



Oak Ridges Corridor Conservation Reserve: Changes in Natural Heritage Conditions 2008-2018

Prepared by Environmental Monitoring and Data Management

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1 Executive summary

A series of objectives relating to the natural heritage found within the Oak Ridges Corridor Conservation Reserve (ORCCR) were identified within the Management Plan (2006). In order to track progress to meeting these objectives the Toronto and Region Conservation Authority (TRCA) initiated a terrestrial long-term monitoring program at the park in 2008. This report summarizes the results obtained from the monitoring program only from 2008 to 2018. It is not a full characterization describing all the natural heritage features and biodiversity.

Flora and fauna communities at the ORCCR have changed between 2008 and 2018 and some of these changes may be related to natural succession, restoration activities or adjacent residential development. The forest vegetation plot is experiencing natural succession towards a more mature forest community as observed by high mortality rates of pin cherry (a mid-successional species). Several non-native flora species were found for the first time in 2018 related to a new informal trail within the plot. Forest bird communities have not changed over time (since formal monitoring began in 2008) and consist of a mixture of species representing both forest/generalist/edge environments. Veery was detected for the first time in 2018 at station 2 and is an area-sensitive species known to occur in disturbed or regenerating forests.

Wetland vegetation plots in the west end of the park may be showing declines in the proportion of native species but continued monitoring is needed. Common buckthorn is spreading in wetland vegetation plots, especially in WV7D in the middle/north area of the site where extreme water level changes have occurred. The occurrence of common buckthorn is cause for concern since it is an aggressive non-native species capable of outcompeting native species.



Figure 1. Spatial summary of monitoring findings from wetland vegetation transects from 2009 to 2018.

There were declines in the number of Virginia Rails at a station in the middle to east end of the park (Figure 2). Residential development recently occurred at this location.



Figure 2. Spatial summary of monitoring findings from wetland bird stations between 2008 and 2018.

Six frog species were found using the park (breeding habitat and summer foraging) and the number of species has not changed temporally at any of the stations. Frequency of occurrence of spring peeper was the highest occurring at all stations, while wood frogs at station 1 in the west end have only been detected in low numbers in recent years (Figure 3). The frequency of occurrence of green frog has declined and they haven't been detected at one of the west end stations since 2015. These declines warrant further investigation.



Figure 3. Spatial summary of monitoring findings from wetland frog stations from 2009 to 2018.

Several species of regional concern were detected at meadow bird stations including most notably bobolink (*Dolichonyx oryzivorus*) although numbers of this species, along with several other meadow bird metrics (such as meadow-dependent bird species richness, proportion of birds using meadow habitat), have been declining at stations in the west end (Figure 4). These declines may be occurring due to the recent nearby residential development or re-forestation efforts.

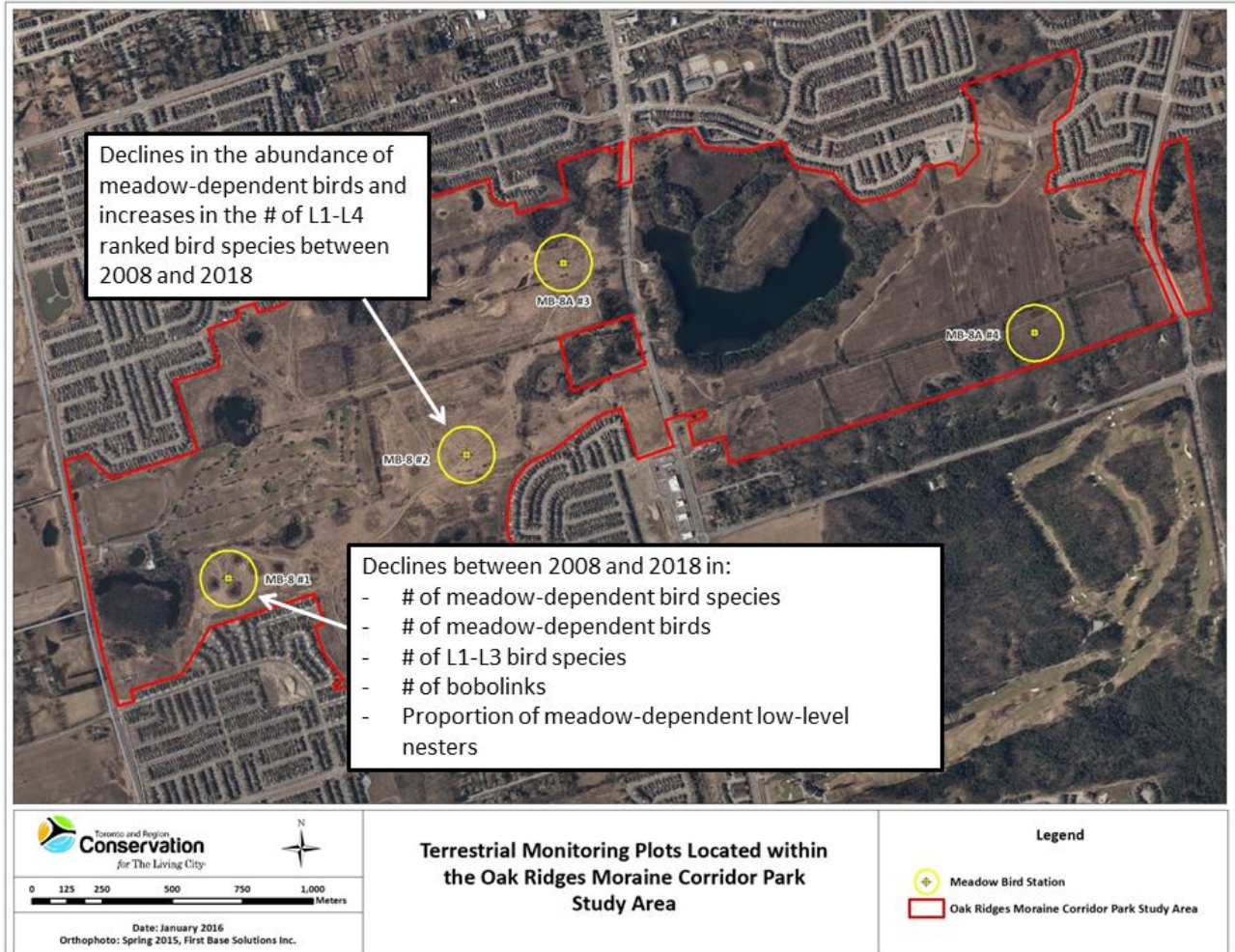


Figure 4. Spatial summary of monitoring findings from meadow bird stations from 2008 to 2018.

2 Introduction

Oak Ridges Corridor Conservation Reserve (ORCCR) is a 428 ha parcel of land located just south of the community of Oak Ridges in the Town of Richmond Hill (Figure 5). Historically this land was used by First Nations but more recently has been used for farming, recreation and residential purposes. The site contains numerous ecological features including wetlands and kettle lakes and represents one of the most diverse collections of wildlife, plant species and habitats found on the Oak Ridges Moraine (TRCA 2006).

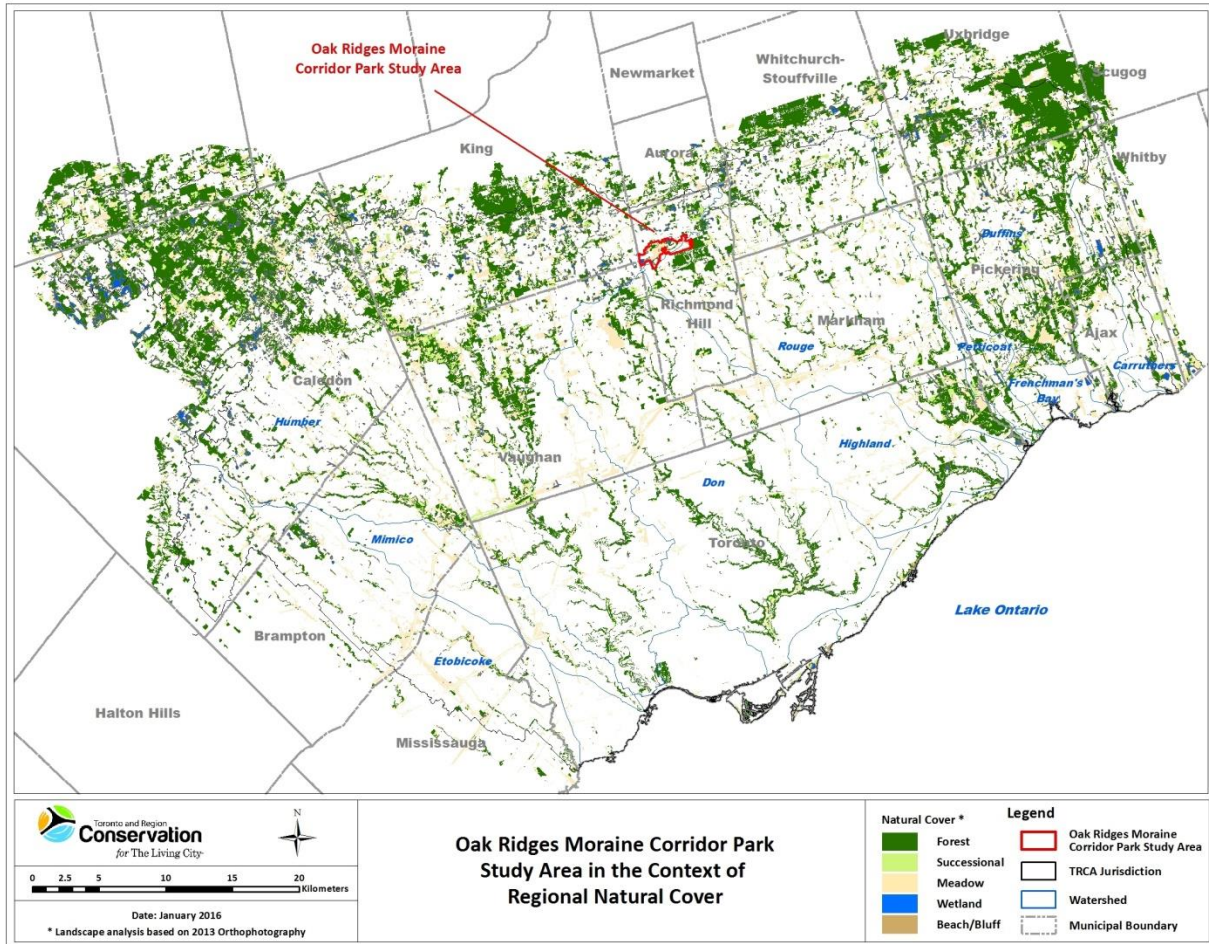


Figure 5. Oak Ridges Moraine Corridor Park study area in the context of regional natural cover.

The vision of ORCCR is to 1) create and maintain a sanctuary for nature while providing an important ecological linkage on the Oak Ridges Moraine and 2) provide opportunities for visitors to learn about ecosystem features, functions, wildlife and human activities while enjoying recreational activities compatible with park values. There are numerous objectives related to reaching this vision outlined in the Oak Ridges Corridor Park Management Plan (TRCA 2006), and several are directly related to terrestrial flora and fauna. These include:

Natural Heritage

- Protect, restore and enhance the forests, kettle lakes and wetlands of the park as a functioning natural heritage system including natural features and processes, wildlife habitats, wildlife movement, and

linkages to other natural systems on the Oak Ridges Moraine and the watersheds of the Humber and Rouge Rivers.

Environmental Sustainability

- Protect the park from negative external influences such as invasive species, encroachment, pets, traffic, and changes to the hydrology.

Monitoring

- Collaborate with agencies, universities, NGOs and other institutions to ensure long-term monitoring of the park's resources and environmental functions, and to provide guidance for any changes to park policies and operations.

In addition to these vision related goals, there are more specific goals for protection and restoration at the site including:

- Protect existing natural habitats
- Increase the amount of forested habitats
- Provide interior forest habitat
- Enhance wetland and forest distribution for connectivity
- Provide grassland habitats
- Reduce mortality of wildlife on roads by providing suitable crossing areas

In order to assess progress towards meeting these objectives the Toronto and Region Conservation Authority (TRCA) developed a monitoring program to track changes in communities and species over time. The monitoring methodology follows the same regional monitoring protocols used in the regional (TRCA jurisdiction) program.

Achieving the vision of the park through these restoration activities is a long-term plan. While this report will not directly assess progress from a restoration perspective, it will examine short-term changes in flora and fauna and these changes may be attributable to local, short-term changes in vegetation resulting from restoration activities. This report will examine changes in forest and wetland flora, forest, wetland and meadow bird communities and wetland frog communities between 2008 and 2018. Recommendations for management and restoration will also be made based on observations of flora and fauna.

3 Methodology

The monitoring methodology employed by TRCA is very closely based on that which is used by Environment Canada in its Ecological Monitoring and Assessment Network (EMAN) and Credit Valley Conservation (CVC) (EMAN 2004a, EMAN 2004b, CVC 2010). For the full monitoring methodology used by TRCA for its forest, wetland, and meadow stations refer to TRCA (2011a-g). The monitoring at ORCCR is on a 3-year cycle whereas the regional sites are collected annually. The schedule and location of flora and fauna monitoring stations/plots are shown in Table 1 and Figure 6.

3.1 Selection of site quality indicators

Long-term monitoring plots were established to identify the health and condition of key biological communities (i.e. vegetation, bird, and frog) associated with forest, wetland and meadow habitat features and to track changes in their condition over time. Ecosystem health can be measured with various indicators, including tree health, flora and fauna species richness, the representation of native versus exotic species, and the presence and abundance of sensitive species (those of conservation concern). Objectives based on such indicators, specific to each habitat type, are outlined below.

Forest monitoring plots were designed to:

- Determine the health of forests
- Determine regeneration rate and species composition of understorey saplings and shrubs
- Determine if the population and abundance of flora species, including those of conservation concern and invasive species, are changing over time
- Determine the floristic quality of the site

Wetland monitoring plots were designed to:

- Determine the health of wetlands
- Determine if the population and abundance of flora and fauna species, including those of conservation concern, are changing over time
- Determine the floristic quality of the site

Meadow monitoring plots were designed to:

- Assess overall trends in meadow bird species richness and abundance

Indicators were selected in accordance with these monitoring objectives prior to plot set-up. Table 2 provides an overview of the indicators chosen to interpret site quality.

Table 1. Schedule of TRCA long-term monitoring at ORCCR, 2008-2018. Regional stations are monitored annually and project sites on a 3-year cycle.

Monitoring Type	Monitoring Plot / Transect / Station Type	Station Code	Year Monitored										
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Project	forest bird	FB-26A #1	x	x			x			x			x
		FB-26A #2	x	x			x			x			x
		FB-26A #3	x	x			x			x			x
	forest vegetation	FV-26A	x ^a	x			x			x			x
	meadow bird	MB-8A #3	x	x			x			x			x
		MB-8A #4	x	x			x			x			x
	wetland bird	WB-7A #2	x	x		x	x	x	x	x	x	x	x
		WB-7A #3	x	x		x	x	x	x	x	x	x	x
	wetland frog	WF-7A #2		x	x	x	x	x	x	x	x	x	x
		WF-7A #3		x	x	x	x	x	x	x	x	x	x
	wetland vegetation	WV-7A	x ^b	x			x			x			x
		WV-7B	x ^b	x			x			x			x
		WV-7D	x ^b	x			x			x			x
		WV-7E	x ^b	x			x			x			x
Regional	meadow bird	MB-8 #1	x	x	x	x	x	x	x	x	x	x	x
		MB-8 #2	x	x	x	x	x	x	x	x	x	x	x
	wetland bird	WB-7 #1	x	x	x	x	x	x	x	x	x	x	x
	wetland frog	WF-7 #1		x	x	x	x	x	x	x	x	x	x
	wetland vegetation	WV-7	x ^b	x	x	x	x	x	x	x	x	x	x

^a FV 26A in 2008 only had tree health data collected because the plots were set-up late in the season.

^b Woody regeneration was not measured at WV 7-7E in 2008.



Figure 6. Terrestrial monitoring plots at Oak Ridges Moraine Corridor Park.

Table 2. List of monitoring high-level indicators chosen for monitoring and analysis.

Habitat type	Monitoring indicator(s)	Description
Forest	Tree health	Proportion healthy trees
	Floristic quality index (FQI)	Proportion of habitat sensitive species
	Flora species richness	Number of species of urban concern
	Bird species richness	Presence of forest guild species Number of species of urban concern
Wetland	Mean floristic quality index (FQI)	Proportion of habitat sensitive species
	Flora species richness	Number of species of regional concern Presence of wetland guild species
	Bird species richness	Number of species of regional and urban concern
	Virginia rails	Number of Virginia rails
	Amphibian species richness	Presence of frog species Presence of meadow guild species
Meadow	Bird species richness	Number of species of regional and urban concern
	Bobolinks	Number of bobolinks

The assessment of tree health provides a wealth of information on the condition and resilience of forest communities. Variables such as tree mortality and crown vigour are measures of tree health that are standard monitoring variables used throughout the world. While there is a long history of assessing tree health, the measurement and interpretation of species richness and biodiversity are a more recent development and some clarification is provided here.

Species richness (i.e. the number of different species) and the relative dominance of native or exotic species are important indicators of ecosystem health. A closer look at the native flora and fauna present at any given site reveals that they vary in their degrees of tolerance to disturbance. Some are indicators of high-quality remnant habitat, thus of successful preservation or restoration efforts. They are of greater regional conservation concern. Others occur in a wide range of disturbed habitats. Various methods of assessment can be used to interpret any observed changes in composition of plants or animals. Toronto and Region Conservation Authority has developed a local ranking system for flora and fauna species; this ranking system was designed to reflect the ability of each species to thrive in the changing landscape of the Toronto region. The ranks range from the extremely sensitive species (L1) to the largely urban tolerant species (L5), with an additional L-rank for exotic (non-native) species (L+). Ranks are reviewed annually and subject to updates (TRCA 2017). Species with ranks of L1 to L3 are considered to be of concern throughout the TRCA jurisdiction, while those ranked L4 are of intermediate sensitivity and are of conservation concern within urban and suburban landscapes only.

An additional ranking system for plants, the coefficient of conservatism (CC) was used for calculating Floristic Quality Index (FQI) of the plots. The CC is assigned to native plants and is a measure of a plant's fidelity to high-quality remnant habitats (with 10 being the most sensitive score and 0 the lowest). This system is used for various regions across North America (Masters 1997). It therefore provides us with a continent-wide standard for assessing site biodiversity and quality. The CC values used by the TRCA are those assigned for southern Ontario plants by Oldham et al. (1995).

Breeding bird diversity is tracked by referring to habitat preferences; these preferences are listed in the Appendix (Table A.1) and were produced primarily through staff understanding of the various species' nesting requirements.

Other variables measured include the number of bobolinks on meadow plots and the number of Virginia rails (*Rallus limicola*) on wetland plots. Bobolinks (*Dolichonyx oryzivorus*) are a meadow-dependent species that require large patches of meadow for breeding (Johnson and Igl 2001). They are listed as threatened at the provincial level and are recommended by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to be listed as threatened under the federal Species-at-Risk Act (SARA). This makes the species a good indicator of meadow habitat quality. Virginia rails are a secretive, wetland-dependent bird species that nests in wetlands and are declining throughout the Great Lakes basin (Conway 1995, Marsh Monitoring Program 2015). This species was chosen to represent marsh quality.

3.2 Forest monitoring methodology

3.2.1 Forest vegetation plots

Forest plots were set up according to standards developed by Environment Canada's Ecological Monitoring and Assessment Network (EMAN 2004a, EMAN 2004b, Roberts-Pichette and Gillespie 1999), with slight modifications. This protocol is almost identical to that used by the Credit Valley Conservation in its forest vegetation plot monitoring, although there are differences in sapling assessment (CVC 2010).

Detailed information on plot set-up can be found in TRCA (2011a). In summary, each forest vegetation plot consists of one 20 x 20 m square plot (i.e. 400 m²) for monitoring tree health; and five 2 x 2 m subplots (i.e. 4 m²) for monitoring woody regeneration (tree saplings, shrubs and woody vines). Four of the subplots are placed 1 m outside the perimeter of the 20 x 20 m tree health plot, and the fifth is located in its centre. Ground vegetation is measured in a 1 x 1 m subsection (1 m²) of each subplot at its southwest quarter. Two visits are conducted per year: in the spring and in early-to-mid summer.

3.2.2 Forest bird stations

Forest birds were monitored using the Ontario Forest Bird Monitoring Program (FBMP) protocol designed by the Canadian Wildlife Service (TRCA 2011b). The forest bird stations are monitored twice per year at times considered optimum for recording forest breeding bird species. The first count is conducted between May 24th and June 17th; the second count is conducted no sooner than 10 days after the first visit and between the dates June 15th and July 10th. Many species that are recorded before the first week of June may still be passing through the area as migrants, therefore registering a second observation in late June or July supports the indication of a territorial and likely breeding individual. All counts are completed between 05:00 a.m. and 10:00 a.m. The second visit is completed at the same time of day as the first visit and an attempt is made to maintain the same timing schedule of visits in subsequent years.

Counts are conducted in weather conditions that optimize the detection of songbird species. Ideally there should be very little to no wind, and precipitation should be at most a light rain. The FBMP requires the biologist to plot every individual bird observed and heard within a 100 m circle centred on the point station over a 10 minute period. In addition, any birds identified at distances beyond the 100 m circle are mapped at their approximate position. For the purposes of analysis it was decided to consider only those individuals and species located within the 100 m count circle.

3.3 Wetland monitoring methodology

3.3.1 Vegetation transects

Wetland vegetation is monitored along a 50 m transect, capturing a gradient of conditions (terrestrial to aquatic) that occur in most wetlands (TRCA 2011d). Where possible, the transect starts immediately outside the wetland in an adjacent terrestrial system, while the remainder of the transect lies within the wetland proper. Posts (lengths of white polyvinyl chloride or “PVC” pipe) are placed at 10 m intervals along the transect, and vegetation monitoring subplots occur 5 m on either side of each post. Thus, there are paired subplots at the 0, 10, 20, 30, 40 and 50 m points along the transect: 12 in total. Subplots for woody regeneration (tree saplings, shrubs and woody vines) are 2 x 2 m (4 m²), while the rear outer quarter (1 x 1 m subplot) of each 4 m² subplot is used for ground vegetation). Detailed information on wetland transect layout can be found in TRCA (2011d).

All wetland vegetation data are collected concurrently, in mid-to-late summer (late July to mid-September). This corresponds with full vegetation expansion before autumnal die-back and with relatively low water levels. The timing also harmonizes with the schedule for the forest plots, which are sampled earlier in the season.

3.3.2 Wetland bird stations

Monitoring stations were set-up following the Marsh Monitoring Program (MMP) protocol that was established by Bird Studies Canada (TRCA 2011e). Observations and counts are undertaken in a 100 m-radius semi-circle from the station marker since in general, stations are located at the edge of the wetland. Multiple stations within the same site were separated by 250 m in order to avoid double-counting the same individual. The wetland stations are monitored twice per year at times considered optimum for recording wetland bird breeding species. The first count is conducted between May 20th and July 5th; the second count is conducted no sooner than 10 days after the first visit.

Counts are conducted in weather conditions that optimize the opportunity for the biologist to hear and observe wetland bird species. Ideally, there should be no wind (very light wind is acceptable), and precipitation should be light rain at the very most. The surveys are conducted in the morning hours a half hour before sunrise and end by 10:00 a.m. during appropriate weather conditions for bird activity. The field protocol for monitoring wetland birds requires counts to be made of individuals located only within the 100 m-radius semi-circle.

3.3.3 Frog stations

Stations were set-up and monitored following the MMP in the same manner as wetland birds (TRCA 2011f). The frog stations are 100 m semi-circles with orientation noted and maintained on each visit; these frog stations need to be at least 500 m apart. Temperature guidelines change with each visit. For the first visit in the spring, night temperatures should be above 5°C, at least 10°C for the second visit and at least 17°C for the third and final visit. Surveys begin one half hour after sunset and end before midnight. Frogs were recorded as present and the observer estimated the number of individuals present along with the call code (1=no overlap of calls and an exact measurement of abundance of frogs calling can be determined, 2=calls begin to overlap and an estimate of abundance of frogs can be determined, 3=full chorus and the number of individuals cannot be counted).

3.4 Meadow monitoring methodology

3.4.1 Meadow bird stations

In the absence of any bird monitoring protocols designed specifically for meadow habitat it was decided to simply use the FBMP protocol and to adjust the suite of target species during analysis (TRCA 2011g). Each station is sampled twice per year with the first visit occurring between May 15th and May 30th, and the second visit between May 30th and June 15th, with at least 10 days between visits. Counts are conducted between 05:00 a.m. and 10:00 a.m., and at approximately the same time of day on subsequent visits from year to year. The field protocol for monitoring meadow birds is adapted from the forest bird protocol which requires counts to be made of individuals located both within and beyond the 100 m count circle. For the analysis of results, as with the forest and wetland results, it was decided to consider only those individuals and species located within the 100 m count circle.

3.5 Data analysis

3.5.1 Temporal trends

Temporal trends were analyzed using Mann-Kendall tests (R Core Team 2018). The Mann-Kendall test is a non-parametric test for identifying temporal trends in time series data. This test was chosen over traditional regression analyses because the data did not meet the assumption of independent samples required for regression analyses because the data are collected at the same site from one year to the next and are not independent. The Mann-Kendall test uses the S statistic to determine an associated p-value. A p-value of less than 0.05 denotes a significant trend (increasing or decreasing) and a p-value of greater than 0.05 indicates that there is no increase or decrease over time and that the variable of interest is stable. Declining trends with $0.05 < p < 0.20$ are indicated as potential declines.

4 Results

4.1 Forest monitoring

4.1.1 Forest vegetation

Floristic Quality Index, Percent Native Species and Number of L1-L4 Species

Between 2009 and 2018, the number of flora species in the forest plot varied minimally from 25 species in 2012 to 30 species in 2018 (Table 3). The composition of species also remained relatively similar among years. Several new non-native species were found in 2015 that had not been found previously including garlic mustard (*Alliaria petiolata*), shrub honeysuckle (*Lonicera x bella*) and Manitoba maple (*Acer negundo*). Both shrub honeysuckle and Manitoba maple were not found in 2018 but may be present in future years. Seven new species were found in 2018 that had previously not been found including four native species: smooth serviceberry (*Amelanchier laevis*), red osier dogwood (*Cornus stolonifera*), sticky willow herb (*Epilobium ciliatum* ssp. *ciliatum*), calico aster (*Symphyotrichum lateriflorum* var. *lateriflorum*) and three non-native species: bittersweet nightshade (*Solanum dulcamara*), creeping thistle (*Cirsium arvense*) and urban avens (*Geum urbanum*). All of these new species, except for calico aster, were noted as being found along an informal trail that was created in the southwest corner of the monitoring plot since 2015. Even with these changes in composition and increases in the total number of flora species, the % native flora species, FQI and % L1-L4 species has remained relatively constant.

Table 3. Temporal changes in forest flora species metrics between 2009 and 2018.

Metric	Year			
	2009	2012	2015	2018
Total number of flora species	26	25	27	30
% native flora species	81	76	74	79
Floristic quality index	19.0	17.7	18.3	19.0
% L1-L4 flora species*	27	20	22	24

* No L1-L3 species were found in the plot.

Tree Composition

As of 2018, a total of 29 live trees were being monitored in the forest vegetation plot at ORCCR. Between 2008 and 2018, six species were found in the plot including sugar maple (*Acer saccharum* ssp. *saccharum*), white ash (*Fraxinus americana*), pin cherry (*Prunus pensylvanica*), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*) and Norway maple (*Acer platanoides*; a non-native species; Figure 7). The number of live trees has declined from 32 in 2009 to 29 in 2018 due to the death of 5 trees including sugar maple, pin cherry and white ash. There was a small increase in the relative abundance of sugar maple between 2008 (72%) and 2018 (83%). Pin cherry decreased in relative abundance and was no longer found in the plot by 2015. Mortality in this species could be due to its shade intolerance and the direct competition with shade tolerant trees such as sugar maple. One pin cherry did have an open wound and signs of a fungal infection in 2008 and died by 2012.

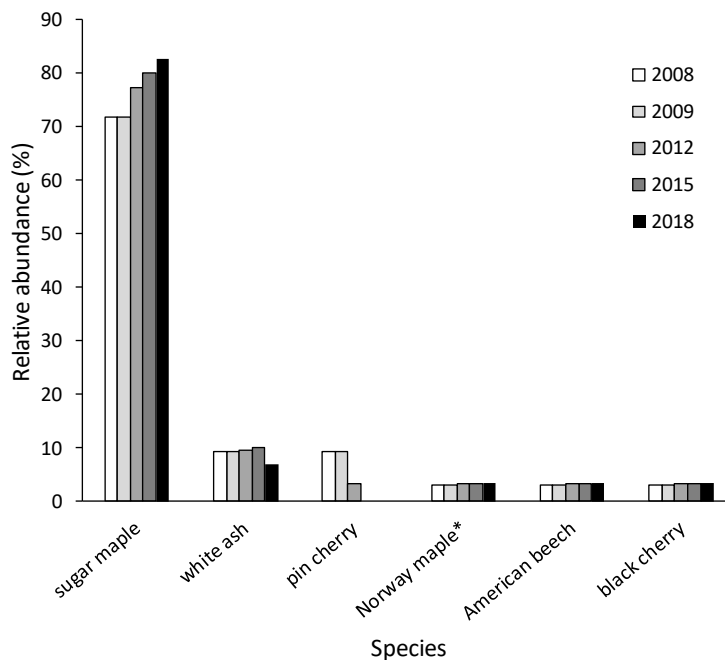


Figure 7. Relative abundance of live tree species in the forest vegetation plot (2008-2018). Exotic species are indicated with an asterisk (*).

Forest Sapling and Shrub Composition

A total of four woody species were found in the regeneration layer of FV 26A including sugar maple, white ash, pin cherry and Norway maple (Figure 8). Relative cover in all years was dominated by sugar maple because the plots consisted primarily of larger individuals (>2m in height), except for in 2015 where three smaller individuals were establishing. Pin cherry dominated in 2009 based on relative abundance with nine individuals present. All of these individuals were less than 55cm in height and appear to have died out between 2009 and 2012. Again, pin cherry is shade-intolerant making establishment difficult in all but early successional conditions (open canopy, high light levels). Norway maple was recorded for the first time within the regeneration layer in 2018 should be cause for concern because this species is invasive and regenerating within the plot.

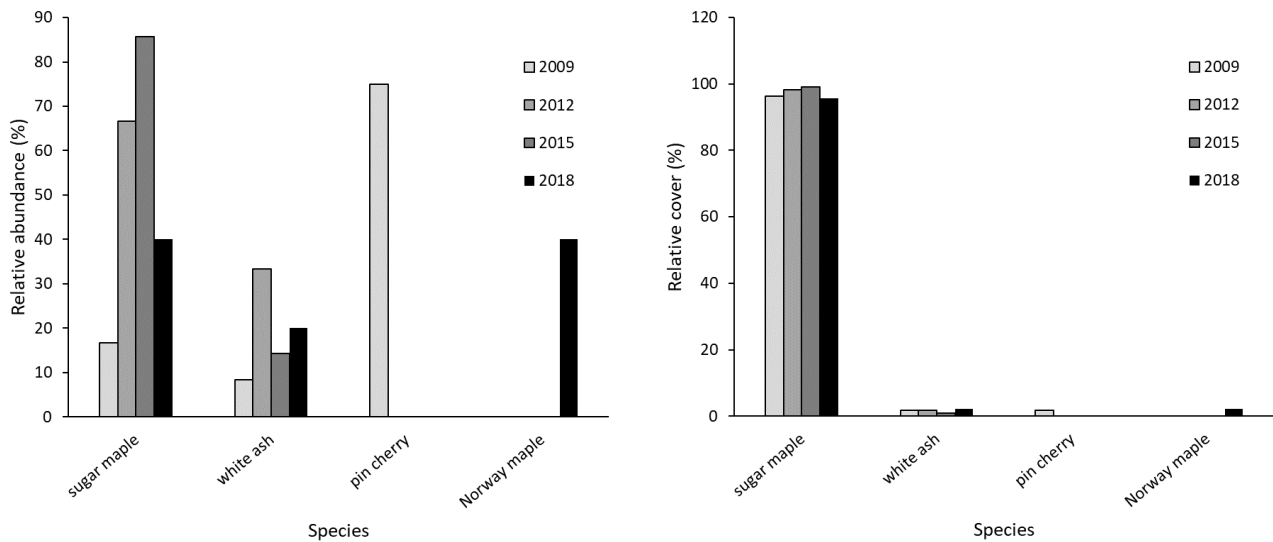


Figure 8. Relative abundance and relative cover of woody species in the forest regeneration layer (2009, 2012, 2015, 2018).

Forest Ground Vegetation Composition

Ground vegetation at FV 26A between 2009 and 2018 consisted of 14 species including two L4 species (long-styled blue cohosh (*Caulophyllum giganteum*) and pin cherry), 8 L5 species (black cherry, enchanter’s nightshade (*Circaea canadensis ssp. canadensis*), ironwood (*Ostrya virginiana*), Jack-in-the-pulpit (*Arisaema triphyllum*), riverbank grape (*Vitis riparia*), sugar maple, white ash and yellow trout-lily (*Erythronium americanum ssp. americanum*)) and two non-native species (Manitoba maple (*Acer negundo*) and Norway maple; Figure 9). Long-styled blue cohosh had the greatest maximum relative cover in all years followed by yellow trout lily, enchanter’s nightshade, sugar maple and Jack-in-the-pulpit. All other species had a maximum relative cover of <1%. Norway maple seedlings were found for the first time in 2018 in the ground vegetation layer sub-plots.

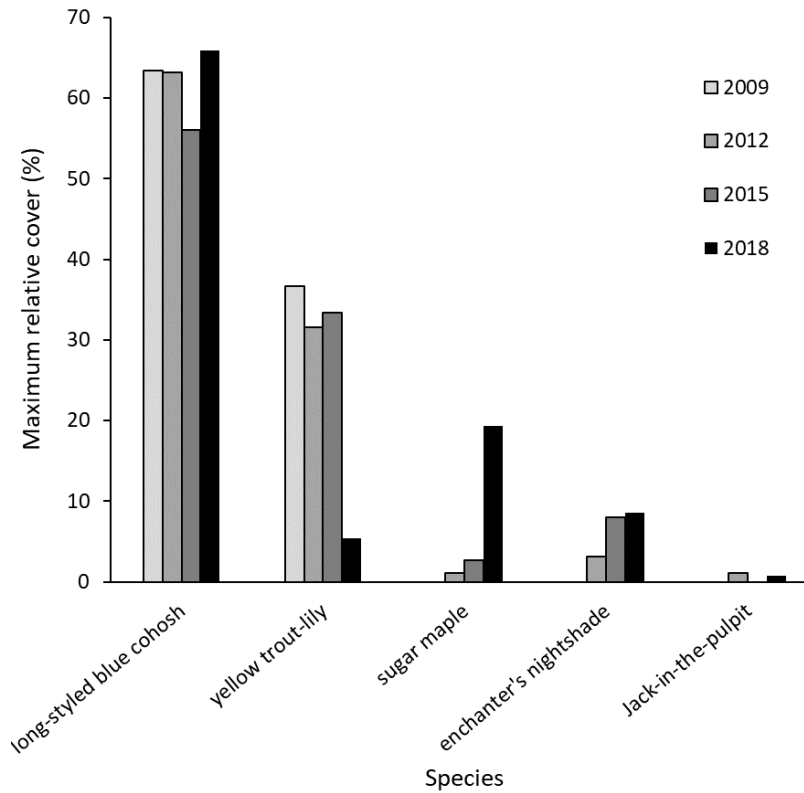


Figure 9. Maximum relative percent cover of species in the ground vegetation layer with covers of >1% (2009, 2012, 2015, 2018).

Tree Health

Crown Vigour – Crown Classes Dominant and Co-dominant

The position of trees in the forest canopy (crown class) affects the overall health (crown vigour) because trees with crowns that are dominant and co-dominant are naturally less stressed because they receive more sunlight than crowns that are intermediate or suppressed. For this reason crown vigour was analyzed using only live trees with crown classes of dominant and co-dominant (classes 1 and 2).

Crown vigour of dominant and co-dominant trees consisted primarily of healthy trees (95.5% on average between 2008 and 2018; Figure 10). The percent of trees in healthy condition did not change significantly between 2008 and 2018 ($p=0.81$). On average 2.3% of trees were in light to moderate decline and 2.2% were in severe decline. The percent of living trees with crowns in severe decline reached the highest value in 2009 and consisted only of pin cherry. The percent of trees in severe decline decreased between 2009 and 2018 because the declining trees from the previous years died and thus were not included in further analysis.

There was variation in crown vigour among tree species with only white ash and pin cherry showing signs of decline (Figure 11). Pin cherry showed higher average values of decline than any other species in 2008, 2009 and 2012. American beech is only shown in 2009 and 2012 because it switched from a crown class of 3 (intermediate) in 2008 to 2 (co-dominant) in 2009/2012 and then back to 3 in 2015 and 2018.

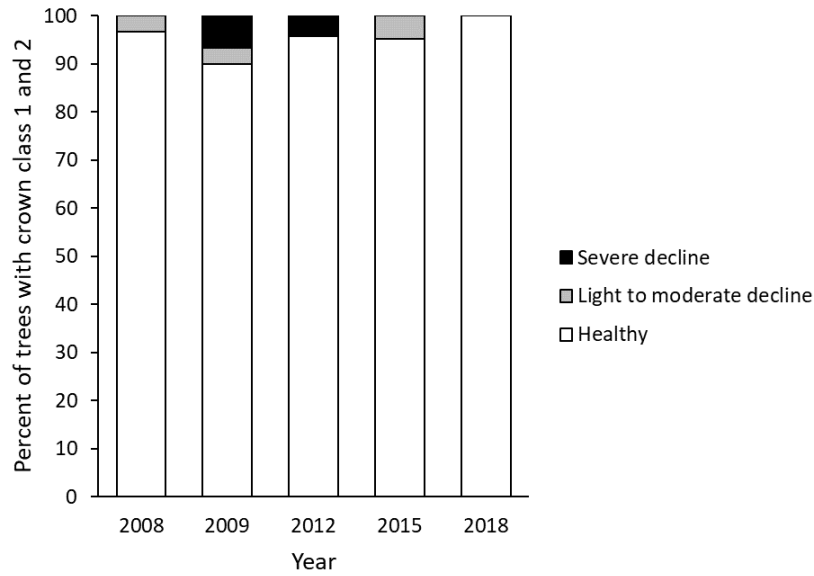


Figure 10. Temporal changes in crown vigour of living trees with crown classes 1 and 2 (dominant and co-dominant).

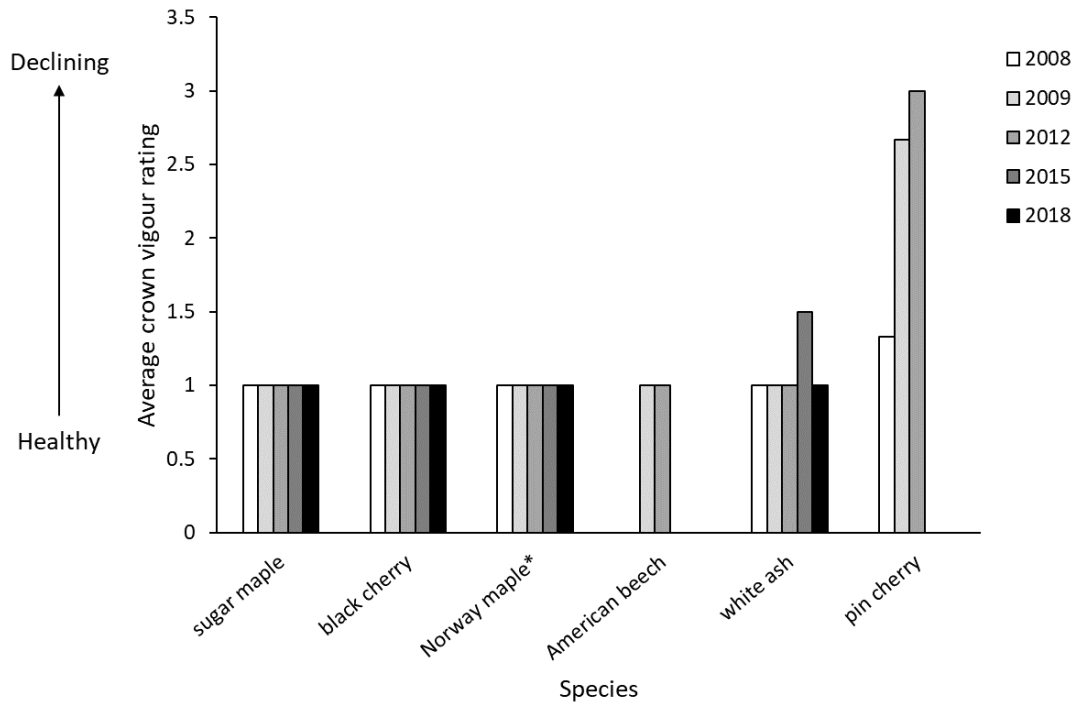


Figure 11. Temporal trends in average crown vigour of dominant and co-dominant trees for selected tree species between 2008 and 2018. For each species, bars on the graph run left to right chronologically by year.

Anecdotal observations by flora biologists in 2016 suggested that trails now surround the periphery of the forest vegetation plot and due to the proximity to residential areas, there is evidence of garbage/litter near the trails. There has also been damage to trees near trails (e.g. intentionally broken branches) due to human

activity. By 2018, the informal trails were expanded into the vegetation plot although evidence of garbage/litter was not noted.

Mortality

Mortality was measured by determining the number of trees that changed in status from living to dead between two consecutive years. Trees in all crown classes were included (dominant, co-dominant, intermediate and suppressed). There was no mortality between 2008 and 2009; however, 2012, 2015 and 2018 all had mortality occur (Table 4). The majority of species dying were pin cherry but one sugar maple died between 2012 and 2015 and one white ash died between 2015 and 2018. Sajan (2006) suggests further research into the cause of mortality if average annual mortality exceeds 5% in dominant and co-dominant trees. When only dominant and co-dominant trees were included in mortality analyses, mortality rose to 7% for both 2009-2012 and 2012-2015 but remained below 5% for 2015-2018. This higher mortality in dominant and co-dominant trees is not a result of more trees dying but because fewer trees were included as the total sample size (i.e. intermediate and suppressed trees were excluded). Plots were not surveyed annually so it is difficult to determine if this mortality rate is of concern based on mortality rates calculated over a 3-year time span. As discussed previously, pin cherry is an early successional species requiring ample sunlight to be successful and the increasing shaded conditions in the plot over the years is the likely cause of pin cherry mortality. These mortality events were also forecast in the analysis of average crown vigour with pin cherry showing signs of decline over all years. The single sugar maple that died between 2012-2015 had shown structural damage and the presence of eutypella canker (*Eutypella parasitica*) in the years prior to 2015. The white ash that died between 2015 and 2018 started forming epicormic shoots in 2012 indicating that the tree was under stress. This could be due to emerald ash borer (*Agrilus planipennis*) although this was not confirmed.

Table 4. Annual tree mortality of trees of all crown classes between 2008 and 2018.

Years	Mortality (% of trees that died)	Species
2008-2009	0	-
2009-2012	5.71	Two pin cherry trees
2012-2015	5.56	One sugar maple and one pin cherry
2015-2018	2.78	One white ash

Alive Trees vs. Snags

Tree snags were counted as long as they remained standing. The percentage of snags has remained relatively constant (on average 5.5%) between 2008 and 2018 although there was a slight drop in 2009 due to one of the snags from the previous year falling (Figure 12). Snag species composition varied annually but included white ash and pin cherry in 2008, white ash in 2009, two new pin cherry individuals in 2012, a sugar maple and new pin cherry in 2015 and a sugar maple and a new white ash in 2018. Many of the snags created in a year had fallen by the following year leading to high turnover in the individuals comprising the snags.

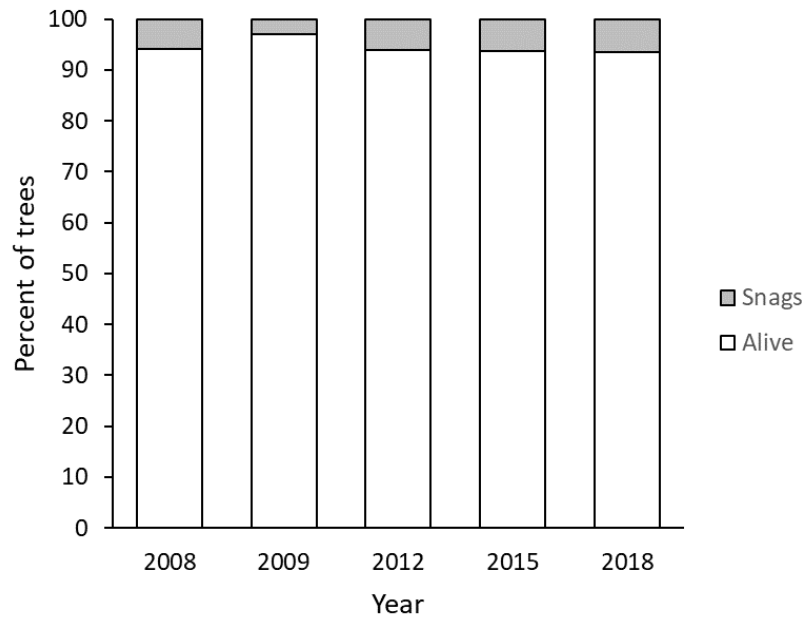


Figure 12. Percent of trees classified as snags or alive.

Pests and Disease

Incidences of pests and diseases were low across years (Table 5). The presence of gypsy moth (*Lymantria dispar*) was documented on one sugar maple tree in 2015 with larvae identified but defoliation due to larval consumption of leaves was not recorded. Beech scale (*Cryptococcus fagisuga*), an insect vector of beech bark disease, was observed on the one beech tree in the plot in 2008 and continues to affect the same tree in 2018 now with hyphae and adult nymphs observed. Eutypella canker was found on one sugar maple tree only in 2008. Sugar maple is most susceptible to the disease which usually does not kill the tree but may cause limbs or the trunk to break where the canker is present. It appears that the disease did lead to the death of this sugar maple as structural damage to the tree was observed before the tree died between 2012 and 2015. One other sugar maple had several exit holes noted in 2018 indicating a wood boring pest. One white ash was being affected by emerald ash borer in 2018 with a D-shaped hole observed and many woodpecker feeding holes along the trunk.

Table 5. Occurrence of identified pests and diseases at FV 26A between 2008 and 2018.

Pest/disease		2008	2009	2012	2015	2018
Gypsy moth	# live stems affected	-	-	-	1	-
	% live stems affected	-	-	-	2.7%	-
Beech scale	# live stems affected	1	-	-	-	1
	% of live beech stems affected	100%	-	-	-	100%
Eutypella canker	# live stems affected	1	-	-	-	-
	% of live maple stems affected	4%	-	-	-	-
Emerald ash borer	# live stems affected	-	-	-	-	1
	% of live ash stems affected	-	-	-	-	25%

4.1.2 Forest birds

Forest Bird Community Composition

Forest bird communities differed based on station location (Figure 13). Red-eyed vireo (*Vireo olivaceus*) dominated both station 1 and 3 while black-capped chickadee (*Parus atricapillus*) dominated station 2. Nesting habitat preference (e.g. forest upper-level nester, generalist mid-level nester, etc.) also varied based on station location although there did not appear to be any temporal changes in species composition based on habitat preference (Figure 14).

The presence of red-eyed vireo and eastern wood-pewee (*Contopus virens*) indicates a more mature, closed canopy forest; however, all stations had a mixture of species representing both forest-related and more generalist or edge environments. This diversity indicates that the forests have not completely matured and/or are in patches too small to attract forest interior species. If forest interior habitat is created in the long-term, ovenbird (*Seiurus aurocapillus*) or scarlet tanager (*Piranga olivacea*) may be documented in forest bird surveys. Veery was detected at station 26A.2 for the first time in 2018. This species prefers wet sites, can occur in disturbed or regenerating forests and is area-sensitive meaning that it prefers to nest in larger forest tracts (Rosenberg et al. 2003). It is important to note that the mere presence of a species does not indicate that the habitat is of high quality because the species could still be subject to high nest predation rates due to matrix influences (e.g. predators associated with urban housing developments).

Notable species of regional conservation concern found at forest bird stations include least flycatcher (*Empidonax minimus*) and yellow-billed cuckoo (*Coccyzus americanus*) at station 1, mourning warbler (*Geothlypis philadelphia*) at station 2 and American redstart (*Setophaga ruticilla*) at stations 2 and 3 (all ranked L3). Brown-headed cowbirds (*Molothrus ater*), a nest parasite of numerous bird species, were found at both stations 1 and 2 but was not detected at station 3. This species can significantly decrease the number of young produced from each nest it parasitizes and is thought to contribute to declines in forest bird populations (Brittingham and Temple 1983).

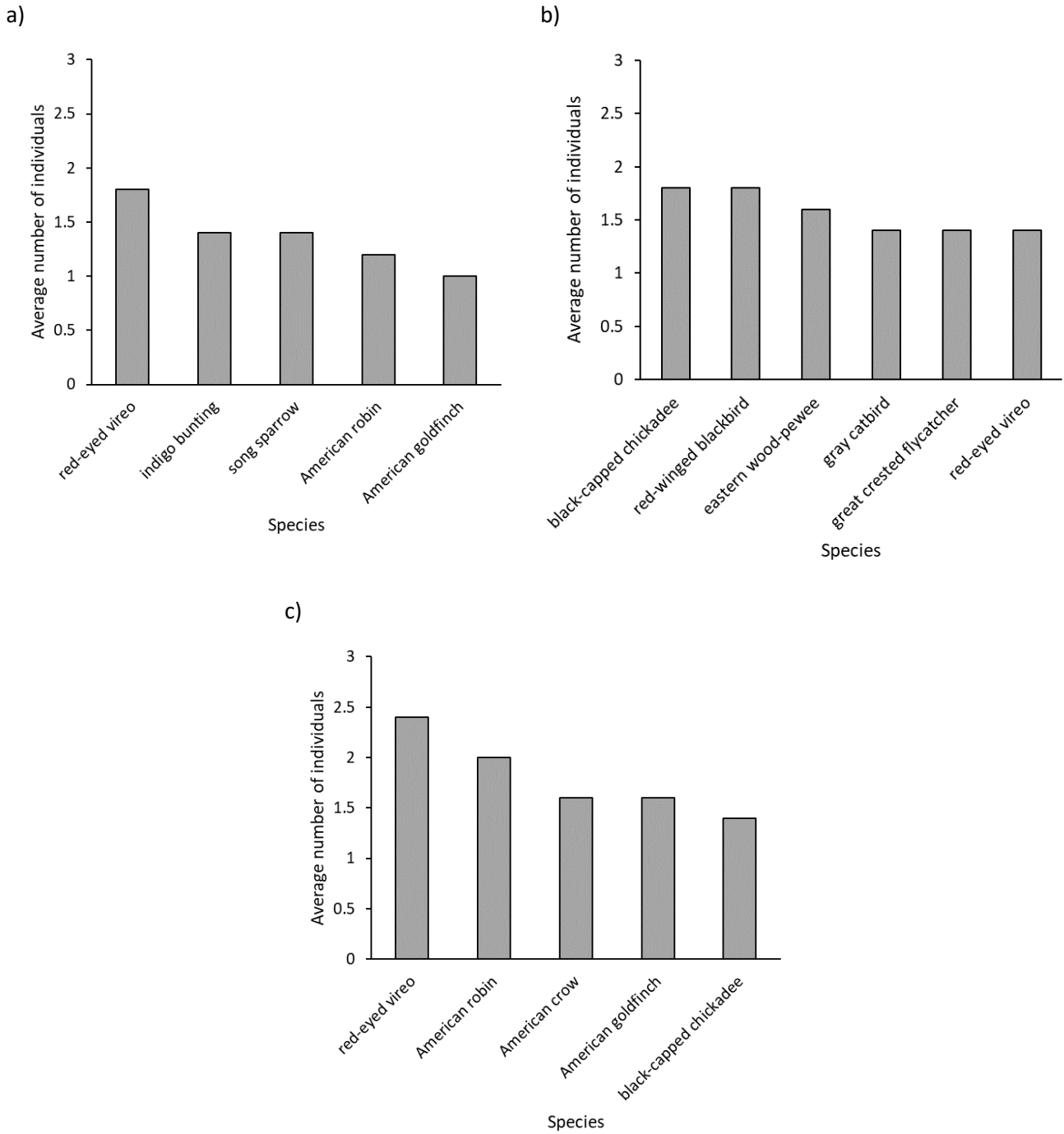


Figure 13. Community composition of the five most abundant species (averaged 2008-2018) recorded at forest bird monitoring stations a) FB 26A.1, b) FB 26A.2 and c) FB 26A.3.

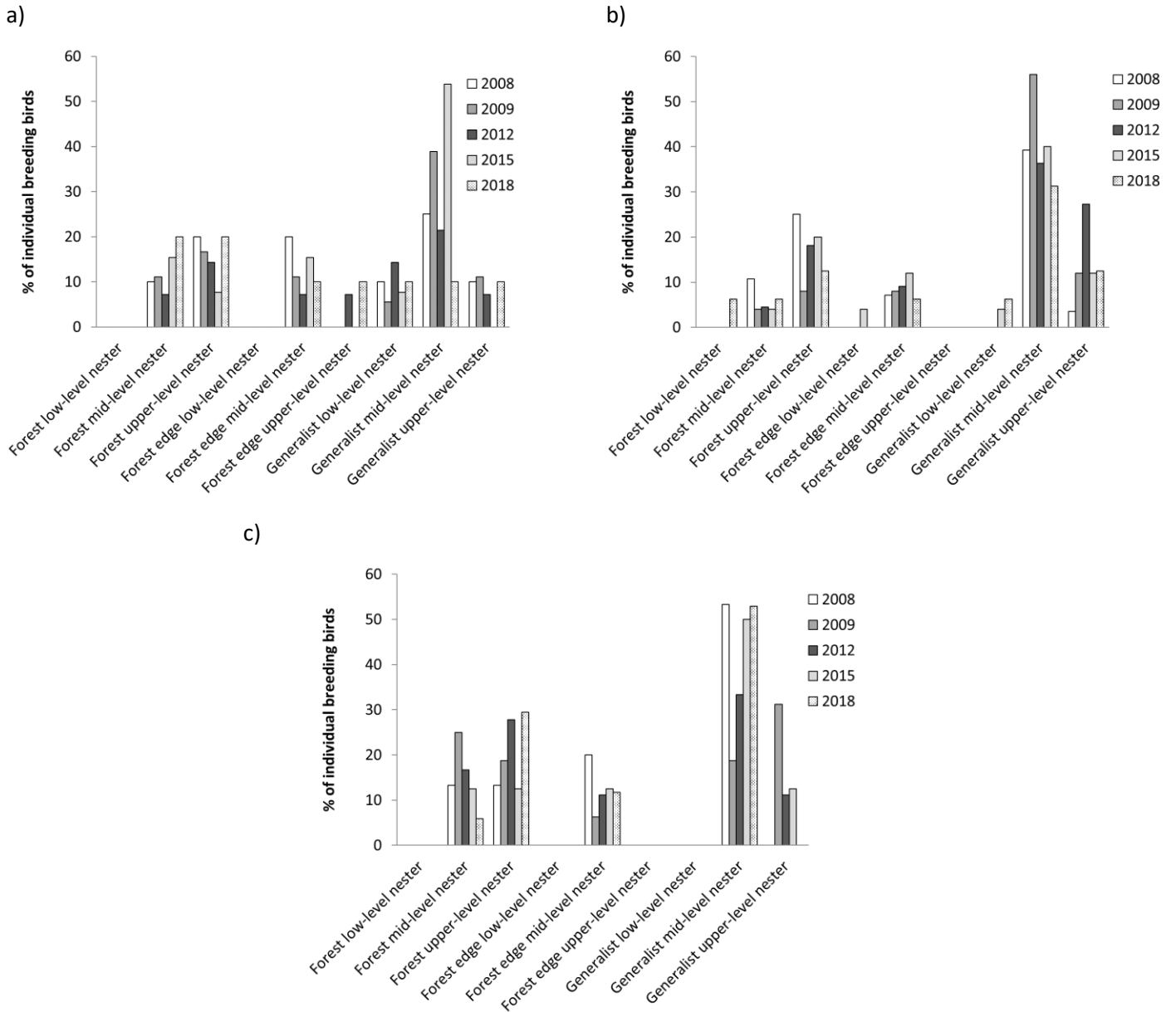


Figure 14. Proportion of individual breeding birds by habitat and nesting location at forest bird monitoring stations a) FB 26A.1, b) FB 26A.2 and c) FB 26A.3.

Temporal Trends in Forest Bird Monitoring Indicators

Temporal trends were examined for the abundance of forest-dependent birds, species richness of forest-dependent birds, and the number L1-L4 bird species. Bird species were defined as forest-dependent based on their nesting requirements in forest or swamp habitat (Appendix Table A.1). There was no significant change temporally in any of these variables between 2008 and 2018 (Figure 15; all $p > 0.31$).

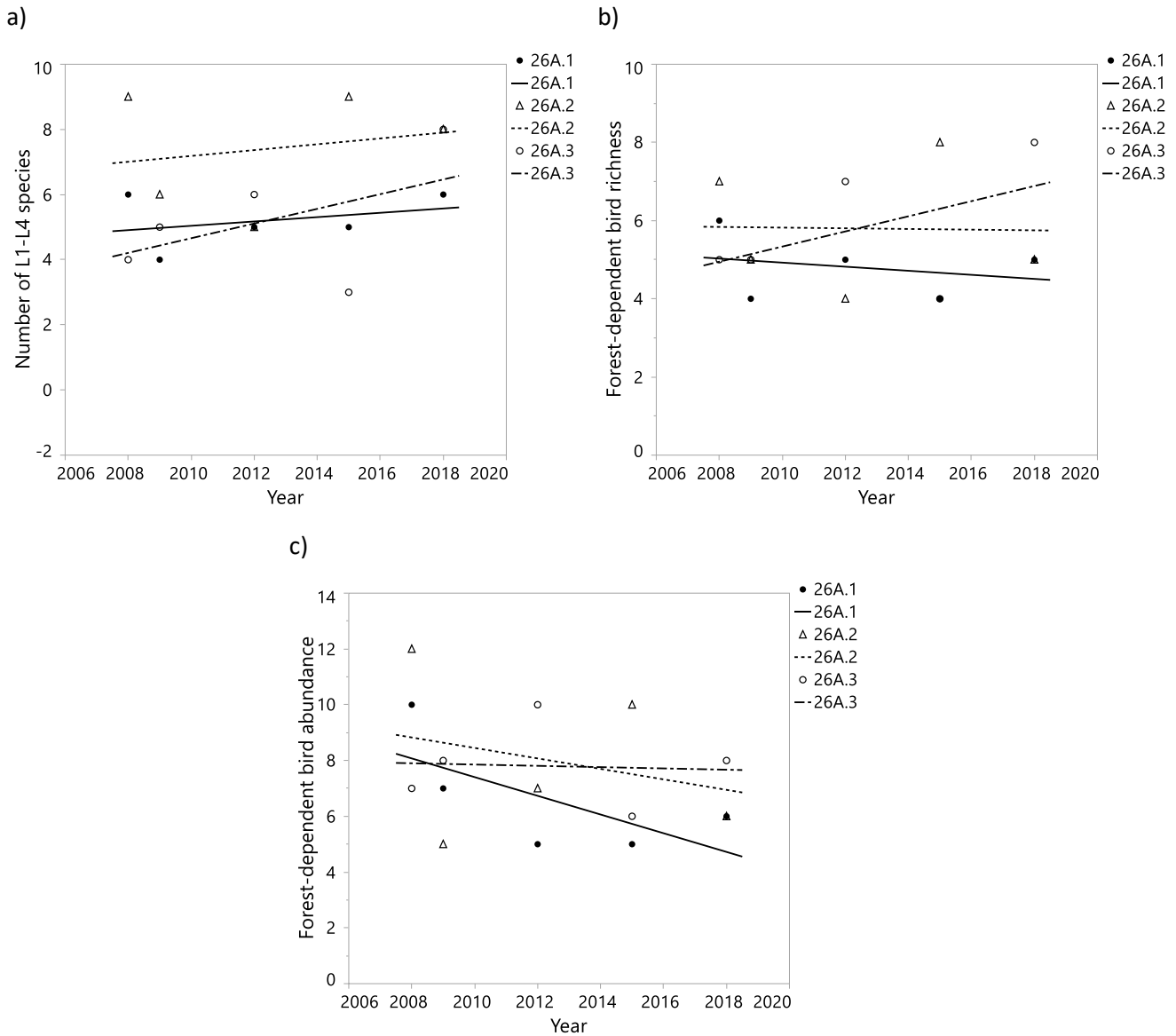


Figure 15. Temporal trends in forest bird high-level indicators a) number of L1-L4 bird species, b) forest-dependent bird richness and c) forest-dependent bird abundance. Trends are shown for each station separately.

4.2 Wetland Monitoring

4.2.1 Wetland vegetation

Floristic Quality Index, Percent Native Species, Number of L1-L3 Species

Floristic quality index (FQI) varied among wetland vegetation transects (Figure 16). Higher floristic quality index values indicate an area with many native species and/or many species that have a low tolerance to disturbance and a high fidelity to specific natural habitats (Bourdagh et al. 2004). Tolerance to disturbance and site fidelity are combined to create a coefficient of conservatism value for each species which is used to calculate FQI. For example, a species that is common to floodplain forests and riverbanks but is also found in urban areas would be assigned a low value for its coefficient of conservatism (Chadde 1998). If many species in one area share this characteristic, the value of FQI will be low.

Transect 7B had the highest FQI value meaning that this transect contained species with high coefficient of conservatism values and a large number of native species. Alternatively, transect 7D had the lowest FQI value because the species found there had low coefficient of conservatism values and there was a small number of native species (even though it had a moderate percentage of native species). These qualities are also seen in the number of species of regional concern (L1-L3). Transect 7D had the smallest number of L1-L3 species and transects 7 and 7A had the greatest number of L1-L3 species.

These variables at most stations have remained constant between 2008 and 2018 ($p > 0.19$). The percentage of native species may be declining at station WV-7 although the results were only approaching significance ($p = 0.12$). The FQI may be increasing at station WV-7E although again, these results were only approaching significance ($p = 0.09$).

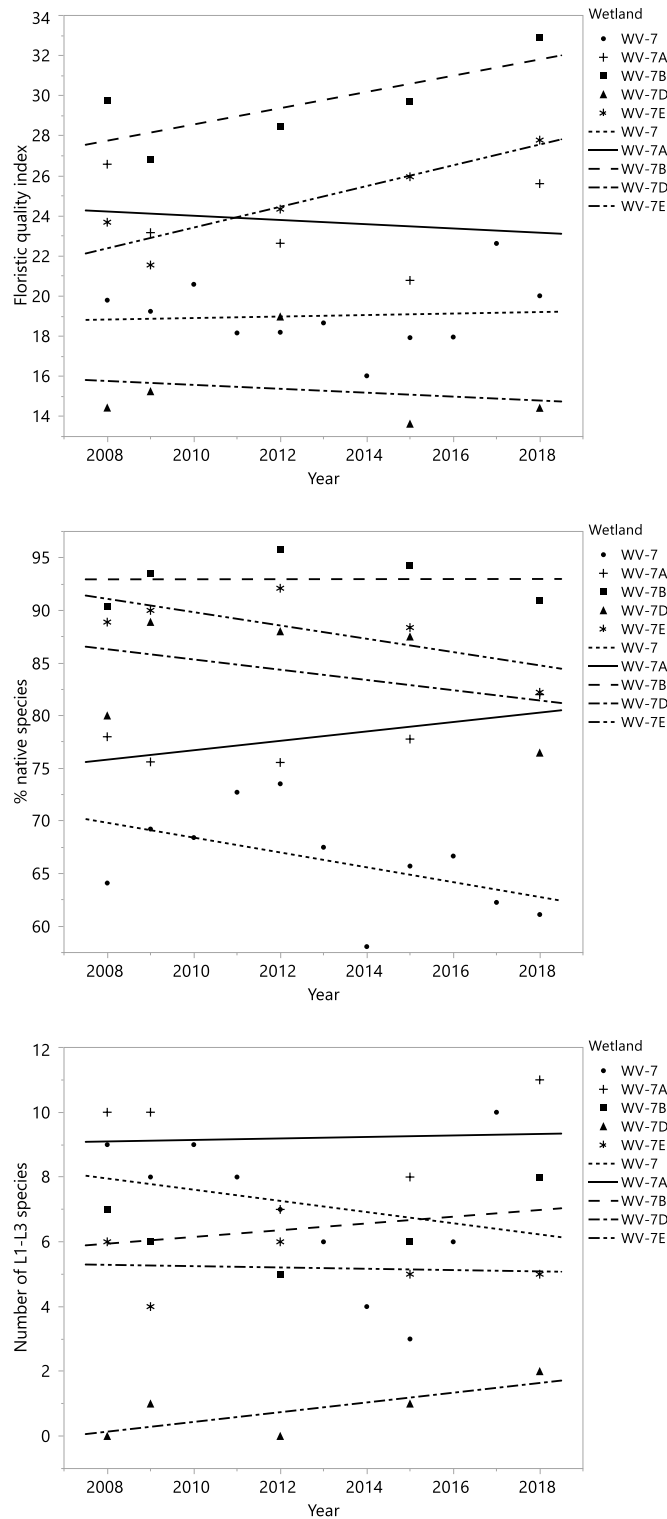


Figure 16. Temporal changes in wetland flora species metrics between 2009 and 2018. Trends are shown for each transect separately. ** = $p < 0.05$, * = $0.05 < p < 0.09$.

Wetland Water Levels

Changes in wetland hydrology were apparent between 2009 and 2018 at transect 7D (Table 6). Water depths increased by on average 77 cm along the entire length of the transect between 2009 and 2018.

Table 6. Water depths at the 0, 10, 20, 30, 40 and 50 m points along wetland vegetation transects between 2008 and 2018.

Transect	Visit Year	Water Depth 0 m	Water Depth 10 m	Water Depth 20 m	Water Depth 30 m	Water Depth 40 m	Water Depth 50 m
WV 7	2008	19	48	55	46	55	93
	2009	28	65	86	75	73	110
	2010	29	-	-	71	-	110
	2011	11	58	73	70	81	107
	2013	27	73	87	78	91	116
	2014	17	71	84	84	85	104
	2015	21	59	74	61	59	110
	2016	0	26	43	43	47	77
	2017	29	73	72	76	89	123
	2018	27	67	74	74	83	118
WV 7A	2008	0	48	46	33	0	0
	2009	4	96	100	89	22	34
	2015	0	53	63	52	0	0
	2018	0	51	69	50	0	12
WV 7B	2008	0	0	11	0	5	1
	2009	0	0	5	0	0	0
	2015	0	0	19	0	0	0
	2018	0	4	29	0	14	0
WV 7D	2008	0	8	13	5	12	0
	2009	0	14	21	12	15	1
	2015	0	83	88	64	76	75
	2018	11	104	106	94	99	84
WV 7E	2008	0	0	0	0	0	0
	2009	0	20	20	20	20	20
	2015	0	0	0	0	0	0
	2018	0	0	0	0	0	0

Wetland Woody Regeneration Species Composition

Relative percent cover of wetland woody regeneration was dominated by slender willow (*Salix petiolaris*) on transects 7 and 7A, red osier dogwood (*Cornus stolonifera*) on transects 7B and 7E and common buckthorn (*Rhamnus cathartica*) on transect 7D (Figure 17). The dominance in cover by common buckthorn on transect 7D (35%) is new and surpassed silver maple (*Acer saccharinum*) for the first time in 2018.

Red osier dogwood also dominated transects 7B and 7E based on relative abundance (Figure 18). Common buckthorn is the new dominant species by relative abundance in transect 7 in 2018. Winterberry had the highest relative abundance in transect 7A. Silver maple remains the dominant species by relative abundance in transect 7D.

Winterberry and shining willow were the only two species in the top five based on relative cover and abundance that are species of regional concern (ranked L3). Winterberry was ranked in the top five species based on relative percent cover and relative abundance on transects 7A, 7B and 7E, while shining willow was ranked in the top five on transects 7A and 7E based on relative percent cover. Black choke-berry (*Aronia melanocarpa*) was another notable species (ranked L2) that was found on transect 7E although was not ranked in the top five species.

Several exotic species with invasive characteristics were found ranked in the top five based on relative abundance including common buckthorn on transects 7, 7D and 7E, shrub honeysuckle on transect 7, and bittersweet nightshade (*Solanum dulcamara*) on transects 7A, 7B, 7D and 7E. These species also often had high relative covers especially on transects 7 and 7D. It may be cause for concern that common buckthorn has increased in cover at transect 7D, now the dominant species by percent cover in the transect. It has also increased in relative abundance on transect 7, again, now the dominant species by relative abundance.

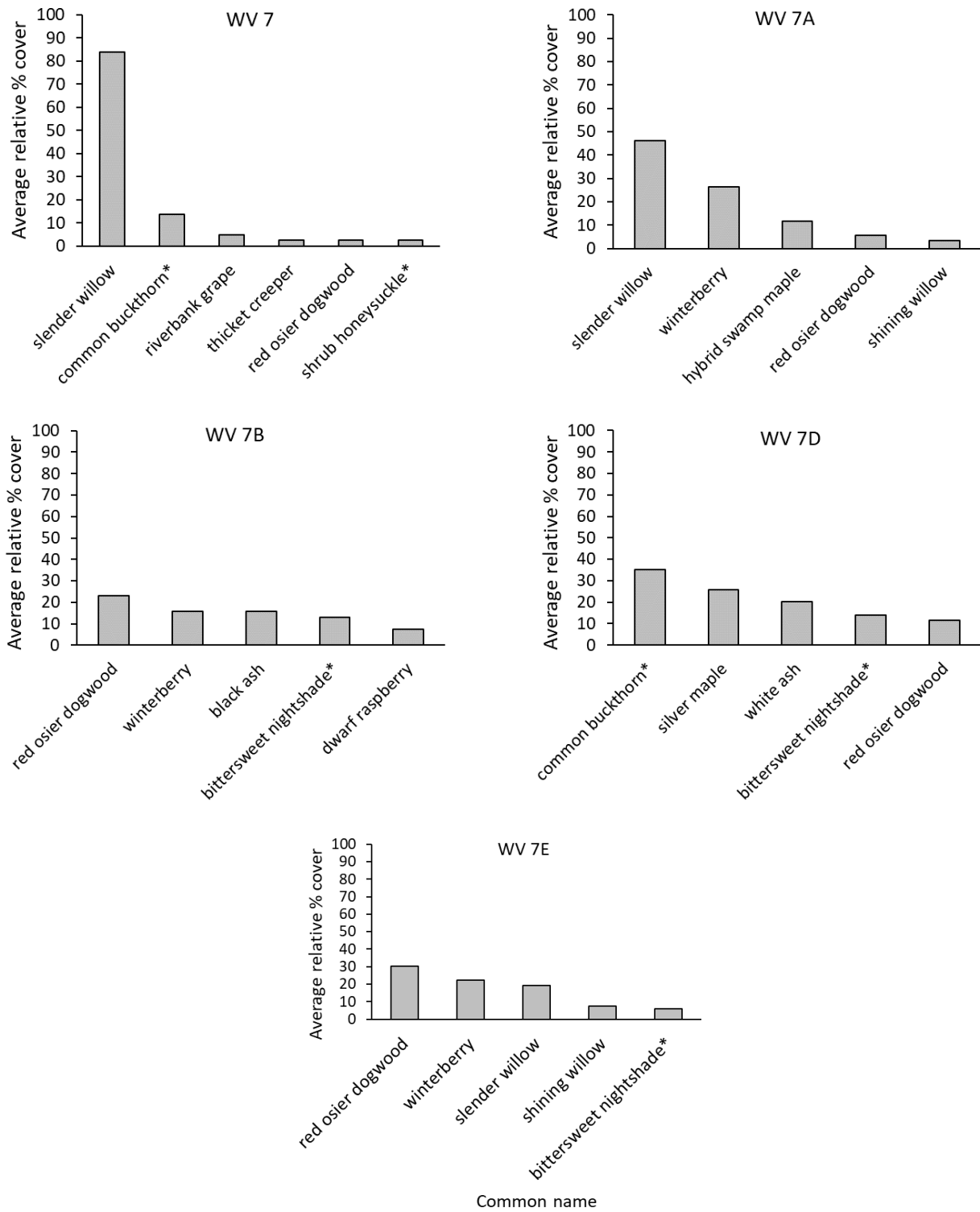


Figure 17. Average relative percent cover of the five most common wetland woody species at wetland vegetation transects WV-7, 7A, 7B, 7D and 7E. Exotic species are indicated with an asterisk (*).

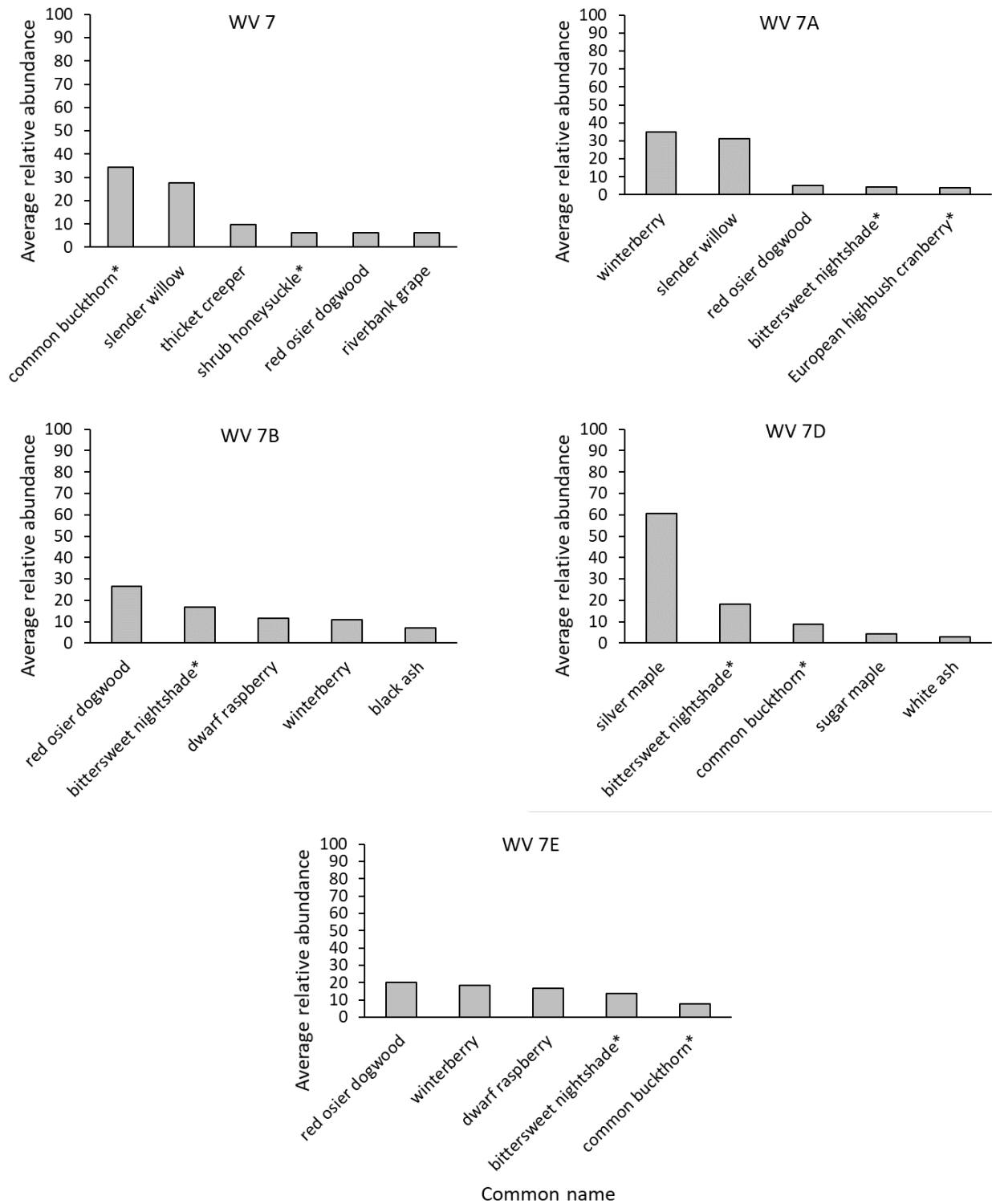


Figure 18. Average relative abundance of the five most common wetland woody species at wetland vegetation transects WV 7, 7A, 7B, 7D and 7E. Exotic species are indicated with an asterisk (*).

Wetland Ground Vegetation Species Composition

Transects varied greatly in ground vegetation species composition for the top five ranked species based on relative percent cover (Figure 19). The majority of species in the top five based on relative cover on transects 7 and 7A were species of regional concern (ranked L3) including flat-stemmed pondweed (*Potamogeton zosteriformis*), floating pondweed (*Potamogeton natans*), bushy naiad (*Najas flexilis*), northern manna grass (*Glyceria borealis*), Small's spike-rush (*Eleocharis palustris*) and star duckweed (*Lemna trisulca*). Transect 7B did not contain any L3 species in the top five. Star duckweed and dotted water-meal (*Wolffia borealis*) were the two L3 ranked species with relative covers in the top five of transect 7D. Fringed sedge (*Carex crinita*) was the only L3 ranked species with a relative cover in the top five of transect 7E. Least pondweed (*Potamogeton pusillus ssp. tenuissimus*), lesser bur-reed (*Sparganium natans*) and three-way sedge (*Dulichium arundinaceum*) were three other notable species (ranked L2) that were found on transect 7 although were not ranked in the top five species. Invasive species were essentially absent from the top five ranked species.

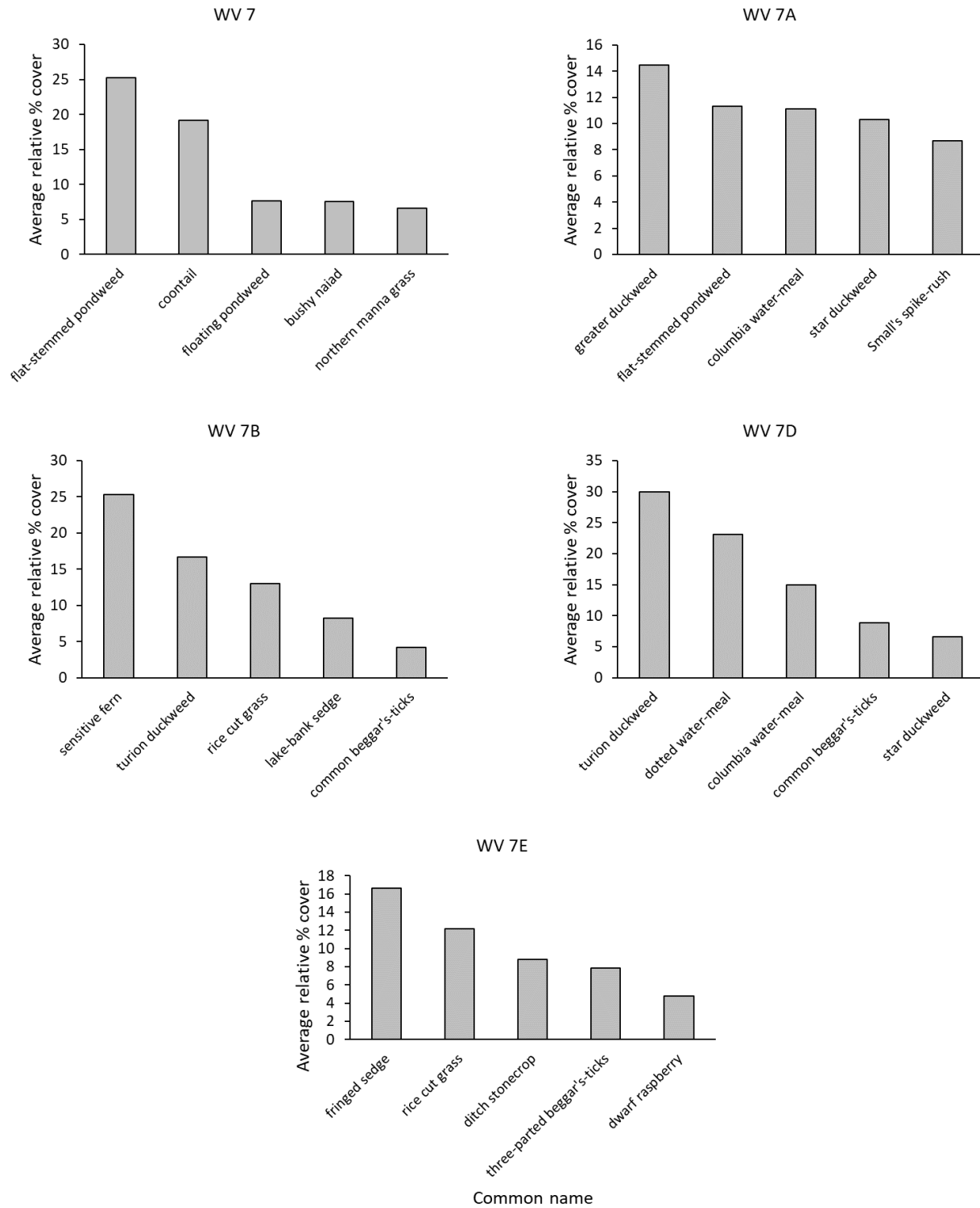


Figure 19. Average relative percent cover of the top five ranked ground vegetation (herbaceous) species on transects 7, 7A, 7B, 7D and 7E. Exotic species are indicated with an asterisk (*).

4.2.2 Wetland birds

Wetland Bird Community Composition

Wetland bird communities differed based on station location (Figure 20). Mallard (*Anas platyrhynchos*) dominated station 1, Canada goose (*Branta canadensis*) dominated station 2 and swamp sparrow (*Melospiza georgiana*) dominated station 3. Nesting habitat preference (e.g. wetland low-level nester, generalist mid-level nester, etc.) did not vary greatly based on station location and there do not appear to be any temporal changes in species composition based on nesting habitat preference (Figure 21).

Notable species of regional conservation concern (L3) found at wetland bird stations include least flycatcher (*Empidonax minimus*) at station 1 and American redstart at all three stations. Multiple L3-ranked species were detected at station 3 between 2008 and 2018 including alder flycatcher (*Empidonax alnorum*), black-throated blue warbler (*Setophaga caerulescens*), black-throated green warbler (*Setophaga virens*) and veery. Although these species are not completely reliant on wetland habitat, they may have been using this habitat for migration (warblers) or nesting since these flycatchers and the American redstart sometimes use swamp edges or wet areas for nesting (Sherry and Holmes 1997, Lowther 1999, Tarof and Briskie 2008).

Species of regional conservation concern (ranked L3) highly dependent on wetland habitat include Virginia rail (*Rallus limicola*) at stations 1, 2 and 3, hooded merganser (*Lophodytes cucullatus*) at station 1, sora (*Porzana carolina*) at station 1 and 2, and pied-billed grebe (*Podilymbus podiceps*) at stations 1 and 2.

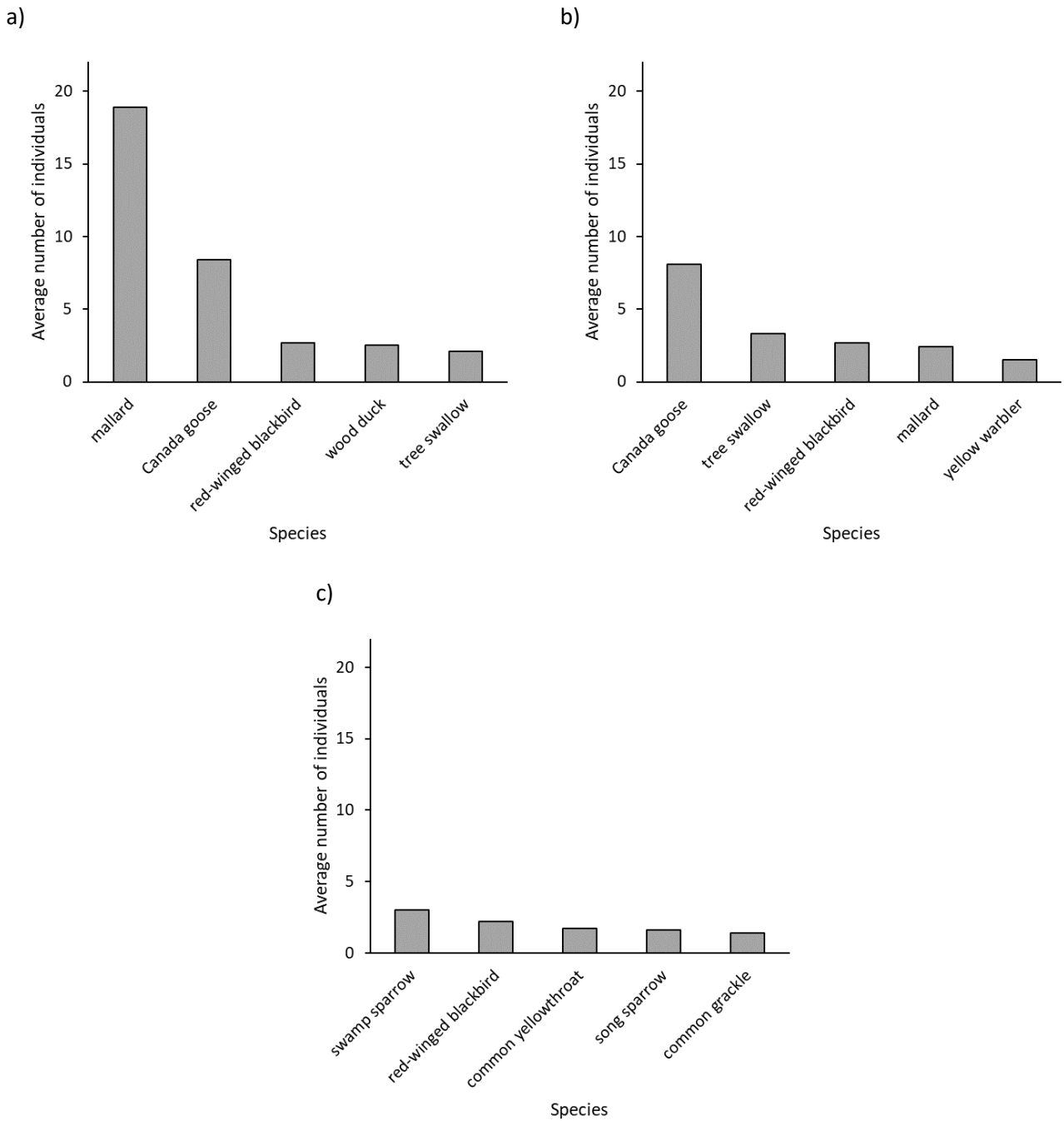


Figure 20. Community composition of the five most abundant species (averaged 2008-2018) recorded at wetland bird monitoring stations a) WB 7.1, b) WB 7A.2 and c) WB 7A.3.

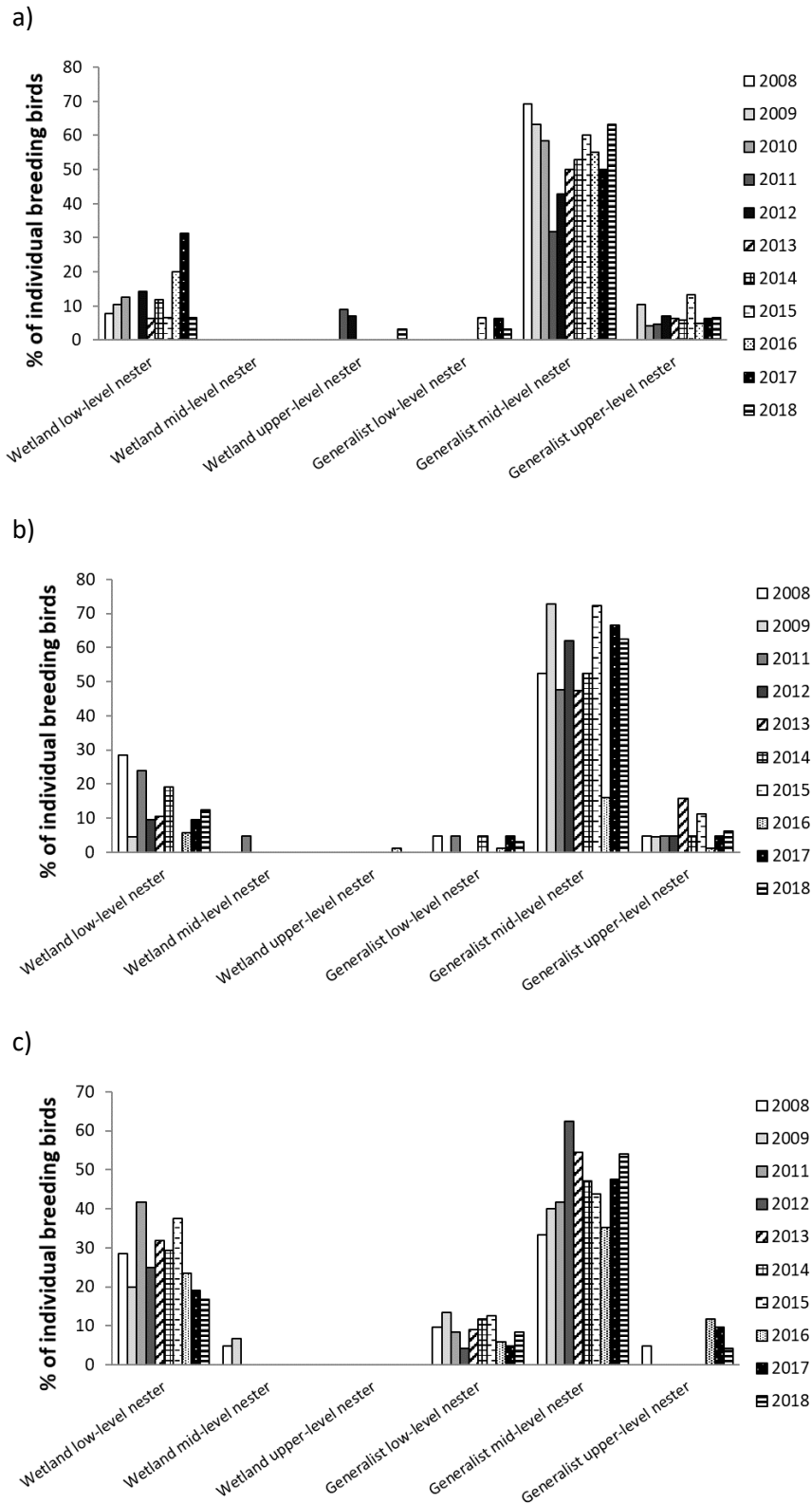


Figure 21. Proportion of individual breeding birds by habitat and nesting location at wetland bird monitoring stations a) WB 7.1, b) W 7A.2 and c) WB 7A.3. Canada goose and mallard were excluded.

Temporal Trends in Wetland Bird Monitoring Indicators

Temporal trends were examined for the abundance of wetland-dependent birds (excluding Canada goose and mallard), species richness of wetland-dependent birds, the number L1-L3 bird species, the number of L1-L4 bird species and the number of Virginia rails. Bird species were defined as wetland-dependent based on their nesting requirements (Appendix Table A.1). There were no significant temporal trends for wetland-dependent bird abundance, richness, L1-L3 and L1-L4 species (all $p > 0.12$). There were significant declines in the number of Virginia rails between 2008 and 2018 at station 7A.3 ($p = 0.02$) and there were increases in the number of wetland-dependent bird species at station 7.1 although the results were only approaching significance ($p = 0.09$; Figure 22).

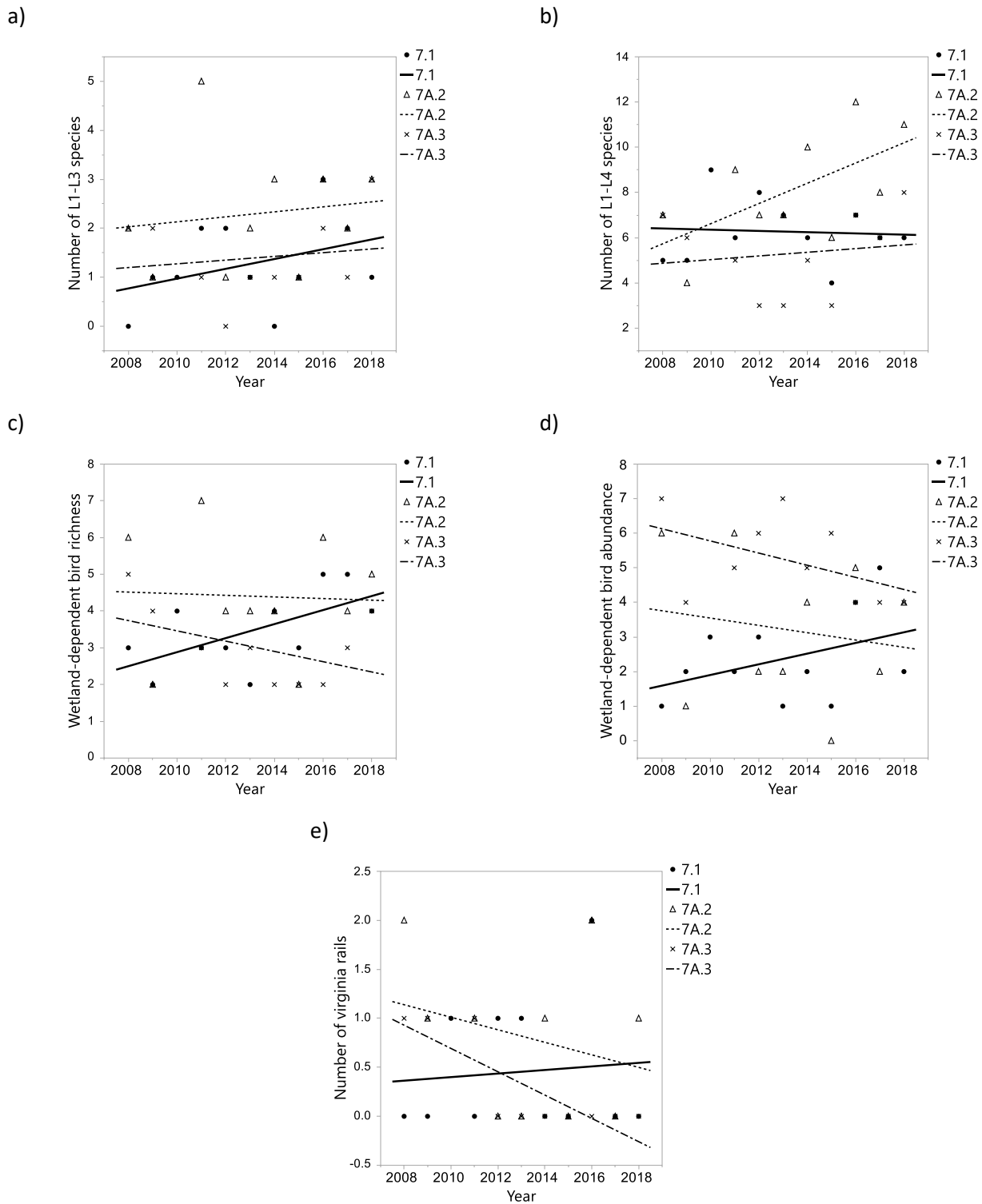


Figure 22. Temporal trends in wetland bird high-level indicators a) number of L1-L3 bird species, b) number of L1-L4 species, c) wetland-dependent bird richness, d) wetland-dependent bird abundance and e) number of Virginia rails. Trends are shown for each station separately.

4.2.3 Frogs

Frog Species Composition

Six frog species were detected at wetland frog stations between 2009 and 2018 including green frog (*Lithobates clamitans*), spring peeper (*Pseudacris crucifer crucifer*), wood frog (*Lithobates sylvatica*), tetraploid grey treefrog (*Hyla versicolor*), northern leopard frog (*Lithobates pipiens*) and American toad (*Anaxyrus americanus*). Each of the six individual species were found in at least one year at each station except for Northern leopard frog which was not detected station 7A.3.

Percent of Stations Occupied

Only frogs detected within the 100 m radius semi-circle were included in temporal analyses. There were no significant temporal changes in the number of frog species detected between 2009 and 2018 at any of the wetland frog stations (all $p > 0.12$; Figure 23). Since surveys measure frog abundance based on a calling code (refer to methods section) it is often difficult to measure temporal changes in absolute abundance. Instead, the proportion of stations occupied was used to measure changes in occurrence temporally. Spring peeper occupied all stations in all years suggesting the population is healthy at this site. The proportion of stations occupied by green frogs has declined since 2009 ($p = 0.01$). Between 2009 and 2013 all stations were occupied, but since then, only two of three stations have been occupied. There were no significant declines between 2009 and 2018 in the proportion of stations occupied for all other frog species (all $p > 0.34$; Figure 24). Even though there were no significant changes in occurrence, tetraploid grey treefrog and wood frog had negative trend lines.

A further examination of the data was conducted to determine if these species were disappearing from a specific station or stations. The green frog was present at all stations until 2014 when it was not detected at WF 7A.2 and in 2015 when it was not detected at station WF 7A.3. At station WF 7A.2, green frogs continue to be undetected (or absent) between 2016 and 2018. At station WF 7A.3, green frogs were again detected between 2016 and 2018.

The occurrence of tetraploid grey treefrog seems to fluctuate among years and stations and is likely reflecting differences in detectability based on seasonal variation in weather or natural variability in the population. This species was detected at all stations in 2018.

The wood frog was present at all stations in 2009, 2010 and 2011; however, this species has not been detected at station WF 7.1 since 2011 except for one individual detected in 2017. The calling code of this species also slowly declined with a full chorus in 2009, to only one to two individuals detected since then. The lack of detection of this species from station WF 7.1 is cause for concern and warrants further investigation.

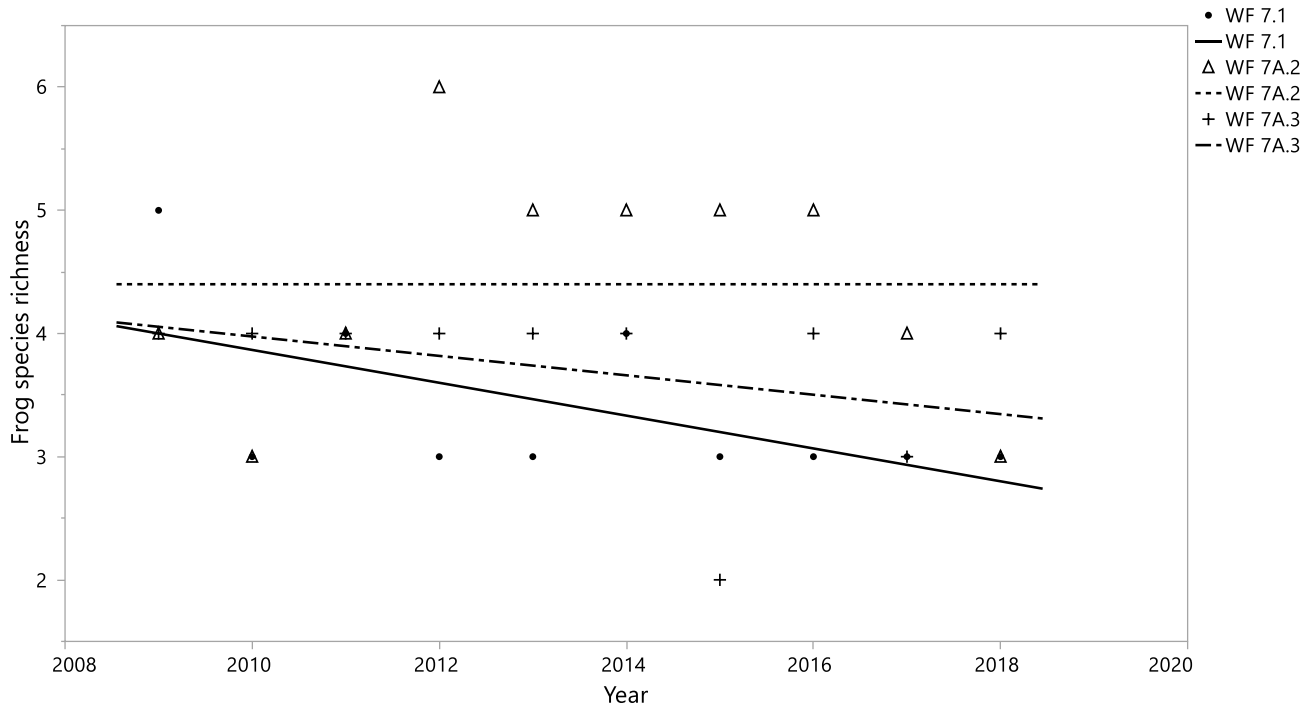


Figure 23. Temporal trends in frog species richness at stations WF 7.1, WF 7A.2 and WF 7A.3 between 2009 and 2018.

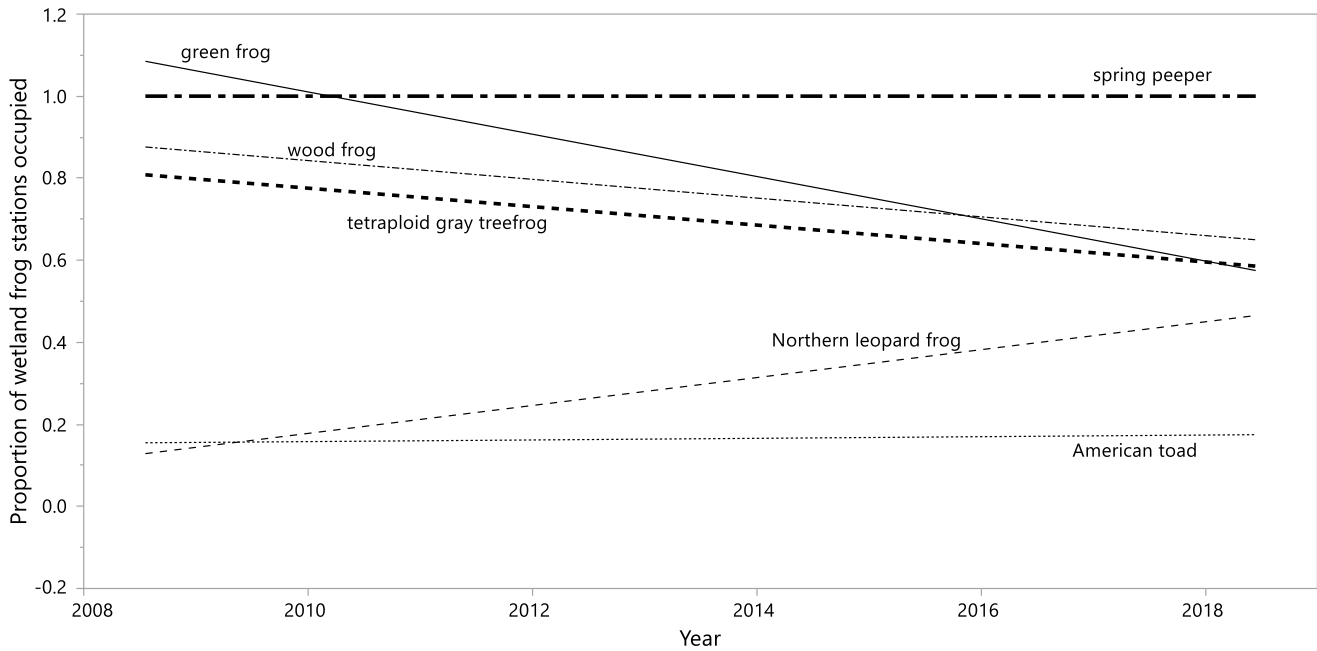


Figure 24. Temporal trends in the percent of sites occupied by specific frog species from 2009 to 2018.

4.3 Meadow monitoring

4.3.1 Meadow birds

Meadow Bird Community Composition

Meadow bird communities differed based on station location (Figure 25). Red-winged blackbirds (*Agelaius phoeniceus*) dominated station 1 while savannah sparrow (*Passerculus sandwichensis*) dominated station 2 and song sparrow (*Melospiza melodia*) dominated stations 3 and 4. Nesting habitat preference (e.g. meadow low-level nester, generalist mid-level nester, etc.) varied greatly based on station location (Figures 26 and 27). Stations 1 and 2 had a greater proportion of meadow-nesting species than stations 3 and 4 which had a similar proportion of generalist species and more forest-associated species. The proportion of individuals that are meadow-dependent low-level nesters declined significantly between 2008 and 2018 at station 1 ($p=0.004$) and station 2 ($p=0.008$).

Bobolink is a notable species of regional conservation concern (ranked L2) and was found at meadow bird stations 1 and 2. This species is area-sensitive meaning it relies on large grassland patches for breeding and generally avoids edges near woody vegetation (Johnson and Igl 2001). In addition to being a species of regional conservation concern by TRCA this species is listed as threatened by the Species at Risk Act in Ontario.

Other species of regional conservation concern (ranked L3) detected at meadow stations include brown thrasher (*Toxostoma rufum*) at stations 2 and 3, eastern meadowlark (*Sturnella magna*) at station 2, chestnut-sided warbler at stations 3 and 4, and alder flycatcher, mourning warbler (*Geothlypis philadelphia*), clay-coloured sparrow (*Spizella pallida*), blue-winged warbler (*Vermivora pinus*) and eastern towhee (*Pipilo erythrophthalmus*) at station 4.

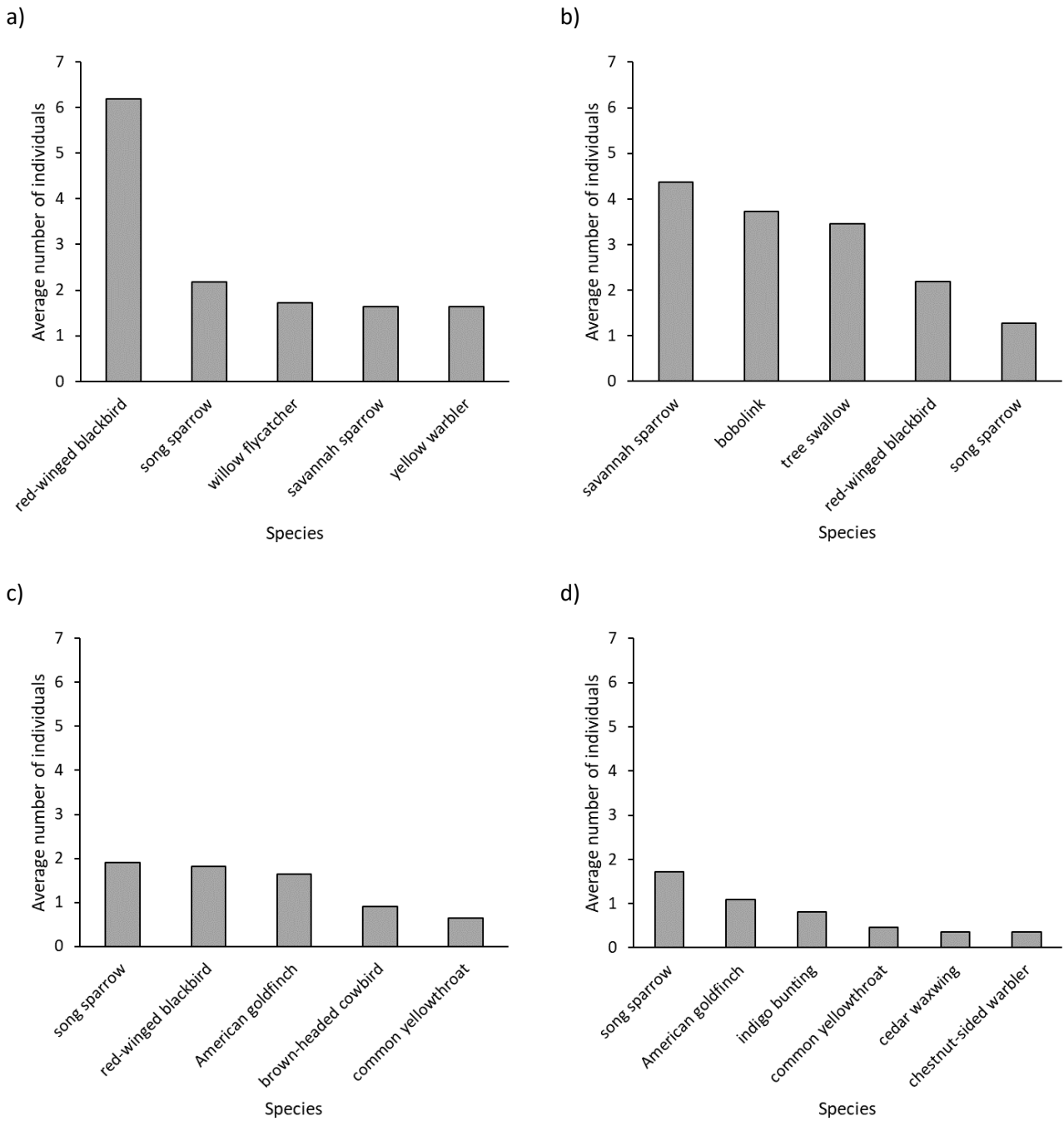


Figure 25. Community composition of the five most abundant species (averaged 2008-2018) recorded at meadow bird monitoring stations a) MB 8.1, b) MB 8.2, c) MB 8A.3 and d) MB 8A.4.

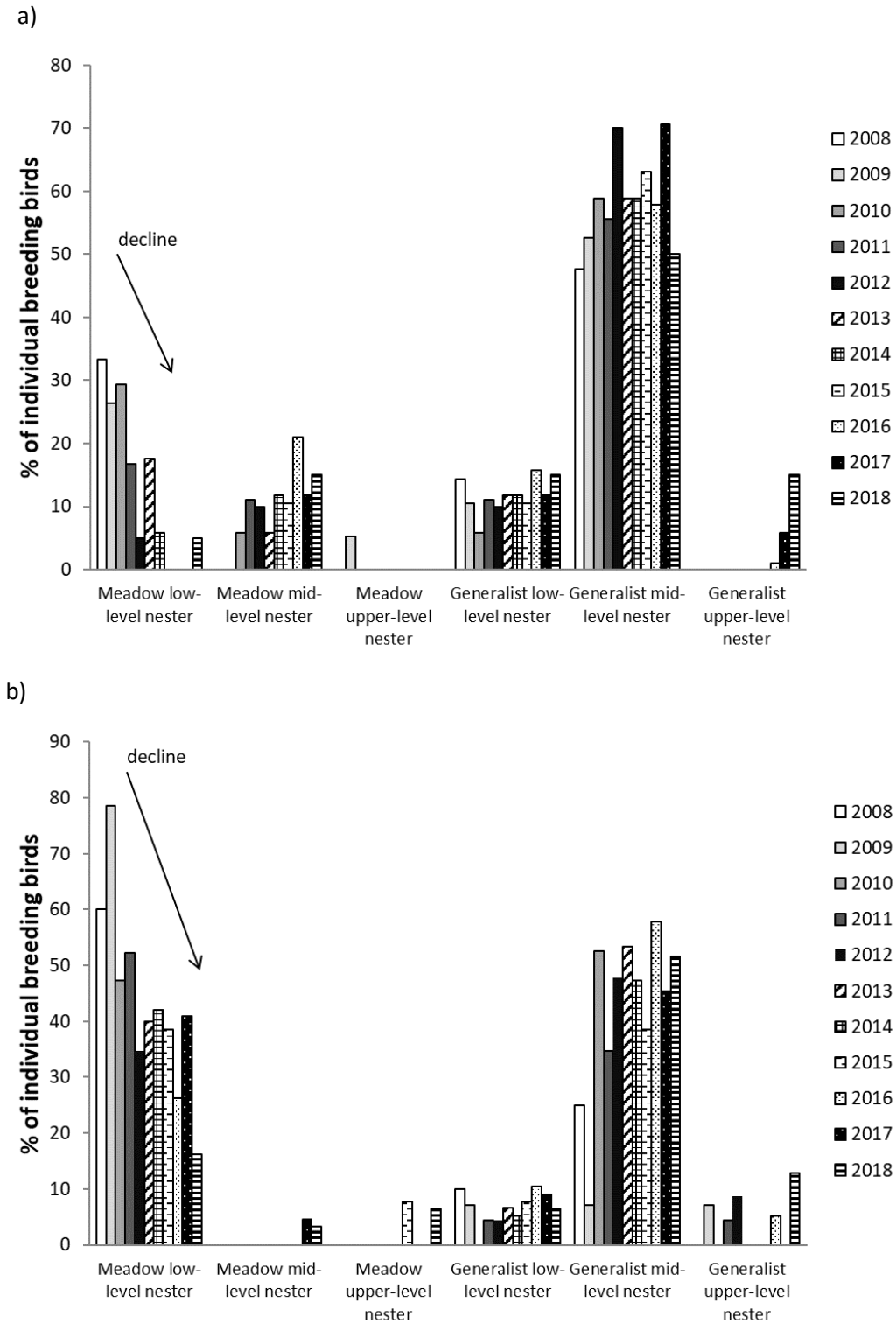


Figure 26. Proportion of individual breeding birds by habitat and nesting location at meadow bird monitoring stations a) MB 8.1 and b) MB 8.2.

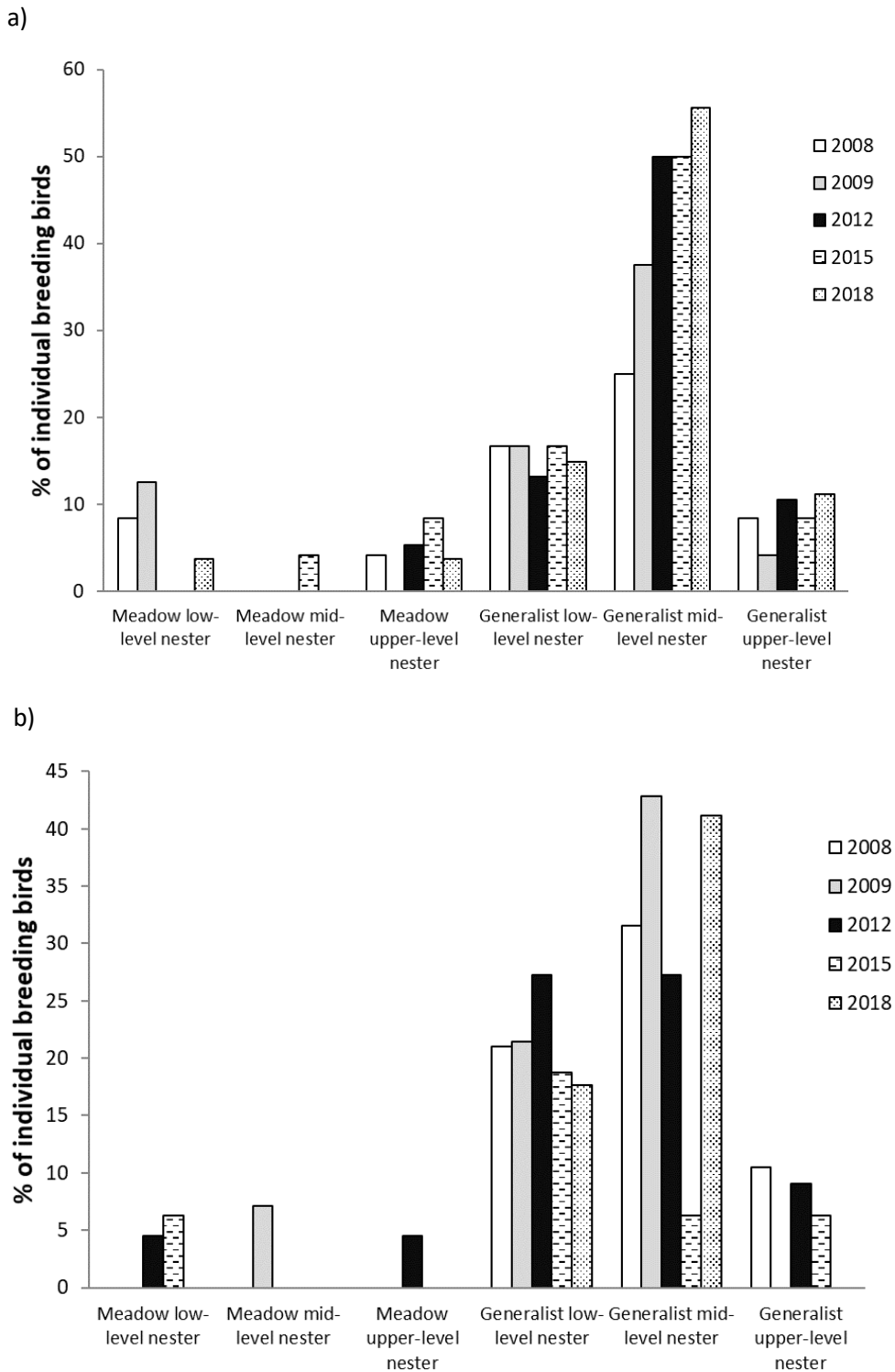


Figure 27. Proportion of individual breeding birds by habitat and nesting location at meadow bird monitoring stations a) MB 8A.3 and b) MB 8A.4.

Temporal Trends in Meadow Bird Monitoring Indicators

Temporal trends were examined for the abundance of meadow-dependent birds, species richness of meadow-dependent birds, the number L1-L3 bird species, the number of L1-L4 bird species and the number of bobolinks. Bird species were defined as meadow-dependent based on their nesting requirements (Appendix Table A.1). There were no statistically significant changes in any of these variables at stations 3 and 4 (all $p > 0.13$, Figure 28). There were several changes temporally in these variables affecting stations 1 and 2. At station 1 between 2008 and 2018 there were significant declines in the abundance of meadow-dependent birds ($p=0.011$), the number of L1-L3 bird species ($p=0.011$), meadow-dependent bird species richness ($p=0.012$) and the number of bobolinks ($p=0.013$). Significant declines in meadow-dependent bird abundance were also found at station 2 along with an increase in the number of L1-L4 ranked bird species ($p=0.051$).

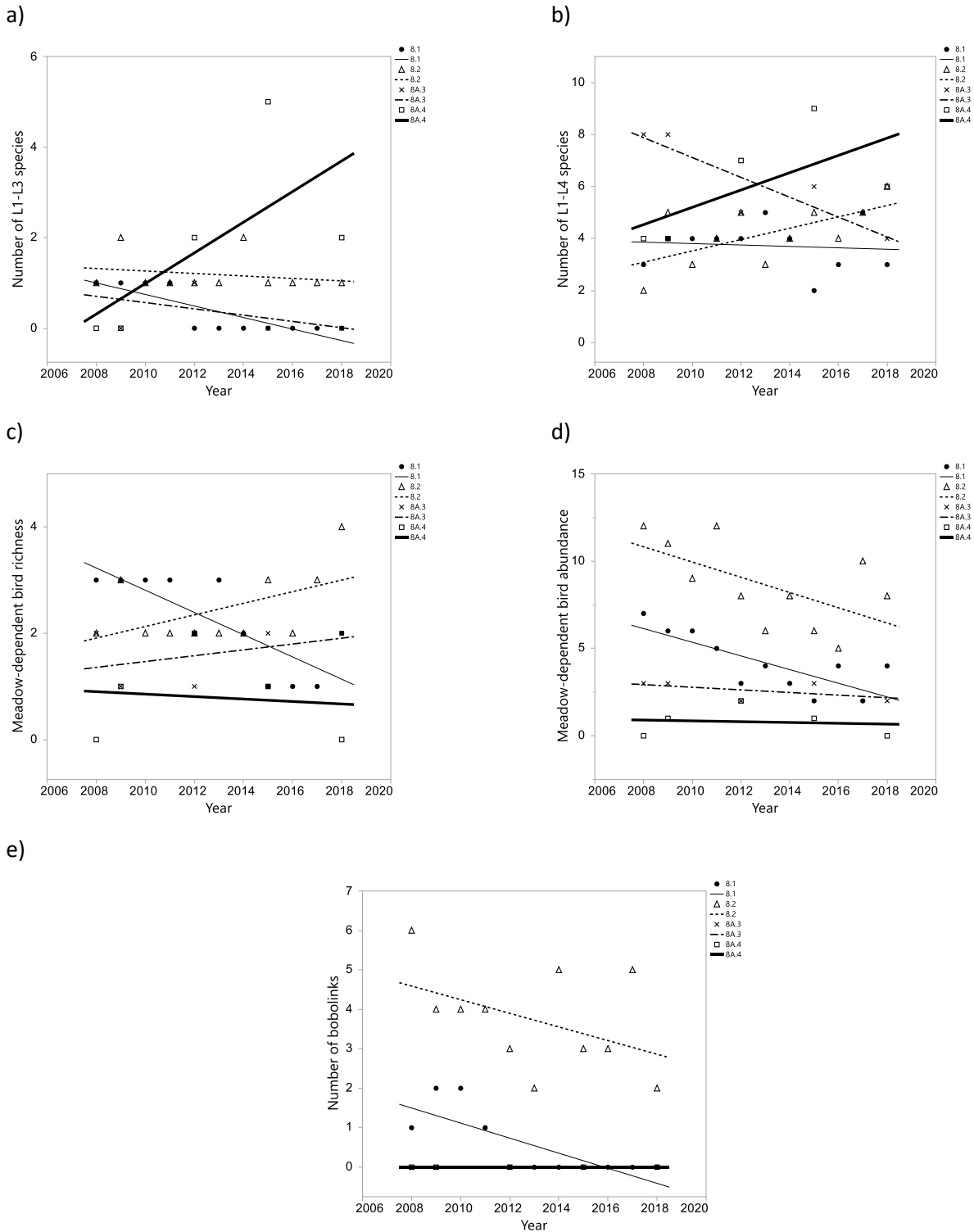


Figure 28. Temporal trends in meadow bird high-level indicators a) number of L1-L3 bird species, b) number of L1-L4 species, c) meadow-dependent bird richness, d) meadow-dependent bird abundance and e) number of bobolinks. Trends are shown for each station separately.

5 Discussion

5.1 Forest monitoring

5.1.1 Forest vegetation

Between 2009 and 2018, the number of flora species in the forest plot varied minimally and the composition remained relatively similar although several new native and non-native species appeared in 2018 along an informal trail in the plot. The plot continues to be dominated by sugar maple with other tree species occurring to a lesser extent. Pin cherry no longer occurs in the community as was predicted in the 2010 report (TRCA 2010) and is most likely due to heavy competition with sugar maple as the forest matures. Pin cherry is a short-lived, early successional species intolerant of shade and the loss of this species by 2015 suggests the forest is continuing to mature (TRCA 2010). Declines, and the eventual absence of pin cherry, were also apparent in the composition of the regeneration layer which continues to be dominated by sugar maple. The regeneration layer has changed based on relative abundance from a community dominated by pin cherry in 2009 to a community dominated by sugar maple in 2018. Norway maple was recorded for the first time within the regeneration layer in 2018 and this should be cause for concern because this species is invasive and regenerating within the plot. Ground vegetation composition continues to be dominated by long-styled blue cohosh; a spring ephemeral. Yellow trout lily, another spring ephemeral, had the second highest cover until 2018 when sugar maple had the second highest relative cover. A forest community rich in spring ephemerals (>5 species), is known to be one of many possible indicators of good forest health (Keddy and Drummond (1996) so hopefully as the forest matures, more spring ephemeral species will establish within the forest plot although the discovery of Norway maple seedlings in 2018 is again cause for concern.

Tree health for the plot was good overall except for the declining health of white ash and decline/mortality of pin cherry. The decline in crown vigour for white ash reflects the regional pattern of higher declines in crown vigour and this is likely due to the impact of emerald ash borer (*Agrilus planipennis*). Emerald ash borer is an invasive wood-boring insect attacking ash trees that was first detected in Detroit in 2002 and has since spread throughout southern Ontario (TRCA 2012).

5.1.2 Forest birds

Forest bird communities at the three forest bird monitoring stations consisted of species typical of the mid- to late-successional stage of the forest, the small forest size and urban context. Many forest interior species, such as ovenbird, wood thrush (*Hylocichla mustelina*) and scarlet tanager, have yet to be detected. These forest-interior species prefer not only mature tracts of forests but also large tracts of forest in a less urbanized landscape context (Austen et al. 2001). Veery was detected at the site for the first time in 2018 and is a species that uses forest-interior habitats (Rosenberg et al. 2003). Although restoration efforts may be successful in creating a larger forest patch with the goal of attracting sensitive forest-interior species, longer-term monitoring is needed to determine if other forest-interior species will use the site.

There was no temporal change in the number of L1-L4 ranked species, forest-dependent bird richness and forest-dependent bird abundance between 2008 and 2018 at any of the stations. Also, there were no obvious temporal changes in the percent of breeding birds using the various habitat types (forest, generalist, wetland, meadow) at various canopy heights (low-, mid-, upper-). There may be increases in the proportion of species that are forest mid-level nesters at station 26A.1, and this would be important to watch as the forest matures. The majority of birds at all three stations were generalist mid-level nesters (10-56%) such as American goldfinch

(*Carduelis tristis*), American robin (*Turdus migratorius*), northern cardinal (*Cardinalis cardinalis*) and black-capped chickadee. As forest growth and restoration efforts continue, there may be an increase in the proportion of forest-nesting species and a decline in generalists.

5.2 Wetland monitoring

5.2.1 Wetland vegetation

Temporal changes in flora communities reflect the dynamic nature of wetlands. There have been distinct temporal changes in woody vegetation along transects (measured as percent cover and abundance) including the invasion, establishment and subsequent dominance of common buckthorn in later years at WV 7. The increase in common buckthorn is cause for concern at almost all of the stations and reflects a regional pattern of common buckthorn increasing in both relative cover and relative abundance on wetland transects (TRCA 2015). Common buckthorn occurs at all other wetland transects including WV 7B that has also been invaded by bittersweet nightshade that by 2018, had the second highest stem count next to red-osier dogwood.

Dominance at WV 7D has been variable among years switching between silver maple, common buckthorn and white ash in the woody regeneration layer. As of 2018, common buckthorn dominated the percent cover in the regeneration layer for the first time. These changes in woody vegetation composition at transect 7D are likely due to changes in wetland hydrology (water depth) among years. Between 2009 and 2018, water levels at transect 7D increased by on average 77 cm. Wetland plants are closely associated to hydrology with different species having different tolerances to water depth or even fluctuating water depths (Raulings et al. 2010). It would be worthwhile looking into the cause of such drastic water level changes at this wetland such as the potential influence of a storm water pond and the associated siltation that may be occurring as the pond discharges water.

Woody vegetation in transect 7E has been primarily dominated by red osier dogwood between 2009 and 2018. Invasion by bittersweet nightshade was also evident at transect 7E since it was only found in 2012 and has increased in abundance since then.

Cover of ground vegetation was very dynamic among years on all wetland flora transects with no exotic species ranking within the top five species by cover and mostly L3, L4 and L5-ranked species. Overall, changes in composition along wetland flora transects reflect the dynamic nature of wetlands; however, careful consideration should be given to changes involving the invasion and/or spread of invasive species, potentially detrimental large inflows of water or declines in native species or species of regional concern.

There were no significant changes temporally in the FQI, percent native species or number of L1-L3 ranked species at most of the wetland transects. Wetland flora are susceptible to urbanization in the surrounding landscape and two new residential developments were built between 2010 and 2015 (Figure 29). The increase in impervious surfaces caused by development can increase run-off containing higher quantities of nutrients (leading to eutrophic conditions), sediments (leading to higher turbidity) and chemicals such as pesticides and/or road salts (Magee et al. 1999, Lougheed et al. 2001). The increase in development is minimal and may not be great enough to elicit effects, although the additional development could have caused short-term impacts (e.g. run-off, siltation) associated with the construction process. In addition to run-off and pesticides from residential areas, the golf course may be impacting these wetlands through inputs of pesticides, nutrients (in fertilizers) and mowing activity that was observed very close to the edge of transect 7.

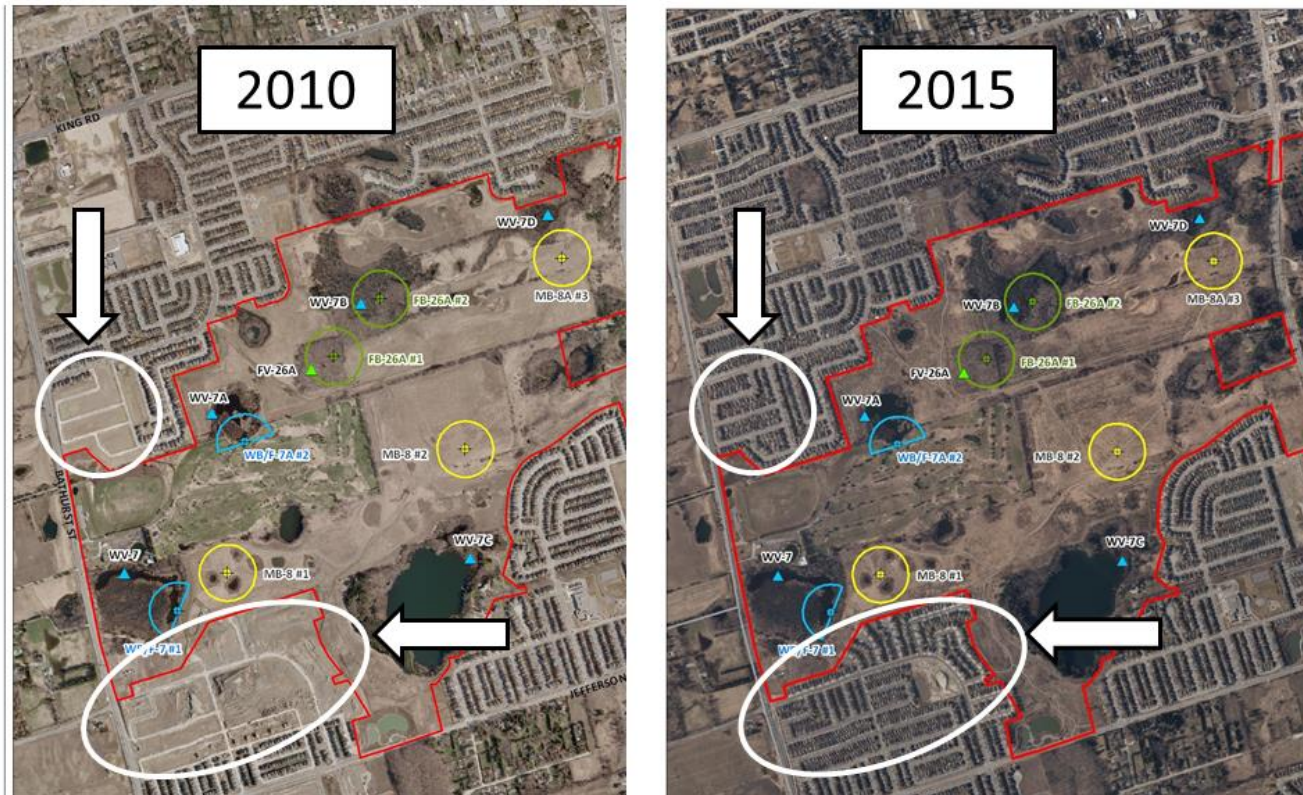


Figure 29. Changes in residential development in the matrix surrounding ORCCR between 2010 and 2015.

5.2.2 Wetland birds

The use of wetlands by several wetland-dependent bird species including Virginia rail, hooded merganser, sora and pied-billed grebe is a notable observation for the site. These species are species of regional conservation concern (ranked L3) and often rely exclusively on wetland habitat and cannot nest/forage in areas other than wetlands. These species were primarily found using stations 1 and 2 suggesting that these wetlands provide more suitable habitat (e.g. food, vegetation cover, open water cover).

Nesting habitat preference varied only slightly among stations suggesting that birds using these wetlands have approximately the same nesting requirements (i.e. wetland low-level nester). All stations were dominated by generalist mid-level nesters including those using the edges or more scrubby portions of the wetland such as yellow warbler (*Setophaga petechia*) or other generalist nesters such as red-winged blackbirds. Wetland low-level nesters were moderately more abundant at station 3 because of the numerous swamp sparrows and common yellowthroats (*Geothlypis trichas*) using this wetland compared to other wetlands. In general, there do not appear to be any temporal changes in the nesting preferences of birds using these wetlands between 2008 and 2018.

There were significant declines between 2008 and 2018 in the number of Virginia rails at station 3. Other than station 3, there were no significant temporal trends for any wetland bird variables. It would be worthwhile investigating reasons for these declines primarily at station 3. In addition to development in the west end of the park, there has been recent residential development immediately adjacent to this survey station. Wetland birds are known to be sensitive to many factors including urban development near the wetland (DeLuca et al.

2004), urban noise (Cartwright et al. 2013) and water depth (Hoover 2006) and this could be a potential cause for declines.

5.2.3 Frogs

Six frog species were detected at ORCCR stations between 2008 and 2018 including green frog, spring peeper, wood frog, tetraploid grey treefrog, northern leopard frog and American toad. These six species are the same six species most frequently detected through regional LTMP monitoring although both the chorus frog (*Pseudacris triseriata*) and bullfrog (*Lithobates catesbeiana*) have been found in LTMP surveys but were not detected at ORCCR. Even though they were not found, these are two of the least recorded species in LTMP monitoring so their absence does not necessarily reflect poor conditions for frogs.

There was variation in the number of stations occupied each year by each of these species. Spring peepers were detected most frequently, occupying all stations in all years. Green frog, wood frog and tetraploid grey treefrog were also found very frequently, although their frequency of occurrence has been declining between 2009 and 2018 (although only green frog declines were significant). It may be important to continue to monitor changes in occurrence of these species since wood frogs have almost completely disappeared from station 1 and green frog has disappeared from station 2. This suggests that there may be station-specific impacts (e.g. adjacent development) causing these species to be relatively undetected in recent years.

5.3 Meadow monitoring

5.3.1 Meadow birds

Meadow bird community composition differed based on station location with more sensitive meadow bird species (e.g. bobolink, eastern meadowlark) more likely to occupy stations 1 and 2. There was a significant decline in the proportion of meadow-dependent low-level nesters at stations 1 and 2 between 2008 and 2018. This decline corresponded to other declines (meadow-dependent abundance and number of bobolinks) seen primarily at stations 1 and 2 suggesting there are changes occurring at these stations making the habitat less appropriate for sensitive meadow bird species. One potential reason for these declines is the forest restoration occurring close to these stations where conifers have been planted and are maturing (TRCA 2006). Some meadow birds, such as bobolink, require large areas of meadow for nesting (Johnson and Igl 2001) and forest restoration in some of the meadow habitat has created smaller sized meadow patches. Smaller patches are likely subject to edge effects such as competition, brood parasitism and predation making smaller patches less productive (Johnson and Igl 2001). The exact patch size needed for breeding is variable ranging in size from 5-50 ha (Herkert 1991, Herkert 1994, Bollinger and Gavin 1992, Helzer and Jelinski 1999); however, the amount that was present prior to forest planting appears to have been sufficient for breeding. Another factor that may be affecting meadow birds at station 1 could be the residential development that occurred between 2010 and 2015 very close to the station and potentially stormwater inputs into the meadow.

6 Conclusions

Monitoring data are integral to evaluate if the goals of the park are being met and to inform an adaptive management process. The data are useful for identifying potential issues (e.g. recreational impacts) and successes (e.g. increased native biodiversity) within the park and to inform specific management actions (e.g. further habitat restoration). Several goals related to terrestrial monitoring are again outlined below and results/recommendations are provided on progress.

Natural Heritage

- Protect, restore and enhance the forests, kettle lakes and wetlands of the park as a functioning natural heritage system including natural features and processes, wildlife habitats, wildlife movement, and linkages to other natural systems on the Oak Ridges Moraine and the watersheds of the Humber and Rouge Rivers.

This goal is only partially being met. Overall, the natural areas within the park are providing habitat for many flora and fauna species that otherwise would not be present if the park was developed. The flora and fauna present in the park are generally higher quality than urban conditions/communities throughout the jurisdiction which are generally poorer quality. Also, data are showing that there are several important temporal declines in wetland flora, birds, frogs and meadow birds.

Environmental Sustainability

- Protect the park from negative external influences such as invasive species, encroachment, pets, traffic, and changes to the hydrology.

This goal is not being met. Invasive species, such as common buckthorn, are spreading in wetland flora transects. Norway maple is regenerating within the forest plot and several new non-native species were introduced to the forest plot from an informal trail (e.g. bittersweet nightshade, creeping thistle, urban avens). Extreme changes in wetland hydrology were observed at one wetland vegetation station (WV 7D) through manual measurements by flora biologists. Water levels along this transect increased on average 77 cm between 2009 and 2018.

Monitoring

- Collaborate with agencies, universities, NGOs and other institutions to ensure long-term monitoring of the park's resources and environmental functions, and to provide guidance for any changes to park policies and operations.

This goal is partially being met. A long-term terrestrial monitoring program has been developed and implemented by the TRCA throughout the park.

7 Recommendations

Based on terrestrial monitoring data, several recommendations can be made to provide guidance for possible changes to management in order to protect the species and communities present within the park.

- To prevent further encroachment by invasive species, trails could be located away from sensitive areas to prevent spread by human vectors. Efforts could be made to target existing populations of invasive species that are prevalent in the sensitive and high-quality areas.
- Look to install boot brush stations all trail heads to help reduce and bring awareness to the problem of unintentional transfer of invasive plant seeds.
- A change in grass mowing practices should be considered. Savannah sparrows that nest in meadows arrive in early May to set up breeding territories and will be often found along the trail edge. By mowing in late fall or mid-April, ahead of the arrival of the savannah sparrows, the grass will be too short and not attractive to the birds for a nesting location. If this is established ahead of the breeding season, then continued mowing could occur during the breeding season. However, if the grass is not cut outside of the breeding season, no mowing should be conducted from the last week in April until the middle of July to ensure the birds have a chance to produce their young (mowing was occurring in May during breeding bird surveys during one of the survey years).
- Signage should also be used (if not in place already) to educate the public about littering, off-leash pets and planting gardens beyond backyard property boundaries. In addition, signage could be used to highlight some of the unique landforms and flora and fauna species that reside in the park.
- Look for opportunities at Bathurst Glen golf course to reduce impacts on the surrounding wetland communities. Explore options to increase / provide a buffer around the wetland that lies on the north side of the golf course. Mowing practices at present have grass cutting up close to the edge of the wetland. Buffers around the wetland would help to increase water quality by reducing run-off (e.g. pesticides, fertilizers) and reduce the amount of disturbance and noise for breeding wetland birds.
- Explore options to mitigate high road mortality of turtles along Bathurst St. in front of Bathurst Glen golf course that was identified during the 2015 road and trail mortality monitoring study (TRCA 2016). Mitigation options may include providing additional turtle basking and nesting sites away from the road and/or the provision of wildlife passage under the roadway with appropriate directional fencing in strategic locations.
- Resources should be allocated towards the complete collection of road mortality data for all roads surrounding the park. The study conducted in 2015 missed the main amphibian movement that occurs in the spring when they travel from their upland overwintering sites to breeding ponds. By having at least one full year of data further informed recommendations around mitigation could be made.
- Further exploration is required in order to understand and mitigate the declines observed in both the quality of vegetation and bird and frog communities in the wetland to the south of Bathurst Glen golf course along Bathurst St. Increased water levels and sedimentation may be a result of the grading that has occurred for the residential development.
- Ensure proper resources continue to be allocated to the long-term terrestrial monitoring program. Next scheduled data collection should be in year 2018 (3-year cycle).

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9 Appendix

Table A.1. Nesting habitat preferences for bird species found in the TRCA region. Preferences were used to determine the dependence of a species on a particular habitat (forest, wetland or meadow). Swamp nesters were included as forest-dependent.

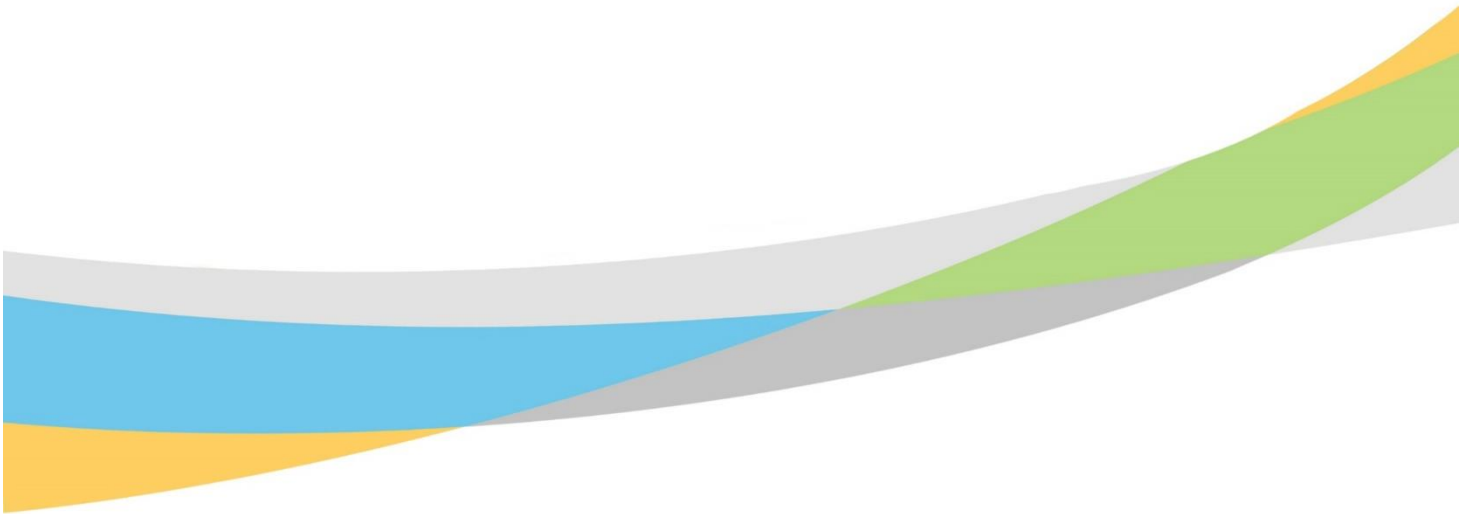
Common name	Scientific name	Forest	Edge	Wetland	Meadow	General
Acadian flycatcher	<i>Empidonax vireescens</i>					
barred owl	<i>Strix varia</i>					
black and white warbler	<i>Mniotilta varia</i>					
Blackburnian warbler	<i>Setophaga fusca</i>					
black-throated blue warbler	<i>Setophaga caerulescens</i>					
black-throated green warbler	<i>Setophaga virens</i>					
blue-grey gnatcatcher	<i>Poliptila caerulea</i>					
blue-headed vireo	<i>Vireo solitarius</i>					
broad-winged hawk	<i>Buteo platypterus</i>					
brown creeper	<i>Certhia americana</i>					
canada warbler	<i>Cardellina canadensis</i>					
cerulean warbler	<i>Setophaga cerulea</i>					
Cooper's hawk	<i>Accipiter cooperii</i>					
eastern screech-owl	<i>Megascops asio</i>					
eastern wood-pewee	<i>Contopus virens</i>					
golden-crowned kinglet	<i>Regulus satrapa</i>					
great-crested flycatcher	<i>Myiarchus crinitus</i>					
hairy woodpecker	<i>Picoides villosus</i>					
hermit thrush	<i>Catharus guttatus</i>					
hooded warbler	<i>Setophaga citrina</i>					
long-eared owl	<i>Asio otus</i>					
magnolia warbler	<i>Setophaga magnolia</i>					
merlin	<i>Falco columbarius</i>					
northern saw-whet owl	<i>Aegolius acadicus</i>					
nothern goshawk	<i>Accipiter gentilis</i>					
olive-sided flycatcher	<i>Contopus cooperi</i>					
ovenbird	<i>Seiurus aurocapillus</i>					
pileated woodpecker	<i>Dryocopus pileatus</i>					
pine siskin	<i>Carduelis pinus</i>					
pine warbler	<i>Setophaga pinus</i>					
red-breasted nuthatch	<i>Sitta canadensis</i>					
red-eyed vireo	<i>Vireo olivaceus</i>					
red-shouldered hawk	<i>Buteo lineatus</i>					
ruffed grouse	<i>Bonasa umbellus</i>					
scarlet tanager	<i>Piranga olivacea</i>					
sharp-shinned hawk	<i>Accipiter striatus</i>					
veery	<i>Catharus fuscescens</i>					
whip-poor-will	<i>Caprimulgus vociferus</i>					
white-breasted nuthatch	<i>Sitta carolinensis</i>					
white-winged crossbill	<i>Loxia leucoptera</i>					
winter wren	<i>Troglodytes hiemalis</i>					
wood duck	<i>Aix sponsa</i>					
wood thrush	<i>Hylocichla mustelina</i>					
worm-eating warbler	<i>Helmitheros vermivorus</i>					
yellow-bellied sapsucker	<i>Sphyrapicus varius</i>					
yellow-throated vireo	<i>Vireo flavifrons</i>					

Oak Ridges Corridor Conservation Reserve 2008-2018

Common name	Scientific name	Forest	Edge	Wetland	Meadow	General
American redstart	<i>Setophaga ruticilla</i>					
American woodcock	<i>Scolopax minor</i>					
black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>					
blue-winged warbler	<i>Vermivora pinus</i>					
brown thrasher	<i>Toxostoma rufum</i>					
chestnut-sided warbler	<i>Setophaga pensylvanica</i>					
downy woodpecker	<i>Picoides pubescens</i>					
eastern bluebird	<i>Sialia sialis</i>					
eastern towhee	<i>Pipilo erythrophthalmus</i>					
golden-winged warbler	<i>Vermivora chrysoptera</i>					
indigo bunting	<i>Passerina cyanea</i>					
least flycatcher	<i>Empidonax minimus</i>					
mourning warbler	<i>Geothlypis philadelphia</i>					
Nashville warbler	<i>Oreothlypis ruficapilla</i>					
purple finch	<i>Carpodacus purpureus</i>					
red-bellied woodpecker	<i>Melanerpes carolinus</i>					
red-headed woodpecker	<i>Melanerpes erythrocephalus</i>					
ring-necked pheasant	<i>Phasianus colchicus</i>					
rose-breasted grosbeak	<i>Pheucticus ludovicianus</i>					
ruby-throated hummingbird	<i>Archilochus colubris</i>					
white-throated sparrow	<i>Zonotrichia albicollis</i>					
wild turkey	<i>Meleagris gallopavo</i>					
yellow-billed cuckoo	<i>Coccyzus americanus</i>					
yellow-breasted chat	<i>Icteria virens</i>					
yellow-rumped warbler	<i>Setophaga coronata</i>					
alder flycatcher	<i>Empidonax alnorum</i>					
American bittern	<i>Botaurus lentiginosus</i>					
American black duck	<i>Anas rubripes</i>					
American coot	<i>Fulica americana</i>					
black tern	<i>Chlidonias niger</i>					
black-crowned night-heron	<i>Nycticorax nycticorax</i>					
blue-winged teal	<i>Anas discors</i>					
Canada goose	<i>Branta canadensis</i>					
canvasback	<i>Aythya valisineria</i>					
Caspian tern	<i>Sterna caspia</i>					
common gallinule	<i>Gallinula galeata</i>					
common tern	<i>Sterna hirundo</i>					
common yellowthroat	<i>Geothlypis trichas</i>					
double-crested cormorant	<i>Phalacrocorax auritus</i>					
gadwall	<i>Anas strepera</i>					
great black-backed gull	<i>Larus marinus</i>					
great blue heron	<i>Ardea herodias</i>					
great egret	<i>Casmerodius albus</i>					
green heron	<i>Butorides virescens</i>					
green-winged teal	<i>Anas crecca</i>					
herring gull	<i>Larus argentatus</i>					
hooded merganser	<i>Lophodytes cucullatus</i>					

Common name	Scientific name	Forest	Edge	Wetland	Meadow	General
least bittern	<i>Ixobrychus exilis</i>					
mallard	<i>Anas platyrhynchos</i>					
marsh wren	<i>Cistothorus palustris</i>					
mute swan	<i>Cygnus olor</i>					
osprey	<i>Pandion haliaetus</i>					
pieb-billed grebe	<i>Podilymbus podiceps</i>					
ring-billed gull	<i>Larus delawarensis</i>					
sora	<i>Porzana carolina</i>					
swamp sparrow	<i>Melospiza georgiana</i>					
trumpeter swan	<i>Cygnus buccinator</i>					
Virginia Rail	<i>Rallus limicola</i>					
Wilson's snipe	<i>Gallinago delicata</i>					
bobolink	<i>Dolichonyx oryzivorus</i>					
clay-coloured sparrow	<i>Spizella pallida</i>					
eastern kingbird	<i>Tyrannus tyrannus</i>					
eastern meadowlark	<i>Sturnella magna</i>					
field sparrow	<i>Spizella pusilla</i>					
grasshopper sparrow	<i>Ammodramus savannarum</i>					
Henslow's sparrow	<i>Ammodramus henslowii</i>					
horned lark	<i>Eremophila alpestris</i>					
loggerhead shrike	<i>Lanius ludovicianus</i>					
northern harrier	<i>Circus cyaneus</i>					
savannah sparrow	<i>Passerculus sandwichensis</i>					
sedge wren	<i>Cistothorus platensis</i>					
short-eared owl	<i>Asio flammeus</i>					
spotted sandpiper	<i>Actitis macularia</i>					
upland sandpiper	<i>Bartramia longicauda</i>					
vesper sparrow	<i>Pooecetes gramineus</i>					
western meadowlark	<i>Sturnella neglecta</i>					
willow flycatcher	<i>Empidonax traillii</i>					
American Crow	<i>Corvus brachyrhynchos</i>					
American goldfinch	<i>Carduelis tristis</i>					
American kestrel	<i>Falco sparverius</i>					
American robin	<i>Turdus migratorius</i>					
Baltimore oriole	<i>Icterus galbula</i>					
barn swallow	<i>Hirundo rustica</i>					
black-capped chickadee	<i>Parus atricapillus</i>					
blue jay	<i>Cyanocitta cristata</i>					
Carolina wren	<i>Thryothorus ludovicianus</i>					
cedar waxwing	<i>Bombycilla cedrorum</i>					
chimney swift	<i>Chaetura pelagica</i>					
chipping sparrow	<i>Spizella passerina</i>					
cliff swallow	<i>Petrochelidon pyrrhonota</i>					
common grackle	<i>Quiscalus quiscula</i>					
common nighthawk	<i>Chordeiles minor</i>					
eastern phoebe	<i>Sayornis phoebe</i>					

Common name	Scientific name	Forest	Edge	Wetland	Meadow	General
European starling	<i>Sturnus vulgaris</i>					
great-horned owl	<i>Bubo virginianus</i>					
grey catbird	<i>Dumetella carolinensis</i>					
house finch	<i>Carpodacus mexicanus</i>					
house sparrow	<i>Passer domesticus</i>					
house wren	<i>Troglodytes aedon</i>					
killdeer	<i>Charadrius vociferus</i>					
mourning dove	<i>Zenaida macroura</i>					
northern cardinal	<i>Cardinalis cardinalis</i>					
northern flicker	<i>Colaptes auratus</i>					
northern mockingbird	<i>Mimus polyglottos</i>					
orchard oriole	<i>Icterus spurius</i>					
peregrine falcon	<i>Falco peregrinus</i>					
red-tailed hawk	<i>Buteo jamaicensis</i>					
red-winged blackbird	<i>Agelaius phoeniceus</i>					
rock dove	<i>Columba livia</i>					
song sparrow	<i>Melospiza melodia</i>					
tree swallow	<i>Tachycineta bicolor</i>					
warbling vireo	<i>Vireo gilvus</i>					
yellow warbler	<i>Setophaga petechia</i>					
northern waterthrush	<i>Parkesia noveboracensis</i>					
prothonotary warbler	<i>Protonotaria citrea</i>					
bank swallow	<i>Riparia riparia</i>					
belted kingfisher	<i>Ceryle alcyon</i>					
brown-headed cowbird	<i>Molothrus ater</i>					
northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>					
purple martin	<i>Progne subis</i>					
turkey vulture	<i>Cathartes aura</i>					



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