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Spatial and Temporal Patterns in Amphibians and Reptiles Found on Roads in Canada Revealed Through Community Science Data

David C. Seburn[1,3] and Reta L. Meng[2]

[1]*Canadian Wildlife Federation, 350 Michael Cowpland Drive, Ottawa, Ontario K2M 2W1, Canada*
[2]*Department of Biology, McMaster University, 1280 Main Street West, Hamilton, Ontario L8S 4L8, Canada*
[3]*Corresponding author, e-mail: davids@cwf-fcf.org*

***Abstract.*—Road mortality is a major concern for the viability of wildlife populations worldwide, particularly for amphibians and reptiles due to their life-history traits, slow movement, and strong site fidelity. Standardized road mortality surveys provide detailed temporal and spatial roadkill trends but are geographically limited and require significant personnel and time commitments. Community science datasets offer an alternative for examining trends at a national level. We obtained data from the Canadian Amphibians and Reptiles on Roads project from iNaturalist Canada. The data spanned from 1978–2024, and contained 21,214 geo-referenced observations from 2,890 contributors, including observations of 13 salamander, 20 anuran, four lizard, eight turtle, and 23 snake species alive or dead on roads. Reptiles accounted for 81% of records, with significantly more turtle than snake observations. The Painted Turtle (*Chrysemys picta*) was the most common species on roads. Our analysis revealed strong spatial biases, with sampling hotspots concentrated in southern Ontario and southern British Columbia. Temporally, turtle observations peaked in June, snakes in September, and both salamanders and anurans in April and October. Despite spatial biases and observer variability, this dataset provides nationwide insights into amphibian and reptile patterns on roads in Canada. Our study is the first to summarize Canada-wide road patterns in herpetofauna using community science data, highlighting the importance of unstandardized, volunteer-driven data collection. While observer biases and data quality issues persist, advances in open-source data collection methods can improve large-scale wildlife monitoring and mitigation strategies.**

Key Words.—community-based monitoring; herpetofauna; iNaturalist; road ecology; wildlife-vehicle collisions

Introduction

Anthropogenic stressors increasingly threaten global biodiversity, with road mortality emerging as a significant driver of population declines (Grilo et al. 2021). Roadways fragment habitats, cause habitat loss, restrict wildlife movement, and expose animals to fatal collisions (Forman et al. 2003). These impacts disproportionately affect reptiles and amphibians due to their movement patterns, habitat requirements, and life-history traits, potentially leading to population declines (Andrews et al. 2008; Rytwinski and Fahrig 2012; Winton et al. 2020; Pinto et al. 2024). Turtles are particularly vulnerable to population declines from road mortality due to their delayed sexual maturity and low fecundity (Congdon et al. 1993). Nesting females are especially prone to road mortality, which can lead to male-biased populations and reduced viability (Gibbs and Shriver 2002; Aresco 2005; Piczak et al. 2019). Snakes and lizards also suffer high mortality rates, as they frequently use road surfaces for thermoregulation and movement (Santos et al. 2011; Wagner et al. 2021). Additionally, intentional vehicle strikes further increase snake mortality (Ashley et al. 2007). Amphibians face similar risks, especially during mass annual migrations from or to breeding sites. Their small size, delicate skin, and poor visibility to drivers result in extremely low survival rates after collisions (Hels and Buchwald 2001; Gibbs and Shriver 2005). Given the conservation implications of road mortality, systematic wildlife roadkill monitoring is essential for identifying species most affected by roads, locating mortality hotspots, and informing mitigation strategies, while also providing broader insights into population trends, species distributions, and animal behavior (Schwartz et al. 2020).

Canada supports diverse reptile and amphibian populations, with 46 native amphibian species (24 anurans and 22 salamanders) and 38 native reptile species (excluding sea turtles), including 25 snakes, eight freshwater turtles, and five lizards (https://inaturalist.ca/observations?place_id=6712&view=species). With a land mass of about 10 million km² and over

1 million km of roads (https://tc.canada.ca/en/corporate-services/transparency/corporate-management-reporting/transportation-canada-annual-reports/transportation-canada-2023/road-system), monitoring nation-wide road mortality comprehensively is both labor-intensive and constrained by capacity. To date, Canada lacks a nationwide, systematically summarized dataset on road mortality, limiting the ability to assess trends at a national scale. One promising solution is community science, which has emerged as a valuable tool for large-scale documentation of spatial and temporal wildlife patterns, including roadkill occurrences. Platforms such as iNaturalist (www.inaturalist.org) facilitate widespread data collection, enabling national-scale projects to identify high-risk areas and seasonal trends across diverse species (Shin et al. 2022; Unger 2022).

We used community science data from the iNaturalist Canada project Canadian Amphibians and Reptiles on Roads, established by the Conservation Committee of the Canadian Herpetological Society. This project includes observations of herpetofauna found alive or dead on roads. We retained alive-on-road observations, as these individuals remain at risk of mortality if not moved off the road, and their presence provides insight into movement patterns, habitat connectivity, and species most frequently encountering roads. Our objectives were to analyze spatial and temporal trends of amphibians and reptiles on roads across Canada, specifically, to investigate monthly patterns, geographic variation in sampling intensity, and identify species most affected by road mortality. By identifying high-risk species and regions, we aim to inform conservation strategies, improve mitigation measures such as road crossing structures and seasonal protections, highlight the value of community science data collection, and support future species status assessments. Our findings can help guide targeted road mortality reduction efforts, contributing to the conservation of amphibians and reptiles in Canada.

Materials and Methods

We downloaded observations from the iNaturalist Canada project Canadian Amphibians and Reptiles on Roads at the end of December 2024. Given that the data were added to the project by many people, we performed several data review and cleaning processes to reduce the risk of the dataset containing records of amphibians or reptiles that were not on roads or road shoulders. For example, filtering for the term basking revealed one observation of a turtle basking in a wetland adjacent to a road. Because this turtle may not have left the wetland, the observation was removed from the final dataset. Similarly, filtering for the term egg resulted in one observation of a frog egg mass in the water adjacent to a road. We also excluded records of depredated turtle nests along the side of roads. Not all observations had comments allowing us to screen for keywords, but the low number of invalid observations we found suggests that iNaturalist users were responsibly adding observations to the project. A few observations in this project were from the USA, usually close to the Canadian border, and were removed from our dataset manually.

Several observations lacked any photographs to confirm the identification. We opted to exclude these records from the final dataset unless the observer was known to us as someone with extensive experience with amphibians and reptiles. Not all observations could be identified to the species level given the poor condition of the dead animal. Although sometimes these observations were identified to the genus level (e.g., *Thamnophis*), we opted to collapse these records down to broad taxonomic categories (unidentified anuran, salamander, lizard, snake, or turtle) to reduce the number of categories. Additionally, some observations were identified to the species level by the observer but lacked confirmation from another iNaturalist user. Observations on iNaturalist achieve research grade status only when at least two users verify the identification. We examined all observations that lacked confirmation of the species identification. In some cases, we were able to verify the identification; however, most observations involved road-killed amphibians and reptiles in poor condition, making species-level identification impossible. These were instead classified into the appropriate unidentified categories. The Jefferson Salamander (*Ambystoma jeffersonianum*) and the Blue-spotted Salamander (*Ambystoma laterale*) are both part of a unisexual polyploid complex and were found in the dataset. Because individual species cannot be readily distinguished from unisexual polyploids in the field (Bogart 2019), we grouped these observations under *Ambystoma* complex for analysis purposes. Differences between groups were compared using a Chi-square Test. Comparisons between the number of observations of species found on roads and not found on roads were made using the non-parametric Mann-Whitney U Test. Significance for both tests was $P \leq 0.05$.

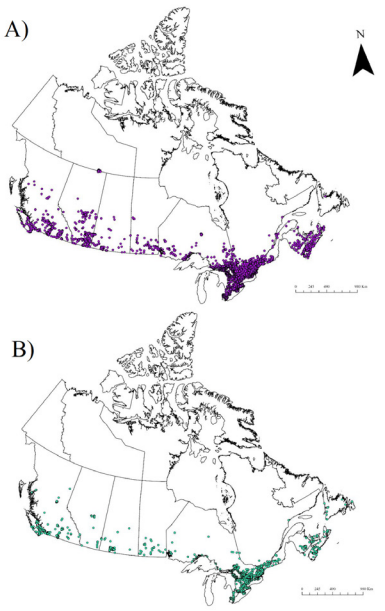

Figure 1. Spatial distribution of observations on roads in the Canadian Amphibians and reptiles on Roads Project on iNaturalist Canada, for (A) reptiles (n = 18,171) and (B) amphibians (n = 4,033).

Spatial analyses.—We generated Kernel Density maps using the Kernel Density tool in ArcGIS Pro 2.0 (Esri, Redlands, California, USA) separately for amphibians and reptiles. First, we created nationwide maps for both groups to visualize national hotspots and spatial sampling bias. We then produced provincial maps across the 10 provinces and one territory of Canada that had observations to assess spatial bias at a finer scale. The primary goal of this analysis was to visualize spatial sampling intensity. Due to a strong spatial bias toward southern Ontario, the national-scale map lacked a detailed representation of other regions. Similarly, provincial and territorial maps lacked meaningful hotspots due to small sample sizes. Consequently, we retained only the maps focused on southern Ontario and southwestern British Columbia, the two regions with the highest observation counts.

iNaturalist obscures the locations of some species of conservation concern, by mapping a random point in a grid cell 0.2 × 0.2 degrees, roughly 20 × 20 km, depending upon the latitude of the observation (https://help.inaturalist.org/en/support/solutions/articles/151000169938-what-is-geoprivacy-what-does-it-mean-for-an-observation-to-be-obscured). Given this lack of spatial accuracy, we did not conduct analyses on correlations between observations on roads and habitat characteristics. Instead, we used spatial analysis outputs to visually identify potential sampling hotspots.

Temporal analyses.—To conduct temporal analyses of monthly reptile and amphibian observation trends, we first summarized all species level observations. We conducted analyses at the species level in this study, as geographic boundaries between subspecies are not always clear. We also excluded any species with < 50 observations to ensure that our analyses of temporal trends were robust and based on sufficient sample sizes. Due to the small sample size of lizard species, we did not create a temporal figure to avoid displaying misleading trends. We created temporal figures using the ggplot2 package in R software (R Development Core Team). Given the non-parametric nature of our dataset, we used Chi-square Tests to identify trends in monthly observation counts. This method is commonly applied to compare road mortality data across months (Shin et al. 2022; Unger 2022). We first analyzed monthly differences between reptiles and amphibians, then further divided them into taxonomic groups, including salamanders, anurans, snakes, turtles, and lizards. To assess significance, we compared the two months with the highest observation counts for each group, determining whether the top month had significantly higher observations than the second.

Results

General trends.—We found 21,214 observations of amphibians and reptiles on roads in Canada (Fig. 1). The observations were contributed by 2,890 people, with an average of 7.3 (range of values, 1–884) observations per person. While the average observer contribution was comparatively low, the top 10 individuals submitted a combined 5,106 observations, or 24.1% of the data. Of the 21,214 observations, 20,747 were identified to species. Observations spanned the years 1978–2024. Almost all records (92.1%) were from 2019 to 2024, with a maximum of 4,736 observations in 2024. The data included 13 species of salamanders, 20 species of anurans, four species of lizards (including the non-native Common Wall Lizard, *Podarcis muralis*), eight species of turtles (including the non-native Pond Slider, *Trachemys scripta*), and 23 species of snakes (Fig. 2).

There were significantly more observations of reptiles (n = 17,181) than amphibians (n = 4,033; χ^2 = 8,148.9, df = 1, $P < 0.001$). Within amphibians, there

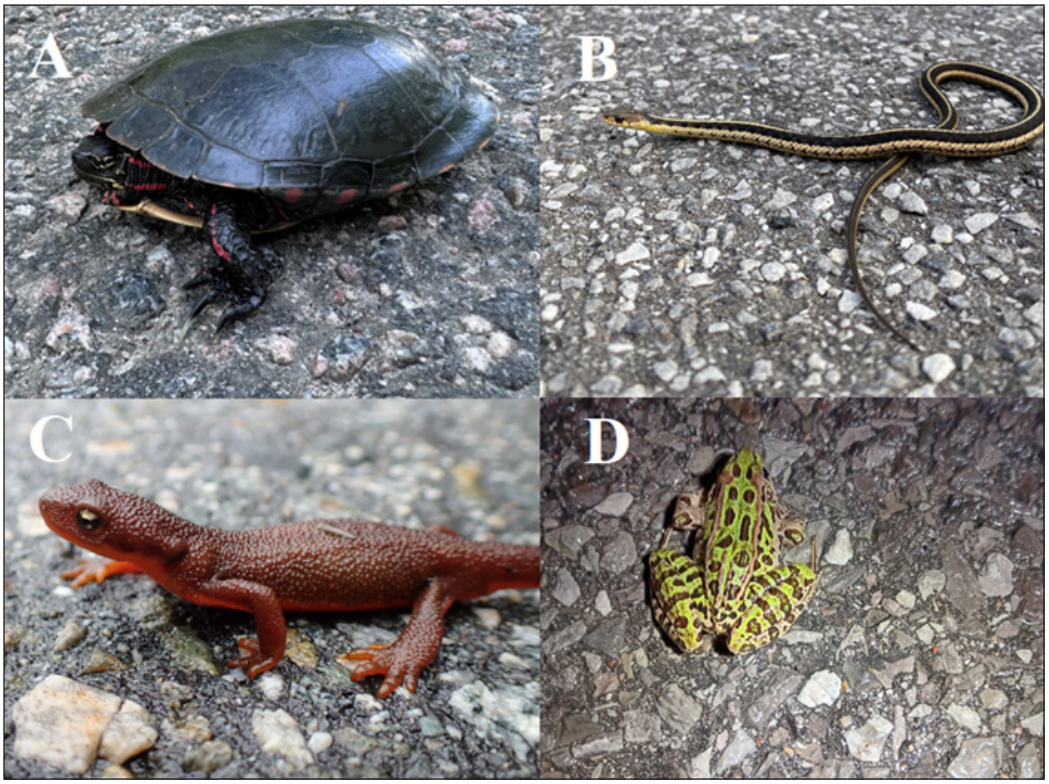

Figure 2. Examples from the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada of the most common species in the four main taxonomic categories. (A) Painted Turtle (*Chrysemys picta*); (B) Common Garter Snake (*Thamnophis sirtalis*); (C) Rough-skinned Newt (*Taricha granulosa*); and (D) Northern Leopard Frog (*Lithobates pipiens*). (Photographed by iNaturalist Canada users A, ventana; B, zookeepermcintyre; C, johndreynolds; D, davidseburn).

were significantly more anurans (n = 2,867) than salamanders (n =1,162; χ^2 = 721.5, df = 1, P < 0.001). Among reptiles, there were significantly more turtles (n = 10,036) than snakes (n = 7,106; χ^2 = 500.8, df = 1, P < 0.001; Fig. 3). There were significantly more Painted Turtles (*Chrysemys picta*; n = 4,902) found on roads than the second most common species, the Common Snapping Turtle (*Chelydra serpentina*; n = 2,500, χ^2 = 779.5, df = 1, P < 0.001). The 10 species with the most observations accounted for 75.1% of the species-level observations (15,589 of the 20,747 observations; Table 1). The majority of unidentified herpetofauna on roads were anurans (311 of 467; 66.6%).

Only five Canadian reptile species (excluding sea turtles) were not found on roads, compared with 13 amphibian species, although this difference was not significant (χ^2 = 3.55, df = 1, P = 0.059). Species found on roads had significantly more observations in general on iNaturalist Canada (median = 1,966; range of values, 12–40,260) compared with species not found on roads (median = 79, range of values, 2–933; Z = 5.33, P < 0.001). Even removing the 10 species with the most observations on roads resulted in the remaining species having significantly more observations in general (median = 1,503, range of values, 12–10,099) compared with those species not found on roads (Z = 5.03, P < 0.001).

Spatial analyses.—Observers reported amphibians and reptiles on roads from all 10 provinces and one territory (Fig. 1). Despite this, the data were strongly

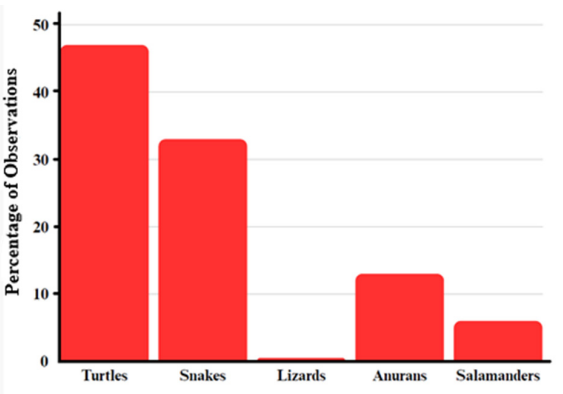

Figure 3. Percentage of observations (n = 21,214) of herpetofauna from the Canadian Amphibians and Reptiles on Roads project from iNaturalist Canada by taxonomic category.

Table 1. The 10 species of amphibians and reptiles with the most observations on roads in Canada, from the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. The letter n = number of observations on roads. The percentage of all 20,747 species level observations on roads is indicated in parentheses.

Common name	Scientific name	n (%)
Painted Turtle	*Chrysemys picta*	4,902 (23.6)
Common Snapping Turtle	*Chelydra serpentina*	2,500 (12.0)
Common Garter Snake	*Thamnophis sirtalis*	2,287 (11.0)
Blanding's Turtle	*Emydoidea blandingii*	2,037 (9.8)
Northern Leopard Frog	*Lithobates pipiens*	887 (4.3)
Common Watersnake	*Nerodia sipedon*	810 (3.9)
Red-bellied Snake	*Storeria occipitomaculata*	715 (3.4)
American Toad	*Anaxyrus americanus*	545 (2.6)
DeKay's Brownsnake	*Storeria dekayi*	501 (2.4)
Eastern Milksnake	*Lampropeltis triangulum*	405 (2.0)
Total		15,589 (75.1)

spatially biased with 82.8% of observations in Ontario compared with only 6.8% of observations in British Columbia, the province with the second most observations, and the number of observations in the two provinces differed significantly (χ^2 = 13,694, df = 1, $P < 0.001$). This spatial bias is also borne out by the observer data, with 99% of the data from the top 10 observers coming from Ontario. Similarly, considering all records of amphibians and reptiles in Canada on iNaturalist, the majority of observations were in Ontario (64.6%), with British Columbia a distant second (12.3%), and the number of observations in the two provinces differed significantly (χ^2 = 145,010, df = 1, $P < 0.001$).

We detected three spatially biased sampling regions for reptiles in Ontario: the eastern shoreline of Georgian Bay, the Greater Toronto area, and the Kingston to Ottawa area (). For amphibians, fewer observations were recorded, but the same three sampling regions emerged. In British Columbia, observations were concentrated in the southwestern region. A region with high spatial sampling bias for reptiles was found in the Okanagan Valley near the city of Kelowna, with a smaller sampling region that was highly sampled located to the east of the Okanagan Valley, and additional scattered hotspots on the southern tip of Vancouver Island (Fig. 4). Amphibian observations in British Columbia were also fewer than those for reptiles, with a small region with high spatial sampling bias in the Vancouver metropolitan region and another southeast of the city. Smaller pockets of biased sampling regions were found near Victoria on the southern tip of Vancouver Island.

Across the 10 provinces and one territory, nine different species were the most common in a given jurisdiction (Table 2). Only the Common Garter Snake (*Thamnophis sirtalis*) and the Plains Garter Snake (*T. radix*) were the most common species in more than one jurisdiction. The Common Garter Snake was the most common species in the top five species in each jurisdiction, appearing in 10 of 11 top species in a jurisdiction (Table 2).

Temporal analyses.—Significant variation in monthly roadkill observations was observed for both amphibians and reptiles. Within amphibians, while the number of anurans reported on roads varied greatly across months, the number in October (n = 533) and April (n = 486), the two most common months, did not differ significantly (χ^2 = 2.2, df = 1, P = 0.141). The number of salamanders reported on roads also varied greatly across months, with significantly more observations in April (n = 363) than in October (n = 202), the month with the second most observations (χ^2 = 45.9, df = 1, $P < 0.001$). Significantly more snakes were found on roads in September (n = 1,732), than October (n = 1,144), the second most common month (χ^2 = 120.2, df = 1, $P < 0.001$). Significantly more turtles were found on roads in June (n = 4,315), than in May (n = 2,321), the second most common month (χ^2 = 599.2, df = 1, $P < 0.001$). Only 39 lizards were found on roads and the number found in May (n = 12) did not differ from July or August (n = 8), the second most common months (χ^2 = 0.80, df = 1, P = 0.371).

At the species level, many anurans had a bimodal distribution with peaks in March or April and September or October (Fig. 5). Salamanders typically had a similar bimodal distribution with usually few observations on roads during the summer (Fig. 6). Some snakes had a bimodal distribution but many species either had a spring or fall peak in observations (Fig. 7). Some species were uni-modal, with peaks in observations on roads occurring only during the fall, such as the Western Tiger Salamander (*Ambystoma mavortium*) and the Red-bellied Snake (*Storeria occipitomaculata*), or in summer, like the Western Rattlesnake (*Crotalus oreganus*). In contrast, turtles were all uni-modal, with almost all species having a peak in the number of observations on roads during

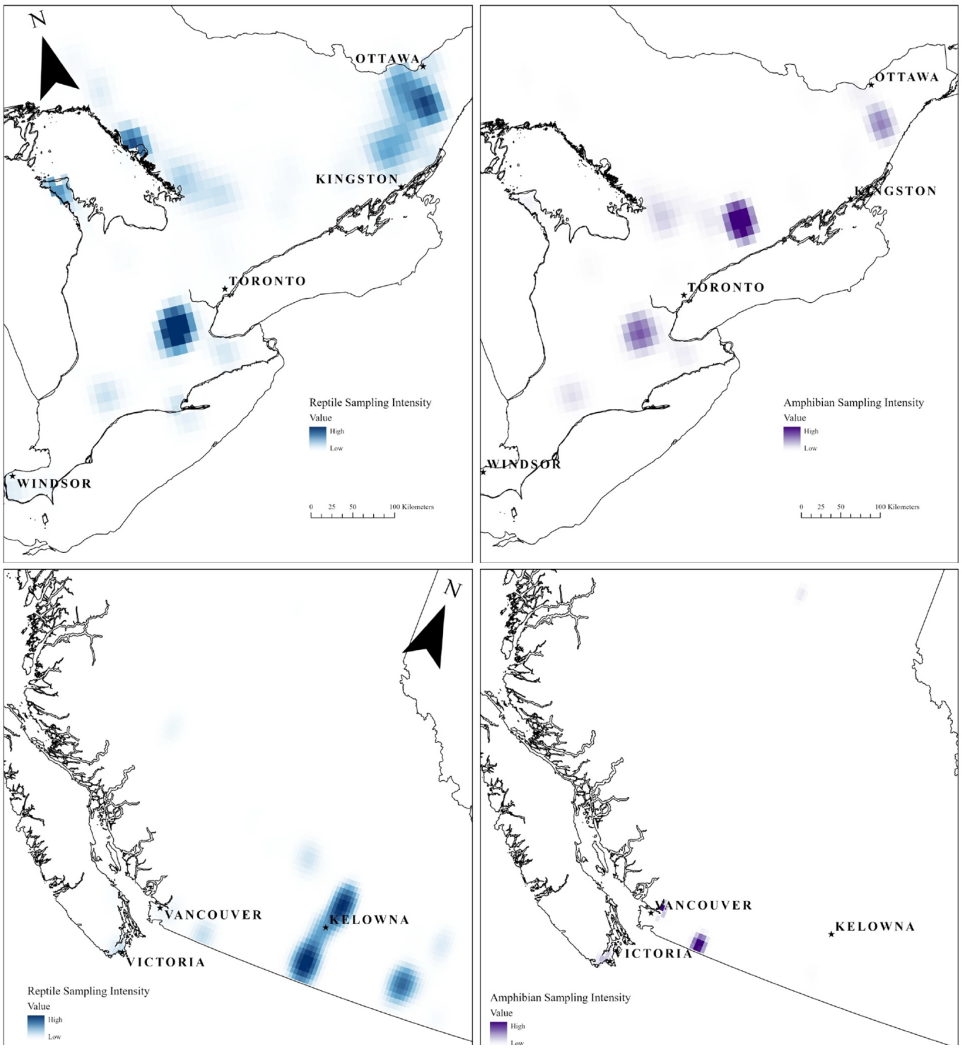

Figure 4. Kernel density maps of two regions in Canada with the highest number of observations on roads in the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. (Top Panels) Southern Ontario spatial sampling intensity for reptiles and amphibians. (Bottom Panels) Southwestern British Columbia spatial sampling intensity for reptiles and amphibians.

June (Fig. 8).

Discussion

Data obtained from community science projects can have numerous biases and limitations. For example, data on iNaturalist are biased towards the recent past, as the number of users and observations has grown exponentially (Di Cecco et al. 2021). This trend likely explains why > 90% of our data had been collected since 2019. iNaturalist data are also biased towards more developed areas (Di Cecco et al. 2021). This could partially explain the strong Ontario bias to our data, as Ontario is highly urbanized (https://www12.statcan.gc.ca/census-recensement/2021/as-sa/98-200-x/2021002/98-200-x2021002-eng.cfm).

We found that reptiles made up approximately 80% of all observations of herpetofauna on roads. In contrast, many systematic road surveys from temperate North America found that amphibians made up more than 80% of the herpetofauna found on roads (Ashley and Robinson 1996; Langen et al. 2007; Glista et al. 2008; Garrah et al. 2015). There are several reasons why the iNaturalist data may be biased towards reptiles. Driving surveys will greatly underestimate the number of amphibians found on roads (Langen et al. 2007), likely because amphibians are small and hard to detect from moving vehicles. We do not know how all of the iNaturalist data were collected, but likely many observations were taken by drivers, stopping to take observations

Table 2. Observations of the five amphibian and reptile species most commonly reported on roads by province or territory, based on data from the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. For each species, we provide the percentage of the total observations of herpetofauna found on roads in that jurisdiction. We compared the number of observations for the top two species in each jurisdiction using a Chi-square Test and the top species is in bold when it had significantly more observations. The letter n = number of observations of herpetofauna on roads for that province or territory and # spp = number of native species (number of exotic species) reported on roads for that jurisdiction. Common names of the most common anurans are given in Fig. 5, all salamanders in Fig. 6, all snakes in Fig. 7, and all turtles in Fig. 8. The remaining common names of anurans are *Anaxyrus hemiophrys* (Canadian Toad) and *Spea bombifrons* (Plains Spadefoot). Names of provinces and territories (P/T) are AB = Alberta, BC = British Columbia, MB = Manitoba, NB = New Brunswick, NFLD = Newfoundland, NS = Nova Scotia, NWT = Northwest Territories, ON = Ontario, PEI = Prince Edward Island, QC = Quebec, SK = Saskatchewan. Both species found in Newfoundland are not native to the province but are native elsewhere in Canada.

P/T	n	# spp	#1 species (%)	#2 species (%)	#3 species(%)	#4 species (%)	#5 species (%)
NWT	37	1	*Thamnophis sirtalis* (100)				
BC	1,438	21 (2)	***Taricha granulosa*** (22.4)	*Thamnophis sirtalis* (10.6)	*Thamnophis elegans* (10.4)	*Anaxyrus boreas* (8.5)	*Crotalus oreganus* (7.1)
AB	376	14	*Thamnophis radix* (33.5)	*Crotalus viridis* (29.8)	*Pituophis catenifer* (15.2)	*Thamnophis elegans* (7.4)	*Thamnophis sirtalis* (4.8)
SK	204	14	*Thamnophis radix* (27.0)	*Crotalus viridis* (18.6)	*Ambystoma mavortium* (12.7)	*Spea bombifrons* (12.3)	*Pituophis catenifer* (7.8)
MB	333	12	***Lithobates pipiens*** (53.8)	*Thamnophis radix* (14.1)	*Thamnophis sirtalis* (8.1)	*Anaxyrus hemiophrys* (6.3)	*Ambystoma mavortium* (4.5)
ON	17,573	32(1)	***Chrysemys picta*** (26.3)	*Chelydra serpentina* (12.9)	*Emydoidea blandingii* (11.0)	*Thamnophis sirtalis* (10.6)	*Nerodia sipedon* (4.5)
QC	480	21	*Chelydra serpentina* (18.5)	*Chrysemys picta* (17.7)	*Thamnophis sirtalis* (16.9)	*Emydoidea blandingii* (16.3)	*Storeria occipitomaculata* (6.7)
NB	160	15	***Thamnophis sirtalis*** (21.9)	*Chelydra serpentina* (11.9)	*Chrysemys picta* (11.9)	*Ambystoma maculatum* (11.3)	*Storeria occipitomaculata* (6.3)
NS	582	20	*Ambystoma maculatum (*19.2)	*Chelydra serpentina* (19.1)	*Chrysemys picta* (13.1)	*Thamnophis sirtalis* (10.3)	*Storeria occipitomaculata* (6.7)
PEI	16	6	*Storeria occipitomaculata* (43.8)	*Thamnophis sirtalis* (25.0)	*Ambystoma maculatum* (12.5)	*Anaxyrus americanus* (6.3)	*Notophthalmus viridescens* (6.3)
NFLD	13	(2)	***Anaxyrus americanus*** (76.9)	*Thamnophis sirtalis* (15.4)			

and hence biased towards larger animals like snakes and turtles. In general, iNaturalist data tend to be biased towards larger-bodied species (Callaghan et al. 2021). In addition, anurans often move across roads in large numbers (Dole 1971; Mazerolle 2004), with hundreds of anurans potentially crossing during one night (Linck 2000). Given that, iNaturalist observers may be more apt to just record a few individuals of each species rather than all individual anurans. This hypothesis is supported by the fact that each observer contributed only 7.3 observations, on average. A study of iNaturalist data on roads in the USA, found that reptiles made up 90% of the herpetofauna (Unger 2022), suggesting that iNaturalist data undercounts amphibians on roads.

Within reptiles, we found that turtles were more common on roads than snakes, with turtles making up three of the four most common species found on roads. Some systematic road surveys in north-eastern North America have found more turtles than snakes on roads (Ashley and Robinson 1996; Langen et al. 2009), while others have found more snakes than turtles (Baxter-Gilbert et al. 2015; Garrah et al. 2015; Choquette and Valliant 2016), and some have reported similar numbers of both taxa (Boyle et al. 2017). This variation may be due to several factors, including the amount of suitable wetland habitat for turtles found along the surveyed roads, and if surveys extend into the fall to capture late season movement by snakes. In contrast to our study, a study of iNaturalist wildlife dead on roads in the

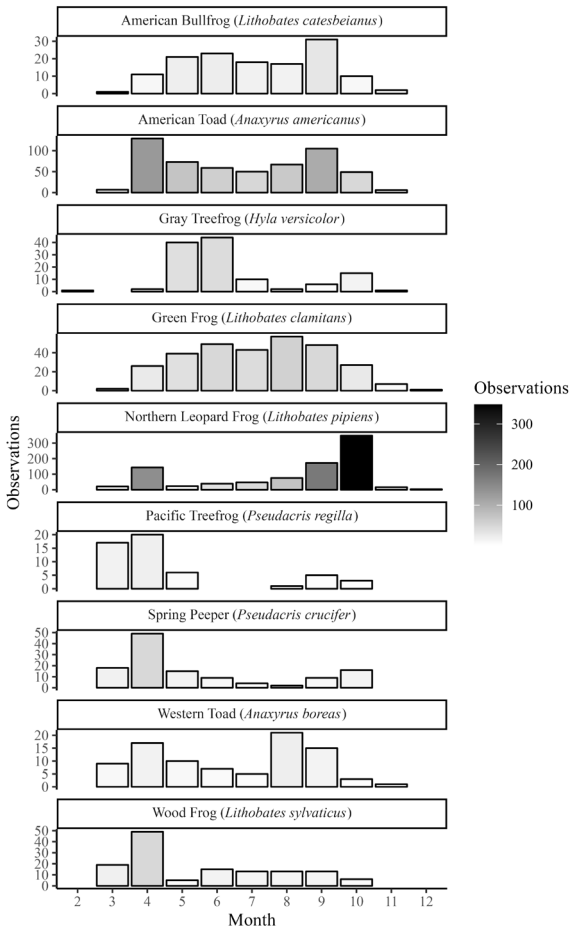

Figure 5. Monthly observations of anuran species on roads in the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. Observations were summarized at the species level and species with < 50 observations in total were excluded.

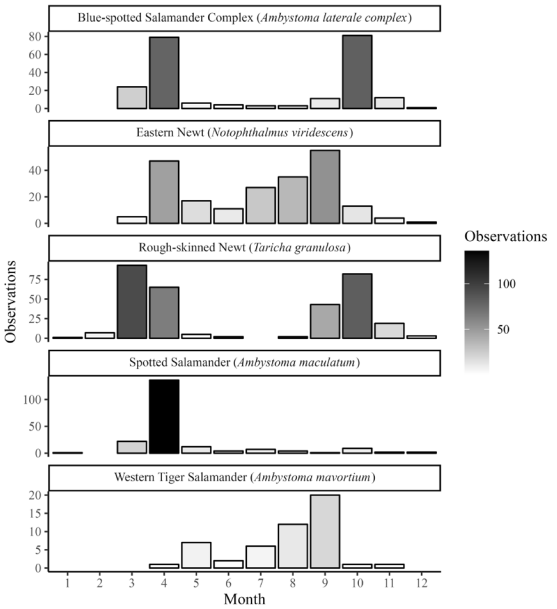

Figure 6. Monthly observations of salamander species on roads in Canada in the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. Observations were summarized at the species level and species with < 50 observations in total were excluded.

USA found more snakes than turtles and that snakes made up the 10 most common herpetofauna (Unger 2022). Turtles may have been more common in our dataset for a few reasons. We did not just include herpetofauna that were dead on roads, but also turtles nesting on road shoulders, which could increase the number of turtle observations compared with snakes. Our data is also strongly biased towards Ontario, the province with the most turtle species. If the data had been biased towards western provinces such as Alberta and Saskatchewan, where turtles are rare, the data may have been biased towards snakes.

Within amphibians, we found twice as many observations of anurans compared with salamanders. While salamanders can travel across roads in large numbers (Mitchell 2000; Mazerolle 2004; Seburn et al. 2019; Wilkinson and Romansic 2022), their numbers may be poorly documented because of their small size, low persistence probability (Santos et al. 2011), and being largely limited to road crossing during spring and fall migrations (Mazerolle 2004) while at least some anurans are more apt to be found on roads at other times of the year as well. Systematic road surveys have also found that anurans greatly outnumber salamanders (Mazerolle 2004).

Lizards made up < 1% of all observations of herpetofauna on the road (Fig. 3). Lizards often make up a small portion of the herpetofauna roadkill (Fitch 1949; Dodd et al. 1989). The small number of lizards found on roads in our study is likely a result of several factors, including the restricted range of lizard species in Canada (Cook 1984), their small size making them harder to detect on roads, and a tendency for them to avoid open areas like roads (Rutherford and Gregory 2003; Brazeau and Hecnar 2018). Nonetheless, some Canadian lizards such as the Common Five-lined Skink (*Plestiodon fasciatus*) have been found dead on roads during systematic road surveys (Farmer and Brooks 2012). The presence of the non-native Common Wall Lizard in the road data is not surprising as the species is the most commonly reported lizard in iNaturalist Canada.

The Painted Turtle was the most commonly observed species on roads (Table 1). Systematic surveys in eastern Canada have usually found this species to be the most common turtle on roads (Ashley and Robinson 1996; MacKinnon et al. 2005; Seburn

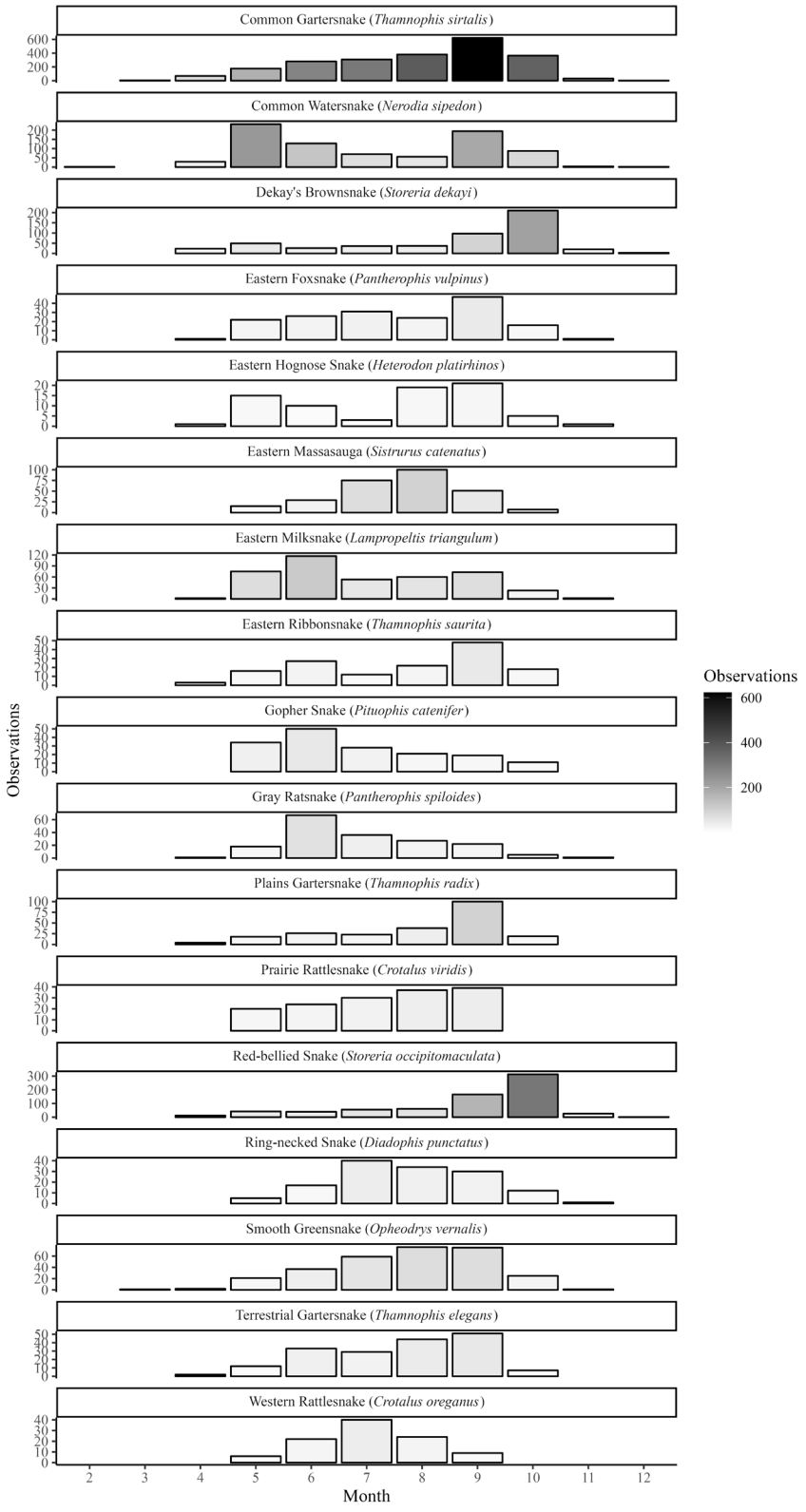

FIGURE 7. Monthly observations of snake species on roads in Canada in the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. Observations were summarized at the species level and species with < 50 observations in total were excluded.

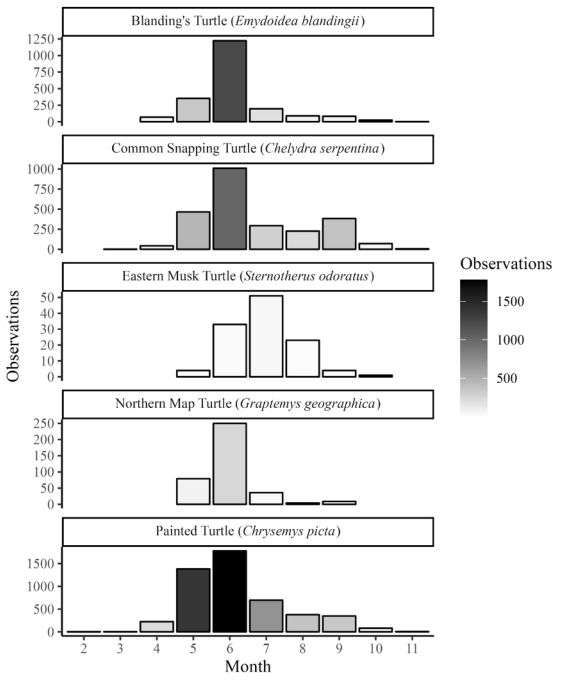

Figure 8. Monthly observations of turtle species on roads in Canada in the Canadian Amphibians and Reptiles on Roads project on iNaturalist Canada. Observations were summarized at the species level and species with < 50 observations in total were excluded.

et al. 2022) as it remains widespread and relatively common in Canada compared to other turtle species (Browne and Hecnar 2007; Dupuis-Desormeaux et al. 2021). Despite being the species most commonly found on roads, the Painted Turtle was only the most common species on roads in one province, Ontario, although it was found in the top five species in many eastern provinces.

Excluding sea turtles, 18 species of amphibians and reptiles native to Canada were not found on roads. Six of those species are quite rare in Canada and have fewer than 50 observations on iNaturalist. A few of the species are either completely aquatic (e.g., Common Mudpuppy, *Necturus maculosus*), or primarily aquatic and rarely move far from water, such as the stream salamanders, or the Spiny Softshell (*Apalone spinifera*), the only native turtle species not found on roads. The spatial distribution of observations of amphibians and reptiles on roads was strongly biased towards the province of Ontario which had over 80% of the data. While part of this bias is likely because Ontario has the largest human population, the province only has 38% of the Canadian population (https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=9810000101.), suggesting that other factors such as relatively high herpetofaunal diversity, a large road network, and a large number of iNaturalist users, contributed to the large percentage of observations. Similarly, the province of Quebec has the second largest population, with 23% of the Canadian population, yet this province had < 3% of the observations. Factors such as the more northerly location of the province and reduced hepetofaunal diversity likely contributed to there being fewer observations from Quebec.

Provincial patterns in species abundance were likely influenced by several factors including the presence or absence of dedicated survey programs for certain species or taxa. The iNaturalist data indicated that the Plains Garter Snake and the Prairie Rattlesnake (*Crotalus viridis*) are the most common species found on roads in Alberta and Saskatchewan and systematic road surveys have also found these two species to be the most common snake species found on roads in Saskatchewan (Fortney et al. 2012). The Common Garter Snake was in the top five species for all but one province, reflecting its wide range and high abundance.

The Rough-skinned Newt (*Taricha granulosa*) was the most common species found on roads in British Columbia, and this is unusual, as most other provinces had a turtle or snake as the most common species. High rates of road mortality of newts in the genus *Taricha* have been documented (Wilkinson and Romansic 2022) and the Rough-skinned Newt was assessed as being at high risk from road mortality (Brehme et al. 2018). Snakes did occupy three of the five most common species on roads in British Columbia, although there were significantly more observations of newts than any snake species. The number of newt observations is likely at least partially due to apparent survey effort to document newts crossing roads in spring on their way to breeding ponds, as one iNaturalist user contributed over 40% of the observations of Rough-skinned Newts on roads.

Monthly patterns in herpetofauna on roads were quite varied. While a bi-modal pattern was common for many species, with a peak in spring and fall, likely correlated with movements from and towards overwintering sites, there were a number of variations. It is noteworthy that the significant peak in anuran movements in October is largely driven by the Northern Leopard Frog (*Lithobates pipiens*). No other anuran had a peak in that month. The Northern Leopard Frog peak was driven by two observers who contributed roughly 50% of the October data for this species. The lack of a spring or fall peak in some

species should be viewed cautiously as a missing spring or fall peak may be due to low sampling effort, for example in the Western Tiger Salamander (*Ambystoma mavortium*). Lack of spring or fall observations may also be due to seasonal variation in survey effort. Various species that lack both a spring and fall peak in our data, such as the Spotted Salamander (*A. maculatum*), Red-bellied Snake (*Storeria occipitomaculata*), and Gophersnake (*Pituophis catenifer*), appear to have bi-modal patterns of roadkill based on survey work (Mazerolle 2004; McAllister et al. 2016; Blais et al. 2023).

In contrast to many snake species, the Western Rattlesnake had the most observations in July. Road surveys in British Columbia found that Western Rattlesnakes were consistently common from June to August (McAllister et al. 2016) suggesting that summer road mortality is more common in this species. All but one of the turtle species had their peak observations on roads in June, which coincides with the main nesting period for most turtles in Canada (Christens and Bider 1987; Standing et al. 1999; Dupuis-Désormeaux et al. 2024). In contrast, the Eastern Musk Turtle (*Sternotherus odoratus*) had the peak number of observations on roads in July. Most Eastern Musk Turtle nests are < 45 m from water (Ernst and Lovich 2009), suggesting that movements across roads may not always be for nesting purposes but could be for dispersal or moving between wetlands.

Roads can pose a threat to many species of amphibians and reptiles. Our data show that over 4,700 amphibians and reptiles were found on roads in Canada in 2024 alone. This number likely greatly underestimates the actual number found on roads as over 80% of the iNaturalist data are from Ontario, and therefore amphibians and reptiles on roads in other provinces are under-surveyed. In addition, the iNaturalist data likely greatly underestimates the number of amphibians on roads as previously noted.

Assessing the effect of roadkill on amphibian and reptile populations is more complicated than simply counting total observations. High roadkill numbers may indicate high local abundance rather than a high mortality rate, while species with low reproductive rates or small populations may suffer severe impacts from just a few roadkill incidents, other factors being equal. For example, the roadkill of just three adult female Grey Ratsnakes (*Pantherophis spiloides*) per year was enough to increase the extinction probability to more than 90% (Row et al. 2007). In contrast, road surveys that detect just a few road-killed individuals of a species may be a result of the population already having decreased from years of roadkill, making it difficult to assess true impacts based solely on raw numbers (Eberhardt et al. 2013). In general, temperate turtle populations are thought to be at risk from roads given their life-history traits of high egg and hatchling mortality and delayed sexual maturity (Congdon et al. 1993; Gibbs and Shriver 2002). In our dataset, although the Painted Turtle was the most frequently recorded species on roads, population-level impact of roadkill remains unclear, as high roadkill counts may reflect higher population density rather than a high rate of roadkill. In contrast, the globally endangered Blanding's Turtle (*Emydoidea blandingii*; van Dijk and Rhodin 2011), the fourth most common species in our data, likely faces greater risk of population decline due to its life-history traits and already imperiled population status. Given that roadkill can drive declines in both common and rare species, efforts to mitigate road mortality are urgently required at numerous locations across Canada for the Blanding's Turtle and many other species.

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Literature Cited

Andrews, K.M., J.W. Gibbons, and D.M. Jochimsen. 2008. Ecological effects of roads on amphibians and reptiles: a literature review. Pp. 121–143 *In* Urban Herpetology. Mitchell, J., R.E. Jung Brown, and B. Bartholomew (Eds.). Herpetological Conservation 3. Society for the Study of Amphibians and Reptiles, Salt Lake City, Utah, USA.

Aresco, M.J. 2005. The effect of sex-specific terrestrial movements and roads on the sex ratio of freshwater turtles. Biological Conservation 123:37–44.

Ashley, E.P., and J.T. Robinson. 1996. Road mortality of amphibians, reptiles and other wildlife on the Long Point Causeway, Lake Erie, Ontario. Canadian Field Naturalist 110:403–412.

Ashley, E.P., A. Kosloski, and S.A. Petrie. 2007. Incidence of intentional vehicle-reptile collisions. Human Dimensions of Wildlife 12:137–143.

Baxter-Gilbert, J.H., J.L. Riley, D. Lesbarrères, and J.D. Litzgus. 2015. Mitigating reptile road

mortality: fence failures compromise ecopassage effectiveness. PLoS ONE 10:1–15. https://doi.org/10.1371/journal.pone.0120537.

Blais, B.R., B.E. Smith, and J.L. Massie. 2023. Road ecology and microhabitat assessment of Black Hills Red-bellied Snakes and Smooth Greensnakes in an isolated mountain range. Herpetological Conservation and Biology 18:301–314.

Bogart, J.P. 2019. Unisexual salamanders in the genus *Ambystoma*. Herpetologica 75:259–267.

Boyle, S.P., J.D. Litzgus, and D. Lesbarrères. 2017. Comparison of road surveys and circuit heory to predict hotspot locations for implementing road-effect mitigation. Biodiversity and Conservation 26:3445–3463.

Brazeau, D.J., and S.J. Hecnar. 2018. Summer movements of the Common Five-lined Skink (*Plestiodon fasciatus*) in the northern portion of its range. Herpetological Conservation and Biology 13:743–752.

Brehme, C.S., S.A. Hathaway, and R.N. Fisher. 2018. An objective road risk assessment method for multiple species: ranking 166 reptiles and amphibians in California. Landscape Ecology 33:911–935.

Browne, C.L., and S.J. Hecnar. 2007. Species loss and shifting population structure of freshwater turtles despite habitat protection. Biological Conservation 138:421–429.

Callaghan, C.T., A.G.B. Poore, M. Hofmann, C.J. Roberts, and H.M. Pereira. 2021. Large-bodied birds are over-represented in opportunistic citizen science data. Scientific Reports 11:1–11. https://doi.org/10.1038/s41598-021-98584-7.

Choquette, J.D., and L. Valliant. 2016. Road mortality of reptiles and other wildlife at the Ojibway Prairie Complex and Greater Park Ecosystem in southern Ontario. Canadian Field-Naturalist 130:64–75.

Christens, E., and J.R. Bider. 1987. Nesting activity and hatching success of the Painted Turtle (*Chrysemys picta marginata*) in southwestern Quebec. Herpetologica 43:55–65.

Congdon, J.D., A.E. Dunham, and R.C. van Loben Sels. 1993. Delayed sexual maturity and demographics of Blanding's Turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7:826–833.

Cook, F.R. 1984. Introduction to Canadian Amphibians and Reptiles. National Museums of Canada. Ottawa, Ontario, Canada.

Di Cecco, G.J., V. Barve, M.W. Belitz, B.J. Stucky, R.P. Guralnick, and A.H. Hurlbert. 2021. Observing the observers: how participants contribute data to iNaturalist and implications for biodiversity science. BioScience 71:1179–1188.

Dodd, C.K., Jr., K.M. Enge, and J.N. Stuart. 1989. Reptiles on highways in north-central Alabama, USA. Journal of Herpetology 23:197–200.

Dole, J.W. 1971. Dispersal of recently metamorphosed Leopard Frogs, *Rana pipiens*. Copeia 1971:221–228.

Dupuis-Désormeaux, M., K. McDonald, D. Moro, T. Reid, C. Agnew, R. Johnson, and S.E. MacDonald. 2021. A snapshot of the distribution and demographics of freshwater turtles along Toronto's Lake Ontario coastal wetlands. Journal of Great Lakes Research 47:283–294.

Dupuis-Désormeaux, M., G. Van Alstyne, M. Mueller, R. Takayesu, V. D'Elia, T. Tan, and S.E. MacDonald. 2024. Social media-based community science for turtle nest monitoring and conservation. FACETS 9:1–7, https://doi.org/10.1139/facets-2023-0044.

Eberhardt, E., S. Mitchell, and L. Fahrig. 2013. Road kill hotspots do not effectively indicate mitigation locations when past road kill has depressed populations. Journal of Wildlife Management 77:1353–1359.

Ernst, C.H., and J.E. Lovich. 2009. Turtles of the United States and Canada. 2nd Edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Farmer, R.G., and R.J. Brooks. 2012. Integrated risk factors for vertebrate roadkill in southern Ontario. Journal of Wildlife Management 76:1215–1224.

Fitch, H.S. 1949. Road counts of snakes in western Louisiana. Herpetologica 5:87–90.

Forman, R.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, L. Fahrig, R. France, C.R. Goldman, K. Heanue, et al. 2003. Road Ecology. Science and Solutions. Island Press, Washington, D.C., USA.

Fortney, A.N., R.G. Poulin, J.A. Martino, D.L. Parker, and C.M. Somers. 2012. Proximity to hibernacula and road type influence potential road mortality of snakes in southwestern Saskatchewan. Canadian Field-Naturalist 126:194–203.

Garrah, E., R.K. Danby, E. Eberhardt, G.M. Cunnington, and S. Mitchell. 2015. Hot spots and hot times: wildlife road mortality in a regional conservation corridor. Environmental Management 56:874–889.

Gibbs, J.P., and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16:1647–1652.

Gibbs, J.P., and W.G. Shriver. 2005. Can road mortality limit populations of pool-breeding amphibians? Wetlands Ecology and Management 13:281–289.

Glista, D.J., T.L. DeVault, and J.A. DeWoody. 2008. Vertebrate road mortality predominantly impacts amphibians. Herpetological Conservation and Biology 3:77–87.

Grilo, C., L. Borda-de-Água, P. Beja, E. Goolsby, K. Soanes, A. le Roux, E. Koroleva, F.Z. Ferreira, S.A. Gagné, Y. Wang, and M. González-Suárez. 2021. Conservation threats from roadkill in the global road network. Global Ecology and Biogeography 30:2200–2210.

Hels, T., and E. Buchwald. 2001. The effect of road kills on amphibian populations. Biological Conservation 99:331–340.

Langen, T.A., A. Machniak, E.K. Crowe, C. Mangan, D.F. Marker, N. Liddle, and B. Roden. 2007. Methodologies for surveying herpetofauna mortality on rural highways. Journal of Wildlife Management 71:1361–1368.

Langen, T.A., K.M. Ogden, and L.L. Schwarting. 2009. Predicting hot spots of herpetofauna road mortality along highway networks. Journal of Wildlife Management 73:104–114.

Linck, M.H. 2000. Reduction in road mortality in a Northern Leopard Frog population. Journal of the Iowa Academy of Science 107:209–211.

MacKinnon, C.A., L.A. Moore, R.J. Brooks, G. Nelson, T. Nudds, M. Beveridge, and B. Dempster. 2005. Why did the reptile cross the road? Landscape factors associated with road mortality of snakes and turtles in the South Eastern Georgian Bay area. Pp. 153–166 *In* Protected Areas and Species and Ecosystems at Risk: Research and Planning Challenges. Nelson, G., T. Nudds, M. Beveridge, and B. Dempster (Eds.). Proceedings of the Parks Research Forum of Ontario and Carolinian Canada Coalition Annual General Meeting, University of Guelph, Guelph, Ontario, Canada.

Mazerolle, M.J. 2004. Amphibian road mortality in response to nightly variations in traffic intensity. Herpetologica 60:45–53.

McAllister, J.M., and J.R. Maida. 2016. Diet of roadkilled Western Rattlesnakes (*Crotalus oreganus*) and Gophersnakes (*Pituophis catenifer*) in southern British Columbia. Northwestern Naturalist 97:181–189.

Mitchell, J.C. 2000. Mass mortality of Red-spotted Newts (*Notophthalmus viridescens viridescens* Rafinesque) on a central Virginia road. Banisteria 15:45–47.

Piczak, M.L., C.E. Markle, and P. Chow-Fraser. 2019. Decades of road mortality cause severe decline in a Common Snapping Turtle (*Chelydra serpentina*) population from an urbanized wetland. Chelonian Conservation and Biology 18:231–240.

Pinto, T., N. Sillero, A. Mira, and S.M. Santos. 2024. Using the dead to infer about the living: amphibian roadkill spatiotemporal dynamics suggest local populations' reduction. Science of the Total Environment 927: 1–11. https://doi.org/10.1016/j.scitotenv.2024.172356.

R Development Core Team. 2025. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. http://www.R-project.org.

Row, J.R., G. Blouin-Demers, and P.J. Weatherhead. 2007. Demographic effects of road mortality in Black Ratsnakes (*Elaphe obsoleta*). Biological Conservation 137:117–124.

Rutherford, P.L., and P.T. Gregory. 2003. Habitat use and movement patterns of Northern Alligator Lizards (*Elgaria coerulea*) and Western Skinks (*Eumeces skiltonianus*) in southeastern British Columbia. Journal of Herpetology 37:98–106.

Rytwinski, T., and L. Fahrig. 2012. Do species life history traits explain population responses to roads? A meta-analysis. Biological Conservation 147:87–98.

Santos, S.M., F. Carvalho, and A. Mira. 2011. How long do the dead survive on the road? Carcass persistence probability and implications for road-kill monitoring surveys. PLoS ONE 6:1–12. https://doi.org/10.1371/journal.pone.0025383.

Schwartz, A.L., F.M. Shilling, and S.E. Perkins. 2020. The value of monitoring wildlife roadkill. European Journal of Wildlife Research 66:1–12. https://doi.org/10.1007/s10344-019-1357-4.

Seburn, D.C., M. Burns, E. Kreuzberg, and L. Viau. 2022. Do turtle roadkill hotspots shift from year to year? Canadian Field-Naturalist 136:145–152.

Seburn, D.C., E. Kreuzberg, and L. Viau. 2019. Roadkill of Eastern Newts (*Notophthalmus viridescens*) in a protected area in Quebec. Canadian Field-Naturalist 133:101–104.

Shin, Y., K. Kim, J. Groffen, D. Woo, E. Song, and A. Borzée. 2022. Citizen science and roadkill trends in the Korean herpetofauna: the importance of spatially biased and unstandardized data. Frontiers

in Ecology and Evolution 10:1–21. https://doi.org/10.3389/fevo.2022.944318.

Standing, K.L., T.B. Herman, and I.P. Morrison. 1999. Nesting ecology of Blanding's Turtle (*Emydoidea blandingii*) in Nova Scotia, the northeastern limit of the species' range. Canadian Journal of Zoology 77:1609–1614.

Unger, S. 2022. On the road again: touring iNaturalist for roadkill observations as a new tool for ecologists. Journal of Wildlife and Biodiversity 6:72–86.

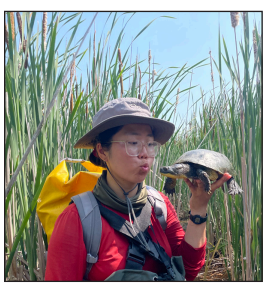
van Dijk, P.P. and A.G.J. Rhodin. 2011. *Emydoidea blandingii* (errata version published in 2019). The IUCN Red List of Threatened Species 2011. International Union for Conservation of Nature. http://www.iucnredlist.org.

Wagner, R.B., C.R. Brune, and V.D. Popescu. 2021. Snakes on a lane: road type and edge habitat predict hotspots of snake road mortality. Journal for Nature Conservation 61:1–9. https://doi.org/10.1016/j.jnc.2021.125978.

Wilkinson, J.A., and J.M. Romansic. 2022. The effect of road-based mortality on a local population of newts along a narrow two-lane road in California. Frontiers in Ecology and Evolution 10:1–18. https://doi.org/10.3389/fevo.2022.944848.

Winton, S.A., C.A. Bishop, and K.W. Larsen. 2020. When protected areas are not enough: low-traffic roads projected to cause a decline in a northern viper population. Endangered Species Research 41:131–139.

David C. Seburn is the Freshwater Turtle Specialist with the Canadian Wildlife Federation. He earned a B.A. from Western University, London, Ontario, Canada, and a M.S. from the University of Alberta, Edmonton, Alberta, Canada. David has published more than 20 papers on Canadian amphibians and reptiles, but his passion is freshwater turtle conservation and road ecology. (Photographed by Hannah Delion).



Reta Lingrui Meng is a Ph.D. Candidate at McMaster University, Hamilton, Ontario, Canada. She holds a B.Sc. in Biology and Environmental Science with a minor in GIS from McMaster University, Hamilton, Ontario, Canada. Her research focuses on weaving Indigenous Knowledge and Western Science to co-create place-based recovery strategies for species at-risk freshwater turtles in Ontario. (Photographed by Alexis McGregor).