Investigation of Round Field Marsh in Queen's University Biological Station

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Summary

Wetlands play a critical role in maintaining ecosystem processes, including providing unique habitats for species, essential conditions for symbioses, natural cycles, and contributing to hydrological regulation. Wetlands also have social and ecological value. However, with the development of human being, wetlands have gradually disappeared. In this report, our group show the situation of wetlands at Queen's University Biological Station (QUBS). We describe the general situation of the wetlands and focus on Round Field Marsh, one of the wetlands in QUBS.

Introduction

A wetland is defined as: land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment (National Wetlands Working Group, 1988). Wetlands are commonly referred to as fens, bogs, marshes, swamps and shallow water. They situate intermittently across the landscape along lakes, rivers, steams, and other areas in which the water table is close to the surface. Their sizes vary from a fraction of a hectare to many thousands of hectares.

Wetlands play a critical role in maintaining ecosystem processes. They provide a great amount of primary production and provide unique and specialized habitat for a great variety of species including fish, shellfish, shorebirds, waterfowl, and forbearing mammals, which support food chains and can not live anywhere else. They also provide essential conditions for symbioses, natural cycles, such as carbon, nitrogen and water, and remove excess nutrients , various chemicals and potentially toxic elements. Notably, they contribute to a complex series of hydrological regulatory functions, including water holding, groundwater recharge and discharge, flood prevention or attenuation, water purification and the retention of nutrient and sediments (Millennium Ecosystem Assessment, 2005; Finlayson, 2011). Additionally, Wetlands have many social and ecological values to people. They provide products for food such as wild rice, cranberries, fish, wildfowl; energy such as peat, wood, charcoal; and building materials such as lumbers. What's more, wetland are recreational areas for activities such as hunting, fishing, and birdwatching. Nonetheless, wetland are vulnerable to a range of anthropogenic pressures, including agriculture, aquaculture, and other human activities, which disrupt regional hydrological regimes, pollute water body and produce excessive nutrient, as well as bring in invasive species and overexploitation of biomass, plant and animals. In some regions of the world, many wetlands have been lost, with conversion for agricultural uses being one of the primary reasons for these ongoing wetland losses.

Globally, wetlands cover at least 6% of the earth's terrestrial surface (Finlayson and D'Cruz, 2005), of which 32% is in Asia and 31% is in North America (Ramsar Convention Secretariat, 2011). It is estimated that more than half of the world's original wetlands have disappeared (Zedler, J.B. and Kercher, S. 2005). In Canada, 14% of the land area is covered by wetlands, approximately 1.5 million km^2 (National Wetlands Working Group. 1997, Davidson, I., Vanderkam, R. and Padilla, M. 1999), most of which are near the great lakes or along the St. Lawrence River. They were once abundantly distributed through out the country. Recently, wetlands have been deceasing increasingly in settled area of the country. They have been adversely affected by land usage practices that have resulted in vegetation destruction, nutrient and toxic loading, sedimentation, and altered flow regime. For example, in southern Ontario, 68% of the original wetlands have been converted from their original state to support alternative uses such as agriculture and housing. In the northern Ontario, however, most of the wetlands are intact. The government of Canada already have some programs to protect the remaining wetlands, such as the North American Waterfowl Management Plan (NAWMP). In 1986, Canada

and U.S. signed the program in reaction to the sharp decline in waterfowl populations associated with the destruction of their habitats. And they were joined by Mexico in 1993 (Website of environment Canada).

Our wetlands assessment is based on 7 wetlands at Queen's University Biological Station, which is located on the shores of Lake Opinicon, one of the lakes of the Rideau Canal, approximately 50 kilometers north of Kingston, Ontario, Canada. The main facility consists of 32 buildings. A series of real estate purchases and gifts to Queen's have expanded the facility to more than 3200 hectares, including six small lakes and extensive shoreline on Lake Opinicon and Hart Lake, and habitats ranging from abandoned farmland to mature second-growth forest. For 70 years, researchers and students have gathered at the Queen's University Biological Station to conduct research and participate in courses spanning ecology, evolution, conservation and environmental biology.

From July 23rd 2015 to August 9th 2015, it was the 10th anniversary installment of an innovative biology field course, in which 20 students from Fudan, Tongji, Southwest and Beijing Normal Universities join 11 Canadian students to examine the impact of human development on aquatic environments and biodiversity. The field course is created by Dr. Yuxiang Wang and co-taught by Dr. Stephen Lougheed, which is offered annually alternating between QUBS and China. The students are decided into groups. Each group is assigned with a wetland assesment. My group is consists of two Chinese students and two Canadian students. We investigated Round Field Marsh, a small marsh at QUBS, located at 44.517497° N, 76.387663° W. In this report, we will describe the features of wetlands at QUBS generally, and then focus on Round Field Marsh about its geological features, configuration, and discuss the biodiversity, invasive species and the impact of human activities.

Materials & Methods

We chose eight wetlands to represent the range of wetland types present at QUBS, ranging from large lacustrine wetlands to small upland marshes (Refer to Table 1). They are Barbs Marsh, Round Field, Beaver marsh, Grouse Wood, Lerol, Telephone Bay and Cow Island, respectively. Each student group consisted of 4 or 5 members was assigned a single wetland. Wetlands were surveyed on two separate days, 5 August 2015, and 6 August 2015 from 6:00 am EST to approximately 17:00 pm EST. Each group measured the perimeter and the area of the wetland, many kinds of variables of water, such as temperature, pH, oxygen saturation, salinity and conductivity, and figure out the species in these wetlands, such as algae, plants, adjacent trees, herpetofauna, avifauna, and aquatic inverts. In addition to these, my group's work on Round Field Marsh focus on describing the geology, the configuration, the biodiversity, the invasive species and the human impacts.

At Round Field Marsh, we measured the perimeters and areas with the help of GPS device and Google Earth. we measured the overstory density of surrounded forest and the woods in water

region by using SPHERICAL DENSIOMETER (Model-A). Hold instrument level 12”~18” in front of body and at elbow height so that operator’s head is just outside of grid area. Assume four equi-spaced dots in each square of the grid and systematically count dots equivalent to quarter-square canopy openings. Multiply the total count by 1.04 to obtain percent of overhead area not occupied by canopy. Make four readings per location, facing north, east, south and west, then record and average. We got measuring tape of 5 meters and TANGENT HEIGHT GAUGE from Dr. Lougheed to measure the height of trees. And we got YSI 85 (Model# 85/50 FT; SN: 03A0424 AD), Conbo pH & EC (HI 98129), HORIBA Water Quality Monitor (Model U-2001) to measure the features of water. YSI 85 (Model# 85/50 FT; SN: 03A0424 AD) is an equipment for measuring the dissolved oxygen, conductivity, salinity and temperature of the water. Conbo pH & EC (HI 98129) is an equipment for measuring the pH, EC and temperature of the water. HORIBA Water Quality Monitor (Model U-2001) is an equipment for measuring the conductivity, temperature, turbidity, depth of the water, etc.

Results

General information of the wetlands

We assigned 7 wetlands at QUBS, which are called Barbs Marsh, Round Field, Beaver marsh, Grouse Wood, Lerol, Telephone Bay and Cow Island, separately (Refer to Table 1). Their areas are varied from 19113 square meters to 52867 square meters. For some wetlands, almost all the areas are water surface. However, only 16.9% of the area of Round Field Marsh is water surface. Among these seven wetlands, five are palustrine, which are basin marshes; another two are lacustrine, which are littoral emergent marsh. We measured many variables of the water, including the temperature, the pH, dissolved oxygen and oxygen saturation, salinity and conductivity, the turbidity and the total dissolved solid(TDS) (Refer to Table 2). Generally, the water temperature of the wetlands at QUBS in summer is around 22.5 C; the water pH of the wetlands at QUBS in summer is around 7.3; And the dissolved oxygen of the wetlands at QUBS in summer is around 6.51 mg/L. Paradoxically, conductivity data from YSI 85 is very different from that from Horiba. We also show the data of turbidity and TDS in the Table2. Nonetheless, the turbidity and TDS varied a lot in the wetlands. We also detected the water sample of the wetlands.We identified some algae and aquatic inverts (Refer to Appendix 1 & 2). There is few organisms in the water and the reason has not been elaborated clearly. Except for water, we collected the data of the flora and fauna in the wetlands, including the plants, the adjacent trees, the herpetofauna and the avifauna (Refer to Appendix 3, 4, 5 & 6).

Geology and configuration of Round Field Marsh

Round Field Marsh, one of the wetlands at QUBS, besides Lower Rock Lake, is situated at UTM 18T Easting 389648 northing 4930303. As its name, its shape is like a round. The total area is about 29344 m2. There are adjacent trees along its boundary. And in the centre of Round Field Marsh, there is a small part of water surface, which is about 4946 m2, only 16.9% of the total area. Frogbits, willows, sedges grow above the water. Between the water surface and adjacent trees is there a ring-like region called ecotone, which is a grass. We observed that, in the grass,

the closer the plants live to the water surface, the lower they are. We took 11 samples around Round Field Marsh, with 6 samples being along the boundary evenly, 4 samples being around the ecotone evenly and a sample at the centre in water. Besides, we took another 8 samples along the radius in ecotone region from the boundary to the centre (Refer to Picture 1). In each sample site, we collected the information of plants including species' name and the number (Refer to Table 3). In addition, at the sites of sample 1~6, we measured the height and the overstory density of boundary trees (Refer to Table 4), the average of which are 18.6 m and 0.62 separately. And at the centre of the water surface, the overstory density is 0.56. We detected the water sample from the centre of the water surface as well. With the equipment, we got to know the variables of water (Refer to Table 2). Under the microscope, we observed nearly 1 daphnia every 10 drops and 1 green algae every 10 drops, which means there is almost no aquatic inverts and algae in the water. But there are a lot of large algae.

Table 1 Geology of the wetlands of QUBS

	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island
Easting (UTM 18T)	390767	389648	389539	389532	N/A	N/A	395215
Northing (UTM 18T)	4931052	4930303	4931043	4929804	N/A	N/A	4935995
Perimeter (m)	1023	1022	460	1069	N/A	1385	N/A
Area (square meters)	45241	29344	19113	35696	27200	52867	N/A
Water Surface	N/A	16.9% Open Water	N/A	55% Open Water	40% Open Water	N/A	N/A
Wetland Type (Lac/ Palustrine)	Palustrine	Palustrine	Plaustrine	Palustrine	Palustrine	Lacustrine	Lacustrine
Canadian Wetland Classification	Isolated/ Discharge Basin Marsh	Discharge Basin Marsh	Emergent mixed community marsh	Basin Marsh	Isolated Basin Marsh	Littoral Emergent Marsh	Littoral Emergent Marsh

Table 2 Measurement of the water in the wetlands of QUBS

	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Average
Temperature (C)	24.3	18.3	19.63	28.4	20.6	22.8	23.8	**22.5**
pH	6.6	7.1	8.14	7.12	7.11	7.7	7.51	**7.3**
Dissolved Oxygen (mg/ L)	4.31	5.56	3.84	10.9	7.49	4.66	8.81	**6.51**
O2 Saturation (%)	52.2	54.4	N/A	N/A	82.3	54	103.5	**N/A**
Salinity (ppt)	0	0	0	0.1	0	0.2	0.1	**N/A**

	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Average
Conductivity by YSI 85 (uS/m)	91	530	37.7	201.1	265.1	338.8	167.4	**N/A**
Conductivity by Horiba (uS/m)	11.6	59.4	N/A	N/A	N/A	N/A	N/A	**N/A**
Turbidity (NTU)	N/A	150-200	11-97.5	53.7	N/A	37	N/A	**N/A**
TDS (g/L)	0.08	0.43	N/A	0.17	N/A	0.29	N/A	**N/A**

Table 3 Co-ordinates and species at sample sites of Round Field

Sample	Coordinates/T,E,N	Species name / number										Sum
1	18T 389599E 4930309N	Cow Vetch / 4	Hay / 6	Queens Anne Lace / 3	Golden Rod / 19	Milk Weed / 1	Red Clover / 4					6
2	18T 389574E 4930218N	Fowl Manna Grass / >20	Daisy Fleabane Erigeron Annuus / 5	Golden Rod / >20								3
3	18T 389691E 4930239N	Spotted Joe-Pye / 18	Wool grass / 9									2
4	18T 389758E 4930266N	Golden Rod / 5	Fowl Manna Grass / 6	Cow Vetch / 2	Bigfoot tremoil / 3	Other (Black) / 1						5
5	18T 389720E 4930356N	Joe-Pye Weed / 2	Sensitive Fern / 4	Sedges / >20	Unknown white flower / 1	Wool grass / 10	Other plant specie / >20					6
6	18T 389635E 4930382N	Daisy Fleabane Erigeron Annuus / 6	Red clover / >20	Black eyed susan / 3	Cow vetch / 2	Golden rod / 1	hay / 4	Unknown little fern / 1	Heal-All (Self heal) Prunella vulgaris / 1	Fowl Manna Grass / 1		9
7	18T 389620E 4930305N	Golden Rod / 3	Red Clover / 7	Golden Rod / 3	Milkweeds / 3	Hay / 3	Fowl Mnna Grass / 1	Queens Annes Lace / 8	Heal-All (Self heal) Prunella vulgaris / 5	Unidentified fern	Unidentified fern	10
8	18T 389655E 4930298N	frogbits	willow	sedges								3
9	18T 389709E 4930283N	Sedges / 13	Spotted Joe-Pye / 1	Unknown fern 3								3

Sample	Coordinates/T,E,N	Species name / number										Sum
10	18T 389607E 4930255N	Wool grass / 16	Cow Vetch / 1	Golden Rod / 4	Fowl Nanna Grass / 5	Hay / 6	Unknown white flower	Unknwon grass				7
11	18T 389691E 4930332N	water cattails / 2	unknown fern plant 2									2
A	18T 389590E 4930313N	Fowl Manna Grass / 15	Hay / 10	Cursed Buttercup Ranuculus sceleratus / 1	Red Clover / >10							4
B	18T 389594E 4930311N	Golden Rod / >20	Red Clover / 6	Queens Annes Lace / 3	Cow Vetch / 1	Hay / 9	Fowl Manna Grass / 4					6
C	18T 389599E 4930309N	Golden Rod / >20	Red Clover / 1	Milkweed / 1								3
D	18T 389605E 4930308N	Milkweed (Big size) / 9	Queens Annes Lace / 6	Heal-All (Self heal) Prunella vulgaris / 3	Hay / 1							4
E	18T 389610E 4930305N	Queens Annes Lace / 6	Milkweed / 3	Golden rod / 1	Fowl Manna Grass / 10	Spotted Joe-Pye / 4	Heal-All (Self heal) Prunella vulgaris / 5					6
F	18T 389614E 4930302N	Golden Rod / 10	Red Clover /	Heal-All (Self heal) / 8	Milkweed / 2							4
G	18T 389618E 4930300N	Queens Annes Lace / 8	Red Clover / 6	Fowl Manna Grass / 5	Unknown Fern A	Unknwon Fern B	Buffalo Grass	Whitetip clover				7
H	18T 389622E 4930296N	Sensitive Fern / 10	Spotted Joe-Pye Weed / 5	Sedges / 4	Wool Grases / 1	Hay / 9						5

Table 4 The height and the overstory density of adjacent trees at QUBS

Sample	Height (m)	Overstory density
1	19.1	0.52
2	25.5	0.63

Sample	Height (m)	Overstory density
3	15.2	0.60
4	15.4	0.72
5	19.4	0.74
6	17.1	0.53
Average	18.6	0.62

Picture 1 The map of Round Field Marsh from Google earth

Discussion

Wetlands at QUBS

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin and others, 1979).
In this case, the wetlands cannot live without water. That's why we can see all the 7 wetlands at QUBS have water surfaces. In the water, the water temperature is around 22.5 C; the water pH is around 7.3; And the dissolved oxygen is around 6.51mg/L. And there is few organisms in water sample.

Round Field Marsh

We spent two days investigating Round Field Marsh. Round Field Marsh have water surface in the centre of it with ecotone around the surface. We found no inflow or outflow of water in Round Field Marsh. So that we supposed that the water comes from the groundwater and it is periodical, which means in one season or year when the water level increase the area of water surface will enlarge; and in one season or year when the water level decrease the area of water will shrink. In the water, it is little microorganisms except for large algae.

In the ecotone, from sample A to Sample H, we found significant change, especially the plant species and the height of the plants. The more the plant stands near the water surface, the lower the height is and the species trend to be shade plants. We observed that the geology of Round Field Marsh is like a funnel, which means the elevation is higher at the fringe of Round Field Marsh. At the fringe, the root of the plants would have to grower deeper to obtain ground water, which might be the reason why that are higher.

Invasive species and human impacts

Half of the species we identified in the wetland are invasive species. Human's activities have affected a lot to these wetlands. We constructed roads and houses around the wetlands, which may disrupt the life of native species. And another question is how do we make a balance between the conservation of the wetlands and the utilization of the wetlands.

Reference

Cowardin and others, 1979. U.S. Fish and Wildlife Service

Davidson, I., Vanderkam, R. and Padilla, M. 1999. Review of wetland inventory information in North America. In Global review of wetland resources and priorities for wetland inventory. Edited by Finlayson, C.M. and Spiers, A.G. Wetlands International Publication 53, Supervising Scientist. Canberra, Australia. Chapter 144. pp. 457-492.

Finlayson, C.M. and D'Cruz, R. 2005. Inland water systems. In: Hassan, R., Scholes, R. and Ash, N. (eds) (2005) Ecosystems and Human Well-being: Current State and Trends, Volume 1. Findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment. World Resources Institute and Island Press, Washington, DC, pp. 551–584.

Finlayson, C.M. 2011. Managing aquatic ecosystems. In: Wilderer, P. (ed.) Treatise on Water Science, Volume 1. Academic Press, Oxford, pp. 35–59.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Wetlands and Water – Synthesis. A Report of the Millennium Ecosystem Assessment. World Resources

Institute, Washington, DC. Available at: www.maweb.org/documents/document.358.aspx.pdf (accessed February 2013).

National Wetlands Working Group. 1988. Wetlands of Canada. Ecological Land Classification Series, No. 24. Environment Canada and Polyscience Publications Inc. Ottawa, Ontario. 452 p.

National Wetlands Working Group. 1997. The Canadian wetland classification system. 2nd edition. Edited by Warner, B.G. and Rubec, C.D.A. The Wetlands Research Centre, University of Waterloo. Waterloo, ON. 68 p.

Ramsar Convention Secretariat. 2011. The Ramsar Convention Manual: A Guide to the Convention on Wetlands (Ramsar, Iran, 1971), 5th edn. Ramsar Convention Secretariat, Gland, Switzerland.

Appendix

Appendix 1 Algae in water samples of QUBS

Genus	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Anabaena	0	0	N/A	0	1	N/A	1	**2**
Aphanizomenon	1	0		0	0		0	**1**
Aulacoseira	0	0		0	1		1	**2**
Chlorella	0	0		0	1		0	**1**
Chroococcus	0	0		0	1		1	**2**
Closteria	0	0		0	1		1	**2**
Chlamydomonas	0	0		0	1		0	**1**
Cosmarium	0	0		1	0		0	**1**
Dinobryon	0	0		0	1		0	**1**
Eudorina	1	0		0	0		0	**1**
Fragilaria	0	0		0	1		1	**2**
Gloeocapsa	0	0		1	0		1	**2**
Gleotichia	0	0		0	1		0	**1**
Microchaete	0	0		0	0		1	**1**
Microcystis	0	0		1	1		0	**2**
Nostoc	1	0		0	0		0	**1**
Oedogonium	0	0		0	1		1	**2**

Genus	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Omnicrocysis	0	0		0	0		1	**1**
Oscillatoria	0	0		0	1		1	**2**
Pediastrum	0	0		1	0		0	**1**
Phormidium	0	0		0	0		1	**1**
Scenedesmus	0	0		1	1		1	**3**
Spirogyra	0	0		0	1		0	**1**
Spirulina	0	0		0	1		0	**1**
Synedra	1	0		0	1		1	**3**
Synura	0	1		0	1		1	**3**
Tribonama	0	0		0	0		1	**1**
Volvox	0	0		0	1		1	**2**
Vulgaris	0	0		0	0		1	**1**
Sum_Wetland_Species	**4**	**N/A**	**N/A**	**5**	**18**	**N/A**	**17**	

Appendix 2 Aquatic inverts in water samples of QUBS

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Bloodworm		1	0	0	0	0	0	0	**1**
Freshwater Leech	*Macrodbella decora*	1	0	1	1	0	0	0	**3**
Freshwater Snail	*Valvata tricarinata*	0	0	1	0	1	0	0	**2**
Water Striders	*Gerridae*	0	0	0	0	1	0	0	**1**
Daphnia	*Daphnia spp.*	0	1	0	0	1	0	0	**2**

Appendix 3 Plants in the wetlands of QUBS

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Common Yarrow	*Achillea millefolium*	0	0	0	0	1	0	0	**1**
Water Plantain	*Alisma plantago-aquatica*	1	0	0	0	0	0	0	**1**
Pearly Everlasting	*Anaphalis margaritacea*	0	0	0	0	0	0	0	**0**
Liverwort	*Anemone hepatica*	0	0	0	0	1	0	0	**1**
Wild sarsaparilla	*Aralia nudicaulis*	0	0	0	0	0	0	1	**1**

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Swamp Milkweed	*Asclepias incarnata*	1	1	0	0	0	0	1	**3**
Milkweed	*Asclepias syriaca*	1	0	1	0	0	0	0	**2**
Wild Indigo	*Baptisia tinctoria*	0	0	0	0	1	0	0	**1**
Rattlesnake Fern	*Botrypus virginianus*	0	0	0	0	0	0	1	**1**
Buffalo Grass	*Bouteloua dactyloides*	0	1	0	0	0	0	0	**1**
Fringed sedge	*Carex crinita*	0	1	0	0	0	0	0	**1**
Greater bladder sedge	*Carex intumescens*	0	0	0	1	0	0	0	**1**
Lake bank sedge	*Carex lacustris*	1	0	0	1	0	0	0	**2**
Long-stalked sedge	*Carex pedunculata*	0	0	0	1	0	0	0	**1**
Cyperus-like sedge	*Carex pseudocyperus*	0	0	1	0	0	0	0	**1**
Rosy Sedge	*Carex rosea*	0	0	0	1	0	0	0	**1**
Schweinitz's sedge	*Carex schweinitzii*	0	0	0	1	0	0	0	**1**
Tussock sedge	*Carex stricta*	1	0	0	0	0	0	0	**1**
Buttton bush	*Cephalanthus occidentalis*	0	0	0	1	1	0	1	**3**
Coontail	*Ceratophyllum deresum*	0	0	1	1	0	1	1	**4**
Muskgrass	*Chara spp.*	0	0	0	0	0	1	1	**2**
Common Thistle	*Cirsium muticum*	0	0	1	1	0	0	0	**2**
Bull Thistle	*Cirsium vulgare*	1	0	0	0	0	0	0	**1**
Queen Anne's Lace	*Daucus carota*	1	1	0	1	1	0	0	**4**
Needle Spikerush	*Eleocharis acicularis*	1	0	0	0	0	0	0	**1**
Canadian Waterweed	*Elodea canadiensis*	0	0	1	0	0	0	1	**2**
Rough Horsetail	*Equisetum hyemale*	0	0	0	1	1	1	1	**4**
Daisy Fleabane	*Erigeron annuus*	0	1	0	0	0	0	0	**1**
Rattlesnake Master	*Eryngium aquaticum*	1	0	0	0	0	0	0	**1**
Spotted Joe-Pye	*Eutrochium maculatum*	0	1	0	0	0	0	0	**1**
Fowl mannagrass	*Glyceria striata*	0	1	0	0	0	0	0	**1**
Sweet Grass	*Hierochloe odorata*	0	0	0	1	0	0	0	**1**
Frogbit	*Hydrocharis morsus-range*	1	1	0	1	1	0	1	**5**
Yellow Star Grass	*Hypoxis spp.*	1	0	0	0	0	0	0	**1**
Orange Jewelweed	*Impatiens capensis*	0	0	0	0	1	0	0	**1**

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Blue flag iris	*Iris versicolor*	0	0	0	1	1	0	0	**2**
Soft Rush	*Juncus effusus*	0	0	0	0	1	0	0	**1**
Common Duckweed	*Lemna minor*	0	0	0	1	0	1	1	**3**
Ivy Duckweed	*Lemna trisulca*	0	0	0	0	0	0	1	**1**
Ox-eye Daisy	*Leucanthemum vulgare*	0	1	0	1	0	0	0	**2**
Bird's- foot Trefoil	*Lotus corniculatus*	0	1	0	0	0	0	0	**1**
Purple Loosestrife	*Lythrum salicaria*	1	0	0	0	0	0	0	**1**
Indian Pipe	*Monotropa uniflora*	0	0	0	0	0	0	1	**1**
Parrot's feather	*Myriophyllum aquaticum*	0	0	0	0	0	0	1	**1**
Milfoil	*Myriophyllum verticillatum*	0	0	0	0	1	1	0	**2**
Yellow Waterlily	*Nuphar lutea*	0	0	1	1	1	0	1	**4**
White waterlily	*Nymphaea alba*	1	0	1	1	0	1	1	**5**
Common Evening Primrose	*Oenothera biennis*	0	0	0	0	1	0	0	**1**
Sensitive Fern	*Onoclea sensibilis*	0	1	0	1	0	0	0	**2**
Common Reed	*Phragmites spp.*	1	0	0	0	0	0	0	**1**
Wheat-like Grass	*Poaceae Spp.*	1	1	0	0	0	0	0	**2**
Water Smartweed	*Polygonum amphibium*	1	0	1	0	0	0	0	**2**
Eel Grass Pondweed	*Potamogeton compressus*	0	0	0	0	1	0	1	**2**
Broad-leaved Pondweed	*Potamogeton natans*	0	0	0	0	1	0	0	**1**
Clasping leaved pondweed	*Potamogeton perfoliatus*	0	0	0	0	0	0	1	**1**
Flat-Stemmed Pondweed	*Potamogeton zosteriformis*	0	0	1	0	0	0	1	**2**
Heal-All (Self heal)	*Prunella vulgaris*	0	1	0	0	0	0	0	**1**
Cursed Buttercup	*Ranuculus sceleratus*	0	1	0	0	0	0	0	**1**
Prickly Gooseberry	*Ribes cynosbati*	0	0	0	0	1	0	0	**1**
Black Raspberry	*Rubus occidentalis*	0	0	0	0	1	0	0	**1**
Black eyed susan	*Rudbeckia hirta*	0	1	0	0	0	0	0	**1**
Grassy Arrowhead	*Sagittaria graminea*	0	0	1	0	0	0	1	**2**
Quillwort Arrowhead	*Sagittaria isoetiformis*	1	0	0	0	0	0	0	**1**
Sandbar Willow	*Salix exigu*	0	1	0	0	0	0	0	**1**

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Hardstem Bulrush	*Schoenoplectus acutus*	1	0	1	1	0	0	0	**3**
Softstem bulrush	*Schoenoplectus tabernaemontani*	1	0	0	0	0	0	0	**1**
Woolgrass	*Scirpus cyperinus*	1	1	0	1	0	0	0	**3**
Baikal skullcap	*Scutellaria baicalensis*	0	0	0	1	0	0	0	**1**
Climbing Nightshade	*Solanum dulcamara*	0	0	0	0	1	0	0	**1**
Goldenrod	*Solidago spp.*	1	1	1	1	0	0	0	**4**
Floating Burweed	*Sparaganium fluctaris*	0	0	1	0	0	0	0	**1**
Lesser Burweed	*Sparganium american*	0	0	1	0	0	0	0	**1**
Giant burreed	*Sparganium eurycarpum*	1	0	0	0	0	0	0	**1**
Sphagnum moss	*Sphagnum spp.*	0	0	0	1	0	0	0	**1**
Fennel Pondweed	*Stuckenia pectinata*	0	0	0	0	1	0	0	**1**
White Heath Aster	*Symphyotrichum ericoides*	0	0	0	0	1	0	0	**1**
Marsh Fern	*Thelypteris palustris*	1	1	1	1	1	0	1	**6**
Delicate Fern Moss	*Thuidium delicatulum*	0	0	0	0	0	0	0	**0**
Poison Ivy	*Toxicodendron radicans*	0	0	0	0	1	0	0	**1**
Hop Clover	*Trifolium aureum*	1	0	0	0	0	0	0	**1**
Red clover	*Trifolium pratense*	1	1	0	0	0	0	0	**2**
Whitetip clover	*Trifolium variegatum*	0	1	0	0	0	0	0	**1**
Common Cattail	*Typha latifolia*	1	1	1	1	1	1	1	**7**
Tapegrass	*Vallisneria spiralis*	0	0	0	0	0	0	1	**1**
Common Mullein	*Verbascum thapsus*	0	0	0	0	0	0	0	**0**
Hoary Vervain	*Verbena stricta*	0	0	0	0	1	0	0	**1**
Cow Vetch	*Vicia cracca*	1	1	0	1	1	0	0	**4**
Smooth Woodsia	*Woodsia glabella*	1	0	0	0	0	0	0	**1**
	SUM_Wetland_Species	**28**	**23**	**16**	**27**	**25**	**7**	**22**	

Appendix 4 Adjacent trees in the wetlands of QUBS

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island
Red Maple	*Acer rubrum*	N/A	N/A	N/A	0	0	N/A	1
Sugar Maple	*Acer saccharum*				1	1		0

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island
Speckled Alder	*Alnus rugosa*				0	0		1
Paper Birch	*Betula papyrifera*				0	0		1
Silver birch	*Betula pendula*				1	0		0
Pignut Hickory	*Carya glabra*				0	0		1
Shagbark Hickory	*Carya ovata*				0	0		1
Dotted Hawthorn	*Crataegus punctata*				0	0		1
Black Ash	*Fraxinus nigra*				0	0		1
Ash	*Fraxinus pennsylvanica*				0	0		1
Black Tupelo	*Nyssa sylvatica*				0	0		1
White Pine	*Pinus strobus*				0	0		1
Bur Oak	*Quercus macrocarpa*				0	1		0
Red Oak	*Quercus rubra*				0	0		1
European Buckthorn	*Rhamnus cathartica*				0	0		1
Eastern White Cedar	*Thuja occidentalis*				0	0		1
Basswood	*Tilia americana*				0	0		1
Eastern Hemlock	*Tsuga canadensis*				0	0		1
American Elm	*Ulmus americana*				0	1		0
English Elm	*Ulmus procera*				0	0		1
Slippery Elm	*Ulmus rubra*				0	0		1

Appendix 5 Herpetofauna in the wetlands of QUBS

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Frogs									
American Toad	*Anaxyrus americanus*	0	0	0	1	0	0	1	**2**
Gray Treefrog	*Hyla versicolor*	0	0	0		1	1	0	**2**
American Bullfrog	*Lithobates catesbiana*	1	0	1	0	1	0	0	**3**
Green Frog	*Lithobates clamitans*	0	1	1	1	1	1	1	**6**
Northern Leopard frog	*Lithobates pipens*	1	1	1	1	1	1	1	**7**
Wood Frog	*Lithobates sylvaticus*	0	0	0	0	0	1	0	**1**
Spring Peeper	*Pseudacris crucifer*	0	1	0	1	1	0	1	**4**

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Boreal Chorus Frog	*Pseudacris maculata*	0	1	0	0	0	0	0	**1**
Salamanders									
Blue-spotted salamander	*Ambystoma laterale*	0	1	0	0	0	0	0	**1**
Yellow-spotted salamander	*ambystoma maculatum*	0	1	0	0	0	0	0	**1**
Snakes									
Northern Water Snake	*Nerodia Sipedon*	1	0	0	0	1	0	0	**2**
Eastern Ribbon Snake	*Thamnophis sauritus*	0	0	1	0	0	0	0	**1**
Eastern Gartnersnake	*Thamnophis sirtalis*	0	0	0	0	1	0	0	**1**
Northern Brown Snake	*Storeria dekayi*	0	1	0	0	0	0	0	**1**
Turtles									
Painted Turtle	*Chrysemys picta*	0	0	0	0	1	1	1	**3**
	Sum_Wetland_Species	3	7	4	4	8	5	5	

Appendix 6 Avifauna in the wetlands of QUBS

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Red-winged blackbird	*Agelaius phoeniceus*	1	1	0	0	0	0	1	3
Wood duck	*Aix sponsa*	0	0	0	0	0	1	0	1
Mallard	*Anas platyrhynchos*	1	0	0	0	0	0	1	2
Great blue heron	*Ardea herodias*	0	0	0	0	0	1	1	2
Cedar waxwing	*Bombycilla cedrorum*	1	1	0	0	0	0	1	3
Canada Goose	*Branta canadensis*	0	0	0	0	0	0	1	1
Red shouldered hawk	*Buteo lineatus*	0	1	1	0	0	1	1	4
American goldfinch	*Carduelis tristis*	1	1	1	1	0	1	1	6
Turkey Vulture	*Cathartes aura*	0	0	0	0	1	0	1	2
Common nighthawk	*Chordeiles minor*	0	0	0	0	0	1	0	1
Yellow-billed cuckoo	*Coccyzus americanus*	0	0	1	0	0	0	0	1
Northern flicker	*Colaptes auratus*	0	1	0	0	0	0	1	2
Eastern wood peewee	*Contopus virens*	0	0	1	1	0	0	1	3
American Crow	*Corvus bracyrhynchos*	0	0	0	0	0	0	1	1

Common Name	Latin Name	Barbs_Marsh	Round_Field	Beaver_Marsh	Grouse_Wood	Leroi	Telephone_Bay	Cow_Island	Sum_Occurence
Blue jay	*Cyanocitta cristata*	1	1	0	1	1	1	1	6
Common Loon	*Gavia immer*	0	0	0	0	0	0	1	1
Common yellowthroat	*Geothlypis trichas*	1	0	1	1	0	0	1	4
Caspian Tern	*Hydroprogne caspia*	0	0	0	0	0	1	0	1
Wood thrush	*Hylocichla mustelina*	0	0	0	1	0	0	0	1
Ring-billed Gull	*Larus delawarensis*	0	0	0	0	0	0	1	1
Belted kingfisher	*Megaceryle alcyon*	0	0	0	1	0	1	1	3
Swamp sparrow	*Melospiza georgiana*	1	1	0	1	1	0	1	5
Song sparrow	*Melospiza melodia*	1	0	1	0	0	1	0	3
Osprey	*Pandion haliaetus*	0	0	0	0	0	0	1	1
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	0	0	0	0	0	0	1	1
Downy Woodpecker	*Picoides pubescens*	0	0	0	0	1	0	1	2
Hairy woodpecker	*Picoides villosus*	1	0	0	0	0	0	1	2
Black-capped chickadae	*Poecile atricapillus*	0	1	0	1	0	1	1	4
Grackle	*Quiscalus quiscula*	0	0	0	0	1	1	0	2
Virginia rail	*Rallus limicola*	0	1	0	0	0	0	0	1
Eastern phoebe	*Sayornis phoebe*	1	0	0	0	0	0	0	1
American woodcook	*Scolopax minor*	0	1	0	0	0	0	0	1
Yellow throated warbler	*Setophaga dominica*	0	1	0	0	0	0	0	1
Magnolia Warbler	*Setophaga magnolia*	0	0	0	0	1	0	0	1
White breasted nuthatch	*Sitta carolinensis*	0	0	0	1	0	0	1	2
Tree Swallow	*Tachycineta bicolor*	0	0	0	0	1	0	0	1
American Robin	*Turdus migratorius*	0	0	0	1	1	0	0	2
Red eyed vireo	*Vireo olivaceus*	0	0	0	1	0	0	1	2
Mourning Dove	*Zenaida macroura*	0	0	0	0	0	0	1	1
	Sum_Wetland_Species	10	11	6	11	8	11	25	

Reference

Cowardin and others, 1979. U.S. Fish and Wildlife Service

Davidson, I., Vanderkam, R. and Padilla, M. 1999. Review of wetland inventory information in North America. In Global review of wetland resources and priorities for wetland inventory. Edited by Finlayson, C.M. and Spiers, A.G. Wetlands International Publication 53, Supervising Scientist. Canberra, Australia. Chapter 144. pp. 457-492.

Finlayson, C.M. and D'Cruz, R. 2005. Inland water systems. In: Hassan, R., Scholes, R. and Ash, N. (eds) (2005) Ecosystems and Human Well-being: Current State and Trends, Volume 1. Findings of the Condition and Trends Working Group of the Millennium Ecosystem Assessment. World Resources Institute and Island Press, Washington, DC, pp. 551–584.

Finlayson, C.M. 2011. Managing aquatic ecosystems. In: Wilderer, P. (ed.) Treatise on Water Science, Volume 1. Academic Press, Oxford, pp. 35–59.

Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Wetlands and Water – Synthesis. A Report of the Millennium Ecosystem Assessment. World Resources Institute, Washington, DC. Available at: www.maweb.org/documents/document.358.aspx.pdf (accessed February 2013).

National Wetlands Working Group. 1988. Wetlands of Canada. Ecological Land Classification Series, No. 24. Environment Canada and Polyscience Publications Inc. Ottawa, Ontario. 452 p.

National Wetlands Working Group. 1997. The Canadian wetland classification system. 2nd edition. Edited by Warner, B.G. and Rubec, C.D.A. The Wetlands Research Centre, University of Waterloo. Waterloo, ON. 68 p.

Ramsar Convention Secretariat. 2011. The Ramsar Convention Manual: A Guide to the Convention on Wetlands (Ramsar, Iran, 1971), 5th edn. Ramsar Convention Secretariat, Gland, Switzerland.

Website of environment Canada: https://www.ec.gc.ca/tho-wlo/default.asp?lang=En&n=B4669525-1

Zedler, J.B. and Kercher, S. 2005. Wetland resources: status, trends, ecosystem services and restorability. Annual Review of Environment and Resources 30:39-74.