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Reducing Human Impacts on White-Tailed Deer and Spotted Salamanders in North America

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Abstract. Reducing human harm to wildlife requires more than installing a crossing structure or recording fewer carcasses. This targeted critical review examines road traffic, habitat fragmentation, forest clearing, and deicing runoff affecting white-tailed deer (*Odocoileus virginianus*) and spotted salamanders (*Ambystoma maculatum*) in North America. Ten primary sources were assessed using their full texts, with attention to sampling units, outcome definitions, study design, and transferability. Evidence supports fencing connected to usable deer underpasses at studied sites, while salamander protection requires attention to migration routes, terrestrial habitat, breeding-water quality, and life stage. However, movement observations, collision counts, experimental survival, and modeled population outcomes measure different processes and cannot be ranked as interchangeable percentages. The review contributes an integrated assessment framework that links exposure reduction, completed movement, habitat suitability, and demographic response. A reconstruction of published salamander counts demonstrates how excluding animals that bypass fences can overstate system performance. The resulting recommendations distinguish supported interventions from plausible measures requiring field validation. Evidence is concentrated in the United States and one Canadian setting; it does not establish a continent-wide effect size or a measured New Jersey outcome. Future evaluations should test whether combined interventions improve both safe movement and subsequent recruitment.

Keywords: White-tailed deer, Spotted salamander, Road mitigation, Habitat conservation, Evidence synthesis

1. Introduction

Human activities can harm individual animals through vehicle collisions while also interrupting access to the habitat needed for reproduction and survival. Management therefore needs an explicit outcome: preventing injury, maintaining movement, or sustaining a population. These objectives overlap, but evidence for one does not automatically establish the others. For white-tailed deer, studies have examined road-crossing interventions and behavioral responses to vehicles and underpasses [1-3]. For spotted salamanders, research has evaluated crossing structures, migration behavior, and population-level consequences of road mortality [4-6]. Other studies have further

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examined terrestrial habitat disturbance and deicing-salt exposure, showing that protection may also depend on conditions beyond the road crossing itself [7-10].

This review asks which measures can reduce human impacts on these two species, under what conditions they are supported, and how success should be evaluated. Its scope is road traffic and associated landscape disturbance, including forest removal and deicing runoff. It is not a comprehensive treatment of hunting, disease, climate change, or every human pressure. "Spotted salamander" refers specifically to *Ambystoma maculatum*, not all salamanders. North America defines the geographic search scope; the available evidence does not represent every region within it.

The contribution is a structured synthesis connecting interventions that are often evaluated separately. It identifies where a measure can succeed on its immediate indicator while leaving another limiting process unresolved. A denominator audit of published crossing counts makes this problem quantitative, and a decision framework turns it into monitoring requirements. This is a contribution in interpretation and study design, not a claim of new field observations, an exhaustive meta-analysis, or the first proposal of integrated wildlife mitigation.

2. Methods

A targeted, iterative English-language search was completed on 3 October 2026 using web searches, publisher platforms, and public research repositories. Search terms combined the focal common or scientific names with "road," "fencing," "underpass," "tunnel," "buffer," "clearcut," "road salt," "vehicle approach," and "citizen science." References and related records were followed when they addressed an identified evidence gap. The accompanying search and evidence record lists representative queries, access routes, retained sources, and exclusion decisions. Search results were not screened as a complete bibliographic database, so no systematic-review coverage or complete exclusion count is claimed.

Sources were retained when they presented North American primary evidence relevant to the focal species and a management question, and their methods and results could be examined in full. Ten sources were included: nine research articles and one transportation research report. The transportation report provides primary monitoring data on a fencing intervention [1]. Two articles describe different outcomes from the same Maine experiment and are treated as complementary, not independent replication [7, 8]. Other species appearing in source studies are not additional focal species; pooled estimates are not relabeled as deer-only or spotted-salamander-only effects.

For each source, extraction recorded location, sampling unit, duration, comparison, outcome denominator, key result, and limitation. Evidence was assessed qualitatively by directness to the proposed intervention, experimental control, replication, duration, and outcome relevance. Appraisal was qualitative rather than score-based. Heterogeneous outcomes were not pooled. Table 1 recalculates proportions directly from published counts using ordinary division; it provides descriptive arithmetic, not a new population estimate or independent statistical test. The main review and the accompanying extraction record distinguish observed results, modeled predictions, and recommendations inferred from multiple sources.

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3. Evidence for reducing harm to white-tailed deer

3.1. Fencing connected to usable underpasses

A Virginia study added fencing to two existing underpasses [1]. Carcass-derived collision frequencies fell by 96.5% at the culvert and 88% at the bridge. Four pre-intervention years were compared with three and two post-intervention years, respectively; an intervening unfenced segment remained approximately stable. Camera monitoring covered two years before and after fencing and recorded increased crossings. These paired outcomes support the intervention more directly than crossing photographs alone. However, sites were not randomized, only two structures were treated, and carcass records omit collisions leaving no recovered carcass. Results support similar local applications, not a universal percentage reduction. Fence-end surveillance remains necessary: no significant increase in collisions was detected within the monitored distances, but this does not establish zero displacement risk everywhere.

The practical implication is to assess whether an existing structure is accessible and usable before adding guidance fencing. A low collision count beside an impassable barrier would meet a road-safety indicator while failing a movement objective. Conversely, more underpass crossings without fewer road deaths could indicate that many animals still reach the carriageway. These alternatives require paired measurements rather than selecting whichever indicator improves. Animals photographed repeatedly must also be distinguished from unique animals when population-level claims are made.

3.2. Behavior and the limits of speed and disturbance evidence

Blackwell et al. analyzed 63 vehicle approaches to free-ranging deer at an Ohio research station [2]. Nighttime flight responses varied substantially and did not show a statistically supported adjustment to approach speed over the tested range. This undermines the assumption that deer reliably compensate for faster vehicles by moving sooner. It supports testing traffic-speed reduction where collisions are concentrated, but the experiment did not measure the effect of a speed-limit policy on collisions. Dry-road conditions, a partly enclosed site, and possible repeated encounters limit transferability.

Nojoumi et al. studied behavior near a divided-highway underpass in Alberta [3]. Only 36 observations met the selection criteria, including 21 deer observations; cameras sampled May–October 2004. Deer-specific observations indicate a flight response to passing vehicles, but the paper's principal regression estimates combine species and must not be presented as deer-only effects. Associations with crossing behavior provide a reason to test visual or acoustic screening. They do not demonstrate that installing screens reduces deer mortality. The small selected sample and one crossing location make this preliminary evidence.

4. Evidence for reducing harm to spotted salamanders

4.1. Crossing structures must work as complete systems

At an Amherst, Massachusetts site, Hedrick et al. monitored two older tunnels during the main adult migration night in each of three years [4]. The 2016 counts included 56 fence climbers, 54 animals that balked, and 14 classified as successful tunnel users. Added lighting in 2017 and an entrance platform in 2018 produced no demonstrated improvement. Each modification had only one treated

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tunnel; small effects could have escaped detection. "Success" meant entry without re-emergence at the same entrance, not independently confirmed arrival at the far exit. Volunteers assisted animals that bypassed or rejected the tunnels, and fatalities were excluded. Thus, the data describe behavior within an assisted system, not unassisted survival.

Patrick et al. provide an important qualification to claims about tunnel dimensions [5]. At one New York site, experimental arrays recorded 446 spotted salamanders over five nights; three nights supplied sufficient samples for the main comparisons. No clear preference was established among the tested diameters of 0.3, 0.6, and 0.8 m or among tested lengths after separating treatment from position. The incomplete balance between position and treatment restricts interpretation. This does not prove that dimensions are irrelevant or that a smaller, differently shaped tunnel is adequate. Natural migration routes, entrance placement, and operating conditions must be evaluated together.

Table 1 reconstructs successive stages of tunnel use from the published raw counts [4]. Reached-entrance counts equal balks plus classified crossings; the full observed denominator also includes fence climbers. For example, 68/124 × 14/68 = 14/124 in 2016. Reporting only conditional tunnel acceptance omits failure before entry. The 2018 conditional value below is recalculated from Table 1 of the source; its narrative reports 8.9%, which does not match 25/224. The recalculated value is used here and documented in the evidence record.

Table 1. Recalculated stages of salamander tunnel use at one site [4]

Year	Reached entrance / all observed	Classified crossing / reached entrance	Classified crossing / all observed
2016	68/124 = 54.8%	14/68 = 20.6%	14/124 = 11.3%
2017	71/108 = 65.7%	15/71 = 21.1%	15/108 = 13.9%
2018	224/357 = 62.7%	25/224 = 11.2%	25/357 = 7.0%

These observations suggest a specific monitoring improvement: record approach to the guidance system, bypass or climbing, entrance arrival, and confirmed exit separately. More animals reaching a tunnel need not increase completed crossings if rejection remains high. A successful entrance modification may likewise have little overall benefit when animals routinely bypass the fence. Because the observations concern adult spring migration, their proportions cannot establish performance for departing adults or juveniles.

4.2. Protection must extend beyond the main adult migration

Sterrett et al. compared volunteer strategies using a stochastic spotted-salamander population model, with 500 simulations and a 50-year horizon [6]. Strategies including newly metamorphosed juveniles generally performed better than adult-only assistance. This is a life-stage hypothesis for management, not a field demonstration that a particular volunteer schedule prevents decline. The model assumes consistent yearly effort, complete route coverage, and a fixed rescue capacity per volunteer. Demographic inputs combine studies, and the model simplifies maturation and excludes immigration among populations. These assumptions make precise staffing prescriptions inappropriate without local validation.

Accordingly, adult migration-night assistance can address an immediate hazard while leaving recruitment unprotected. A more informative local evaluation would monitor adult entry, adult departure, and juvenile departure, then assess which event contributes most to avoidable losses. The relevant comparison is benefit per unit of effort across locally observed migration events, rather than a fixed calendar date borrowed from another region. Traffic restrictions or assistance should be

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evaluated against untreated or pre-intervention conditions; their population benefit is not quantified by the retained field studies.

4.3. Terrestrial habitat and breeding conditions interact

In Maine, Veysey et al. radio-tracked 40 adult salamanders at 11 experimentally assigned pools [7]. Maximum distance from the breeding pool averaged 106.0 m, with a range of 1.6–427.6 m. Movement responses depended on weather and habitat, so a fixed buffer does not enclose all terrestrial use. Only six tracked animals came from the 30-m treatment, limiting power there; juveniles and adults too small for transmitters were not represented. The mean movement distance is therefore not a recommended universal buffer width.

A six-year study of the same 11 pools compared intact forest with 30-m and 100-m buffers surrounded by a 100-m clearcut [8]. Breeding sex ratios became more male-biased in both cut treatments. Low recapture proportions occurred initially in the 30-m treatment, while the abundance response in the 100-m treatment depended on how long pools retained water. Recapture proportion is the share of captured breeders previously marked, not individual survival: immigration and skipped breeding can change it. Random treatment assignment strengthens the disturbance comparison, but there were only three or four pools per treatment. These results reject a simple claim that 100 m invariably protects every demographic outcome.

For planning, terrestrial cover and aquatic breeding conditions should be assessed jointly. If a crossing delivers animals to a pool that dries before development is completed, passage alone may not resolve the main constraint. If surrounding forest is removed, preserving the pool's water surface alone leaves the terrestrial part of the life cycle exposed. This review therefore recommends mapping seasonal habitat connections and monitoring breeding females and juvenile output alongside total adult counts. The proposed combination follows the synthesis; its added benefit still needs a comparative field test.

4.4. Deicing runoff requires exposure control

Karraker et al. experimentally exposed spotted-salamander egg masses to three salt treatments in New York [9]. Mean embryonic survival was 84%, 68%, and 3% at control, 500, and 3,000 µS/cm conductivity, respectively, with ten egg masses per treatment. Separate larval trials used five containers per treatment and 50 larvae per container over 70 days; the container, not each larva, was the replicate. This directly supports harm from salt exposure under the tested conditions. It does not define a continent-wide safe concentration, and conductivity is not itself a mass concentration of salt.

Charney et al. surveyed 541 Massachusetts wetlands in 2008–2010 [10]. Their model associated a threefold conductivity contrast with 29% lower predicted spotted-salamander abundance (SE 11%). This is a modeled cross-site contrast from egg-mass observations, not an observed 29% decline through time. Models addressed detection and environmental covariates, but repeated visits were limited, and conductivity can reflect geology or non-road solute sources. The study supports investigating runoff pathways; it does not measure the improvement achieved by changing salting practice.

Taken together, experimental toxicity and landscape association justify including runoff exposure in conservation plans, while leaving the size of achievable recovery uncertain. Candidate actions include reducing unnecessary salt application and intercepting contaminated runoff before it reaches breeding pools. These should be tested with road-safety requirements maintained, measured chloride

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as well as conductivity, and biological follow-up. Alternative deicers must not be assumed harmless. A distance from a road can help prioritize investigation, but it cannot replace site-specific water measurements or establish a universal protected zone.

5. Synthesis and management implications

5.1. What the comparison adds

The studies differ in what they measure, not merely in effect size. Collision reduction uses an earlier collision frequency as its denominator. Tunnel acceptance uses animals reaching an entrance. Experimental survival uses exposed cohorts over a defined interval. Occupancy and abundance models estimate different population attributes. A statement that one species is "more affected" because one percentage is larger would discard these distinctions. A meaningful comparison instead asks which process limits protection and how directly a study tests a remedy.

The synthesis identifies four linked questions: Has harmful exposure fallen? Can animals still complete necessary movements? Is the habitat reached suitable? Is there evidence of improved survival or recruitment? These are separate evaluation criteria, not a numerical index or a claim that all processes have equal weight. Their value is diagnostic. Better performance at one stage directs attention to the next unmeasured or poorly functioning stage instead of being treated as proof of complete ecological recovery.

Across the retained deer studies, the most directly supported intervention is guidance fencing connected to usable underpasses at evaluated sites [1], while behavioral work informs hypotheses about speed and disturbance [2, 3]. For spotted salamanders, field monitoring shows why installed infrastructure may fail to deliver passage [4, 5], habitat experiments show why successful movement alone is insufficient [7, 8], and salt evidence adds an aquatic exposure pathway [9, 10]. The demographic model highlights a potential mismatch between adult-focused intervention and recruitment [6]. The added understanding lies in linking these otherwise separate findings into explicit conditions for claiming success.

5.2. Confidence and conditions for application

Table 2 summarizes decisions supported by the synthesis. "Direct" denotes an intervention or exposure tested against a comparison; it does not mean certainty or universal transferability. "Conditional" denotes a recommendation whose outcome depends on site context or whose efficacy has not been directly tested in the retained evidence. These labels describe the claim being made, so one study can directly establish a local response while providing only conditional support for another location.

Table 2. Intervention choices and evidence still needed

Management question	Supported interpretation	Required local check
Deer road exposure [1-3]	Fenced usable underpasses have direct local support; speed and screening benefits remain conditional.	Measure collision frequency and confirmed passage; check fence ends and traffic changes.
Salamander road passage [4-6]	Whole-system performance and life-stage coverage matter; simple retrofits are not assured solutions.	Count bypass, entry, exit, and deaths by migration stage and night.

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Table 2. (continued)

Salamander terrestrial habitat [7, 8]	Buffer effects depend on landscape and breeding conditions; no universal safe width follows.	Map movement routes; track breeding females, hydroperiod, and juvenile output.
Salamander runoff [9, 10]	Salt harm is experimentally supported; recovery from reduced application needs testing.	Measure exposure and breeding outcomes before and after management at comparison sites.

Geographic transfer should consider traffic patterns, structure geometry, maintenance, habitat configuration, hydroperiod, and winter salting practices. Evidence here is concentrated in the eastern United States, with one Canadian behavioral study. There are no New Jersey field measurements in the retained set and no basis for assigning New Jersey a measured effect size. The North American scope is therefore a regional evidence base for adapting management, not a spatially representative continental estimate.

5.3. Testable next steps and review limitations

Three predictions follow from this framework. First, combined fence and entrance improvements should increase confirmed crossings per total observed approach more than an entrance modification alone where fence bypass is common. Second, combined runoff and habitat protection should improve salamander recruitment more than a passage-only intervention where breeding habitat is degraded. Third, a successful deer fencing retrofit should reduce collisions without simply shifting them beyond the treated segment. These are proposed tests derived from the synthesis, not results already demonstrated by this review.

Future studies should establish baseline conditions and contemporaneous comparison sites, replicate across locations, and record comparable sampling effort before and after intervention. Follow-up should span multiple migration or breeding seasons, because weather and recruitment vary among years. Researchers should report absolute counts, denominators, uncertainty, and missing observations; distinguish repeat detections from individuals; and publish null results. For salamanders, marked-individual data could separate survival from breeding participation. Such designs would make the proposed framework assessable rather than merely descriptive.

This review remains selective. English-language and accessible-full-text selection can miss relevant evidence, no independent duplicate screening was performed, and publication bias was not estimated. The included studies differ in setting and design, and repeated publications from the Maine experiment do not add independent replication. The crossing calculations reuse published counts, without raw individual histories or a new causal analysis. Population persistence after combined interventions remains poorly established. Consequently, the paper offers a transparent critical synthesis and research agenda, not a validated universal management formula.

6. Conclusion

Reducing harm to white-tailed deer and spotted salamanders requires interventions matched to the process causing harm. The retained evidence supports connected fencing and usable underpasses for deer at studied sites, while salamander protection requires evaluating the complete migration route and both terrestrial and aquatic habitat. The review's contribution is to make the limits between exposure, movement, and demographic evidence explicit and operational. Success should be

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claimed at the level actually measured; stronger claims require evidence that gains persist beyond the immediate intervention and translate into the intended biological outcome.

References

[1] Donaldson, B. M., & Elliott, K. E. M. (2020). Enhancing existing isolated underpasses with fencing to decrease wildlife crashes and increase habitat connectivity. Final Report FHWA/VTRC 20-R28. Virginia Transportation Research Council. https://rosap.ntl.bts.gov/view/dot/55477.

[2] Blackwell, B. F., Seamans, T. W., & DeVault, T. L. (2014). White-tailed deer response to vehicle approach: Evidence of unclear and present danger. *PLOS ONE, 9*(10), e109988. https://doi.org/10.1371/journal.pone.0109988.

[3] Nojoumi, M., Clevenger, A. P., Blumstein, D. T., & Abelson, E. S. (2022). Vehicular traffic effects on elk and white-tailed deer behavior near wildlife underpasses. *PLOS ONE, 17*(11), e0269587. https://doi.org/10.1371/journal.pone.0269587.

[4] Hedrick, B. P., Vander Linden, A., Cordero, S. A., Watt, E., O'Roark, P. M., Cox, S. L., & Sutherland, C. (2019). Keeping salamanders off the streets: Evaluating and modifying one of the first US amphibian road tunnels 30 years after installation. *Journal of Urban Ecology, 5*(1), juz023. https://doi.org/10.1093/jue/juz023.

[5] Patrick, D. A., Schalk, C. M., Gibbs, J. P., & Woltz, H. W. (2010). Effective culvert placement and design to facilitate passage of amphibians across roads. *Journal of Herpetology, 44*(4), 618–626. https://doi.org/10.1670/09-094.1.

[6] Sterrett, S. C., Katz, R. A., Fields, W. R., & Campbell Grant, E. H. (2019). The contribution of road-based citizen science to the conservation of pond-breeding amphibians. *Journal of Applied Ecology, 56*(4), 988–995. https://doi.org/10.1111/1365-2664.13330.

[7] Veysey, J. S., Babbitt, K. J., & Cooper, A. (2009). An experimental assessment of buffer width: Implications for salamander migratory behavior. *Biological Conservation, 142*(10), 2227–2239. https://doi.org/10.1016/j.biocon.2009.04.024.

[8] Veysey Powell, J. S., & Babbitt, K. J. (2015). An experimental test of buffer utility as a technique for managing pool-breeding amphibians. *PLOS ONE, 10*(7), e0133642. https://doi.org/10.1371/journal.pone.0133642.

[9] Karraker, N. E., Gibbs, J. P., & Vonesh, J. R. (2008). Impacts of road deicing salt on the demography of vernal pool-breeding amphibians. *Ecological Applications, 18*(3), 724–734. https://doi.org/10.1890/07-1644.1.

[10] Charney, N. D., Eiseman, C. S., Plunkett, E. B., Record, S., & Warren, P. S. (2025). The reach of road salt into vernal pools and the response of amphibians. *PLOS ONE, 20*(10), e0329680. https://doi.org/10.1371/journal.pone.0329680.