Losses of Amphibians and Reptiles at Point Pelee National Park

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Abstract

Habitat protection is the primary method of conserving biodiversity. However, establishing parks does not guarantee against species losses because small and isolated preserves remain vulnerable to continuing threats. Point Pelee National Park (PPNP) is positioned in the most diverse herpetofaunal region in Canada. Despite a century of protection, PPNP has lost six of 11 amphibian and ten of 21 reptile species. The park is a small isolated fragment of a formerly large contiguous marsh-forest ecosystem. Our goal was to determine the relative importance of 'area-reduction' versus 'isolation' hypotheses in explaining species losses. Species relaxation based on the species-area effect can only explain one to two amphibian and two to four reptile losses. However, distances to the nearest neighbouring populations were significantly greater for extirpated than extant species. Isolation exceeded reasonable dispersal capabilities of extirpated species.

Introduction

Protecting habitat by creating parks and preserves is the primary method used to conserve biodiversity. However, setting aside areas as preserves provides no guarantee that the biota they contain will be protected from species losses. By their very nature, parks are usually smaller and more isolated fragments of formerly larger areas of contiguous natural habitats. The species-area effect, which is almost a law of nature, indicates that smaller areas contain fewer species than large areas (Rosenzweig, 1995). Species richness increases with area because larger areas have more resources to sustain larger populations and the wider variety of habitats they contain can accommodate additional species. Risk of local extinction for individual species decreases as population size increases (Soulé, 1987). Conversely, if an area becomes reduced in size, theory and empirical evidence predict that a 'relaxation' of the biota will occur by local species extinctions until the richness reaches a level that can be supported in the new smaller fragment (Diamond, 1972; Willis, 1974). Besides reducing habitat area, fragmentation also results in increased isolation. As distance between fragments increases, movements decrease resulting in lower immigration and less potential for rescue effects (Brown and Lomolino, 1998). Extreme isolation forms barriers to movement as species' dispersal capabilities are exceeded. Isolation is also of concern in the metapopulation concept. Metapopulations are groups of populations that are interconnected by dispersal (Hanski, 1999). Species living in naturally or anthropogenically fragmented habitats often exhibit metapopulation dynamics. Many amphibian and reptile species appear to exist as metapopulations (e.g., Hecnar and M'Closkey, 1996) or at least a metapopulation framework is useful for understanding their spatial dynamics (Klemens, 2000; Marsh and Trenham, 2001). An important feature of metapopulations is that frequent extinctions of local populations can occur but species persist regionally because of recolonization. Thus, connectivity to other reserves or natural areas is vitally important. In terms of area and isolation, parks often function like islands (Shafer, 1990). However, they are also unlike islands because the matrix in which they are embedded often serves as a source for additional external threats (Janzen, 1983).

Point Pelee National Park (PPNP) is a small (16 km^2) natural area that forms the southernmost portion of Canada's mainland (Figure 1). The park's geographic position places it within the Carolinian zone which is Canada's most diverse region in terms of herpetofauna. In the middle to late 1800s massive deforestation and wetland drainage occurred as most of Essex County's land was converted to agriculture. PPNP was officially established in 1918 by protecting a fragment of the coastal marsh and its associated terrestrial habitat. Six major habitat types that occur in the park are beach, cedar savannah, dry forest, swamp forest, marsh, and pond (Hecnar and Hecnar, 2004). These habitats are further subdivided into 13 vegetation/land-use types but most are of limited area (Table 1). The park has remained through time as a highly isolated 'island' because it is surrounded by water on 80% of its perimeter (Figure 2) and by intensive agricultural land on the remaining 20% (Figure 3). It is also a heavily used park with 300,000 to 500,000 visitors annually. Despite a century of protection, PPNP has lost six of 11 amphibian and ten of 21 reptile species. Our goal was to determine the relative importance of 'area-reduction' versus 'isolation' in explaining species losses.

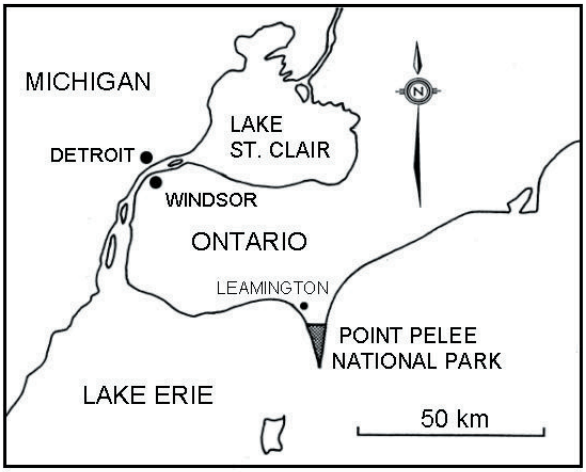

Figure 1. *Location of Point Pelee National Park in southwestern Ontario.*

Table 1. *Vegetation-land cover classification determined by GIS (Source: G. Harvey, PPNP).*

Name	Area (km^2)	Cover (%)
Unclassified	0.000007	0.000046
Upland forest (mature)	1.7690	11.8
Upland forest (immature)	0.6141	4.1
Old field (shrub-dominated)	0.1676	1.1
Old field (open)	0.2273	1.5
Beach	0.8626	5.7
Beach (human use)	0.1608	1.1
Human use	0.1604	1.1
Marsh	6.4882	43.2
Swamp thicket	0.5476	3.6
Swamp forest	0.2655	1.8
Wet meadow	0.0924	0.6
Pond	3.0454	20.3
Pond edges	0.6174	4.1

Figure 2. *Aerial view showing the insular nature of Point Pelee National Park. The Pelee Peninsula extends over 16 km from Ontario's mainland into Lake Erie and is mostly surrounded by water (Source: PPNP).*

Figure 3. *View from the dike which forms the northern boundary of Point Pelee National Park. The park is isolated along the northern boundary by intensively farmed land characteristic of Essex County (Source: C. Browne).*

Methods

To determine the role of area-reduction and tocalculate expected species losses, we constructed species area curves using known information on area (Figure 4) and species richness (Tables 2 and 3) to compare the present state with historical conditions. If species losses occurred primarily because of area-reduction we would expect the actual number of extirpations to closely concur with the predicted number of extirpations.

To determine the role of isolation we calculated the distance from the park to the nearest neighbouring extant population of each species. We located nearest neighbouring populations using the *Ontario Herpetofaunal Summary* maps (NHIC, 2004), personal records, or data from the Michigan and Ohio Departments of Natural Resources. Next, we compared the distances between 'extant' and 'extinct' species using *t*-tests. If isolation played a role in species loss, we would expect that isolation distance would be greater for 'extinct' than 'extant' species. If distance between neighbouring populations does not differ between extinct and extant species groups we can dismiss the isolation hypothesis. For individual extinct species, if distance to the nearest potential source population greatly exceeds dispersal capabilities, the isolation hypothesis is strongly supported.

Table 2. *Distances to the nearest potential source area for amphibian species recorded in the park. Park status is indicated as extant (E) or by year of last record for extinct species.*

Scientific Name	Common Name	Park Status	Distance (km)	Source
Acris crepitans	Northern cricket frog	1972	33	N.W. Ohio
Ambystoma tigrinum	Tiger salamander	1915	33	N.W. Ohio
Bufo americanus	American toad	E	0	Essex County
Bufo fowleri	Fowler's toad	1949	70	Rondeau P.P.
Hyla versicolor	Gray treefrog	1986	70	Rondeau P.P.
Necturus maculosus	Mudpuppy	E	0	Lake Erie
Pseudacris crucifer	Spring peeper	E	6	Hillman Marsh
Pseudacris triseriata	Western chorus frog	E	0	N. boundary
Rana catesbeiana	American bullfrog	1990	42	Holiday Beach
Rana clamitans	Green frog	E	0	N. boundary
Rana pipiens	Northern leopard frog	E	0	N. boundary

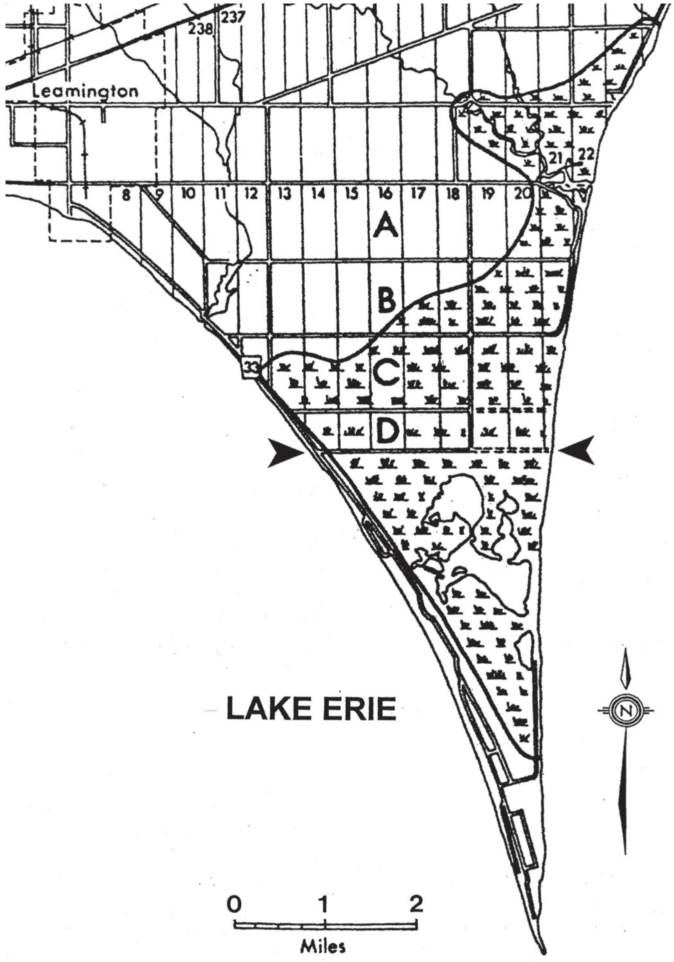

Figure 4. *Original extent of the Point Pelee Marsh ecosystem. The existing marsh extends south from the park's northern boundary (indicated between arrows). The marshland north of the boundary was drained and converted to agriculture (Source: adapted from H. Beldon and Co. map, ca. 1880-1881).*

Table 3. *Distances to the nearest potential source area for reptile species recorded in the park. Introduced species have been excluded. Park status is indicated as extant (E) or by year of last record for extinct species.*

Scientific Name	Common Name	Park Status	Distance (km)	Source
Apalone spinifera	Spiny softshell	E	0	Lake Erie
Chelydra serpentina	Snapping turtle	E	0	N. boundary
Chrysemys picta	Painted turtle	E	0	N. boundary
Clemmys guttata	Spotted turtle	E*	42	Holiday Beach
Coluber constrictor	Eastern racer	1960	14	Pelee Island
Crotalus horridus	Timber rattlesnake	1895	277	S. Ohio
Elaphe gloydi	Eastern foxsnake	E	0	N. boundary
Elaphe obsoleta	Eastern ratsnake	1920	532	E. Ontario
Emydoidea blandingii	Blanding's turtle	E	6	Hillman Marsh
Eumeces fasciatus	Five-lined skink	E	70	Rondeau P.P.
Graptemys geographica	Northern map turtle	E	35	St. Clair shores
Heterodon platirhinos	Eastern hognosed snake	1979	70	Rondeau P.P.
Lampropeltis triangulum	Milksnake	1920	57	Walpole Island
Nerodia sipedon	Northern watersnake	E	6	Hillman Marsh
Sistrurus catenatus	Massasauga	1920	53	LaSalle, ON
Sternotherus odoratus	Stinkpot	E	56	Rondeau
Storeria dekayi	Dekay's brownsnake	E	0	N. boundary
Thamnophis sirtalis	Common gartersnake	E	0	N. boundary

*Likely also extinct because not observed since 1994 (Hecnar and Hecnar, 2004).

Results

Habitat Loss

The standard form of the species area effect is a power function known as the Arrhenius equation (Rosenzweig, 1995):

(1) $$S = cA^{z}$$

Where: S= species richness
c= a system specific constant
A = area
z = slope of the linear form of the function

The linear form of the species area effect can be found by logarithmic transformation equation:

$$\text{(2)} \qquad \log S = \log c + z \log A$$

We know that PPNP historically had at least 11 amphibian species and 18 reptile species, but presently only five and 12 species respectively persist. We excluded three reptiles from our analyses because they are considered either introduced – pond slider (*Trachemys scripta*) and eastern box turtle (*Terrapene ornata*) – or are based on unsubstantiated reports – wood turtle (*Clemmys insculpta*) – at PPNP. We also know that prior to agricultural conversion of the land north of the park, the marsh ecosystem covered 3633 ha (Figure 4). Presently, the park contains an isolated fragment of 1620 ha. Thus we have estimates for S and A, but not c or z. However, the literature indicates that z ranges primarily between 0.13-0.39 (Rosenzweig, 1995) with z values for islands being greater than for equivalent mainland areas. King *et al*. (1997) recently studied the biogeography of the Lake Erie's herpetofauna. Using their data we calculated that $z = 0.37$ for amphibians and 0.29 for reptiles. Taking these values as the upper bound for z and using 0.13 as a lower bound, we can confidently assume that the actual z for PPNP lies somewhere between these values. We can then substitute z and calculate an estimate for c, the last unknown parameter. Having estimates for all parameters allows us to determine how well area reduction can explain species loss at PPNP.

For amphibians:

$$\begin{aligned} 11 &= c(3633)^{0.37} \\ c &= 0.530 \\ S &= 0.530A^{0.37} \\ &= 0.530(1620)^{0.37} \\ &= 8.2 \text{ species} \end{aligned} \qquad\qquad \begin{aligned} 11 &= c(3633)^{0.13} \\ c &= 3.789 \\ S &= 3.789A^{0.13} \\ &= 3.789(1620)^{0.13} \\ &= 9.9 \text{ species} \end{aligned}$$

Thus, the species-area effect predicts that the amphibian fauna should relax from 11 to eight or ten species. The area loss hypothesis can thus account for loss of one or two species. However, the park has lost six species.

Similarly for reptiles:

$$18 = c(3633)^{0.29} \qquad\qquad 18 = c(3633)^{0.13}$$
$$c = 1.67 \qquad\qquad c = 6.20$$
$$S = 1.67A^{0.29} \qquad\qquad S = 6.20A^{0.13}$$
$$= 1.67(1620)^{0.29} \qquad\qquad = 6.20(1620)^{0.13}$$
$$= 14.2 \text{ species} \qquad\qquad = 16.2 \text{ species}$$

Thus, the species-area effect predicts that the reptile fauna should relax from 18 to 14 or 16 species. The area loss hypothesis can thus account for loss of two to four species. However, the park has lost six species. As with the amphibians, area reduction can account for some but not all of the reptile losses.

Isolation

For amphibians (Table 2), distance to the nearest potential source population for extant species ranges from 0-6 km with a mean of 1.0 ± 1.0 km. Distance for extinct species ranges from 14.1 to 70.0 km with a mean of 44 ± 11.1 km. The difference between the two groups is highly significant (t = 7.53, 9 df, P<0.001). Similarly for reptiles (Table 3), distance to the nearest potential source population for extant species ranges from 0-70 km with a mean of 17.9 ± 7.40 km. Distance for extinct species ranges from 14.1 to 532.0 km with a mean of 167.2 ± 82.30 km. The difference between the two groups is highly significant (t = 3.40, 16 df, P = 0.004). For both amphibians and reptiles, the isolation hypothesis is strongly supported.

Conclusions

Point Pelee National Park has been a highly isolated insular fragment for over a century. Assuming that sufficient time for faunal relaxation has passed, our calculations indicated that losses of one to two amphibians and two to four reptiles are expected due to area reduction. However, the park has lost six amphibian and six reptile species. Reptile losses climb to ten species if the spotted turtle (*Clemmys guttata*) and introduced species are included. We cannot entirely dismiss the area reduction hypothesis for losses of some of the species but some factor other than area loss has played a role in local extinctions. The average distances from the park to nearest neighbouring populations was significantly greater for extinct relative to extant species for both amphibians and reptiles. Considering that amphibian movements typically range from 100s of m to several km, and reptile movements range up to just over ten km (Pough *et al*., 2004), it is clear that the specific isolation distances to Point Pelee are several times farther than the reasonable maximum dispersal capabilities of the species that are now extinct. Furthermore, because of the degree of habitat loss that has occurred outside of the park, hostile matrix conditions would also make movements more difficult. Considering the vulnerability of small populations to local extinction, rescue from external populations is virtually impossible for many PPNP species, and that suitable habitat still remains in the park, our results strongly support the isolation hypothesis.

It would be naive to think that area and isolation are the only factors affecting persistence of species at PPNP. The amount of habitat in the park has not been reduced since the park was established, in fact it has increased slightly with recent reclamation of anthropogenic habitat. However, the park's habitats have changed over time through succession. Relative to historic accounts, the park now has less open habitat as the forest matures and encroaches on savanna (Smith and Bishop, 2002), and as the marsh ages (Hecnar and Hecnar, 2004). Canopy closure and reduction of open habitats would have negative consequences for species that require open habitats or basking sites (Hecnar and Hecnar, 2004). Other internal factors may also degrade habitat quality and perhaps increase the risk of extinction. Despite being a small park, Point Pelee has many visitors and there are always concerns regarding visitor disturbance (e.g., Hecnar and M'Closkey, 1998). The park also has elevated densities of subsidized mesopredators, e.g., raccoon (*Procyon lotor*), that are well-known predators of amphibians and reptiles (Browne, 2003; Browne and Hecnar, 2003). PPNP also has a history of chemical contamination and evidence exists for bioaccumulation in its herpetofauna (Russell *et al.*, 1995, 1999; Crowe, 1999).

Evaluating the relative importance of all these factors is outside the scope of this report, but these threats or other stochastic events may have acted as the ultimate mechanisms of extirpation. Regardless of the exact cause(s) of demise, extinction risk in small local populations is high and existence of source populations that can rescue or recolonize a isolated reserve is necessary for long-term population persistence. Point Pelee is a small highly isolated 'island'. For some of the remaining species, e.g., green frog (*Rana clamitans*), gartersnake (*Thamnophis sirtalis*), numerous populations exist outside the park which can potentially rescue or recolonize park populations. For other species such as the spring peeper (*Pseudacris crucifer*) few extant populations exist in Essex County and the species is now truly isolated and vulnerable to future loss. Species losses are inevitable, it is just a matter of when they will occur. The American bullfrog (*Rana catesbeiana*) was considered an extinct species in PPNP since 1990 (Hecnar and M'Closkey, 1997), but several individuals have been recently observed and captured in the park. It is unclear whether these individuals represent a naturally colonizing propagule or were introduced, but we suspect the latter.

Active management through reducing visitor disturbances, predator control, habitat restoration, or contaminant cleanup, may help reduce extinction risk for species that persist at PPNP. However, increasing the amount of natural habitat outside the park and connection with other protected areas are likely the only ways that long-term persistence of extant species can be achieved and is necessary before repatriation can be effective (Hecnar and Hecnar, 2004). Recent land acquisitions outside the park, reduction of anthropogenic habitat in the park, and preliminary discussions on increasing connectivity with other reserves in Essex County (e.g., Hillman Marsh Conservation Area) are encouraging.

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References

Brown, J.H. and M.V. Lomolino. 1998. *Biogeography*, *Second Edition.* Sinauer, Sunderland, Massachusetts.

Browne, C.L. 2003. *The Status of Turtle Populations in Point Pelee National Park.* M.Sc. Thesis, Lakehead University, Thunder Bay, Ontario.

Browne, C.L. and S.J. Hecnar. 2003. The status of turtles in Point Pelee National Park: species loss and shifting population structure. Pp. 293-300. In: C.J. Lemieux, J.G. Nelson and T. Beechey (Eds.) *Parks and Protected Areas Research in Ontario, 2003: Protected Areas and Watershed Management, Proceedings of the Parks Research Forum of Ontario (PRFO) Annual General Meeting, April*

25-27, 2002, Ridgetown College, Ridgetown, Ontario. Parks Research Forum of Ontario (PRFO), Waterloo, Ontario.

Crowe, A.S. 1999. Distribution and persistence of DDT at Point Pelee National Park. Pp. 379-387. In: N. Pollock-Ellwand, K. Van Osch and J.G. Nelson (Eds.) *Parks and Protected Areas Research in Ontario: Proceedings of the Parks Research Forum of Ontario (PRFO) Annual General Meeting, April 22-23, 1999.* Guelph, Ontario.

Diamond, J.M. 1972. Biogeographic kinetics: estimation of relaxation times for avifaunas of Southwest Pacific Islands. *Proceedings of the National Academy of Sciences, USA* 69(11): 3199-3203.

Hanski, I. 1999. *Metapopulation Ecology*. Oxford University Press, U.K.

Hecnar, S.J. and D.R. Hecnar. 2004. *Feasibility of Repatriation of Extirpated Herptiles to Point Pelee National Park*. Draft Final Report of Contract CR02-51, Parks Canada, Ottawa, Ontario.

Hecnar, S.J. and R.T. M'Closkey. 1996. Regional dynamics and the status of amphibians. *Ecology* 77(7): 2091-2097.

Hecnar, S.J. and R.T. M'Closkey. 1997. Changes in the composition of a ranid frog community following bullfrog extinction. *American Midland Naturalist* 137(1): 145-150.

Hecnar, S.J. and R.T. M'Closkey. 1998. Effects of human disturbance on five-lined skink (*Eumeces fasciatus*) abundance and distribution. *Biological Conservation* 85(3): 213-222.

Janzen, D.H. 1983. No park is an island: interference from outside increases as park size decreases. *Oikos* 41(3): 402-410.

King, R.B., M.J. Oldham, W.F. Weller and D. Wynn. 1997. Historic and current amphibian and reptile distributions in the island region of western Lake Erie. *American Midland Naturalist* 138(1): 153-173.

Klemens, M.W. 2000. *Turtle Conservation*. Smithsonian Institution Press, Washington, D.C.

Marsh, D.M. and P.C. Trenham. 2001. Metapopulation dynamics and amphibian conservation. *Conservation Biology* 15(1): 40-49.

NHIC (Natural History Information Centre). 2004. *Natural History Information Centre, Ontario Herpetofaunal Summary Atlas*. Available at: http://www.mnr.gov.on.ca/MNR/nhic/herps/ohs.html

Pough, F.H., R.M. Andrews, J.E. Cadle, M.L. Crump, A.H. Savitzky and K.D. Wells. 2004. *Herpetology, Third Edition*. Pearson Prentice Hall, Upper Saddle River, New Jersey.

Rosenzweig, M.L. 1995. *Species Diversity in Space and Time*. Cambridge University Press, Cambridge, U.K.

Russell, R.W., S.J. Hecnar and G.D. Haffner. 1995. Organochlorine pesticide residues in Southern Ontario spring peepers. *Environmental Toxicology and Chemistry* 14(5): 815-817.

Russell, R.W., S.J. Hecnar, G. Mouland and G.D. Haffner. 1999. Pesticide accumulation in Point Pelee Amphibians. Pp. 371-376. In: N. Pollock-Ellwand, K. Van Osch and J.G. Nelson (Eds.) *Parks and Protected Areas Research in Ontario, 1999: Proceedings of the Parks Research Forum of Ontario (PRFO) Annual General Meeting, April 22-23, 1999, Guelph, Ontario*. Parks Research Forum of Ontario (PRFO), Waterloo, Ontario.

Shafer, C.L. 1990. *Nature Reserves: Island Theory and Conservation Practice.* Smithsonian Institution Press, Washington, D.C.

Smith, M. and H. Bishop. 2002. Red cedar savanna: a disappearing habitat at Point Pelee National Park. Pp. 283-292. In: C.J. Lemieux, J.G. Nelson and T. Beechey (Eds.) *Parks and Protected Areas Research in Ontario, 2003: Protected Areas and Watershed Management, Proceedings of the Parks Research Forum of Ontario (PRFO) Annual General Meeting, April 25-27, 2002, Ridgetown College, Ridgetown, Ontario*. Parks Research Forum of Ontario (PRFO), Waterloo, Ontario.

Soulé, M.E. 1987. *Viable Populations for Conservation*. Cambridge University Press, Cambridge, U.K.

Willis, E.O. 1974. Populations and local extinctions of birds on Barro Colorado Island, Panama. *Ecological Monographs* 44(2): 153-169.