LONG POINT WATERFOWL AND WETLANDS RESEARCH PROGRAM

Technical Report

1 April 2019 to 31 March 2020

By Douglas C. Tozer, PhD
Port Rowan, ON

P.O. Box/B.P. 160 (courier/ courier: 115 Front Street), Port Rowan, ON, Canada N0E 1M0
Phone/Tél. 519 586 3531 Fax/Téléc. 519 586 3532 birdscanada.org

Sora Photo: Tim Arthur

Long Point Waterfowl and Wetlands Research Program

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Phone/Tél. 519 586 3531 Fax/Téléc. 519 586 3532 birdscanada.org

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Summary

The Long Point Waterfowl and Wetlands Research Program is Birds Canada's umbrella for all of its waterfowl and wetlands research at Long Point and in the lower Great Lakes. It was established in the 1980s with support from The Bluff's Hunting Club, who continues to be concerned about the long-term welfare of waterfowl and wetlands at Long Point. The program's mission is to advance the conservation of waterfowl and other wetland wildlife and their habitats through research and monitoring. The program has a vision of being recognized and respected internationally as a leader in high-quality applied science for conservation planning by federal, provincial, state, and non-profit partners.

Research projects undertaken by the Long Point Waterfowl and Wetlands Research Program are selected according to the program's mission, vision, and strategic plan, and are vetted by a scientific advisory committee comprised of waterfowl and wetland specialists. This ensures high-quality projects that are relevant and useful for waterfowl and wetland conservation. The program's strategic plan currently calls for research that aims to:

- Advance scientific understanding of successful conservation and management of waterfowl and other wetland wildlife;
- Monitor populations of waterfowl and other wetland wildlife and their habitats;
- Answer timely questions of conservation interest and address emerging science needs of waterfowl and wetlands stakeholders; and
- Provide diverse training and development for young wildlife professionals.

The program is committed to achieving its goal and vision by providing hands-on opportunities for young wildlife technicians, biologists, and scientists in all aspects of wildlife science. Over the past year, the program pursued 17 research projects, trained 8 young professionals, continued collaborations with 2 former students of the program, and published 6 peer-reviewed manuscripts in scientific journals. Students and staff gave presentations at the North American Duck Symposium, Winnipeg, Manitoba; Ontario Invasive Plant Council annual meeting, London, Ontario; and the Long Point World Biosphere Research and Conservation Conference, Simcoe, Ontario. Plus, 1 student successfully defended his undergraduate honours thesis and is now doing his MSc with the program, and 3 students successfully obtained jobs in wildlife conservation.

The tremendous success of the Long Point Waterfowl and Wetlands Research Program of Birds Canada is due to its diverse partners and supporters in Canada and the U.S. These include private donors, foundations, governments, corporations, universities, non-government organizations, and various granting agencies. A heartfelt thank you to each and every one of you for your support and partnership!

In the pages that follow we highlight results from projects we worked on over the past year. We hope you like what you see.

With best regards,

Douglas C. Tozer

Douglas C. Tozer, Ph.D.
Director, Waterbirds and Wetlands
- *Long Point Waterfowl and Wetlands Research Program*
- *Great Lakes Marsh Monitoring Program*
- *Canadian Lakes Loon Survey*

Photo by Jeremy Bensette

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Spatially explicit network analysis reveals multi-species annual cycle movement patterns of sea ducks

Juliet S. Lamb[1,2], Peter W.C. Paton[1], Jason E.Osenkowski[2], Shannon S. Badzinski[3], Alecia M. Berlin[4], Tim Bowman[5], Chris Dwyer[6], Luke J. Fara[7,8], Scott G. Gilliland[3], Kevin Kenow[7], Christine Lepage[3], Mark L. Mallory[9], Glenn H. Olsen[4], Matthew C. Perry[4], Scott A. Petrie[10], Jean-Pierre L. Savard[3], Lucas Savoy[11], Michael Schummer[12], Caleb S. Spiegel[6], Scott R. McWilliams[1]

[1] Department of Natural Resources Science, University of Rhode Island
[2] Rhode Island Department of Environmental Management
[3] Canadian Wildlife Service, Environment and Climate Change Canada
[4] U.S. Geological Survey Patuxent Wildlife Research Center
[5] Sea Duck Joint Venture, U.S. Fish and Wildlife Service
[6] Migratory Birds Division, U.S. Fish and Wildlife Service
[7] U.S. Geological Survey, Upper Midwest Environmental Sciences Center
[8] Cooperative Wildlife Research Laboratory, Department of Zoology, Southern Illinois University
[9] Department of Biology, Acadia University
[10] Delta Waterfowl
[11] Biodiversity Research Institute
[12] State University of New York College of Environmental Science and Forestry

Conservation of long-distance migratory species poses unique challenges. Migratory connectivity, that is, the extent to which groupings of individuals at breeding sites are maintained in wintering areas, is frequently used to evaluate population structure and assess use of key habitat areas. However, for species with complex or variable annual cycle movements, this traditional bimodal framework of migratory connectivity may be overly simplistic. Like many other waterfowl, sea ducks often travel to specific pre- and post-breeding sites outside their nesting and wintering areas to prepare for migration by feeding extensively and, in some cases, molting their flight feathers. These additional migrations may play a key role in population structure, but are not included in traditional models of migratory connectivity. Network analysis, which applies graph theory to assess linkages between discrete locations or entities, offers a powerful tool for quantitatively assessing the contributions of different sites used throughout the annual cycle to complex spatial networks. We collected satellite telemetry data on annual cycle movements of 672 individual sea ducks of five species from throughout eastern North America and the Great Lakes. From these data, we constructed a multi-species network model of migratory patterns and site use over the course of breeding, molting, wintering, and migratory staging. Our results highlight inter- and intra-specific differences in the patterns and complexity of annual cycle movement patterns, including the central importance of staging and molting sites in James Bay, the St. Lawrence River, and southern New England to multi-species annual cycle habitat linkages, and highlight the value of Long-tailed Ducks (*Calengula haemalis*) as an umbrella species to represent the movement patterns of multiple sea duck species. We also discuss potential applications of network migration models to conservation prioritization, identification of population units, and integrating different data streams.

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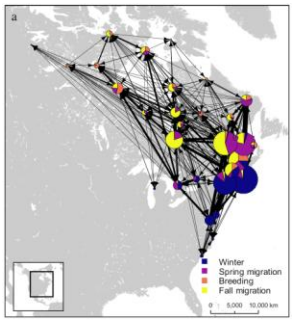

Movement network for five species of sea ducks (Black Scoter, Surf Scoter, White-winged Scoter, Long-tailed Duck, and *dresseri* Common Eider) by season within the annual cycle, 2002–2017. (a)

Origins of harvested Mallards from Lake St. Clair, Ontario: a stable isotope approach

Mathew D. Palumbo[1,2,*], Douglas C. Tozer[2], Keith A. Hobson[3]

[1] University of Wisconsin—Stevens Point
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Western University
**** Long Point Waterfowl and Wetlands Research Program postdoctoral researcher***

Determining origins of waterfowl is important for establishing appropriate management and conservation strategies. In North America, much information is available from long-term mark-recapture programs involving banding on breeding or molting grounds. However, this approach is less able to identify origins of individuals across broad areas where banding effort is low. We used stable hydrogen isotope analyses of feathers from Mallards (*Anas platyrhynchos*) harvested during the 2014–15 and 2015–16 hunting seasons at Lake St. Clair (LSC), Ontario, Canada (*n* = 237 individuals). We created a feather isoscape and applied Bayesian assignment approaches involving priors related to probability of origin based on banding data from the Central, Mississippi, and Atlantic flyways. The proportion of hatch-year Mallards produced locally (i.e., at the same latitude as LSC), as opposed to farther north or south of LSC, ranged from 13.1% to 22.0% with almost no difference by sex. The proportion of after-hatch-year (AHY) birds that molted locally ranged from 3.5% to 13.5%, with slightly fewer local AHY females compared to local AHY males. Nearly all birds that did not originate locally came from latitudes to the north of LSC, and only two from south of LSC. Whether this pattern is representative of locations in the Great Lakes beyond our study area is unknown, but is of great relevance for harvest management. As such, we are expanding our study with plans to examine isotope-based origins of Mallards and other harvested waterfowl species at locations throughout the Great Lakes region. Due to its unique potential to fill knowledge gaps, we advocate the use of the stable isotope technique in the management of North American waterfowl and encourage more research in this area.

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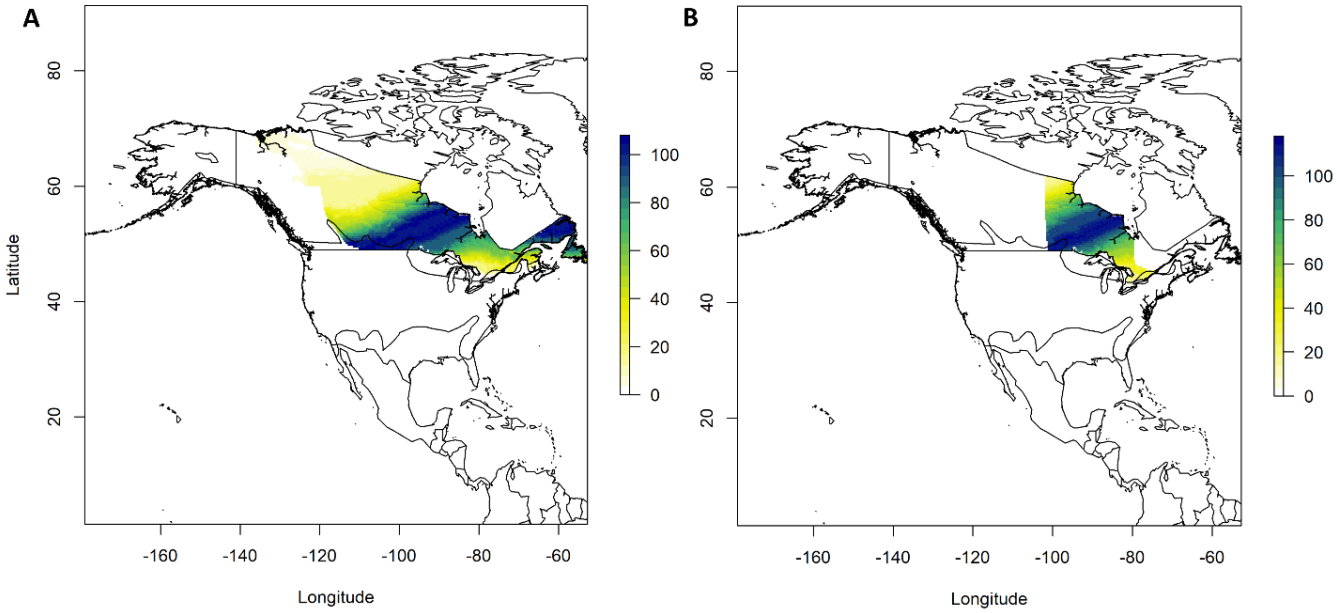


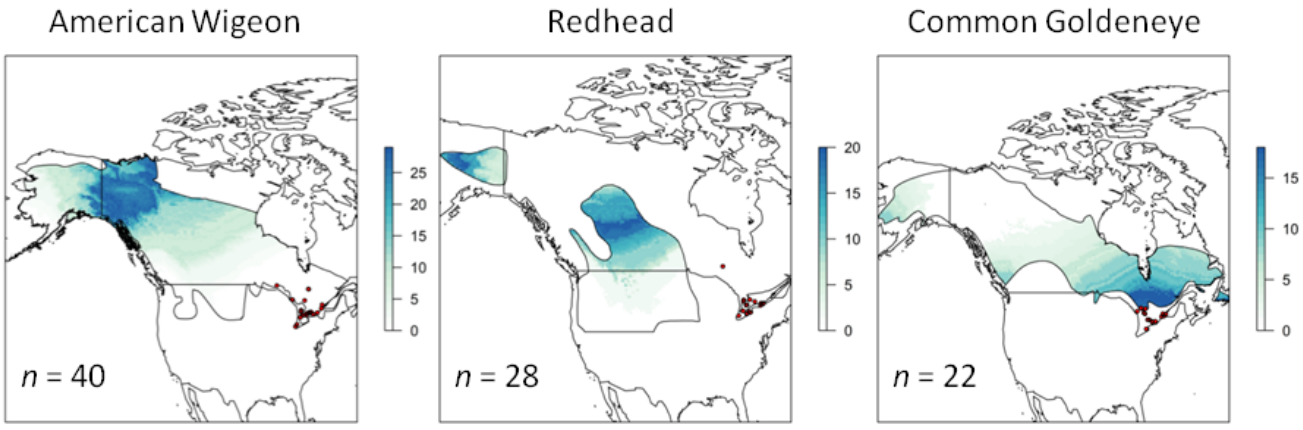
Depiction of probable origins of immigrant Mallards harvested along the eastern shore of Lake St. Clair (LSC), Ontario, 2014-2016. Legend number corresponds to number of individuals assigned at each pixel based on a 2:1 odds ratio criterion (see Methods). Figure A depicts origins without the application of a Bayesian prior. Figure B is the depiction constrained by band recovery probabilities for the Central (0.017), Mississippi (0.829), and Atlantic (0.154) flyways.

Migratory connectivity of waterfowl using the Great Lakes

Jackson Kusack[1,2,*], Douglas C. Tozer[2], Simon J. Bonner[1], Keith A. Hobson[1]

[1] Western University
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
**** Long Point Waterfowl and Wetlands Research Program PhD student***

Waterfowl harvest regulations in North America are based on careful scrutiny of demographics of breeding, staging, and overwintering birds within each of four major migratory flyways. A diverse suite of information flows into this decision-making process guided by the North American Waterfowl Management Plan. The information includes extensive abundance and habitat monitoring data, as well as data from various extrinsic sources such as banding, satellite tags, and radio-transmitters, and various intrinsic sources including genetic markers and isotopes. Each of these sources of information has advantages and disadvantages depending on the research question being pursued. Taken together, they generally form for most species a reasonable understanding of which populations are being harvested, and in some cases by how much, although numerous knowledge gaps remain. Analysis of stable hydrogen isotopes in feathers of harvested waterfowl has proven to be useful and efficient for identifying harvested populations at broad scales, and in the Great Lakes region has been examined to a certain extent in Mallards, American Black Ducks, and Lesser Scaup, but to our knowledge not in other species. In this study, we analyze stable hydrogen isotope signatures of flight feathers of males and females of both hatch-years and after-hatch-years of multiple waterfowl species harvested throughout the Great Lakes region. Our main goal is to better define natal and molt origins of waterfowl harvested in the Great Lakes. We also examine origins as a function of sex, age, date, and breeding pair abundance. We include information from band recoveries as informative priors in models, and range extent as a constraint on model output. Results from the study will enhance knowledge of the origins of harvested waterfowl in the Great Lakes, and will improve the ability of waterfowl managers to make informed decisions when setting annual harvest quotas.



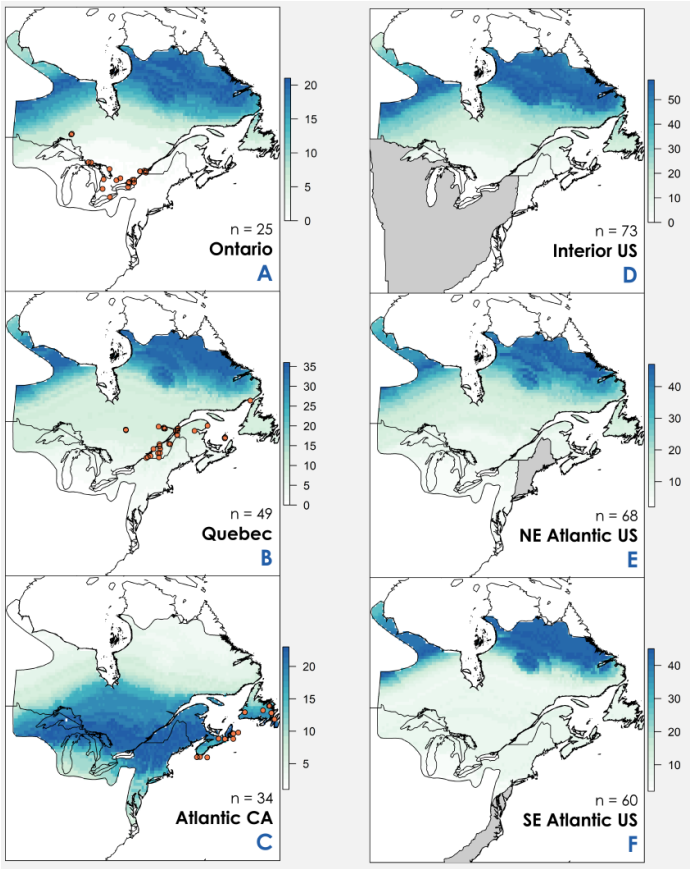
Preliminary depictions of probable origins of individuals of three different duck species harvested in southern Ontario. Darker blue shows most probably areas of origin; red dots show harvest locations; sample size of the number of individuals is also shown (*n*).

Origins of harvested American Black Ducks: a stable isotope approach

Jackson Kusack[1,2,*], Douglas C. Tozer[2], Simon J. Bonner[1], Keith A. Hobson[1]

[1] Western University
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
**** Long Point Waterfowl and Wetlands Research Program PhD student***

The international adaptive harvest management strategy for the American Black Duck (*Anas rubripes*) uses information from harvested and banded individuals and assumes that they originate from the same regions located throughout the species' range. However, various lines of evidence suggest otherwise. As a result, the 'flyover' hypothesis has been proposed, which states that Canadians are more likely to harvest birds from the southern portion of the breeding range and birds in the northern boreal are more likely to be harvested by Americans. To test the flyover hypothesis, we used stable-hydrogen isotope analysis of flight feathers of harvested individuals to estimate origins. We chose this method because it allows for the tracking of migratory waterfowl without the need for extrinsic markers (such as leg bands). This is because stable hydrogen values within feathers reflect those of the site of feather growth, which are in turn related to patterns of stable hydrogen in precipitation along a broad latitudinal gradient. This aspect of the method was critical for testing the flyover hypothesis because banding operations are almost entirely absent throughout the northern portion of the American Black Duck's breeding range. Using preliminary data from the 2017-2018 hunting season, we found that hatch-years harvested in the US, Ontario, and Quebec likely originated in the northern boreal, whereas individuals harvested in Atlantic Canada had more southerly or local origins. Origins of hatch-years harvested in Atlantic Canada provide preliminary support for the flyover hypothesis. It is unclear why the same pattern is not shown by individuals harvested in Ontario and Quebec. We will continue to investigate patterns in origins by increasing our sample size within and across hunting seasons, including additional covariates in assignment models, and by better refining our estimates of origin with additional data.



Probabilistic origins of harvested hatch-year American Black Ducks separated by region of harvest (A–Ontario, B–Quebec, C–Atlantic Canada, D–Interior US region, E–North Atlantic US region, F–South Atlantic US region). Colour gradients represent the number of individuals assigned to each pixel based on a 2:1 odds ratio. Harvest points for Canadian provinces are represented by red dots, whereas harvest points for US states are represented by black duck management regions shown as grey polygons.

Origins of Blue-winged Teal harvested in Ontario and Prairie Canada based on stable isotopes: implications for sustainable management

Matthew D. Palumbo[1,*], Jackson W. Kusack[1,2,*], Douglas C. Tozer[1], Shawn W. Meyer[3], Christian Roy[3], Keith A. Hobson[2,3]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Western University
[3] Environment and Climate Change Canada
**** Long Point Waterfowl and Wetlands Research Program postdoctoral researcher / PhD student***

Determining the source areas of harvested individuals is important for effective conservation and management of migratory game birds. Banding has provided much information about source areas, but obtaining samples of marked individuals representative of all potential breeding areas is difficult for most species. To add to previous knowledge of harvest derivation based on banding data and to assist with regulatory decisions, we used stable hydrogen isotope (d2H) techniques to estimate natal and molt source areas of Blue-winged Teal (*Spatula discors*) harvested in southern Canada in 2014 and 2017. We found that most birds harvested in southern Saskatchewan, southern Manitoba, northern Ontario, and southern Ontario likely originated in the prairie and boreal plains regions of Canada and the United States, which is the core production area for the species. Based on feather d2H values, some birds harvested in Ontario may have also originated in Ontario. Our results differ from those of a long-term analysis of band recovery data that revealed that most Blue-winged Teal harvested in Ontario originated in the eastern part of the province and areas along the lower Great Lakes and southwestern Quebec. We found that nearly all birds harvested in Ontario in our study likely originated from areas north and west of the province. Together, banding and stable isotopes likely provide the best information available on source areas of harvested birds for regulatory decision making.

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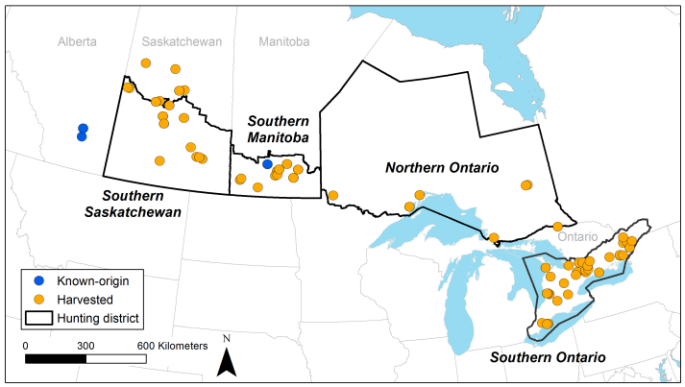
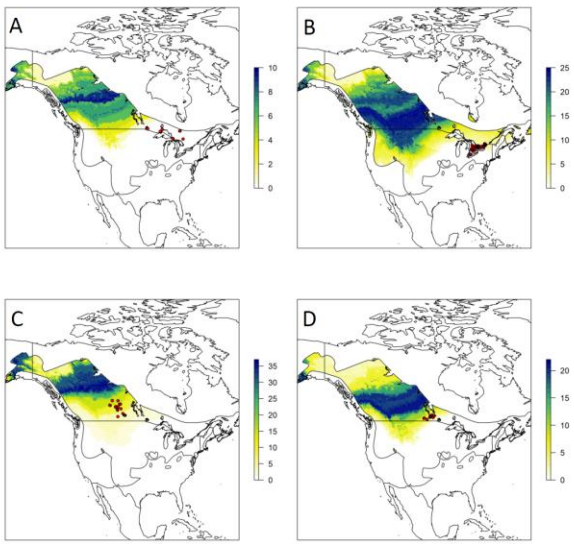


Locations of known-origin (n = 17) and harvested (n = 144) Blue-winged Teal. Note that some of the locations overlap on the map. Also shown is the extent of each of four hunting districts: southern Saskatchewan (Saskatchewan Hunting District No. 2), southern Manitoba (Manitoba Hunting Zone No. 4), northern Ontario (Ontario Hunting District No. 2), and southern Ontario (Ontario Hunting District No. 4).



Depiction of likely origin of Blue-winged Teal harvested in (A) northern Ontario, (B) southern Ontario, (C) southern Saskatchewan, and (D) southern Manitoba, Canada during the 2014/2015 and 2017/2018 hunting seasons. Locations where individuals were harvested are shown by red dots. Legend number corresponds to the number of individuals assigned at each pixel based on a 2:1 odds ratio. Polygon outlines the breeding range of Blue-winged Teal in North America (BirdLife International 2017).

Source areas of Northern Pintails harvested in northeastern North America

Dariusz Wojtaszek[1,2,*], Douglas C. Tozer[1], Michael L. Schummer[3], Keith A. Hobson[2,4]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Western University
[3] State University of New York College of Environmental Science and Forestry
[4] Environment and Climate Change Canada
**** Long Point Waterfowl and Wetlands Research Program MSc student***

Banding suggests that the majority of Northern Pintails harvested in the Atlantic Flyway of northeastern North America are derived from the Prairies or Alaska. However, few pintails are banded on the breeding grounds in remote areas in northern Ontario and Quebec due to logistical challenges, so it is unlikely that banding reflects the true sources of harvested birds. For instance, over-wintering females marked with satellite transmitters along the Atlantic coast revealed that 80% of 55 birds used an eastern migration corridor and all but 2 settled to breed in the southern James Bay lowlands of Ontario or locales farther east. Our objective is to use stable isotope techniques to determine origins of Northern Pintails harvested across the Atlantic Flyway and at specific stop-over sites like Winous Point, Ohio and the Montezuma Wetlands Complex, New York, where large numbers of pintails congregate during migration. We are particularly interested to estimate proportions of harvested individuals that breed or molt in Alaska versus the Prairies versus eastern Canada. The results from the study will enhance knowledge of the origins of harvested pintails in the Great Lakes and elsewhere in eastern North America, and will inform and help improve management and conservation of pintails.

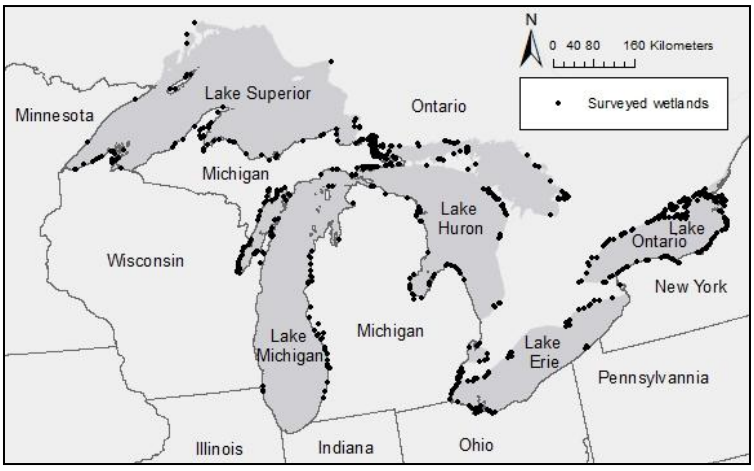
Male Northern Pintail. Photo: Rick Leche.

Hierarchical modeling to identify habitat associations of wetland-obligate birds in Great Lakes coastal wetlands

Lisa H. Elliott[1,2,*], Annie Bracey[1], Gerald J. Niemi[1], Douglas H. Johnson[1], Thomas Gehring[3], Erin E. Gnass Giese[4], Greg Grabas[5], Robert W. Howe[4], Christopher J. Norment[6], Douglas C. Tozer[2]

[1] University of Minnesota – Duluth
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Institute for Great Lakes Research, Central Michigan University
[4] Cofrin Center for Biodiversity, University of Wisconsin – Green Bay
[5] Environment and Climate Change Canada
[6] The College at Brockport, State University of New York
**** Long Point Waterfowl and Wetlands Research Program PhD student***

We used data from the Great Lakes Coastal Wetland Monitoring Program (*n* = 641 wetlands, 2011-2017) to model occupancy and habitat associations for each of six declining wetland-obligate bird species of conservation concern throughout the Laurentian Great Lakes basin in the US and Canada: Pied-billed Grebe (*Podilymbus podiceps*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), Common Gallinule (*Gallinula galeata*), Least Bittern (*Ixobrychus exilis*), and American Bittern (*Botaurus lentiginosus*). Our five-level hierarchical models accounted for all of the processes influencing occurrence and detection (wetland, year, sample point, visit, point count interval), an approach never previously applied to these species in the basin. We identified several novel patterns: 1) three or more species had lowest occupancy in Lake Superior, mid-way in Lake Erie, and highest in Lake Michigan and Lake Huron; 2) Virginia Rail and Least Bittern had higher availability than other species across years in occupied wetlands, and American Bittern had higher occupancy across sample points in occupied wetlands; and 3) most species had similar point and wetland-level occupancy, whereas Virginia Rail had low point-level and high wetland-level occupancy, and American Bittern showed the opposite. We found few other significant habitat associations: occupancy of some species was influenced by wetland classification (e.g., lacustrine), wetland area, spring temperature, amount of emergent vegetation or open water within 200 m, and amount of woody wetland or forest within 200 m. By contrast, we found no influence of human population density, watershed-scale percentages of agriculture and development, or percentages of cropland and development within 200 m. Many of the estimated habitat relationships had wide Bayesian credible intervals. These results suggest: 1) these species tolerate a broad range of environmental conditions in coastal systems, 2) they respond to wetland characteristics that we did not model, or 3) we did not have adequate statistical power. If our models are accurate, then protecting and restoring all Great Lakes coastal wetlands regardless type, size, or landscape context will be valuable for conservation of these declining bird species.



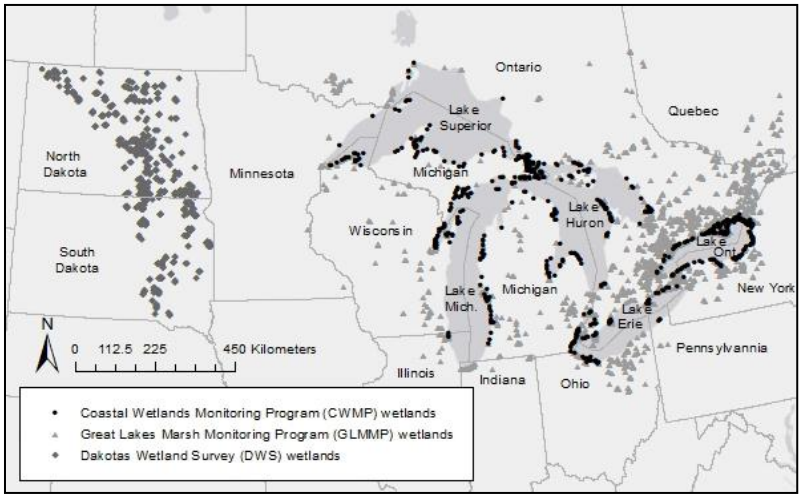
Distribution of 641 coastal wetlands in the Great Lakes basin that were sampled for birds in 2011-2017 as part of the random sample of wetlands in the Great Lakes Coastal Wetland Monitoring Program.

Regional modeling of habitat associations for wetland-obligate birds in the Upper Midwest and Great Lakes basin

Lisa H. Elliott[1,2,*], Annie Bracey[1], Gerald J. Niemi[1], Douglas H. Johnson[1], Thomas Gehring[3], Erin E. Gnass Giese[4], Greg Grabas[5], Robert W. Howe[4], Christopher J. Norment[6], Douglas C. Tozer[2]

[1] University of Minnesota – Duluth
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Institute for Great Lakes Research, Central Michigan University
[4] Cofrin Center for Biodiversity, University of Wisconsin – Green Bay
[5] Environment and Climate Change Canada
[6] The College at Brockport, State University of New York
**** Long Point Waterfowl and Wetlands Research Program PhD student***

Species exhibit regionally specific habitat associations, but it remains unclear how well models of species density based on habitat associations developed in one region may predict the density of the same species elsewhere. Three existing North American marsh breeding bird survey programs in 1) Great Lakes coastal wetlands, 2) inland Great Lakes wetlands, and 3) the Prairie Pothole Region offer an opportunity to identify characteristics of species-specific habitat use by obligate wetland-breeding birds that are consistent across regions and to test whether region-specific models are transferrable across regions. We developed Poisson models of species density for four species of secretive marsh birds: Pied-billed Grebe (*Podilymbus podiceps*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), and American Bittern (*Botaurus lentiginosus*). We developed independent, species-specific models for each of the three study regions and used adjusted pseudo-R^2 values to compare the amount of variation explained by each model when it was applied to data collected in its region and to data collected in the other regions. Habitat models consistently explained more variation in the density of a species in that respective region than did habitat models created elsewhere. However, certain habitat characteristics, such as wetland area, were consistently important across regions. When we applied a model developed in one region to data collected in another region, we found that most models still had a substantial amount of explanatory power, and models created from inland Great Lakes wetland data had the highest median levels of explanatory power when applied to other regions. Therefore, we suggest that conservation planning should emphasize the use of regionally specific habitat association models whenever possible; but, in the absence of regional data, it is feasible to apply models of habitat associations developed in one region in another region. Additionally, we found that median explanatory power was higher when local-scale habitat characteristics were included in models, which suggests that, whenever possible, these region-specific models should be based on a combination of local and landscape-scale habitat characteristics..



Distribution of wetlands surveyed as part of three monitoring programs: the Great Lakes Coastal Wetlands Monitoring Program (CWMP) and the Great Lakes Marsh Monitoring Program (GLMMP) in the Great Lakes basin and the Dakotas Wetland Survey (DWS) dataset in the Prairie Pothole Region of North and South Dakotas.

Species-habitat relationships and priority habitat areas for marsh-breeding birds in southern Ontario

Douglas C. Tozer[1], Rebecca L.M. Stewart[2], Owen Steele[3], Mark Gloutney[3]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Birds Canada
[3] Ducks Unlimited Canada

Populations of marsh-breeding birds have declined throughout the southern Laurentian Great Lakes basin. To advance conservation of these species, we used occupancy modeling, a regional prioritization scheme, and data from Birds Canada's Great Lakes Marsh Monitoring Program (2016-2018) to describe species-habitat relationships and identify priority habitat areas for 7 obligate marsh-breeding bird species in southern Ontario, Canada: American bittern (*Botaurus lentiginosus*), common gallinule (*Gallinula galeata*), least bittern (*Ixobrychus exilis*), marsh wren (*Cistothorus palustris*), pied -billed grebe (*Podilymbus podiceps*), sora (*Porzana carolina*), and Virginia rail (*Rallus limicola*). Given these species respond to land cover at widely varying spatial scales, we initially identified the most informative scale (buffer=100 m, 200 m, 400 m, 800 m, 1,600 m, 3,200 m, or 6,400 m) for marsh, urban, agricultural, and forest cover to increase model performance. We also considered climate variables, whether sample sites were along a Great Lakes coastline or inland, and covariates influencing detection. Occupancy was best explained by land cover at a wide range of spatial scales depending on the species. All species except Virginia rail responded positively to marsh cover; American bittern and Virginia rail responded negatively to urban cover; least bittern, pied -billed grebe, and Virginia rail responded negatively and sora responded positively to agricultural cover; and American bittern, common gallinule, marsh wren, and pied -billed grebe responded negatively and Virginia rail responded positively to forest cover. Only American bittern responded negatively to mean May‐June temperature; only pied -billed grebe responded positively to start of growing season; and only Virginia rail had higher occupancy at inland marshes compared to coastal. We combined predictions from the best model for each of 5 species with reasonably good model fit (we excluded sora and Virginia rail) to identify priority habitat areas for marsh -breeding birds. Expansion of wetland conservation work from existing priority areas based on waterfowl to also include these new additional priority areas based on marsh -breeding birds will be an important step towards conservation of all birds, and will help slow or maybe even reverse declining population trends. Some restoration activities outside but adjacent to priority areas will also be important for rebuilding marshes for these species across this intensively farmed and developed region.

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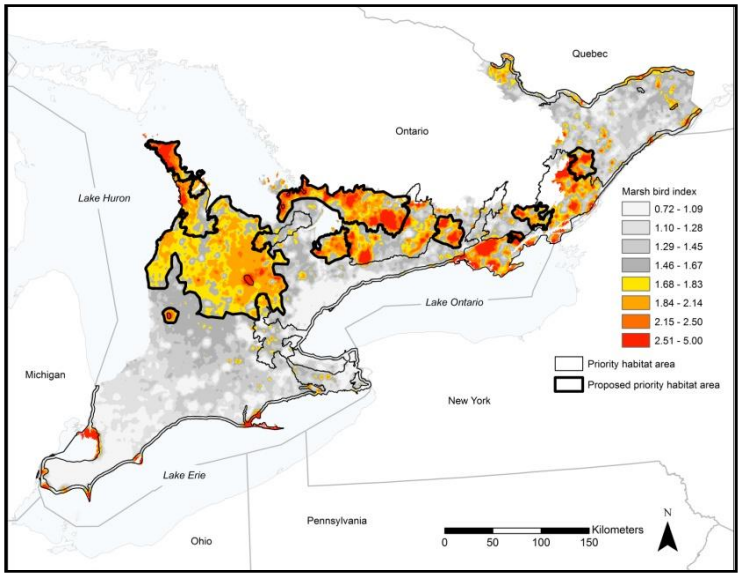


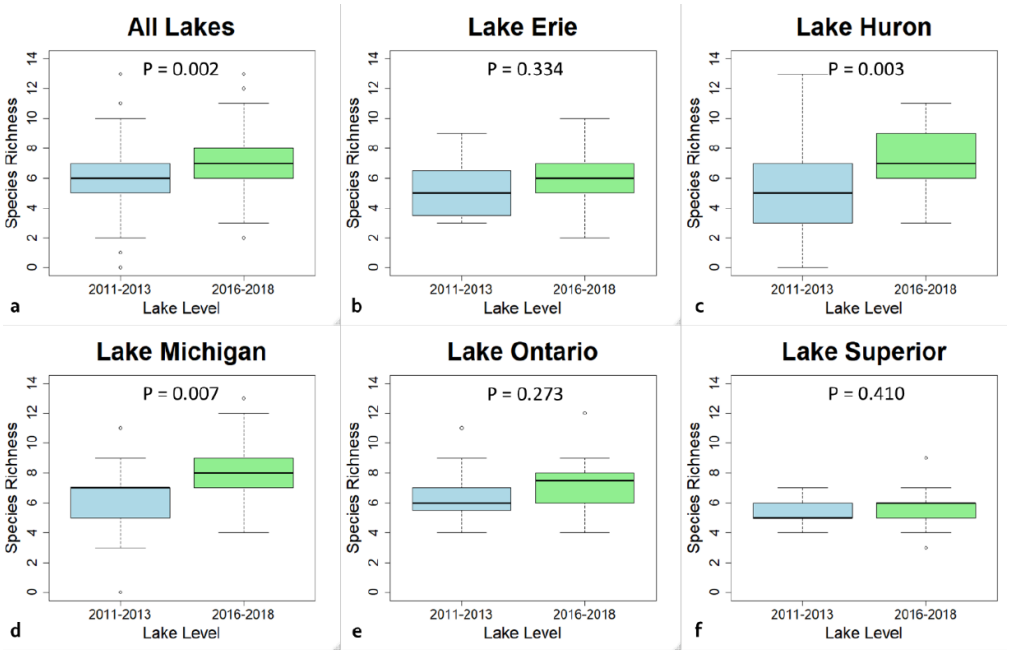
Marsh-breeding bird occupancy index based on 5 obligate marsh-breeding bird species throughout southern Ontario, Canada, 2016–2018: American bittern, common gallinule, least bittern, marsh wren, and pied-billed grebe. We excluded sora and Virginia rail because of poor transferability to un-sampled sites as indicated by poor model fit based on validation data. We considered grid cell index values ≥1.68 for inclusion in new additional priority habitat areas (top 30% of ordered grid cells) and present them in warm colors (yellow, orange, red). We also show more restrictive alternatives: top 20% of ordered grid cells (index ≥1.84; light orange), top 10% (index ≥2.15, dark orange), top 5% (index ≥2.51, red). We present existing priority habitat areas based on waterfowl and new additional (expanded) priority habitat areas based on marsh-breeding birds.

Bird community response to changes in wetland extent and lake level in Great Lakes coastal wetlands

Tara Hohman[1,2,*], Erin E. Gnass Giese[1], Amy T. Wolf[1], Robert W. Howe[1], Gerald J. Niemi[3], Douglas C. Tozer[4], Thomas M. Gerhing[5], and Christopher J. Norment[6]

[1] Cofrin Center for Biodiversity, University of Wisconsin – Green Bay
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Natural Resources Research Institute, University of Minnesota – Duluth
[4] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[5] Institute for Great Lakes Research, Central Michigan University
[6] The College at Brockport, State University of New York
**** Long Point Waterfowl and Wetlands Research Program MSc student***

Coastal wetlands in the Laurentian Great Lakes undergo frequent, sometimes dramatic physical changes at varying spatial and temporal scales. Changes in lake levels and subsequent changes in the juxtaposition of vegetation and open water greatly influence biota that use coastal wetlands. Several regional studies have shown that changes in vegetation and lake levels lead to predictable changes in the composition of coastal wetland bird communities. We report new findings of wetland bird community changes at a much broader scale, covering the entire Great Lakes. Our results indicate that water extent and interspersion increased in coastal wetlands across the Great Lakes basin between low (2013) and high (2018) lake-level years, although variation in the magnitude of change occurred within and among lakes. Increases in water extent and interspersion resulted in a general increase in marsh-obligate and marsh-facultative bird species richness across the basin. Species like American bittern, common gallinule, American coot, sora, Virginia rail, and pied-billed grebe were significantly more abundant during high water years. Lake Huron and Lake Michigan showed the greatest increase in water extent and interspersion among the five Great Lakes, while Lake Michigan showed the greatest increase in marsh-obligate bird species richness. These results suggest that effective management, restoration, and assessment of wetlands must account for fluctuations in lake levels. Although high lake levels generally provide the most favorable conditions for wetland bird species, variations in lake levels and bird species occurrences produce an ecosystem that is both spatially and temporally dynamic.



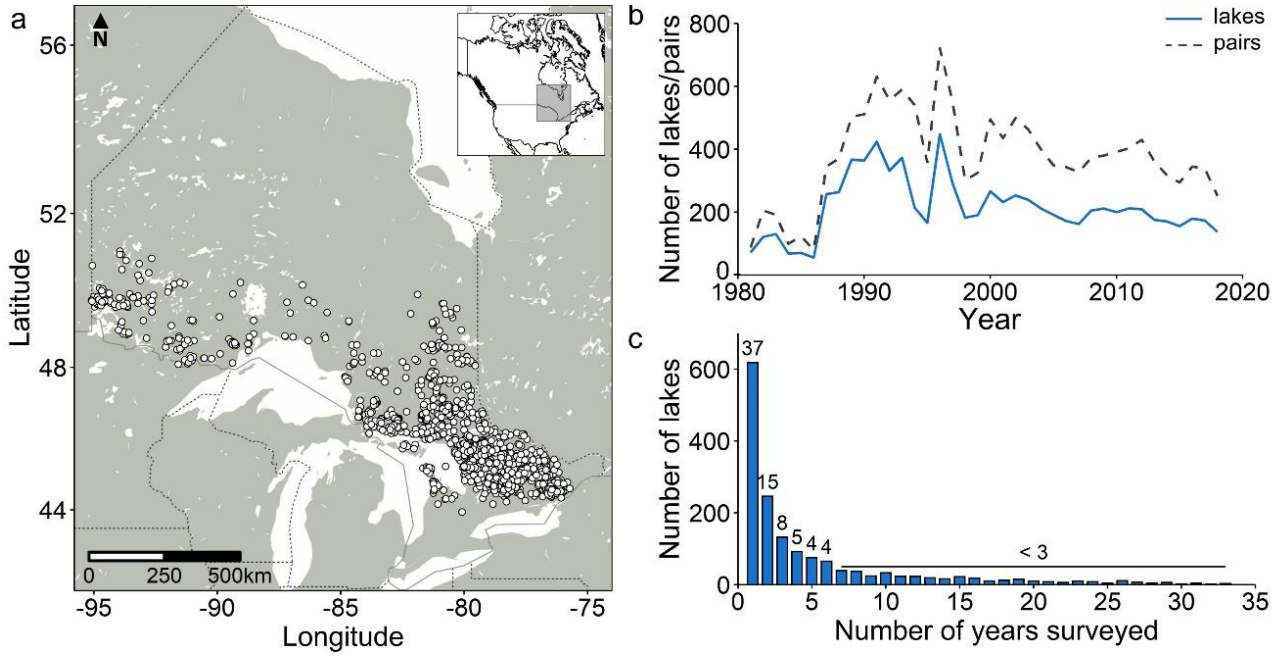
Boxplots of species richness change across the Great Lakes basin (a) and in Lakes Erie (b), Huron (c), Michigan (d), Ontario (e), and Superior (f) for low (2011-2013) and high (2016-2018) lake-level years. P-values are based on Poisson-distributed generalized linear models with species richness as a response against lake, lake-level, and lake*lake-level as predictors ($\alpha = 0.05$).

Drivers of declines in Common Loon productivity in Ontario

Kristin Bianchini[1,2,*], Douglas C. Tozer[2], Robert Alvo[3], Satyendra P. Bhavsar[4], Mark L. Mallory[1]

[1] Acadia University
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Ottawa, Ontario
[4] Ontario Ministry of the Environment, Conservation and Parks
**** Long Point Waterfowl and Wetlands Research Program postdoctoral researcher***

Common Loons (*Gavia immer*) are top predators that depend on lake food webs to successfully fledge chicks. Common Loon reproductive success is consequently recognized as an important indicator of aquatic ecosystem health. Existing evidence points to long-term declines in productivity in portions of the Common Loon range; however, the reason for these declines is not well understood. Our objectives were to define the spatial and temporal patterns of loon reproductive success in Ontario, Canada, and to identify drivers of temporal changes in loon productivity. We analyzed 37 years of reproductive data from over 1600 lakes using data from the Canadian Lakes Loon Survey, a citizen science loon monitoring program managed by Birds Canada that has run annually in Ontario since 1981. Overall, we estimated a declining trend in Common Loon reproductive success of -0.10 young per pair per year in Ontario between 1981 and 2018. We assessed the influence of 14 factors on loon reproductive success and identified low pH, higher mercury, and low fish abundance as factors strongly linked to loon productivity declines. We also demonstrated that lake area, longitude, and April temperatures can predict the number of large young per pair. We hypothesize that climate change-induced stress, acting through multiple interacting pathways involving mercury, acidity, fish presence, lake size, and geographic location, may account for declining loon productivity. These results will be important for focusing future research and conservation efforts to help understand and mitigate threats to Common Loon populations.



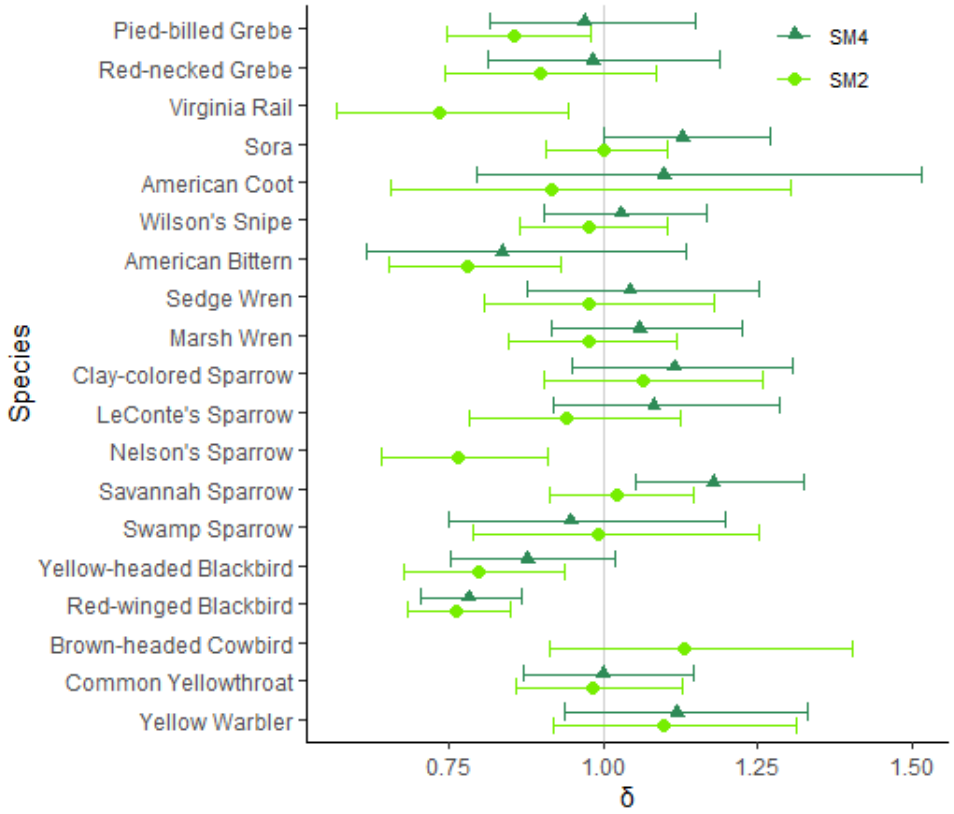
Location of CLLS lakes used to investigate patterns in Common Loon reproductive success in Ontario between 1981 and 2018. Figure inset indicates the study area in North America represented on the map (a). Number of lakes (solid blue line) or Common Loon pairs (dashed gray line) surveyed per year (b) and the number of years that each lake was surveyed (c) by CLLS participants. In panel c, numbers above the bars indicate the value of each bar as a percentage of the total number of lakes surveyed.

Integrating wetland bird point count data from humans and acoustic recorders

Laura N. Stewart[1,2,*], Douglas C. Tozer[1], Janine M. McManus[2], Lucas E. Berrigan[2], Kiel L. Drake[2]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Birds Canada
**** Long Point Waterfowl and Wetlands Research Program Paid Research Intern***

Wetland loss is cause for concern for populations of many wetland bird species throughout North America. The North American Breeding Bird Survey, the primary resource for broad scale avian population data, does not provide sufficient data for many marsh bird species. Targeted marsh bird monitoring programs have been implemented across the continent in an attempt to fill this gap. Despite these efforts, a number of nocturnal wetland species are so elusive that they remain an analytical challenge due to small sample sizes and other issues. Thus, there is need for tools and approaches that will increase sampling efficiency and boost geographic representation. Autonomous recording units (ARUs) have the potential to address some of these challenges, but require the ability to combine in-person survey data with ARU data for collective analysis. Our primary objective was to estimate statistical offsets, or correction factors, to account for systematic differences between in-person and ARU counts of wetland-associated bird species. We found that ARU recordings were generally equivalent to in-person point counts, with some bias in a small number of species. However, bias was removed in all of the species through use of our correction factors. Therefore, our correction factors are effective for integrating in-person and ARU point count data even for species where differences exist. We also found that commercially-available SM4 recorders have larger effective detection radii than SM2 recorders. Researchers should consider the microphone sensitivity and signal-to-noise ratios of any recording unit before purchasing and more sensitive models with lower noise should be used where possible. Our results and particularly our correction factors are useful for wetland managers for combining in-person and ARU point count data to achieve larger sample sizes, higher statistical power, and ultimately better information for more effective wetland conservation.



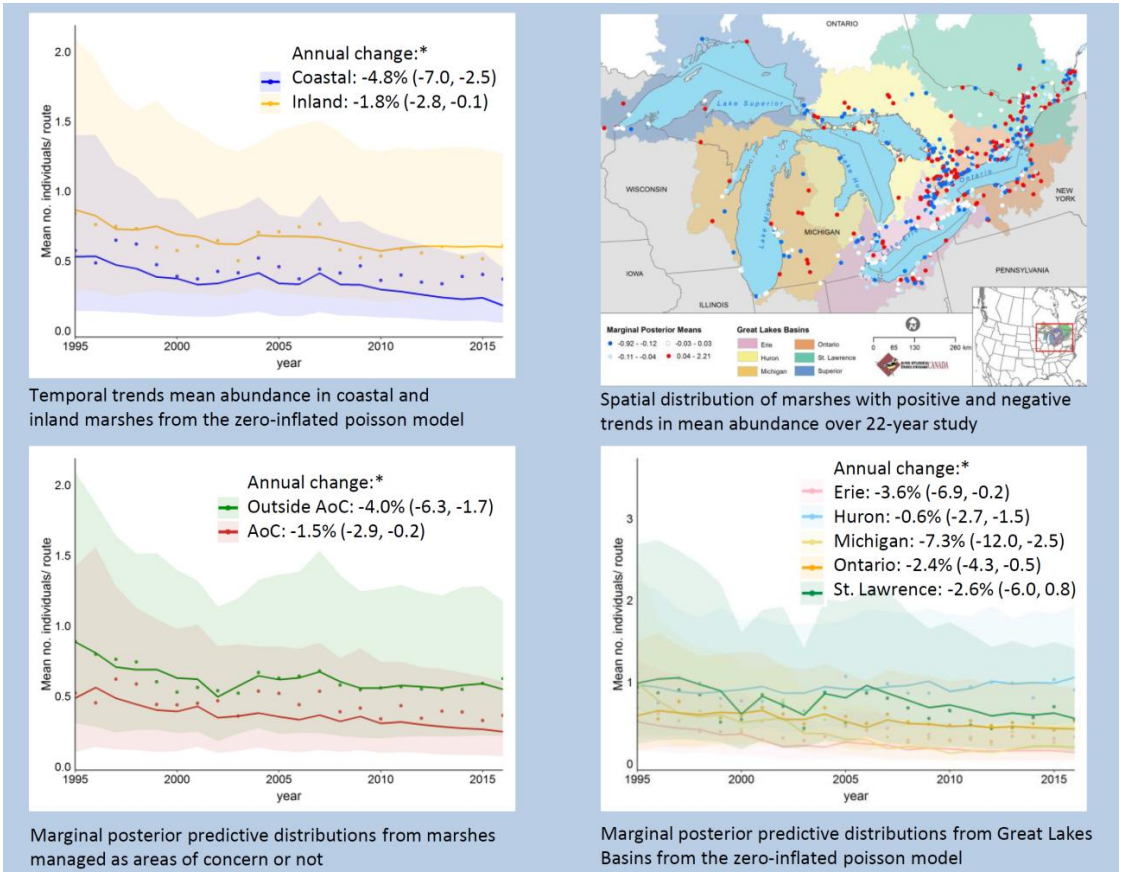
Correction factors (δ) for SM2 and SM4 surveys. Where δ is less than 1, ARUs count fewer individuals on average than in-person surveys. Presented are medians and 95% confidence intervals of maximum likelihood estimates.

Modeling 22-year trends in marsh breeding bird abundance using the spatially explicit INLA approach

Sonya Richmond[1], Tara L. Crewe[1], Douglas C. Tozer[2]

[1] Birds Canada
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada

Temporal trends in abundance are used to assess the status of wildlife populations, and are particularly useful when they are accurate and at spatial scales relevant for conservation. We used the INLA (Integrated Nested Laplace Approximation) approach to model trends in the mean abundance of seven marsh breeding bird species at various spatial scales in the Great Lakes Basin using data collected through Birds Canada's Great Lakes Marsh Monitoring Program (1995-2016). Separate trends were calculated for American Bittern (*Botaurus lentiginosus*), Black Tern (*Chlidonias niger*), Common Gallinlue (*Gallinula chloropus*), Least Bittern (*Ixobrychus exilis*), Pied-billed Grebe (*Podilymbus podiceps*), Sora (*Porzana carolina*), and Virginia Rail (*Rallus limicola*) in the Erie, Huron, Michigan, Ontario, and St. Lawrence lake basins; for Great Lakes coastal and inland marshes; and for marshes designated as Great Lakes Areas of Concern or not. These spatial scales link directly to reporting required under the Canada-US Great Lakes Water Quality Agreement, or are of interest to bird conservation organizations active in the region. Trends were highly variable among lake basins both within and among species. By contrast, negative trends were steeper at Great Lakes coastal locations compared to inland marshes for most species, and trends were more negative at locations within Areas of Concern compared to not for some species. The INLA approach provided a flexible, straightforward, and computationally inexpensive method of modelling trends for marsh birds at scales relevant for conservation in the Great Lakes Basin.



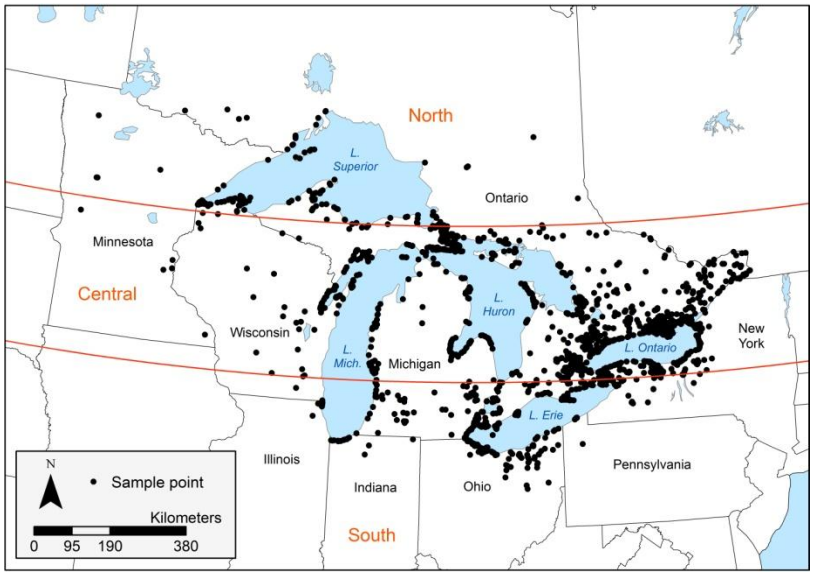
Model output for Virginia Rail, showing the types of predictions that are possible using the spatially explicit INLA approach.

Modeling detection probability to improve marsh-breeding frog surveys in the Great Lakes region

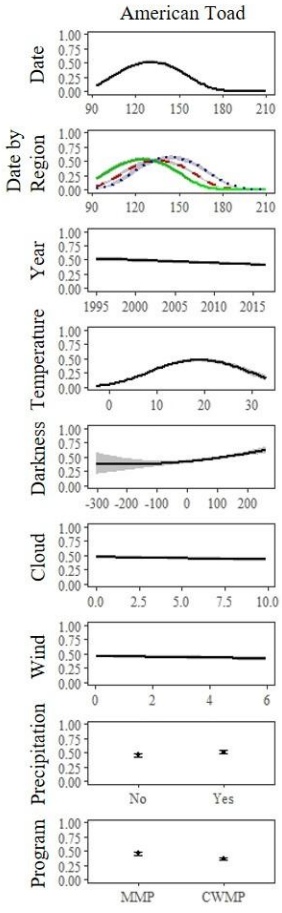
Hayley J. Roberts[1,*], Douglas C. Tozer[1]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
**** Long Point Waterfowl and Wetlands Research Program research intern***

Broad-scale population monitoring programs targeting marsh-breeding frogs (i.e., Anurans) have been active throughout the Great Lakes region for decades, including Birds Canada's Marsh Monitoring Program and Central Michigan University's Great Lakes Coastal Wetland Monitoring Program. These efforts have provided high-quality, critical information on the temporal and spatial distribution and habitat use of each of the common-occurring frog species in the region. It is important to ensure, however, that detectability of each of the targeted species is maximized during surveys, which can be challenging to achieve simultaneously across multiple species due to high variation among species. We used data from over 47,000 point count surveys conducted across the Great Lakes region and species-specific occupancy models to describe the probability of detection of 8 commonly-occurring marsh-breeding frogs as a function of various covariates known to influence frog detection. We found that on average across most species detection was influenced by temperature, time of day, and date, whereas cloud, precipitation, and wind had little influence. The lack of influence of precipitation and wind was likely due to strict constraints imposed by field survey guidelines (little or no precipitation and wind < 20 km/hr). We use our results to suggest improvements to the standard multi-species frog survey field protocol currently used throughout the Great Lakes region. Our results are also useful for developing species-specific field survey guidelines when planning field studies focusing on single species or groups of a small number of species. As such, our results will improve monitoring of frogs at various scales across the Great Lakes and ultimately help further conservation of this important group of animals.



Locations of 47,000 frog point counts conducted throughout the Great Lakes region. Note that each point represents multiple point counts. Also shown are the north, central, and south regions as depicted in the Great Lakes Marsh Monitoring Program frog survey field manual.



An example of results for one of the species, showing the probability of detection of American Toads as a function of several covariates.

P.O. Box/B.P. 160 (courier/ courier: 115 Front Street), Port Rowan, ON Canada N0E 1M0
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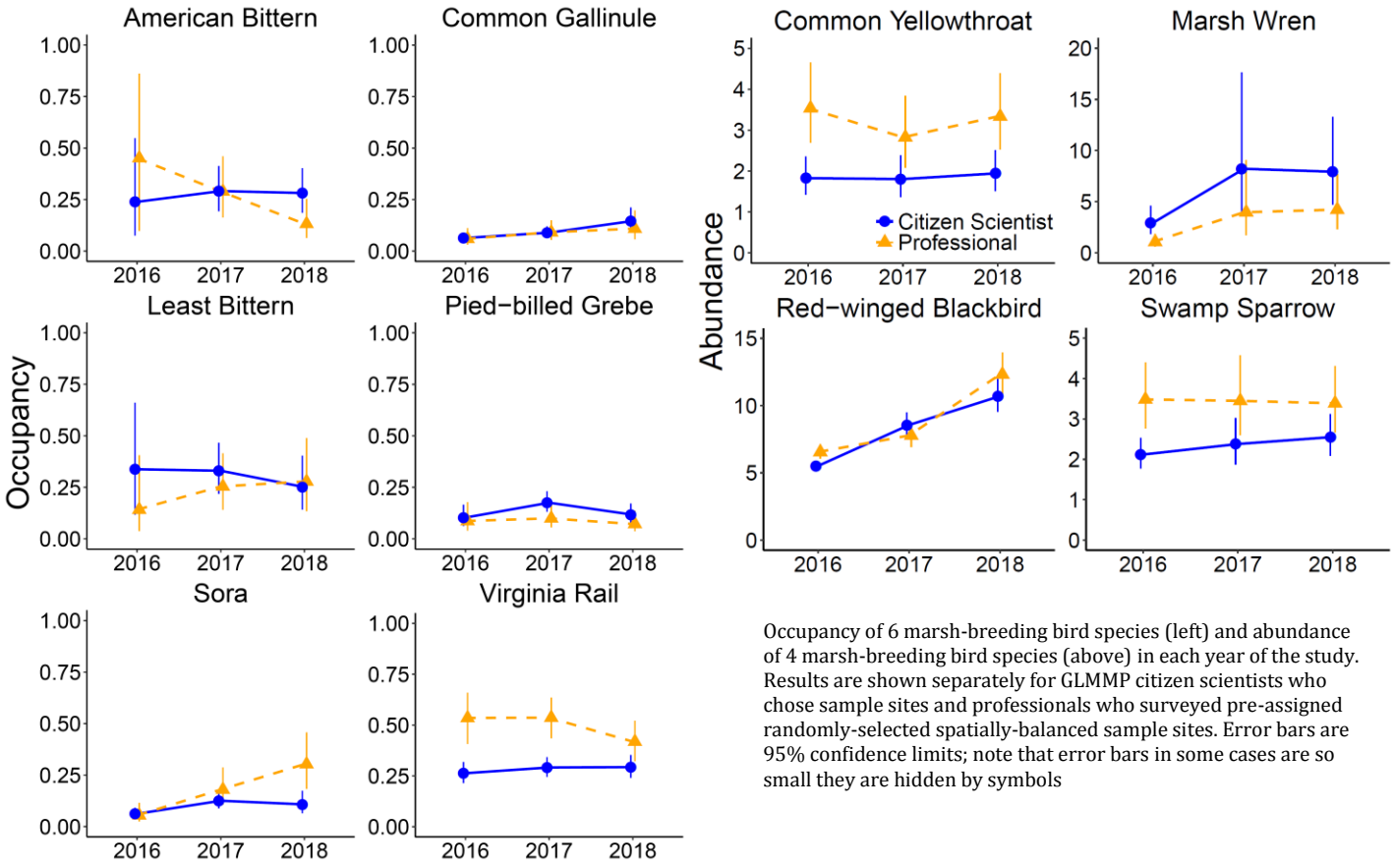
Do citizen scientists who choose marsh bird sample sites yield results similar to professionals at random sites?

Douglas C. Tozer[1], Rebecca L.M. Stewart[2]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Birds Canada

Marsh bird monitoring programs often recruit citizen scientists to boost survey coverage and detections. However, it is unknown whether this approach yields results similar to random sampling by professionals. We compared results based on data collected by participants in Bird Studies Canada's Great Lakes Marsh Monitoring Program (GLMMP) to results based on data collected by professionals who surveyed randomly-selected sample sites using the same field protocol. Our comparison included 1) species richness; 2) occupancy or abundance of 10 breeding marsh bird species; 3) a bird-based index of ecological condition; and 4) local, wetland, and landscape-scale vegetation and habitat. Both citizen scientists and professionals reported similar results for abundance of each of four common songbird species, species richness of bitterns (e.g., *Ixobrychus*) and rails (e.g., *Porzana*), and occupancy of five of the six elusive breeding marsh bird species that the GLMMP monitors. Citizen scientists detected fewer non-target species than professionals, and citizen scientists selected relatively more sample sites along Great Lakes shorelines (coastal) and relatively fewer inland compared to randomly-selected sample sites. An exploratory analysis revealed that GLMMP citizen science data is especially reliable in coastal wetlands, probably because sampling coverage was more similar between the two groups of observers in coastal areas. Overall, our findings show that trained GLMMP citizen scientists who opportunistically choose sample sites yield results similar to professionals who survey pre-assigned randomly-selected sample sites, provided that citizen scientists survey at or above the spatial and temporal frequency of survey coverage achieved during our study.



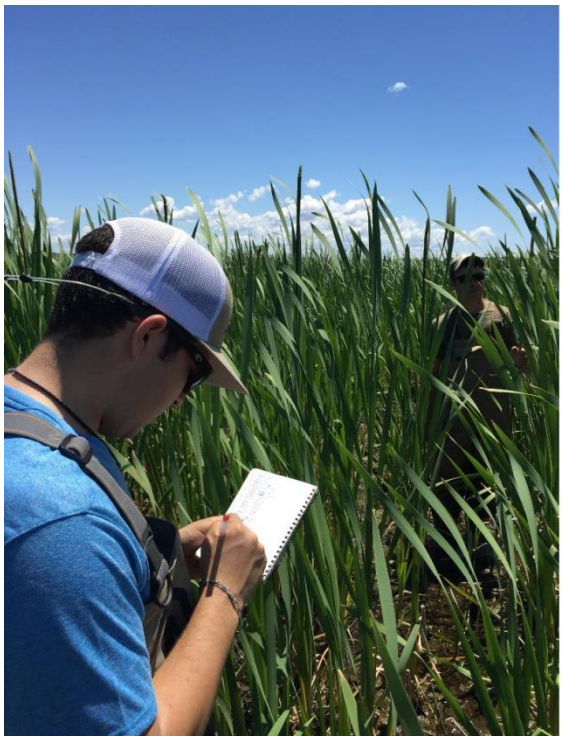
Occupancy of 6 marsh-breeding bird species (left) and abundance of 4 marsh-breeding bird species (above) in each year of the study. Results are shown separately for GLMMP citizen scientists who chose sample sites and professionals who surveyed pre-assigned randomly-selected spatially-balanced sample sites. Error bars are 95% confidence limits; note that error bars in some cases are so small they are hidden by symbols

Influence of partial and full water draw downs on vegetation and waterbirds in the Montezuma Wetlands Complex

Edward Farley[1,2,*], Michael L. Schummer[1], Don Leopold[1], John M. Coluccy[3], Douglas C. Tozer[2], James Eckler[4], Linda Ziemba[5]

[1] College of Environmental Science and Forestry, State University of New York
[2] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[3] Ducks Unlimited
[4] Northern Montezuma Wildlife Management Area
[5] Montezuma National Wildlife Refuge
**** Long Point Waterfowl and Wetlands Research Program MSc student***

Wetland managers often use water draw downs to increase productivity of vegetation, especially for the benefit of foraging waterfowl. I sought to identify effects of three water draw down treatments (full water draw down, partial water draw down, and passive management) on the plant community and bird abundance. I detected few differences in the plant community during summer, but during autumn I detected greater vegetative forage quality index, annual plant cover and seed density in full and partial draw downs than in passive wetlands, and greater monotypic cattail cover and vegetation height variation in passive and partial draw downs. Overall, bird abundance was greater in spring and summer in passive wetlands, and it was greater in autumn in full draw downs. During spring migration, ducks use full and partial draw downs in greater densities than in passive wetlands. Management should focus on providing a mix of full draw downs and passive wetlands to provide habitat for the greatest number of waterbird species throughout the year.



Sampling vegetation. Photo by Edward Farley.

Sampling invertebrates. Photo by Edward Farley.

Control of invasive *Phragmites* increases marsh birds but not frogs

Douglas C. Tozer[1], Stuart A. Mackenzie[2]

[1] Long Point Waterfowl and Wetlands Research Program, Birds Canada
[2] Long Point Bird Observatory, Birds Canada

The non-native invasive form of common reed (*Phragmites australis australis*; hereafter "invasive *Phragmites*") negatively affects certain flora and fauna throughout North America. As a result, much effort is spent in some locations controlling invasive *Phragmites*, although few estimates of the expected benefits of these efforts are available. We used data from Birds Canada's Great Lakes Marsh Monitoring Program and Central Michigan University's Great Lakes Coastal Wetland Monitoring Program to estimate changes in 1) species richness, 2) total abundance, and 3) occurrence of 9 breeding marsh bird species and 8 breeding marsh frog species before and after control of invasive *Phragmites*. Our study took place between 2011 and 2018 throughout 3 Great Lakes coastal wetland complexes located on Lake Huron and Lake Erie in southern Ontario. We found at sample sites where invasive *Phragmites* was controlled that species richness of 5 breeding marsh bitterns (e.g., *Botaurus* sp.) and rails (e.g., *Rallus* sp.) of conservation concern increased by 1.1 species, and that total abundance of these species combined increased by 1.8 individuals. By contrast, we observed no change in these responses at nearby sample sites where no *Phragmites* control occurred. We found no change in occurrence of any frog species or species richness or crude calling frequency of all frog species combined in relation to control of *Phragmites*, although we lacked the ability to detect subtle changes in abundance of frogs, so more information would be helpful before firm conclusions can be made in relation to frogs and control of invasive *Phragmites* in our study system. Our study shows that control of invasive *Phragmites* has a significant positive effect on breeding marsh bird species of conservation concern and suggests that continued effort to restore habitat for these species is warranted, particularly in areas where former breeding marsh bird biodiversity was high.

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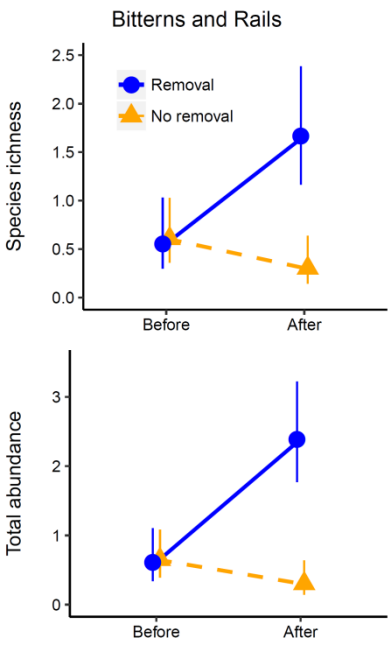
Rolling and compressing invasive *Phragmites* in preparation for a prescribed burn to remove biomass and permit re-growth of native vegetation. Photo by Janice Gilbert.



Response of marsh-breeding bitterns and rails of conservation concern 1-5 years before and 1-5 years after removal of invasive *Phragmites* at sample sites with removal (Removal) and at nearby sample sites without removal (No removal) within three wetland complexes on Lake Huron and Lake Erie in southern Ontario between 2011 and 2018.

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Inset: Putting transmitter on a Mallard Photo: Mike Moynihan

Dr. Doug Tozer, Program Director
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Blue-winged Teal Photo: Theodore Smith

Impactful results:

- Invasive, non-native mussels are not transferring the element selenium at harmful levels to ducks (scaup); resources redirected to address other factors driving population declines.
- More ducks are overwintering in the Great Lakes due to climate change, with less food for waterfowl in remaining wetlands; on-the-ground actions are being implemented.
- First-ever marsh breeding bird "hotspot" maps for southern Ontario identify new priority areas for wetland securement; helps Canada uphold all-bird conservation obligations.
- Wildlife-based prioritization reveals the best and worst Great Lakes coastal wetlands; wetland protection and restoration being done where it counts.
- Invasive vegetation management on Long Point, Ontario benefits numerous wildlife species; spearheads broad-scale *Phragmites* control program—waterfowl and wetlands are rebounding.

Mallards Photo: Theodore Smith

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Great Lakes Restoration

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Ontario

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P.O. Box/B.P. 160 (courier/ courier: 115 Front Street), Port Rowan, ON Canada N0E 1M0
Phone/Tél. 519 586 3531 Fax/Téléc. 519 586 3532 birdscanada.org

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