Habitat mapping for marsh nesting birds and herptiles in the Rainy Lake and Namakan Reservoir area:

Using GIS to assess the effects of the 2000 rule curve changes

Final Report
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Executive Summary

In 2000, the rule curves for water-level regulation in Rainy and Namakan lakes were changed to represent a more natural regime by Order of the International Joint Commission. A plan of study was developed to review the Order and included a project to map marsh nesting bird and herptile habitat by using a geographic information system (GIS) analysis to assess the effects of the 2000 rule curve changes. The approach was to 1. interpret the most complete and available sets of binational aerial photos across the Rainy Lake and Namakan Reservoir area that flanked the 2000 rule curve change period and 2. complete breeding marsh bird and amphibian field surveys to better understand constituency of the marsh-dependent wildlife community. The pre-2000 rule curve change series was from 1995 to 1997, and the post-2000 rule curve time series was from 2008 alone. The study focused on mapping vegetation types that were influenced by hydrologic regulation in Rainy Lake and Namakan Reservoir (which includes Namakan, Kabetogama, Sandpoint, Crane, and Little Vermilion lakes), namely emergent, meadow, and rooted and floating submersed communities.

A decrease in areal extent of all marsh types was observed between the two time series in all lakes. Decreases in areal extent were most apparent in meadow marsh types, particularly in Namakan Lake, where almost half of the meadow marsh has been lost. Although the vintage of aerial photo time series was ideal for this study, further investigation spurred by unexpected results suggested that two time series used in the study were from very different water supply periods. The 1995-1997 period was characterized by relatively low water levels, while 2008 were unusually high. It is unclear to what extent the change in vegetation communities was due to the 2000 rule curve implementation versus water supply extremes. Although other factors may have contributed to the detected loss in wetland extent, including human-related disturbance, natural variability, or photo interpretation/GIS biases, the decrease in wetland area between the two time series represented a biologically significant loss of marsh bird and herptile habitat in the study area. Recent field studies indicated that the present marsh extent at selected sites in the Rainy Lake and Namakan Reservoir area supported an abundance of marsh-dependent breeding bird and amphibian species.

Although the results of this study were inconclusive in determining the 2000 rule curve's effect on marsh nesting bird and herptile habitat, the GIS and wildlife community data are valuable for future lake-level management and to investigators involved in habitat modeling for the Rainy Lake and Namakan Reservoir area under various water-level management scenarios.

Introduction

In 2001, the International Joint Commission (IJC) issued an Order prescribing the method of regulating the levels of the boundary waters of Rainy and Namakan lakes, consolidating and replacing a number of previous orders and supplementary orders (International Joint Commission 2001). This "Consolidated Order" was effective on February 28, 2001 and contained the following provision: "This order shall be subject to review 15 years following adoption of the Commission's Supplementary Order of 5 January 2000, or as otherwise determined by the Commission. The review shall, at a minimum, consider monitoring information collected by natural resource management agencies and others during the interim that may indicate the effect of the changes contained in the Supplementary Order of January 5, 2000."

In 2007, the IJC formed a Rule Curve Assessment Workgroup to develop a plan of study (POS) in which the Workgroup would prioritize the monitoring and analyses required to review the IJC Order in 2015. Specifically, the POS was written to identify priority studies and describe information / data that remained to be collected, identify what entities might collect the data and perform the studies, and provide an estimate for the cost to accomplish this work by 2015. The POS for the Evaluation of the IJC 2000 Order for Rainy and Namakan lakes and Rainy River was completed in 2009 and included a study to map marsh nesting bird and herptile habitat, using a geographic information system (GIS) analysis to assess the effects of the 2000 rule curve changes.

Scope of Work

The purpose of this study was to determine the change in marsh habitat in the Rainy Lake and Namakan Reservoir area by using pre rule curve change (1995-97) and post rule curve change (2008) GIS datasets. The area of interest (Rainy Lake and Namakan Reservoir area) included Rainy Lake which is dammed at International Falls/Ft. Frances and Namakan Reservoir which is dammed at Kettle Falls and Squirrel Falls and regulates Namakan, Kabetogama, Sandpoint, Crane, and Little Vermilion lakes. The habitat of interest was marshes that are influenced by water-level regulation within the system. To distinguish between marshes influenced by regulation and marshes that were close to the lakes but upstream from hydrologic influence (e.g., above beaver dams), the term 'coastal marshes' is used in this report to describe the marshes of interest.

A standard vegetation classification scheme was used to classify all marshes. The United States Geological Survey – National Park Service (USGS-NPS) Vegetation Mapping Program was chosen as a consistent and documented classification system (Hop et al. 2001) for the study. This complete land-classification system categorized vegetation within a hierarchy of vegetation communities, ecological groups, and subgroups, thereby allowing variable landscape scales to be analyzed. A partial spatial dataset for the Rainy Lake and Namakan Reservoir area was completed through the USGS-NPS Vegetation Mapping Program for the historical time series (1995-1997) and was appended to the final spatial database (geodatabase) that contained the suite of binational wetlands.

All coastal marsh habitat within the Rainy Lake and Namakan Reservoir area was mapped for two time periods: current (2008) and historical (1995-1997). Coastal marsh habitat representing nesting marsh bird and herptile habitat was mapped into three classes: meadow marsh, emergent marsh and rooted and floating aquatic marsh.

The historical period (1995-1997) occurred during a previous water-level management scheme that was changed in 2000 to reflect more natural water-level fluctuations. Twenty-year hydrographs (1993-2012) for Rainy and Namakan lakes are included in Appendix 1.

Tasks within the scope of work included:

1. Orthorectifying the 1995 Forest Resource Inventory (FRI) black and white air photos for the Rainy Lake and Namakan Reservoir area. All photos were scanned at 600 dots per inch (DPI) to produce a rectified cell size of 1.0 metre and root mean square (RMS) of less than 2.5 metres.

2. Identifying all marsh habitat within the Rainy Lake and Namakan Reservoir area that is hydrologically influenced by water-level regulation using:

   - FRI and True Colour orthophotography (2008);
   - Colour Infrared Rectified Digital Photos (1995-1997); and
   - USGS-NPS Vegetation Mapping Project Ecological Subgroup class description excerpt.

3. Classifying each coastal marsh polygon in the habitat mapping product to one of three Ecological Subgroups: meadow marsh, emergent marsh, and rooted and floating aquatic marsh.

4. Compiling land-classification summaries at both the Ecological group and subgroup level. Completing statistical analyses using a non-parametric Wilcoxon matched-pairs test for two dependent samples for four landscape analyses:

   - Area by Ecological group;
   - Area by Ecological subgroup;
   - Area to perimeter ratio for Ecological group; and
   - Area to perimeter ratio for Ecological subgroup.

5. Writing a final project report that describes the statistical analyses and methodology used in the data audit. Describing data creation steps (spatial and attribute) and discussing known or plausible limitations and/or information gaps in the final product.

6. Completing a metadata report (Federal Geographic Data Committee compliant) for all new/updated geospatial information.

GIS Methodology

Data Set Creation

i. A series of 1:20000 Forest Resource Inventory (1995) black and white air photos was scanned at 600dpi and orthorectified with a 1.0m ground pixel size. The aerial photograph block was triangulated to develop the image orientation parameters using PCI or DVP software. The parameters included angles during flight and the location of the aircraft during flight. Digital Ontario Base Maps were used to control the aerial photographs at a scale of 1:20000. Both horizontal and vertical ground control were selected from these maps. The Provincial Digital Elevation Model was used as a base for the ground terrain to orthorectify the aerial photography. The final imagery was created in digital files in a .tiff format with .tfw files for positioning within a GIS.

ii. A new project workspace was created. All spatial data sources used in the final product were imported into the workspace. All data were confirmed to have a compatible spatial reference. All data sources were overlaid into a new GIS project. Two new empty Coastal Wetland coverages were created in NAD 83, UTM Zone 15. The first coverage is called 2008 Coastal Wetlands, and the second is called 1995 and 1997 Coastal Wetlands. This is to be the final product when complete. Attributes were defined in the polygon attribute table.

iii. All coastal wetlands were digitized and classified through air photo interpretation, using the USGS-NPS Vegetation Mapping Project Ecological Subgroup Classification System. The coastal marsh types were digitized using heads-up photo interpretation using ArcMap 10. The wetlands were classified into three distinct ecological subgroups by time series: Meadow Marsh, Emergent Marsh, and Rooted and Floating Aquatic Marsh.

iv. A topology was created for the database in ArcEditor. The default cluster tolerance was used. All associated feature classes were incorporated into the topology. A simple set of topology rules was applied that includes: "must not have gaps" and "must not have overlaps." Since the coastal wetland data set is not a continuous coverage, many of the indicated topology errors classified as gaps are actually not errors and are marked as exceptions since there are gaps between individual coastal wetland polygons. A text file was created to document these exceptions. Gaps within polygons and polygon overlaps were corrected using the Error Inspector in ArcEditor to create a clean topology.

v. The metadata content was created using ArcCatalog in ArcEditor 9.3 and is FGDC compliant.

Data Audit

i. The data set was audited at the 30, 60, and 100 percent complete stages during the data-capture process. The audit generated a random sub-sample of 20 percent of the polygon features created. Each polygon was reviewed for two criteria: correct coastal marsh typing and correct coastal marsh boundary delineation. Correction suggestions were recorded where necessary. Audited polygons were recorded on an Excel spreadsheet for future corrections.

ii. Any errors identified in the audit were reviewed by both the auditor and the digitizer, and appropriate corrections were made to the dataset using the audit log created in Microsoft Excel.

Digitizing

i. Each wetland was classified using air photo interpretation. Since the entire data set was not developed using the same type of imagery for the spatial and temporal extent of the project, inherent inaccuracies may have been adopted into the data set, as each type of imagery possesses its own strengths and weaknesses for photointerpretation of wetland communities. The imagery used for the data set includes eFRI (2008), True Colour Orthophotography (2008), Colour Infrared Rectified Photos (1995-1997, 2008) and Black and White Forest Resource Inventory Air Photos (1995).

ii. The 1995-1997 time series data for the U.S. portion of the Rainy Lake and Namakan Reservoir area was provided by the USGS-NPS. The classification methodology used differed slightly since, in some cases, it also included ground-truthing of individual wetland communities that may introduce an accuracy issue into the data set. It also appears that a significant number of wetlands were included as coastal wetlands that clearly are not impacted by regulated water levels since they are upstream from significant beaver dam structures.

iii. The 1995-1997 time series data for the U.S. portion of the Rainy Lake and Namakan Reservoir area that was provided by the USGS-NPS appears to have been digitized at a much coarser level of precision, which may also introduce an accuracy issue into the data set and, in some cases, seemed to have registration issues where wetland boundaries appeared to be shifted.

iv. The scanned images of the Black and White Forest Resource Inventory Air Photos (1995) provided by the Archives of Ontario were scanned at a resolution of 600dpi producing a rectified cell size of 1.0m. This imagery was used primarily for the historical time series (1995-1997) for the Canadian portion of the Rainy Lake and Namakan Reservoir area. The lower quality imagery for this area may create an accuracy issue.

v. The USGS-NPS Vegetation Mapping Project Ecological Subgroup Classification System provided was designed for specific imagery types. Portions of the data set were developed using imagery other than that prescribed in the classification system.

vi. There was evidence in many areas that the wetland communities were in transition in the current time series (2008) due to the change in water levels. In many cases, the communities in transition did not fit the criteria of any of the three marsh types precisely and were often in stages between marsh types (i.e., flooded wet meadows transitioning to rooted and floating aquatic marsh).

vii. Wetland communities were digitized only if they were greater than 0.25ha in area.

viii. Differences in coastal wetland interpretation during the digitizing process can have significant impact on the statistical analyses performed. A coastal wetland can be affected by changing water levels, but upstream from the coast, there is a point where there is no longer a lake-level influence. Beaver dams also affect the nature of lake-level influence.

ix. CONCEPTUAL CONSTRAINTS- Any subjectivity in the USGS-NPS Vegetation Mapping Project Ecological Subgroup classifications is not accounted for. The assumption is that the historic time series (1995/1997) for the U.S. portion was developed in the same manner as those undertaken in this project.

x. DIGITIZING CONSTRAINTS- There are inherent limitations in using various types of aerial photography, imagery, scanning resolution, RMS error in orthorectification process, as well as hardware and software limitations.

Data Analyses

i. Once the photo interpretation was completed, copies of the 2008 and 1995-1997 feature classes (layers) were made within the geodatabase to be used for the spatial analysis process. These analysis feature classes were clipped using an air photo extent feature class to ensure a common study extent was used in the analysis. This process ensures that any wetland on the edge of the air photo coverage without a corresponding wetland from the other year's coverage was the result of inconsistent air photo coverage between years. Therefore, all of these isolated wetlands on the edge of photo coverage were eliminated from the analysis.

ii. Visual inspection of the two features classes revealed that the historical (1995-1997) coverage provided (USWetlandsSelected.dbl) delineated wetlands well beyond physical barriers that would eliminate any coastal influences such as beaver dams. Therefore, the historical analysis feature class was trimmed at beaver dams and other detected physical barriers (i.e., upland area) to match the 2008 coverage, which consisted entirely of coastal wetlands. The historic coverage mapping and thematic accuracy was assumed to be equal in accuracy to that of the recent (2008) feature class.

iii. A union layer of the two analysis feature classes was completed (FinalUnion.shp); wetland 'shell' was also created for each physically separate wetland complex (FinalShell.shp). A union was then performed using the two feature classes (FinalUnion and FinalShell) to create the analysis layer (finalunionwithshell2.shp). The 1995-1997 and 2008 marshes within each shell were matched to create analysis pairs by ecological subgroup (i.e., meadow marsh, rooted and floating aquatic marsh, and emergent marsh). Total marsh area from each shell was also paired for analysis.

iv. Data analysis consisted of land classification summaries comparing 1995-1997 to 2008 wetlands at both the ecological group (marsh) and subgroup level for each of six watersheds; a non-parametric Wilcoxon Matched Pairs Test was completed comparing two dependant samples for:

- Area by ecological group for each lake;
- Area by ecological subgroup for each lake;
- Area to perimeter ratio for ecological group;
- Area to perimeter ratio for ecological subgroup.

GIS Results

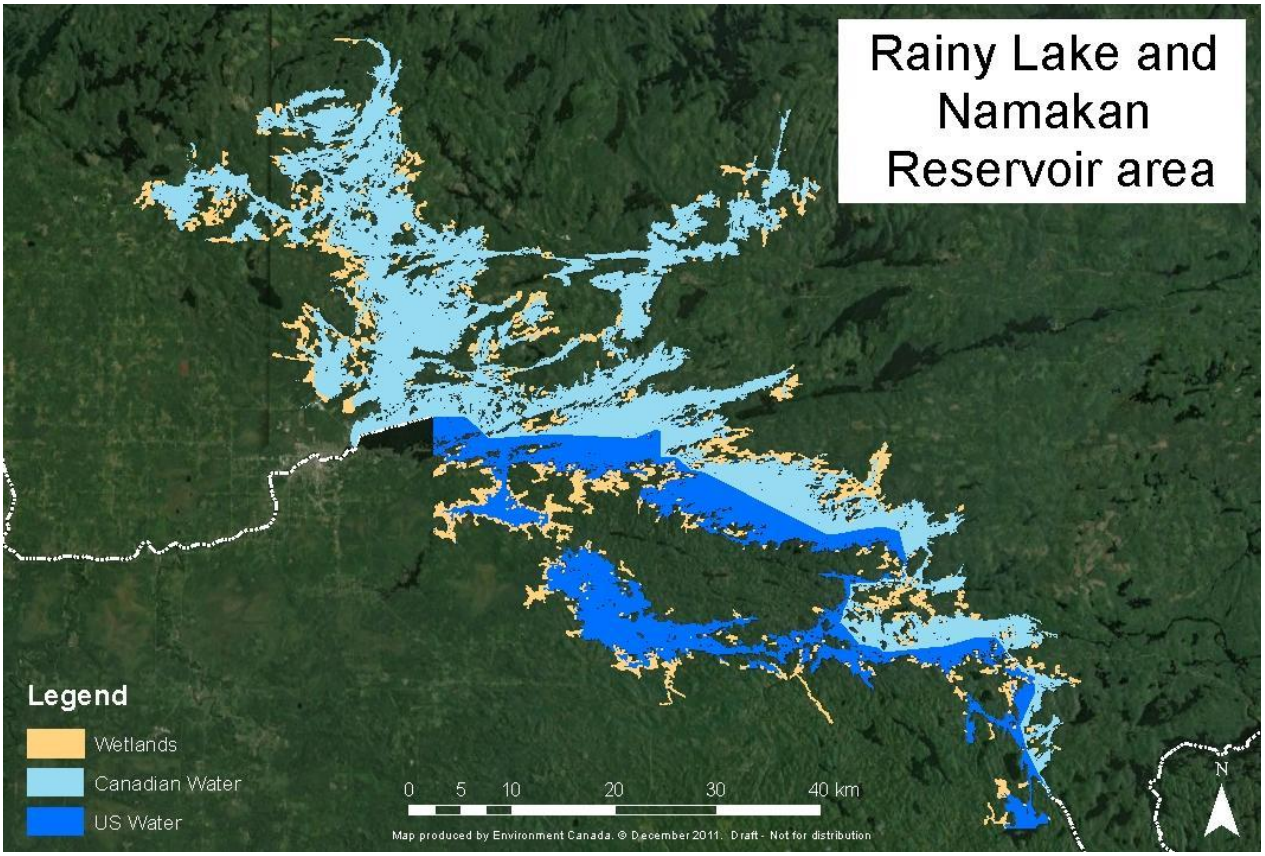

Figure 1. The study area showing location and recent wetland extent in the Rainy Lake and Namakan Reservoir area.

Notable results from the wetland GIS analysis in the Rainy Lake and Namakan Reservoir area (Figure 1) are summarized below, and Table 1 shows the comparison between pre- and post-2000 rule curve change in marsh attributes.

- No increases were observed in areal extent of all marsh types between the two time series in all lakes.
- Overall, there was a 21% decrease in marsh area in the reservoir lakes and 24% decrease in marsh area in Rainy Lake.
- Decreases in areal extent were most apparent in meadow marsh types – particularly in Namakan Lake where almost half of the meadow marsh was lost.
- More than half the meadow marsh in Crane Lake was lost – although the absolute amounts are relatively low.
- Emergent marsh losses were most apparent in Crane and Kabetogama lakes.
- Namakan Lake supported the largest extent of rooted and floating aquatic plant communities. The areal extent of this community remained stable between time series. However, all other reservoir lakes showed decreases rooted and floating aquatic plant communities – in particular Kabetogama.

Table 1. Comparisons of marsh extent attributes in the Rainy Lake and Namakan Reservoir area between pre- and post- 2000 rule curve change time series (1995-1997 and 2008, repectively). Rows in bold represent significant changes ($p<0.05$) using Wilcoxon matched pair tests.

Attribute	Pre 2000 rule curve	Post 2000 rule curve	Percent Change
Rainy Lake			
Total Marsh Area (ha)	**7,274.91**	**5,543.66**	**-24**
Total Marsh Perimeter (m)	2,773,384.22	2,725,587.75	-2
Area:Perimeter Ratio	26.23	20.34	-22
Total Meadow Marsh Area (ha)	**1,580.28**	**994.26**	**-37**
Total Meadow Marsh Perimeter (m)	661,705.07	546,460.38	-17
Meadow Marsh Area:Perimeter Ratio	**23.88**	**18.19**	**-24**
Total Emergent Marshes Area (ha)	**2,521.38**	**1,980.32**	**-21**
Total Emergent Marshes Perimeter (m)	1,133,093.92	1,069,736.55	-6
Emergent Marshes Area:Perimeter Ratio	**22.25**	**18.51**	**-17**
Total Rooted and Floating Area (ha)	3,173.26	2,569.08	-19
Total Rooted and Floating Perimeter (m)	978,585.23	1,109,390.83	13
Rooted and Floating Area:Perimeter Ratio	32.43	23.16	-29
Namakan Lake			
Total Marsh Area (ha)	545.85	483.93	-11
Total Marsh Perimeter (m)	236,301.93	233,386.15	-1
Area:Perimeter Ratio	23.10	20.74	-10
Total Meadow Marsh Area (ha)	**109.57**	**56.71**	**-48**
Total Meadow Marsh Perimeter (m)	54,938.28	36,192.17	-34
Meadow Marsh Area:Perimeter Ratio	**19.94**	**15.67**	**-21**
Total Emergent Marshes Area (ha)	123.50	115.25	-7
Total Emergent Marshes Perimeter (m)	61,968.42	74,936.89	21
Emergent Marshes Area:Perimeter Ratio	19.93	15.38	-23
Total Rooted and Floating Area (ha)	312.78	311.97	0
Total Rooted and Floating Perimeter (m)	119,395.23	122,257.09	2
Rooted and Floating Area:Perimeter Ratio	26.20	25.52	-3

Attribute	Pre 2000 rule curve	Post 2000 rule curve	Percent Change
Kabetogama Lake			
Total Marsh Area (ha)	**688.85**	**540.32**	**-22**
Total Marsh Perimeter (m)	292,295.88	226,965.97	-22
Area:Perimeter Ratio	23.57	23.81	1
Total Meadow Marsh Area (ha)	252.57	241.56	-4
Total Meadow Marsh Perimeter (m)	86,281.01	64,132.79	-26
Meadow Marsh Area:Perimeter Ratio	**29.27**	**37.67**	**29**
Total Emergent Marshes Area (ha)	**325.90**	**224.61**	**-31**
Total Emergent Marshes Perimeter (m)	161,175.75	128,485.07	-20
Emergent Marshes Area:Perimeter Ratio	**20.22**	**17.48**	**-14**
Total Rooted and Floating Area (ha)	110.38	74.15	-33
Total Rooted and Floating Perimeter (m)	44,839.13	34,348.11	-23
Rooted and Floating Area:Perimeter Ratio	24.62	21.59	-12
Sand Point Lake			
Total Marsh Area (ha)	331.22	275.24	-17
Total Marsh Perimeter (m)	127,869.02	124,771.00	-2
Area:Perimeter Ratio	25.90	22.06	-15
Total Meadow Marsh Area (ha)	**56.97**	**36.35**	**-36**
Total Meadow Marsh Perimeter (m)	25,108.07	20,627.84	-18
Meadow Marsh Area:Perimeter Ratio	**22.69**	**17.62**	**-22**
Total Emergent Marshes Area (ha)	82.91	78.37	-5
Total Emergent Marshes Perimeter (m)	41,050.74	37,217.30	-9
Emergent Marshes Area:Perimeter Ratio	20.20	21.06	4
Total Rooted and Floating Area (ha)	**191.35**	**160.52**	**-16**
Total Rooted and Floating Perimeter (m)	61,710.21	66,925.86	8
Rooted and Floating Area:Perimeter Ratio	31.01	23.98	-23
Crane Lake			
Total Marsh Area (ha)	**156.64**	**64.95**	**-59**
Total Marsh Perimeter (m)	67,083.66	41,351.71	-38
Area:Perimeter Ratio	23.35	15.71	-33
Total Meadow Marsh Area (ha)	**38.81**	**15.95**	**-59**
Total Meadow Marsh Perimeter (m)	18,911.49	9,896.44	-48
Meadow Marsh Area:Perimeter Ratio	**20.52**	**16.12**	**-21**

Attribute	Pre 2000 rule curve	Post 2000 rule curve	Percent Change
Total Emergent Marshes Area (ha)	**86.40**	**28.89**	**-67**
Total Emergent Marshes Perimeter (m)	32,246.72	16,806.99	-48
Emergent Marshes Area:Perimeter Ratio	26.79	17.19	-36
Total Rooted and Floating Area (ha)	32.27	20.11	-38
Total Rooted and Floating Perimeter (m)	16,777.39	14,648.28	-13
Rooted and Floating Area:Perimeter Ratio	19.24	13.73	-29
Little Vermilion Lake			
Total Marsh Area (ha)	35.94	28.72	-20
Total Marsh Perimeter (m)	9,681.78	10,140.77	5
Area:Perimeter Ratio	37.12	28.32	-24
Total Meadow Marsh Area (ha)	0.88	0.00	-100
Total Meadow Marsh Perimeter (m)	426.47	0.00	-100
Meadow Marsh Area:Perimeter Ratio	20.66	0.00	-100
Total Emergent Marshes Area (ha)	9.10	5.06	-44
Total Emergent Marshes Perimeter (m)	3,680.36	4,360.42	18
Emergent Marshes Area:Perimeter Ratio	24.74	11.61	-53
Total Rooted and Floating Area (ha)	25.95	23.65	-9
Total Rooted and Floating Perimeter (m)	5,574.95	5,780.35	4
Rooted and Floating Area:Perimeter Ratio	46.55	40.92	-12
Reservoir lakes total*			
Total Marsh Area (ha)	1,758.50	1,393.16	-21
Total Marsh Perimeter (m)	733,232.28	636,615.60	-13
Area:Perimeter Ratio	23.98	21.88	-9
Total Meadow Marsh Area (ha)	458.80	350.57	-24
Total Meadow Marsh Perimeter (m)	185,665.31	130,849.24	-30
Meadow Marsh Area:Perimeter Ratio	24.71	26.79	8
Total Emergent Marshes Area (ha)	627.81	452.18	-28
Total Emergent Marshes Perimeter (m)	300,122.00	261,806.68	-13
Emergent Marshes Area:Perimeter Ratio	20.92	17.27	-17
Total Rooted and Floating Area (ha)	672.73	590.40	-12
Total Rooted and Floating Perimeter (m)	248,296.90	243,959.68	-2
Rooted and Floating Area:Perimeter Ratio	27.09	24.20	-11

*** Wilcoxon matched pairs tests not completed for Reservoir lakes total.**

Bird Survey Methodology

Breeding bird communities were surveyed using a modified Marsh Monitoring Program protocol (Meyer et al. 2006) at 21 sites throughout the Rainy Lake and Namakan Reservoir area (Figure 2). Sites for this study were not chosen randomly throughout the study area, as a random selection of sites would have included many secluded and poorly accessible sites, which would have increased the surveying effort and cost per site. Since relatively few marsh bird surveys have been conducted through the Rainy Lake and Namakan Reservoir area, the number of sites that could be surveyed through a fixed budget was maximized. Sites were chosen throughout the study area that represented a range in size and were relatively easy for surveyors to access.

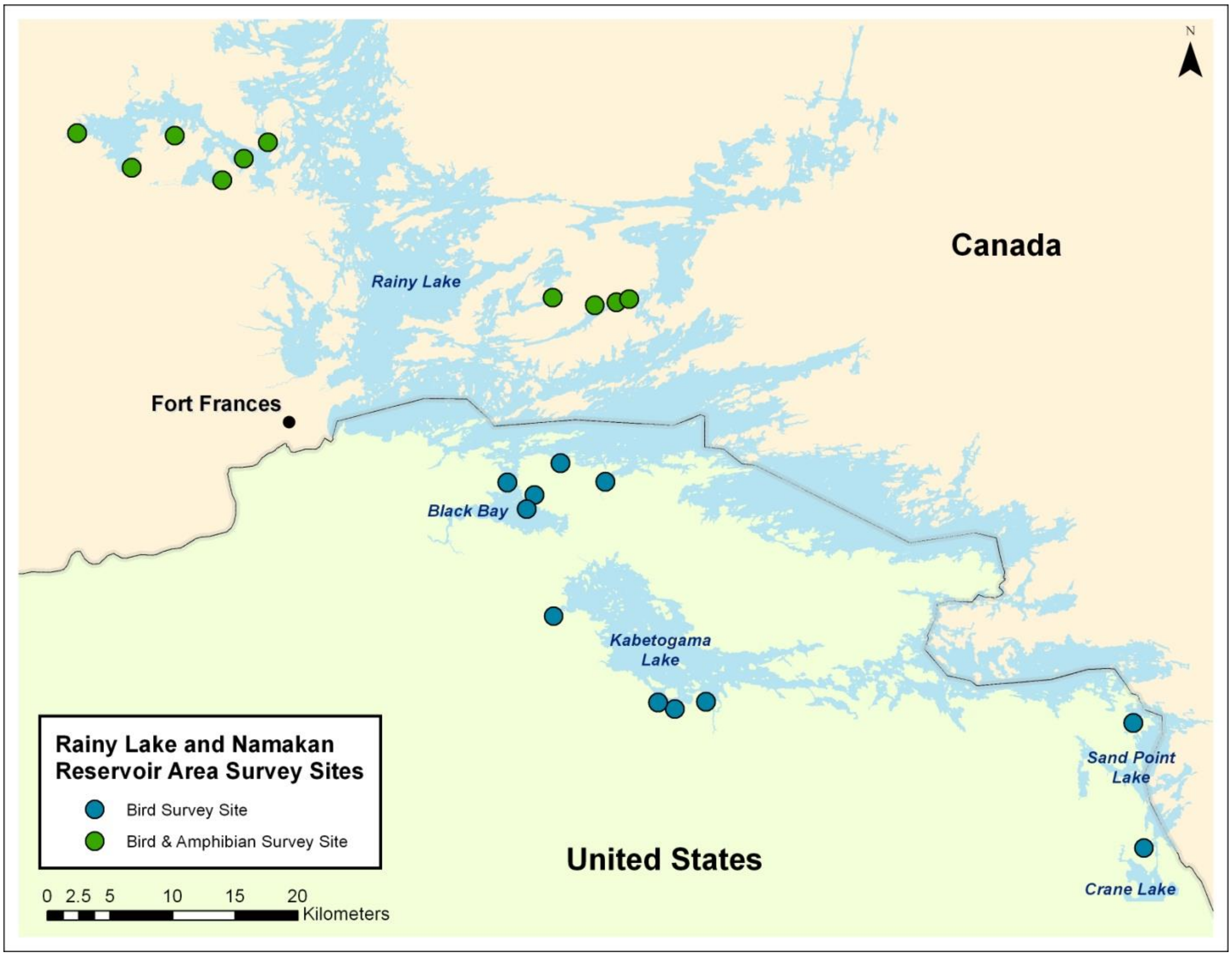

Figure 2. Locations of 2012 Rainy Lake and Namakan Reservoir area breeding marsh bird and amphibian community survey sites.

Each site contained as few as one or as many as nine bird survey stations. Survey stations within sites were established using aerial photographs and set up at least 250 m apart, and only those that had at least 50% of marsh habitat (i.e., non-woody emergent plants) within the sampling radius (100 m) were surveyed. At each station within a site, the survey consisted of a 15-minute point count in which all birds using the wetland within the semicircular sampling radius were documented. Incidental observations outside the sampling radius or survey period were also noted.

Each 15-minute survey period consisted of a five-minute silent passive period, a six-minute call-broadcast period (one minute each of Yellow Rail, Least Bittern, Sora, Virginia Rail, American Coot, and Pied-billed Grebe), and finished with a four-minute silent passive period.

Each survey site/station was surveyed three times over the course of the breeding bird season, from June 2nd to July 18th inclusive, with surveys at a given site/station at least ten days apart.

Bird Survey Results

A total of 77 species were detected during the 2012 Rainy Lake and Namakan Reservoir area marsh bird surveys, with 50 of those detected inside the sampling radius and within the 15-minute survey period (Appendix 2).

Bird Species of Interest

The following species are obligate marsh-nesting species, and were observed during this study. Species that require large amounts of high quality habitat for nesting (i.e., area-sensitive species) are listed in italics; species at risk (Canadian Species at Risk Act) are denoted with an asterisk.

Red-necked Grebe

Red-necked Grebes were observed at three U.S. sites, with breeding evidence (i.e., young) documented at two. Red-necked Grebes nest on freshwater lakes and bays, preferring marshy sites with some emergent vegetation (Peck and James 1983, Stout and Nuechterlein 1999). Foraging often occurs in marshy areas (Stout and Nuechterlein 1999). Significant water-level fluctuations can have a detrimental effect on this species. Decreases can limit access to nests, and increases levels can cause flooding (Sandilands 2005).

Pied-billed Grebe

Pied-billed Grebes were documented on the U.S. side of the study area only, at the Black Bay, Kabetogama Lake, and Cranberry Bay (Rainy Lake) sites. This species breeds in marshy areas (Peck and James 1983) and forages among rooted aquatic plants and emergent vegetation (Muller and Storer 1999). Timmermans et al. (2008) reported that Pied-billed Grebe abundance was positively correlated with Lake Erie-Huron-Michigan water levels, which can vary greatly. Sandilands (2005) noted that low water levels may expose the nest to predation.

Black Tern

Black Terns were observed at only one site: Tom Cod Bay on Kabetogama Lake. Observations of agitated birds suggest breeding near the survey station. This species prefers to breed in marshes of large wetland complexes (Peck and James 1983, Heath et al. 2009) and would be affected by the loss of wetland extent in the Rainy Lake and Namakan Reservoir area. Nest site suitability depends more on emergent vegetation availability and density than it does on water depth (Heath et al. 2009), but in the Lake Ontario – St. Lawrence River hydrosystem, DesGranges et al. (2006) found that populations were reduced when there were rapid or moderate increases in water levels at a site.

Ring-necked Duck

Ring-necked Ducks were observed throughout the study area, including apparent breeding pairs at some sites. Ring-necked Ducks breed in marsh and meadow marsh habitats (Peck and James 1983) and usually forage among flooded emergent vegetation (Roy et al. 2012). Within-season water-level fluctuations may affect breeding populations, as declining levels make nests vulnerable to predation, reduce emergent cover, and make travel to and from the nest more difficult for the female (Sandilands 2005). This species responds to flooding events by increasing the height of an existing nest and is therefore vulnerable to nest flooding only when levels rise quickly (Sandilands 2005).

Trumpeter Swan

Trumpeter Swans were observed at three locations on the western side of Rainy Lake, with some evidence of breeding (pairs). These birds, observed on the Canadian side, may be the result of the Trumpeter Swan restoration project in Minnesota.

American Bittern

American Bitterns were observed throughout most of the study area, with observations absent only from the southeast (i.e., Crane and Sand Point Lakes). This species nests and forages in marshes in lakes and pond edges and is usually associated with larger marshes (Sandilands 2005). In the Lake Ontario – St. Lawrence River hydrosystem, DesGranges et al. (2006) found that American Bittern populations were reduced when there were rapid or moderate increases in water levels at a site.

Least Bittern*

The Rainy Lake and Namakan Reservoir area is at the northern edge of the Least Bittern's range, and the prevalence of this species here is not well-understood. Despite a lack of records for this species in the Rainy Lake and Namakan Reservoir area, it was suspected that this secretive bird may have just gone undetected without targeted surveys. In an effort to elicit a response from potential individuals present in the area, a Least Bittern call broadcast was included in the playback sequence in each survey of this study. As a result, observations were documented at three wetlands (Northwest, Moran's, and Dove bays of Rainy Lake), and an additional incidental observation was made at one other location (also on Rainy Lake, northwest of Turkey Island). Subsequent marsh bird studies in the area should consider targeting this species with call broadcasts to better understand its distribution and abundance in the Rainy Lake and Namakan Reservoir area.

Least Bitterns breed and forage in dense emergent marshes (Sandilands 2005). Timmermans et al. (2008) reported that Least Bittern abundance was positively correlated with variable Lake Erie-Huron-Michigan water levels.

Virginia Rail
Virginia Rails were documented at six sites throughout the study area. This species nests in dense marsh vegetation of lakes, ponds, and rivers (Peck and James 1983) and will also use damp meadows (Sandilands 2005). In the Lake Ontario – St. Lawrence River hydrosystem, DesGranges et al. (2006) found that breeding pair occurrence of Virginia Rails was reduced when there were moderate decreases in water levels at a site. Timmermans et al. (2008) found that Virginia Rail abundance was positively correlated with annual water-level fluctuations on Lake Ontario. Sandilands (2005) stated that "water-level fluctuations during the breeding season are detrimental, with declines in water levels being more serious." This species is able to adapt to increased water levels by building higher nests, but rapid increases will result in flooding and abandonment. Decreases reduce available habitat and make nests prone to predation (Sandilands 2005).

Sora
This species was observed in three wetlands, on both Rainy Lake and Kabetogama Lake. Soras breed in marshes with emergent vegetation and shallow water and rarely in damp meadows (Peck and James 1983, Sandilands 2005). Although Soras prefer wetlands with unstable water levels, rapid increases may flood nests, and decreases may reduce hatching success and prevent renesting (Sandilands 2005).

Yellow Rail*
Three observations of Yellow Rail were documented in three separate wetlands, with each observation occurring on the first visit (first week of June). The observer was of the opinion that it was a fairly dry spring in the Rainy Lake and Namakan Reservoir area, and that there are typically more Yellow Rails present in wet years. This species nests in freshwater marshes and wet sedge meadows and tends to avoid completely dry or deepwater areas (Peck and James 1983, Bookhout 1995, Sandilands 2005). Bookhout (1995) stated that "manipulation of water levels on refuges to benefit migratory waterfowl could adversely affect Yellow Rails if management objective is to provide hemi-marshes or deep-water marshes."

Marsh Wren
Marsh Wrens were observed at most study sites (15 of 21, including one site with only two incidental observations). As its name suggests, this species breeds in marshes and marshy edges of lakes and rivers (Peck and James 1987),but also relies on marshes for foraging (Kroodsma and Verner 1997). In the Lake Ontario – St. Lawrence River hydrosystem, DesGranges et al. (2006) found that Marsh Wren populations were reduced when there were rapid or moderate increases in water levels at a site, and Timmermans et al. (2008) reported that abundance was positively correlated with variable Lake Erie-Huron-Michigan water levels.

Swamp Sparrow
Swamp Sparrow was the most abundant marsh-nesting obligate observed over the course of the study and was observed at all study sites. This species will use marshes and meadows consisting of sedges, grasses, or cattails for nesting (Peck and James 1987, Mowbray 1997) and will forage almost exclusively over standing water or a wet substrate (Mowbray 1997).

Yellow-headed Blackbird

Yellow-headed Blackbirds were documented outside the sampling radius at two locations on Kabetogama Lake (Daley Bay and Irwin Bay). This typically colonial species breeds in marshes of lakes and rivers (Peck and James 1987). Most of the Ontario population of this species occurs west of the study area, near Lake of the Woods.

Amphibian Survey Methodology

Breeding frog (anuran) communities were surveyed using the Marsh Monitoring Program protocol at the 10 breeding bird survey sites on the Canadian side of the Rainy Lake and Namakan Reservoir area (Figure 2).

Each site consisted of as few as one or as many as six amphibian survey stations. At each station within a site, the survey consisted of a three-minute point count, in which all vocalizing anurans were documented. For each detection, the intensity of calling activity was estimated on a three-level scale: code 1 - *individuals can be counted, calls not simultaneous*; code 2 - *calls distinguishable, some simultaneous calling*; and code 3 - *full chorus; calls continuous and overlapping* (Bird Studies Canada 2009). When possible (i.e., codes 1 and 2), the number of individuals was estimated. Observations within and outside a 100-m semicircular sampling radius were recorded.

Each survey site/station was surveyed three times over the course of the breeding season, from May 4th to June 25th inclusive, with surveys at a given site/station at least fifteen days apart.

Amphibian Survey Results

Seven frog species (Table 2) were documented during the 2012 Rainy Lake and Namakan Reservoir area amphibian surveys.

Table 2. The number of frog species detections during surveys, with national (United States; US and Canadian; CDN) and subnational conservation status ranks in Minnesota (MN) and Ontario (ON) See Appendix 3 for definition of ranks. Note that a “detection” may refer to a single individual or a chorus of many individuals.

Species	Scientific Name	US/CDN Rank	Rank MN	Rank ON	No. of Detections
Boreal Chorus Frog	*Pseudacris maculata*	N5/ N5	SNR	S5	6
Green Frog	*Lithobates clamitans*	N5/ N5	SNR	S5	135
Gray Treefrog	*Hyla versicolor*	N5/ N5	SNR	S5	99
Mink Frog	*Lithobates septentrionalis*	N5/ N5	SNR	S5	26
Northern Leopard Frog	*Lithobates pipiens*	N5/ N5	S4	S5	8
Spring Peeper	*Pseudacris crucifer*	N5/ N5	SNR	S5	98
Wood Frog	*Lithobates sylvaticus*	N5/ N5	SNR	S5	3

Amphibian Species of Interest

Boreal Chorus Frog

Boreal Chorus Frogs were detected six times at three sites. This species breeds in marshes and vernal pools, and eggs are often laid in temporary ponds (NatureServe 2013).

Green Frog

Although the study area is close to the northwestern extent of its range, the Green Frog was detected at all ten sites. This species is something of a generalist and will use a variety of water sources for breeding.

Gray Treefrog

Gray Treefrogs were also detected at all ten sites. This species will breed in shallow marshes and other wetlands, as well as temporary ponds (NatureServe 2013).

Mink Frog

This species was detected at eight of the ten sites. Mink Frogs attach their eggs to submerged vegetation in cold lakes and ponds and are often found among emergent or floating vegetation (NatureServe 2013).

Northern Leopard Frog

Eight individuals of this species were documented at five sites. This species breeds in shallow permanent water but will also inhabit wet meadows and fields (NatureServe 2013).

Spring Peeper

Spring Peepers were found at all ten sites that were surveyed. This species typically breeds in temporary woodland ponds but will also use the sheltered margins of larger bodies of water (NatureServe 2013).

Wood Frog

Three individuals of this species were documented at two sites. Wood Frogs breed primarily in wooded habitats, including temporary and permanent pools and the edges of ponds (NatureServe 2013).

American Toad

American Toads were the only expected anuran that was not detected in the area, although the reason for this is unclear.

Discussion

This study compared the extent of marsh nesting bird and herptile habitat in the Rainy Lake and Namakan Reservoir area for periods occurring before and after the 2000 rule curve change. The study focused on marsh habitats that could be affected by changes in water-level regulation in the system. Wilcox and Meeker (1992) suggested that if natural water-level fluctuations were restored, a gradual drawdown of water levels in Rainy and Namakan lakes during the summer might encourage the growth of emergent vegetation over a wider area in normal years.

The 20-year hydrographs (1993-2012) for Rainy and Namakan lakes illustrate the variability in the lakes before and after the 2000 rule curve changes (Appendix 1) and that seasonal fluctuations are much greater in Namakan Lake than Rainy Lake. Meeker and Harris (2011) provide a review of features of the 2000 rule curves for Rainy and Namakan lakes in comparison to the 1970 rule curves. They note changes for Rainy Lake are minimal whereas for Namakan Lake lower elevations (339.0m to 340.0m) are not dewatered as frequently, if at all, and the shoreline zone (340.7m to 340.9m) which was formerly flooded throughout most of the growing season is now gradually dewatered through the growing season. It was expected that the small changes in the Rainy Lake hydroperiod would not result in a change in vegetation community extent while the more extensive hydroperiod alterations in Namakan Lake could have an appreciable positive influence on vegetation community extent.

In general, the 20-year hydrograph shows fairly similar annual within-lake hydrographs for Rainy and Namakan Lakes from 1993 to 1995 (and back to 1988; not shown in Appendix 1). The seasonal 1997 water levels at each lake are similar to the 1988 to 1995 period, but this year was flanked by a relatively high water level year in 1996 and an extreme low in 1998. Water levels returned to typical levels in the lakes for 1999 and 2000 and, following the 2000 rule curve change, there were record highs for the period in 2001 and 2002 followed by an extreme low in 2003. Water levels recovered and remained similar among years in each lake until 2012 with the exception of a relative high throughout the 2008 growing season.

Despite the 2000 Rule Curves being in place for more than seven years, there was no increase in coastal wetland emergent cover detected between the two time series in Rainy Lake or any of the reservoir lakes. A decrease in all coastal marsh types (meadow, emergent and rooted and floating submersed) was detected across all lakes through aerial photo interpretation. This finding was not expected and prompted further investigation into the hydrologic conditions during the aerial photo time series used. Water levels during the earlier time series (1995-1997) included periods of normal water levels with a spike in water levels in the growing season of 1996 while 2008 levels were relatively high. Water levels are known to drive emergent vegetation coverage (Keddy and Reznicek, 1986; Chow-Fraser et al. 1998) and affect the extent and species composition of meadow marsh zones (Wilcox et al. 2005; Wilcox et al. 2008). The response of wetland vegetation to water levels has a lag time that is influenced by several factors (e.g., substrate, wave exposure; Keddy and Reznicek, 1986), including antecedent hydrologic conditions. In addition, the observed decrease in emergent and rooted and floating submersed vegetation types in 2008 may be attributed to unusually high water during the 2008 period when the air photos were taken. The hydrographs for Rainy and Namakan lakes were within the rule curves, without any extreme highs or lows in 2004 through 2007. In 2008, from mid-May to mid-July, water levels throughout the Rainy Lake and Namakan Reservoir area were particularly high and exceeded the rule curves in Namakan and Rainy lakes. This period generally corresponds to a period of substantial growth for wetland emergent plants in temperate regions. Abnormally high mid-May to mid-July water levels may have curbed emergent and floating wetland plant community development and also precluded detection through air photo interpretation. Although this would affect the detection of emergent and rooted and floating submersed communities, it is expected that flooded meadow would be less affected and still easily detected. Because the 2008 imagery was from a growing season with relatively high water levels, additional insight regarding vegetation community extent could be gained by acquiring, interpreting, and analyzing additional post-2000 rule curve imagery from a period of normal water levels as well as a period of low water years. In addition, comparing changes with an unregulated system in a GIS (e.g., Lac St. Croix as a control site) would provide further insights that would also benefit additional analysis and modeling.

It is difficult to comment on or interpret the effect of the 1996 growing season water level spike on the wetland communities in Rainy and Namakan lakes in the context of the 1995-1997 time series. The spike was more pronounced in Rainy Lake and occurred after a period of relatively typical annual hydroperiods. A mosaic of images created the 1995-1997 coverage, and the specific year and area covered by each photo is not known. Further exploration of the image acquisition period for each area would require extensive examination of the photo coverage and is beyond the scope of the project.

It is less likely that higher elevation meadow marsh was impacted by high 2008 water levels than lower elevation emergent vegetation communities; however, an over-representation of meadow marsh may have been identified using the 1995-1997 coverage compared to the 2008 coverage. The 1995-1997 coverage was in black and white with relatively low resolution. During interpretation/mapping using this black and white coverage, it was difficult to detect shrubs in meadow marsh. This may have resulted in an over-estimation of meadow marsh being mapped in 1995-1997 because some areas with significant shrub thickets may have been classified as meadow marsh. While mapping using the colour FRI coverage for 2008, shrubs could clearly be seen in meadow marshes. Delineations would tend to be much more conservative (and accurate) in comparison to the 1995-1997 mapping.

Similarly, rooted and floating submersed marsh was easier to interpret and much more visible using the 2008 colour FRI coverage as opposed to the 1995-1997 black and white coverage. Therefore, it is possible that this marsh type was under-represented in the 1995-1997 black and white mapping. This does not support the detected loss of rooted and floating submersed coverage and suggests loss of this community type may have occurred more extensively than estimated.

This study augmented the existing USGS-NPS Vegetation Mapping Project coverage that accounted for much of the US portion of the project area. Although standard interpretation methods were used in both cases, consistent differences in digitizing and classification between the existing coverage and the augmented coverage, due to different personnel performing the interpretation, could have contributed to the observed decrease in wetland extent in the Rainy Lake and Namakan Reservoir area. Comparisons between the interpreters could be investigated, although this exercise was not part of this project. Other inaccuracies are described in the methods section under 'Digitizing', but they are not expected to bias the comparisons between time series.

It is important to address the suggestion that the decrease in coastal marsh habitat across the Rainy Lake and Namakan Reservoir area could be due to increased watershed-based disturbance throughout the area. Loss of habitat due to watershed-based disturbance is unlikely, as cursory observations of the upland coverage from the 2008 air photo series do not strongly support this.

Photointerpretation inaccuracies, GIS biases, and increasing human related disturbance may have played a relatively small role in the detected loss in wetland area. The most influential driver of marsh extent in the Rainy Lake and Namakan Reservoir area was expected to be water regulation. The results of this study demonstrate that extremes in water supply may influence marsh communities more than previously expected. From this study, it is not possible to determine the relative influence of regulation versus variability in water supply, so it is unclear what the effect of the 2000 rule curves has been on the on marsh vegetation communities throughout the Rainy Lake and Namakan Reservoir area. Meeker and Harris (2011) studied vegetation communities at various depths in Rainy and Namakan lakes and expected that any changes in vegetation communities would be more pronounced in Namakan Lake because the 2000 rule curves altered the hydrology of the Namakan Lake more than Rainy Lake. They suggest that any improvements to the submersed community in Namakan Lake would have started in about 1987-88 when the middle rather than the extremes of the 1970 rule curves were targeted by water-level regulators and the improvements occurred prior to 2002. As such, they found that there was little evidence that the submersed communities changed following the 2000 rule curve changes between 2002 and 2010. In our study, while all other marsh types appeared to decrease in areal extent in all lakes, we did find that there was no decrease in rooted and submersed vegetation types in Namakan Lake. This suggests the improvements to the submersed community identified by Meeker and Harris (2011) may have occurred before the 1995-1997 period and that the 2000 rule curves are not detrimental to the submersed community in Namakan Lake.

Additionally, Meeker and Harris (2011) observed of a 50% reduction in vegetation cover at the 1.25m below mean high water depth in Rainy Lake between 2002 and 2010. Although our study was much broader in scope (GIS vs. in situ quadrats), it provided support for this observation as we found a reduction of more than 600 hectares of submersed and floating vegetation (19% decrease) across Rainy Lake between 1995-1997 and 2008.

The 2012 bird and amphibian surveys provided valuable information on marsh-dependent wildlife in the Rainy Lake and Namakan Reservoir area. Although the survey locations were restricted by access to remote sites, this was most intense single-year binational marsh bird and amphibian community surveying effort in the area of which we are aware. There were no bouts of extreme water levels from 2009 through 2012 that would adversely affect the marsh bird and amphibian communities. We assume that the bird and amphibian taxa observed were fairly representative of the marshes surveyed. All frog species with known distributions in the area were present in the surveys, except American Toad which was not detected despite having a known distribution in the area. Rainy Lake and Namakan Reservoir area marshes are also important for numerous marsh-dependent bird species. A number of these species are sensitive to water levels as their nests are prone to flooding (e.g., Sora, Yellow Rail). One species of note is the Least Bittern, a species of conservation concern, which was thought to rarely nest in the area. Responses from this species during playback surveys suggest that they are more common than originally thought.

The presence of extensive floating macrophyte mats (e.g., cattail, common reed, and shoreline fens) in the Rainy Lake and Namakan Reservoir area was noted by Meeker and Harris (2011) and bird and amphibian community surveyors in 2012. The areal extent of these floating mats and their response to changing hydrology has not been studied. If these mats comprise a substantial proportion of the plant community, they may play a large role in the ecology of the system and should be further studied in the field and accounted for during modeling exercises.

Although the results of this study were inconclusive in determining the 2000 rule curve effect on marsh nesting bird and herptile habitat, the GIS, bird, and amphibian data from this study are valuable for future lake-level management and to investigators involved in habitat modeling for the Rainy Lake and Namakan Reservoir area under various water level-management scenarios.

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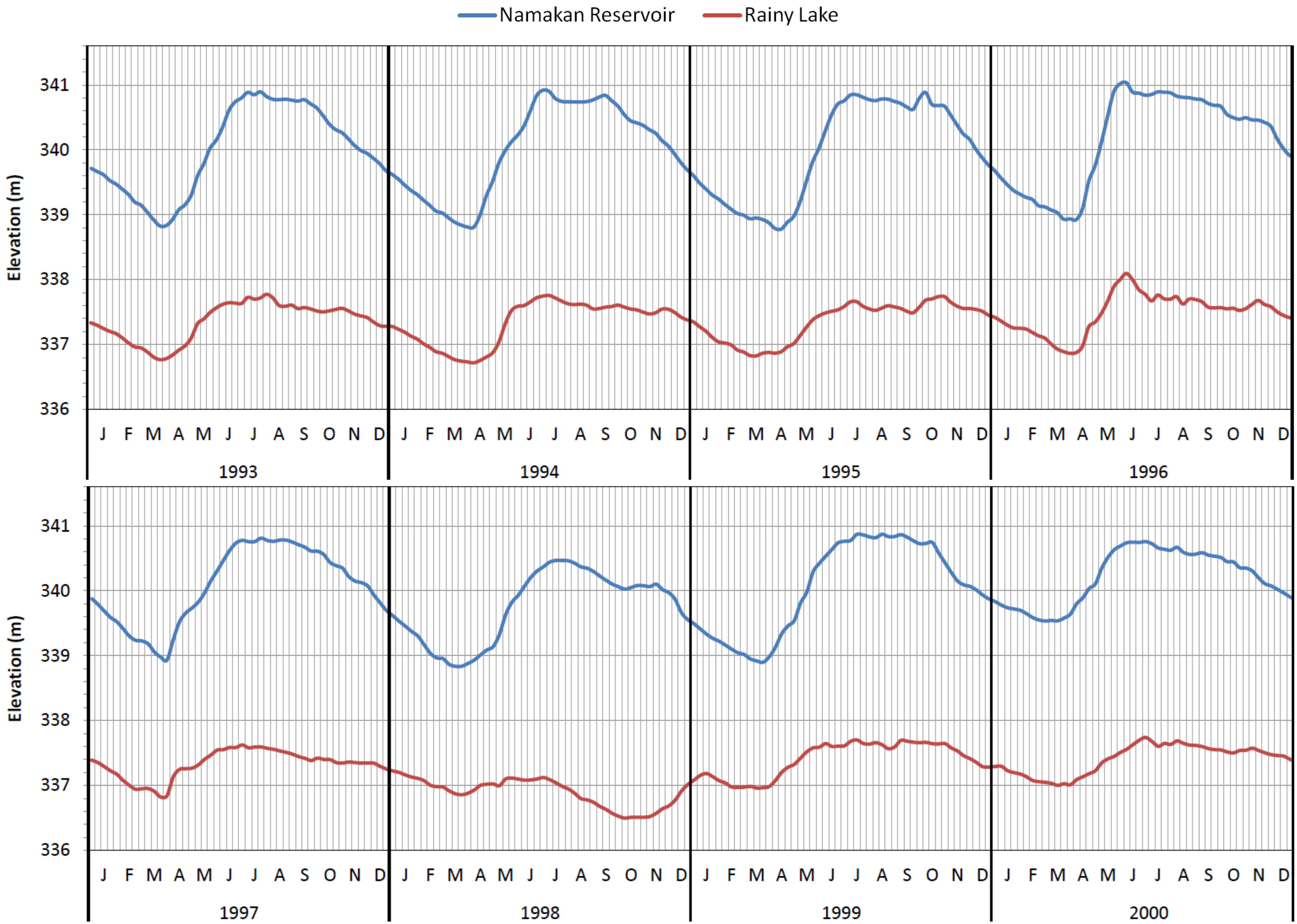
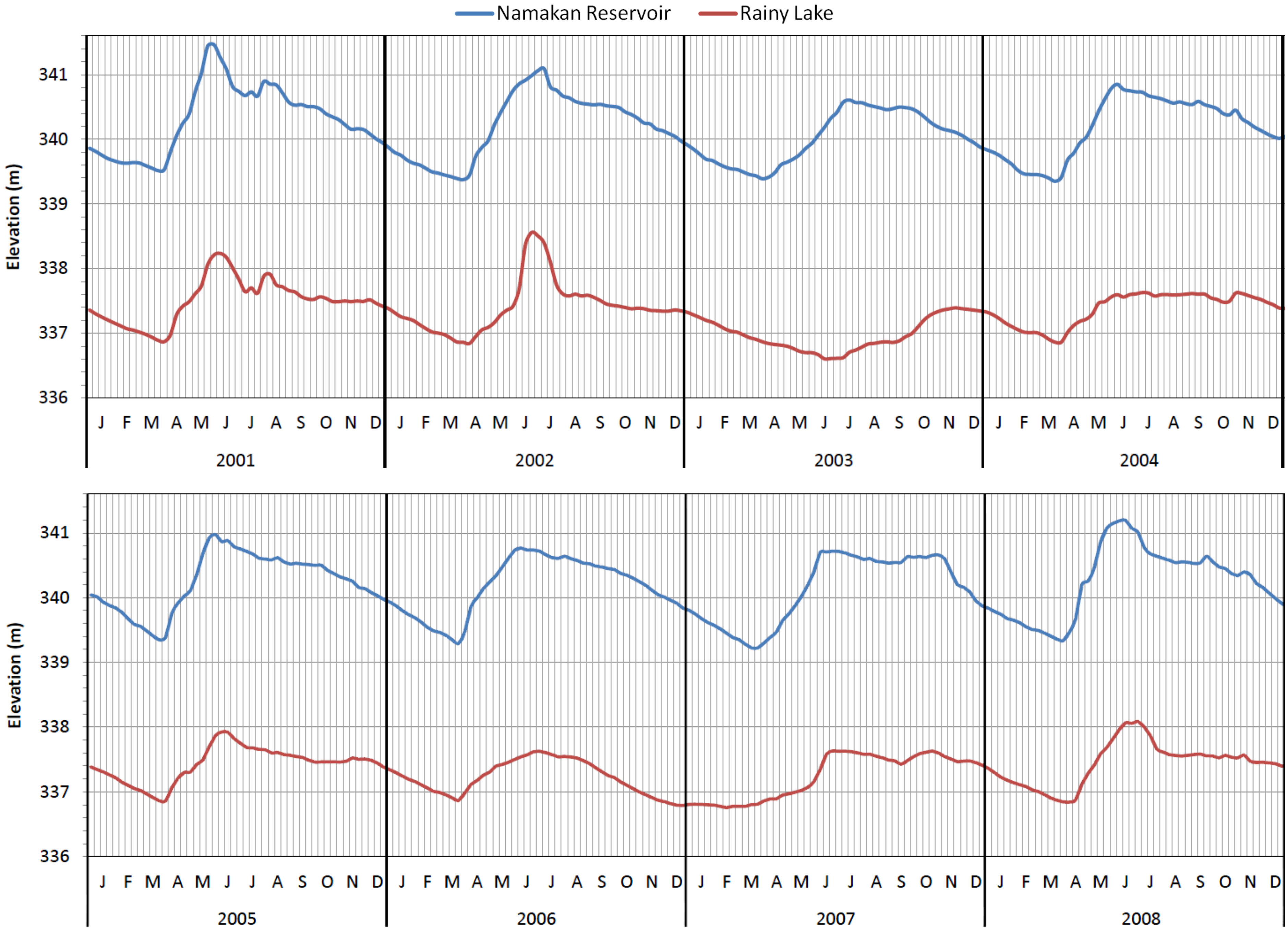
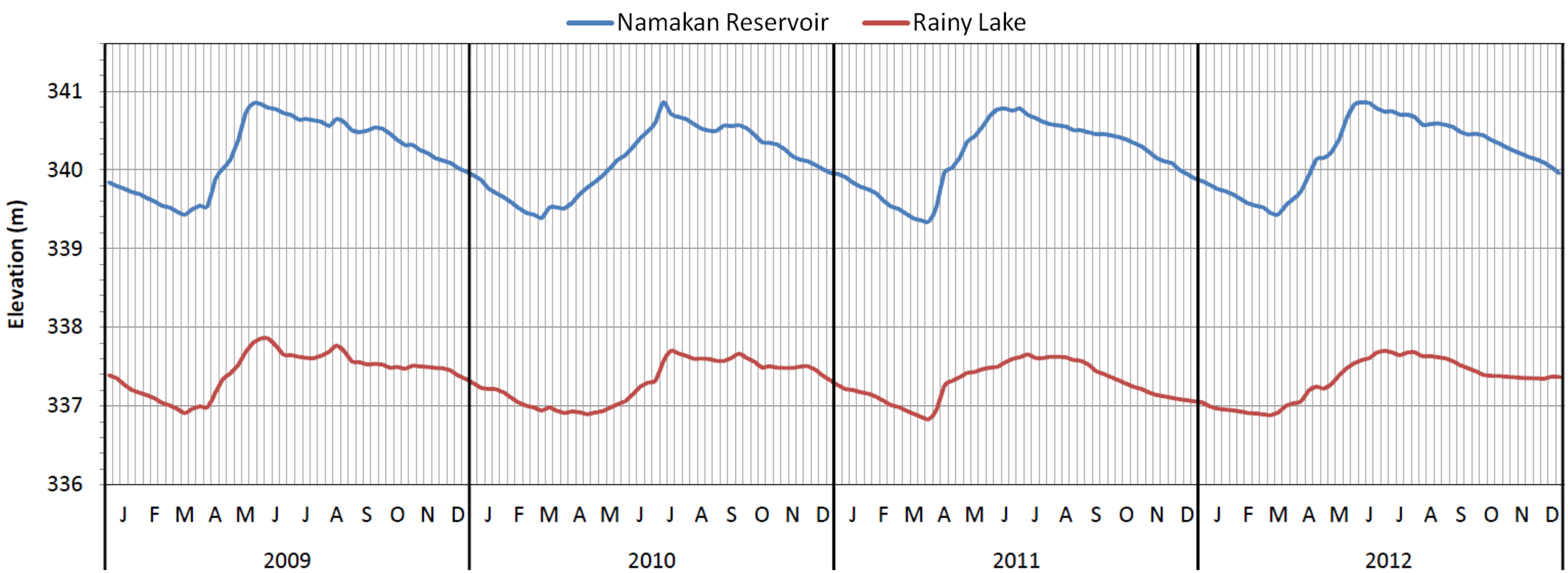
Appendix 1

Mean Weekly Water Levels for Rain Lake and Namakan Reservoir 1993-2012


Namakan Reservoir
Rainy Lake
Elevation (m)
341
340
339
338
337
336
J F M A M J J A S O N D
1993
1994
1995
1996
1997
1998
1999
2000


Namakan Reservoir
Rainy Lake
Elevation (m)
341
340
339
338
337
336
J F M A M J J A S O N D
2001
2002
2003
2004
2005
2006
2007
2008



Namakan Reservoir
Rainy Lake
Elevation (m)
341
340
339
338
337
336
J F M A M J J A S O N D
2009
2010
2011
2012

Appendix 2

Species documented during the 2012 Rainy Lake and Namakan Reservoir area bird surveys, with national and subnational conservation status ranks (Appendix 2, NatureServe 2013). Species observed inside the 100m sampling radius during the 15-minute survey periods are denoted with bold text.

Species	Scientific Name	US Rank	Canada Rank	Minnesota Rank	Ontario Rank
Alder Flycatcher	***Empidonax alnorum***	**N5B**	**N5B**	**SNRB**	**S5B**
American Bittern	***Botaurus lentiginosus***	**N4B,N4N**	**N5B,N3N**	**S4B**	**S4B**
American Black Duck	*Anas rubripes*	N5B,N5N	N5B,N5N	SNRB,SNRN	S4
American Crow	*Corvus brachyrhynchos*	N5B,N5N	N5B,N5N	SNR	S5B
American Redstart	***Setophaga ruticilla***	**N5B**	**N5B**	**SNRB**	**S5B**
American Robin	*Turdus migratorius*	*N5*	*N5B,N5N*	*SNRB,SNRN*	*S5B*
American White Pelican	***Pelecanus erythrorhynchos***	**N4**	**N3N4B**	**S3B**	**S2B**
Bald Eagle	***Haliaeetus leucocephalus***	**N5B,N5N**	**N5B,N5N**	**S3B,S3N**	**S2N,S4B**
Barn Swallow	***Hirundo rustica***	**N5B**	**N4N5B**	**SNRB**	**S4B**
Belted Kingfisher	***Megaceryle alcyon***	**N5B,N5N**	**N5B**	**SNRB,SNRN**	**S4B**
Black Tern	***Chlidonias niger***	**N4B**	**N4B**	**SNRB**	**S3B**
Black-and-white Warbler	*Mniotilta varia*	N5B,N4N5N	N5B	SNRB	S5B
Blue Jay	Cyanocitta cristata	N5B,N5N	N5	SNR	S5
Blue-winged Teal	***Anas discors***	**N5B,N5N**	**N5B**	**SNRB**	**S4**
Broad-winged Hawk	*Buteo platypterus*	N5B	N5B	SNRB	S5B
Canada Goose	***Branta canadensis***	**N5B,N5N**	**N5B,N5N**	**SNR**	**S5**
Cedar Waxwing	***Bombycilla cedrorum***	**N5**	**N5**	**SNRB,SNRN**	**S5B**
Common Goldeneye	***Bucephala clangula***	**N5B,N5N**	**N5B,N5N**	**SNRB,SNRM**	**S5**
Common Grackle	***Quiscalus quiscula***	**N5**	**N5B**	**SNRB,SNRN**	**S5B**
Common Loon	***Gavia immer***	**N4B,N5N**	**N4B,N5N**	**SNRB**	**S5B,S5N**
Common Merganser	*Mergus merganser*	N5B,N5N	N5B,N5N	SNRB,SNRN	S5B,S5N
Common Nighthawk	*Chordeiles minor*	N5B	N4B	SNRB	S4B
Common Raven	***Corvus corax***	**N5**	**N5**	**SNR**	**S5**
Common Redpoll	*Acanthis flammea*	N5B,N5N	N5B,N5N	SNRN	S4B
Common Tern	*Sterna hirundo*	N5B	N5B	S2B	S4B
Common Yellowthroat	***Geothlypis trichas***	**N5**	**N5B**	**SNRB**	**S5B**
Connecticut Warbler	*Oporornis agilis*	N3B	N4N5B	SNRB	S4B
Double-crested Cormorant	***Phalacrocorax auritus***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
Downy Woodpecker	*Picoides pubescens*	N5	N5	SNR	S5
Franklin's Gull	*Leucophaeus pipixcan*	N4B	**N5B**	S3B	SNA
Great Blue Heron	***Ardea herodias***	**N5B,N5N**	**N5B**	**SNRB**	**S4**
Hairy Woodpecker	*Picoides villosus*	N5	N5	SNR	S5
Herring Gull	*Larus argentatus*	N5B,N5N	N5B,N5N	SNRB,SNRN	S5B,S5N
Hooded Merganser	*Lophodytes cucullatus*	N5B,N5N	N5B	SNRB,SNRN	S5B,S5N
Le Conte's Sparrow	***Ammodramus leconteii***	**N3B,N4N**	**N5B**	**SNRB**	**S4B**
Least Bittern	***Ixobrychus exilis***	**N5B,N5N**	**N4B**	**SNRB**	**S4B**
Least Flycatcher	***Empidonax minimus***	**N5B**	**N5B**	**SNRB**	**S4B**
Lincoln's Sparrow	*Melospiza lincolnii*	N5B,N5N	N5B	SNRB	S5B
Mallard	***Anas platyrhynchos***	**N5B,N5N**	**N5B,N5N**	**SNRB,SNRN**	**S5**

Species	Scientific Name	US Rank	Canada Rank	Minnesota Rank	Ontario Rank
Marsh Wren	***Cistothorus palustris***	**N5B,N5N**	**N5B**	**SNRB**	**S4B**
Merlin	*Falco columbarius*	N4B,N4N	N5B,N5N	SNRB,SNRN	S5B
Mourning Warbler	*Geothlypis philadelphia*	N5B	N5B	SNRB	S4B
Nashville Warbler	***Oreothlypis ruficapilla***	**N5B**	**N5B**	**SNRB**	**S5B**
Northern Flicker	***Colaptes auratus***	**N5B,N5N**	**N5**	**SNRB**	**S4B**
Northern Goshawk	*Accipiter gentilis*	N4B,N4N	N5	SNRB,SNRN	S4
Northern Harrier	*Circus cyaneus*	N5B,N5N	N5B,N4N	SNRB,SNRN	S4B
Ovenbird	*Seiurus aurocapilla*	N5B	N5B	SNRB	S4B
Pied-billed Grebe	***Podilymbus podiceps***	**N5B,N5N**	**N5B**	**SNRB**	**S4B,S4N**
Pileated Woodpecker	*Dryocopus pileatus*	N5	N5	SNR	S5
Red-breasted Nuthatch	*Sitta canadensis*	N5	N5	SNR	S5
Red-eyed Vireo	*Vireo olivaceus*	N5B	N5B	SNRB	S5B
Red-necked Grebe	***Podiceps grisegena***	**N5B,N5N**	**N5B,N5N**	**SNRB**	**S3B,S4N**
Red-winged Blackbird	***Agelaius phoeniceus***	**N5**	**N5B,N5N**	**SNRB,SNRN**	**S4**
Ring-billed Gull	***Larus delawarensis***	**N5B,N5N**	**N5B,N5N**	**SNRB**	**S5B,S4N**
Ring-necked Duck	***Aythya collaris***	**N5B,N5N**	**N5B,N5N**	**SNRB,SNRM**	**S5**
Rose-breasted Grosbeak	*Pheuticus ludovicianus*	N5B	N5B	SNRB	S4B
Ruby-throated Hummingbird	*Archilocus colubris*	N5B	N5B	SNRB	S5B
Ruffed Grouse	*Bonasa umbellus*	N5	N5	SNR	S4
Sandhill Crane	*Grus canadensis*	N5B,N5N	N5B	S4B,SNRM	S5B
Sedge Wren	***Cistothorus platensis***	**N4B,N5N**	**N5B**	**SNRB**	**S4B**
Song Sparrow	***Melospiza melodia***	**N5**	**N5B,N5N**	**SNRB,SNRN**	**S5B**
Sora	***Porzana carolina***	**N5B,N5N**	**N5B**	**SNRB**	**S4B**
Spotted Sandpiper	*Actitis macularius*	N5B,N5N	N5B	SNRB	S5
Swamp Sparrow	***Melospiza georgiana***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
Tennessee Warbler	*Oreothlypis peregrina*	N5B	N5B	SNRB	S5B
Tree Swallow	***Tachycineta bicolor***	**N5B,N5N**	**N5B**	**SNRB**	**S4B**
Trumpeter Swan	*Cygnus buccinator*	N4B,N4N	N4B,N5N	S2B	S4
Turkey Vulture	*Cathartes aura*	N5B,N5N	N5B	SNRB	S5B
Veery	*Catharus fuscescens*	N5B	N5B	SNRB	S4B
Virginia Rail	***Rallus limicola***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
White-throated Sparrow	*Zonotrichia albicollis*	N5B,N5N	N5B	SNRB,SNRN	S5B
Wilson's Snipe	***Gallinago delicata***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
Wood Duck	***Aix sponsa***	**N5B,N5N**	**N5B,N5N**	**SNRB,SNRN**	**S5**
Yellow Rail	***Coturnicops noveboracensis***	**N3B,N4N**	**N4B**	**S3B**	**S4B**
Yellow Warbler	***Setophaga petechia***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
Yellow-bellied Sapsucker	***Sphyrapicus varius***	**N5B,N5N**	**N5B**	**SNRB**	**S5B**
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	N5B,N5N	N5B	SNRB	S2B

Appendix 3

Definitions for codes used in national and subnational conservation status ranks.

N1 **S1**	**Critically Imperiled**—Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.
N2 **S2**	**Imperiled**—Imperiled in the jurisdiction because of rarity due to very restricted range, very few populations, steep declines, or other factors making it very vulnerable to extirpation from jurisdiction.
N3 **S3**	**Vulnerable**—Vulnerable in the jurisdiction due to a restricted range, relatively few populations, recent and widespread declines, or other factors making it vulnerable to extirpation.
N4 **S4**	**Apparently Secure**—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
N5 **S5**	**Secure**—Common, widespread, and abundant in the jurisdiction.
NNR **SNR**	**Unranked**—National or subnational conservation status not yet assessed
N#N# **S#S#**	**Range Rank** —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community.
NNA **SNA**	**Not Applicable** —A conservation status rank is not applicable because the species is not a suitable target for conservation activities.
N#B **S#B**	**Breeding**—Conservation status refers to the breeding population of the species in the nation or state/province.
N#N **S#N**	**Nonbreeding**—Conservation status refers to the non-breeding population of the species in the nation or state/province.
N#M **S#M**	**Migrant**—Migrant species occurring regularly on migration at particular staging areas or concentration spots where the species might warrant conservation attention. Conservation status refers to the aggregating transient population of the species in the nation or state/province.