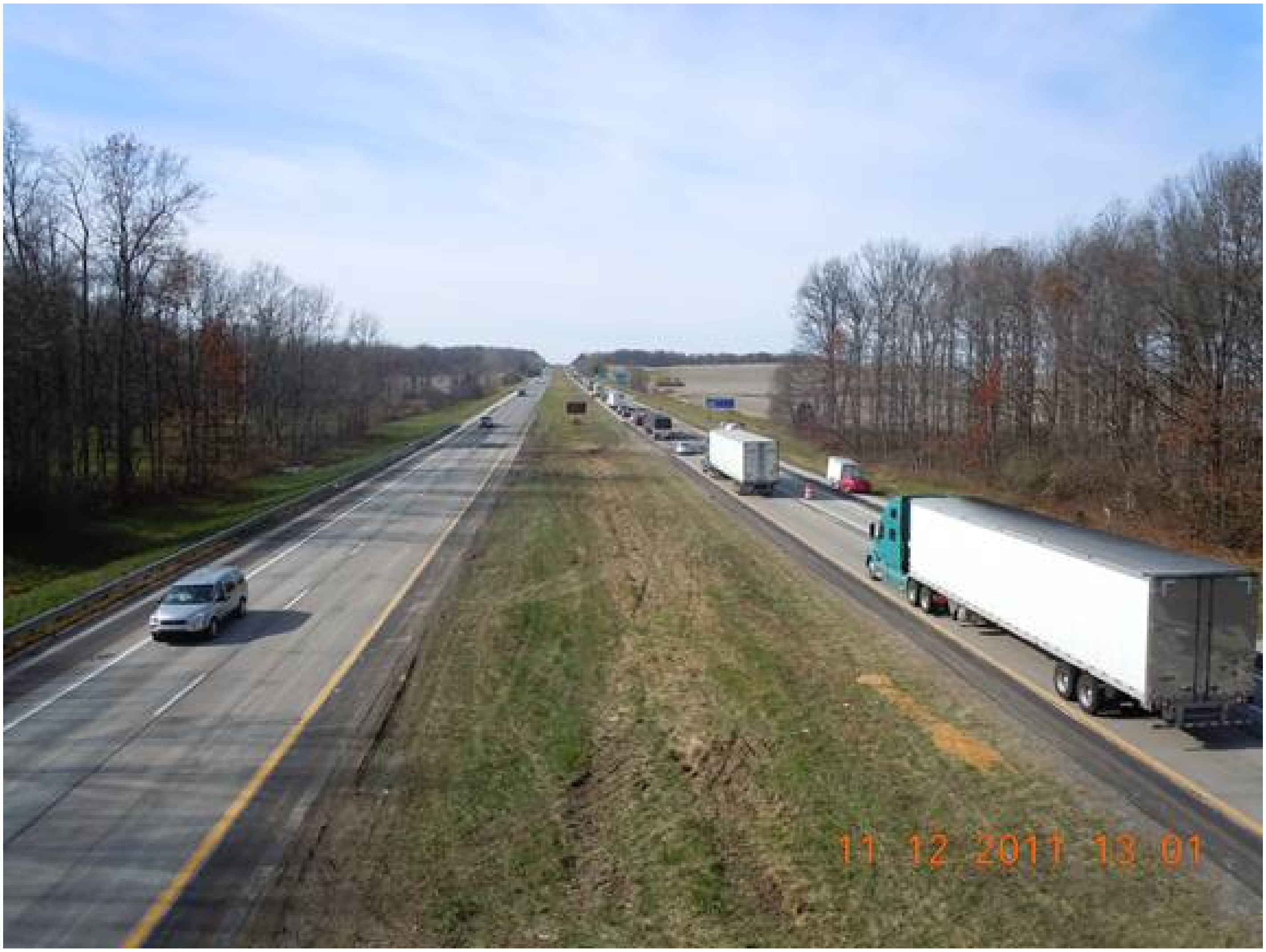
ASSESSMENT OF THE ROLE OF INTERSTATE HIGHWAYS AS BARRIERS TO GENE FLOW AND METAPOPULATION PERSISTENCE IN MAMMALS FROM INDIANA



A study site on Interstate 70. Note the open spaces at the edges of the road and in the median. Small mammals avoid open spaces, due to threats from aerial predators.

Current Status

Fifth year of a five-year project

Funding Sources and Partners

State Wildlife Grants, Purdue University, IDNR Nongame Fund

Project Personnel

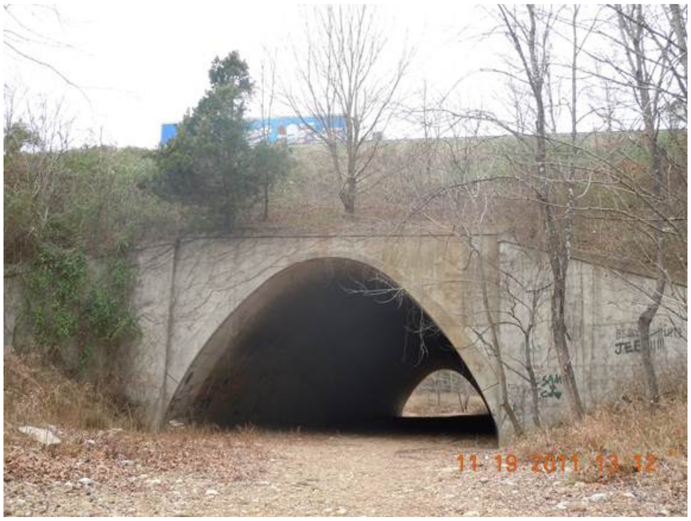
Principal investigator, Pat Zollner
Co-principal investigator, Gene Rhodes
Cecilia Hennessy, Ph.D. graduate research assistant
Matt Beard, Ph.D. graduate research assistant
Tricia Tsai, Ph.D. graduate research assistant
Melissa Mills, undergraduate modeler
Roxanne Pourshoushtari, GIS technician

Background and Objectives

The main goal of this project is to determine whether interstate highways in Indiana are restricting the movements of wild animal species of various sizes, which may result in declines of these species due to losses in genetic diversity. We will investigate the ability of six mammal species to cross the interstate by analyzing genetic information and movement patterns of wild populations.

Methods

Previously, we live-trapped six common species of mammals, including raccoons, opossums, gray squirrels, fox squirrels, chipmunks and white-footed mice, from forests on opposite sides of interstate highways in



The drainage overpass at the study site in Harrison-Crawford State Forest might play an important role in connecting populations of some mammals on opposite sides of the highway.

Indiana. We selected forests separated by the interstate, but that otherwise have good habitat for these species. These are so-called "paired" sites, because each site actually has two parts—one on either side of the interstate. We used box traps, which are like wire cages, to trap the animals. We marked the captured animals with numbered ear tags, and we took a small genetic sample from each animal, usually a tiny piece of the tip of the ear. Collars containing radio telemetry transmitters were attached to adult chipmunks, gray squirrels, fox squirrels and raccoons at a subset of locations. We took the tissue samples back to the wildlife genetics research lab at Purdue University to extract DNA and determine the genetic characteristics of each individual.

Combining the genetic information with location data helped us determine the effect the interstate has on the local populations by allowing us to look for evidence of genetic exchange between populations on either side of the road. Animals that are related share a lot of the same DNA, and the more related they are, the more DNA they have in common. Therefore, a population of animals is likely to share DNA at a relatively high rate because there will be a lot of relatives living near each other. Populations on either side of an interstate can be compared for evidence of gene sharing and relatedness. Lab work with the DNA from field samples allowed us to estimate how related animals are on opposite sides of the highway. During 2012 we conducted statistical analyses of the genetic relatedness of samples from all seven study sites. We used this information to determine where the interstate separated animals of different species on opposite sides into two populations and where there was only a single population across both sides of the highway. In places where the animals on the two sides of the interstate are two separate populations, the interstate may be creating a barrier to animal movements. We expected that some species (chipmunks and squirrels) would find the highway to be more of a barrier to movement than other species (raccoons and opossums) because of differences in the willingness of these species to cross highways.

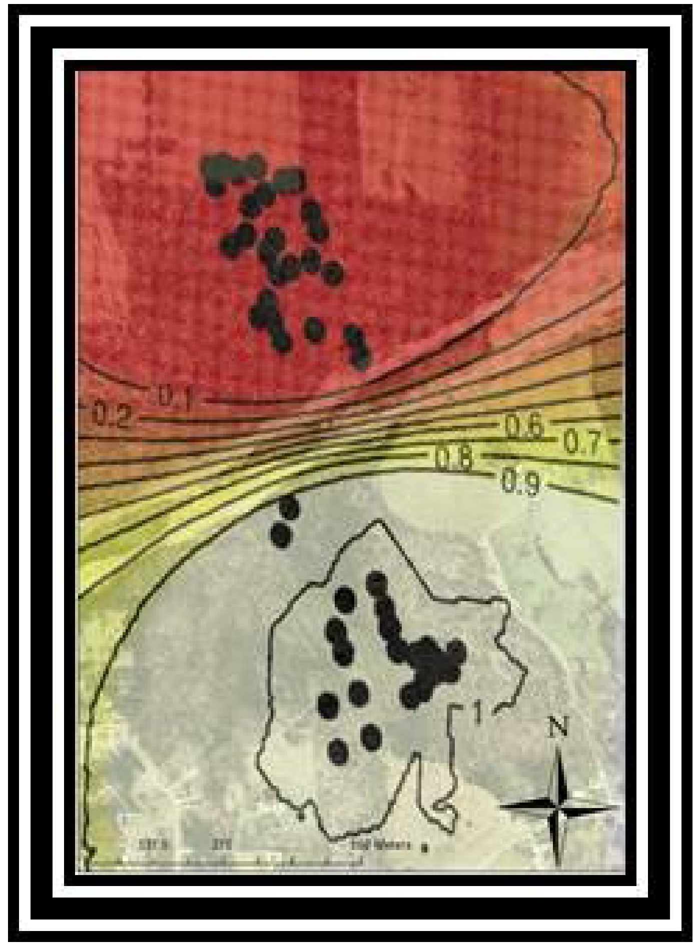
Detailed data on the movement patterns of animals from the telemetry transmitters help us understand the day-to-day response of these animals to highways. That understanding of those daily movement responses, in combination with the genetic data, is critical to building computer models that we use to predict the consequences of interstate highways in Indiana on the long-term persistence of viable wildlife populations. The radio telemetry collars provide us detailed data on the movement patterns of the animals we are tracking at each grid. Animal locations are estimated using six automated telemetry receivers and towers that are mounted on trailers. This system allows us to estimate the location of each collared animal within a grid once every couple of minutes. During the past year we developed a computer program to analyze the radio telemetry data on animal movements. This software helps us identify patterns in how this wildlife species moves and in how those movements are influenced by highways and traffic on those highways. Such patterns in movement trends may be critical drivers of how permeable highways are for different species at different locations. We simulated these movement rules in another computer program we had previously developed. This second computer program was used to simulate how young mammals of each of these species might move when they leave the areas where they grew up and try to establish their own home ranges. Specifically, we used the computer programs to examine the implications of how these animals responded to highways during these movements. Ultimately, we will compare the spatial genetic data with the results of these computer programs to help us understand better for which species of mammals highways act as strongest barriers at which locations. Such inference will be critical in understanding and mitigating the impacts of human activity on the viability of wildlife species.

Progress

This past year, Cecilia Hennessy, the Ph.D. student analyzing the genetic component of this project, defended her dissertation and graduated. Melissa Mills, the undergraduate research student who ran computer programs of how each mammal species interacts with the highway, finished her B.S. degree. Hennessy and Mills were presented with awards for posters they presented based on their research at Purdue's Department of Forestry and Natural Resources annual symposium. Mills was also presented with an award from Purdue's Department of Forestry and Natural Resources for outstanding undergraduate research. Hennessy has started a postdoctoral research position with the U.S. Forest Service in Rhinelander, Wis., and Mills is about to begin working on an M.S. degree at Texas Christian University.

Hennessy's spatial genetic results showed that the interstate highway was not a barrier for fox squirrels at any of the study sites. Raccoons exhibited weak effects of a barrier at two sites, and Virginia opossums exhibited weak effects at one site. Gray squirrels and chipmunks were most strongly affected by the highway, yet there were sites for both species at which there was apparently no barrier effect. Interestingly, the three sites where chipmunks exhibited a barrier effect were the same sites where white-footed mice exhibited a barrier effect. The fact that gene flow among fox squirrels was not affected by the highway was unexpected. Fox squirrels may be crossing the interstate on the ground, or may be using power lines. Since they have not been observed crossing highways, we do not know how they are maintaining genetic connectivity. Finding evidence that the highway was a barrier to raccoons and Virginia opossums was also surprising. The only site that was a barrier for Virginia opossums was also a site that was a barrier for raccoons, Eastern chipmunks and white-footed mice. Hennessy evaluated the site and discovered that it has fewer culverts than any other site, and that two culverts had bars covering the entrances. Interestingly, the barrier effect of the highway was strong for gray squirrels at two sites, but a third site showed no barrier effect, likely due to a low-traffic overpass that connected the habitat on both sides of the highway. One site in Harrison-Crawford State Forest had a large, open drainage underpass. Animals may pass through this underpass, leaving gene flow unaffected. However, white-footed mice, chipmunks and gray squirrels exhibited gene flow disruption at this site in Harrison-Crawford. According to other studies, small mammals prefer small culverts and thus this large underpass might not be suitable for these small mammals to use to cross the highway. The computer programs that Mills ran to simulate movements by wild mammals agreed with the results from the spatial genetic analyses indicating that the local characteristics of each of the seven study sites played an important role in how permeable the highway is at each location. For certain species such as gray squirrels that simulation model also indicated that the animal's risk of being killed while crossing the highway is just as important as the animal's willingness to try to cross the highway.

In coming months, we anticipate submitting three manuscripts to journal for publications based on results from the work that Cecilia Hennessy and Melissa Mills have completed. Before April 2013, Matt Beard and Tricia Tsai will also complete their dissertations and defend their Ph.D. Chapters from those dissertations and additional work by Hennessy will ultimately result in several additional publications to be submitted to



Maps of genetic data analysis for Eastern chipmunks at a site with strong population differentiation. The black lines indicate probability that animals (dots) were assigned to the same population. Note that the interstate highway lines up with the population differentiation, indicating that at this site the highway is a barrier to movement.

relevant peer-reviewed journals such as The Journal of Mammalogy or The Journal of Wildlife Management. These research papers and dissertations will be shared with our funding partners at the conclusion of this project.

Cost: $1,042,067 for the complete five-year study