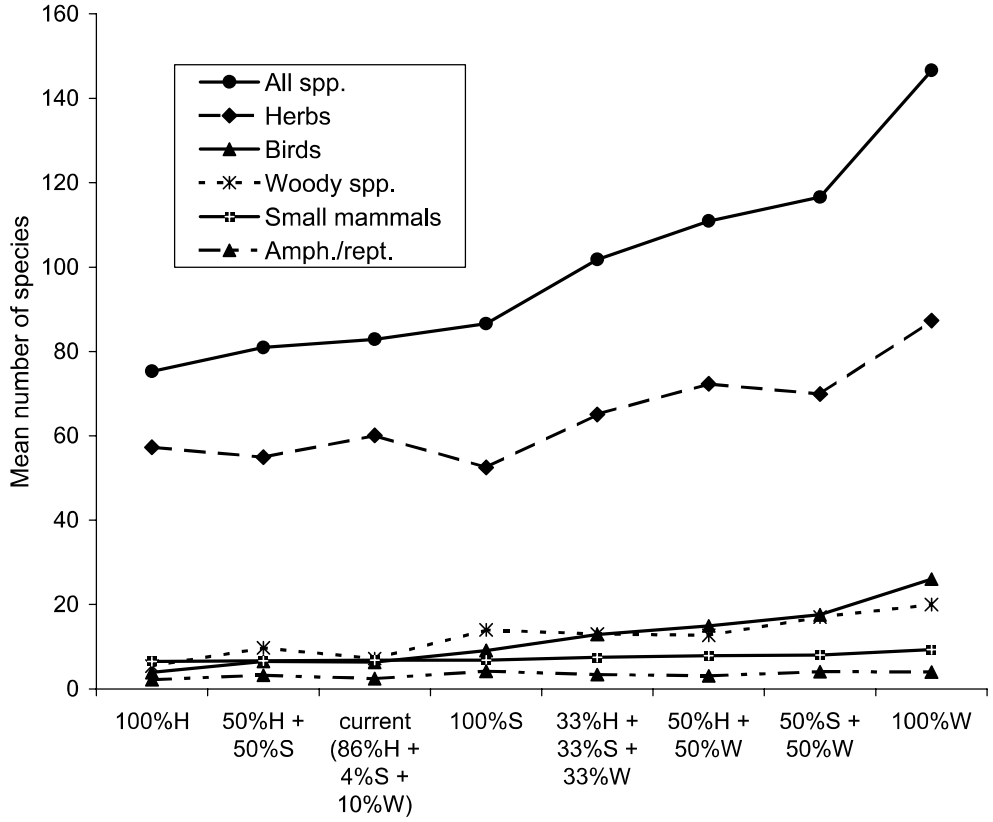

Fig. 3. Mean species number of different taxonomic group expected in riparian habitats according to different scenarios of habitat distribution in the Boyer River watershed, southern Québec (Canada) (H: herbaceous; S: shrubby; W: wooded).

4. Discussion

The surface area covered by riparian habitats was generally low (<2%) relative to the Boyer River watershed area. However, their conservation value was highlighted in intensive agricultural landscapes with little forested habitats because woody riparian strips and hedgerows may represent the sole remnants of woody habitats available to wildlife (Fuller et al., 2001). Native species contribute to the biodiversity pool of the local plant community (Paine and Ribic, 2002) and, although forest-interior species may not find suitable conditions in linear woody habitats (Fritz and Merriam, 1994), forest-dwelling species may find shelter in riparian habitats and hedgerows (de Blois et al., 2002; Freemark et al., 2002). Following subsurface drainage over past decades, riparian habitats constitute most of the remaining wetlands in the Boyer River watershed (Maisonneuve et al., 2000a). Consequently, these habitats are highly valuable to wetland-associated species which thrive in agricultural landscapes (Naiman et al., 1993; Renfrew and Ribic, 2001). The fauna and flora were generally more homogeneous among wooded strips than among herbaceous and shrubby strips, and the former represent a more stable environment compared to the latter two types of strips. The observed species distribution patterns may be related to the larger size of wooded strips, but sampling effort was similar among the three types of strips for all taxonomic groups except for plants which were looked for more thoroughly in wooded strips.

Many insectivorous birds only observed in shrubby and wooded habitats were neotropical migrants showing rangewide population declines (Askins, 1993). Although their density was low, these strips provided suitable breeding sites (Hafner and Brittingham, 1993; Deschênes et al., 2003), and were used as migration stopovers (Johnson and Beck, 1988; Fuller

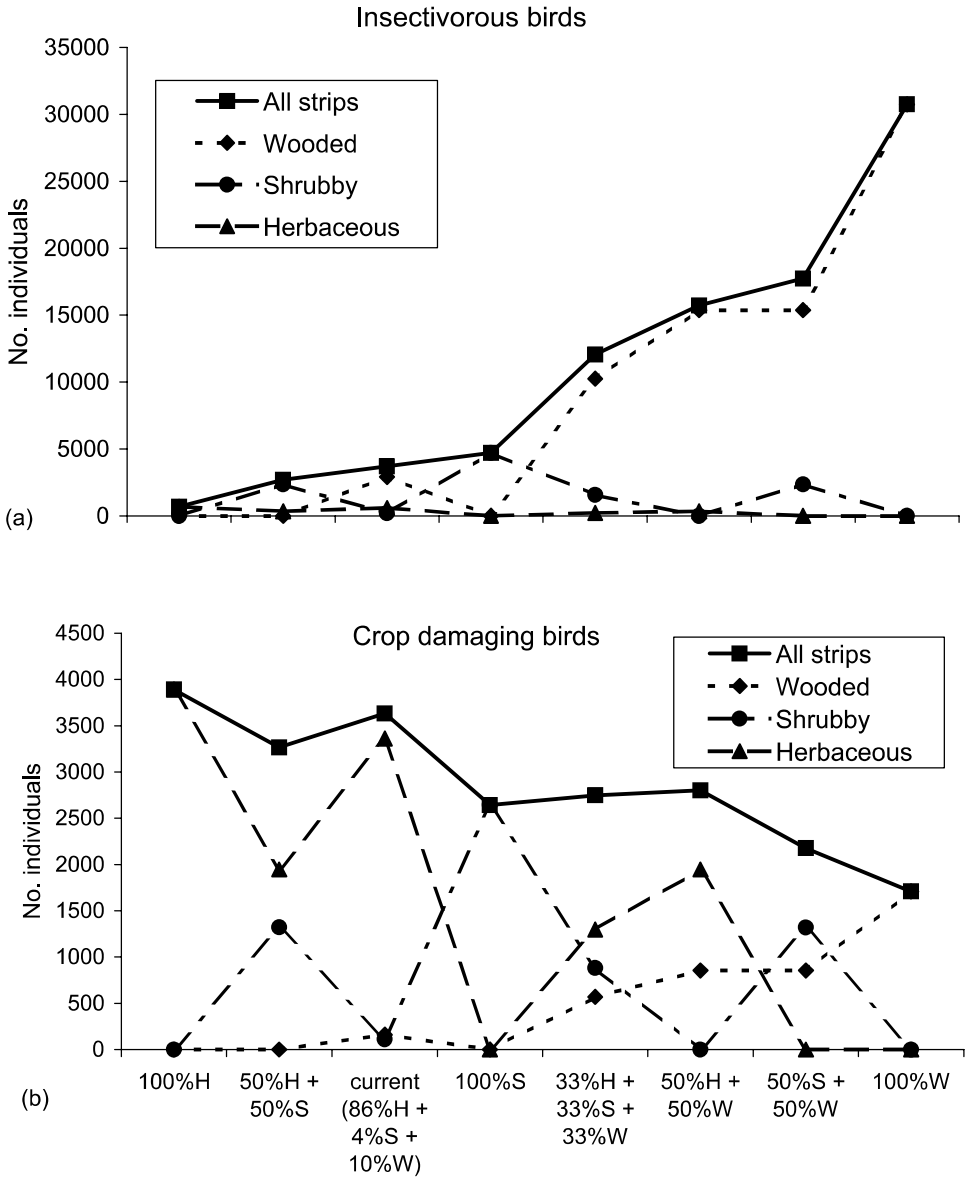

Fig. 4. Estimated number of (a) insectivorous birds in riparian habitats and (b) crop-damaging birds according to different scenarios of habitat distribution in the Boyer River watershed, southern Québec (Canada) (H: herbaceous; S: shrubby; W: wooded).

et al., 2001). In addition, most unique plant species observed in highly structured wooded habitats were non-weeds, perennial and native whereas most of the unique species found in grass-dominated habitats were introduced weed species. Regular mowing and herbicide treatments greatly reduced species diversity and favoured the proliferation of weed species in grassy strips (Marshall and Smith, 1987; de Snoo, 1997; Kleijn and Snoeijing, 1997; Boutin et al., 2001).

Attempting to predict wildlife community responses to habitat changes according to different landscape scenarios provided insights into possible species turnover in the community. This method was previously used to simulate effects of shelterbelt agroforestry practices on wildlife conservation (Pierce

et al., 2001), to determine breeding bird and small mammal responses to alteration of wooded riparian strips (Best et al., 1979; Stauffer and Best, 1980) or to transformation of a monoculture-oriented landscape into a mosaic of crop and non-crop habitats (Best et al., 1995), and to evaluate the response of plant diversity at the landscape scale along a gradient from crop and herbaceous non-crop habitats to an heterogeneous landscape (Freemark et al., 2002). These studies have demonstrated an increase of local biodiversity with the presence of a diverse array of wooded habitats in the landscape. Water quality improvement has also been modelled with respect to landscape scenarios under various farming practices and riparian buffer delimitations (Vaché et al., 2002).

A scenario with wooded strips only throughout the watershed is unlikely because farmers' concerns about wildlife, soil, and water conservation are outweighed by economic concerns which dictate to maximize cultivated acreages. On the other hand, even under the high-intensity agricultural production scenario, some wooded strips would always remain along steep riverbanks unsuitable for agriculture. A scenario where the three types of riparian strips would be well-represented is therefore most likely. This scenario would be the most beneficial to wildlife communities because of high species diversity within wooded strips combined with the presence of all suites of unique species associated with each of the three types of strips (Freemark et al., 2002). In addition to providing suitable habitats for several species associated with wetlands and woody habitats, ecological benefits associated with a wider distribution of wooded strips in the watershed would be numerous. Not only do they act as windbreaks, they also help reducing agrochemical surface runoff from adjacent cropfields into watercourses (de Snoo and de Wit, 1998) and improving water quality (Muscutt et al., 1993; Vaché et al., 2002) with associated benefits to aquatic plants (Gustafson and Wang, 2002), invertebrates (Euliss and Mushet, 1999), and fish (Wang et al., 2002). Additional wooded strips would reduce the abundance of crop-damaging bird species foraging in adjacent cropfields during the breeding season (Deschênes et al., 2003), augment connectivity among habitats and favour species dispersal (Bennett, 1990; Bunce and Howard, 1990), and provide additional quality nesting habitats for waterfowl (Maisonneuve et al., 2000b).

5. Conclusion

Although restoration programs of wildlife habitats do exist in the Boyer River watershed, there is no clear management objectives with respect to riparian strips. Encouraging landowners to protect existing wooded riparian habitats should be the first target in such a program at the watershed scale because it is the most effective and cost-beneficial method to maintain the current level of shrubby and wooded strips distribution. Riparian buffers 5–10 m wide would be sufficient for forbs, shrubs and trees to naturally establish and reduce agrochemical drift into adjacent watercourses (de Snoo and de Wit, 1998). Although this option can be easily implemented at low cost, it requires long-term objectives for natural communities to establish (Homyack and Giuliano, 2002). Promoting shrub and tree plantation along river and stream banks is expensive but provides first hand environmental and agronomic benefits. A combination of approaches including fencing and plantation has been set in place in the Boyer River watershed where more than 80 km of riparian habitats have been restored since 1998, and other projects are scheduled to take place in the coming years.

Conservation planning must be developed over large land units such as the watershed scale for environmental gains associated with local conservation incentives to be realized (Wang et al., 2002). Farming practices adopted by farmers are governed by farm traditions and economics (Medley et al., 1995; Jacobson et al., 2003), but their attitude and behaviour toward conservation actions are dictated by their knowledge and level of information (Lichtenberg and Zimmerman, 1999). Reliable information is essential for landowners and land planners to contribute in the recovery of their regional ecosystem under optimal management (Miller and Hobbs, 2002). Local newspaper articles, press releases and public information sessions are effective tools to increase the general public awareness on environmental problems (Lichtenberg and Zimmerman, 1999), as are government financial incentives to engage farmers in conservation actions (Jacobson et al., 2003). The Québec's Ministry of Agriculture (MAPAQ) has produced a brochure encouraging farmers to protect riparian habitats on their land because of the critical role they play in improving environmental welfare and wildlife habitats (Gonthier

and Laroche, 1992). Such public awareness has had immediate results in the Boyer River watershed and upcoming conservation projects are promising.

Acknowledgements

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