Focusing on
Roadway Dangers

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Parson’s Chameleon. Photo: Avery Tilley
I remember my first experience realizing the impacts roads can have on reptiles. It was while conducting my Masters research on Marbled Salamanders (*Ambystoma opacum*) in western Massachusetts. As a side project, we would mark the Eastern Box Turtles (*Terrapene carolina*) we encountered because they were very rare in the region despite the fact that we saw quite a few at this site. There was a particularly large female we marked who was with eggs; she was a big turtle and old. One day while going out to the field site we saw a local landowner parked on the side of the road right where we would turn into the site. There on the road was the large female, both her and her eggs completely flattened. We didn't see her at first, until in casual conversation the landowner mentioned he killed one of our turtles. He did not even realize what the impact of killing one female Box Turtle can have on the population, and I am not sure he cared. It was my first introduction to the negative impacts roads can have on these species and reinforced something I was already becoming acutely aware of; people do not see these animals as important.

It is experiences like that Box Turtle and many others throughout my career that make me happy to focus this volume of the magazine on roads and their impacts to reptiles and amphibians. It is one of the most important issues that we face when trying to conserve these animals. Whether it is working to conserve a species like the Eastern Indigo Snake (*Drymarchon couperi*) that travels long distances, crossing many roads every year, or the vernal pool breeding amphibians that make an annual migration between uplands and breeding ponds that are bisected by a road, finding ways to deal with this impact is key to conserving these species. I have been encouraged to see that in the last 10 years here in the United States, developing creative ways for wildlife to cross roads has been a growing field. We are seeing salamander tunnels and large wildlife overpasses starting to be incorporated into transportation projects.

If we continue to increase human population on the planet, it is critical that we find ways for wildlife to maintain their numbers at the same time. Reptiles and amphibians have incredible value to our planet and we need to continue to mitigate the impacts of roads as one of the greatest threats. Transportation projects typically have very large budgets and in the future every project should dedicate a portion of the budget to ensuring wildlife can safely cross the road. I hope everyone enjoys this deep-dive on roads and the impacts to reptiles and amphibians and that you become active in doing what you can to help these animals...whether it is helping a Box Turtle cross the road or talking to your local politicians about adding wildlife corridors to the transportation budget, get out there and make a difference.

Dr. Chris Jenkins
CEO, The Orianne Society
The Orianne Society works to conserve critical ecosystems for imperiled reptiles and amphibians using science, applied conservation and education.

Our programs are designed using a customized, science-based approach. Specifically, we work on multiple conservation targets within a series of landscapes. We first examine the threats to each conservation target and then determine the research and applied programs required to achieve conservation for each.

There are many themes that are often used across our work. Our primary theme is that we conduct science that informs conservation and we use science to inform on-the-ground conservation actions. However, to maintain our scientific credibility, we do not engage in advocacy or policy, though our work may be used by other organizations to influence policy.
Our efforts are divided into three initiatives that focus on declining landscapes and species.

**Longleaf Savannas**
- Altamaha River Corridor
- Sandhill Snakes
- Freshwater Turtles

**Great Northern Forests**
- Northeast Kingdom
- Wood Turtles
- Blanding’s Turtles

**Appalachian Highlands**
- Greater Smoky Mountains
- Hellbenders
- Timber Rattlesnakes

Eastern Indigo Snake. Photo: Pete Oxford
River valleys, where flat land and fertile soils provide some of the most vital agricultural resources, are essentially the breadbasket of many communities around the world. The floodplains making up the center of most river valleys on the East Coast are inundated with surging water as heavy rains coincide with melting snow, and in some cases, extreme flow rates and ice scour can strip away much of the vegetation that had built up in recent years. As floodwaters recede, however, a layer of nutrient-rich sediment is deposited in the wake of the surge. What is left behind sometimes resembles a baron, muddy, landscape visibly devoid of plant life, but look closer and you’re sure to see wildlife tracks in abundance. Mink, otter, muskrat, beaver, bear, bobcat, countless shorebirds, and even Wood Turtles that all spend part or most of the year in river valleys leave reminders of their presence in the mud with every step they take. And as the year progresses from mud season to spring proper, the landscape transforms, as if in the blink of an eye, when dozens, or even hundreds of plant species take advantage of the fresh nutrients and spring to life. Within weeks the landscape metamorphoses from a drab brown to one lush with bright greens and vibrant flowers. These bountiful river valleys cut paths through mountainous terrain and serve as linkage corridors, helping wildlife migrate up and down watersheds and allowing distant populations to maintain genetic connectivity. Those same valleys are also travel corridors for people… and our machines, as the flat land that is easy to till, is also easy to pave, so many rivers are paralleled by roads, spelling disaster for the wildlife that lives there.

Drive a river valley road on a rainy spring night and you’ll see firsthand the carnage that can ensue when roads parallel rivers. Thousands, sometimes tens of thousands, of frogs and salamanders can be killed on a single night. Predators like raccoons, skunks, and vultures are then attracted to what is essentially a paved buffet, and in turn, can be struck and killed too. Wood Turtles, which make frequent trips between rivers and upland habitat, might travel across the same road several times per year, and the loss of just two adults per year to human causes can result in local populations going extinct. None of the difficulty wildlife faces in regards to roads are unique to river valleys, but the animals dependent on floodplain ecosystems take more than their fair share of the problem, and traffic is only getting worse. Increasingly, states are now working to address the problem of wildlife road mortality by creating structures to guide and facilitate movement...
over or under roads. It’s a small and expensive step, but a critical one because until cars can fly, which not many people are counting on, every animal relying on river valley habitat is at great risk of meeting an untimely end between asphalt and rubber. In pristine settings, river valleys are biodiversity hotspots, and roads play no small part in the loss of richness and diversity these ecosystems are presently experiencing. For species such as the Wood Turtle, how long their populations can handle that stress is a big unknown, and preserving the rich biodiversity in these systems requires that we act sooner rather than later.
Could you please share your first experience or encounter that involved reptiles/amphibians (herping)?

I was always interested in wildlife, so I have many vague recollections of encountering reptiles and amphibians as a young child. However, the early experiences that made a lasting impression on me involved Eastern Diamond-backed Rattlesnakes. My grandfather owned a large farm in southwest Georgia, so rattlesnakes were encountered fairly often. Unfortunately these were the bad old days when these snakes were killed on sight. Every single encounter left two strong impressions on me. One, these were magnificent and beautiful animals. Two, it seemed so unfair to my young mind that they would be killed so casually. I never forgot that sad feeling, and in some ways I think this guided my future career as a biologist.

Reptiles and amphibians often get overlooked by many, but not by you, why is that? What is it that appealing to you about these animals? Have they enhanced your life in any way?

As a Professor of Biology with interests in conservation and wildlife management, I am trained to be aware of all the parts of an ecosystem, including reptiles and amphibians. However, their appeal goes much farther back. I loved roaming the woods as a child, and reptiles and amphibians added a touch of mystery to these trips. You could never be assured of finding certain species. Others only came out at the right time of year or in the right weather. Over time I would come to have a scientific appreciation of their biology but, for me, the appeal has always been more basic. It’s just fun to search out these interesting animals. It was when I was 10 years old, and it still is today.

Are there any friends or family that you’ve helped introduced herps to?

Yes! The Orianne Society’s own Houston Chandler is my son. My wife and I are both biology professors, so he grew up around wildlife and biological research. He was constantly being hauled around to biological stations and study sites as a child. Although I am an ornithologist and my wife is a mammalogist, birds and mammals did not seem to make much of an impression on Houston. He was always most interested in flipping over rocks and logs to look for salamanders and snakes. We encouraged his interest as much as possible, and it turned into a career for him.

What is your favorite reptile or amphibian and why?

That’s a tough one. However, stemming from my early experience described above, I would say the Eastern Diamond-backed...
Rattlesnake. They are such beautiful and impressive animals to encounter in the field. They are also closely associated with the biodiverse longleaf systems of the southeast that I love. The Diamondback is just such a great part of our natural heritage here in the southeast.

Are there any herps on your “to find” list?

Many years of working in the field as a biologist means that I have seen most of my “most wanted” in the US. However, there are lots of species I would love to see in other parts of the world. The species of bushmaster vipers (Lachesis) are probably at the top of the list right now.

In which ways have you been involved with The Orianne Society? Is there a certain event with us that was particularly memorable and why?

My participation is mostly as a spectator. I enjoy following The Orianne Society’s activities on social media and through their publications (newsletter, magazine, and peer-reviewed journal articles). However, I do help out with field surveys when I get the chance.

What first inspired you to become a member with The Orianne Society?

I heard of The Orianne Society a number of years ago, but I did not fully appreciate the scope of their work. Once my son was hired I got first-hand insight into the good work Orianne was doing. Because I am involved in conservation-oriented research in my own work, I know how important public support and funding are to successful conservation. Thus, I wanted to help and was inspired to join and donate.

What do you enjoy most about being an Orianne Society member?

I most enjoy the feeling of satisfaction from knowing that my contributions to The Orianne Society help fund research and habitat management that benefit reptile and amphibian populations. Successful conservation depends on effective outreach to the public, protection and proper management of habitat, and science-based decision making. I believe The Orianne Society does a good job in all of these areas, and I enjoy supporting their work.

What is the single most memorable moment that you have had that involved reptiles/amphibians?

I’ve been fortunate to have many memorable moments, but the best always seem to go back to childhood. I will never forget the first time I encountered amphiumas. They were in a road-side ditch after days of heavy rain. What an amazing animal! In a roadside ditch! The exotic name only added to the memory (my grandfather told me they were “conger cels”).
Since European settlement, the human population across the southeastern United States has grown dramatically, leading to high rates of urbanization and development. As cars became the primary mode of transportation during the 20th century, dense road networks began to form. Today, roads are a near constant landscape feature that not only connect cities and towns but also wind through most of the available landscape. There are few remaining wild places left in the southeastern U.S. that are a significant distance from some type of roadway.

While convenient for getting from point A to B, roads have widespread and diverse effects on the ecosystems they pass through. Dense road networks contribute substantially to habitat destruction, degradation, and fragmentation at a landscape scale, which are generally viewed as the primary challenges facing conservation biologists. Road construction converts large areas of natural habitats directly into anthropogenic use, creating a network of unsuitable environments that animals must traverse to successfully move across the landscape. This increases fragmentation when animals either avoid crossing roads, are unable to cross roads, or suffer high mortality rates due to vehicle collisions. High mortality rates from failed road crossings have been documented in many different groups, including all of the major terrestrial vertebrates (mammals, birds, amphibians, and reptiles). The presence of roads can also have secondary effects on wildlife populations, including contributing to pollution, siltation of aquatic environments, and flooding via storm water runoff. These types of effects are often wide reaching and create an impacted area much larger than the actual road itself. Over the long-term, the negative effects of roads on wildlife populations can be significant, leading to lower wildlife abundance near roads or even localized extinctions.

Road impacts on wildlife populations are perhaps most severe for turtles and tortoises. Most turtle populations depend on high adult survival compared to low egg and

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### Featured Article

**A PERVERSIVE LANDSCAPE FEATURE FOR GOPHER TORTOISE POPULATIONS IN GEORGIA**

By: Houston Chandler

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Tortoise near road. Photo: Houston Chandler - Edited
hatchling survival. Long times to reach sexual maturity further put a premium on long-lived adults that are already of reproductive age. Turtles generally cross roads at slow speeds and may even sit on a warm road surface for extended periods of time, increasing the chances of a vehicle encounter. Drivers have a tendency to intentionally hit turtles on the road leading to higher than expected mortality rates. Female turtles making nesting movements are often disproportionately hit by vehicles and, over time, this can alter the sex ratio in turtle populations that are exposed to consistent road mortality. A reliance on high adult survival means that turtle populations can be pushed towards extinction from just a few road mortality events per year.

Gopher Tortoise Conservation

Gopher Tortoise (Gopherus polyphemus) populations have declined over much of their range for a variety of factors. Gopher Tortoises inhabit primarily longleaf pine uplands in the Coastal Plain of the southeastern United States. Populations of Gopher Tortoises can be found from extreme southeastern Louisiana to extreme southern South Carolina and south over almost the entire Florida peninsula. Western populations of Gopher Tortoises were listed as threatened under the U.S. endangered species act in 1987, primarily because of habitat loss and overexploitation. Unlisted populations in the eastern portion of the species’ range are currently a candidate for federal listing and are generally considered to be declining for many of the same reasons that western populations were listed. Throughout their range Gopher Tortoises are a critical component of upland longleaf pine savannas. Tortoises dig long (ca. 20–30 foot) burrows in sandy soils, which they use to shelter from predators and unfavorable environmental conditions.

Public road segments from the Gopher Tortoise range in Georgia scored from 0–5 based on the likelihood that they will impact tortoise populations or high quality tortoise habitat. Figure: Houston Chandler
conditions. Over 300 other species have been documented using Gopher Tortoise burrows at some point during their life history, making tortoises one of the most important landscape features in upland longleaf pine forests throughout their range.

Declining Gopher Tortoise populations combined with the importance of tortoise burrows has led to increased conservation focus in recent years. In Georgia, a large scale conservation initiative focused on conserving tortoise populations is currently underway. The Gopher Tortoise Conservation Initiative (GTCI) brings together government agencies, non-profits, private citizens, businesses, and other stakeholders with the goal of permanently protecting identified viable tortoise populations in the state. Viable tortoise populations (those that are likely to persist for the foreseeable future) occur across the species' range in Georgia, existing on both private and public lands.

The focus on tortoise conservation has highlighted the need to identify threats that could impact tortoise populations on protected lands. There is little data to elucidate the specific effects of roads on tortoise populations. However, tortoises are routinely observed, both alive and dead, on roads in Georgia, and desert tortoise (G. agassizii) populations can be severely impacted by roads passing through suitable habitat. Furthermore, Gopher Tortoises inhabit areas where roads are generally built (dry uplands), and Georgia’s dense road network is likely to continue to expand in future years.

Thus, it became apparent that a tool was needed to assess where roads traversed currently known tortoise populations and habitat. We recently completed a project with the Georgia Department of Transportation (GA DOT) examining 1) where roads pass through high quality tortoise habitat across their Georgia range; and 2) how roads are distributed around viable tortoise populations.

**Gopher Tortoises and Roads in Georgia**

The Gopher Tortoise range in Georgia covers an estimated 92,000 square kilometers, occurring at least partially in 93 counties. Within this area, there are approximately 101,650 km of public roads mapped in GA DOT’s database, a majority (64%) of which are paved. This translates to a road density of approximately 1.1 km of road per square km of land area. However, road density is not evenly distributed across southern Georgia, and some counties, especially those with larger cities, have a significantly higher road density than others (range: 0.35–3.45 km of road per square km). The only relatively large land areas without public roads are major rivers and their associated floodplains, the Okefenokee Swamp, and large military installations (e.g., Fort Stewart, Fort Benning, and Fort Gordon – these properties do have large private road networks).

Over a spatial scale this large, it is incredibly difficult, if not impossible, to assess each road segment visually in a reasonable amount of time. A paucity of road crossing data also makes it difficult to identify any hotspots where tortoises are known to regularly cross roads. Because of these challenges, we created a model that assigned each road segment in the tortoise range in Georgia a...
‘Gopher Tortoise Score’. This score ranged from 0–5 and was based on three factors: 1) the quality of the surrounding habitat; 2) the presence of large contiguous habitat patches; and 3) the presence of a viable population. High scores indicated high quality habitat and a known tortoise population, while low scores represented unsuitable habitat.

Based on this model, approximately 83% of roads in southern Georgia likely have little to no impact on Gopher Tortoises (scored as a 0 or 1). This is unsurprising given the habitat loss that has already occurred, the sheer number of roads, and the relatively restricted nature of suitable tortoise habitat. Only 417 km of road received a score of 5, and 2,497 km received a score of 4. Approximately half of these ~3,000 km of road had characteristics that would make them most likely to negatively impact tortoises (e.g., high traffic volumes). This model appeared to be a good first step in narrowing down areas or even specific roads that could cause conflict with tortoise populations, but were the model predictions accurate?

To test our model, we drove 190 road segments, totaling approximately 865 km predicted to have high quality Gopher Tortoise habitat (scored 4–5). Tortoise burrows were visible from the road on 54 (28%) segments, and suitable habitat was present along 140 segments (74%). Some areas that now appeared unsuitable would have historically been suitable but had been altered by anthropogenic activities (e.g., row pine, clear cut, or natural habitats that were clearly fire suppressed). Overall, the model results appeared consistent across the landscape, and this model can now be used by GA DOT and other partners to identify areas where populations should be considered.

In addition to creating this model, we also identified specific road segments that could affect viable populations. There are a total of 122 viable tortoise populations in Georgia. Roads were a nearly ubiquitous feature of these populations, with all but three populations having at least 1 km of roadways either bordering or bisecting the tortoise habitat (range: 0–75.6 km). Encouragingly, the road density in 114 (93%) of the viable tortoise populations was lower than the average road density for southern Georgia, and a majority (60%) of the road segments within tortoise populations were small, dirt roads. However, sixty four (52%) of the viable tortoise populations were completely bisected by at least a two-
Dr. Javan Bauder measuring a Gopher Tortoise. Photo: Pete Oxford
lane paved road, and an additional 15 roads separated two viable populations. For example, state highway 117 in Telfair County near the Orianne Indigo Snake Preserve bisects a large population, dividing it almost in half between sections north and south of the highway. Dead on the road tortoises as well as Eastern Indigo Snakes (*Drymarchon couperi*) have been collected from this stretch of highway. These 79 road segments likely represent the roads that pose the greatest challenge to current conservation efforts.

What comes next?

Roads are a pervasive feature of the modern landscape in southern Georgia and have been impacting wildlife populations, both directly and indirectly, for many years. Road densities along with the size of roads and traffic volumes are likely to increase as the human population continues to grow. The extent of the road network in Georgia passing through or near Gopher Tortoise populations and habitats makes it difficult, if not impossible, to completely remove the negative effects of roads. However, the work described above lays the groundwork for mitigating road impacts on Georgia’s tortoise populations. The 79 roads bisecting tortoise populations can be further prioritized using both road (size, traffic volume) and tortoise characteristics (size and distribution of the population). Additional research is then needed to identify when and how often tortoises cross roads, and what effect roads have on populations over the long-term.

In the short-term, several strategies exist for mitigating the effects of roads on wildlife populations. Barriers can prevent animals from accessing roads and can be combined with wildlife crossing structures to limit the effects of fragmentation. It is fairly easy to restrict tortoise movement with fences, and this represents the easiest way to limit road mortality along major highways. While relatively easy to implement these types of strategies are expensive, especially at a landscape scale. Other management actions that can reduce road mortalities include signs warning drivers to be on the lookout for wildlife. In rare cases roads can even be closed seasonally or maintenance work can be limited to certain times of year. These mitigation techniques can all reduce the negative effects of roads but need to be targeted to areas where they have the largest impact. The model described above represents an ideal opportunity to make decisions using better spatial data than has been available in previous years. Overall, roads represent a significant challenge for Gopher Tortoises and many other species. Without mitigation efforts, road mortality and habitat fragmentation will continue to be an issue for tortoise populations in Georgia.
I definitely wasn’t about to argue taxonomy with a truck full of young good ol’ boys. I had heard the arrhythmia-inducing bass from their truck fading in long before their headlights came into my view - and was instantly looking forward to it fading away. One can feel pretty small on the side of a pitch-black rural connector road in the middle of a rainy early-spring night. And despite the fact that I have trouble remembering the password to my computer on a regular basis, I can dredge up details from every slasher movie I have ever seen as soon as I am alone on the side of that road on an inky black night. And so small talk with strangers in this context, and for this card-carrying introvert, is very near to the bottom of my to-do list. The truck slowed down and pulled into the wrong lane to get closer to me. The music stopped. And my own heartbeat pounding inside my skull replaced the bass. As the window rolled down, and skunky PBR-infused smoke cleared, I could feel my adrenals drain and I braced myself for what I expected was the next logical step…a beer bottle to my head. So, when the driver asked me about lizards, I figured it was a trick to get me within striking range. Stupidly, I stepped closer to their rig – right up to the window.

“Yeah. Just moving them out of the road.” I showed them the Spotted Salamander that I was jockeying to the wetland side of the road. It was truly a beautiful specimen of our flagship species. It was hard to believe it had just spent the entire long winter underground, likely in an old rodent burrow. It was just so utterly fresh and pristine looking. Nearly perfectly round spots of brilliant yellow popped on a shiny black background. The gravid female did her PR work well.

Genuine sounds of admiration from an encounter with wildlife followed. “Thanks! We’ll be extra careful….good luck with that tunnel you’re trying to build!” Cue music in the cab…and I was once again alone – just me and hundreds of migrating amphibians. This was two years before S. D. Ireland Construction finally broke ground for the project in 2015. I was suddenly profoundly
struck, by a realization rather than a beer bottle, by how successful our small cadre of conservation-minded local volunteers had been with messaging. Our grassroots effort garnered attention from the coffee counter at the Monkton General Store to Senatorial banter in Washington D.C. and well beyond that to banners of news outlets as far away from the small town of Monkton as Sidney, Australia and Taipei, China. To be clear, that attention wasn’t always supportive, but here in Monkton there was a genuine sense of ownership and stewardship for this site and the diverse population of amphibians, as evidenced by my new friends out for a late-night drive. That was good news. Very good news indeed. And then I got back to moving and counting amphibians.

The Monkton Road Site
The effort to retrofit Monkton Road in Addison County, Vermont with wildlife crossing culverts was a marathon of data collection, fundraising, public meetings, and engineering design that began sometime in 1997 when Jim Andrews, Coordinator of the Vermont Reptile and Amphibian Atlas Project, encouraged Monkton resident and wildlife biologist Steve Parren to field check Jim’s topographical hunch he had noticed while looking at a map. Steve confirmed that this indeed is a significant site. It turns out that the combination of upland hardwood habitat adjacent to a spectacular wetland complex, known locally as the Huizenga Swamp, in Addison County in the Champlain Valley of Vermont, was the perfect mix to provide everything a cornucopia of amphibians could possibly need to thrive for centuries. These topographic and biological scenarios are played out thousands of times throughout the northeast, but very few to the scale of the Monkton Road site. This site is truly a gem; a regional treasure of biodiversity; a whopper of a population that had gone virtually unnoticed. It only reveals itself so unabashedly during the spring, and to a lesser extent during the fall, migrations. The generalized equation is simple: most (not all) of the amphibians spend the winter in the upland forest underground and under cover. In the early spring, during the first soaking rains when the ice on the wetlands begins to recede, the amphibians are triggered to emerge and head to the wetlands to breed. In the spring of 1997, Steve began regularly visiting the site on nights when the weather foretold prime crossing conditions and kept careful data on the amphibian movement observed. The count was uncomplicated: date, time, weather conditions, number of animals, species, direction travelling, number of cars passing, and successful crossing vs. roadkill. The list of amphibians regularly documented on crossing counts consists of Spotted Salamander (Ambystoma maculatum), Blue-Spotted Salamander (Ambystoma laterale), blue-spotted/Jefferson Salamander hybrid group (Ambystoma jeffersonianum x laterale complex), Four-toed Salamander (Hemidactylium scutatum), Eastern Newt (Notophthalmus viridescens), Spring Peeper, (Pseudacris crucifer) Wood Frog (Lithobates sylvaticus), American Toad (Anaxyrus americanus), Leopard Frog (Lithobates pipiens), Green Frog (Lithobates clamitans), and
Gray Tree Frog (*Hyla versicolor*).

The curveball to the long-term sustainability of this population is that for 8-tenths of a mile an increasingly busy road bisects two critical pieces of amphibian habitat. The Monkton Road travels directly between the upland habitat and the wetland habitat, thus forcing amphibians to cross this road to breed. For decades, local traffic on the Monkton Road was light enough to have a negligible impact on this population. While individual amphibians would regularly have taken a hit, the population was stable - i.e. more animals were being reproduced than were being killed. This had been a rural dirt road for over 100 years, until evolution of the Vermont landscape required the paving of this road. As the population of Vermont, especially in Chittenden County (the population hub of VT) and Addison County increased, so too did the numbers of cars. Moreover, savvy drivers and impartial navigation systems identified Monkton Rd as a pleasant shortcut and detour around the Burlington metro area. With an annual average daily traffic (AADT in transportation engineer parlance) of between 2,000 – 3,000 vehicles, this is not a terribly busy road by US standards. However, it is unquestionably and significantly busy if your lifecycle requires you to crawl slowly across the road on your belly in the dark, sans reflective apparel, at least twice a year. Monitoring of amphibian crossings at Monkton Road during spring migration demonstrated a grim reality. On a busy migration night, with anywhere from one to a dozen volunteers moving amphibians, traffic was claiming around 50% of the animals counted. The detailed and consistent data that Steve Parren had collected for over a decade at this site was a critical factor, perhaps “the” critical factor, in demonstrating the need for an infrastructure fix at this site. Similarly, it cannot be overstated how important that data was in justifying the expenditure of public funds from two large federal grants for the wildlife crossings. Without Steve’s data, it is unlikely that we would have had a project.

**Fundraising...**

Steve and I were collecting data one spring night around 2005 and discussing, among other things, how unsustainable the situation seemed for both amphibians and volunteers. The cost to amphibians was becoming crystal clear. From our bipedal perspective, cars and trucks hurtled by us at speeds considerably higher than the posted 45 mph. And despite our flashlights, ANSI Class 2 reflective vests, ad hoc temporary warning signs, and our commitment to step off the pavement when cars approached, it just didn’t feel safe. It was asking a lot for drivers to expect a couple of herpetological shepherds around the next curve. Moreover, the data was demonstrating that even with...
our help, nearly half of the migratory attempts ended in a one-way ticket out of the gene pool. Having been to the 2003 International Conference on Ecology and Transportation in Lake Placid, NY, I knew that there were potential retrofits that could keep amphibians off the road and provide safe passage under the road. Scott Jackson’s famous salamander crossing in Amherst, MA, was proof positive.

So, an idea was hatched. Maybe we could build something like that here if we could raise the money. How hard could that be? Joining forces with the Monkton Conservation Commission and the Lewis Creek Association (a regional watershed conservation group), Steve and I dialed in on the Federal Highway Administration Transportation Alternatives Program. This program is administered in Vermont by the Vermont Agency of Transportation (VTrans) Municipal Assistance Bureau.

In the interest of full disclosure, it is important for me to point out that I am gainfully and gratefully employed by VTrans. While I am deeply involved in habitat connectivity issues in my role at VTrans, this Monkton Road crossing was not part of a programmed VTrans project, or my responsibilities at VTrans.

My involvement was as a Monkton resident on the Conservation Commission, and as a board member of the Lewis Creek Association. And while I tried to keep my professional and volunteer roles very separate on this project, my worlds did inevitably converge. It certainly helped the success of this project that I understand the transportation project development process well; and the Transportation Alternatives process well enough to know that this was feasible - but luckily not well enough to know how hard it would be to bring these crossings from an idea to construction as a volunteer.

The Transportation Alternative (TA) grants have a grant category for Environmental Mitigation to “reduce vehicle-caused wildlife mortality or to restore and maintain connectivity among terrestrial or aquatic habitats.” TA grants are competitive grants that allocate federal transportation dollars to several project categories that enhance the surface transportation system in the US. These grants come from a stand-alone dedicated funding source as mandated by the Federal Transportation Bill, and do not extract dollars from a state’s transportation budget.

Our first attempt at a TA grant ended in utter disappointment. According to the rumor mill, our proposal generated a few laughs. We quickly learned that the Environmental Mitigation category was not frequently used. We also learned that the notion of salamander crossings seemed quite fringe at the
time, and that raising money for an amphibian crossing was going to be an incredibly difficult task. And so began our informal campaign of education and salamander crossing PR. Our second attempt, juiced up with a little support from friendly reporters at local and regional media outlets, resulted in a 2008 $25,000 TA grant to conduct a “feasibility study” that resulted in the drafting of conceptual plans. The feasibility part of the Feasibility Study was a critical reality check. We knew that with careful engineering it was possible to use infrastructure to cross animals under a road. What we didn’t realize was how utterly expensive it would be to retrofit that entire 8-tenths of a mile stretch of road. Complete mitigation of that site was not feasible for a grassroots effort. It was possible in terms of engineering and construction; it was just not feasible for a local group of volunteers to fund it. Back to the proverbial drawing board and the TA program.

Our next attempt at TA money was to fund final design and construction of two crossings within the site at the most critical locations—a north culvert and a south culvert. Our estimates put that price tag somewhere around $400,000. We were asking for the maximum TA amount of $300,000, with the understanding that the TA grant would be supported by a local match. That 2009 attempt resulted in $0.00. Motivated by the grim spring ritual of counting amphibians at this site, we beefed up our application package and resubmitted for the 2010 cycle and were awarded $150,000 in construction funds. Euphoria! While this was still not enough to build the project, we knew that this federal grant was going to be the catalyst that leveraged the rest of the money.

**Weathering the “Wasteful Spending” Storm**

Word of the grant award spread fast. The story was picked up by a Burlington Associated Press reporter and by noon the day after announcement of the award the story appeared globally from the Burlington Free Press and Vermont Public Radio (VPR) to the New York Times online, Taipei Times, Sidney (Australia) Journal. The response was largely positive, sometimes neutral, and sometimes negative. The negativity was mostly reserved for the comment sections, and the Monkton Conservation Commission and Lewis Creek Association salamander crossing crew felt like nothing could scuttle our success now. Our overconfidence was short-lived. Listening to VPR on my way to work the next day, I learned that Senator Tom Coburn, (R) Oklahoma, had included our Monkton Road project on page 15 of Wastebook 2010; A Guide to Some of the Most Wasteful Spending of 2010 - his infamous list of wasteful government spending. As a river of sweat trickled down my spine and a feeling of complete and utter defeat permeated my being, I finished the drive. When I got to my office, I noticed a couple of messages on my cell phone. One message was informing me that at least one VT legislator was not happy with this news and wanted to pull back the grant. The second message was from Tom Berry from Senator Patrick Leahy’s (D) Vermont office. Tom’s message said something like, “Give me a call, Chris. We are going to push back on this.” Over the next couple of days an overwhelming flood of support attempted to stop the bleeding as we perceived it. Apparently, the VTrans Secretary’s phone mail and email were clogged with messages saying “Please don’t pull this grant.” Secretary David Dill called me in to his office and sat me down. The beloved leader of VTrans looked me in the eye and said, “We
made a commitment with that grant. With something like this we can expect 50% of the people are going to love it and 50% of the people will not. That grant application was backed by science and data, it was reviewed by a committee of professionals. We’re not going to back out of our commitment. Now see what you can do about getting those emails to stop.”

Throughout the fundraising process, project partners from Monkton Conservation Commission, Lewis Creek Association, and the project design team were on the hook to answer difficult questions from skeptics. We took this on enthusiastically, and we felt it was perfectly acceptable to be skeptical and ask tough questions. Most of the time the questions were absolutely fair, except for the time, shortly after the unwelcome notoriety from Wastebook 2010, when Jim Andrews was invited by Fox and Friends for a live interview and subsequently subjected to sophomoric jokes about salamander sex. Jim handled the ambush on live national TV with grace and resisted the urge to take the bait. I personally had many conversations with neighbors while buying gas, milk, or beer at the Monkton General Store. I stood in front of the Monkton Select Board and public meetings describing the project and reassuring folks that this was not a whimsical undertaking, but a serious contribution to the well-being of Vermont’s biodiversity. One particular 2011 Select Board meeting stands out in my mind as a turning point. Just back from my father’s funeral, I was in a surly mood and definitely less patient that I should have been. There were some new members of the Select Board who had legitimate questions and were considering not accepting the 2010 TA grant. Feeling righteously indignant did not serve me well. And while I felt like I made some good points, I knew I was not doing a good job at communicating. Mercifully, a local contractor who had asked some of the same questions at a previous meeting stood up and bailed me out. “Look,” he said. “This is a legitimate project. The Conservation Commission did their homework and won a competitive grant to bring this work into our town to do some good. This project brings real money to our community – at no cost to us. If we don’t take this project the money goes elsewhere.” The Select Board voted unanimously to continue supporting the project.

Onward!

Thankfully the rest of the fundraising was less dramatic, albeit arduous and slow. The US Fish & Wildlife Service through a $70,000 State Wildlife Grant became an enthusiastic federal partner in the project. Over the next four years we banked smaller, but not less significant, private grants from Defenders of Wildlife/TransWild Alliance, Central Vermont Public Service (CVPS) Zetterstrom Award, and the Davis Conservation Foundation to the wonderful tune of $61,500. Direct appeal donations managed through the Lewis Creek Association brought in another $67,676.69 and an immeasurable amount of goodwill including a heartwarming bake sale from a daycare. Our final push was to reach beyond Vermont with a crowdsourcing Indiegogo campaign supported with a video from Peregrine Productions and artwork from Woody Jackson. This netted another $42,780. With nearly $350,000 in the bank, it was time to make a difficult decision: build what we can with what we have, or keep on fundraising.

We had tapped our funding well dry, and the price of concrete wasn’t going down. Our 2010 TA grant (which is a reimbursement program) had been waiting patiently, and the grant administrators were pushing us for movement on the project. We had enough money to put this project out to bid, in the hopes that bids would come in slightly lower than our projected cost.

The most flexible, but completely indispensable, component of our design are the retaining walls that keep the animals off the road and direct them into the culverts. Without retaining walls (a.k.a. drift fencing) it would be utterly dumb luck for the animals to find the culverts. The number of animals that we collect and direct through the crossings is in direct proportion to the length of the
walls we provide.

We now faced a crossroads: do we build the length of walls that we want, or do we build the length of walls that we can afford? Some passionate and heated debates followed. After consulting with Scott Jackson, who helped guide the design of the project, we decided, not unanimously, to put the project out to bid with the money we had and then change the length of walls to suit our budget and the successful bid. Scott’s advice still resonates a reassuring tone. To paraphrase his guidance, “You have an excellent design. It is going to work. These animals might not have the time to wait for enough money for the perfect outcome. It might be more important to get something in the ground sooner rather than later.”

**Design**

One of our goals was to develop a design that could be transferrable to other locations throughout the world. Moreover, one of our pitches was that we were going to make these crossing structures big enough that they would provide safe passage to other taxonomic groups beyond amphibians. So, while our primary customers are the amphibians that come in and out of the Huizenga Swamp, and our flagship species is the Spotted Salamander, we branded this project as a wildlife crossing. We hired the design firm of Lamoureux & Dickinson Consulting Engineers from Essex Junction, Vermont, to develop the design in close collaboration with herpetologist Jim Andrews. Together they brought together the best ideas from similar projects around the world and applied them to Monkton, Vermont. The biggest challenge was designing cost-effective and low maintenance retaining walls. The elegant solution was to utilize stackable waste concrete blocks. Installed, these blocks cost approximately $30.00/linear foot.

The culverts themselves are 5’ x 5’ pre-cast concrete bottomless box culverts. These are large enough to allow for ambient light to penetrate the entire length of the culverts. The boxes are buried into the natural substrate that follows the topographical contours of the landform. To help facilitate airflow and moisture into the culverts, two slotted grates (a.k.a. manhole covers) are installed in the center of each lane at each crossing structure. Squares of slate are placed along the retaining walls and within the culverts as cover objects, so that migrating amphibians may find refuge during migrations.

**Success!**

Low bid on the project was S. D. Ireland Companies of Vermont, who broke ground for construction in September of 2015. Construction was smooth and the project was buttoned up, seeded, and mulched before the snow flew that winter. By the spring Jim had two Reconyx cameras, one in each culvert, mounted and set to take time lapse photos at night throughout the crossing season. Throughout the fundraising and design, we were asked many times “Are these things going to work?” My response was a consistent, “Of course they are going to work. They are backed by solid science and engineering.” But I would be lying if I said I wasn’t absolutely elated and amazed when I saw the first Spotted Salamander walk through. Jim’s cameras recorded over 2,000 animals that first spring. The camera counts have been consistent in subsequent years with over 2,000 amphibians crossed each year. But we pitched these culverts as “wildlife crossings,” and they haven’t let us down. We consistently capture images of bobcat, mink, Virginia opossum, porcupine, ermine, Milk Snakes, Garter Snakes, groundhog, eastern cotton tail, raccoon, and mice sharing the space with amphibians.

In 2017 the Monkton Road Wildlife Crossing Project was recognized by the Federal Highway Administration with an Environmental Excellence Award for “exemplary achievement ecosystems, habitat, and wildlife.”
I first became aware of the dangers that roads pose to wildlife when I was 8 years old. On a warm and rainy night, my grandfather and I were riding in his truck over the dirt roads of the Wisconsin Northwoods. As we crept up the final incline to his farm, I noticed movement near a pond. The road was covered in a knot of tiny American toadlets just embarking on their fall migration in search of overwintering sites. A definite necessity in the frozen tundra of Northern WI, to be sure. I shouted out for my grandfather to stop before he squished them, and we sat for a few minutes, watching their urgent hopping through the foggy windshield. Soon, however, my grandfather grew impatient. He was a dairy farmer with plenty of chores waiting for him at home. But driving over the toadlets was unthinkable to me, and I refused to let him proceed until, together, we had carried dozens of toad metamorphs to safety.

Did you know that 83% of the U.S. land area lies within one kilometer (0.63 miles) of a road? And every one of those roads, including backcountry ones infrequently traveled, threatens the persistence of wildlife populations in myriad ways. Designed to link people and places in the most direct manner (those of you who live on a winding mountainous road may beg to differ on this statement!), transportation corridors often bisect the natural connections between habitats that species depend upon. When individuals traverse road surfaces in search of resources, they risk getting struck by a vehicle. For some regions and species, on-road fatalities can serve as a significant source of mortality. One way that roads also indirectly threaten population viability is via fragmentation. Populations that were once connected become isolated over time as fewer individuals move among them, either as the result of direct mortality or active avoidance of the road corridor. Why does this isolation raise such a conservation concern? It all comes down to
When individuals are lost, so is genetic diversity, and ultimately a population’s ability to adapt when faced with environmental change. In fact, scientists have already attributed local population declines in diverse taxonomic groups, including species of diurnal flying insects, Barn Owls, Desert Tortoises, Grizzly Bears, and Florida Panthers (sadly, this is not an exhaustive list) to the direct and indirect effects of roads.

As a group, herpetofauna are particularly vulnerable to road effects. The habitats (and resources associated with them – think refugia, mates and prey) required by many species to successfully complete their life cycles vary seasonally and are often patchily distributed across the landscape. When forced to cross roads during movements between these resources, mortality risk increases. Mass migrations of frogs and salamanders between terrestrial and wetland sites as described in the opening narrative offer the perfect example. Adults move to ponds in the spring to breed, while young leave the sites after metamorphosis in the fall. Similarly, diverse species of reptiles depend on particular substrates for nesting. During the nesting season, adult females experience high road-mortality rates when attempting to find the perfect site to lay their eggs. In some cases, individuals are even attracted to road surfaces and associated edges. This is a major issue on gravel and dirt roads. For example, over just two consecutive evenings last summer in northern Wisconsin I encountered 30 Painted Turtles and Snapping Turtles excavating roadside nests! Many of those individuals would have been struck by vehicles, but I intervened to either direct traffic around them or provide a personal escort across the road. In fact, multiple studies have linked the losses of adult female turtles during such events to population declines and male-biased sex ratios. Furthermore, a second pulse of mortality occurs when hatchling reptiles emerge and disperse from nests.

Injury or mortality risk on roads is further influenced by the timing of movements with respect to traffic volume and crossing behavior of individuals. When movement occurs during late evening or early morning, the likelihood of a successful crossing event typically increases. This is often the case for breeding migrations and summer forays. However, the relationship between mortality risk and traffic volume isn’t as clear cut as one would expect, because individual behavior plays a role as well. For example, dispersal ability influences the total time that it will take for an individual to cross a road, and let’s face it, some of our favorite herp species are not known as speed demons! As ectotherms, their performance is temperature dependent. Vagility (a term that encompasses both the extent and frequency of movement) and reaction times can be extremely reduced during cool temperatures. Yet, this is precisely when the warmer conditions associated with roads are so alluring. I have frequently observed gravid snakes or those digesting a meal pressed tightly against a paved surface. Finally, some species are known to immobilize
in response to the vibrations and lights of oncoming vehicles. When considering environmental conditions and behavior, even a few vehicles are sufficient to inflict high levels of mortality. On multiple occasions, I have observed the death of all individuals attempting to cross a road with just five vehicles passing in an hour.

Despite these factors, herpetofauna were largely underrepresented when the field of road ecology first emerged (with the exception of some great work on amphibians and crossing structures in Europe). Early studies tended to focus on mammals due to their increased visibility on roads and the extent of property damage and human injury associated with collisions. However, by the late 90s researchers in the U.S. began to fully appreciate the complicated relationship between road effects and wildlife populations. The timing of this shift coincided perfectly with my acceptance to graduate school at Idaho State University (ISU) in Pocatello, Idaho. My advisor, Dr. Charles R. Peterson had been approached by the Idaho Fish and Game Department and the USDA Forest Service to write a literature review of the effects of roads on amphibians and reptiles including a summary of any ongoing efforts designed to minimize negative effects. I entered the department of Biological Sciences at ISU to lead this effort. This offered an amazing opportunity for me to meld my interests in herpetofauna and road ecology, and I spent the whole first year of my master’s program diving into (or shall I say driving through) the literature. I read. A lot. This project also led to a collaboration with researchers at the University of Georgia who had been approached by the US Department of Transportation to compile a similar review. Ultimately, we published 3 syntheses, each with a slightly different focus.

While working on these projects, it became apparent to me that the number of rigorous road studies focused on snakes were rather limited. Don’t get me wrong, folks have been cruising roads for snakes and reporting about all the cool species they find for decades. It is how some get hooked on this field in the first place, and how some desert species were even hunted down for the pet trade. However, studies focused on which species or individuals cross or when, and where, and what this all can mean for populations were largely lacking. I had finally come up with a research project, and southeastern Gophersnake on road. Photo: Noah Fields
Idaho offered a great location to address some of these important conservation questions. Pinning down some of these details could assist in the timing or placement of mitigation measures.

I identified a 183-kilometer (114-mile) road circuit, composed of six different sections, located on the upper Snake River Plain in southeastern Idaho. Although each road section is paved and has two lanes, they differ with regard to average traffic volume per day (this ranged from 300 to 2200 vehicles per day in 2003 when I conducted this study). The route traverses the Idaho National Laboratory, a Department of Energy facility, that encompasses the largest contiguous reserve of sagebrush-steppe ecosystem. The landscape was at first quite foreign to my Wisconsin eyes, but breathtaking all the same - vast stretches predominated by large desert shrubs with a perennial grass and forb understory.

The study region is shaped by volcanic activity: basalt outcrops, lava flows, and cinder cones abound. To survive freezing winter temperatures, the six species of snakes that occur on the site overwinter communally in rocky hibernacula. These hibernacula are defined by a unique combination of slope, aspect, and depth, and are therefore limited and patchily distributed across the landscape. Annual surveys conducted by members of the ISU Herpetology Laboratory at three of the largest hibernacula on the site have offered a glimpse into just how many individuals depend on these features, and the relative abundance of species. Important information that does not always accompany road ecology studies. Assisting with these surveys remains one of the most amazing experiences I have had in the field. Take a minute and imagine carefully treading across the rocky edges of a collapsed lava tube with the buzzing of rattles accompanying each step. Basking snakes would quickly slither into crevices in attempts to avoid capture. On a really prime day, we could catch over one hundred snakes! Individuals migrate to and from these hibernacula in an annual cycle that includes the search for refugia, prey, mates, and oviposition (for species that lay eggs) and gestation (for species that give birth to live young) sites. Individuals often retrace the same pathway during long-distance movements between these resources, and when roads bisect movement corridors, problems arise. In this case, although we knew the location of the largest dens and had established an on-going monitoring program of snake populations, we had limited information on the magnitude of road mortality and the potential drivers influencing it.

I conducted surveys during 2003 for live and road-killed snakes by slowly driving (48 kilometers per hour) the complete route and recording a variety of data each time I observed an individual. Sometimes a fellow graduate student or aspiring young scientist accompanied me, but often I was alone. Can I just tell you that I invested in a Sirius satellite radio, so I could at least listen to some good tunes while road cruising (at the time, all I had was a tape deck)? It definitely got me through some of the slower days. I also drank a lot of coffee - the surveys took from four to eight hours to complete, depending on the number of snakes I encountered and traffic volume. I drove at least three routes per week during the spring migration and only one during summer and fall. I completed 56 total surveys between May and October, traveled 10,248 total kilometers (6,368 miles), and killed my station wagon by the end! I encountered 251 total snakes (ranged from a low of zero to a high of 16 individuals per survey) during these surveys. Almost ALL of the individuals (93.2%) were DOR (dead on the road), so the mortality rate was 2 snakes for every 100 kilometers (62 miles) traveled. Although the overall snake count was lower compared to studies in snake-rich regions, the proportion of DOR individuals ranked among the highest reported for systematic road surveys in the literature.

This extent of mortality was surprising to me, particularly on stretches where I didn’t see many vehicles. Wondering if this value was simply inflated due to the time it took me to drive the entire circuit, I conducted 12 additional surveys in 2004 along a focal stretch of 10 kilometers (6.2 miles) during periods of peak snake activity. I traveled 746 total kilometers (464 miles) and observed 80 total snakes; 59 of these individuals were either DOR or likely would have ended up so without my intervention, and four avoided crossing. I documented an even greater mortality rate along this short stretch of the circuit (8 snakes for every 100 kilometers traveled), suggesting that roads have the potential to isolate local snake populations, either through vehicle-inflicted mortality or crossing avoidance. Sadly, these mortality rates were similar to those documented in other comparable ecosystems with one striking difference: my observations consisted primarily of just two species! The data revealed differences in which species were crossing roads across the study area. Of the 251 snakes that I encountered during surveys in 2003, Gophersnakes (Pituophis catenifer) comprised the majority of road observations (74.5%) with Western Rattlesnakes (Crotalus oreganus) more common (18.3%) than either Terrestrial Gartersnakes (Thamnophis elegans) or Striped Whipsnakes (Masticophis taeniatus), with each of those species...
representing less than 10%. Although present locally, I did not detect any Racers (*Coluber constrictor*) or Desert Nightsnakes (*Hypsiglena chlorophaea*). The prevalence of Gophersnake observations compared to Rattlesnakes was completely unexpected! Of the over 4,000 individual snakes captured during 15 years of intensive surveys at hibernacula by the ISU herpetology lab, Rattlesnakes comprised the greatest proportion (76%) of captures followed by Gophersnakes (11%) and Gartersnakes (9%). One explanation for these contrasting results – we were simply underestimating Gophersnake abundance. During visual searches of hibernacula in spring and fall, Rattlesnakes definitely make their presence known, while Gophersnakes are more difficult to detect. In fact, several radiotelemetry studies of Gophersnakes have revealed extensive subterranean behavior. However, the three focal hibernacula were also completely encircled by drift fences that included funnel and pitfall traps. When only considering these survey methods, the proportion of Gophersnakes captured increases to 22%.

This is still a large discrepancy, and raises an interesting question: Are Gophersnakes more susceptible to road mortality in this particular study system? Perhaps it comes down to ecological or behavioral tendencies. Research has shown connections between road mortality rates and vagility; the more frequently you move and the greater the distance you travel, the more likely you are to end up squashed on a road. In this case, Gophersnakes and Rattlesnakes depart from the same hibernacula in the spring to locate feeding grounds, but once they get there, their feeding ecology differs. Gophersnakes actively seek out their prey, while Rattlesnakes ambush them. In addition, Gophersnakes are considered generalists, and may therefore be more willing to traverse a greater range of habitats compared to Rattlesnakes. I also observed differences in crossing behavior between these species. The few live Gophersnakes I encountered tended to remain stretched out across the road surface and froze in response to oncoming vehicles, creating a more conspicuous target, while Rattlesnakes tended to coil. It is easy to visualize how crossing success could be related to body size and shape, and this is especially true for snakes. On multiple occasions, I watched in horror as motorists deliberately swerved to strike a snake, a phenomenon reported elsewhere in the literature.
The data also revealed differences in which individuals tended to traverse roads and when snakes were more likely to be hit. In terms of age and sex, I mainly encountered adults (63.3% of all road observations) and males (64.9%) when considering all observations. These proportions are slightly greater than expected based on the survey data from the focal hibernacula and are likely explained by differences in movement tendencies among the demographic groups. Radiotelemetry studies show that adult male Gophersnakes are active on a greater number of days and move more frequently than adult females or subadults, while adult male Rattlesnakes tend to move greater distances than adult females or subadults. In addition, while the increased vagility of males of both species during their respective mating seasons increases their chances of finding females, it also leads to more road crossing events. When plotting all observations across time, two distinct pulses of mortality appeared: one during spring egress from, and the other during fall ingress to hibernacula. The peak mortality events in spring (> 10 snakes) stretched across the entire season, while those in fall were limited to just 15 days. Indeed, snakes still crossed roads during the summer months, but they restrict activity to cooler temperatures, when traffic volumes are typically lower.

I also learned that the which and when depended on each other; not all individuals were susceptible to road mortality during the same season. Adults experienced the greatest road mortality during spring compared to other seasons. This corresponds to the time when both sexes leave the hibernacula to locate their established feeding grounds. Adult male Gophersnakes get hit hardest during this time, because they are also searching for mates. I detected fewer adult snakes during the fall ingress than I expected. I think this was due to the fact that individuals began their return trip to hibernacula as early as mid-August, so peak activity coincided with lower traffic volumes. Conversely, subadult deaths spiked dramatically during the fall; I recorded an intense mortality event of neonate Gophersnakes during two weeks in September. Gophersnake nests are located in distinct habitats distant from hibernacula, and after hatching, the young need to find their way to communal dens. These movements typically overlap with increased traffic flow because individuals must wait for temperatures to warm up before they can move. Rattlesnakes, however, give birth to live young, and females typically remain near the hibernacula during this time, which
likely explains why I failed to observe a similar peak for this species.

The location of snake observations across the road circuit was not random; aspects of roadside habitat and landscape features influenced where snakes crossed. To identify the factors underlying these spatial patterns, I categorized the local habitat in the field and used GIS to measure features on a broader scale. My analysis detected nine variables associated with crossing events; five linked to local vegetation and refugia availability and four tied to the extent and type of vegetation further from the road and the distance to known hibernacula. I will focus on one key factor here with serious conservation implications. Gophersnakes and Rattlesnakes preferentially crossed roads in areas with dense grass cover. Although the native shrub and grass community remains largely intact across the study area, the abundance and distribution of non-native cheatgrass and crested wheatgrass has recently shifted. While intentionally planted along roadsides to limit erosion, they have since spread, as is the case in other western states. Studies report lower densities of small mammals and burrows in areas dominated by these grass species, which equates to fewer prey and refugia for snakes. Consequently, individuals may perceive this habitat as unsuitable and increase their movements to simply get through it. This result is particularly concerning because roads offer a conduit for the spread of many non-native species. When the habitat changes associated with these spreads lead to greater movement of individuals, road mortality risk increases.

What do all of these results boil down to? The answer to the burning question of why the snake crossed the road, is… complicated. There are many factors to consider: the ecology and behavior of different species and demographic groups, the season, aspects of roadside habitat, and the surrounding landscape to name just a few. When attempts to assess or mitigate the negative effects of roads account for even one of these which, when, or where aspects, efficacy can improve. In this particular case, the ISU Herpetology Laboratory expanded monitoring efforts of snake populations to include road surveys during the spring and fall. When funding or personnel are limited, focusing survey efforts to coincide with months of peak activity can offer valuable insight into the extent of road effects. In several instances, the temporary closure of low-traffic roads during high-risk times of the year have increased connectivity between key habitats for multiple species of herpetofauna. Underpasses and overpasses link habitats bisected by roads but are expensive to install and maintain. The placement of these structures within the landscape context of
target species can determine their success at providing safe passage for individuals.

As a supporter of the Orianne Society, you are likely aware of how roads affect the species that you care about. While the conservation challenges related to transportation networks may seem daunting, there are things that YOU can do to make a difference:

- Move individuals (when safely permitted to do so) across roads in the direction that they are headed! Animals are crossing in search of resources and you want to provide transport assistance. Do not place them in what you deem to be a “better spot” – simply move them across. In addition, concentrated efforts during mass migrations can serve to greatly reduce the number of individuals killed on roads.

- Contribute your observations to a citizen-science platform (e.g. HerpMapper) to help scientists and managers identify hot-spots of road mortality and crossing events.

- Place signs or stand in an area to bring awareness to crossings. I admit that this may not always be successful, but I have personally observed a few instances where it encourages travelers to drive slower.

- Avoid placing attractants near road edges on your property. In the case of my study, landowners placed rocks cleared from fields in large piles along the road. While these piles provided some great places for snakes (and lizards) to bask, shed, and overwinter, they also led to hotspots of road mortality.

- Be a voice for the animals we care about. If you have an opportunity to provide comments during a proposed road construction or expansion project, suggest approaches that will help minimize mortality. Something as minor as an alteration to the timing of the project can be beneficial.

- Finally, support conservation efforts designed to increase connectivity of habitats and populations.

If you are interested in reading more in-depth about the effects of roads on herpetofauna please contact me via e-mail (denimjochimsen@gmail.com) for links to some exemplary reviews and original research that has advanced our understanding of road ecology.
Feeling right at home in the North Carolina Sandhills

Have you ever found that place where you just feel at home? A place that seems to have infinite possibilities and mysteries around every corner? The North Carolina Sandhills is just such a place for me. I remember the first time I visited this hallowed ground in pursuit of reptiles and amphibians. I was around 18 years old and fresh out of both high school and basic training from the US Army. It seems that my love affair with this region is also inextricably intertwined with the military both because the region is still used by the Army for training and many of my trips coincided with various times of training or deployment for myself. Prior to my Iraq Deployment in 2005, I spent that last few days I was home road cruising backroads for mole kings and pygmy rattlesnakes, and I planned my mid-tour leave around spring herping. I stop in the sandhills conveniently (or inconveniently if you’re my wife) every time we’re headed to the North Carolina coast and I just so happen to get gas at a spot I’ve found corn snakes at in the past. If I can make an excuse to drive East, I do it happily.

I found my first Scarlet Kingsnake, Pygmy Rattlesnake, Southern Hognose and Cottonmouth in the North Carolina Sandhills. I’ve had the privilege to witness amphibians only a few have seen and been in awe of the diversity held in the Sandhills. I learned about the art of road cruising by a longtime friend and mentor in all things viper, Zach Orr, and above all else, I learned of the rich biodiversity of species in this region. It’s why when asked about a specific locality or spot I always dodge the question like an old-time fisherman guarding his honey hole. Although I hope everyone gets to experience this wonderful region of extreme beauty and biodiversity, I truly hope many of you stay home too. It’s such a mixed feeling because I also am not a resident to the area and I have no right to lay claim to it either. I travel almost 2 hours from my home near Winston-Salem, North Carolina to those coveted game lands and other regions where pines outnumber oaks and sand replaces piedmont red mud.

One such adventure in June around 2 years ago, Thomas Lavine and I had one of those nights of all nights in the sandhills. We found what seemed like every species of tree frog and many species of snakes that we were seeking. As with all memorable adventures, this one
started with excitement as I drove to meet Thomas at our prearranged spot, but catastrophe stuck while I was traveling east. I was maybe 30 minutes from the designated meeting area and my trusty 2000 Nissan Altima off-road vehicle (sarcasm) began to decelerate on the highway despite my heavy foot pressing the gas pedal to the floorboard, my engine continually sputtered to a dramatic stop as I coasted off the highway to the nearest exit.

As my car jerked and gyrated while I transitioned off of Highway 220 to the subsequent backroad my car ambled onto at the end of the exit ramp, I found myself waiting to hear banjos in the distance. There were signs all around indicating I was in the pottery capital of the world just on the far side of Randolph County. This wasn't good. My car coasted downhill and I was able to pull over on a side street and call my wife, and then Triple A to come get my downed vehicle. This was one of those exits where there were no signs of life, just long empty roads in both directions and it left me to wonder if this night could get any worse. I had been daydreaming all day about this trip to the Sandhills and all the animals I wished to see that night, so I hoped that this setback wasn't any indication of the night to come. I called Thomas and he readily came and picked me up to where my car was stranded. Thankfully we didn't have to fight off any angry pottery shard wielding locals during this malady because I'm sure this was the most excitement that sleepy little road had seen in quite some time.

We watched as the flatbed tow truck hauled my car up the ramp and dragged it with a cable to center it on the bed. I gave the driver directions to my mechanic some 90 miles away and I loaded my camera gear into Thomas’ vehicle. Nothing could stop us, not even my dead vehicle. It didn't dawn on Thomas until a few miles into the trek that he'd also have to take me all the way home after our adventure. That dude is a saint!

Not long after we resolved the issue with my car, we got back on the road we passed the small town of Candor, NC and saw an Eastern Box turtle doing it's best to get across the road. Excitedly I rushed to my chelonian brother and moved him across the road in the direction he was headed. Once the road transitioned from hardball to sandy bottom, we saw our first snake, a juvenile Corn Snake, and we both took a few minutes to lay prone in the dirt to photograph this accommodating serpent. I have always loved finding Corn Snakes, although they can be considered a common species at times, they always give me a great deal of joy to find them. I love the slow creep we do as we are road cruising for reptiles and amphibians with windows down and humid night air wafting into the vehicle, there's nothing quite like it.

The sun hadn't even set yet and it was already shaping up to be an amazing adventure. We drove through the sunset and the next few hours seemed like maybe we had gambled wrong on our trip because there was just nothing on the road, until there was. We had all but lost hope and as we turned the corner on an old country road with broken pavement and tufts of grass growing in some of the cracks which seemed like an island between the roads made of hardened sand. I yelled for Thomas to stop the vehicle. We slid to a stop and I jumped out of the passenger door before the car had completely stopped. Right on the edge of the road was a gorgeous sub-adult Pygmy Rattlesnake. We were elated! We spent a few minutes photographing this beautiful serpent.
and then moved it safely off the road in the direction he was traveling. If the trip had ended here, we wouldn’t have minded but as if by magic, the night seemed to just get better and better. It seems that trips like these to the sandhills, whether we are road cruising or hiking in the region, usually go one of two ways. You either find copious amounts of reptiles and amphibians or nothing at all. Thankfully this was one of the nights where our experience was the former and not the latter but if I had to guess I’d say our trips typically end with us scratching our heads and we either find nothing at all or simply drive 2 plus hours only to find toads in the roads.

After our experience with the pygmy we drove back to a few other areas and the ditches and roadside vernal pools seemed to be alive with a cacophony of frog calls. We heard and saw all matter of frogs that evening from Barking Treefrogs to Pinewoods Treefrogs and Copes Gray Treefrogs, we even spotted a Scarlet Snake out on the crawl. Just when we thought it couldn’t get any better, it did. The highlight of the entire evening was when we were able to spot a Pine Barrens Tree Frog. This was the first time find for both Thomas and I and we spent maybe two hours tracking this one individual.

It must have been 3 am on some dusty backroad when we finally found this vocal Pine Barrens Tree Frog. We would play frog calls on our phones and try our best to even imitate the calls ourselves and after a few minutes we would hear a faint reply call and then nothing. After painstakingly triangulating where the calls were coming from we finally found this gorgeous little frog in his bandit mask. We photographed him on the branch he was calling from for several minutes and decided the night couldn’t get any better than this and called it a night, or well morning, and went homeward. Thomas and I both fought sleep the entire ride home, which is one of the sketchy side effects of an all-night herp trip I suppose. We did all we could do to keep our eyes open by blasting the air conditioning and loading up on copious amounts of gas station caffeine. I’d like to say that the thrill and excitement left us on an all-night high from our successful adventure, but I believe once the hum of the tires and rhythmic motions of the car on the highway set in it just made our eyes heavier. I got home as the sun was beginning to rise thankful that we had made it and realizing Thomas still had another 2 hours to go to get to his house. I felt bad for him and offered to let him sleep it off at my house, but he said he felt wide awake for some reason and then he set off southward to his house, again that dude is a saint.

In contrast, my most recent road trip to the sandhills was quite the opposite of that adventure. I erratically did a few aggressive U-Turns for corn leaves or patterned tree roots and pine needles splayed out in the middle of the highways
while on my way to all of my favorite spots only to find...nothing. What I did find were other fellow herpers out enjoying the area. Almost as soon as I turned off the main highway on to a sandy dirt road I saw a Subaru with South Carolina plates and “I brake for snakes” and other reptile related bumper stickers on the back. “Great,” I said to myself. This was going to be one of “those days.” As it turned out I ran into this gentleman about an hour later as I was lumbering out of the woods and he was driving by. It turned into a great conversation about the beauty of the sandhills and how much we loved the area and the animals that called this place home. As I made my maddening loops from spot to spot I ran into quite a few other people that I’d met in passing online on one form of social media or another and we all seemed to be friends of friends sharing a similar passion to see endemic herps.

The highlight of my day was my time speaking to Brady Beck, a state biologist works with a team of biologists, foresters, and technicians to manage the game lands. This man has a passion for the sandhills, to say the least. We geeked out over camera gear and lamented how things have changed somewhat over time in the region and tried to think of creative ways to both keep this place a secret and also illustrate its beauty so that it will be loved and protected by all. It’s that fine razors edge of loving a place without exploiting it. I feel like in many ways I learned that these trips to the sandhills often have very little to do with the animals and sometimes its about the people you meet along the way that make this place so amazing.

In the almost 20 years that I’ve been making the road trip to and from this area I’ve seen it change in dramatic ways. For example, the peach orchards that dotted many of the old backroads in the area have been converted to solar farms. My initial thought was that although this was done with the environment in mind and with good intentions, I wondered what impact it may have had on the endemic animals that lived in the area and relied on those peach orchards. I was, however, reminded that those peaches were outside invaders too and were imported from Asia a century or more ago. The native Longleaf Pine habitat was cut down and removed to plant those orchards and the solar farms were just a new chapter in an already scarred land. Perhaps just the perceived beauty of the area and nostalgic cultural history had changed but as far as impact it was a neutral move. Time will tell. Many neighborhoods and businesses have seemed to spring up out of the sandy soil from nowhere over the last handful of years along the roads to the sandhills and I both mourn the loss of old haunts and wonder how the new tenants will treat the native wildlife they will most certainly encounter. Is all progress bad?

With the advent of internet forums and popularity of the internet in general over the last few decades, I’ve seen a rise in people coming...
from out of state to observe wildlife, and some to collect it. The former and latter can both be a destructive factor when done unethically or unintentionally. Let me explain. As previously mentioned, I love this area. I love the wildlife here and I’m sure many of you do as well but have you ever thought about the impact we are having on the region as a whole each “Hogtober” when the roadways and subsequent wood lines are scoured for the elusive Southern Hognose Snake. As we undoubtedly stalk these wonderful animals how many rare plants are being trampled en route to the coveted snakes? Does our need to out Instagram our peers contribute to unscrupulous followers finding our spots and collecting these rare gems from the wild? Does our need to out Instagram our peers contribute to unscrupulous followers finding our spots and collecting these rare gems from the wild? Have we unwittingly opened up our favorite spots to disreputable herpers who may not share the ethics we do? These are all the questions I ask of my friends and myself as we set out on these road trips.

Will this make me stop taking these trips? No! But it does make me consider the ethics of what we do a lot more. For example, when I post pictures, I do my absolute best not to stress any animal more than necessary, the goal is obviously not to stress them at all but I imagine my mere presence as a potential predator elicits some level of stress to said animal. I try to crop in as close as I can on habitat shots and not show any identifiable features so as not to invite people to find out where exactly I am. In these sacred spots I do my best not to allow my zeal to share pictures or videos of these wonderful creatures to trump my desire to conserve and protect their wellbeing.

I know it’s debatable but personally I don’t log information in any of the herp related nature apps for that very reason, although I fully understand the scientific value of data collection in the region in regard to citizen science for population density and etc. I am often more afraid that people will reverse engineer these sites to find and disturb these animals. Usually when I’ve found something remarkable I take note and send an email to the appropriate personnel at the state level and let them log the data their way. I guess I’m still old school like that.

I’ve talked to many game wardens in the area and although they are stretched very thin they are definitely finding people who bring collection gear into the game lands and have even busted people recently with backpacks containing protected species. I realize in many ways I am preaching to the choir with this group, but I hope we can find a way to both communicate the value of these creatures without overexploiting the region at the same time. I’ve often heard from herpers much older than myself that in our excitement to check species off a “lifer” list that many people can overexploit an area and essentially “love them to death” by simply just having more foot traffic in a given area. I’m not sure I have the answer because I both want people to enjoy the outdoors and conserve it as well. My passion has always been to showcase these animals in a positive light so that others will become passionate and collectively we can save species.
I think with many of us growing up on the exploits of Steve Irwin we may have thought that each snake needed to be captured by hand with vigor and enthusiasm but as I’ve gotten older, I’ve seen that is less and less the case anymore. The stress to the snakes isn’t worth the adrenaline rush or danger (to both me and the animal) that once felt like a necessity. It seems the more time I spend with these animals the more I want to just watch from a safe distance and film and photograph their behavior and not just action shots of some weirdo (me) catching them because I am as guilty, or even more so, than anyone of this behavior. I guess I just recognize it now and it seems that moving forward I’d love to show their beauty in a much bigger way to protect them for generations to come.

With the rise of white-nose syndrome in bats, Chytrid, snake fungal disease and other funguses and diseases plaguing wildlife we must be more vigilant than ever with our herping ethics. As we tromp around caves or vernal pools or different regional habitats we have to be aware not only of what others may have taken from an area but also what we are introducing. It’s always a good habit to sanitize your gear between trips and it’s something I’ve recently tried to be more aware of personally. It breaks my heart to read about the declining amphibians worldwide and the bats dying off en masse in the eastern United States due to diseases most likely transmitted by well-meaning individuals just trying to enjoy nature.

With climate change, habitat loss, species decline and many other issues looming on the horizon there is also hope. There’s always hope. The burden and responsibility fall on our shoulders but as a people who champion the creatures that many abhor, I have full confidence that we are up to the task and able to make positive change. I have heard from officials with NC Wildlife that there are many positive things happening in the sandhills right now. They have been able to procure more land for the game lands which serves more or less as a preserve for many animals. State biologists are working with the North Carolina Zoo to help the embattled Gopher Frogs and Ornate Chorus frogs rebound from their severe decline by doing head start programs by releasing tadpoles reared in captivity back into their historic pools as well as newly created wetlands. There have been at least 3 large wetlands restored on the Sandhills Game lands as well as the creation of others in hopes to support these rare amphibians.

The Red-Cockaded Woodpecker populations in the area have rebounded significantly thanks to a partnership with state biologists and the Fort Bragg military compound over the last few years because they saw the value of protecting the organisms that relied on the same land that they did for training. When it is good for wildlife it is also good for humans and that symbiotic relationship between humans and wildlife gives hope for a future for both.

Although this ecosystem is fragile and has many perils in the coming years, there’s hope that it can rebound and in many ways be the treasure it’s been for me for generations to come.

I think if we, as the people who enjoy these spaces, can think ethically about how we interface with the outdoors then the road to the future will be one of hope. If we can educate ourselves and others to do simple ethical things in the field, it could go a long way. We could do things such as make sure our gear is clean between trips. Make sure we put rocks and logs back if we peek under them to preserve micro habitats. We can assure that we aren’t wantonly ripping the bark off dead pine trees in search of wildlife and just do the pull and peek method with a flashlight to keep the bark upright and intact. We can pay attention to when and where we are tromping around and to be aware of the impact our images and videos may have on the region. Remember that while you’re traversing this region trying to get to the “good spots” that the roads that transect the game lands and other areas also contain wildlife so watch your speed while you’re going from point A to point B. Too many times people will speed through this habitat not paying attention to the tiny hatchling snakes or toads we may inadvertently run over while focused on the next hot spot. Try to slow down and pay attention because you may be rewarded with something tiny that you weren’t expecting, and who knows, you may even save a life. If we consider the impact we are having both good and bad and address these things accordingly, then the future will be much brighter for this region and the wildlife that we love.
PHOTOS

1. **Harper Wolf**
   - Black Rat Snake

2. **Gary Williamson**
   - Timber Rattlesnake

3. **Matthew Mead**
   - Wood Turtle

4. **Andrew Oullette**
   - Painted Turtle

5. **Brooke Roberts**
   - Corn Snake

6. **Spencer Siddons**
   - Grey Tree Frog

7. **Cynthia Brown**
   - American Toad

8. **Bryce Wade**
   - Plethodon shermani x Plethodon leythahilei Hybrid

9. **Tucker Stonecypher**
   - Eastern Indigo Snake

10. **Russell Tillman**
    - Eastern Diamond-backed Rattlesnake

11. **Travis Russell**
    - Wood Turtles
UPCOMING events

February 2020

SOUTHEASTERN WILDLIFE EXPOSITION
February 14-16
Charleston, SC

SOUTHEASTERN PARTNERS FOR AMPHIBIAN AND REPTILE CONSERVATION ANNUAL
Meeting - February 27 - March 1
Nauvoo, AL

March 2020

FIRE & LONGLEAF ACADEMY HOSTED BY THE LONGLEAF ALLIANCE
March 3-5
Tallahassee, FL

GREENSBORO SCIENCE CENTER TALK
March 5
Greensboro, NC

CLAXTON WILDLIFE AND RATTLESNAKE FESTIVAL
March 14-15
Claxton, GA

PRESENTATION: “BIG NIGHT” AMPHIBIANS AT THE NATURE MUSEUM
March 26
Grafton, Vermont

SPOTTED TURTLE DAYS
March 28-29
Georgia

April 2020

EARTH DAY
April 22

MASTER HERPETOLOGIST PROGRAM SNAKE FIELD TRIP HOSTED BY THE AMPHIBIAN FOUNDATION
April 25
Atlanta, GA

NORTHWEST PARTNERS FOR AMPHIBIAN AND REPTILE CONSERVATION
April 28 - May 1
Spokane, WA

May 2020

VERNAL POOL AND AMPHIBIAN WORKSHOP IN PARTNERSHIP WITH THE VERMONT LAND TRUST
May 9 (subject to change)
Concord, Vermont

WORLD TURTLE DAY
May 23

= The Orianne Society will be participating

Want to announce an upcoming herpetology or land management event in the next issue of Indigo Magazine?

E-mail the event information to info@oriannesociety.org by April 1, 2020 to be included in the next edition.
TAKE action

BECOME A DONOR
From pledging a reoccurring donation, to becoming a member, to making a one time donation, our supporters are the backbone of the organization. Donations can be made through our secure website or by contacting us directly at 706-224-1359.

SPREAD THE WORD
We don’t underestimate the power of word of mouth when it comes to letting people know about our work and the ways they can contribute! Please consider sharing this magazine with others who have an interest in conservation, and follow us on Facebook, Twitter and Instagram.

PLAN YOUR GIVING
Don’t just plan for your future—plan for the future of reptiles, amphibians and the great places they inhabit. Whether you prefer to set up an annual donation or a deferred gift, we can work with you to determine what you want your gift to support and how it will benefit these amazing animals and landscapes. Please contact us at info@oriannesociety.org or 706-224-1359 for more information about our planned giving opportunities.
Our members are the backbone of our organization, and we cannot accomplish all we do without your support! This year, we have expanded our membership program to offer differing levels of support to encourage members to become sustaining supporters of reptiles, amphibians and their habitats:

**Spotted Salamander**
**Membership: $35**
- Decal
- Invitations to Exclusive Events
- Monthly E-newsletters
- Magazine and Annual Report (electronic)
- Bragging Rights!

**Wood Turtle**
**Membership: $100**
In addition to the $35 member benefits, you’ll have the option to receive one of the following:
- Printed Magazine and Report
- Limited Edition Print

**Indigo Snake**
**Membership: $150**
In addition to the $35 member benefits, you’ll receive both of the following:
- Printed Magazine and Report
- Limited Edition Print
The Orianne Society is a proud, nonprofit partner of 1% for the Planet and EarthShare Georgia.

Barking Tree Frog. Photo: Stan Lake

Front Cover. Corn Snake on road. Photo: Stan Lake