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Avian Use of Dairy Farm Ponds and Landowners' Perceptions of Their Management for Wildlife Conservation

Luc Bélanger [1,*], Charles Maisonneuve [2] and Jean Rodrigue [1]

[1] Canadian Wildlife Service, Environment and Climate Change Canada, Québec, QC G1J 0C3, Canada; jean.sonia@videotron.ca

[2] Direction de la Recherche sur la Faune, Société de la Faune et des Parcs du Québec, Ministère des Forêts de la Faune et des Parcs du Québec, 675 boul. René-Lévesque Est, ler Étage, Québec, QC GIR 5V7, Canada; charlaigle@gmail.com

* Correspondence: blanger.luc@gmail.com

Simple Summary: Because of the ongoing intensification of agriculture and a trend towards urbanization in all rural landscape types of the St. Lawrence Valley lowlands (Southern Quebec, Canada), farm ponds are among the last remaining lentic wetland habitats. The sound ecological management of their surrounding vegetated areas may become very important for the conservation of regionally declining biodiversity. However, their wildlife value is often poorly documented. Moreover, little is known about farmers' perceptions concerning the presence of these ponds on their lands or their willingness to maintain them to enhance greater wildlife use. Using birds as biodiversity indicators and conducting a survey of ponds' landowners, we studied dairy 61 farm ponds located in rural landscapes of the St. Lawrence Valley lowlands in Southern Quebec, Canada. Bird use was positively related to the area of adjacent fallow land and to the width of riparian strips; however, the areas of annual crops, forests, and farm buildings had a negative influence. Most farm pond landowners were in agreement with efforts to promote wildlife on their lands, particularly if they were given support from an external partner organization. Widening riparian strips and leaving adjacent uncultivated field margins around ponds would benefit several regionally declining farmland bird species.

Abstract: Farm ponds are among the last remaining lentic wetland habitats in human-dominated agricultural and suburban landscapes. However, their wildlife value and farmers' willingness to maintain them for the conservation of regionally declining biodiversity are often both poorly documented. The objectives of this study of 61 dairy farm ponds located in Southern Quebec (Canada) were to (1) describe their biophysical features and birds' use, (2) determine habitat and landscape characteristics that influence the bird community, and (3) assess the willingness of farmers to support wildlife use. The studied ponds were small (0.17 ha) and had rectangular shape with rocky/muddy steeply slopes (21°), surrounded by 3 m wide riparian strips and pastures, hayfields, and fallows. They were located about 300 m from farmhouses, buildings, streams, and adjacent ponds. A total of 1963 individuals belonging to 46 bird species were observed. The abundance of all bird species, of species with declining populations, and of crop damaging species were positively related to the area of fallow land and to the width of riparian strips; the areas of cereals and of mixed-wood forest had a negative influence. Only two habitat variables had influence on species richness: the width of riparian strips (+) and the distance to the closest farm buildings (–). Most pond landowners (>80%) were in favour of increasing wildlife use if they were given access to associated financial support and logistical assistance. Wider riparian strips and adjacent uncultivated field margins are recommended.

Keywords: agriculture; biodiversity; birds; Canada; farm ponds; rural landscapes

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1. Introduction

Agricultural intensification leading to an increase in land clearing for urbanization and other anthropogenic needs in rural areas has resulted in the fragmentation, loss, and

degradation of most natural non-cropped habitats. This, in turn, has had negative effects on biodiversity, including the diversity of birds [1–3]. Thereby, 74% of grassland species are declining, the largest magnitude of total population loss among the North American avifauna [4], whereas the populations of 57 of 77 farmland-associated bird species have decreased since the 1960s as a result of rapid changes in farming practices to low tillage systems, heavy pesticide use, and widespread conversion of grassland habitat to cropland in North America [5].

A lot of attention has been devoted to sound agroecological management of the residual natural terrestrial habitats on agricultural land (such as hedges and riparian strips), in order to prevent soil erosion, maintain water quality, and provide additional habitats for biodiversity [6,7]. Given the alarming loss of wetlands in human-dominated areas, more attention has also been focused on farm ponds, which are often the only remaining lentic freshwater habitats in drained agricultural landscapes [8,9]. It has been estimated that there are millions of farm ponds across the eastern Great Plains region of the United States alone [8,9]. Although individually small in size, farm ponds thus collectively represent a very significant acreage of potential habitats.

Several authors have shown the wildlife value of natural, semi-natural, and man-made farm ponds, in Asia, Europe, and North America [10–16]. These studies have demonstrated the role of ponds' intrinsic biophysical characteristics (area, shape, water depth, etc.) and extrinsic landscape settings (location and connectivity) as well as the importance of effective management (mechanical control of aquatic and riparian vegetation, periodic drying, etc.) in order to maximize their value for biodiversity, notably for declining farmland bird species [17–20]. In order for farm ponds to help mitigate biodiversity loss associated with the extensive wetland destruction in rural areas, there is still an urgent need to increase our understanding of environmental features that influence their use by wildlife, as this will inform pond management and conservation actions [16].

Farm ponds are usually located on privately owned agricultural land and, consequently, the traditional legal protected areas strategy, e.g., purchase and protect, does not apply to them. Indeed, an approach geared more to stewardship conservation needs to be considered since farmers as primary stakeholders can positively influence biodiversity, ecosystem services, and agronomic outcomes in a shared perspective of sustainable agriculture [20–23]. Therefore, significant long-term efforts to focus on the conservation of farm ponds depend on having a good understanding of the perceptions that farmers have of these ponds and their willingness to help manage them for wildlife. Applying conservation social science in order to understand the motivations and needs of farmers, along with the constraints they face, is thus an essential element in the success of any wildlife conservation initiative, policy, or practice [11,19].

About 3600 ha of wetlands have been lost or degraded due to agricultural operations over the last few decades in the St. Lawrence Valley of Southern Quebec, Canada; more than 45,000 kilometres of small streams have been straightened and excavated to improve drainage of about 1.5 million ha of lands. Today, marshes and shallow waters cover less than 2% of the area [24], and farm ponds are often the only remaining lentic wetland habitats. Many of these ponds, originating mostly from natural wet depressions that have accumulated snow melt and spring run-off water over the years, have been modified to meet various human needs such as water reservoirs for irrigation, stock watering for livestock, fire prevention for buildings, and sewage water treatment. Some have also been created and are used for the rearing of domestic ducks or simply to add aesthetic value to the farm property.

There is no reliable estimate of the total number of farm ponds in Southern Quebec. They are thought to be more common in areas where more traditional market gardening and dairy farming predominate, and there are no quantitative data on their use by wildlife or on the biophysical and landscape features that would influence wildlife use. The objectives of this study were, therefore, to (1) determine the overall biophysical characteristics of the farmland ponds surveyed, (2) assess their use by birds, particularly declining species,

(3) determine pond habitat features and landscape settings influencing avian use, and (4) assess the willingness of farmers to support the conservation of wildlife associated with their ponds. In this study, birds were used as an overall biodiversity indicator since they play an important role in ecosystem health and functioning, they show community responses to environmental conditions, and they can be easily detected.

2. Materials and Methods

2.1. Study Area

Our study took place in the St. Lawrence Valley lowlands (46°06′ N, 70°96′ W), which corresponds to the Quebec portion of the Lower Great Lakes/St. Lawrence Plain Bird Conservation Region in Southeastern Canada (Figure 1). Today, this region of approximately 34,000 km^2 consists of highly heterogeneous and fragmented rural landscapes (intensive agriculture, traditional dairy farming, agroforestry, suburban, etc.). It represents one of Canada's largest human-dominated agroecosystems with close to 7 million peoples living there [25,26].

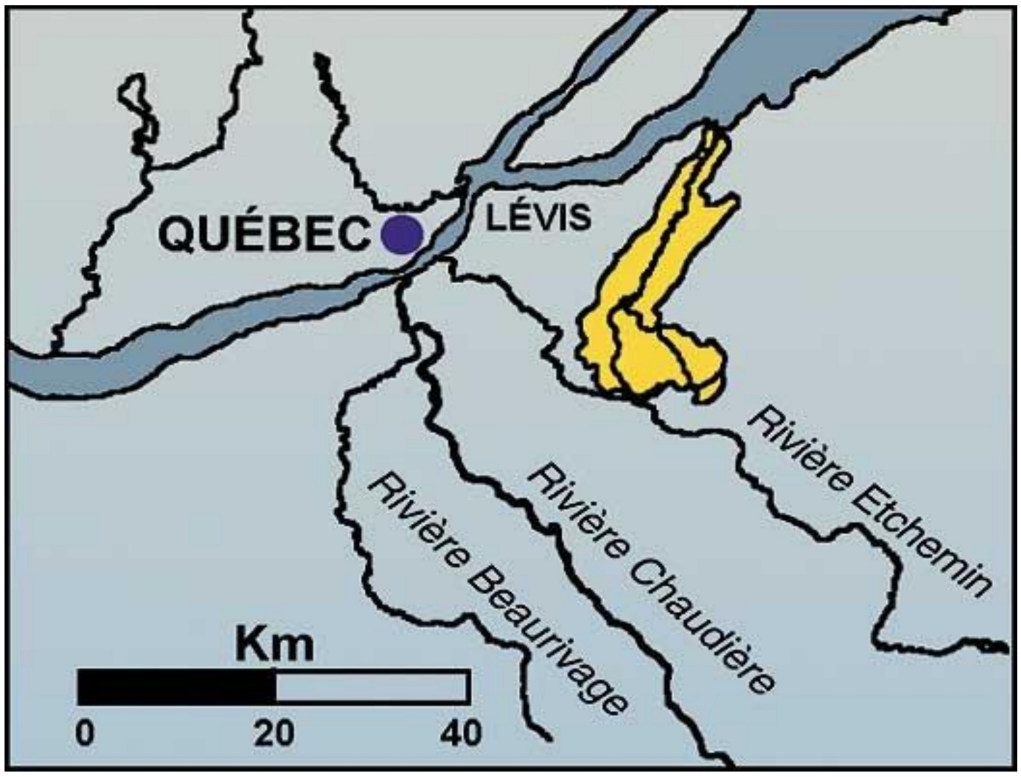


Figure 1. Location of the Boyer River watershed (46°53′ N, 70°51′ W), St. Lawrence Valley lowlands, Southern Quebec (Canada). From: https://www.environnement.gouv.qc.ca/milieu_agri/pratiques-agri/boyer/intro.htm (accessed on Fall 2020).

Because of the ongoing intensification of agriculture (conversion of pasture and forage lands to annual crops, large-scale drainage works, etc.) and a trend towards urbanization in all landscape types found there [27], there is only a small amount of residual natural land cover [28]. Consequently, it is one of the Canadian regions where biodiversity is most at risk, and has one of the lowest index values of wildlife habitat capacity on agricultural land [28]. Of the 240 bird species that occur in this area, 68 species have been identified as priority species in the Lower Great Lakes/St. Lawrence Plain Bird Conservation Region in Southeastern Canada due to their rarity (22 species with at-risk status) or because they are representative of this ecological region. Bird species of open and agricultural habitats there are considered to be those experiencing the most severe declines in abundance and probability of observation [29,30].

To conduct this study, we selected the Boyer River watershed (46°53′ N, 70°51′ W) which is located on the south shore of the St. Lawrence River near Quebec City (Figure 1). This river's hydrographic network comprises a total 345 km of streams and brooks, more than 70% of which have been affected by extensive drainage work. Farmland covers more than 65% of this 217 km^2 watershed, whereas woodlots and wooded hedgerows account for 23% of the surface area. Wetlands are scarce (0.6%) and consist almost exclusively of peatlands. This sector of Southern Quebec is characterized as a traditional dairy farming landscape [6].

In all, 275 dairy farms and a few pig farms account for more than 13,000 ha of agricultural land in the study area. Forage crops are the dominant type of production (43%), followed by cereal crops (14%) and cornfields (2%). A total of 179 farm ponds were present in this watershed at the time the study began. About a third of all these ponds (61) were ultimately selected for the study based on their accessibility and the landowners' willingness to grant us access to their lands.

2.2. Biophysical Features and Landscape Metrics

In early spring 1996, the length and width of the ponds were measured in the field using a tape measure that was 30 m long, as was the width of the riparian strips surrounding them (i.e., interface between land and water on the edge of farm fields). Percent cover of bare soil, herbaceous, shrub, and wooded layers in the total area of these strips were visually estimated in the field by assessing the rough relative percent cover (0, 25, 50, 75, 100%) covered by the different vegetation categories around the studied ponds. The presence of submerged vegetation, signs of mowing or cutting of riparian vegetation, and the possibility of cattle access to the pond were also noted. Four measurements (corresponding to the four cardinal directions) of bank slopes were also taken at each pond with a clinometer, and the mean value of the measurements was used in subsequent analyses. Finally, the geographical location of each pond was determined using Global Positioning System (GPS) in the field.

We determined the land-use types present (see below) within a 200 m, 500 m, and 1 km cumulative radius of each pond (representing the central point) using four LANDSAT Thematic Mapper satellite images, acquired in 1993–1994, with a pixel size of 30 m (1:50,000 scale). These had previously been classified using the maximum likelihood algorithm, together with training areas defined on the basis of various reference documents related to the agricultural environment, forest habitats, and wetlands. The accuracy of the classification structure based on the calculated confusion matrix was around 86%.

A total of 27 land-use types were defined from these images, and these were aggregated into six main categories (representing a given percentage of total coverage of 100%): (1) cash crops (cornfield, cereals, specialized crops, plowed fields); (2) dairy farming (hayfield, pastureland, old fields, abandoned cultivated land or fallow non-cropped land); (3) forest (deciduous, mixed and coniferous forests, shrub or tree areas under regeneration, and alder stands); (4) anthropogenic (urban development, housing, roads); (5) wetland (deep water, shallow waters, marsh, bogs, submerged vegetation); and (6) other (clouds, unclassified pixels).

Black and white aerial photos (1:15,000) were also used to determine distances between ponds and their position within the hydrology network. The following variables were also evaluated for each selected pond: distance from the closest pond, and the type of water source (i.e., fed directly by a stream or ditch, or isolated and fed by a high-water table and surface run-off).

2.3. Avian Abundance and Richness

Breeding bird surveys were carried out from mid-June to the end of August 1996 and 1997. Ponds were surveyed when weather conditions were favourable, using two approaches: (a) a 10 min passive observation period (point count), followed by (b) an active search made by walking around the pond and beating the vegetation. The passive

observation period enabled us to gather data on breeding birds, and the active search was aimed at flushing hidden or secretive non-singing birds. All birds seen or heard were noted, but birds flying overhead were excluded. When possible (see below), a total of eight visits were conducted at each pond, between sunrise and 10:00 a.m., the period of greatest diurnal bird activity.

Four indicators of bird use were considered: (1) the total bird abundance (i.e., the total cumulative number of birds recorded), (2) the total bird species richness (i.e., the total cumulative number of species recorded per pond during the eight surveys conducted), (3) the total abundance of crop damaging bird species in Southern Quebec (from [31]), and (4) the total abundance of declining bird species based on their population trends index in Southern Quebec and Eastern North America (from [32]).

2.4. Origin and Farm-Related Use of Ponds

A landowner survey was also carried out during face-to-face encounters with farmers between July and October 1995–1996 to obtain details about the origin and uses of ponds. Questions asked during the visits targeted the following type of information: date of creation or of modification of the pond, past and farm-related use at the time of the study, and their perception of wildlife conservation, related crop damage, and their willingness to manage their ponds for agronomic and wildlife benefits.

2.5. Statistical Analyses

We performed statistical analyses using the STATIST1X (version 2.2) (Analytical Software, Tallahassee, FL, USA), and SAS (version 8.0) software (SAS Institute Inc., Cary, NC, USA). The significance probability level was set at $\leq$0.05. The Shapiro–Wilk test was first used to check the normality of all bird-related and biophysical data. Log or square transformations were applied to dependent and independent variables. We checked for multicollinearity among continuous variables using the correlation matrix. If a correlation existed, one of a pair of strongly correlated variables was removed ($r > 0.75$).

The distribution of answers between various categories for each question asked of landowners was compared with the expected proportions using the chi-square test. For continuous variables, a multiple linear regression was used to investigate the influence of habitat and landscape continuous variables on the species richness and total abundance of the avifauna associated with ponds, as well as on the total abundance of declining species and crop damaging species. The normality of the residual distribution was checked by using the Shapiro–Wilk test.

For some statistical analyses, the number of ponds analyzed was less than 61 because (1) there were missing values for some of the variables (e.g., the year of creation); (2) some ponds could not be surveyed 8 times due to inclement weather conditions; (3) the irregular surface areas of ponds precluded easy calculation based on the length and width measurements; (4) landowners' refusal to respond to one question on the survey.

3. Results

3.1. Origin, Farm-Related Use, and Habitat Features of Ponds

Ponds were dug or created between 1955 and 1994 (Figure 1) mostly through excavation of the soil (50%). Most of them (87.5%) were supplied with water by diverting flow from small brooks located nearby or isolated, fed by a high-water table and surface run-off. (Table 1). Sixty-nine percent of the ponds had a rectangular shape (Table 1), with an average width and length of 36.0 $\pm$ 20.0 m and 40.1 $\pm$ 23.6 m, respectively (Figure 1). They were usually small, covering 0.17 ha on average (Figure 1).

Table 1. Biophysical characteristics of the 61 farm ponds studied in the Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada). Sample size differs for the following variable: the estimated area (n = 52).

VARIABLE	MEAN (±SD)	MINIMUM	MAXIMUM
Length (m)	40.1 ± 23.6	5	108
Width (m)	36.0 ± 20.0	3	100
Area (m^2)	1666.5 ± 1385.7	18	7600
Riparian strip width (m)	7.2 ± 13.8	1	99
Slope (degrees)	21.1°	4.3°	33.4°
Vegetal cover (%):			
Herbaceous	78.6	0.0	100.0
Shrubs	3.8	0.0	40.0
Trees	13.4	0.0	100.0
Distance to the closest (m):			
Cultivated field	29.4 ± 129.1	1	1000
Farmhouse	373.6 ± 387.9	8	1500
Farm Building	322.0 ± 364.3	1	1500
Stream	565.7 ± 375.2	1	1001
Pond	286.4 ± 216.5	25	1001
No. of adjacent ponds/radius:			
200 m	0.6 ± 0.7	0	2
500 m	2.2 ± 1.7	0	6
1000 m	5.8 ± 3.0	0	11

Riparian strips around ponds had a mean width of 7.2 ± 13.8 m (Figure 1), but this includes situations where ponds were directly adjacent to a woodlot. When these situations are excluded from the calculations, the mean width of riparian strips is reduced to about 3 m, which represents the common situation. The herbaceous layer covered close to 80% of the area in these strips, and the shrub and wooded layers were much less extensive (Table 1). A number of different terrestrial grasses and low herbaceous plants surrounded the ponds, such as reed canary grass (*Phalaris arundinacea)*, sensitive fern *(Onoclea sensibilis)*, brambles (*Rubus* spp.), and smartweeds (*Polygonum* spp.). The muddy and/or rocky bank slopes were relatively steep (21 ± 4.3°) (Table 2), and aquatic emergent and/or submerged vegetation (mainly cattail (*Typha latifolia*), common duckweed (*Lemna minor*), and water milfoil (*Myriophyllum* spp.)) was present at 56% of the surveyed ponds (Table 2). Nearly half of the owners (48%) said they carried out some mechanical control of the terrestrial vegetation in riparian strips, but almost all of them (92%) did not control emergent or submerged aquatic vegetation (Table 2). Only 53% of surveyed farmers had cattle, and of those 78% did not allow the animals to have access to the ponds (Table 2).

In terms of landscape settings, most ponds were located more than 500 m from the nearest stream, and more than 300 m from the closest farmhouses or buildings (Figure 1). Mean distance to the closest agricultural land was almost 30 m (Figure 1). Distance between ponds varied from a minimum of 25 m to a maximum of 1 km, the average being 286 m. (Table 1). Regardless of the radius considered, a landscape of dairy farms made up of hayfields, pastures, and fallows predominated near ponds (Figure 2).

Table 2. Characteristics of the 61 farm ponds studied in the Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada). Sample size differs for the following variables: pond origin (n = 54) and access to cattle (n = 32).

Variable/Category	%	x^2	df	p
Origin				
Excavated	50.0	16.5	2	≤0.001
Existing depression	40.6			
Other [1]	9.4			
Water source				
Derivation [2]	87.5	34.3	1	≤0.001
Other [3]	12.5			
Pond water supply				
Underground	56.3	0.97	1	>0.05
Ditch	43.7			
Shape				
Rectangular	68.8	20.0	3	≤0.001
Polygonal	14.1			
Square	7.8			
Circular (or oval)	9.3			
Shoreline				
Regular	85.9	32.9	2	≤0.001
Irregular	12.5			
Unknow	1.6			
Bank slope/soil				
Soft/muddy	37.5	19.2	2	≤0.001
Abrupt/rocky	21.9			
Others [4]	40.9			
Terrestrial surrounding vegetation				
Low gramineous	23.4	4.9	2	≤0.05
Forbs	20.3			
Others [5]	56.3			
Aquatic vegetation				
None (bare soil)	43.8	3.0	1	≤0.05
Present (vegetated)	56.2			
Management of riparian strip				
Mechanical (cutting)	54.7	67.6	2	≤0.001
None	29.7			
Chemical or cattle grazing	15.6			
Management of aquatic vegetation				
None	92.2	43.6	1	≤0.001
Mechanical	7.7			
Access to cattle				
No	78.1	10.12	1	≤0.001
Yes	21.9			

[1] Such as natural enlargement and natural weir on small stream. [2] Nearby small stream derivation. [3] Such as the retention of spring flooding waters. [4] Abrupt/muddy and unknown. [5] A mix of various plant species such as Onoclea sensibilis, *Rubus* spp., *Polygonum* spp.

3.2. Avian Use of Ponds

A total of 1963 individuals belonging to 46 bird species were observed (Table 3). The Red-winged Blackbird (*Agelaius phoeniceus)* (19%), Song Sparrow (*Melospiza melodia*) (11%), Savannah Sparrow (*Passerculus sandwichensis*) (10%), Common Grackle (*Quiscalus quiscula)* (9%), and European Starling (*Sturnus vulgaris)* (6%) were the five most abundant species, accounting for more than half (53%) of all bird observations. The birds were present at between 39% to 84% of all ponds studied, depending on the species considered (Table 3). Declining species accounted for 76% of all bird observations, whereas birds considered as crop damaging species in Southern Quebec represented 44%.

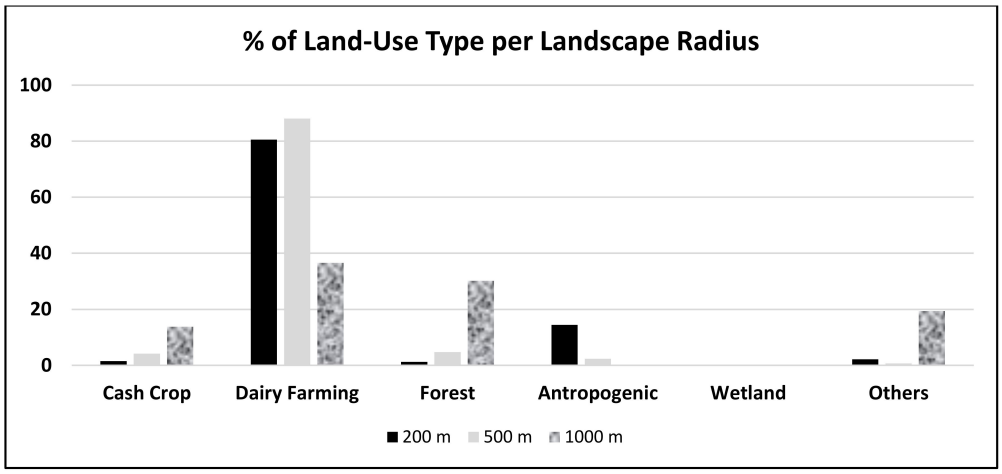


Figure 2. Percentage of land-use type per landscape radius surrounding the 61 farm ponds studied in the Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada). (1) Cash crops (cornfield, cereals, specialized crops, plowed fields); (2) dairy farming (hayfield, pastureland, old fields, abandoned cultivated land, or fallow non-cropped land); (3) forest (deciduous, mixed and coniferous forests, shrub or tree areas under regeneration, and alder stands); (4) anthropogenic (urban development, housing, roads); wetland (deep water, shallow waters, marsh, bogs, submerged vegetation); other (clouds, unclassified pixels).

Table 3. Relative abundance (%) and frequency of occurrence (%) of bird species at the 61 farm ponds studied in the Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada). Abbreviations for declining bird species: Qc (Quebec); ENA (Eastern North America).

Species		Species Feature				Relative Abundance	Pond Occurrence
		Wetland Dependent	Crop Damaging	Declining			
				Qc	ENA		
Red-winged Blackbird	*Agelaius phoeniceus*		X	X	X	19.1	70.5
Song Sparrow	*Melospiza melodia*			X	X	11.0	84.3
Savannah Sparrow	*Passerculus sandwichensis*			X	X	10.0	84.3
Common Grackle	*Quiscalus quiscula*		X		X	9.1	49.0
European Starling	*Sturnus vulgaris*		X		X	6.4	39.2
Spotted Sandpiper	*Actitis macularia*	X			X	4.7	33.3
Cedar Waxwing	*Bombycilla cedrorum*					4.6	29.4
Killdeer	*Charadrius vociferus*			X		4.2	49.0
Bobolink	*Dolichonyx oryzivorus*			X	X	3.9	43.1
American Robin	*Turdus migratorius*		X			3.2	43.1
Common Yellowthroat	*Geothlypis trichas*				X	3.0	33.3
House Sparrow	*Passer domesticus*			X	X	2.5	23.5
American Goldfinch	*Cardualis tristis*				X	1.8	31.4
Eastern Kingbird	*Tyrannus tyrannus*				X	1.7	15.7
Rock Dove	*Columba livia*					1.5	9.8
American Crow	*Corvus brachyrhynchos*					1.5	19.6
Chipping Sparrow	*Spizella passerina*					1.4	17.7
Solitary Sandpiper	*Tringa solitaria*					1.3	11.8
Barn Swallow	*Hirundo rustica*			X	X	1.2	17.7
Tree Swallow	*Tachycineta bicolor*					1.2	15.7
Horned Lark	*Eremophila alpestris*			X		0.9	17.7
American Black Duck	*Anus rubripes*	X				0.7	20.0
Brown-Headed Cowbird	*Molothrus ater*			X	X	0.6	7.8

Table 3. *Cont.*

Species		Species Feature				Relative Abundance	Pond Occurrence
		Wetland Dependent	Crop Damaging	Declining			
				Qc	ENA		
Belted Kingfisher	*Ceryle alcyon*	X			X	0.4	9.8
Ruby-throated Hummingbird	*Archilochus colubris*					0.4	9.8
Yellow Warbler	*Setophaga petechia*					0.4	11.8
Mallard	*Anas platyrhynchos*	X				0.3	7.7
Vesper Sparrow	*Pooecetes gramineus*			X	X	0.3	5.9
American Redstart	*Setophaga ruticilla*					0.3	4.0
Alder Flycatcher	*Empidonax alnorum*					0.2	4.0
House Finch	*Haemorhous mexicanus*					0.2	2.0
Common Snipe	*Gallinago gallinago*	X			X	0.2	4.0
Connecticut Warbler	*Oporornis agilis*					0.2	4.0
Black-capped Chickadee	*Poecile atricapillus*					0.2	4.0
Red-eyed Vireo	*Vireo olivaceus*					0.2	4.0
Ovenbird	*Seiurus aurocapilla*					0.1	2.0
Black-throated Green Warbler	*Setophaga virens*					0.1	4.0
Great Blue Heron	*Ardea herodias*					0.1	4.0
Northern Flicker	*Colaptes auratus*				X	0.1	4.0
Eastern Wood-pewee	*Contopus virens*			X	X	0.1	2.0
Least Sandpiper	*Calidris minutilla*	X				0.1	2.0
Black-crowned Night-heron	*Nycticorax nycticorax*	X				0.1	2.0
Northern Harrier	*Circus hudsonius*					0.1	2.0
Black-billed Cuckoo	*Coccyzus erythropthalmus*					0.1	2.0
Chestnut-sided Warbler	*Setophaga pensylvanica*				X	0.1	2.0
Blue Jay	*Cyanocitta cristata*				X	0.1	2.0
Yellow-bellied Sapsucker	*Sphyrapicus varius*					0.1	2.0
Mourning Dove	*Setophaga pensylvanica*					0.1	2.0
Other Unidentified Birds						1.5	15.9

Total bird abundance (all species combined), total abundance of crop damaging species, and total abundance of declining species were positively related to the adjacent area of fallow land, for all landscape radii considered (i.e., 200 m, 500 m, and 1 km) (Table 4). The area of cereals and of mixed-wood forest surrounding the pond had a negative influence on the three selected bird abundance indicators. Width of riparian strips also had a positive effect on the abundance of declining species, except with the model obtained for the 500 m radius (Table 4). In contrast, only two habitat variables had an effect on species richness: width of riparian strip had a positive effect, and distance to the closest farm building had a negative effect (Table 4).

Table 4. Results of multiple regression analyses carried out to determine habitat and landscape variables influencing bird use of the 61 farm ponds studied in the Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada).

Bird Use Indicator	RADIUS (M)	R2	Variables Included in the Model	Parameter Estimate	F	*p*
Total abundance of all bird species	200	0.45	Area of fallow land	0.001	35.06	≤0.001
			Area of mixed wood forest	−0.0005	6.92	≤0.01
			Area of cereals	−0.002	11.96	≤0.001
			Area of corn	0.002	4.97	≤0.05
	5000	0.13	Area of fallow land	0.0002	7.56	≤0.01
	1000	0.09	Area of fallow land	0.00005	4.84	≤0.05
Total abundance of crop damaging species	200	0.41	Area of fallow land	0.001	30.12	≤0.001
			Area of mixed wood forest	−0.0005	10.78	≤0.01
			Area of cereals	−0.001	9.20	≤0.01
	5000	0.15	Area of fallow land	0.0001	8.72	≤0.01
	1000	0.11	Area of fallow land	0.00005	6.41	≤0.05
Total abundance of declining species	200	0.42	Area of fallow land	0.001	32.61	≤0.001
			Area of mixed wood forest	−0.0005	8.14	≤0.01
			Area of cereals	−0.002	11.79	≤0.001
	5000	0.22	Area of fallow land	0.0001	6.58	≤0.01
			Width of riparian strip	0.27	5.03	≤0.05
	1000	0.20	Area of fallow land	0.00005	5.47	≤0.05
			Width of riparian strip	0.29	5.90	≤0.05
Total species richness	200, 500, and 1000	0.34	Distance to closest building	−0.004	22.69	≤0.001
			Width of riparian strip	0.05	4.21	≤0.05

3.3. Pond Landowners' Perceptions

The proportion of farm owners who said they appreciated the presence of wildlife on their lands (81%) was greater than expected, as was the proportion (83%) of those in agreement with efforts to promote wildlife (Table 5). Some landowners (19%) said they had been affected by crop damage problems due to wildlife; this percentage was lower than would be expected as a result of chance alone. Among these, a greater proportion (80%) of those willing to give an answer considered the level of damage to be acceptable, and 55% of them believed that the depredation was not related to the presence of a pond on their land; this percentage does not differ from what would be expected by chance alone (Table 5).

More than 90% of landowners were inclined to maintain the current environmental conditions of their ponds, which is a significantly greater proportion than expected (Table 4). From the standpoint of protection of riparian vegetation, the proportion fell to 61%, which was still greater than expected. More than half of the landowners conduct mechanical maintenance of the vegetation in riparian strips. Among landowners who have cattle, 53% indicated they were willing to limit the access of their livestock to ponds in the future; this proportion was greater than expected (Table 5) but lower than the proportion who currently limit access. The proportion of those willing to consider implementing field practices to promote wildlife use (22%) did not differ from what would be expected by chance. However, this proportion would have been significantly greater (48%) if potential financial incentives were involved, and if the responsibility for maintenance activities was given to an external organization (Table 5).

Table 5. Results of the survey of landowners' perception of the presence of farm ponds on their lands and their willingness to maintain them for a greater wildlife use, Boyer River watershed, St. Lawrence Valley lowlands, Southern Quebec (Canada).

Question Asked	Answer	%	X^2	df	*p*
Is the presence of wildlife on your farm appreciated? (*n* = 57)	Yes No Uncertain	80.7 3.5 15.8	52.8	2	≤0.001
Should wildlife presence be favoured? (*n* = 48)	Yes No Uncertain	83.3 2.1 14.6	62.4	2	≤0.001
Are there depredation problems on your farm? (*n* = 52)	Yes No	19.2 80.8	21.3	1	≤0.001
Is the crop damage acceptable? (*n* = 10)	Yes No Uncertain	79.6 11.4 11.4	8.98	2	≤0.01
Is the crop damage related to the presence of the pond? (*n* = 10)	Yes No Uncertain	22.4 55.2 22.4	2.11	2	>0.05
Would you be willing to maintain the pond in its actual state? (*n* = 56)	Yes No Uncertain	91.1 1.8 6.2	82.0	2	≤0.001
Would you be willing to maintain the surrounding vegetation? (*n* = 54)	Yes No Uncertain	61.1 24.1 14.9	16.8	2	≤0.001
Would you be willing to block access to cattle? (*n* = 32)	Yes No Uncertain	53.0 9.5 37.5	9.4	2	≤0.01
Would you be willing to do management work to increase wildlife? (*n* = 49)	Yes No Uncertain	22.4 30.6 46.9	4.7	2	≤0.05
Would you be willing to authorize an organization to manage the pond at its expense and to insure maintenance? (*n* = 50)	Yes No Uncertain	48.0 4.0 48.0	43.0	2	≤0.001

4. Discussion

4.1. Overall Bird Use of Farm Ponds

Forty-six bird species were observed at the farm ponds studied, with five of them (the Red-winged Blackbird, Song Sparrow, Savannah Sparrow, Common Grackle, and European Starling) accounting for 56% of all bird observations. According to Hickman, 1994, [33] who studied the avian use of ponds constructed on abandoned farmland in Illinois (USA), the newly constructed ponds allowed five species previously absent from the studied site to use the new habitat. One of the bird species that benefited the most from the presence of ponds in this study was the Red-winged Blackbird. Ten bird species were using livestock watering ponds in South Dakota (USA), including the Red-winged Blackbird [34]. In this same area, it was reported by [35] that the Red-winged Blackbird was the most abundant species in landscapes where ponds provide abundant over-water nesting habitat (generally cattails).

With regard to studies specifically documenting waterfowl use of farm ponds during the breeding season, twenty-two species of ducks and geese were observed using watering ponds in Wyoming (USA), the mallard being one of the two dominant species recorded [36]. Seven species of dabbling ducks were using various types of watering ponds in South Dakota (USA); these ponds supported more mallard pairs than all other types of wetlands studied [15]. The Mallard and the genetically related American black duck are the only two duck species that were observed during this study. The American Black Duck is relatively

abundant in Southern Quebec where it cohabits with the mallard [37]. Its density was found to be highest in dairy farm and agroforestry landscapes, whereas mallard densities were similar across all landscape types. Both species seem to be attracted to areas supporting adequate habitats [37], which could explain the use of farm ponds by these two species in the study area.

4.2. Declining Bird Species and Crop Damaging Species

According to Rosenberg et al. (2019) [4], more than 90% of the total cumulative avian loss in North America could be attributed to just 12 bird families, including sparrows and blackbirds. Among the ten most abundant species we surveyed, eight species (the Red-winged Blackbird, Song Sparrow, Savannah Sparrow, Common Grackle, European Starling, Spotted Sandpiper (*Actitis macularius)*, Cedar Waxwing, and Kildeer) representing 64% of all individual birds observed in this study have experienced significant declines in their populations in recent decades, in Quebec and across Eastern North America (Table 3). Among these, the Spotted Sandpiper is the only true wetland obligate species. The presence of farm ponds may, therefore, be of prime importance to this species. As noted by Swartz et al. (2019) [22], farm ponds not only benefit aquatic bird species but also terrestrial species because of the various behavioral needs and ecotone interactions for nesting or foraging for instance. Small habitats such as ponds may act as a key landscape element for terrestrial birds in semi-arid regions, which corresponds to intensively drained agricultural lands to some extent [16].

Vegetation complexity in farm pond margins had an influence (direct and indirect) on the abundance and the number of both water-dependent and terrestrial bird species in farmland habitats [23]. Indeed, the use of up to 85% of all the farm ponds studied by the eight most abundant declining bird species mentioned above cannot be attributed solely to their presence. Most of these species are closely associated with open habitats in surrounding agricultural landscapes. The presence of farm ponds and their associated riparian strips, which provide nesting and foraging habitats, may be particularly important for them, and may contribute to maintaining viable regional populations of these declining species.

Nearly half of all individual birds observed around the ponds also belonged to species considered crop damaging species in Southern Quebec. Emergent plant species such as cattails colonize pond margins and are considered weedy and undesirable (not aesthetic, attractive to nuisance species, etc.) by many farmers. However, considering the number of visits made at each pond (8) and the number of ponds involved (51), the mean number of individuals belonging specifically to such a bird group was only 2.0 birds/pond. We thus considered that the presence of those species does not represent a significant threat to adjacent crops during the spring and summer breeding periods. Furthermore, insects represent the bulk of the food taken by many of the crop damaging bird species (such as the Red-winged Blackbird and the European Starling). They may contribute to the control of pest insect populations in nearby cultivated fields at that time of the year. This is consistent with farmers' beliefs since only a few reported being affected by depredation problems, and most of the latter considered the damage to be acceptable.

4.3. Intrinsic and Extrinsic Pond Features Influencing Bird Use

We observed that the area of fallow land in the vicinity of the studied ponds was the only variable that was consistently used in the regression models developed to explain the effect of biophysical and landscape characteristics on the total abundance of birds, and the total abundance of declining species as well as crop damaging species, regardless of the land-use radius (200, 500, and 1000 m) around the ponds. These fallow lands may represent the only remaining nesting habitats for many species in a landscape dominated by agriculture where suitable vegetative cover may generally be lacking.

Surrounding semi-natural habitats had a positive influence on bird communities at farm ponds [12]. This is also the case in this study as shown by the positive influence

of fallow lands and the negative one of the area of cereals within 200 m of the ponds. The latter generally offers poor nesting cover for birds. The area of forests within 200 m of the ponds also had a negative influence on bird abundance, with most of the bird species recorded known to use open habitats. As observed by [38], an increase in bird species richness and abundance was associated with managed open-canopy ponds. Bird communities at managed open-canopy ponds showed higher bird abundance and species richness compared with overgrown ponds [18].

The width of riparian strips was also an important habitat variable explaining bird use of farm ponds. Both plant diversity and structure increase with wider riparian strips, creating a diversity of habitats suitable for more individuals and more bird species. However, unlike several studies specifically focusing on waterfowl use of ponds in agricultural landscapes in North America [13,15,36,39], in our study, pond size was not included in any regression models conducted to assess the influence of various biophysical features on avian use. This result could also be explained by the small variation in the area of the ponds studied (Figure 1). Moreover, it was observed that water birds have a stronger relationship than land birds with man-made pond biophysical features [11].

4.4. Farmers' Perceptions and Willingness

Several authors have reported that farmers' attitudes to sustainable agriculture influence their intentions to implement wildlife-oriented practices on their farms, in such a way that they can balance their profit and non-profit objectives without adversely affecting their nearby natural environment [38]. This underscores the importance of understanding landowners' perceptions of rural ponds from a social science perspective in terms of their attitudes and stewardship values [10,22,40]. Such information can provide insight into the decision-making process that leads farmers to adopt certain maintenance practices which, in turn, influence ponds' biophysical conditions.

Our study reveals that a majority of landowners appreciate the presence of wildlife on their lands. Only a few reported experiencing depredation problems due to wildlife, which was not related to the presence of a pond on their land. Farmers believe that restricting cattle access to their pond is important and are willing to do it in the near future. They are willing to maintain ponds in their current environmental state (i.e., the one at the time of the study), although riparian vegetation management was an issue for some of them. Only 22% of surveyed farmers were willing to put in place maintenance practices to promote the use of their pond by wildlife; however, this percentage would increase significantly (48%) if an external partner organization took care of these tasks. In comparison, 57% of surveyed farm landowners in the United States said they would be willing to change their land management practices to benefit aquatic organisms and to partner in pond conservation efforts [22].

Managing existing ponds or creating new ones for both agronomic and wildlife conservation benefits is crucial for establishing an effective bird conservation strategy in farm landscapes. For instance, bird abundance and species richness were both higher for managed versus non-managed ponds in the United Kingdom [18]. In Ireland, it was concluded that the importance of conserving artificial ponds should not be underestimated as part of a global wetland conservation initiative in agricultural landscapes [14]. Although such ponds do not replicate natural ponds, they have higher aquatic and terrestrial invertebrate richness and abundance which in turn positively influence avian use.

5. Conclusions

More agroecological and social science studies are needed to include wildlife-oriented management and restoration guidelines for farm ponds in existing sustainable agriculture programs. This could include the possibility of having an individual farm-based bird conservation action plan implemented by a partner biodiversity conservation organization [19,38]. A better understanding of farmer typologies such as those developed by [11,41] is also needed to better inform outreach conservation programs. Finally, citizen-

science-based surveys involving farmers themselves should be implemented to document farmland bird population trends, and to relate them to pond maintenance practices put in place [21,42].

At the landscape level, maintaining traditional dairy farm landscapes in Southern Quebec is an important objective in order to prevent regional avian biodiversity declines as suggested elsewhere [16,43]. Creating a pond network, restoring environmental conditions around open-canopy ponds, and widening riparian strips and the adjacent uncultivated field margins would have a beneficial effect on the regional populations of several farmland bird species without significantly impacting agricultural practices and crop yields [5]. Farm ponds could also contribute to maintaining local populations of amphibians and salamanders since all of the 54 studied ponds and 30% of them were also used by different species of these two animal groups (J. Rodrigue, CWS, unpublished data).

One of the main goals of this study was to compare the use of birds of various types of farm ponds in a traditional dairy farming landscape in Southern Quebec. If the biophysical and bird surveys took place several years ago, the data (both habitats and birds) were taken at the same time, which, therefore, made it possible to examine the avifauna–habitat relationships. However, some species are probably less or more abundant today, and changes in the biophysical features of some ponds (or even their availability) may have occurred since. However, we do not believe that there have been significant changes, although we believe that updating the information acquired (recent surveys of birds, new interviews with the landowners, and use of current satellite images) would be an excellent opportunity for comparison and mapping trends through time. Twenty years after our study (2005) during a field visit in the study area (Boyer River watershed), it was found that nearly 10% of the ponds previously studied had been drained and filled, but that a new one had been excavated. (J. Rodrigue, personal observation). Unfortunately, there is no data available on the trend in the number of farm ponds in Canada or even in southern Quebec. Their small size makes them difficult to detect on satellite images generally used to determine the gradual loss of wetlands. Finally, it is important to remember that the preservation of natural marshes in the watershed of the Boyer River where our study took place, as well as elsewhere in Southern Quebec, remains the highest priority in terms of habitat conservation.

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