Road Mortality of Amphibians, Reptiles and Other Wildlife on the Long Point Causeway, Lake Erie, Ontario

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Ashley, E. Paul, and Jeffrey T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point causeway, Lake Erie, Ontario. Canadian Field-Naturalist 110(3): 403–412.

Wildlife road mortality on a 3.6 km section of a two-lane paved causeway adjacent to Big Creek National Wildlife Area on Lake Erie was censused from spring to autumn for two 2-year periods, 1979-1980 and 1992-1993. Total recorded mortality exceeded 32 000 individuals, the majority being young of the year Leopard Frogs. One hundred vertebrate species were recorded, 7 amphibians (n = 30 034), 10 reptiles (n = 864), 21 mammals (n = 282) and 62 birds (n = 1302). Amphibian (Leopard Frog, Bullfrog, Green Frog, American Toad) and reptile (Painted Turtle, Snapping Turtle, Blanding's Turtle and Garter Snake) mortality showed seasonal patterns consistent with life history phenology. Amphibian mortality was significantly associated with adjacent roadside vegetation and turtle road mortality with adjacent open water areas ($P \leq 0.05$). Factors that influence herpetofaunal road mortality and management options for reducing mortality on the causeway are discussed.

Key Words: amphibians, reptiles, mammals, birds, mortality, road, causeway, vehicle, wetland.

Roads, once restricted by topography, now traverse almost any terrain. Far from being innocuous features of the landscape, roads affect wildlife by altering and isolating habitat (Mader 1984; Foster 1992) and populations (Reh 1989), deterring the movement of wildlife (Garland and Bradley 1984; Mader 1984; Dalrymple and Reichenbach 1984) and promoting extensive wildlife mortality (Oxley et al. 1974; Gelder 1973; Case 1978; Rosen and Lowe 1994). This is perhaps most evident when roads are constructed through wetlands.

In Ontario, highway 59 crosses the eastern edge of the Big Creek National Wildlife Area (BCNWA) on the north shore of Lake Erie along a 3.6 kilometre raised earth asphalt causeway, joining the mainland to the Long Point peninsula (Figure 1). The causeway cuts across the wetland-bay continuum and divides the habitat of many wetland species. Many amphibians, reptiles, birds and mammals of the adjacent Big Creek wetland are killed on the road. Some animals are simply trying to cross to habitat on the other side whereas others make use of the habitat and conditions created by the road and roadbed. The vast majority of the annual road mortality on the causeway are amphibians and reptiles. These species migrate along and across the highway seasonally to find suitable foraging, breeding, nesting and overwintering sites, while at other times they use roadside habitat itself. Some species also use the highway for thermoregulation. Roadways also attract birds and mammals where they find digestive grit, water puddles, food, nesting sites (Dhindsa et al. 1988) and dispersal corridors (Getz et al. 1978; Huey 1941).

To investigate the extent of this mortality, censuses were performed by the Canadian Wildlife Service (CWS) in 1979 and 1980 and again in 1992 and 1993. In this paper we report the vehicular induced road mortality, and for amphibians and reptiles identify habitats associated with significant crossing areas and discuss seasonal patterns of road mortality.

Study Area

The Big Creek wetland is part of a 1200 ha wetland west of highway 59 at the head of Long Point Bay on Lake Erie, Regional Municipality of Haldimand-Norfolk, centred at 42°35′15″ N, 80°27′30″ W. The wetland is shallow and dominated by Bluejoint Grass (*Calamagrostis canadensis*) and Sedges (*Carex* spp.). Deeper water emergents are found around large ponds within the wetland.

Since 1973 the eastern 600 ha of the wetland has been managed by the Canadian Wildlife Service of Environment Canada as the Big Creek National Wildlife Area (BCNWA). In 1982 the Long Point wetlands were designated as a Ramsar site identifying them as "Wetlands of International Importance". The Long Point ecosystem was designated as a World Biosphere Reserve by the Man and the Biosphere Program of UNESCO in 1986.

This ecosystem provides habitat for 34 species of amphibians and reptiles (Gartshore 1987). Two herptiles found at BCNWA, the Spotted Turtle (*Clemmys guttata*) and the Fowler's Toad (*Bufo woodhousii fowleri*) are listed as "vulnerable" by the Committee on the Status of Endangered Wildlife in Canada. (COSEWIC 1986). Provincially significant populations of Blanding's Turtles (*Emydoidea blandingi*) and Fox Snake (*Elphae vulpina gloydi*) are also found in the wetland.

In 1926 a two-lane causeway was constructed on earth fill, providing road access to the Long Point peninsula. Since then, the highway has been raised to 1.5 metres above mean summer lake level. Two of three original bridges have been eliminated by fill. The remaining bridge spans Big Creek near its mouth. The causeway is paved, 7 m wide with 1 m gravel shoulders. Undeveloped sections of the causeway are protected by concrete rubble and rock. The posted speed limit is 70 km/hr.

Since the early study (1979-1980) there has been increased development along sections of the causeway and the Big Creek wetland has undergone major structural changes (Table 1). To create a more diverse wetland, 89 ha of the wetland were impounded by a dyke system in 1985. Approximately 1400 metres of the dyke and borrow ditch parallels the causeway, fifty metres west of the highway.

To document the influence of localized roadside habitat on road mortality, the causeway was subdivided into five sampling sections, labelled A - E (Figure 1). These sections correspond to zones of development and habitat along the causeway. The roadside habitat was mapped in 1979 and again in 1992 to document changes in vegetation and development. The total length of the sampled section of the causeway is 3.56 km.

Methods

Road-Kill Count

The causeway was surveyed by walking or bicycling along the shoulder every Monday, Wednesday and Friday beginning in April (except 1979 when sampling began in June) and concluding at the end of October. All carcasses found between the outer shoulders of the road were recorded. The species, location along the causeway, and age (adult or after hatching year, immature or hatch year) were recorded if possible. If identification was not possible, then the lowest taxonomic group was recorded. Specimens were removed to avoid later duplication.

Identification of road-kills can be difficult due to deterioration of carcasses by traffic and weather. The category of "unidentified anurans" is comprised largely of specimens that were either small Bullfrogs (*Rana catesbeiana*) or Green Frogs (*Rana clamitans*) and toads that were either Common (*Bufo americanus americanus*) or Fowler's as well as Chorus Frogs (*Pseudacris triseriata triseriata*), Gray Treefrogs (*Hyla versicolor*) and possibly Spring Peepers (*Pseudacris crucifer*). This data does not fully represent the total road mortality during the period studied as road-killed furbearers Mink (*Mustela vison*), Raccoon (*Procyon lotor*) and Muskrat (*Ondatra zibethica*) are occasionally removed for their pelts, birds for study skins and Bullfrogs for their legs. Scavengers also feed on carcasses along the causeway.

Traffic volume information, expressed as average summer daily (24 hour) two-way traffic was obtained from Ontario Ministry of Transportation. Associations of road mortality between road segments were tested using Chi square tests with expected frequencies adjusted to compensate for the differing lengths of road.

Results and Discussion

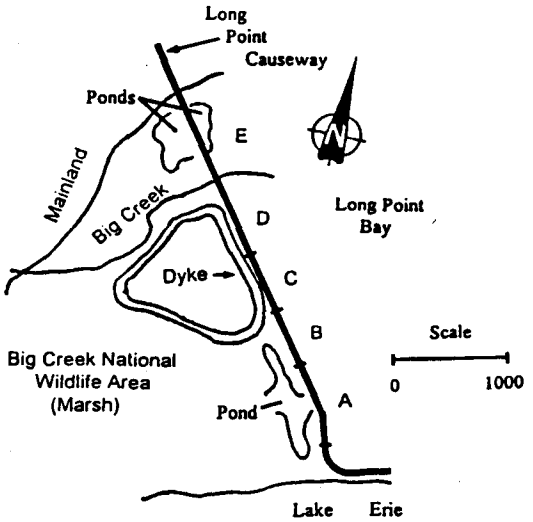
Species Composition of Road Mortality

One-hundred vertebrate species were identified: 7 amphibian, 10 reptiles, 21 mammals and 62 birds. All known species of amphibian and reptiles endemic to the Big Creek Wetland except Spring Peeper, Wood Frog (*Rana sylvatica*) and the aquatic Mudpuppy (*Necturus maculosus*) were recorded during the study. Of the 25 species of mammals known to inhabit BCNWA (McKeating and Dewey 1984), 20 were encountered as road mortalities. One feral cat (*Felis domesticus*) was also found. Those species not recorded as road mortalities are the Norway Rat (*Rattus norvegicus*), Red Fox (*Vulpes vulpes*), Coyote (*Canis latrans*), Striped Skunk (*Mephitis mephitis*) and White-tailed Deer (*Odocoileus virginianus*). More than 300 species of birds seasonally migrate through the area and 80 seasonally nest in BCNWA (McCracken 1979).

Total observed road mortality over the four years exceeded 32 000 individuals, 27 846 (85.4%) being Leopard Frogs. Amphibians accounted for 92.1% of the total road mortality, reptiles 2.7%, birds 4.3%, and mammals 0.9%. (Table 1)

Road mortality of birds was much higher in 1979 than the other three years. Of note is the decline in Red-winged Blackbirds (*Agelaius phoeniceus*) and Long-billed Marsh Wrens (*Cistothorus palustris*). Some of this apparent decline may be explained by the higher percentage of unidentified birds in the latter studies. Trends for the other species groups were not as evident. One species, the Opossum (*Didelphis marsupialis*) appears to have expanded its range into the Long Point area in the interval between the studies. None were recorded during the early study, but 19 were recorded during 1992 and 1993.

Wetlands are one of the most dynamic, productive and diverse of all natural systems, consequently roads through them can be particularly detrimental to habitat and wildlife. A comparison between this study and one performed by Oxley et al. (1974) shows much lower road mortality/km/sampling day for all groups along sections of highways 7A and 7B in the counties of Frontenac, Lanark, Leeds and Russell that border mixed hardwood forest in southeastern Ontario. Over the four-year (716 day) study period between the months of April and October road mortality on the causeway averaged the following: 11.65 amphibians/km/day, 0.34 reptiles/km/day, 0.51 birds/km/day and 0.11 mammals/km/day. In



Legend:

Section	Length (m)	Current habitat west side	Current habitat east side	Change since initial survey
A	816	dominated by bluejoint grass, sedges, bulrush and cattails; 250 m is an open pond adjacent to the road	three marinas occur along this segment with no natural habitat remaining.	yes, east side has had development of a trailer park on former wetlands
B	627	dominated by cattail and bluejoint grass	open water with scattered cattail and bulrush along the shoreline	no
C	662	cattail dominated wetland community with deep borrow ditch 50-70 m from the roadway which parallels a dike	cattail and bulrush community extending 30 m into the water	yes, west side has had diking for marsh management activity
D	1453	similar to C above	half of this segment has cottage development. Remaining areas are cattail dominated	yes, west as above and east side has seen some new cottage construction and installation of vertical steel breakwalls
E	728	10 m of cattails extends into shallow pond along the entire segment	bordered by a diked cattail marsh with a channel running parallel with the road 30 m into the marsh. A small open pond is adjacent to the road at the north end of this segment	no

FIGURE 1. Map of Point causeway sampling sections.

TABLE 1. Road mortality on the Long Point causeway over a four year period.

Amphibians		1979	1980	1992	1993
Northern Leopard Frog	*Rana pipiens*	9172	10753	445	7476
Bullfrog	*Rana catesbeiana*	576	514	101	154
Green Frog	*Rana clamitans*	12	19	26	10
Western Chorus Frog	*Pseudacris triseriata triseriata*	0	0	12	0
Gray Treefrog	*Hyla versicolor*	0	0	4	11
American Toad	*Bufo americanus americanus*	164	55	83	131
Fowler's Toad	*Bufo woodhousii fowleri*	12	16	0	1
Unidentified Anurans		104	109	40	34
Total Amphibians		10040	11466	711	7817
Reptiles					
Painted Turtle	*Chrysemys picta marginata*	95	74	93	79
Spotted Turtle	*Clemmys guttata*	1	0	7	9
Snapping Turtle	*Chelydra serpentina*	75	74	45	78
Blanding's Turtle	*Emydoidea blandingii*	19	7	17	18
Map Turtle	*Graptemys geographica*	12	5	2	6
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	26	43	13	32
Northern Water Snake	*Nerodia sipedon*	4	2	0	2
Fox Snake	*Elaphe vulpina gloydi*	5	13	3	3
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	0	1	0	0
Northern Ribbon Snake	*Thamnophis sauritus septentrionalis*	0	0	0	1
Total Reptiles		237	219	180	228
Birds					
Tree Swallow	*Iridoprocene bicolor*	19	11	12	18
Barn Swallow	*Hirundo rustica*	40	20	2	3
Rough-winged Swallow	*Stelgidopteryx ruficollis*	0	0	2	0
Cliff Swallow	*Petrochelidon pyrrhonota*	0	0	12	1
Bank Swallow	*Riparia riparia*	13	6	75	18
Purple Martin	*Progne subis*	11	10	13	2
House Sparrow	*Passer domesticus*	13	19	1	1
White-throated Sparrow	*Zonotrichia albicollis*	2	5	2	0
Song Sparrow	*Melospiza melodia*	2	0	2	3
Swamp Sparow	*Melospiza georgiana*	53	8	10	1
Savanah Sparrow	*Passerculus sandwichensis*	0	1	1	0
Chipping Sparrow	*Spizella passerina*	0	0	0	1
House Finch	*Carpodacus mexicanus*	0	0	0	2
Long-billed Marsh Wren	*Cistothorus palustris*	35	14	3	6
Cedar Waxwing	*Bombycilla cedrorum*	3	1	0	0
Hermit Thrush	*Catharus guttatus*	0	1	0	0
Swainson's Thrush	*Catharus ustulatus*	1	0	0	0
American Robin	*Turdus migratorius*	4	8	10	3
Brown Thrasher	*Toxostoma rufum*	4	1	1	0
Gray Catbird	*Dumetalla carolinensis*	0	2	1	0
European Starling	*Stumus vulgaris*	51	26	39	16
Common Grackle	*Quiscalus quiscula*	25	11	0	0
Brewer's Blackbird	*Euphagus cyanocephalus*	0	0	0	1
Red-winged Blackbird	*Agelaius phoeniceus*	142	67	8	11
Common Yellowthroat	*Geothlypis trichas*	9	4	0	0
Northern Oriole	*Icterus galbula*	1	0	0	0
Brown-headed Cowbird	*Molothrus ater*	1	0	0	0
Yellow-shafted Flicker	*Colaptes auratus*	1	1	0	1
Mourning Dove	*Zanaida macroura*	0	1	0	0
Rock Dove	*Columba livia*	0	1	0	0
Yellow-billed Cuckoo	*Coccyzuz americanus*	0	1	0	0
Black-billed Cuckoo	*Coccyzus erythropthalmus*	2	1	0	0
Eastern Kingbird	*Tyrannus tyrannus*	5	4	1	0
Willow Flycatcher	*Empidonax traillii*	0	0	1	0
Slate-colored Junco	*Junco hyemalis*	0	0	0	1
Eastern Wood Pewee	*Contopus virens*	0	2	0	0
Common Nighthawk	*Chordeiles minor*	1	0	0	0

Continued

TABLE 1. *Concluded*

Birds		1979	1980	1992	1993
Common Gallinule	*Gallinula chloropus*	3	0	0	0
American Coot	*Fulica americana*	0	1	0	0
Killdeer	*Charadrius vociferus*	5	5	0	0
Semi-palmated Sandpiper	*Calidris pusilla*	2	0	0	0
Mallard	*Anas platyrhynchos*	9	0	0	0
Wood Duck	*Aix sponsa*	0	1	0	0
Canada Goose	*Branta canadensis*	0	0	7	0
Common Merganser	*Mergus merganser*	0	0	0	0
Common Snipe	*Capella gallinago*	1	1	0	0
Sora	*Porzana carolina*	1	2	2	0
Clapper Rail	*Rallus longirostris*	0	0	0	1
Virginia Rail	*Rallus limicola*	2	2	0	0
Short-billed Dowitcher	*Limnodromus griseus*	1	0	0	0
Ring-billed Gull	*Larus delawarensis*	0	0	0	2
Belted Kingfisher	*Megaceryle alcyon*	1	0	0	0
Palm Warbler	*Dendrocia palmarum*	0	1	0	0
Myrtle Warbler	*Dendrocia coronata*	0	1	0	0
Yellow Warbler	*Dendrocia petechia*	2	3	8	6
Northern Waterthrush	*Seiurus noveboracensis*	0	0	0	1
American Goldfinch	*Carduelis tristis*	0	1	2	2
Golden-crowned Kinglet	*Regulus satrapa*	4	0	0	0
Least Bittern	*Ixobrychus exilis*	1	1	2	1
American Bittern	*Botaurus lentiginosus*	0	1	0	0
Saw-whet Owl	*Aegolius acadicus*	0	0	2	0
Domestic Chicken	*Gallus gallus*	0	1	0	0
Unidentified Birds		32	40	70	106
Total Birds		502	287	289	224
Mammals					
Opossum	*Didelphis marsupialis*	0	0	12	7
Short-tailed Shrew	*Blarina brevicauda*	5	7	0	2
Star-nosed Mole	*Condylura cristata*	0	1	0	0
Little Brown Bat	*Myotis lucifugus*	1	0	1	0
Red Bat	*Lasiurus borealis*	4	0	0	0
Long-tailed Weasel	*Mustela frenata*	9	1	0	1
Short-tailed Weasel	*Mustela erminea*	11	1	1	0
Mink	*Mustela vison*	6	10	14	11
Woodchuck	*Marmota monax*	0	0	3	2
Raccoon	*Procyon lotor*	0	2	13	3
American Red Squirrel	*Tamiasciurus hudsonicus*	0	0	1	0
Eastern Chipmunk	*Tamias striatus*	0	0	0	1
Eastern Gray Squirrel	*Sciurus carolinensis*	0	0	1	0
Meadow Jumping Mouse	*Zapus hudsonius*	26	7	10	0
Deer Mouse	*Peromyscus maniculatus*	0	7	9	1
House Mouse	*Mus musculus*	0	0	0	1
White-footed Mouse	*Peromyscus leucopus*	3	0	0	0
Meadow Vole	*Microtus pennsylvanicus*	23	13	12	9
Muskrat	*Ondatra zibethica*	2	1	1	2
Eastern Cottontail	*Sylvilagus floridanus*	2	2	2	1
Domestic Cat	*Felis domesticus*	1	0	0	1
Mouse spp.		0	5	9	11
Unidentified Mammals		0	9	0	1
Total Mammals		93	66	89	54
Total Road Mortality		10872	12038	1269	8323

Census Dates:
1979: 8 June - 26 October; 1980: 18 April - 31 October; 1992: 27 April - 30 October; 1993: 16 April - 28 October.

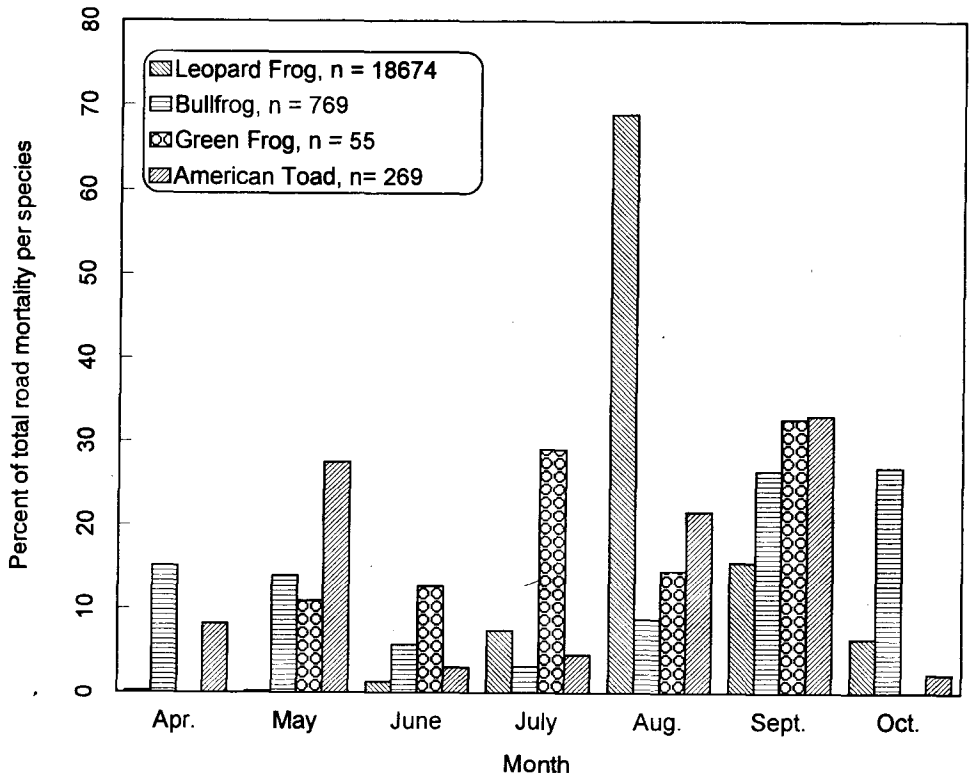


FIGURE 2. Monthly road mortality of selected amphibians on the Long Point causeway as a percent of total road mortality per species, 1980, 1992, 1993 (1979 data excluded).

comparison, over a 116 day period between 1 June and 18 September 1972 Oxley et al. (1974) observed road mortality at the following rates: 0.02 amphibians/km/day (< 1% of our average), 0.03 reptiles/km/day (9%), 0.03 birds/km/day (5%) and 0.04 mammals/km/day (36%).

Of wildlife groups most associated with wetlands, amphibians and reptiles are especially vulnerable to road mortality. Compared to homeothermic animals they are characteristically slow and not cognizant of the danger presented by passing vehicles. Certain species are more vulnerable to road mortality along the causeway than others. Short-lived species producing many young have by far the greatest number of annual road mortality. Within this group, some species are more likely victims of road mortality than others. Critical factors include use of roadside habitat found along and adjacent to the causeway and life histories. For example, Chorus Frogs and Spring Peepers are heard in high numbers along sections A and B in the spring but comprise a relatively small proportion of the overall amphibian road mortality.

The only amphibian species encountered regularly were the Leopard Frog, Bullfrog, Green Frog and American Toad. Very high counts of Leopard Frog road mortality were recorded in 1979, 1980 and 1993. Road mortality for 1992 Leopard Frogs and Bullfrogs was comparatively very low but Leopard Frog numbers in 1993 increased to counts comparable to earlier surveys. Bullfrogs showed a slight increase in 1993 but were still less than 30% of the counts recorded during the 1979 - 1980 study. Counts of American Toads followed a similar trend to that of Leopard Frogs. The observed low counts of Leopard Frog road mortality and many other amphibians and reptiles in 1992 are indicative of poor spawning or recruitment success in a previous year. Alternatively, a shortened dispersal period occurring during periods of lesser traffic volume may also be responsible for the low numbers.

Road mortality of reptiles remained relatively constant over the four-year study period with the exception of the Spotted Turtle (n = 17) which increased from 1 in 1979 to 9 in 1993. This pattern coincides with observations that indicate that the local population is increasing. The most common reptile road mortality was the Painted Turtle (*Chrysemys picta marginata*) (n = 341), followed by the Snapping Turtle (*Chelydra serpentina*) (n = 272). The Spotted,

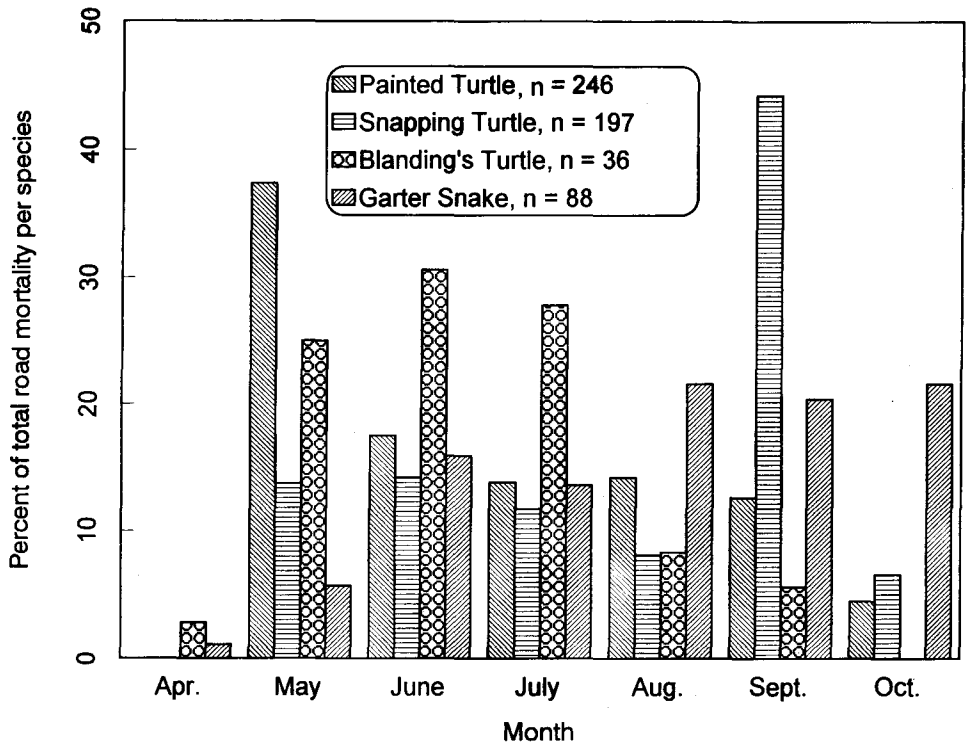


FIGURE 3. Monthly road mortality of selected reptiles on the Long Point causeway as a percent of total road mortality per species 1980, 1992, 1993 (1979 data excluded).

Blanding's and more aquatic Map Turtle (*Graptemys geographica*) had lower road mortality although the populations of these latter species do not appear as high as the Painted and Snapping Turtles. The most common snake road mortality was the Eastern Garter Snake (*Thamnophis sirtalis sirtalis*) (n = 114). Annual road mortality of both Garter Snake and Fox Snake were the greatest in 1980.

An important factor in the composition of road mortality is the time of day the causeway is occupied by wildlife. Mature reptiles tend to occupy the causeway during the afternoon, which increases the likelihood of collisions, especially species that bask on the highway and use it as a thermoregulatory source. Conversely most amphibian migration across the causeway occurs at night when use by motorists is at a daily minimum.

Several studies have addressed the issue of traffic volume on anuran population densities. A study of the breeding migration of the Common Toad (*Bufo bufo*) by van Gelder (1973) estimated that 60 cars/hour passing by his site would kill ninety percent of the adult toads during breeding migration. Reh and Seitz (1990) report two other studies on the impact of road mortality on the Common Toad. In the first, Kuhn (1987) found that 50% of the migrating toads at his site were killed at a traffic volume of 24 - 40 cars per hour, and Heine (1987) concluded that a rate of 26 cars per hour passing by his site would kill all migrating toads. Even along lightly travelled roadways adjacent to wetlands Palis (1994) found road mortality of amphibians to be high. Average daily two-way traffic volume on the causeway during the summer months increased 9% from 2800 in 1978 to 3050 in 1992. With a summer daily traffic volume on the causeway in 1992 of 127 cars per hour it is most probable that some anuran populations are experiencing a significant negative effect.

Seasonal Patterns of Mortality

In general, wildlife road mortality on the causeway follows the observed trend of seasonal highs in the spring and autumn (Case 1978). Mortality patterns of amphibians are readily explained by the life history pattern of each species; particularly reproduction and dispersal. Total road mortality of the four dominant amphibian and reptile species compiled monthly for the years 1980, 1992, 1993 show unimodal and bimodal patterns (Figure 2). Because sampling began in June of 1979, that year's data were excluded. Leopard Frog road mortality is unimodal. The first road mortality appeared in April,

possibly a consequence of the low annual count. Annual road mortality/km of amphibians occurred comparatively less often in section E of the causeway over the four-year period (Table 2). The ends of the causeway, (A and E) with adjacent shallow ponds produced the majority of turtle road mortality. Section B characterized by shallow water emergents (Bluejoint, Sedge) consistently produced the lowest turtle road mortality on the adjacent causeway.

A chi-square comparison of the spatial distribution of road mortality along the causeway of the most frequently occurring amphibian and reptilian species showed significant ($p \leq 0.05$) differences between the 1979-1980 study and the 1992-1993 study except Snapping Turtles in section E. When the impoundment and dyke were constructed along sections C and D in 1985, the borrow ditch along the dyke improved water circulation and increased water depth between the dyke and the causeway. The vegetation community responded by shifting from a shallow wetland community dominated by Bluejoint and *Carex* to a deeper water community dominated by Cattail. This change in community structure altered the species composition of amphibians and reptiles along these sections of the causeway.

Use of this area (C and D) by the semi-terrestrial Leopard Frog appears to have decreased as indicated in the reduction of road mortality. With less Leopard Frog habitat adjacent to the causeway those sections possessing drier wetland adjacent to the causeway (A and B) produced the majority of road mortality in the latter study. The change in habitat created more favourable conditions for the more aquatic Bullfrog and corresponding road mortality increased. Both the Painted Turtle and the Snapping Turtle showed significant ($P \leq 0.05$) increases in road mortality in section C and decreases in section D in the latter study period. The borrow ditch and dyke in this section created overwintering and nesting sites for turtles in this area of the wetland.

Management Considerations

The most important aspect of this study is the clear demonstration that, compared to other habitats, road mortality along the causeway (and presumably along all wetlands) is very high. Assessing the impact of road mortality on fluctuating wildlife populations is often difficult (van Gelder 1973; Langston 1989). Recently, Fahrig et al. (1995) studied several disparate populations of anurans under different intensities of traffic volume and concluded that road mortality has a significant negative effect on the density of local anuran populations. Some wildlife populations along the causeway are probably being depressed through the added mortality presented by the road, while road mortality in other populations may have little effect. Such uncertainty underscores the need for continued long term monitoring and the cautious interpretation of short-term data, but should not curtail current conservation efforts. Reducing amphibian and reptile road mortality has focused on identifying why and where certain species are crossing the causeway. In response, several experimental initiatives have been implemented, including drift fencing leading to a culvert, alternative nesting sites for turtles, and erection of wildlife crossing signs.

Acknowledgments

We are indebted to the following individuals who walked many kilometres and scraped thousands of animals off the causeway: Carol Flynn, Josephine MacLean, Susan Purves, Mary Young, Jane Ashenden, Frank Hubbs, Jon McCracken, Will Fick, Ron Walker, Lori Stewart, Rick Tiegrob, Jess Deming, Garth Herring, Matthew Brock, Holly Vanhuen. Funding for the earlier studies was through the Summer Youth Employment Program. Surveys in 1992 and 1993 were funded through the Environmental Youth Corps Program of the Ontario Ministry of Natural Resources. Thanks also to the reviewers who provided many excellent suggestions.

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Received 23 May 1995
Accepted 25 April 1996