1995-2012 The Great Lakes Marsh Monitoring Program

18 years of surveying birds and frogs as indicators of ecosystem health

Pied-billed Grebe. Photo: Sandra Horvath

BIRD STUDIES CANADA
ÉTUDES D'OISEAUX CANADA

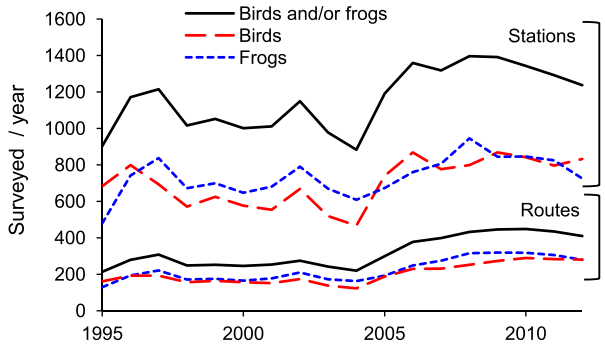
MARSH MONITORING PROGRAM

ABOUT THE PROGRAM

The Great Lakes Marsh Monitoring Program (GLMMP) was launched bi-nationally in 1995 by Bird Studies Canada (then Long Point Bird Observatory) in partnership with Environment Canada and the United States Environmental Protection Agency. In 18 years, more than 1400 volunteers have collected data on birds, frogs, and their habitats at more than 5000 unique survey locations (Fig. 1, 2). This impressive effort allows us to achieve many important outcomes, including:

1. Assess populations of marsh birds and frogs at scales ranging from individual marshes to the entire Great Lakes basin;
2. Investigate associations between marsh birds and frogs and habitat;
3. Contribute to conservation management and planning; and
4. Increase public awareness of the importance of wetland conservation.

Fig. 1. Number of routes and stations surveyed per year in the Great Lakes basin by the Great Lakes Marsh Monitoring Program. Data are shown separately for birds and frogs, as well as combined (birds and/or frogs).



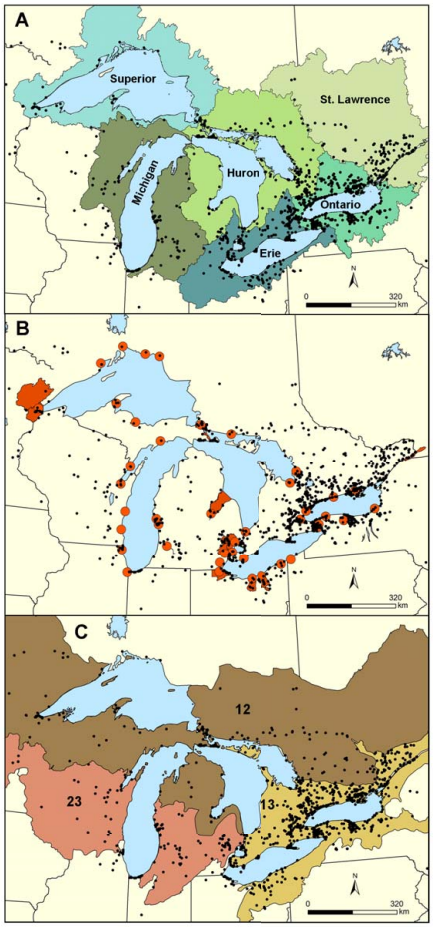


Fig. 2. Locations of routes surveyed between 1995 and 2012 by the Great Lakes Marsh Monitoring Program in relation to (A) Great Lakes basins (routes surveyed for birds and/or frogs), (B) Areas of Concern (AOCs) (routes surveyed for birds and/or frogs), and (C) Bird Conservation Regions (BCRs) (routes surveyed for birds only). Note that AOCs represented by orange circles are not to scale.

SUMMARY

This report summarizes changes in populations of marsh birds and frogs from 1995 to 2012 at various scales within the Great Lakes basin, upstream from the Ontario-Québec border on the St. Lawrence River. Populations of most marsh breeding birds declined across the Great Lakes basin during the period, whereas populations of most frogs remained stable. The results suggest that marsh ecosystem health has not improved in the Great Lakes basin over the past 18 years. The results also illustrate the utility of using citizen science programs to monitor wildlife as indicators of environmental stress.

Populations of most marsh breeding birds declined across the Great Lakes basin, whereas populations of most frogs remained stable.

Photo: Ryan Archer

METHODOLOGY

Surveys

Marshes were chosen by volunteers or randomly assigned, and were at least 1 ha in size, covered mostly by non-woody plants such as cattails or grasses. Participants conducted bird and/or frog surveys at 1-8 semi-circular 100 m-radius stations along routes within one or several marshes. Surveys were timed to maximize the chances of detecting as many species as possible. Each station was visited 2-3 times during the breeding season in each year. Stations were visited only under favorable weather conditions, in the morning or evening for birds, and at night for frogs. Volunteers played calls during bird surveys to entice individuals of especially secretive species to reveal their presence by approaching or vocally challenging the supposed 'intruder'/surveyor in their breeding territory. Habitat information was collected annually at each station. Most stations (90%) were located on shore and were placed to avoid double-counting individuals (more than 250 m apart for birds; more than 500 m apart or back-to-back for frogs).

Analyses

Participants recorded the number of individuals of each bird species identified during each bird survey. We used the maximum number of individuals of a particular bird species from any one of the multiple surveys made at each station throughout the year for analysis, expressed as abundance, or the mean number of individuals per station along a route per year. By contrast, reliable estimates of numbers of frogs were not possible. Instead, we used the presence of at least one individual of a particular frog species on any one of the multiple surveys made at each station throughout the year for analysis, expressed as occupancy, or the probability of finding at least one individual of a particular species in a station along a route in any particular year. For example, a probability of a station being occupied of 0.3 means that at least one individual of the species is likely to be found at 30% of stations.

What is abundance and occupancy?

Abundance is the mean number of individuals of a particular bird species detected per station along a route per year. By contrast, occupancy is the probability of detecting at least one individual of a particular frog species in a station along a route in any particular year

We compared population trends, abundance, and occupancy (see boxes on p. 2 and 7 for definitions) of different species among different areas to learn more about factors influencing populations. Our ability to make meaningful comparisons was best at Great Lakes coastal marshes versus inland marshes and within versus outside of Areas of Concern (AOCs) due to large and similar sample sizes; smaller sample sizes in certain areas somewhat limited our ability to make comparisons among Great Lakes basins, like Lake Ontario versus Huron, and among Bird Conservation Regions (BCRs). See "How good is the GLMMP" for more details. Differences in population trends and indices are described only when they were statistically significant[1], unless otherwise noted.

[1] Population trends over time and abundance or occupancy in each year were modeled at the route level (by including the number of stations as an offset) using Poisson or logistic regression in a Bayesian mode of inference with uninformative priors and route as a random intercept. Statistically significant differences were determined via Bayesian p values or visual inspection of credibility intervals.

Common Gallinule. Photo: Jim Richards

RESULTS

Birds

Ten of 19 marsh-associated breeding species (53%) showed population declines across the Great Lakes basin (Fig. 3). Seven of the 19 species—American Bittern, American Coot, Common Gallinule, Least Bittern, Pied-billed Grebe, Sora, and Virginia Rail—were analyzed in more detail below due to their nearly complete dependence on marshes for breeding, and because broadcasts of their calls were used during surveys to increase detections of all but one of them (American Bittern). These "focal species" are among the best indicators of marsh ecosystem health.

Populations of 6 of the 7 focal species (86%) declined across the Great Lakes basin (labeled in bold, Fig. 3). To illustrate population changes over time, abundance is shown for each year for each focal species (Fig. 4). Population trends for focal species did not differ significantly among Great Lakes basins (insufficient data for Superior); at Great Lakes coastal marshes versus inland marshes; within versus outside of Areas of Concern (AOCs); and among Bird Conservation Regions (BCRs) (locations of basins, BCRs, and AOCs shown in Fig. 2; see boxes on p. 3 for definitions). There were exceptions for American Bittern and Sora, both of which increased over time in BCR 12 but decreased over time in BCR 13 and 23.

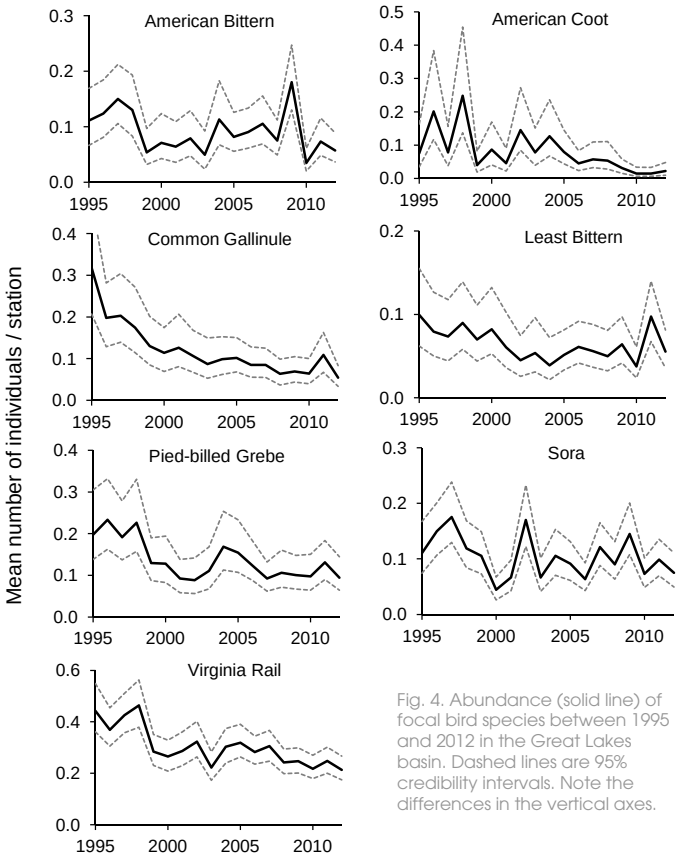


Fig. 4. Abundance (solid line) of focal bird species between 1995 and 2012 in the Great Lakes basin. Dashed lines are 95% credibility intervals. Note the differences in the vertical axes.

Fig. 3. Population trends between 1995 and 2012 in the Great Lakes basin for 19 bird species that regularly or always nest in marshes. Statistically significant trends are shown with green bars (positive trends) or red bars (negative trends); white bars indicate stable trends. Vertical lines are 95% credibility intervals. Populations of half the species declined, including 6 of the 7 focal species (shown in bold; see Results—Birds for a definition).

What is a Great Lakes Area of Concern (AOC)?

A geographic area along the Great Lakes coast where restoration and remediation are being used to improve especially degraded environmental conditions, as determined by criteria in the Canada-US Great Lakes Water Quality Agreement.

What is a Bird Conservation Region (BCR)?

A geographic region defined by unique landforms, climate, and bird assemblages where conservation activities are coordinated by the North American Bird Conservation Initiative.

Populations of nearly all focal bird species declined across the Great Lakes basin.

Sora. Photo: Sandra Horvath.

It is worth noting that population trends for all of the focal species decreased faster within versus outside of AOCs (Fig. 5), and abundance of most focal species was lower in most years at Great Lakes coastal marshes and within AOCs than at inland marshes and outside of AOCs (Fig. 6, 7). In most cases, these differences were not statistically significant, but may be important because they occur consistently across many species and years. Although it was short-lived, in 2011 the abundance of the Threatened Least Bittern jumped at coastal marshes and within AOCs to levels comparable with 1995 levels (Fig. 6,7).

Fig. 5. Population trends for focal bird species between 1995 and 2012 inside of Areas of Concern (AOCs) (red triangles) versus outside of Areas of Concern (green circles). Vertical bars are 95% credibility intervals. Although the difference was statistically significantly only for Virginia Rail, population trends for all species were more negative within compared to outside of AOCs.

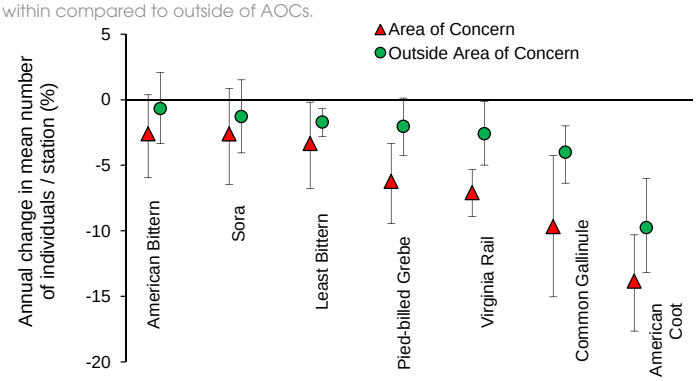


Fig. 6. Abundance of focal bird species between 1995 and 2012 at Great Lakes coastal marshes (solid blue lines) versus inland marshes (dashed orange lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Although differences were statistically significant in most years only for Sora and Virginia Rail, abundance for most species was lower in most years at coastal marshes compared to inland marshes.

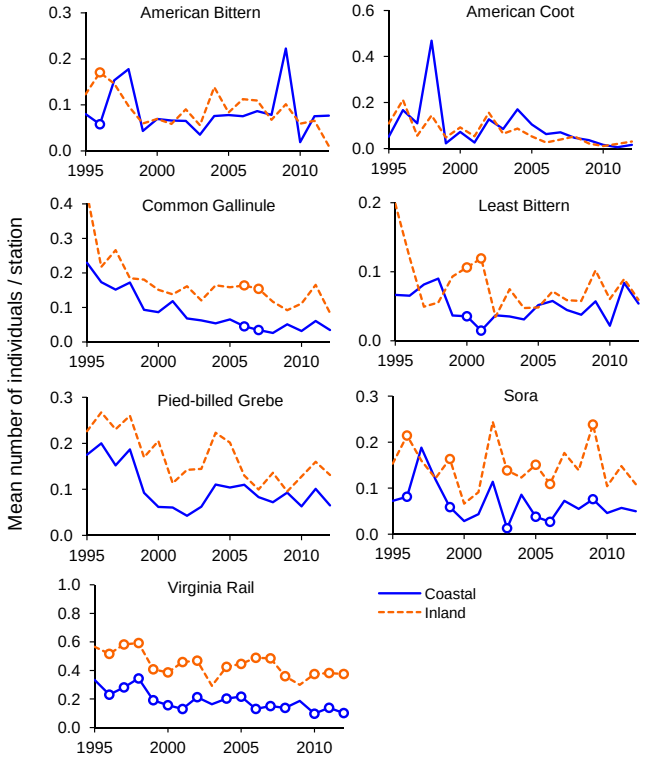
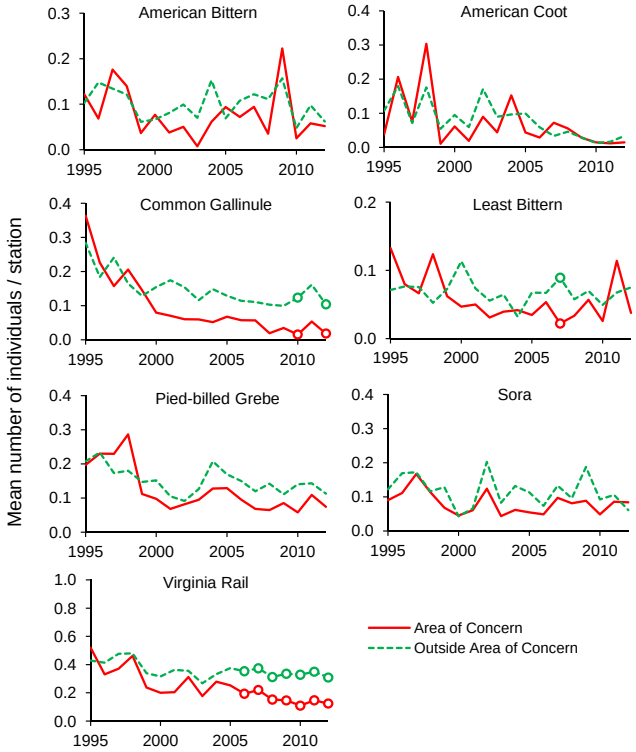


Fig. 7. Abundance of focal bird species between 1995 and 2012 inside of Areas of Concern (AOCs) (solid red lines) versus outside of Areas of Concern (dashed green lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Although differences were statistically significant in only a few cases, abundance of most species was lower in most years within compared to outside of AOCs.



Populations of most frog species were stable across the Great Lakes basin.

Gray Treefrog. Photo: Peter Ferguson

Frogs

Six of 8 species (75%) showed stable populations across the Great Lakes basin (Fig. 8). Chorus Frog showed a declining population, whereas Green Frog showed an increasing population. To illustrate change over time, occupancy is shown for each year for each species (Fig. 9).

Population trends did not differ among Great Lakes basins (insufficient data for Superior); at Great Lakes coastal marshes versus inland marshes; and within versus outside of Areas of Concern (AOCs) (locations of basins and AOCs shown in Fig. 2; see boxes on p. 3 for definitions). There were exceptions for Green Frog, which decreased in the Lake Huron basin but increased in each of the other lake basins, and Spring Peeper and Wood Frog, both of which increased within but remained stable outside of AOCs.

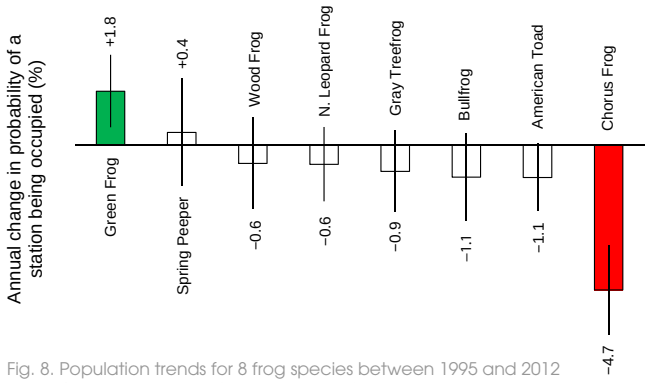
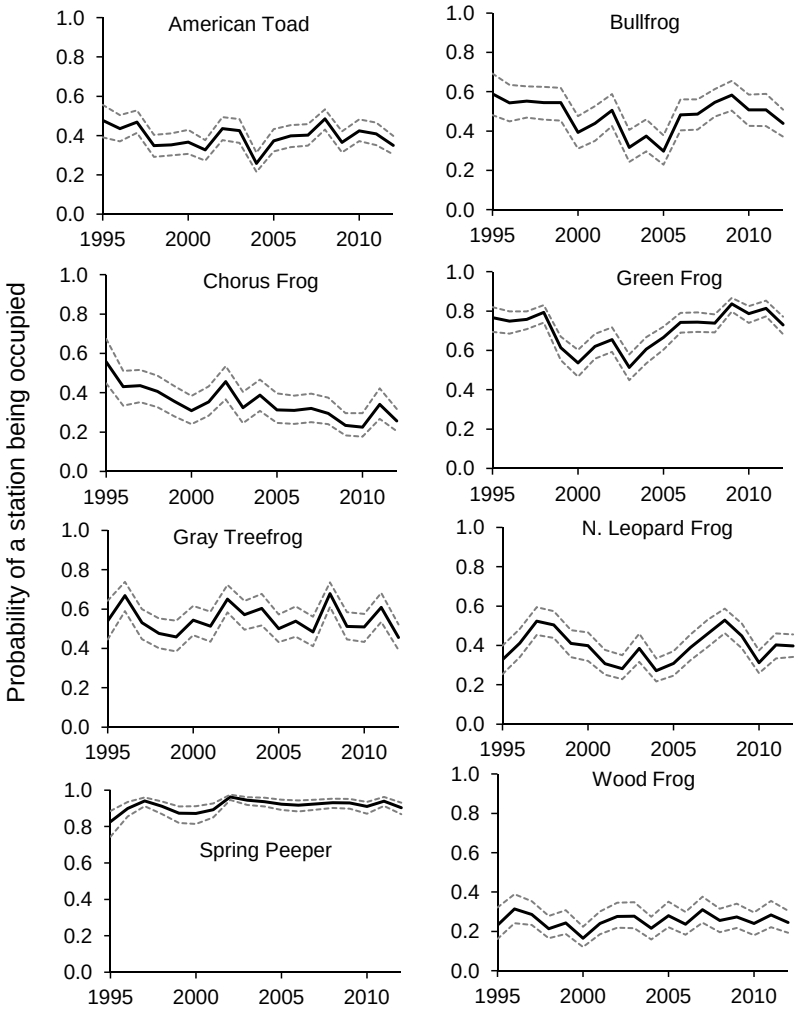


Fig. 8. Population trends for 8 frog species between 1995 and 2012 in the Great Lakes basin. Statistically significant trends are shown with green bars (positive trends) or red bars (negative trends); white bars indicate stable trends. Vertical bars are 95% credibility intervals. Populations of most species remained stable.

Fig. 9. Occupancy (solid line) of frog species between 1995 and 2012 in the Great Lakes basin. Dashed lines are 95% credibility intervals.



Wood Frog. Photo: Scott Gillingwater

Occupancy for most species was lower in most years at Great Lakes coastal marshes compared to inland marshes (Fig. 10). As well, occupancy for Spring Peeper and Wood Frog was lower in most years within compared to outside of AOCs, but recently increased within AOCs to levels similar to areas outside of AOCs (Fig. 11).

Fig. 10. Occupancy of frog species between 1995 and 2012 at Great Lakes coastal marshes (solid blue lines) versus inland marshes (dashed orange lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Occupancy for most species was lower in most years at coastal marshes compared to inland marshes.

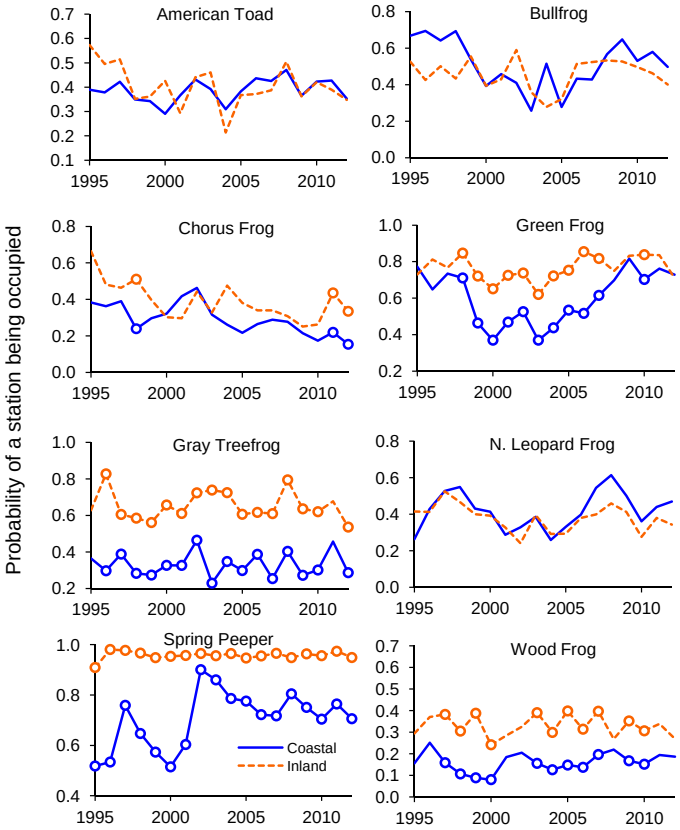


Fig. 11. Occupancy of frog species between 1995 and 2012 inside of Areas of Concern (AOCs) (solid red lines) versus outside of Areas of Concern (dashed green lines). Note the differences in the vertical axes. Statistically significant differences are indicated for years with open circles. Occupancy for Spring Peeper and Wood Frog was lower in most years within AOCs compared to outside of AOCs, but recently increased within AOCs to levels similar to areas outside of AOCs.

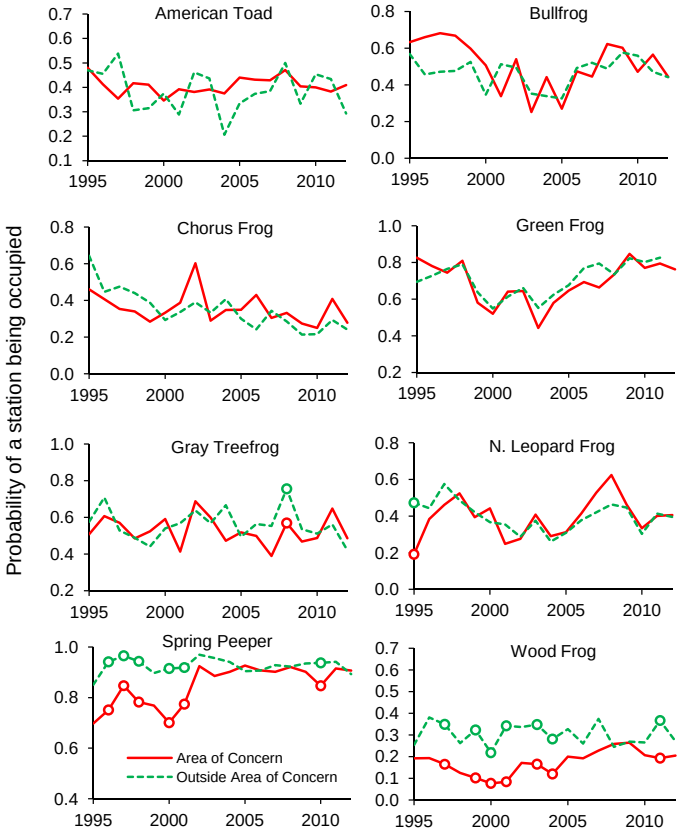


Photo: Ryan Archer

HOW GOOD IS THE GLMMP?

The program has the ability to detect statistically significant annual population trends across the Great Lakes basin as small as 1.0% on average (range: 0.4 to 1.7%) for focal bird species and 0.9% on average (0.7 to 1.1%) for the 8 frog species analyzed in this report[2]. This ability is quite good; for example, the values are much lower than the 3-7% population reductions per year typically required to designate a species as Threatened or Endangered. The program is also able to detect annual population trends as small as 1.6% on average (0.5 to 6.7%) for all other combinations of species and areas presented in this report (e.g., within Great Lakes basins like Lake Ontario or Erie, at Great Lakes coastal marshes or inland marshes, and within or outside of AOCs).

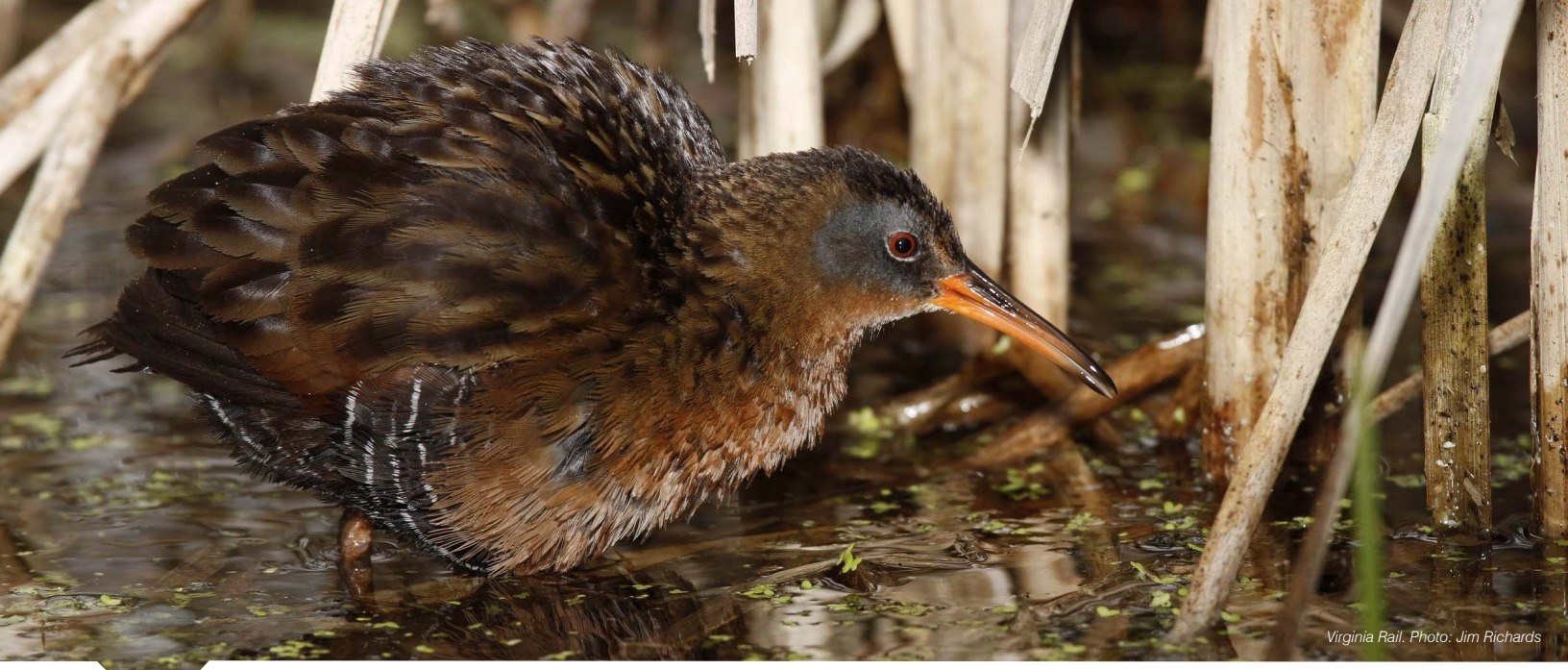
[2] Minimum detectable annual change was calculated using the posterior distribution of trend estimates.

Marsh Wren. Photo: Jim Richards

What is a population trend and associated 95% credibility intervals?

A population trend is an estimate of how much the abundance or occupancy of a particular species increases or decreases over time, expressed as percent change per year. It is based on a line of best-fit through annual abundance or occupancy over time. There is a 95% chance that the true population trend lies somewhere within a population trend estimate's associated 95% credibility intervals. For example, a population trend estimate of -5% per year with 95% credibility intervals running from -2% to -8% means that there is a 95% chance that the true population trend is somewhere between -2% and -8% per year.

American Coot. Photo: Jim Richards.



Virginia Rail. Photo: Jim Richards

WHAT ABOUT MISSED BIRDS AND FROGS?

Inevitably, some birds or frogs are visible, or call within stations during surveys, but are not detected. This could be due to a number of reasons. For example, the surveyor may have been busy writing on the field sheet, or may have been looking in a different direction, at the only moment when a particular bird was visible. Currently, Bird Studies Canada (BSC) takes the maximum count of individuals of each bird species from any one of the multiple surveys made throughout the year to account for missed individuals on any particular survey. Likewise, BSC considers a station occupied by a frog species if at least one individual is detected on any of the three visits made throughout the year. Alternatively, there are now more sophisticated mathematical techniques to adjust abundance or occupancy upwards to account for missed or undetected individuals.

GLMMP bird survey. Photo: Jennifer Howard

However, preliminary tests of the performance of one of the new mathematical techniques[3] on simulated data for focal bird species showed that it performed poorly compared to the current approach of taking the maximum count. The new technique adjusted trends too much, being above or below the true value by a difference of 4.1% per year on average, whereas taking the maximum count produced trends that were above or below by a difference of only 2.5% per year on average. It is unclear at this point why the new technique underperformed taking the maximum count. Perhaps the relatively long 15-minute count duration, call broadcast, multiple visits per season, and weather restrictions during surveys mean that few individuals go undetected, such that the counts are already so close to the actual numbers that the new technique, in its current form, is ineffective at more closely approximating the actual number. Active research in this area may improve the performance of the new technique in the future.

GLMMP habitat survey. Photo: Anna Sheppard

[3] Royal, J.A. 2004. Generalized estimators of avian abundance from count survey data. Animal Biodiversity and Conservation 27.1:375-386.

Wetland loss and environmental stress linked to human population growth surrounding coastal marshes and within AOCs probably contributed to most of the patterns in this report.

Least Bittern. Photo: Andrew Chin

Common Reed. Photo: Steve Timmermans

CONCLUSIONS

Populations of most marsh breeding birds declined between 1995 and 2012 across the Great Lakes basin. By contrast, populations of most frogs remained stable. The prevalence of declining and stable populations of birds and frogs suggests that marsh ecosystem health did not improve across the Great Lakes basin between 1995 and 2012.

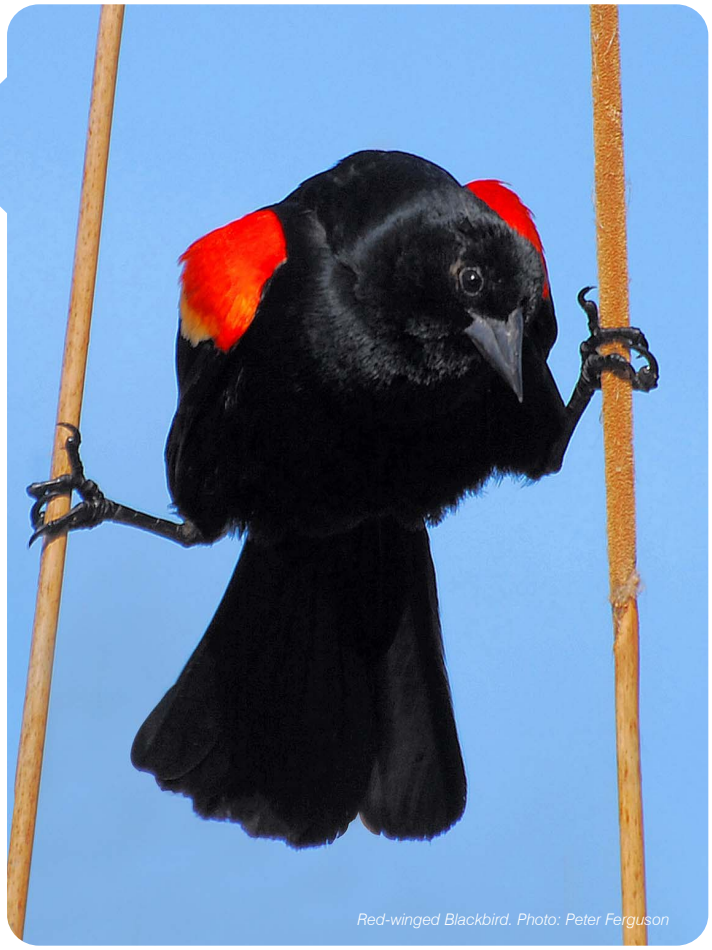
It is surprising that there were fewer declining populations among species of frogs compared to birds, because both birds and frogs are thought to be sensitive to changes in marsh ecosystem health. Most of the bird species are migratory, whereas the frog species are not; so it may be that factors beyond the Great Lakes basin (perhaps along migration routes or on wintering grounds) are contributing to bird declines. Alternatively, the abundance of some frog species may be declining, but we were unable to detect it due to our reliance on occupancy.

Even though the results suggest that there was no improvement in marsh ecosystem health overall, there is cause for optimism.

Sedge. Photo: Peter Ferguson

Abundance of birds and occupancy of frogs across multiple species and years suggest that marsh ecosystem health was lower at coastal marshes and within AOCs than at inland marshes and outside of AOCs. Wetland loss and environmental stress linked to human population growth surrounding coastal marshes and within AOCs probably contributed to these patterns, highlighting the need for restoration of AOCs, conservation of coastal marshes, and the importance of relatively healthier inland wetlands throughout the Great Lakes basin.

Even though the results suggest that there was no improvement in marsh ecosystem health overall, there is cause for optimism. Occupancy of Spring Peeper and Wood Frog, species generally considered to be sensitive to environmental stress, increased within AOCs between 1995 and 2012. As well, abundance of the Threatened Least Bittern rose abruptly within AOCs in 2011. Thus, restoration efforts within AOCs appear to be having some positive effects on marsh ecosystem health. There is reason to hope that these and other conservation efforts will result in further improvements in the future across the entire Great Lakes basin.



Red-winged Blackbird. Photo: Peter Ferguson

If you would like to participate in the Great Lakes Marsh Monitoring Program, or you would like more information, please contact:

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Pied-billed Grebe. Photo: Frank Horvath

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