NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Conservation Concerns:
Investigating Threats to Native Wetland Biodiversity

by
Krystal A. Nunes
Department of Chemistry and Biology
Toronto Metropolitan University, Toronto, ON, Canada

Part I – The Decline of Native Wetland Biodiversity

Possessing qualities of both freshwater aquatic and terrestrial ecosystems, wetlands represent some of the most ecologically diverse habitats on Earth (Ontario Ministry of Natural Resources and Forestry (OMNRF), 2017). The term "wetland" encompasses several habitat types including marshes, fens, and peatlands. Thousands of species rely on such habitats including fish, molluscs, reptiles, amphibians, insects, mammals, and plants. Over 450 species of wetland plants are found in the province of Ontario, Canada alone (OMNRF, 2017; United Nations Environment Programme, 2021). These wetlands not only support unique communities, but also provide essential services for humans such as water filtration, flood and erosion mitigation, climate moderation, and social and cultural benefits (OMNRF, 2017). Unfortunately, wetlands are extremely vulnerable to anthropogenic activity as urbanization, agriculture, invasive species, pollution, and climate change all contribute to their continued degradation (United Nations Environment Programme, 2021).

In this case study, you will examine plant diversity in four hypothetical wetlands in Ontario. Swamps and marshes can be found in the southern portion of the province with peatlands dominating the northern region. Some of the threats to Ontario wetlands include habitat fragmentation and invasive species. These threats to biodiversity are the focus of this case study.

Question

1. Table 1 (next page) provides information on the conservation status and life history traits of eight North American wetland plant species. Based on the information provided, identify two traits that might make a native plant species more susceptible to population decline in the face of habitat loss. (See p. 3 for photos.)

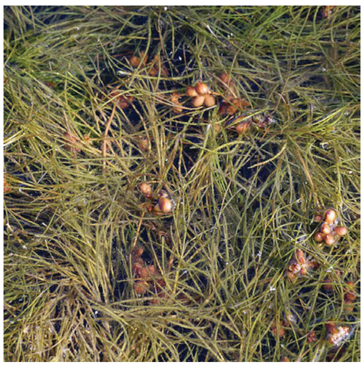
Although some life history traits may exacerbate the decline of a wetland population (or conversely, contribute to their success), there are many factors outside of life history traits of individuals species that contribute to their decline. For instance, novel competitive relationships with non-native species can lead to the extirpation of native populations.

Table 1. Characteristics of herbaceous wetland plants native to North America. Conservation status is based on Canadian classifications. See Supplementary Information (Table 2) for images of plants.

Plant Species	*Conservation Status*	*Life History*	*Reproduction*	*Growth Rate*	*Fruit/Seed Abundance*	*Pollination*	*Seed Dispersal*
American water-willow *(Justicia americana)*	Threatened	Perennial	Vegetative (rhizomes) and seeds	Rapid	Medium	Insect (many species)	Little known
Bent spike-rush *(Eleocharis geniculata)*	Endangered	Annual	Seeds	Average	Little known	Little known	Limited, gravity-based
Fennel pond-weed *(Stuckenia pectinata)*	Least Concern	Perennial	Vegetative (tubers, plant fragments) and seeds	Rapid	Medium	Water	Water
Marsh sandwort *(Arenaria paludicola)*	Endangered	Perennial	Vegetative (rhizomes) and seeds	Average	15–20 seeds per fruit but few fruits produced	Little known, self or insect pollination?	Little known
Rigid hornwort *(Ceratophyllum demersum)*	Least Concern	Perennial	Vegetative (plant fragments) and seeds (minimal)	Rapid	Low, 1 seed per fruit	Water	Water
Unbranched bur-reed *(Sparganium emersum)*	Least Concern	Perennial	Vegetative (rhizomes) and seeds	Rapid	1 seed per fruit	Self-pollinated or wind	Water or animal (fish)
Water smartweed *(Persicaria amphibia)*	Least Concern	Perennial	Vegetative (rhizomes) and seeds	Rapid	1 seed per fruit	Insect (many species)	Water or animal (birds)
Western prairie fringed orchid *(Platanthera praeclara)*	Endangered	Perennial	Seeds	Average	Capsules with thousands of seeds but ~2% of stems produce capsules annually	Insect (sphinx moth only)	Wind

American water-willow *(Justicia americana)*
Credit: Mason Brock, PD.

Bent spike-rush *(Eleocharis geniculata)*
Credit: HQ, CC-BY-SA-2.0.

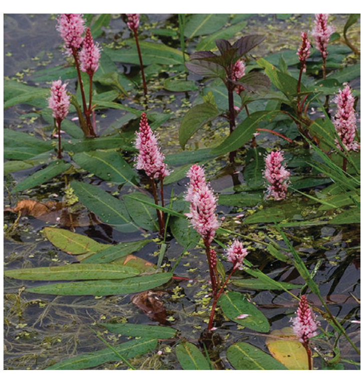


Fennel pondweed *(Stuckenia pectinata)*
Credit: Christian Fischer, CC BY-SA 3.0.

Marsh sandwort *(Arenaria paludicola)*
Credit: Stickpen, PD.

Rigid hornwort *(Ceratophyllum demersum)*
Credit: chiuluan, CC BY 4.0.

Unbranched bur-reed *(Sparganium emersum)*
Credit: Stefan.lefnaer, CC BY-SA 4.0.



Water smartweed *(Persicaria amphibia)*
Credit: Svdmolen, CC BY-SA 3.0.

Western prairie fringed orchid *(Platanthera praeclara)*
Credit: National Park Service, PD.

Part II – Wetland Invasion

When species are intentionally or accidentally introduced to an area outside of their historical range, many fail to survive or only form small populations that have no negative impact on native species (referred to as "naturalized" species). However, a species is classified as "invasive" when they have a negative impact on native biodiversity. For example, *Phragmites australis* subsp. *australis* (hereinafter referred to as *Phragmites*) is a wind-pollinated perennial wetland grass native to Eurasia. It reproduces both vegetatively and through seed, resulting in rapid dispersal rates and the formation of dense stands. It has invaded wetlands in North America, displacing native species such as cattails (*Typha* spp.) and bent spike-rush (*Eleocharis geniculata*) (Environment Canada, 2016).

Figure 1. Phragmites australis. *Credit:* Alexis Garretson, PD.

In southern Ontario, *Phragmites* is expanding rapidly. Wilcox et al. (2003) found that *Phragmites* stands in Long Point, Ontario expanded from 18 hectares in 1995 to 137 hectares in 1999. This exponential growth has continued with an increase in *Phragmites* cover of 14–37% annually, far exceeding initial predictions from the 1990s (Jung et al., 2017).

Question

2. Most non-native species that are introduced to an area do not become widespread; only a few reach the status of an "invader." Identify two characteristics of plant species that may increase their likelihood of becoming invasive in a new habitat.

Competing plants sometimes have a *direct* negative effect on neighbouring plants through the process of allelopathy. Allelopathy occurs when a plant produces chemical compounds that inhibit the growth or survival of other nearby species. Evidence suggests that *Phragmites* is allelopathic as significant changes in soil and water chemistry were observed in invaded areas compared to uninvaded areas, and plant leachate inhibited germination rates of other plant species (Uddin et al., 2017). However, it is far more common that competitors negatively impact neighbouring plants via *indirect* negative effects.

Question

3. Suggest two ways that the wetland invader *Phragmites* may have an indirect negative effect on native wetland plant species.

Part III – Habitat Fragmentation

Along with introduced species, habitat fragmentation may also negatively impact biodiversity. When destroyed or modified for agriculture or urban sprawl, critical wetland habitats needed to sustain native species are eliminated. The remaining areas are smaller in size and more isolated, supporting smaller populations that are at greater risk of local extinction (i.e., extirpation). The ecological rationale behind reduced species diversity in small, isolated habitats lies in the theory of island biogeography (MacArthur & Wilson, 1967).

Originally developed through observations of islands, MacArthur and Wilson's theory of island biogeography has since been more widely applied in the field of conservation biology. Habitat fragmentation due to anthropogenic activities can convert a once continuous habitat to a patchy landscape. Conservation areas can act as islands within a human-altered landscape, and depending on the size and quality of the habitat, may result in small populations at increased risk of extirpation. For instance, Hooftman (2015) found a significant positive relationship between the degree of habitat patch isolation and plant species extirpation rates.

Table 2. List of plant species found in four Ontario protected wetlands.

Plant Species	*Wetland A*	*Wetland B*	*Wetland C*	*Wetland D*
Common reed *(Phragmites australis australis)*	Present	Present	Present	Present
Unbranched bur-reed *(Sparganium emersum)*	Present	Present	Present	Present
Water smartweed *(Persicaria amphibia)*	Present	Present	Present	Absent
Rigid hornwort *(Ceratophyllum demersum)*	Present	Present	Absent	Present
Fennel pondweed *(Stuckenia pectinata)*	Absent	Absent	Present	Present
American water-willow *(Justicia americana)*	Present	Present	Present	Absent
Bent spike-rush *(Eleocharis geniculata)*	Absent	Present	Absent	Absent
Western prairie fringed orchid *(Platanthera praeclara)*	Absent	Absent	Present	Absent
Marsh sandwort *(Arenaria paludicola)*	Absent	Present	Absent	Absent

Questions

4. Table 2 above provides a list of plant species present in four hypothetical protected wetlands. Based on the information provided, complete the following tables of species diversity measures. Beta diversity should be calculated using the Jaccard's index of similarity (report values to two decimal places).

Gamma Diversity: _________

	Wetland A	*Wetland B*	*Wetland C*	*Wetland D*
Species Richness (α diversity)				

	Wetland A vs B	*Wetland A vs C*	*Wetland A vs D*	*Wetland B vs C*	*Wetland B vs D*	*Wetland C vs D*
Jaccard's Index (β diversity)						

5. According to the theory of island biogeography, the number of species found in a habitat is strongly influenced by habitat size and the level of isolation from the source population. Based on the alpha diversity you calculated in Question 4, how would you expect the four wetland conservation areas to differ in size and level of isolation from a source population (i.e., a large, continuous wetland minimally affected by fragmentation)? Assign each of the four wetlands (A, B, C, and D) to one of the following descriptions:

   Large, nearby: ________________________________

   Large, far away: ________________________________

   Small, nearby: ________________________________

   Small, far away: ________________________________

6. Explain the rationale behind your classification of the wetlands in Question 5.

7. Are island size and isolation the only factors that determine species richness? Is it possible for several small islands to have more diversity than one large island, and if so, how?

8. Table 3 below provides relative abundances of plant species found in two protected areas: wetlands B and D. Use this information to construct rank-abundance curves for both wetlands. You can use the grid on the following page to construct your graph.

   Step 1: Calculate the log relative abundance for each plant species. Record these values in Table 3.

   Step 2: Create rank-abundance curves for both wetlands. Both curves should be drawn on the same graph. Be sure to use the *log* rank abundance values to construct your curves.

Table 3. Relative abundance (RA) of the plant species found in two of the wetland conservation areas.

Plant Species	*Wetland B RA*	*Wetland B Log RA*	*Wetland D RA*	*Wetland D Log RA*
Common reed *(Phragmites australis australis)*	0.35		0.62	
Unbranched bur-reed *(Sparganium emersum)*	0.2		0.2	
Water smartweed *(Persicaria amphibia)*	0.2		0	
Rigid hornwort *(Ceratophyllum demersum)*	0.15		0.15	
Fennel pondweed *(Stuckenia pectinata)*	0		0.03	
American water-willow *(Justicia americana)*	0.04		0	
Bent spike-rush *(Eleocharis geniculata)*	0.05		0	
Western prairie fringed orchid *(Platanthera praeclara)*	0		0	
Marsh sandwort *(Arenaria paludicola)*	0.01		0	

9. Which island has greater species evenness? How are you able to determine this from your rank abundance curves?

Part IV – Wildlife Corridors as a Conservation Strategy

Wildlife corridors are strips of naturalized habitat used to connect habitat patches that would otherwise be separated from one another. The purpose of the corridors is to facilitate the movement of species across the unfavourable landscape between patches. Based on the principles of the theory of island biogeography, wildlife corridors are used as a conservation tool to minimize the level of isolation between populations.

Questions

10. How might you expect corridors to affect species richness and evenness within habitat patches? Why?

11. Revisit Question 1 in which you identified two traits that may affect native plant species population declines. Discuss if/how wildlife corridors might mitigate the risk of extirpation experienced by plants with these traits. Justify your response.

12. Revisit Question 2 in which you identified two traits likely to make a plant a successful invader. Discuss if/how wildlife corridors might affect the survival and/or spread invasive plant populations.

13. In your opinion, do you think wildlife corridors are an effective conservation strategy for wetlands? Why or why not?

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