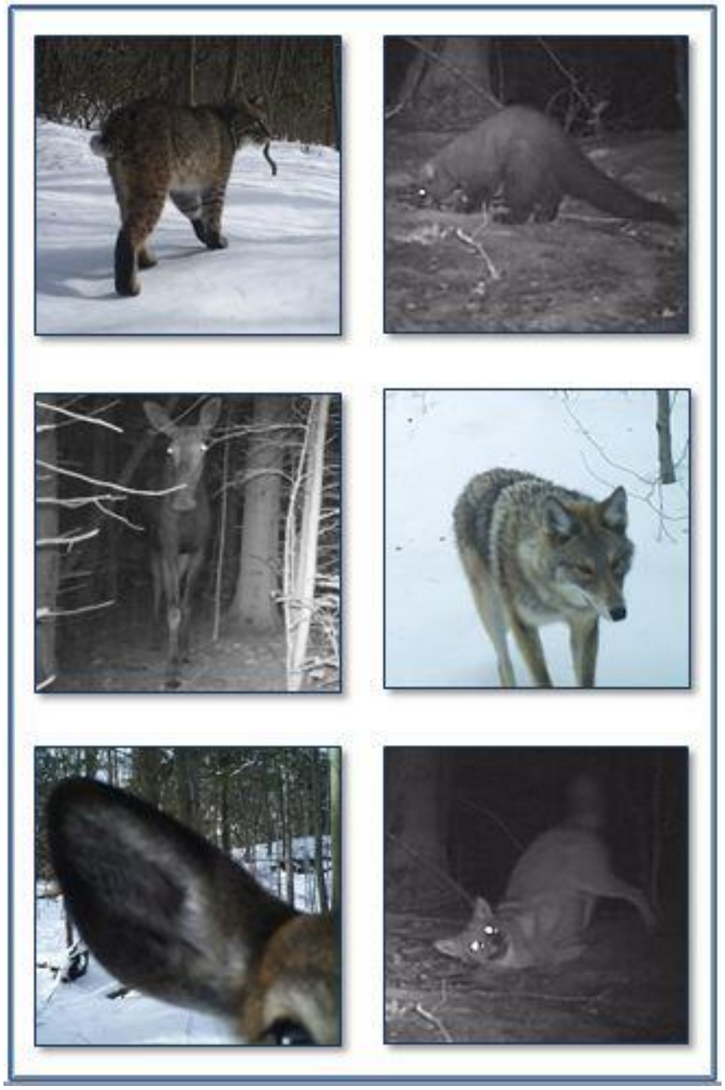
Wildlife connectivity in western Massachusetts: Results and recommendations from a 2013-14 study of wildlife movement in two corridors



September 30th, 2014 (corrected December 2014; see Appendix H)

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Executive Summary

The Appalachian forests of eastern North America stretch from Maine and Canada to Georgia -- the most intact temperate broadleaf and mixed forest in the world. People living within this forest rely on it for clean drinking water, air that is free of pollution (both particulates and carbon), forest products from maple syrup to timber, and as the base of tourism and recreation industries. Wildlife living within this forest are often found within habitat "cores," large areas of forest and the wetlands, streams, and open shrublands and grasslands embedded within them. Cores contain winter and summer habitat, feeding grounds and breeding grounds, and enough space for even the most wide-ranging species to roam. However, all wildlife need to be able to move to find food and habitat, and need to be able to move from one core habitat to another to adapt their ranges in response to climate change. Both wildlife and people, therefore, depend on a landscape that includes large, intact, healthy cores surrounded and connected by a much larger area of forest within which animals and people alike can safely get where they need to go.

With partners in the Staying Connected Initiative, The Nature Conservancy has been identifying corridors throughout the Northern Appalachian forests of New England, New York, and Canada. Western Massachusetts contains one of those important corridors, called the Berkshire Wildlife Linkage. Within the linkage, there is a patchwork of core habitats, as well as potential barriers to wildlife moving between them in the form of well-traveled roads and areas of residential and commercial development along these roads. This report details a study conducted along two parts of the Berkshire Wildlife Linkage that seem, based on computer models and conditions on the ground, likely to enable most animals to move between core habitats. Both of these areas – the southern Berkshires and the Westfield River watershed -- also contain roads that have the potential to prevent movement. Using winter tracking of mammal species, motion-triggered wildlife cameras, and surveys of roadkill, we studied where animals are able to move across these roads. We combined field data from 2013-14 with computer modeled data to suggest ways to maintain and enhance the ability of wildlife to move through the southern Berkshires and Westfield River watershed. We include suggestions for landowners and groups interested in wildlife movement, but many of these same conservation actions will also safeguard the ability of eastern US forests to continue to provide people with the clean air, water, products, and economic and recreational opportunities we count on.

In the Westfield River watershed portion of the Berkshire Wildlife Linkage, we suggest a focus on maintaining the existing ability of wildlife to move freely. The corridor studied within the Westfield watershed is almost entirely in natural cover, with low densities of development. We found abundant wildlife along the Westfield River and an adjacent ridge, with 13 mammal species observed by trackers and cameras. We did not find that route 112, a north-south highway with relatively high traffic volume, was a significant barrier to mammal movement. 4.5 successful crossings per mile on average were observed after each winter storm (min 0, max 22.8), and our roadkill surveys found that mammal roadkill were rare (note that amphibians and reptiles show greater roadkill mortality than mammals). We suggest continuing to build on the history of land conservation and stewardship in this area, and conserving a continuous path of protected land between the cores.

In the southern Berkshires portion of the Berkshire Wildlife Linkage, the large core habitat in and around Mt. Washington is somewhat disconnected from habitats to the northeast. We suggest a focus on protecting the areas where wildlife appear able to move and restoring portions of the areas where they do not appear to be able to cross route 7. Route 7 and 23 each showed areas of successful road crossings and adjacent areas where no crossings were observed this winter. On average, route 7 had 3.8 successful mammal crossings per mile after each winter storm (min 0, max 13.6), and route 23 had 7.7 (min 0, max 25.6). Both route 23 and route 7 contain areas that are currently heavily used by animals but are vulnerable to future development, where additional land conservation to protect and widen crossing spots may be appropriate. In the portions of the road that did not have crossings, restoration of natural vegetation, or changes to transportation infrastructure (especially road-stream crossings) are suggested as ways to increase the ability of wildlife to move between the core habitats to the southwest and northeast.

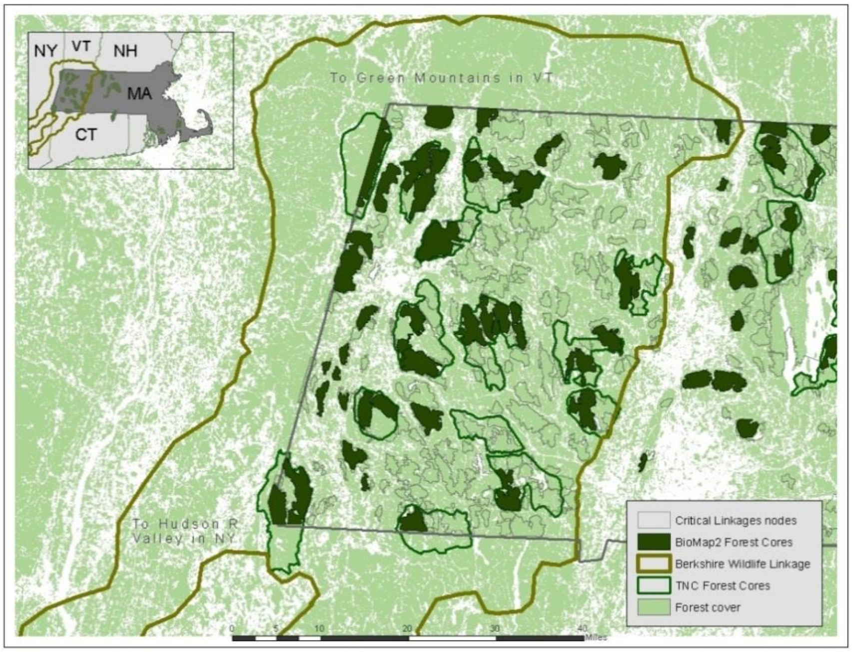
Both the Westfield and Berkshires have a strong history and ethic of careful stewardship and land conservation. Additional work to protect land in areas used by wildlife to cross roads, improve road infrastructure to get wildlife under the roads where appropriate, and support landowners who steward their land for wildlife is needed in the corridors. Our hope is that this study may provide a new focus to existing efforts to safeguard the habitat that provides so much of the quality of life in this area.

Introduction:

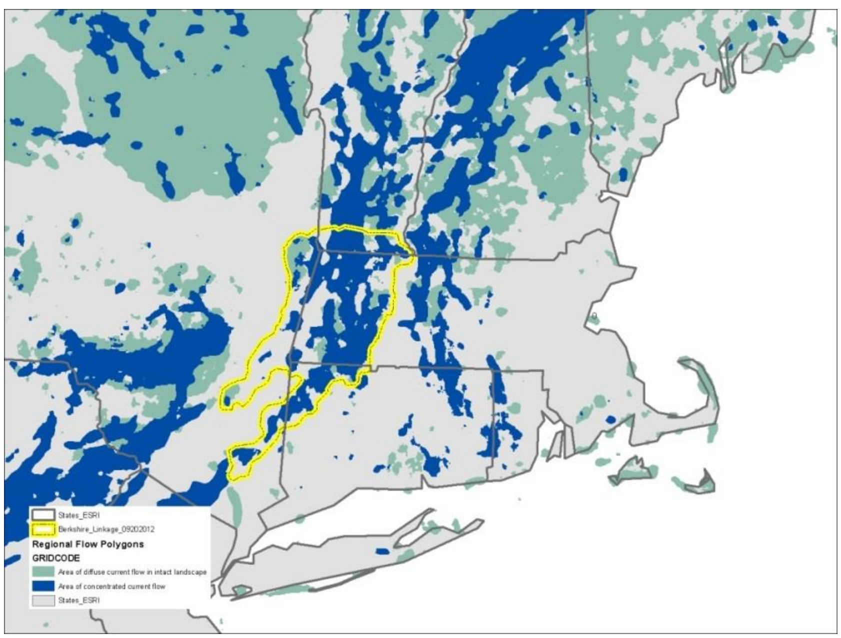
Western Massachusetts is part of a formerly un-fragmented forested landscape stretching from the Northern Appalachians in Maine and Canada to the Central Appalachians in Pennsylvania and Southern Appalachians extending south to Georgia. While large stretches of intact forest, wetland and river habitat exist in western Massachusetts, these areas have been historically fragmented by clearing for agriculture. Most of these areas have returned to forest or other natural cover, but are becoming increasingly fragmented by an extensive road network and the spread of suburban development. Land use conversion to development and fragmentation from roads divide areas of natural cover into smaller and smaller pieces. Dams and undersized crossings continue to fragment rivers into stretches too small to support many of our native fish species. Habitat fragmentation causes public safety issues including vehicle-animal collisions and road washouts, and it makes moderately mobile species (including salamanders, turtles, porcupines, and many others) more vulnerable to natural disturbance and disease. Fragmentation also threatens the genetic viability of populations of wildlife. Wildlife that live on islands, whether actual islands or places where the area surrounding the habitat is unable to be crossed by wildlife, are vulnerable to natural disasters and tend to show local extinction of species. The healthier and more diverse wildlife communities are, and the more habitat they have to utilize, the more resilient they will be in the face of future landscape alteration and impending climate change.

Most of western Massachusetts falls within the Berkshire Wildlife Linkage, an area that connects the Green Mountains in Vermont and the Hudson River Valley in New York (Map 1). The Nature Conservancy has identified this area as a critical juncture for ensuring a continuous path of connected habitat between the Northern and Central Appalachians (Map 2). The linkage includes 14 forest cores, areas of at least 15,000 acres of minimally fragmented, mostly interior forest habitat and the wetlands, rivers, and other natural cover contained within these forests (Appendix C). Within a core, wildlife are able to move freely due to the low level of development, roads, and other fragmenting features. Between cores, animals may or may not be able to move freely because corridors connecting core habitats can contain major roads and developed areas.

In the Massachusetts portion of the Linkage, core habitats and the connections between them are assessed by the University of Massachusetts-Amherst's Critical Linkages model. Critical Linkages compares habitat "nodes," areas smaller than forest cores (though often overlapping with cores) that provide places where wildlife can find at least some of the habitat conditions they require, and can re-energize if they are moving from core habitat to core habitat. The model identifies nodes that, if lost to land conversion or degraded, will disrupt animal movement the most. Similarly, Critical Linkages models the impact of severing the connection between each pair of nodes. Appendix C details how the habitat nodes and corridors studied here rank compared to other areas across the state.



Map 1. Berkshire wildlife linkage map displaying forest cover, TNC forest cores, BioMap2 forest cores, Critical Linkages nodes, and the Berkshire wildlife linkage.



Map 2. Regional flow patterns, showing the concentration of well-connected habitat in the Berkshire Wildlife Linkage in dark blue.

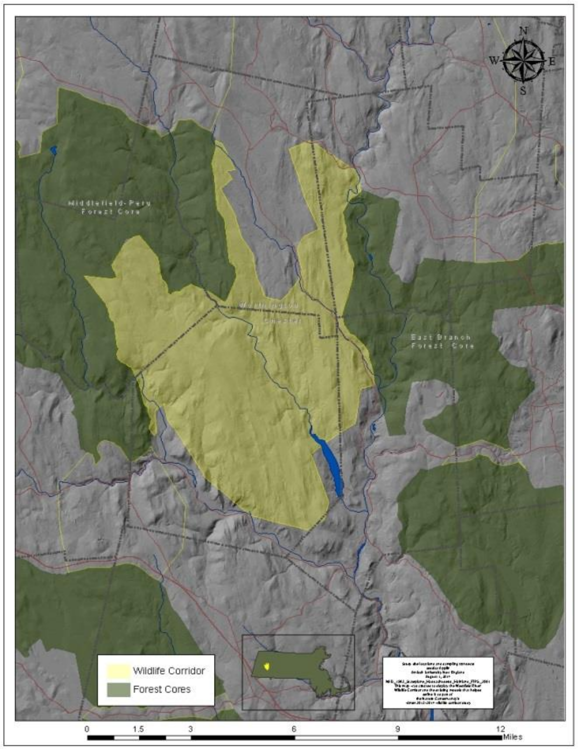
Models such as Critical Linkages are, at the time of this writing, state-of-the-art when considering how to identify places and connections that enable wildlife to move between habitats. In many cases they are cost-effective and accurate substitutes for on-the-ground studies of wildlife movement. However, biological data about where animals are moving and the level of barrier represented by different types of roads can also complement these models, especially in places where large investments in conservation action have already been made and are continuing to be made. As part of our broader analysis of the condition of and wildlife movement through the Berkshire Wildlife Linkage, The Nature Conservancy studied the movement of mammals in two locations in fall of 2013 through spring 2014. This study in two parts of the Berkshire Wildlife Linkage helped to answer the question of whether existing roads and development impair movement of moderately mobile mammals. Having both modeled and biological data in these two locations will help us to apply the lessons learned here and detailed in this report to other important corridors throughout the linkage.

The Westfield River watershed and the southern Berkshires were the two locations chosen within western Massachusetts for this study (Maps 3 and 4). We chose these areas based on our previous investment in the forest core habitats on either side, and the strong interest among many partner organizations and agencies in better understanding the corridors that connect those core habitats areas and what conservation action could maintain and/or restore the ability of wildlife to move freely. When viewed in the context of the entire linkage, these two corridors are not the most essential for securing the most direct and well connected pathway between the forests of the Northern and Central Appalachians. However, Critical Linkages data and other datasets (Appendix C) do support that these are important areas for connectivity. Portions of the Middlefield-Peru, East Branch, and Beartown forest cores rank among the top 10 nodes out of 136 nodes total in the Berkshire Wildlife Linkage. The Westfield corridor helps to broaden the swath of well-connected habitat in the central part of the linkage. The southern Berkshires corridor connects an important source habitat to the rest of the Berkshire Wildlife Linkage, even though the corridor itself is not part of the best-connected path in the center of the Linkage.

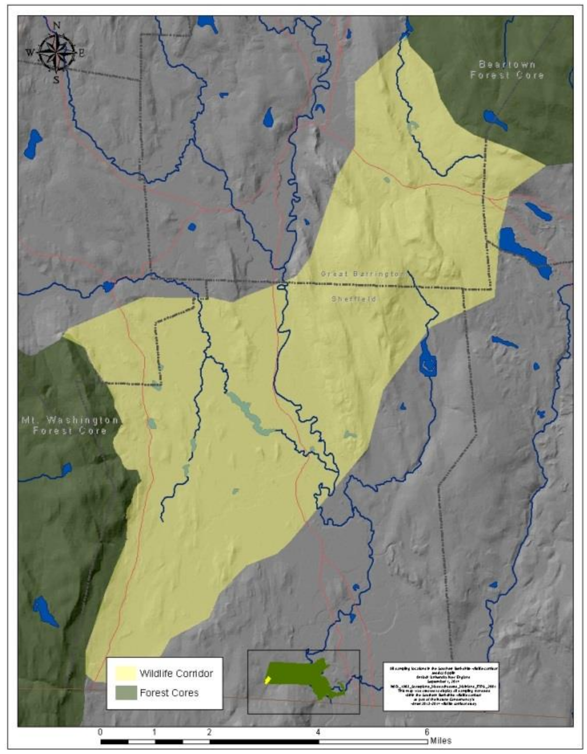
Our near-term goal in collecting biological data to add to existing modeled data within these two chosen corridors was to better understand where/how the wildlife communities that are found in various parts of these corridors are moving through them. To do this, we:

1. Assessed overall wildlife movement and habitat use in three locations within the Westfield River watershed corridor and two locations within the southern Berkshires corridor in order to create a picture of what animal communities are present and how active species are within each area.
2. Investigated wildlife crossing activity along Route 112 in the Westfield and along Routes 7 and 23 in the southern Berkshires to help identify sections where there may be possible barriers to movement or crossing hot spots.
3. Compared movement between sampling locations, and investigated whether or not there are differences in movement and communities inside vs. outside the predicted corridors.

Our long-term goal is to use this information to define and prioritize conservation efforts, including land protection, transportation improvement projects, and land management, that will maintain and/or restore areas through which animals can move between large habitats within the Westfield and southern Berkshire areas.



Map 3. Westfield River predicted corridor connecting Middlefield-Peru and East Branch forest cores.



Map 4. Southern Berkshire predicted corridor connecting Beartown and Mt. Washington forest cores.

Site Descriptions

The Westfield River Watershed:

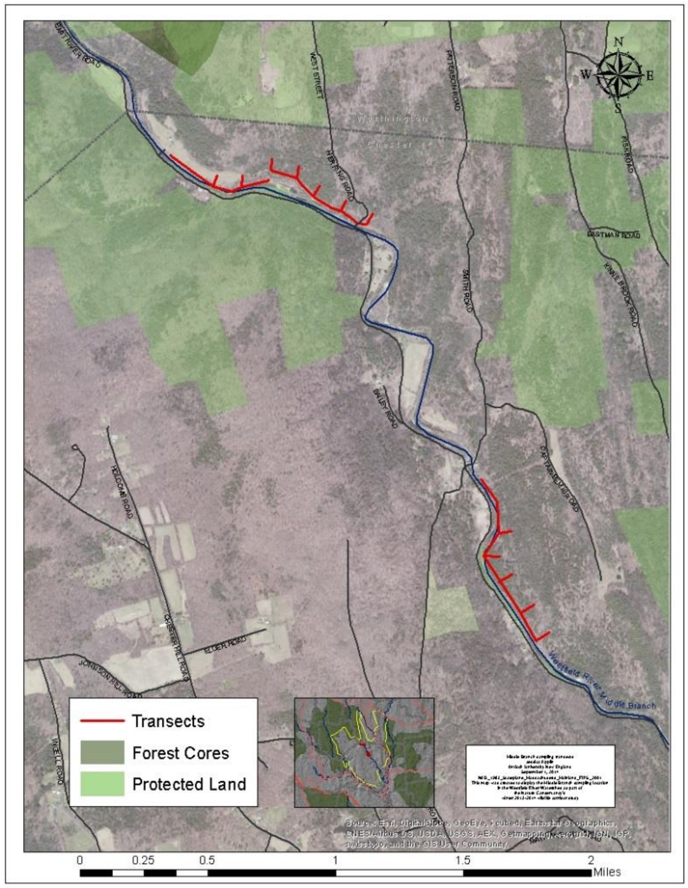
The Westfield River watershed is one of the least fragmented in Massachusetts and one of The Nature Conservancy's highest conservation priorities across New England. Yet the watershed is also crisscrossed by roads, ranging from small dirt roads such as sections of Kinne Brook Road, to paved and relatively high-volume roads such as Route 112 in Huntington and Worthington.

The predicted corridor within the Westfield River watershed is located in the towns of Worthington, Chesterfield, Middlefield and Chester Massachusetts (Map 3). It covers over 91 square miles (58,000 acres/23,000 hectares) and connects two forest cores, the East Branch forest core and the Middlefield-Peru forest core. The predicted corridor encompasses a broad area of local connectivity, as modeled by the UMass Conservation Assessment and Prioritization System (UMass CAPS).

This area is highly variable containing two of the three main branches of the Westfield River, several wetlands, upland ridges, the major roadway Route 112, and has a combination of residential and commercial farmland scattered throughout. Within the predicted corridor, three areas were selected as sites for collecting wildlife movement observations: the Middle Branch of the Westfield River, an upland ridgeline, and Route 112. These areas represent the largest barrier within the corridor (Rt 112) as well as two areas with the highest expected connectivity value for wildlife (the riparian corridor along the Middle Branch, and the intact forests of the upland ridge).

Middle Branch

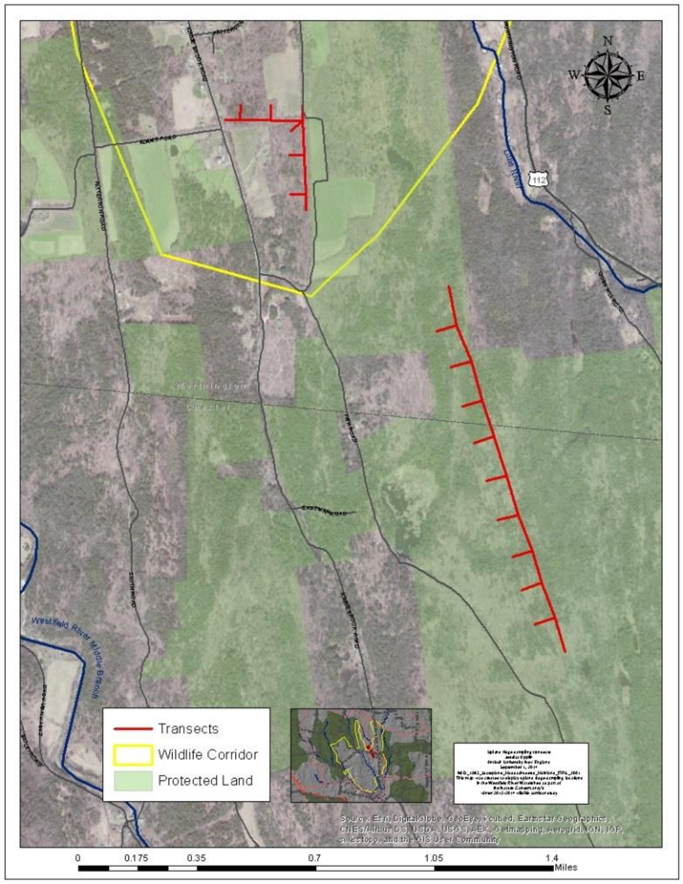
The Middle Branch sampling site was located in the town of Chester, MA along two portions of the river following East River Road. The northern portion consisted of 1.4 miles of transect (2200 m), and the southern portion consisted of 1.1 miles of transect (1700 m). Elevation in this area ranged from approximately 630-760ft (192-232m) along the river. The combination of the two sections provided a mosaic of habitats giving an honest representation of the variability found along this branch of the Westfield River. The northern transects ran through a mixture of agricultural fields, shrub cover, deep hemlock stands, floodplain forest with a large sycamore component, and young mixed forest patches. There was also an area of large glacial rock outcroppings with an active porcupine den. Along the southern transects there was a also representation of hemlock forest, deciduous forest, floodplain forest with a large American hornbeam component, an old apple orchard, an old white pine stand, and areas of young mixed forest patches. Both areas had evidence of old access roads, stone walls, and earlier agricultural activity as well as a combination of steep embankments, low flat areas, and entering tributaries. The river itself is wide in this area with lots of large cobble and an island area where the river divides for about a quarter of a mile (400 m).



Map 5. Middle Branch sampling location displaying northern and southern transects.

Upland ridge

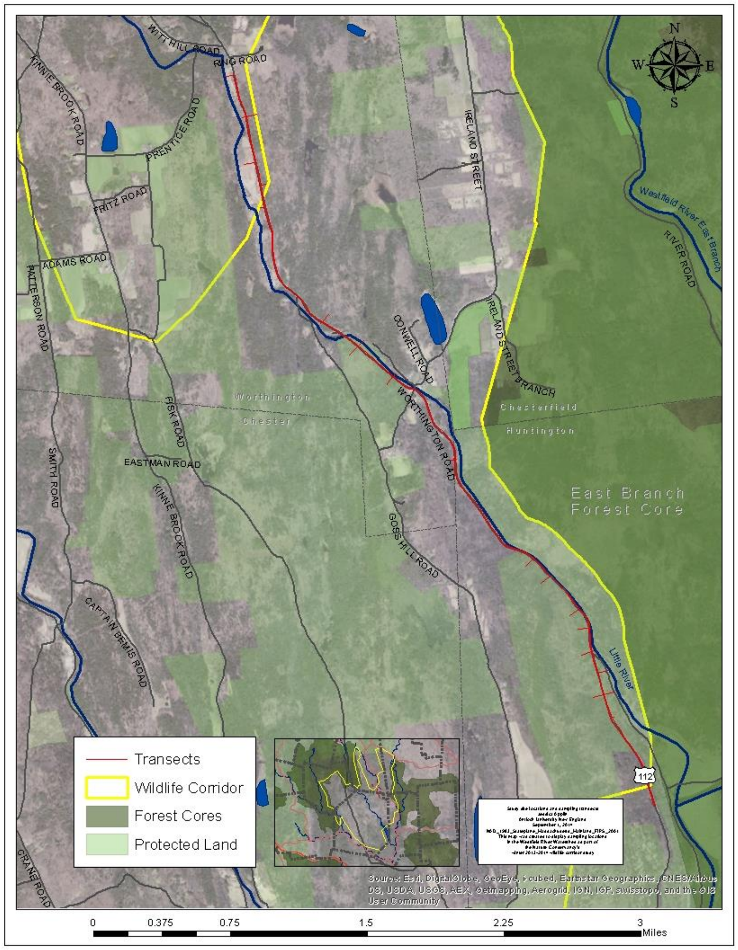
The upland ridge site was located in the towns of Worthington and Chester, MA. Sampling locations were also broken into two sections, but in this case, each section represented an area along the ridge either falling inside the predicted corridor, or outside the predicted corridor. The northern sampling location was outside the predicted corridor and consisted of .8 miles of transect (1300m) and averaged an elevation of 1200ft (366m). This location had a surprising diversity of habitat and landscape features within a relatively small area. Transects had a representation of dense coniferous forest with lots of white pine (possibly being cultivated by the land owner), agricultural fields, a sugarbush, a snowmobile trail along an old woods road, young deciduous forest, and a small ephemeral stream. There were also several stone walls, and a small drainage pond. This location also served as somewhat of a transitional zone between the heavily developed agricultural land and denser continuous forest cover.



Map 6. Upland ridge sampling location displaying transects inside and outside the corridor.

The southern sampling location was inside the predicted corridor and consisted of 1.7 miles of transect (2700m). This location had a much denser forest cover overall, and was set back away from all major and secondary roads. It also represented some of the highest elevation found within the predicted corridor including White Rock Hill which stands at 1188 feet (362m). In terms of habitat, there were large mature hemlock stands with several large downed trees and tip ups, combined with large stands of deciduous forest mostly dominated by American beech, both mature and densely populating the understory. Scattered throughout were several small upland wetlands, and potential vernal pool locations, as well as a pocket of very old white pine (approximately 150 yrs.). The topography on either side of the ridge varied from steep drop offs, to gently tiered decreases in elevation. There were also many areas with large rocky outcrops, large glacial till, a high stone wall at the southern end of the transect, and an old access road leading up to it. Further, there was also evidence of older hunting activity in the form of flagging and what seemed to be an abandoned tree stand, as well as a large wetland with beaver activity, flanking the south west portion of the transect.

Route 112



Map 7. Route 112 sampling location displaying transects inside and outside the corridor.

The route 112 sampling location was located in the towns of Worthington and Huntington, MA, and consisted of approximately 6 miles of transect. 4.44 miles (7146m) were inside the predicted corridor and 1.3 miles (2092m) were outside predicted corridor. Route 112 parallels the Little River resulting in a highly variable mosaic of habitat and topography, and with an elevation ranging from 700-1400ft (213-427m). Here you get a combination of steep drop offs to the river, sheer rock faces and cliffs resulting from carving out the roadway, and areas of road infrastructure such as guard rails, rip rap, and culverts. In terms of habitat, this section of road cuts through some of the densest and most wild sections of forest in the watershed, with large areas of mixed and riparian forest combined with coniferous stands. Of the 4.86 miles (7800m) of roadside surveyed (this distance includes only the areas tracked along the roads, not the perpendicular transects that extended outward into nearby habitat), 4.39 miles (7069m) were bordered by forest, 0.21 miles (342m) by agricultural fields or open habitat, and 0.25 miles (397m) by developed land. The northernmost and southernmost portions of the sampling transects that fall outside the predicted corridor are where you start to see more residential areas, development, and agricultural land.

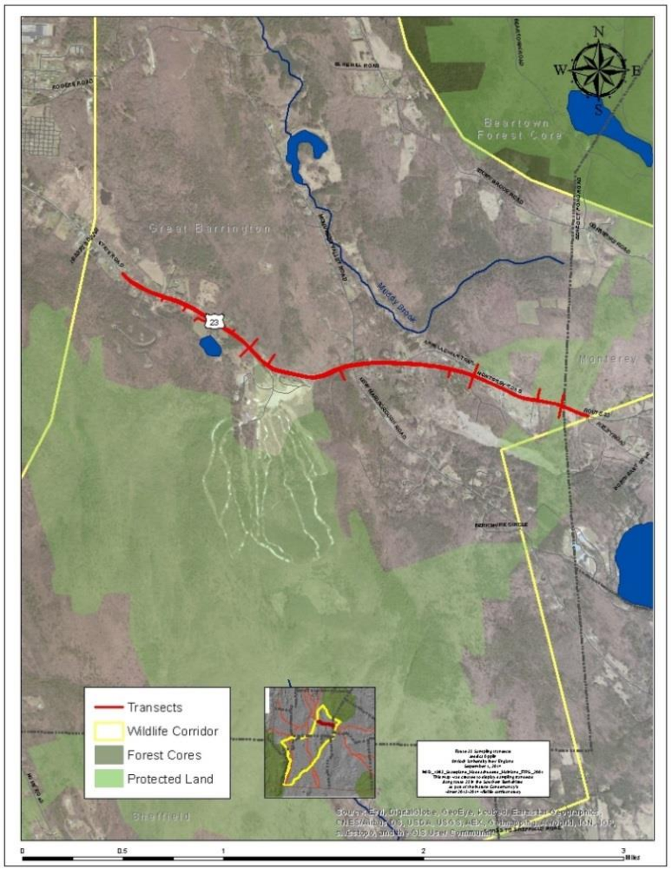
The southern half of the sampling transects ran along the valley floor, paralleling the river. There is a steep terrain to the west with dense hemlock stands and deciduous forest. To the east the terrain descends sharply into an area that serves as an impoundment for the Knightville Dam which remains frequently flooded and is dominated by invasive knot weed. There are also old logging roads as well as snowmobile trails throughout this area, and a virtually uninterrupted guardrail running along the entirety of this section. The northern portion of sampling transects ran through a combination of sparsely populated residential area, agricultural fields, shrub cover, deep hemlock stands, floodplain forest, and young mixed forest. To the east of the road there is a combination of floodplain forest, young mixed forest and small stands of hemlock and deciduous forest. The steep banks and the presence of the road here confine the river, however much of its banks remain well covered with native vegetation. In South Worthington, there are small cascades and evidence in that the river was once harnessed for power. Where Ireland Street intersects with 112, knot weed was in abundance, spreading along the road and starting to encroach upon the river.

The southern Berkshires:

The southern Berkshires is part of a backbone of mountainous forest that stretches across the entirety of western Massachusetts. Its rolling hills and unique wetland systems provide important and rare habitat for a number of species. Within this area are also several important forest cores. One of these, the Mt. Washington forest core, has had a longer and more successful history of habitat protection than most other places in the Berkshire Wildlife Linkage. The Beartown forest core, including Beartown State Forest, is a smaller but also well-protected forest core. While smaller in size, East Mountain State Forest and the surrounding habitats may function as a stepping stone between the forest cores, where animals requiring large habitats to support themselves can rest and re-energize, even if they can't live out their life cycles. Smaller or less area-dependent animals may be able to live in the stepping stone. Between these habitats, however, lies Route 7 and a strip of highly developed land, as well as a less-developed but still significant road, Route 23, that separates East Mountain from Beartown.

The predicted corridor connecting the Mt. Washington and Beartown habitats (Map 4) lies southern Berkshire County in the towns of Sheffield, Great Barrington, and Monterey. It covers over 39 square miles (25,089 acres/10,153 hectares) and connects two large conserved forests, or "forest cores" (as modeled by Mass CAPS). Between these forests lies a series of smaller conserved forests, agricultural, residential, commercial, wetland, upland ridges, and the major roadways Route 7 and Route 23. Route 41 also runs north-south through the corridor, but was not included in this study due to a combination of its lower traffic volume and level of development, and constraints on study staff capacity and funding.

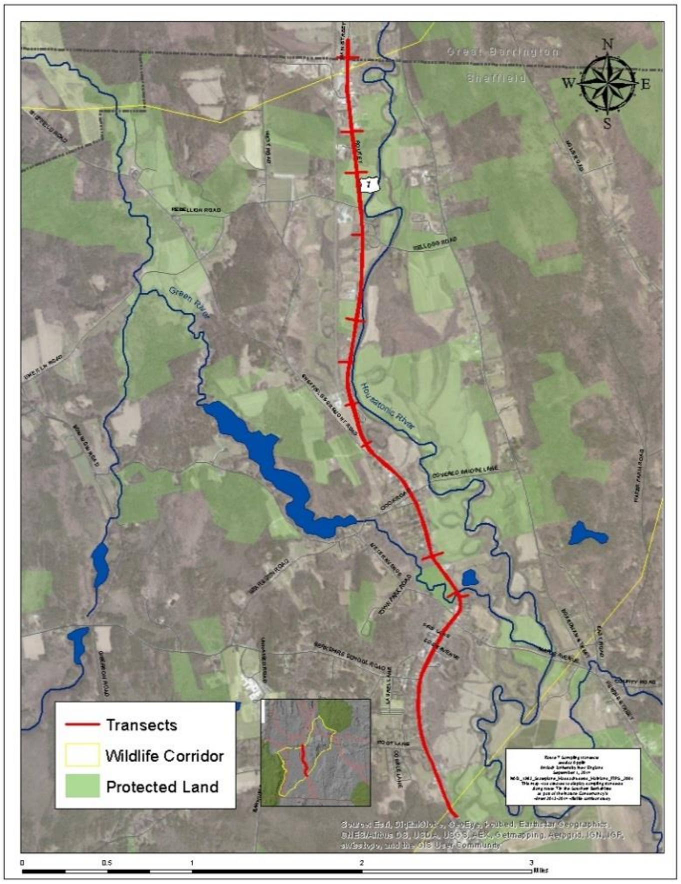
Route 23



Map 8. Route 23 sampling location displaying transects within the predicted corridor.

The Route 23 sampling site was located in the town of Great Barrington, MA along the major roadway route 23. The sampling site consisted of approximately 3.2 miles (5150m) of transect. Elevation in this area ranged from approximately 740-1,100ft (226-335m). The transects ran along route 23 and through a mixture of residential, recreational (ski resort), shrub cover, deep hemlock stands, young deciduous forests, and mature mixed forests. Of the 2.54 miles (4102m) of transect along the road (excluding the short transects that ran perpendicular to the road into surrounding habitat), 1.47 miles (2360m) were bordered by forest, 0.26 miles (426m) by agricultural land and open habitats, and 0.82 miles (1316m) by developed land. Mudd Brook and the Barbieri Reservoir as well as Lake Buel and other small streams and ponds make up the hydrological features in this area. The section of route 23 in the predicted corridor is a two-lane high volume roadway that travels east to west. Scattered residential development and a large ski resort define the surrounding landscape.

Route 7

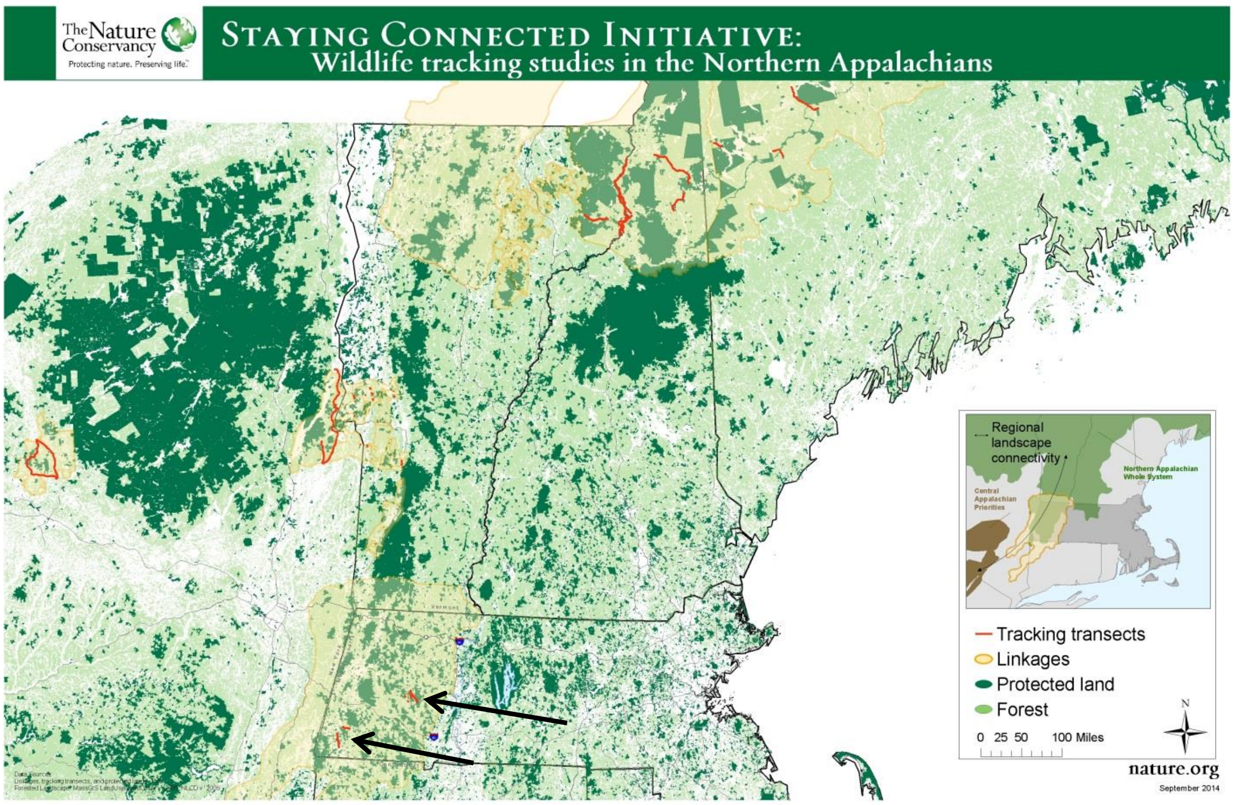


Map 9. Route 7 sampling location.

The Route 7 sampling site was located in the town of Sheffield, MA along the major roadway Route 7. The sampling site consisted of approximately 6 miles (9656m) of transect. Elevation in this area ranged from approximately 660-680 ft (201-207m). The transects ran along route 7 and through a mixture of agricultural corn fields, commercial, grassland, shrub cover, mixed mature deciduous forest, mixed mature riparian forest, and young deciduous forest. Of the 4.90 miles (7885m) of transect along the road (excluding the short transects that ran perpendicular to the road into surrounding habitat), 1.09 miles (1752m) were bordered by forest, 1.23 miles (1983m) by agricultural land and open habitats, and 2.56miles (4150m) by developed land. The Housatonic and Green Rivers are major hydrological features in this area as well as several small ponds and oxbow lakes created by the river. The section of route 7 studied is a two-lane high volume roadway that travels north to south. Scattered residential and commercial development, downtown Sheffield, and the meandering Housatonic River define the surrounding landscape.

Methods

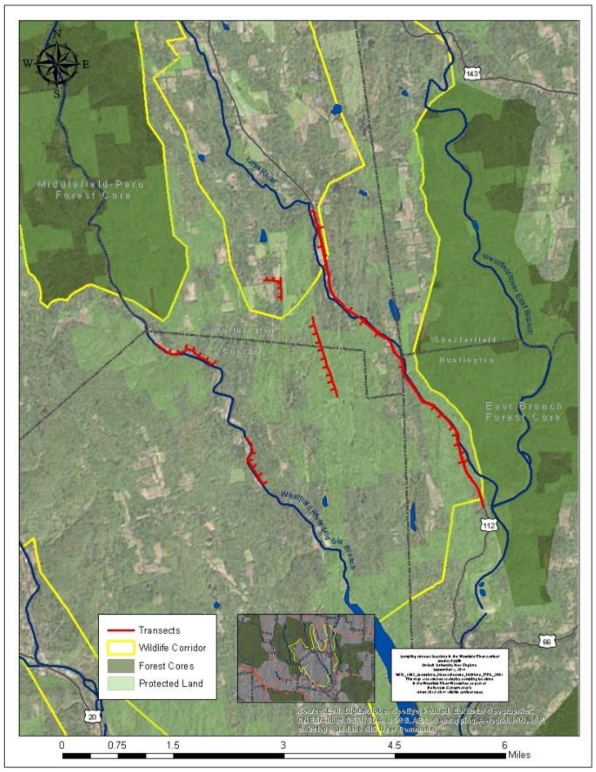
In the northeast, winter mammal tracking is an effective way to collect information on species' presence, frequency of occurrence, relative activity, and movement through an area (Appendix D). Many other studies done as part of the Staying Connected Initiative have used tracking as their main means of data collection, and we used winter tracking in combination with motion-triggered cameras and roadkill surveys to study wildlife movement in our chosen corridors. Map 10 shows the location of our study and others throughout the Northern Appalachians.



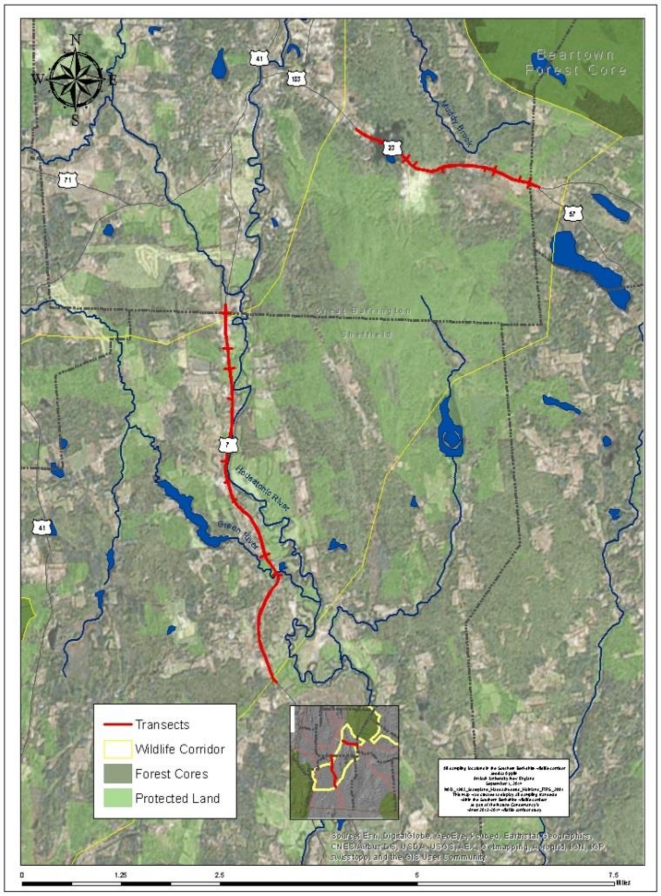
Map 10. Staying Connected Initiative map displaying wildlife tracking studies, including this one, across the Northern Appalachians.

Experimental Design

In the Westfield River Watershed predicted wildlife corridor, sampling areas were chosen to represent three key landscape features: a river system (Middle Branch of the Westfield River), an upland ridgeline, and a major roadway and potential barrier to wildlife movement (route 112). Two additional locations along route 112 and on the upland ridge were also chosen outside the predicted wildlife corridor for comparison. In the southern Berkshires, sampling areas represented the most likely barriers to animal movement. Route 23 may be a barrier due to the amount of traffic along the road and the relatively high level of development. Route 7 is a more heavily-traveled road and has a wide strip of residential and commercial development along it, interspersed with agricultural fields, wetlands, and a few scattered forested areas. In both areas transect locations were determined based on topographic feasibility and landowner permissions using ArcGIS and ground truthing. Landowner generosity contributed greatly to what we were able to accomplish. Landowners not only gave us access to their land for tracking and camera research, but a few even allowed us parking access. These access points significantly increased the overall quality of our research, allowing trackers to cover more distance and collect more data. Transects were paced and marked using flagging every 20m for line visibility and data collection. Transects consist of a long parallel line following the landscape feature of each location with shorter 100m perpendicular transects running every 200m where feasible.

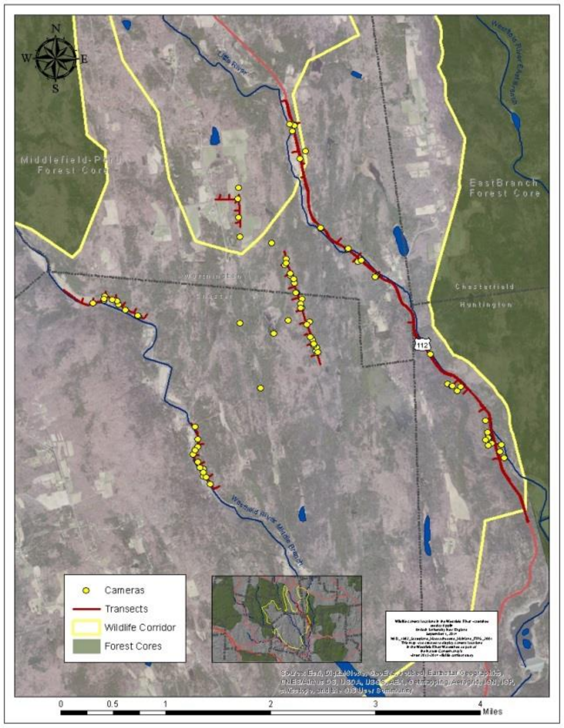


Map 11. All sampling locations in the Westfield River wildlife corridor.

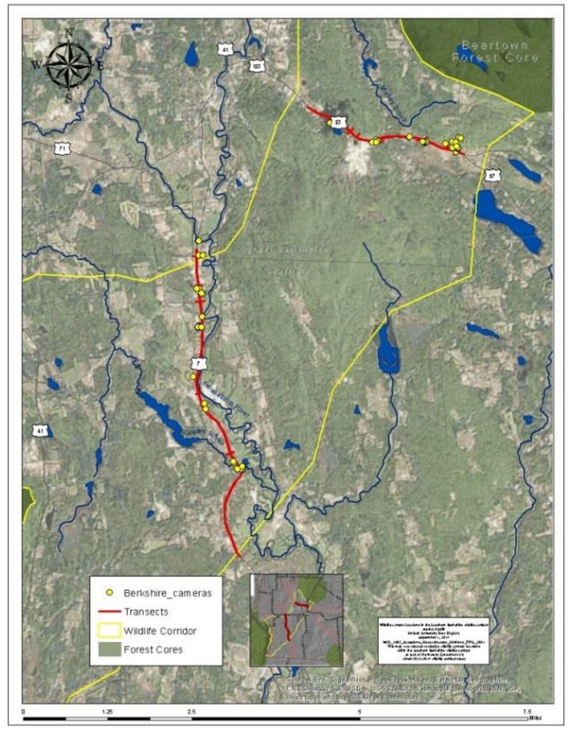


Map 12. All sampling locations in the Southern Berkshire wildlife corridor.

In some locations, topography (steep cliffs, streams) or inability to secure permission from private landowners to track on their land forced us to create perpendicular transects that were shorter than 100m, and/or spaced more widely apart than every 200m (see Maps 5-9 for actual transect routes). On Routes 112, 7, and 23 the roads themselves were considered the transects and were tracked on both sides to help capture road crossing data, and perpendicular transects were located to either side where feasible.   Line intercept track identification was used to determine wildlife communities and activity levels within each area. In addition, wildlife cameras were deployed and rotated throughout the sampling areas. The purpose of the cameras was to help confirm tracking observations, capture animals missed through tracking, and to give a more complete picture of wildlife species moving in the fall and spring months when snow tracking was not feasible (Maps 13 & 14).



Map 13. Locations of wildlife cameras in the Westfield River From Nov. 2013-June 2014



Map 14. Locations of wildlife cameras in the southern Berkshire corridor from Nov. 2013- June 2014

__Data Collection__

Line intercept snow tracking was conducted between 24-72 hours after every snowfall event producing more than 2 inches of snow, from December, 2013 through March, 2014. Each snow event was carefully monitored by several team members across the area, and an overall judgment call was made as to when a snow event had officially ended. In addition, conditions following a storm were also monitored carefully, and on a couple occasions trackers made the call to end early due to inclement weather. There were 7 storms creating suitable conditions for tracking during the winter. In one case along routes 23 and route 112, there was not sufficient time to cover the entire transect length within the 24-72 hour post-storm window. Three storms resulted in a less-than-complete tracking survey on route 7. When analyzing road crossings, we used average crossings per storm to account for the unequal survey effort between some stretches of road/transect and others. In the case of animal community and relative activity measures, we did not include data from incomplete tracking surveys.

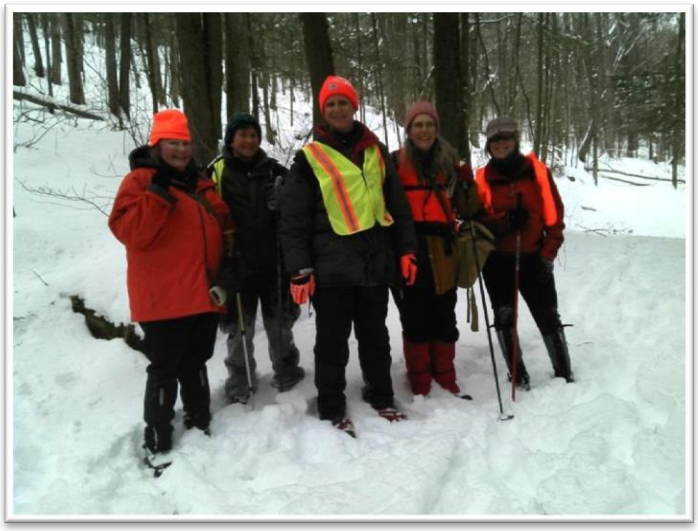


Figure 1. Volunteer tracking team working on the Route 112 transects. Photo courtesy of Meredyth Babcock.

Any tracks or fresh wildlife sign that crossed the transects were identified to species when possible, a point marked with a GPS unit, and photos taken. Tracking teams consisted of a combination of paid contractors and volunteer trackers. Track identification was always confirmed in the field by experienced wildlife trackers, at least one of whom was certified by CyberTracker or Keeping Track. Volunteer participation was a key part of data collection which could not have been conducted at this scale without the over 350 hours contributed by volunteer trackers. Wildlife species recorded were any mammals larger than a grey squirrel including weasel species. Game birds such as turkey and grouse were also collected. Movement behavior, direction, forest type, forest cover, and physical location in meters were also recorded. In addition, overall conditions were recorded for each tracking location including: new snowfall amount, snow conditions, temperature, weather, disturbances, and anything else of note. Wildlife cameras were moved on a 10 day rotation on average. The locations were chosen opportunistically based on habitat features and places of interest within transect areas.

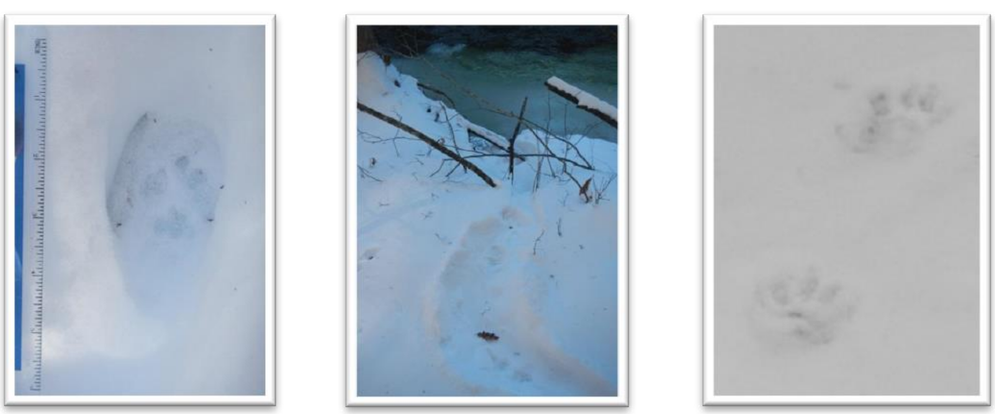
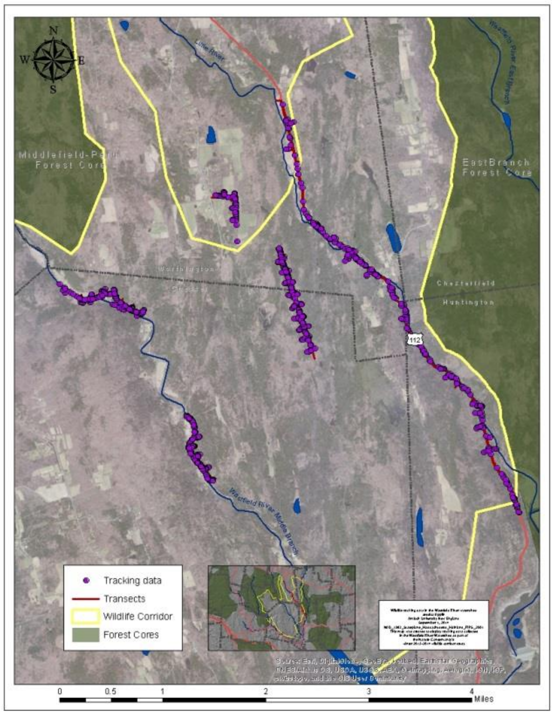
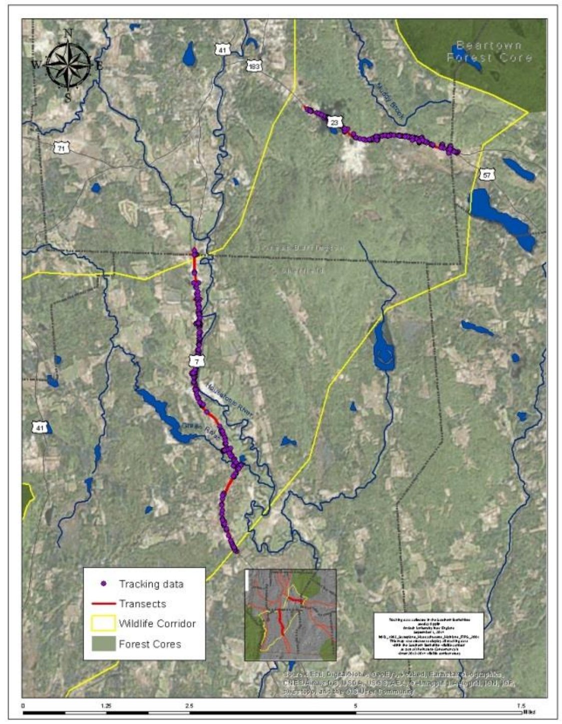


Figure 2. (left to right) Photo of bobcat track on upland ridge, otter slide on Middle Branch, and fisher tracks on ice.

__Data Analysis__



Map 15. Tracking data collected in the Westfield corridor from December 2013-March 2014



Map 16. Tracking data collected in the Berkshire corridor from December 2013-March 2014

Wildlife tracking data was used to determine wildlife communities, diversity, abundance, and activity levels within each location by calculating average intercepts, relative frequencies, and the Simpson's diversity index. Mammal tracks that crossed the transect were counted as an intercept and the average intercepts and relative frequency index were calculated by species to establish how frequently a mammal was encountered individually and relative to other species that were found. Both the Simpson's Diversity index (D_s) and the inverse of the Simpson's index (d_s) were calculated by transect as a measure of diversity or dominance based on the probability of interspecific encounter. This was based on the suggestion that d_s is preferred to dominance (D_s) when these values are close to 1.0 and similar (Brower, Zarr & von Ende, 1998). The Simpson's Diversity index can be interpreted as the lower the number, the higher the diversity. In contrast, the inverse of the Simpson's Diversity index is more intuitive where the higher, the higher the diversity. Calculations of average intercepts and relative frequency indices were based on Van de Poll (1996). Diversity and activity levels were then compared between each location to get a sense of how areas within the predicted corridor are utilized by wildlife. Activity level comparisons between locations were made looking at the wildlife communities as a whole, as well as on a species specific level. Further, the same comparisons were made between the data collected within the predicted corridor and the data collected outside the predicted corridor in order to investigate the models. All calculations and comparisons were made using JMP software and Excel 2010.

Wildlife camera data was used qualitatively to further flesh out wildlife communities in each location as well as to identify species that were not active during the winter tracking months. Photo documentation was also used to confirm species identifications made in the field, and to capture any species that happened to not cross the transects.

Figure 3. Female moose on the Middle Branch of the Westfield River.

Results/Interpretation:

Wildlife Communities

In order to describe the wildlife communities found within each of the five study areas we investigated several different metrics, calculating the Simpson's diversity index, relative activity levels, and average intercepts. We did this to not only find out how diverse a location was, but to also understand what kind of impact each species has within a community, looking at how active they are within it and what kind of presence they have in relation to each other. The following is a breakdown of the communities found within each area, their activity levels and diversity indices followed by an overall comparison between areas.

The Westfield River Watershed:

Route 112

112 had the highest diversity level of all locations with 14 different species represented (D_s = .15, d_s = 6.7). In terms of activity levels, route 112 reflects its high diversity with no one species showing dominance. Deer, coyote, weasel and red fox are all strongly represented, with fisher and mink also showing a notable presence (Table 1).

Investigating field observations can help us further understand these communities in terms of animal behavior and how they are utilizing the landscape. In the northern areas of route 112 where there is more agriculture, trackers noted seeing evidence of deer and red fox frequently foraging on the bounty of old apple trees. In the southern areas it was noted that there was a high level of weasel activity, and that there was evidence of these animals utilizing culverts for passage under the road. Also to the south deer and moose seem to be using an area of mixed deciduous and heavy conifer cover along one of the steeper slopes as a place to both bed down and forage for the winter. Taking into account these observations documented in the field in conjunction with the hard data points are important to understanding the whole picture of how and why these animals are moving through the corridor.

Data collected on the wildlife cameras helps understand and flesh out this community even further. Raccoon and deer were captured the most often on camera, but in the case of raccoon, the tracks of these animals were not found in abundance. Raccoon were also mostly captured on camera during the second half of January while the season was still very cold and the ground still snow covered. In contrast, species such as weasel, coyote and gray fox that were found to have higher activity levels based on their tracks were not found as often, or at all on the cameras.

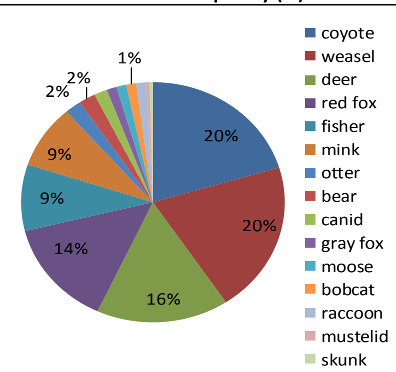
Route 112 species list and activity levels, inside predicted wildlife corridor, based on 6 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
bear	*Ursus americanus*	0.7	
bobcat	*Lynx rufus*	0.4	
coyote	*Canis latrans*	7.1	
deer	*Odocoileus virginianus*	5.7	
fisher	*Martes pennanti*	3.1	
gray fox	*Urocyon cinereoargenteus*	0.4	
mink	*Neovision vision*	3	
moose	*Alces alces*	0.4	
otter	*Lontra canadensis*	0.7	
raccoon	*Protocyon lotor*	0.4	
red fox	*Vulpes vulpes*	5	
skunk	*Mephitis mephitis*	0.1	
weasel	*Mustela erminea or Mustela frenata*	7.1	
canid		0.6	
mustelid		0.1	

Table 1. Species list, average species intercepts, and relative frequency index recorded and calculated for Route 112 transects falling within predicted wildlife corridor.

Middle Branch

The Middle Branch also demonstrates a high diversity with 9 species represented (D_s = .25, d_s = 4.0) and showing a wide range of activity levels. However there is dominance of deer at 44% and a fairly strong presence of coyote at 22%. There is also a notable presence of weasel and fisher and a smaller representation of the other five species found in this area (Table 2).

This community breakdown can be further understood by taking into account animal behavior and species associations ascertained from the tracks and trails that crossed the transects. Deer and coyote activity levels were high because this section of the river was clearly one that was used as part of their normal travel route. Deer moved in and out of this well-worn trail looking to forage, coming from patches of denser hemlock, and higher elevations that may have been serving as wintering areas. The high coyote activity in this area seemed to come from one or two packs, in two separate locations along the river. The behavior demonstrated in these areas suggested that these locations were acting as hunting grounds, as kill evidence was found in both areas on separate occasions.

Other animal activity such as otter and fisher was constant throughout, but lower mostly because of location, weather conditions, and timing. Otter were clearly active along the river all winter long, but when the river was free flowing tracks could not be observed. Similarly, when the river was completely frozen, as was common for much of this winter because of the frequent negative temperatures, there were nearly no otter tracks observed on top of the ice. Most of our otter data was collected when the river was partially frozen, and the animals could move in and out of it, as well as from a location that was clearly being used as both an eating spot as well as a latrine based on other sign. Fisher activity was also consistent all winter long, but lower as these animals don't usually travel together. There were definitely distinct times however, where there were bursts in fisher activity. One of these times was in late January and early February where fisher seemed to be pairing up with each other for courtship or mating, and long clear trails could be followed (Appendix A, Table 13). During this time, we also noticed a drop off in otter activity. Further, we also noted that when the river was completely frozen over, fisher seemed to utilize it for crossing. Since fisher and otter tracks are so similar, this was determined by several observations, and the absence of slides which otter will almost always do if tracked for any length of time. Similarly, both deer and coyote utilized the frozen river, crossing back and forth frequently throughout the winter. In some of these areas we were able to connect these crossings with tracks moving up the other bank, across East River Rd. and into the forest cover on the other side.

There was also species activity that was either very local movement behavior, very low, or collected in a much shorter time window during the winter. Porcupine data was collected from one distinct location where there was a den nearby and a clear trail where the porcupine would cross the transect as it made its way to an area of hemlock forage. Raccoon activity was low as data was only collected towards the very end of the winter as the raccoon started to become active again. Mink, red fox, and grey fox were also tracked, but only in very specific areas, and only on one or two occasions. The low activity level of red fox in this area is somewhat surprising given the composition of habitats available to them. In this case, we are assuming that some of the tracks that could only be identified as canid, but were not clear enough to identify further, may very well have been red fox. This of course cannot be concluded without further evidence. There was also beaver activity observed in the area with evidence of fresh chew, but no tracks were observed, and the activity was not close enough to the transects to capture.

Data collected from the cameras can also help to further flesh out the wildlife community found along the Middle branch. As mentioned above, beaver activity was noted in the area, and beaver was also captured on video. The felling of a small tree was also captured on camera (before and after), but unfortunately not the moments the beaver made its final chew. There was also a photo in November of what is thought to be the back of a black bear based on the size of the fallen tree in the picture, but cannot be identified with certainty. However, the cameras did capture black bear during the summer months in this location after official sampling had ended. There were also numerous photos and videos of raccoon captured as they became more active, as well as animals such as skunk and opossum that became active after our snow tracking had ended. Finally, there were two exciting captures caught on camera. One was that of a bobcat coming up from the river, though no bobcat were tracked in this areas during the study. The second was of two female moose moving along the southern end of our Middle Branch transects in late July. Two individual cameras caught these animals, believed to be a mother and her daughter from last spring. Again, these videos came after official sampling had ended, but only add to our findings in a positive way. These bits of camera data serve as very important pieces in helping to capture the entirety of the wildlife community utilizing the river corridor.

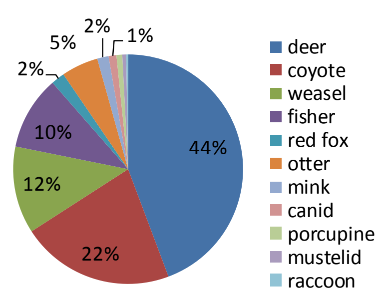
Middle Branch species list and activity levels, based on 5 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
coyote	*Canis latrans*	15.8	
deer	*Odocoileus virginianus*	32.4	
fisher	*Martes pennanti*	7.6	
mink	*Neovision vision*	1.2	
otter	*Lontra canadensis*	3.8	
porcupine	*Hystricomorph Hystricidae*	0.6	
raccoon	*Protocyon lotor*	0.2	
red fox	*Vulpes vulpes*	1.4	
weasel	*Mustela erminea or Mustela frenata*	9.6	
canid		0.8	
mustelid		0.4	

Table 2. Species list, average species intercepts, and relative frequency index recorded and calculated for transects along the Middle Branch of the Westfield River.

<u>Upland ridge</u>

The ridge location inside the corridor had a lower diversity than the river with 9 species represented (D_s = .39, d_s = 2.5), and had a strong dominance of deer at 46% and turkey at 42% with a much smaller representation of other species. Coyote, weasel, and fisher were also active, but their frequency seems much lower when compared to the overly active deer and turkey. Also represented, though with a much lower presence were bobcat, porcupine, otter, and moose (Table 3).

Again, the key to understanding these activity levels is to investigate the behavior behind them. In terms of deer and turkey overabundance, the upland ridge was clearly acting as a wintering site for both species. Deer were utilizing the pockets of dense hemlock for winter cover, confirmed by the many deer beds accompanying the high level of tracks and trails. Their trails were also clearly moving between these locations through large areas of beech dominated forest that they were utilizing for winter forage. Similarly, turkey moved up and down the ridge digging up large areas of snow covered ground foraging for beech nuts. However, this foraging behavior was also found under heavy hemlock cover as well. Both species used the entirety of the upland site for the full winter season.

Coyote activity was only observed in January, and at lower levels than what was found on the river. Weasel activity was low but steady throughout the season, and bobcat activity was only observed on one tracking day at the very end of January where the activity level was noticeably high along the majority of the ridge line (Appendix A, Table 14). Porcupine data was collected from two separate denning sites on either end of the ridge and was always from the same well-worn paths made as the porcupine came out to forage. The otter activity was an interesting one time occurrence that we tracked for a quite a distance in both directions to understand the behavior. The otter seemed to have moved in a fairly straight line across the ridge, across a small upland wetland located on the transect, and then towards a much larger wetland complex on the other side of the ridge. This behavior suggests much more than localized movement as both the East Branch and Kinne Brook to the west, are quite a distance off the ridge. Other notable animal behavior stemmed from our one moose data point, which was from the fresh browse of a young red maple tree. This was not the only moose activity observed along the ridge, but was the only evidence found during our data collection. Early in December, when laying the transects and deploying the first of the cameras (before the snow fell), there was an abundance of fairly fresh moose scat found all along the southern half of the ridge, and a well walked trail with fresh tracks and hobblebush browse at the very southern end of the transect. The shift in activity over the winter months suggests that the food supply up on the ridge is not enough to sustain these animals, but that they utilize this area at least during the fall months.

Like the Middle Branch, the camera data collected in this area also sheds light on the wildlife community found on the ridge, and helps complete the story. Similar to the river, we only captured raccoon activity on camera toward the end of the winter where there was a notably high level of activity, and raccoon were almost always captured in pairs, presumably beginning their mating behavior. Also captured on camera were several bobcat photos and videos from two separate days different from the time frame we tracked them in. This suggests that they do indeed utilize the ridge and that the one time we caught them in our tracking data doesn't represent a singular occurrence. Finally, our cameras captured black bear photos and video on several occasions throughout the winter, though we never came across bear tracks along the transects. Not only was it clear by the camera data that bear are very active on the ridge, they also remained active for a good portion of the winter months, through the very end of January. Presumably, this is due to the large areas of beech forest found on the ridge and what seems to have been a productive year for beech nuts, possibly even a mast year. This is further supported by the high activity levels of turkey seen on the ridge this winter, which the cameras also captured, showing extremely large flocks of these birds ripping up the ground to forage.

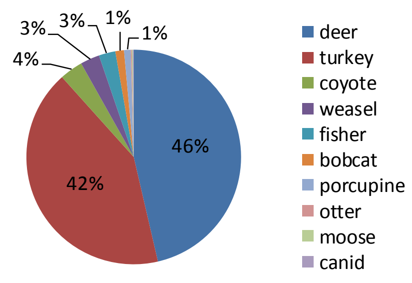
Upland ridge species list and activity levels, inside predicted wildlife corridor, based on 5 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
bobcat	*Lynx rufus*	1.8	
coyote	*Canis latrans*	4.8	
deer	*Odocoileus virginianus*	64	
fisher	*Martes pennanti*	3.4	
moose	*Alces alces*	0.2	
otter	*Lontra canadensis*	0.2	
porcupine	*Hystricomorph Hystricidae*	1.4	
turkey	*Meleagris gallopavo*	58	
weasel	*Mustela erminea or Mustela frenata*	4	
canid		0.2	

Table 3. Species list, average species intercepts, and relative frequency index recorded and calculated for Upland Ridge transects falling within predicted wildlife corridor.

Westfield River Watershed Outside the Corridor:

Route 112

When investigating diversity levels in locations outside the predicted corridor, route 112 shows a lower diversity outside the corridor, with 6 species represented (D_s = .37, d_s = 2.7), compared to inside the corridor where there is more than double. Interestingly though, it is still higher than either location along the ridge, though the number of individuals represented in the calculation is a bit low to make any definitive conclusions (Table 4).

The lower diversity of 112 where it falls outside the predicted corridor can be understood by looking at how strongly deer dominate the wildlife community at 57% of the total activity. There is also a fairly strong presence of red fox at 18%, but all other species are low in comparison.

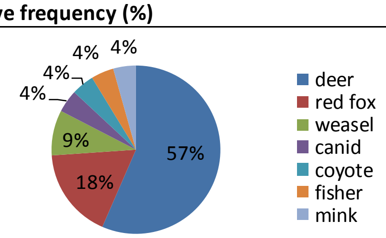
Route 112 species list and activity levels, outside predicted wildlife corridor, based on 6 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
coyote	*Canis latrans*	0.4	
deer	*Odocoileus virginianus*	3.4	
fisher	*Martes pennanti*	0.4	
mink	*Neovision vision*	0.2	
red fox	*Vulpes vulpes*	1.4	
weasel	*Mustela erminea or Mustela frenata*	0.4	
canid		0.4	

Table 4. Species list, average species intercepts, and relative frequency index recorded and calculated for Route 112 transects falling outside predicted wildlife corridor.

Upland ridge

The ridge site falling outside the predicted corridor has a diversity level very close to the ridge site inside the corridor, but still comes in a bit lower (D_s = .42, ds = 2.4), and has fewer species overall with only 5 species represented.

Similarly to 112, outside the predicted corridor there is a clear dominance of deer at 58%. There is also a strong presence of coyote (20%) and weasel (18%), but low levels of all other species. This over dominance of deer and lower representation of most other species present further validates what the diversity indices show (Table 12).

This lower diversity was also clear when tracking these animals and interpreting their behavior. The wildlife community composition was also understandable when observing the habitats available to them. This was an area with a large human presence. There was an actively managed sugarbush, hayfield, an active snowmobile trail, and a white pine stand. It created copious amounts of forage for deer, and lots of slash and brush that would support an ample rodent food supply for coyote and weasel. However, it was a smaller area than the deeper ridge location, with lots of edge habitat and minor disturbance, characteristics that support animals such as these well, but would not be ideal for other wildlife such as bobcat, fisher, or moose. Surprisingly though, there was no definitive identification of red fox in this location, who would also tend to prefer this type of habitat mosaic, though some of the canid tracks were classified as such because there was uncertainty. This suggests that red fox could have also been part of the community found in this location.

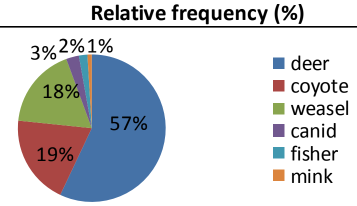
Upland ridge species list and activity levels, outside predicted wildlife corridor, based on 5 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
coyote	*Canis latrans*	4.2	
deer	*Odocoileus virginianus*	12.2	
fisher	*Martes pennanti*	0.4	
mink	*Neovision vision*	0.2	
weasel	*Mustela erminea or Mustela frenata*	3.8	
canid		0.6	

Table 5. Species list, average species intercepts, and relative frequency index recorded and calculated for Upland Ridge transects falling outside predicted wildlife corridor.

The southern Berkshires:

Route 23

Route 23 had the second highest diversity of all sampling locations (D_s = .164, d_s = 6.1) with 12 individual species identified. This locations high diversity can be understood by investigating its species composition and overall lack of dominance of any one species.

Of the 12 species represented, red fox (19%), deer (17%), cottontail (16%), and bobcat (13%) demonstrate the highest activity in this area. Coyote are also well represented at 8%, which may be higher depending on how many of the unidentified canids (14%) were actually coyote. Gray fox and turkey also make enough of an appearance to be noted.

There are also some species specific data that further flesh out what is happening in this community on a behavioral level. For instance, gray fox activity was only recorded on two tracking days in late January (Appendix A, Table 16). This is at the height of winter when these animals tend to utilize human made trails, roads, and other infrastructure in order to move around more freely. There was also a surge in deer activity during the very beginning of January that was much higher than the rest of the tracking season. Considering the relatively late start to winter, this increase in movement could indicate a shift in habitat use for the winter season as these animals moved from one location to another.

Camera data collected on Route 23 reveals the presence of several additional species to the community that were not found during tracking such as raccoon, bear, and skunk. However, bear and skunk were only found on a few occasions, and during a short time window. Bear were caught on camera during a brief period early on, and skunk were only captured on camera during late February coinciding with their usual mating time in New England. Deer, cottontail and bobcat were found on camera in abundance, further validating tracking results. Species such as red fox, gray fox, and weasel were however not captured on camera though they had a definite presence in this community. The absence of these species on camera is not surprising though, and was also a common result in the watershed as well, where these species were most definitely present. They seem to display an uncanny ability to avoid our cameras, no matter how strategically placed.

Route 23 species list and activity levels, based on 6 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
bobcat	*Lynx rufus*	4.3	
cottontail	*Sylvilagus floridanus*	5	
coyote	*Canis latrans*	2.7	
deer	*Odocoileus virginianus*	5.6	
fisher	*Martes pennanti*	0.1	
gray fox	*Urocyon cinereoargenteus*	1.4	
mink	*Neovision vision*	0.4	
opossum	*Didelphis virginiana*	0.3	
red fox	*Vulpes vulpes*	6.3	
turkey	*Meleagris g. silvestris*	1	
weasel	*Mustela erminea or Mustela frenata*	0.1	
canid		4.6	

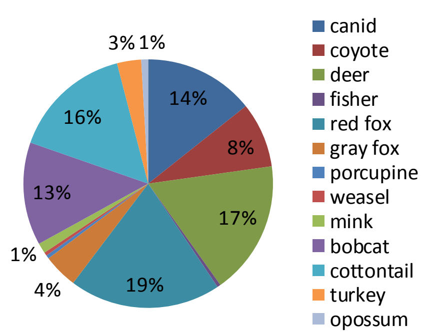


Table 6. Species list, average intercepts, and relative frequency index recorded and calculated for Route 23 transects falling inside the predicted wildlife corridor.

Route 7

The sampling area of Route 7 demonstrated a lower diversity than Route 23 with 9 species represented (D_s = .24, ds = 4.2). In total, 99 tracks were identified over the course of 4 tracking days covering 18 miles (38,624m) of transect. Comparing this site to the Westfield River watershed locations, it still has a lower diversity that Route 112, but was higher than the

Middle Branch and upland ridge locations. It also has the lowest overall animal activity of all locations.

Here there seems to be a clear dominance of canid species with unidentified canids at 28%, red fox at 28% and gray fox at 16%. Interestingly, coyote only represents 9%, but may in actuality be higher depending on which species the unidentified canids represent. There is also a presence of cottontail in this area, but fairly low representation of other species.

An interesting note about this area compared to all other tracking locations inside the predicted corridors is that there was a much lower activity level overall with only 104 individuals recorded (99 identified). Taking into account total tracking days, there were 4 full tracking days along Route 7, 5 on the river and ridge, 6 on Route 23, and 6 along Route 112. This however does not explain that over twice the number of individuals were tracked on Route 112 inside the corridor, and more than 4 times the number of individuals were tracked on the river. Further investigation shows that transect length would also not be a factor. Route 7 had an approximately equal transect length to Route 112 with 6 miles tracked compared to a little over 3 miles of transect along Route 23. This lower count on Route 7 could very well be reflecting the amount of development seen along this road. We are also seeing this reflected in the species composition found in this area. The highest activity levels are from species that are better able to utilize edge areas such as red fox while other species tracked in this location such as raccoon and cottontail do well living in and around human development. Further investigation of the high gray fox activity in this area shows that the majority were tracked within deciduous forest patches, riparian areas and scrub land (Appendix B, Table 23). This coincides with this species' habitat preference and stealthy nature. Finding this species so active around human development is also more common during the winter months.

Along the Route 7 sampling transects, camera data collected again shows the importance of incorporating other methodologies when studying wildlife. Cameras were able to capture an abundance of deer whose tracks did not reveal themselves during sampling. Porcupine were also captured on camera, and not tracked during sampling, though this was from one specific location near an active den site. Bobcat were also observed on camera much more frequently than their tracking numbers indicate, further confirming their importance and activity in this community. Similar to other locations, raccoon activity was high, but unlike what was observed on the Westfield River, they remained active throughout the entire course of sampling.

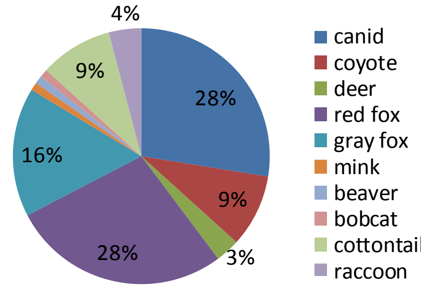
Route 7 species list and activity levels based on 4 tracking surveys			
Common name	**Latin name**	**Average intercepts/km**	**Relative frequency (%)**
Beaver	*Castor canadensis*	0.25	
Bobcat	*Lynx rufus*	0.25	
Cottontail	*Sylvilagus floridanus*	2.25	
Coyote	*Canis latrans*	2.25	
Deer	*Odocoileus virginianus*	0.75	
Gray fox	*Urocyon cinereoargenteus*	4	
Mink	*Neovision vision*	0.25	
Racoon	*Protocyon lotor*	1	
Red fox	*Vulpes vulpes*	6.75	
Canid		6.75	

Table 7. Species list, average intercepts, and relative frequency index recorded and calculated for Route 7 transects.

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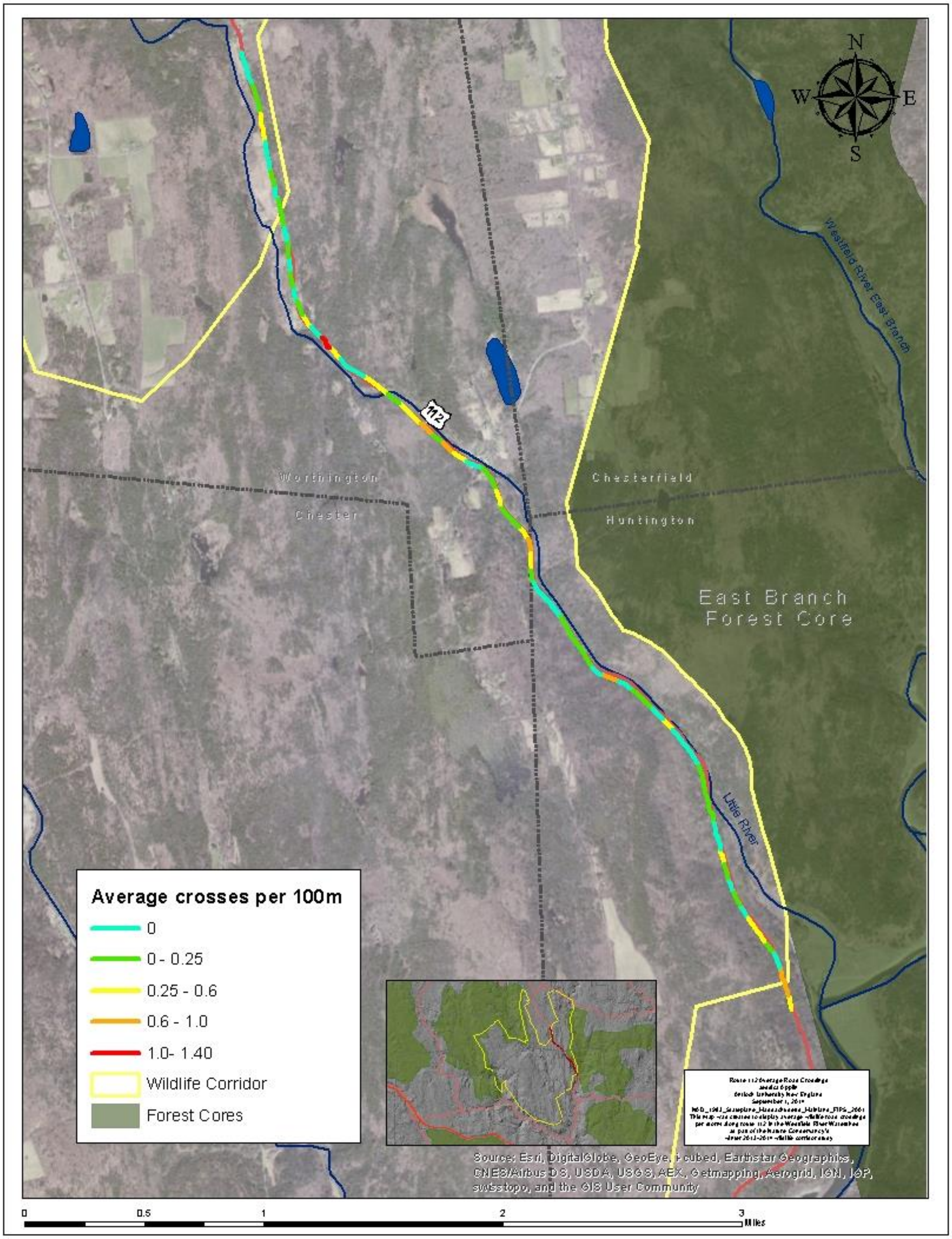
Road crossings

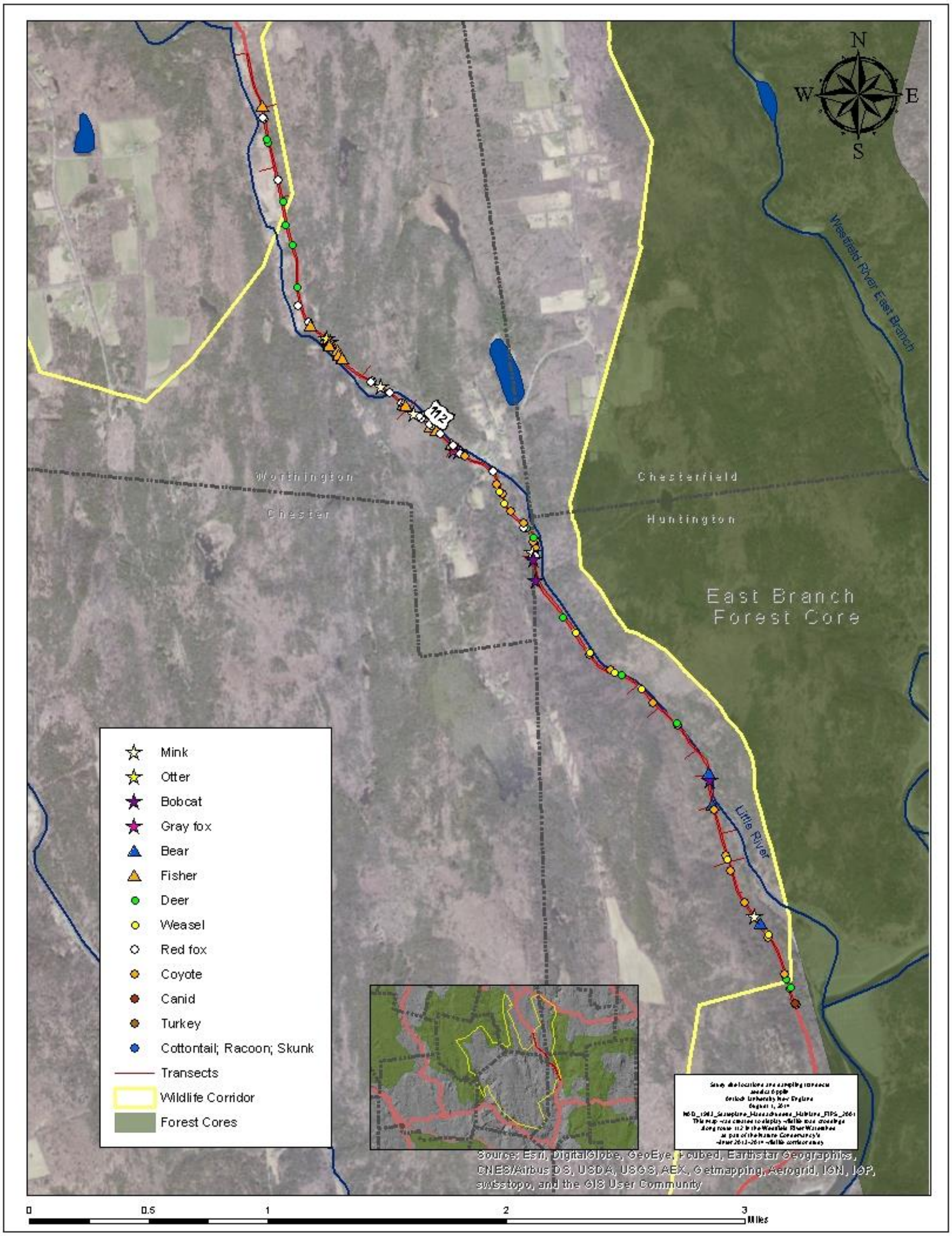
In addition to tracking and camera data, on Route 112 in the Westfield River Watershed and Routes 7 and 23 in the southern Berkshires, individual species road crossings were also recorded. This allowed us to gain some insight into how animals are able to navigate these roads as they attempt to move from one area of forest cover to another. What was of the most interest was whether or not animal movement seemed to be negatively impacted by the presence of a major roadway, and if there seemed to be any particular areas where there were either no crossings or areas that were heavily crossed.

Route 112

The results suggest that crossing activity as a whole is spread fairly evenly over the portion of 112 that was tracked. There are no large areas where there is an absence of animal movement, nor are there areas where there seems to be a heavy concentration (Map 17). There are of course differences in where specific species are choosing to cross 112 (Map 18), but as a whole, animals seem to be getting across (individual species maps available upon request).



Map 17. Average road crossings per 100m after each winter storm on Route 112 in the Westfield River watershed wildlife corridor.



Map 18. Road crossings by species on Route 112

An investigation of specific species presence along the roads reveals that some species seem to show a preference to where they cross while others do not. Mink, fisher, and red fox crossing activity is only observed towards the northern portion of the sampling area in fairly concentrated areas. Interestingly, this area is also where we see some of the higher crossing averages, and is the narrowest part of the predicted wildlife corridor, nestled between the East Branch forest core and active farm lands. Bear on the other hand are only recorded crossing towards the southern end where the transect runs closest to the East Branch forest core. Other species, such as deer and coyote show crossing activity along the entire sampling area of 112.

In addition to crossing data, we were also able to take a look at species presence along the roadway verses their presence further back from the road under deeper forest cover as well as the type of movement behavior in relation to the roadway. What is important to note here is that the total road transect length is much greater than the length of our perpendicular transects and will have an effect on the number of species observed. That said, most of the species tracked along 112 were found along the road transects as well as away from the road (on both sides), suggesting that the road itself is not an absolute deterrent to movement for the set of species observed. Of all 14 species identified in this area, only turkeys were found deeper in the woods but not along the roadway. In contrast, several species were found only along the roadway, such as black bear, bobcat, grey fox, otter, raccoon, and skunk, but there numbers were not very high on the roadway either. This may just reflect the much shorter overall length of the perpendicular transects.

Species	Total number	Number along road transects	Number along perp transects	Road crossings	Road avoidance	Movt. parallel to road	Movt. perpendicular to road	In road	Road Other
Bear	5	5	0	3	0	2	0	0	0
Bobcat	3	3	0	3	0	0	0	0	0
Canid	4	3	1	1	0	1	0	0	2
Coyote	50	39	11	19	3	1	5	3	7
Deer	34	13	21	6	1	2	2	0	2
Fisher	22	18	4	13	0	2	0	2	1
Gray fox	3	3	0	2	0	1	0	0	0
Mink	19	14	5	3	0	6	1	0	4
Moose	3	2	1	0	0	1	1	0	0
Mustelidae	1	1	0	0	0	0	0	1	0
Otter	5	5	0	2	0	1	0	0	2
Racoon	3	3	0	0	0	3	0	0	0
Red fox	35	30	5	16	0	4	3	1	6
Skunk	1	1	0	0	0	0	0	0	1
Unid	21	17	4	4	0	2	1	2	8
Weasel	50	32	18	9	1	9	5	1	8
Total	**259**	**189**	**70**	**81**	**5**	**35**	**18**	**10**	**41**

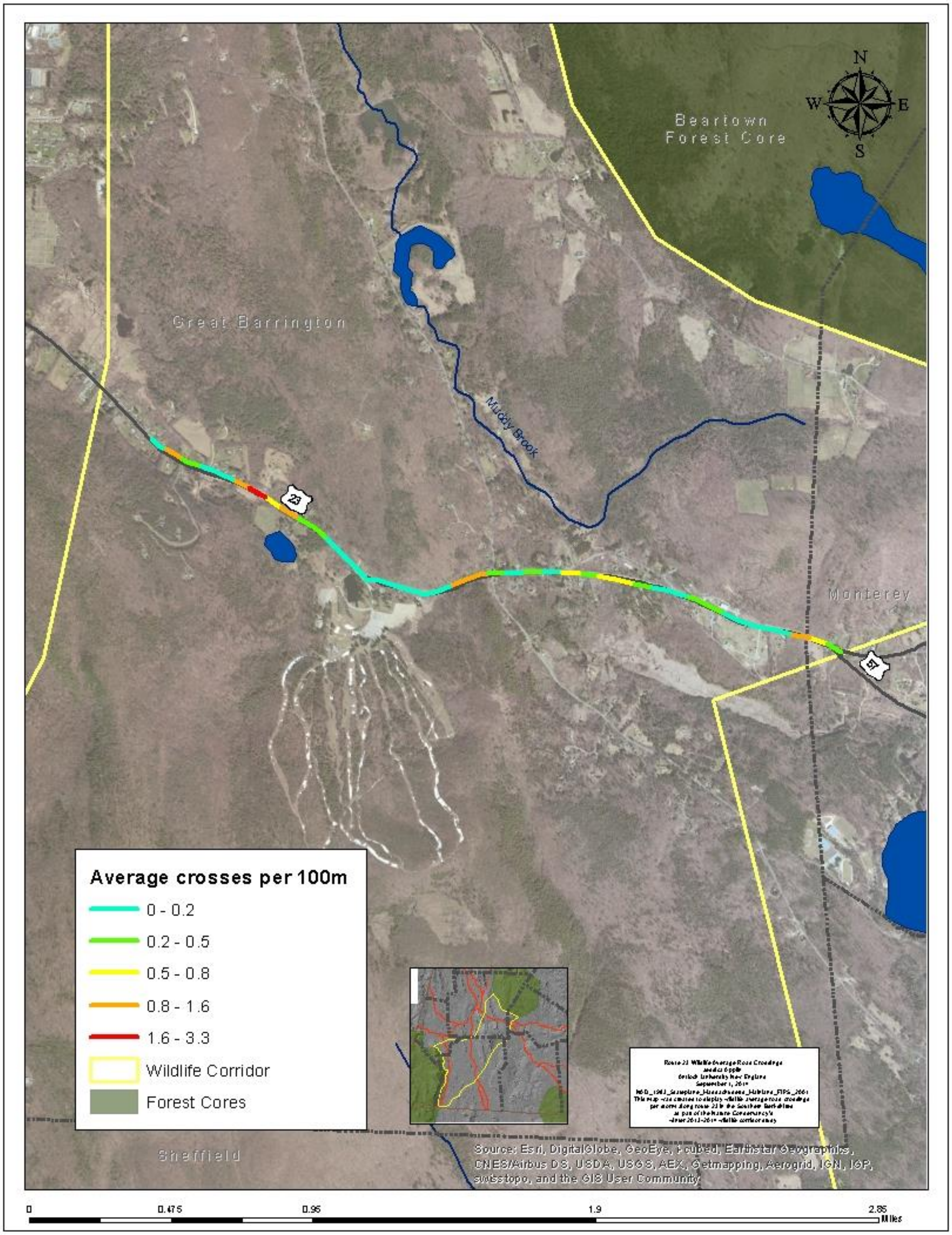
Table 9. Road crossings and movement behavior of species along 112 transects. Total transect length approximately 6 miles (9,656m). Road transect length approximately 5 miles (7,800m), Perpendicular transect length approximately 1 miles (1,545m). Data based on 6 tracking surveys.

Route 23

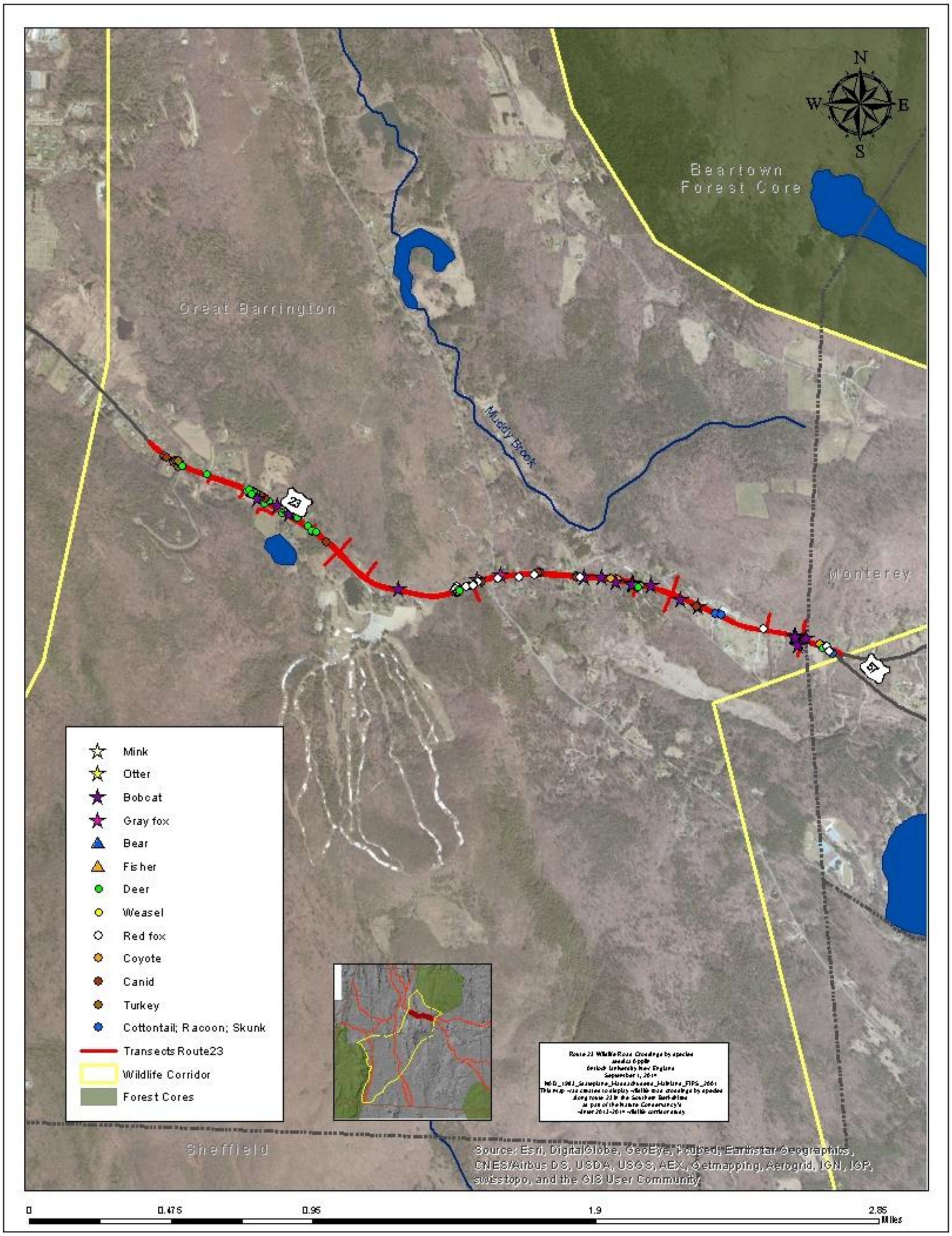
Similar to Route 112, the crossing densities on Route 23 are fairly well distributed with the exception of two locations. The area of road directly across from the Butternut ski resort shows a clear absence/low level of crossings (Map 19). However, there were numerous mammal tracks (just not complete road crossings) observed on the north side of the road. It is not clear whether tracks were truly absent or the high level of human and vehicle activity during the winter season at Butternut interfered with our ability to find tracks on the south side of the road. There is also another clear gap in crossings found directly across from the Eagleton School. A fence at this location may have played a role. It is interesting that these two highly trafficked locations in terms of human activity show so little wildlife activity.

Activity levels along the road compared to what was observed along the perpendicular transects show some interesting differences. Of course, the sampling transect lengths are different, with the road transects being almost three and a half times longer. That said there are still comparisons that can be made proportionally. Certain species such as deer and coyote are highly active along the road, but not as much along the perpendicular transects further out. This was also true for red fox, but not so glaringly (Table 10). Other species such as cottontail and gray fox were observed more frequently along the perpendicular transects as opposed to the road. In lesser numbers, but still something to note, we observed mink, porcupine, opossum and fisher along the perpendicular transects, but not along the roads. In contrast, turkey and deer were found only along the roads, but not on the perpendicular transects, and in higher numbers. Another interesting observation is that there is one of the highest concentrations of road crossings exactly where the Appalachian Trail crosses Route 23.

In investigating specific species road crossing behavior, there are some areas that seem to be preferred by certain animals. Deer are crossing in one particular area located close to some of the larger agricultural fields west of the Butternut resort. Red fox crossings on the other hand are grouped east of the resort in a more suburban residential area. Interestingly, bobcat crossings are distributed fairly evenly along the entirety of Route 23 with the exception of the two areas across from Butternut and the Eagleton School (Map 20).



Map 19. Average road crossings per 100m along Route 23 in the southern Berkshires.



Map 20. Wildlife road crossings by species along Route 23 in the southern Berkshires.

Species	Total number	Number along road transects	Number along perp transects	Road crossings	Road avoidance	Movt. parallel to road	Movt. perp to road	In road	Road other
Bobcat	23	20	7	13	0	0	0	3	0
Canid	31	27	5	14	2	2	1	6	1
Cottontail	30	19	15	4	0	0	1	2	8
Coyote	18	17	2	12	0	0	1	3	1
Deer	38	39	0	34	1	0	0	2	1
Fisher	1	0	1	0	0	0	0	0	0
Gray fox	9	5	4	3	0	0	0	0	2
Mink	3	1	2	0	0	1	0	0	0
Opossum	2	0	2	0	0	0	0	0	0
Porcupine	1	0	1	0	0	0	0	0	0
Red fox	39	37	7	18	1	2	0	10	1
Turkey	6	7	0	3	0	0	0	1	0
Unid	13	0	13	9	0	0	0	2	1
Weasel	1	0	1	0	0	0	1	0	0
Totals	**215**	**172**	**60**	**110**	**4**	**5**	**4**	**29**	**15**

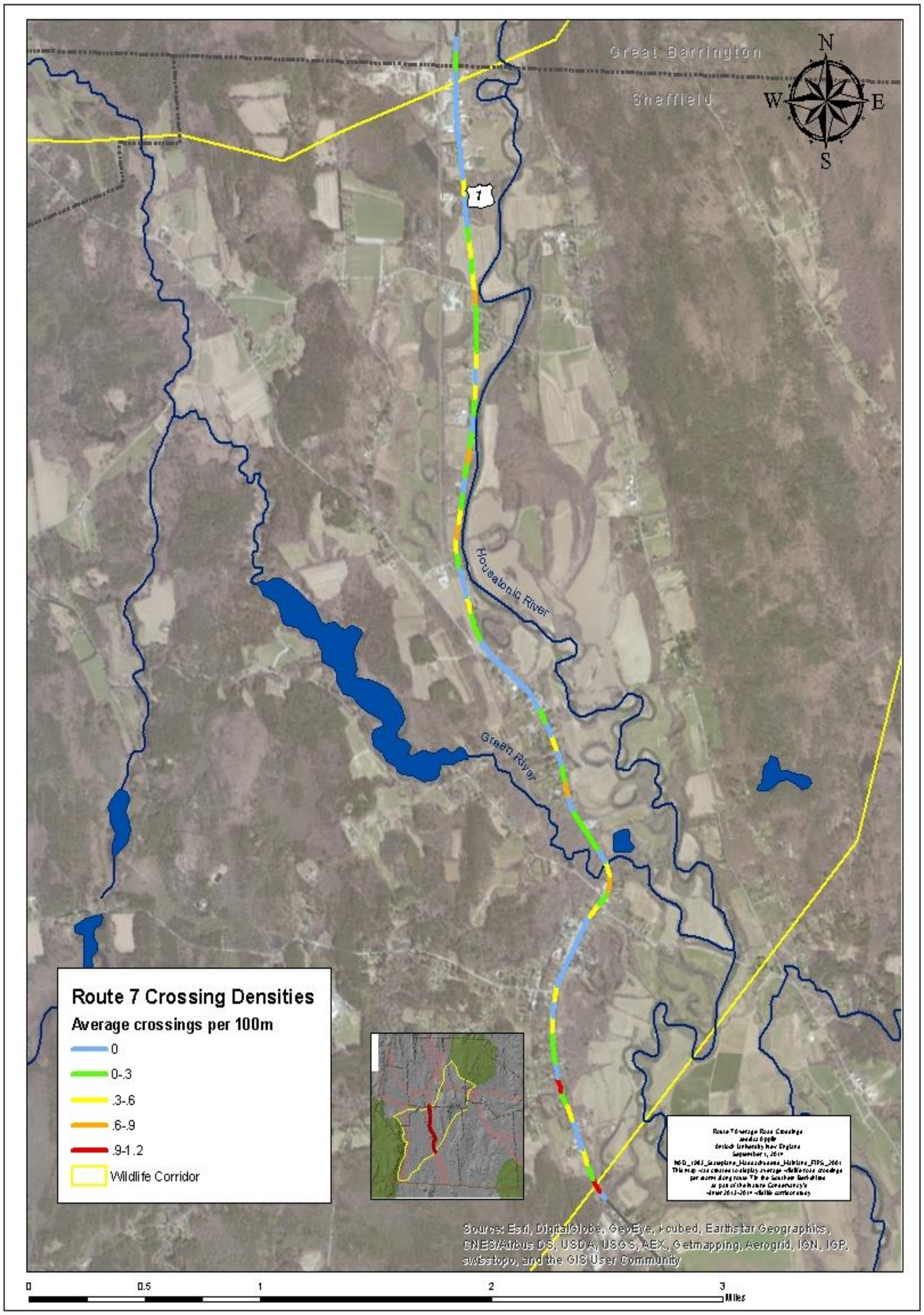
Table 10. Road crossings and movement behavior of species along Route 23 transects. Total transect length approximately 3.2 miles (5150m). Road transect length approximately 2.5 miles (4000m). Perpendicular transect length approximately .7 miles (1,105m). Data based on 6 tracking surveys.

Route 7

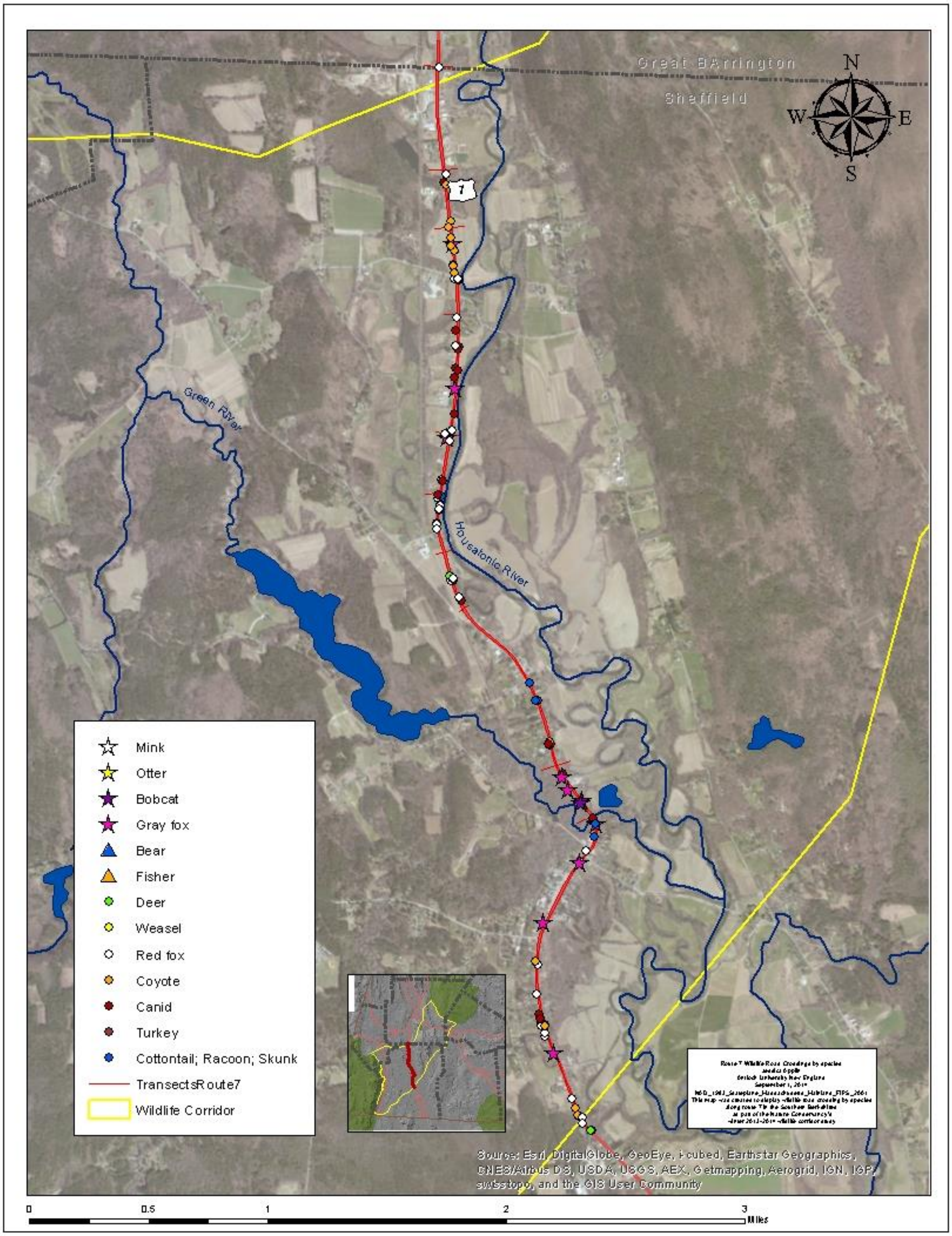
In contrast to Route 112, what we are seeing along Route 7 are clear areas where wildlife are either crossing the roads or are not crossing the roads. The most active crossing area is the northern portion of our sampling area and overlaps our predicted corridor boundary. The second highest crossing area is towards the southern end with a couple smaller, more isolated spots observed toward the center (Map 21).

By investigating these crossing areas by species we can start to see patterns. For instance, the majority of coyote crossings seem to be concentrated in a very specific area along the north section of road with a smaller concentration of crossings happening much further south (Map 22). There also seems to be preferred areas to the south where gray fox are crossing more frequently. In contrast, there are also species such as the red fox that seem to show no preference at all and whose crossing activity is distributed along the whole sampling area.

Further comparison of the road transects versus the perpendicular transects shows that there are some differences. Regardless of the difference in transect length, proportionally; grey fox activity is higher away from the roads than it is along them. This is also true for cottontail activity. In terms of species presence and absence in these areas, beaver were only observed along the perpendicular transects, and mink were only observed along the road. It is important to recognize that there was only a single occurrence of each, so no substantial conclusions can be drawn from these observations.



Map 21. Average road crossings per 100m along Route 7 in the southern Berkshires.



Map 22. Wildlife road crossings by species along Route 7 in the southern Berkshires.

Species	Total Number	Number along road transects	Number along perp transects	Road crossings	Road avoidance	Movt. parallel to road	Movt. perp to road	In road	Road other
Beaver	1	0	1	0	0	0	0	0	0
Bobcat	2	1	1	0	0	0	1	0	0
Canid	28	22	6	11	2	0	0	7	2
Cottontail	12	7	5	0	1	1	0	2	3
Coyote	11	10	1	9	1	0	0	1	0
Deer	9	4	1	2	0	0	0	0	0
Gray fox	13	7	6	4	0	0	0	1	2
Mink	1	1	0	0	0	0	0	1	0
Racoon	4	3	1	0	0	0	0	0	0
Red fox	24	21	3	13	2	0	1	6	0
Unid	5	1	1	3	0	0	0	1	0
Total	**110**	**77**	**26**	**42**	**6**	**1**	**2**	**19**	**7**

Table 11. Road crossings and movement behavior of species along Route 7 transects. Total transect length approximately 6 miles (9656m). Road transect length approximately 5 miles (7900m). Perpendicular transect length approximately 1 mile (1.577m). Numbers reported here include data from 4 storms in which the entire transect was surveyed, excluding one tracking survey.

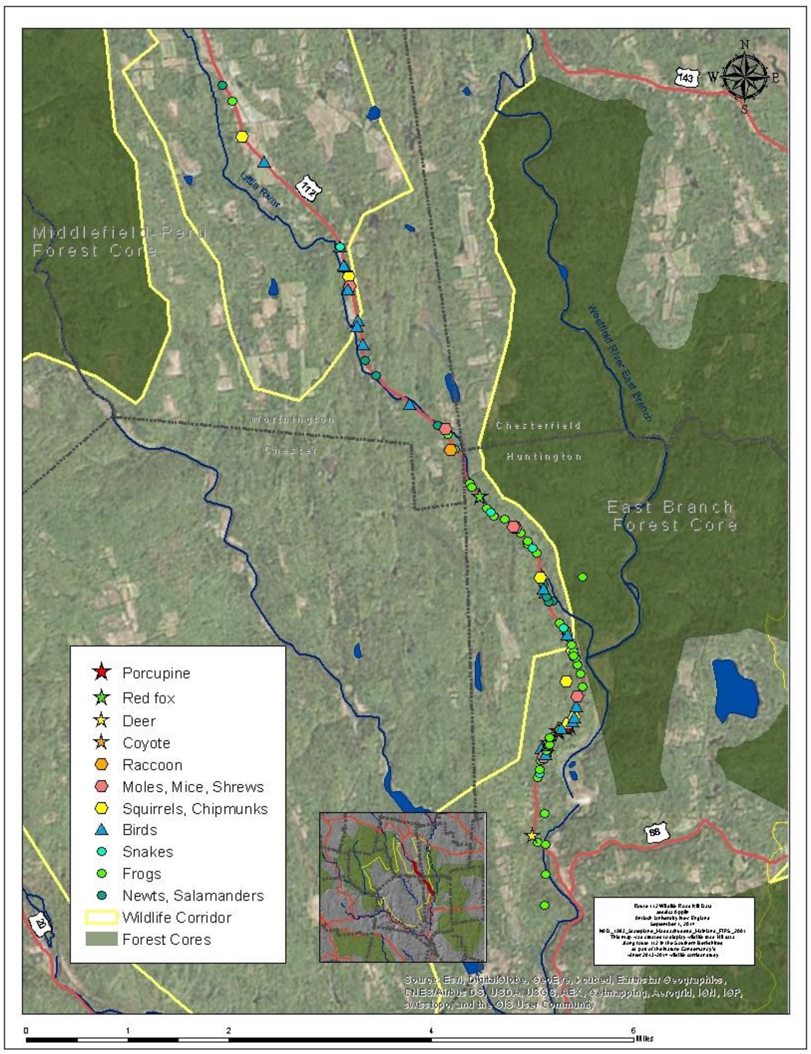
Road Kill:

The road kill data collected along our three sampling road ways represent an almost yearlong sampling effort. This data can be used to supplement road crossing data to further understand high activity hot spot areas and locations where there are gaps and/or trouble spots for wildlife. For example, an area with a high density of road crossings but also a high density of roadkill might represent an area with a lot of animal activity but not necessarily a safe spot for wildlife to cross the road. An area with a high density of road crossings but an average or low density of roadkill might more clearly represent a spot that is safe for wildlife to cross. Overall, road kill data was sparse compared to the tracking data collected, so more in depth statistical analysis was not possible. However, it captured a wider range of species such as reptiles, amphibians, birds, and the smaller mammals, that we were not able to capture through snow tracking. This data helps to paint and even broader picture of animal movement in these locations, and further fleshes out what we have collected through winter snow tracking. It provides us with an even deeper understanding of the stories we have already started to reveal. It is important to remember when interpreting this data that a good portion of road kill will not stay on the road for long. Other animals will scavenge the remains of others, and larger road kill from species such as deer or bear will be collected off of the road soon after they are hit.

Route 112

Of the three sampling locations road kill data along Route 112 was by far the most robust with over 400 recorded individuals. Of these, 72% were amphibians consisting mostly of frogs and newts, but also a few salamanders. The next highest species group recorded was the reptiles at 9%. These consisted mostly of snakes, with only four turtles found. Birds, small rodents as well as squirrels and chipmunks were also found in abundance. Other medium to large mammal species were also found such as porcupine, deer, red fox, raccoon and mink, but only as singular occurrences (Appendix F, Figure 7).

Investigating how road kill is distributed along the entirety of the Route 112 sampling location, we can see that similar to the road crossing data, road kill seem to be distributed fairly evenly. There are however patterns that start to emerge when looking at things on a species specific level. The majority of amphibian and reptile road kill is only found in the southern half of the Route 112 sampling area along a section of road that runs right up against the East Branch Forest Core. There are also several of these species recorded along this section continuing a bit south of the forest core which runs along Gardner State Park. Porcupine were another species that was only found along the road in one specific area towards the southern end next to a particularly dense patch of hemlock. All other species recorded seemed to be distributed evenly across the entire section of road.

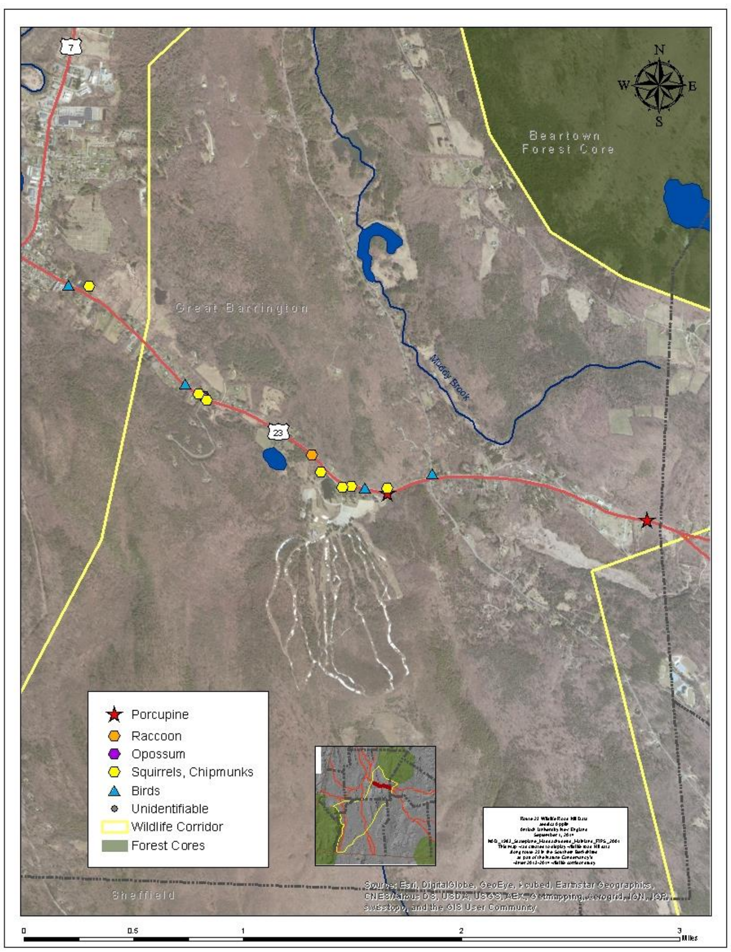


Map 23. Road kill data collected along Route 112 in the Westfield River Watershed from December 2013 through August 2014

Route 23

Route 23 was the sparsest in terms of road kill with only 18 individuals observed even though it was sampled for the same length of time and at the same frequency. This road was surveyed less frequently than other locations, every few weeks rather than every week, and amphibians and reptiles were not recorded. In this location, squirrels and birds made up the majority of road kill noted, both representing 33% of the total. The second most abundant species was porcupine at 11%, but with such low numbers this represented only two individuals. Chipmunk, opossum, and raccoon were also present (Appendix F, Figure 8).

Comparing this data to the road crossing data we see an interesting inverse. There is more road kill noted along the section of road directly across from the Butternut ski resort than any other location. Most of these occurrences are species such as gray squirrel and chipmunk, but it is interesting nonetheless. Similar to what was observed on Route 112, birds are found seemingly evenly along the entirety of the road, while porcupine are found in two specific locations adjacent to dense patches of hemlock.

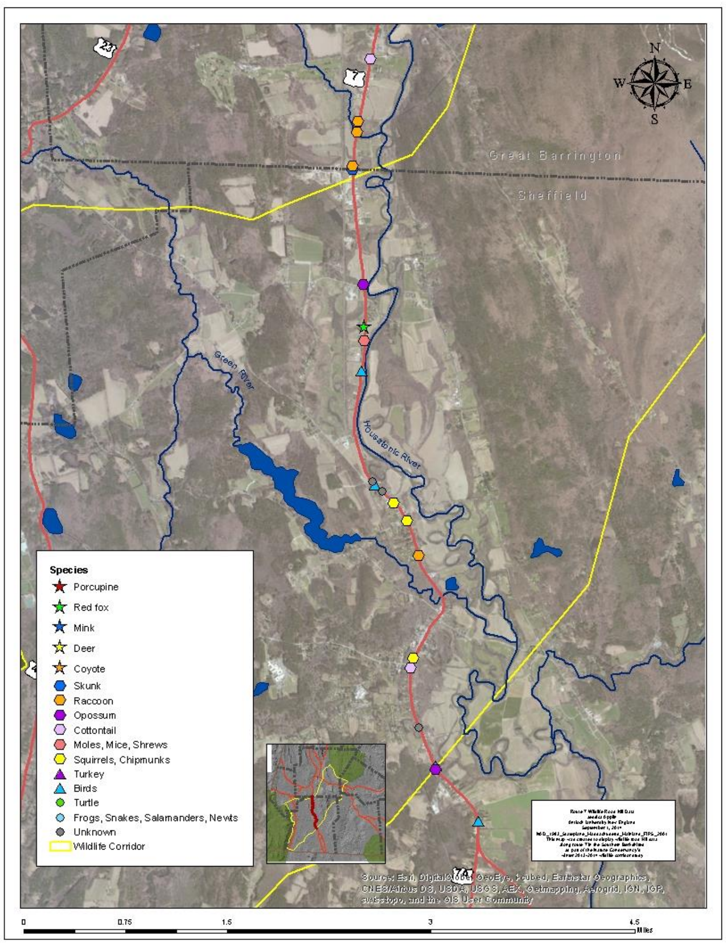


Map 24. Road kill data collected along Route 23 in the southern Berkshires from December 2013 through August 2014.

Route 7

The road kill data along Route 7 totaled 41 individuals. In terms of species composition, there is a diverse set of species recorded, with little group dominance observed. Squirrels and chipmunks consist of 20%, birds 17%, amphibians 15% and raccoon at 10% total road kill. Other species/species groups that were found in some abundance were opossum, skunk, small rodents, and cottontail (Appendix F, Figure 9).

The distribution of road kill shows some similarity to the distribution seen in our road crossing data with gaps observed in two of the same areas, one in the northern most section near the Great Barrington border, and one towards the southern end where there are both dense pockets of development. There is also an interesting difference noticed when comparing the two sets of data. Road crossing data shows a clear gap near the very center of the Route 7 road transect, while several road kill observations were also made along this portion of the route. Specific species observations show that the amphibian/reptile occurrences are found close to the river in low wet areas. Other species such as raccoon are found only in the northern section, while birds were recorded throughout.



Map 25. Road kill data collected along Route 7 in the Southern Berkshires from September 2013 through August 2014

Overall comparison:

Wildlife communities

Location	Number of Individuals	Number of different species	Simpson's diversity index	Simpson's diversity index inverse
Route 112 inside predicted corridor	229	14	0.15	6.7
Route 23 inside predicted corridor	169	12	0.164	6.1
Route 7 inside predicted corridor	88	9	0.24	4.2
Middle Branch	390	10	0.25	4.0
Route 112 outside predicted corridor*	19	6	0.37	2.7
Ridge inside predicted corridor	365	9	0.39	2.5
Ridge outside predicted corridor	109	5	0.42	2.4

Table 12. Simpson's diversity index calculations for all sampling locations in the Westfield River and Berkshires corridors. *Transect length was so short for Route112 outside of the predicted corridors that results may not be reliable for this transect.

The three areas tracked in the Westfield watershed and two areas tracked in the Berkshires this winter show clear differences in wildlife community composition, activity levels, and diversity. There are also differences seen in the areas that were tracked outside the predicted corridor.

The sampling sites along the roads show the highest species diversity of all locations tracked (Table 12). Route 112 has overall the highest species diversity followed by Route 23 and 7. The Middle branch of the river also demonstrates a fairly high diversity and finally the upland ridge site reveals the lowest. It may be that the different levels of habitat diversity within these locations are contributing to this. The higher habitat variation along 112, 23 and 7 that are observed as a result of different levels of disturbance (such as varying levels of development, road work, agriculture, etc.) may influence the diversity of species that are able to utilize the area by providing more diverse habitats. In contrast, the lower diversity found along the inner ridge reflects the larger areas of consistent beech and hemlock forest and lower level of habitat variation.

Though habitat diversity may be higher overall along the three roadways sampled, animal activity levels tell a different story when investigating Route 23 and Route 7 where human development is much higher. In these two locations there may be more species represented, but there are clearly fewer mammals moving around. On Route 7 only 104 animals were tracked over the course of the winter, and on 23, there were 213. Compared to Route 112 in the Westfield corridor which totaled 244, or the Middle Branch which totaled 367 individuals, the number of mammals on the ground is much lower. As discussed earlier, having less tracking days on Route 7 still does not account for this disparity proportionally. These activity levels when considered along with the diversity levels calculated in these areas help to understand the bigger picture of what is happening in these locations. Route 7 may have a higher diversity than the Middle Branch of the Westfield River, but there is over four times the number of animals moving through and utilizing that area, and over four times the activity along the upland ridge site.

Looking more closely at the types of species represented in these areas also reveals differences in community composition. This further clarifies the higher diversity found in these lower activity areas and shows the impact higher development has on wildlife community composition. Along Route 7, we see a higher representation of species commonly thought of as urban wildlife, such as raccoon and cottontail. Similarly, the wildlife community on Route 23 includes species such as opossum, cottontail and skunk. There is also a higher activity level of species such as red fox who do well living on the outskirts of human activity. Interestingly, there is also the highest bobcat activity of all locations found within the Route 23 sampling site. In the Westfield corridor which is much less developed we see a slightly different set of species. Coyote display much higher activity levels, and species such as otter are present. In the two locations away from the main roadway there is a much higher representation of deer, and in the case of the upland ridge, a dominating presence of both deer and turkey.

As predicted, the tracking location falling outside the corridor on Route 112 shows a lower level of diversity than its "in" corridor counterpart. Interestingly enough, the wildlife community found outside the corridor on route 112 is still more diverse than the ridge within it. Again, it is important to remember that the small data set collected in the outer 112 location prevents us from making any solid conclusions, but is still something to consider.

Overall, the relative activity levels calculated in each of these areas shows that there are not only different compositions of species found across areas, but also different in terms of how active they are in relation to each other. Camera data further confirms the results pulled from our tracking data and in most cases fleshes out our communities even more, or provides deeper understanding to the numbers we are seeing.

Road crossings

In the Westfield corridor Route 112 does not seem to be acting as a significant barrier to movement of mammals with no areas of road showing major gaps in wildlife movement or hot spot/pinch point areas of crossings. There are however differences in where individual species cross the road which is not spread as evenly throughout. In the case of Routes 23 and 7 there are much clearer areas where there are crossing concentrations being observed as well as areas where there is a lack of crossing activity that seems to coincide with the highest human activity areas and development. Similar to 112, these roads also demonstrate areas where individual species seem to show crossing preference.

Caveats and areas of further research:

Several caveats relate to our research. We studied wildlife activities and communities for only one year, and were able to use tracks only for the winter months when snow cover was adequate. We urge caution in assuming that the activities and communities identified in these areas are representative of what occurs every year. In reality, New England weather is just too variable for animals to behave the same way season to season, or winter to winter. There are also larger behavioral and physiological responses we cannot always be aware of, or take into account. It is important to understand that when researching wildlife, there are countless variables interacting at all times, and there is no way to account for all of them in any one study. Further, we are assuming all tracks were identified accurately. Although trackers were extremely careful, and conservative in their identifications, human error is unavoidable, but most likely not enough to skew any results. One of the most difficult sets of tracks to distinguish between in snow substrate are weasel and red squirrel. The high number of weasels detected after certain storms may represent fewer individuals showing bursts of local movement which is more common in the winter months, and we also acknowledge that some of the activity attributed to weasels may have been squirrels, resulting in a slight over-estimate of weasels. Another thing to consider is that although trackers tried carefully to record only one of each individual, this can sometimes be impossible taking into consideration their larger movements. For example, a deer may cross a transect line and venture off into the woods for several miles before coming back and crossing the transect line again much further down. This caveat also comes into play when investigating road crossings. We are not claiming that each road crossing is an individual animal. In some instances, it may very well be the same individual (or group of individuals), crossing in the same location after every snow event. This is why we are presenting this data as species activity levels in terms of movement, and not suggesting that these movements represent population densities.

Because of the caveats listed above, the sheer size of the area we were trying to cover and the many different species living in the both in the Westfield River watershed and southern Berkshires, future research is highly encouraged. Ideally, continuing a similar study over several more years would help to confirm communities living in each of the locations as well as individual species activity levels. A better understanding of the populations that live within these corridors as a whole, not just those who left evidence in the form of tracks or camera images along our transects, becomes important as future landscape changes occur. A research project of this size is hard to fund and execute, but smaller scale research and monitoring would also be beneficial. Specifically, setting up cameras in these locations throughout the course of a year would give huge insight into how wildlife communities shift and change with the seasons as well as year to year. If used over the long term, this method could also help identify shifts in community composition in response to factors such as landscape development or climate change. Incorporating bait stations could also be explored in order to get a better sense of the species that are present, but harder to capture on camera (such as weasel or moose).

Figure 4. Black bear crossing frozen pond

Figure 5. Bobcat moving along upland ridge

Another piece of this research we had hoped to explore more was the differences seen inside versus outside the corridor. If future work is done in these areas, it is recommended that wildlife communities outside the corridors be studied further so that more in depth comparisons can be made. Specifically, for Routes 112, the shorter transect length outside the corridors resulted in very low tracking observations so calculations will hold less weight. This makes it problematic in comparing species diversity or activity levels to the more robust data collected inside the corridor. Tracking methods can also continue to be utilized even if not at the same scale.

Tracking several smaller transects throughout the course of the winter would also provide solid wildlife community data, and be easier to execute/divide up among several people. There is also a huge benefit to tracking in a less structured way by simply wandering through these areas and seeing what wildlife are moving around. If done frequently enough, patterns in activity will emerge, shifts in community will become apparent, and interesting behavioral changes will present themselves. Even with so many possibilities for further study, the research conducted and the data collected was done with great care, and with the highest of standards. The resulting data is robust and complete and can provide us with an incredibly detailed picture of wildlife communities and movement in these areas. It provides us with an incredibly strong foundation in which to move forward with decisions on conservation with complete confidence.

Conclusions/Moving forward

As a whole, the results we found from our tracking, camera, and roadkill work suggest that both the Westfield River watershed and southern

There are three main strategies that will ensure movement of a wide range of wildlife species through the corridors we studied: 1) land protection, 2) improvements to the structure and/or management of roads, and 3) support for landowners to steward their land in a way that maintains or improves connectivity.

Berkshire corridors allow for movement of moderately mobile mammal species. In the Westfield River corridor, the high level of natural cover, the low- to medium-density development, and the suggested permeability of route 112 to animals trying to get from one side to the other seem to be working together to support native animal communities. Our main message here is one of maintaining the conditions that exist, and guarding against future changes that would prevent animals from moving and fulfilling their basic needs. In the southern Berkshire corridor, wildlife still seem to be moving between forest cores, but the most highly developed areas around routes 7 and 23 are acting as barriers. The main message for the southern Berkshires is to increase permeability of the roads by maintaining or enhancing the areas where wildlife are able to cross, and considering ways to create continuous natural cover paths between the two forest cores.

<u>Land protection</u>:

The strongest connection between core habitats includes a continuous path of permanently protected land, in natural cover, from one core to the other. That path should be embedded within a corridor that is a patchwork of ownerships but predominantly in natural cover. In the Westfield River watershed corridor, protection of an additional dozen parcels in Chester and Worthington could result in such a path between the two forest cores. In the Berkshires, creation of a continuous path would include permanently protecting several dozen parcels in Sheffield and Great Barrington in three areas (see maps 26 and 27 and associated text). For landowners and organizations/agencies considering land protection, a report from Staying Connected Initiative colleagues (including The Nature Conservancy) in New Hampshire and Vermont suggests four criteria to use in prioritizing areas for permanent land protection. These criteria -- functional connectivity, threats to connectivity values, land ownership patterns and feasibility, and valuable wildlife habitat features -- are explained in Appendix E, and seem as relevant here in southern New England as they are in areas to the north. A particularly useful concept for land protection is the idea of “no-regrets” actions. A no-regrets land protection project is one that is done to improve wildlife connectivity *in addition to achieving other goals*. For example, protecting land that not only shows evidence of wildlife movement but also has high recreational value and ability to produce clean drinking water will always be a good investment, even if any one of those values is later diminished.

One caution when considering land protection in a corridor is to recognize that wildlife corridors may be conserved for a different goal than land in core wildlife habitats. In corridors, large changes to the land cover type (forest to grassland or shrubland, or forest to agricultural field (or vice versa), for example) may be less disruptive than those same changes in habitat cores. Easement language specific to ecological goals in wildlife corridors can be obtained from the Staying Connected Initiative (Steckler & Bechtel 2013). With limited resources available for conservation action, it is all the more important to carefully consider the benefit to wildlife passage relative to the investment and level of protection of any given piece of land.

Our study strongly reinforced the importance of maintaining the wide range of habitat types found within the corridor. A mix of riparian and upland habitat, and forests of a diversity of ages and types are part of what makes a corridor suitable for the full range of native wildlife species. Even mammal species strongly associated with a particular habitat type, such as a riverbank or a cliff, were found moving through other habitat types. For example, we observed an otter crossing the ridge line in the Westfield corridor, outside of the riparian habitat where this species is usually observed.

Roads:

While our study did not support the idea that routes 112, 23, and 7 are impassable, “hard” barriers to mammal movement, they all still hinder wildlife movement to varying degrees. Transportation improvements along these routes should consider their impact on wildlife and whether they are maintaining the overall permeability of the road. We also suggest several actions that might help maintain or increase wildlife passage along these three roads.

112: Of the three roads we studied, route 112 is the most passable by wildlife. Mammal crossings were observed along most of the length of road surveyed, with no obvious or consistent gaps. This pattern is consistent with the land cover along route 112 (~90% forested), and with the results of UMass Critical Linkages II models (see Appendix C) which suggest that there are many places along route 112 where animals are likely to be able to move east/west across the road. Mammals were also rarely seen in our roadkill data (though there were some notable exceptions, including several porcupines found in surveys after the end date of the study). Models, land cover, and tracking all pointed to the same conclusion – the goal for route 112 should be to maintain the forested cover, right-of-way management, and traffic volume on this road.

Route 112 may serve as a model when working to restore passage along roads that are more of a barrier to mammals. In most areas, the 112 right-of-way is shrubby or forested rather than kept as wide areas of mowed grass, and shoulders are narrow. The natural cover extending to the road edge on both sides along many stretches of route 112 is almost certainly helping animals to successfully cross. We saw little evidence of edge effects on this road – mammals were no more abundant on our transects extending away from route 112 than they were along route 112, and two trackers noted that they have seen roadkill along 112 being scavenged by mammals. While low curbs have recently been added to much of the length of route 112 we surveyed, they also contain numerous breaks in the curb for drainage. Speeds on this road are somewhat kept in check by the nature of the road, perhaps another factor that contributes to the ability of mammals to successfully cross. It may not be realistic to recreate the low level of development seen along route 112 along other roads with similar traffic volumes, but it may be possible to match the width of the road plus cleared right-of-way where doing so would not compromise safety, or to increase the length of road bordered on both sides by natural cover to more closely mimic route 112.

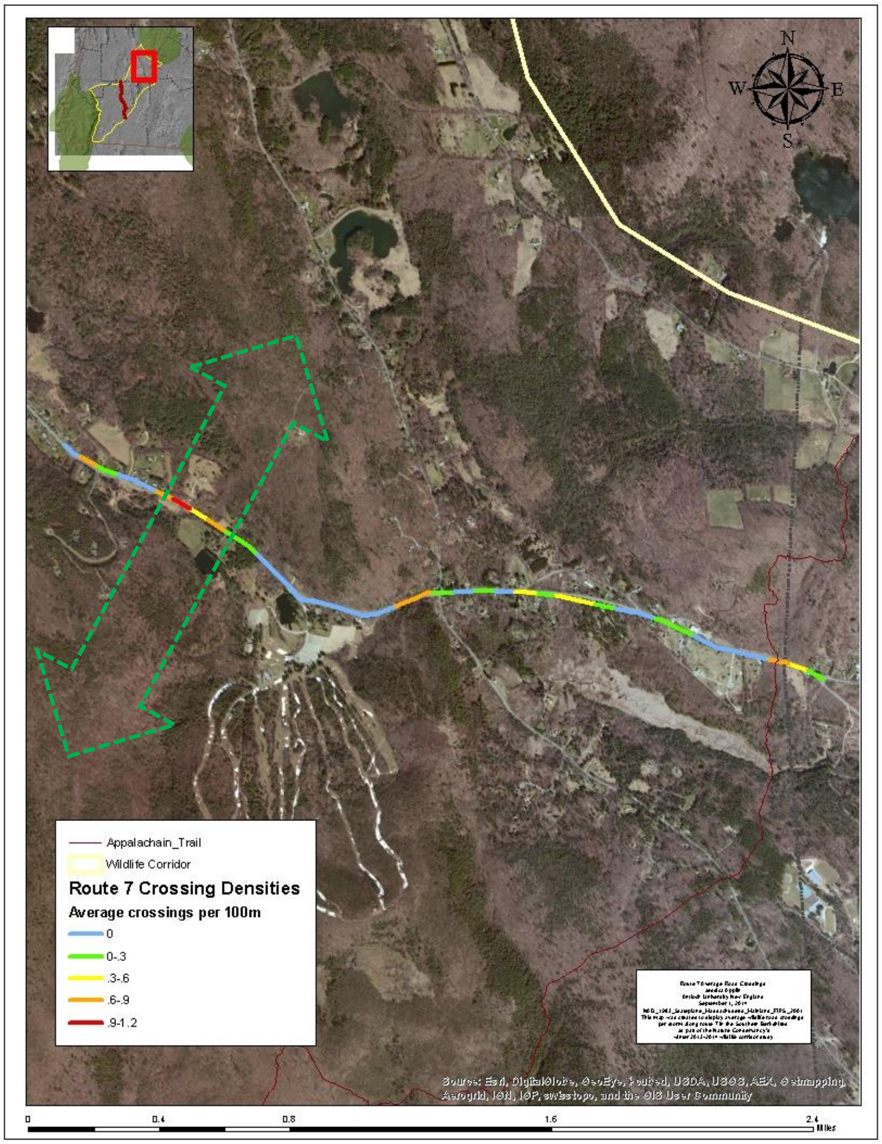
We would suggest monitoring wildlife crossings and roadkill before and after management changes, as this study provides no causal link between the permeability of route 112 and the characteristics of the right-of-way and surrounding landscape. It will be important to prove the benefit of proposed road management changes before making them on a large scale, and to continue to improve our roadkill maps on route 112. As many of the study participants live near route 112 and travel it frequently, we are also sensitive to the safety concerns of pedestrians and motorists along route 112. If in the future there are portions of route 112 that roadkill surveys indicate have high concentrations of animal/vehicle collisions, the use of fencing, of deliberate clearing and widening of the right-of-way, or other techniques to make an area less attractive as a mammal crossing could likely be employed without significant harm to wildlife populations. In this case, introducing a section of barriers on an otherwise crossable road might have more benefit (in both reducing animal mortality and increasing public safety) than harm (in making a section of the road act as a barrier to wildlife).

Route 112 was a greater cause of mortality for amphibians and reptiles than for mammals, including numerous snakes our roadkill survey volunteer reported near a den site. Another reason to continue collection of road kill data is to determine whether mammals are able to cross the road, but amphibians and reptiles are not. We were not able to determine whether route 112 is a significant source of mortality for some of the non-mammal species living along it.

<u>23:</u> Route 23 has one permanently protected, heavily used corridor surrounding the Appalachian Trail, on the eastern side of our tracking transect. There is a second potential corridor on the western side of the transect. This area is the only road section that showed a statistically significant “hotspot” of crossings, and while much of the surrounding land is in natural cover it is not permanently protected from conversion and development. This is an important area to work with willing landowners to ensure that this path remains intact for wildlife. Creating a second continuous, largely protected corridor to the west of Butternut would complement the already-protected corridor along the Appalachian Trail.

Again, our tracking data match up very closely with Critical Linkages data (see Appendix C). Both our tracking data and this model point to two areas as being most permeable to wildlife, with the areas in between acting as more of a barrier (Map 26). This modeled data was particularly important in this site, as on route 23 there are gaps in successful crossings observed, but the lack of crossing data here doesn’t give the full picture. In the case of Butternut Ski Resort there is an absence of crossings, but not an absence of tracks. Wildlife are still moving along the north side of the road. Because of the high traffic in this location and heavy plow use, animals could very well be crossing here and their tracks are being compromised due to this activity and just not noticed by trackers. They may also be crossing to either side of this area during the resort's active winter months, but perhaps crossing on to the ski resort in the fall, spring and summer. Given this uncertainty, we are not convinced that this location is acting as a barrier to movement. Investigating the other gap area on route 23 around the Eagleton School reveals a fence line and further tracking evidence that mammals are moving along it before crossing the road. In this case, the school isn't acting so much as a barrier, but more of a funnel, so focusing on the areas to either side of the fence line would be important. It is interesting that the impact of the fence, which is a split rail fence and could be crossed by many species, is so strong.

In addition to land protection in the western corridor along route 23, there may be opportunities to get wildlife under route 23 in this area. Improving existing culverts in this area could have multiple benefits: improve the passage of fish and other aquatic organisms, reduce the risk of the culvert failing in a flood, and if the culvert is built to current standards (which require a portion of the bank to be included in the width of the culvert) improve passage of medium-sized animals under rather than over route 23. If a passage were large enough to allow deer to pass under the road, there could also be a significant public safety benefit, as we found tracks indicating that deer were crossing route 23 at the end of a curve in the road where visibility was not ideal. A database of road-stream crossings in western Massachusetts including information on whether terrestrial animals of various sizes can use them to go under rather than over roads is available upon request from the Berkshire Environmental Action Team in Pittsfield or from The Nature Conservancy. Efforts to improve road-stream crossings in Massachusetts are well-established and have an excellent record of success – while not the focus of this report, they are a critical strategy both along route 23 and throughout the Berkshire Wildlife Linkage.



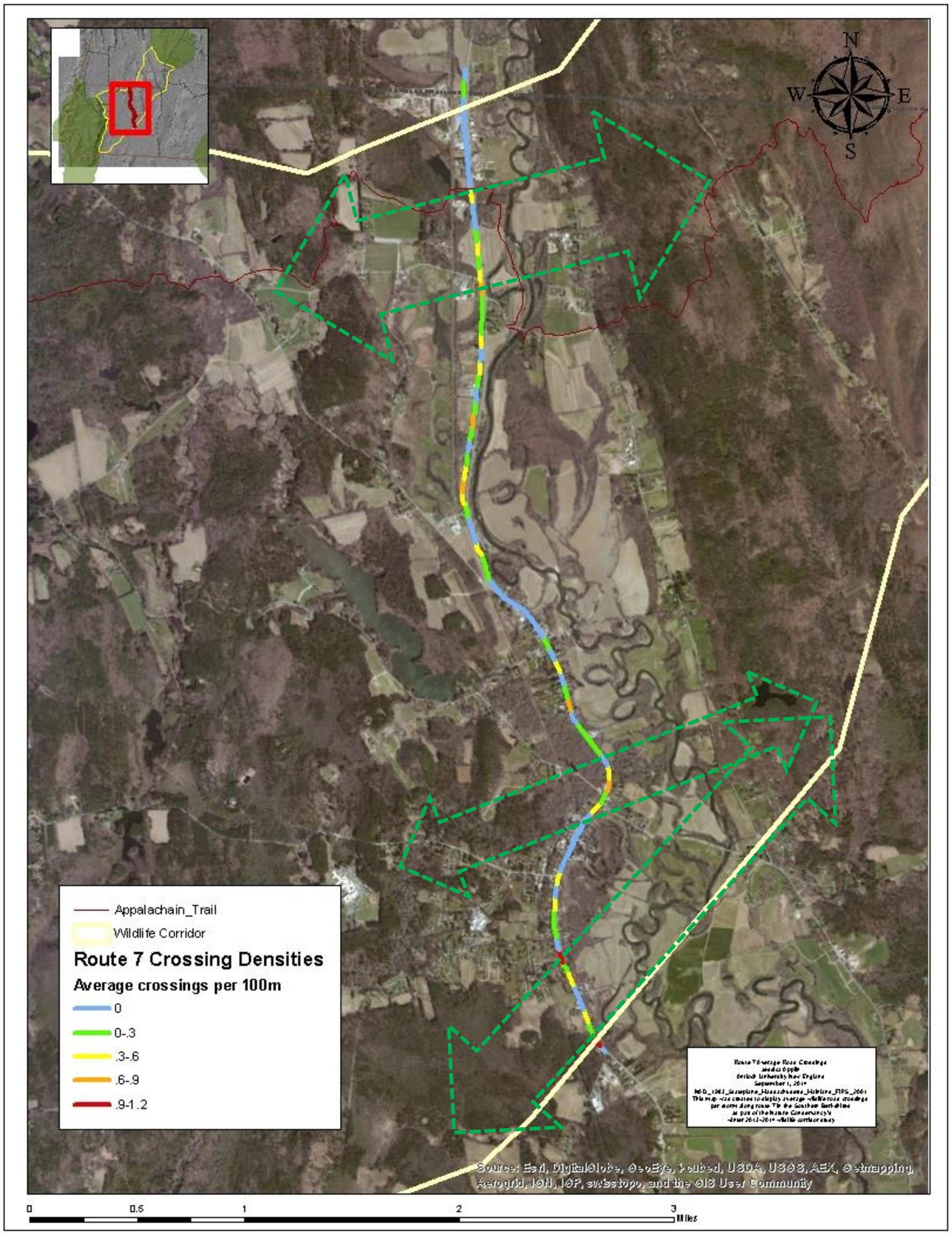
Map 26. Areas along route 23 showing road sections where animals are successfully crossing the road. The arrow indicates a concentration of mammal road crossings where we suggest a focus on land protection and road infrastructure work. See text for further explanation.

7: Along route 7 there are spots that are very clearly deterring mammals from crossing the road. Of the three roads, this is the one we are most confident in calling a barrier to wildlife movement given our tracking results. Crossings were rare in areas with commercial and residential development along the roadside, though we observed successful crossings in the northern and southern ends of our transect where the road was bordered by agricultural fields, wetlands, and/or forest (Map 27). The lower animal activity levels along route 7 further suggest that this road is acting as a partial barrier to wildlife movement, and again, our tracking results tended to agree with modeled results from Critical Linkages II (see Appendix C). Critical Linkages indicated that the most permeable section of route 7 would be near the Appalachian

Trail, and this was a section where we found abundant canid species crossing the road. We also found crossings in the very few road sections that are bordered by forest or wetland on both sides of the road.

For route 7, then, there are two different actions that are needed: making some areas of route 7 that are currently not safe crossing spots more useable by wildlife (restore permeability), and protecting/expanding the narrow areas that showed the highest level of successful crossings: along and just south of the Appalachian Trail crossing and at the southern edge of the corridor near and south of the Schenob Brook wetlands (maintain permeability). Restoration could be accomplished in areas with few successful mammal crossings by restoring riverbanks beneath bridges crossing the Green River and Hubbard Brook that currently have concrete walls and no suitable passage for terrestrial wildlife. If done as part of a scheduled infrastructure project, this could potentially be done without significantly adding to the project cost. Another restoration action could be to increase the areas of route 7 that are bordered by natural plant cover, perhaps by planting or encouraging the growth of native shrubs and trees. It is possible that the addition of cover would decrease the perceived width of the road – enabling species that avoid being out in the open for long distances to stay under cover except for the short distance across the two lanes of route 7.

Restoration of permeability on route 7 needs to be paired with action to maintain permeability in the places where wildlife were able to successfully cross the road. For winter mammals, route 7 had three sections where crossing activity was particularly high, though not significantly so when we tested it using a GIS hotspot analysis (see Appendix G). We suggest several actions that could be taken along route 7. The first would be to widen the permanently protected strip of land around the Appalachian Trail, to ensure that the heavily-used crossing area will remain in natural cover (or agriculture, which given the small size of farms in the Berkshires does not appear to be incompatible with wildlife movement, especially in winter when fields are not mowed or otherwise managed). The area around the Appalachian Trail corridor was identified as a well-connected area both in our tracking data and by Critical Linkages modeling, giving us additional confidence that this area is a key crossing spot. A second action would be to shore up an alternative corridor, by permanently protecting the areas near and south of Schenob Brook where forests and wetlands come up to both sides of route 7 (Map 27). A third action would be to look particularly carefully at additional development and transportation improvements planned for this area, considering the impact on wildlife and their usage patterns in this area.



Map 27. Areas along route 7 showing road sections where animals are successfully crossing the road. The northern arrow indicates an area at and south of the Appalachian Trail where we suggest additional land protection. The southern arrows indicate potential alternative corridors where wetlands border both sides of the road. See text for further explanation.

<u>All sites:</u> The Massachusetts Department of Transportation is a leader among state agencies in considering the impact of road-stream crossings on aquatic species, and of transportation infrastructure in general on wildlife habitat. Many of the partner groups and volunteers involved in tracking and roadkill surveys for this study remain keenly interested in

helping with actions that could help wildlife to move across roads in the Berkshires and Westfield corridors. A key aspect in both the Westfield and Berkshire corridors will be continued cooperation between landowners and volunteers, towns and planning agencies, and state agencies including the Departments of Transportation and Fish and Game. Some of the suggestions for improving the permeability of roads to wildlife trying to cross are expensive and require the assistance and expertise of state groups while others can be done cheaply or individually by landowners and land managers, and both techniques will be needed.

Land stewardship:

Western Massachusetts as a whole, but especially the Westfield River watershed and Berkshires, benefit from the already very high level of support for the river and forest resources in these places. The history of decisions made by landowners in this area are what have kept both corridors in relatively good condition for wildlife movement. It is important to continue to connect landowners within each corridor to each other as well as to existing resources that can help them manage their land in ways that balance wildlife habitat with a desire to generate income or enhance privacy, aesthetics, and other features. The Nature Conservancy has compiled a list of landowner resources and some general suggestions for ways landowners interested in supporting wildlife movement can do so through their land management. These materials are available upon request.

In both corridors, additional work could be done with towns and planning agencies to make the importance of the corridor (and where it is) known, and to suggest that development and transportation projects within the corridor consider their impact on wildlife. Our results do not argue for freezing development, or for making dramatic changes to road infrastructure, but rather for considering wildlife movement to support decisions regarding development and roads. A caution in both corridors is that work with partners and landowners should not focus so exclusively on wildlife movement that it ignores the many other benefits we get from living within and helping to maintain a connected, natural, landscape. Like wildlife, we also depend on a landscape that consists of large core habitats and connected areas of natural cover between them. This pattern of land cover is what enables our forests and the wetlands and streams that run through them to be resilient to climate change and other threats. Those resilient forests provide us with clean drinking water, clean air including carbon storage, forest products of all kinds, and the additional economic benefits of tourism and recreation industries.

The bigger picture:

Preserving forest cover and connectedness in areas like the Westfield and Berkshire corridors allows for the broader movements of species that are necessary for dispersal and maintaining genetic diversity. Without conserving a level of connectedness, and providing a mosaic of habitats, this level of movement is restricted, and the viability of populations over time will suffer. This is especially important given climate change, which is forcing animals to move longer distances more quickly than they have before. The Westfield corridor contains a range of topography, soils, and plant communities. While not as intact as the forest cores it connects, the corridor has many of the same elements of resilience as the cores, suggesting that as the climate changes this area will continue to act as a passageway for animals, able to bounce back from natural disturbances and provide a range of habitats that will ensure it remains forested, even if the species found in that forest shift and change over time. The southern Berkshires corridor contains a concentration of calcareous wetland habitats. These globally rare and important habitats support a wide diversity of native plants and animals. The corridor also contains cliffs and floodplains as well as agricultural fields that appear, at least in winter, to provide significant hunting habitat for a range of mammals.

By doing our part in the Berkshire Wildlife Linkage, we are helping to ensure that animals can move through the linkage to the Green Mountains to the north in Vermont, the Hudson River Valley to the southwest in New York, and beyond to the rest of the Appalachians. For the most part, the corridors detailed in this report are in good shape. We saw the benefits of the habitat diversity and largely natural landscape in the activity levels of mammals found in these corridors. When beginning the tracking study, we were not certain we would record species such as bobcat and fisher, which are still active in both corridors. We can be rightly proud of the amount and quality of habitat even in the corridors between the core habitats, while recognizing that we need to improve connections across the few barriers that do exist. Actions outlined here will maintain or improve the land's ability to provide services used by people as well as by nature. These are true "no-regrets" actions in the corridor. It is not necessary to wait for perfect or concrete information about wildlife passage to move forward with land protection, programs that encourage good stewardship, and careful transportation planning. Allowing movement of wildlife is just one of many benefits these corridors are providing to the communities within them.

Figure 10. Middle Branch of the Westfield River taken from transect.

Appendices

Appendix A: Species data by date

Westfield River Watershed

Date	Beaver	Canid	Coyote	Deer	Fisher	Mink	Mustelidae	Otter	Porcupine	Raccoon	Red fox	Unid	Weasel	Total
12/16/2013	0	2	0	25	3	0	0	0	0	0	1	0	0	**31**
12/20/2013	0	0	19	69	2	0	0	13	1	0	0	0	2	**106**
1/4/2014	0	0	12	1	1	0	0	4	1	0	3	0	3	**25**
1/29/2014	0	1	51	11	29	2	0	0	1	0	3	0	38	**136**
2/8/2014	0	1	1	51	3	4	2	2	0	1	0	0	4	**69**
Total	**0**	**4**	**83**	**157**	**38**	**6**	**2**	**19**	**3**	**1**	**7**	**0**	**47**	**367**

Table 13. Species counts from Middle Branch transects displayed by tracking date. Total transect lengths approximately 2.42 miles (3900m)

Date	Bobcat	Canid	Coyote	Deer	Fisher	Grouse	Moose	Otter	Porcupine	Turkey	Weasel	Total
1/5/2013	0	0	8	123	0	0	1	0	1	72	2	**207**
12/19/2013	0	0	0	73	2	2	0	0	4	66	0	**147**
1/21/2014	0	0	11	50	15	0	0	0	0	62	3	**141**
1/28/2014	9	1	5	55	0	0	0	0	1	90	10	**171**
2/7/2014	0	0	0	19	0	1	0	1	1	0	5	**27**
Total	**9**	**1**	**24**	**320**	**17**	**3**	**1**	**1**	**7**	**290**	**20**	**693**

Table 14. Species counts from southern ridge transects displayed by tracking date. Total transect lengths approximately 1.7 miles (2700m)

Date	Bear	Bobcat	Canid	Coyote	Deer	Fisher	Gray fox	Mink	Moose	Mustelid	Otter	Raccoon	Red fox	Skunk	Unid	Weasel	Total
12/19/2013, 12/20/2013	0	0	1	2	0	0	0	1	0	0	0	0	0	0	0	1	**5**
1/4/2014, 1/5/2014	0	0	0	3	5	0	0	3	0	0	1	0	1	0	1	1	**15**
1/20/2014, 1/21/2014	5	2	0	15	3	8	3	5	1	0	1	0	17	0	9	0	**69**
1/28/2014, 1/29/2014	0	0	3	7	12	14	0	3	0	1	0	2	14	0	8	20	**84**
2/7/2014, 2/8/2014	0	0	0	4	12	0	0	4	0	0	3	1	1	0	1	22	**48**
2/15/2014, 2/17/2014	0	1	0	19	2	0	0	3	2	0	0	0	2	1	2	3	**35**
Total	**5**	**3**	**4**	**50**	**34**	**22**	**3**	**19**	**3**	**1**	**5**	**3**	**35**	**1**	**21**	**47**	**256**

Table 15. Species counts from route 112 inside predicted corridor displayed by tracking dates.

Southern Berkshires

Date	Bobcat	Canid	Cottontail	Coyote	Deer	Fisher	Gray fox	Mink	Opossum	Porcupine	Red fox	Turkey	Unid	Weasel	Total
12/12/2013	6	6	10	4	5	0	0	0	0	1	15	0	2	0	49
1/5/2014	7	2	1	3	29	0	0	1	0	0	6	1	1	0	51
1/21/2014	0	3	6	3	1	0	5	0	2	0	7	1	0	0	28
1/28/2014	2	17	4	3	2	1	4	2	0	0	6	1	5	0	47
2/7/2014, 2/8/2014	1	0	2	0	1	0	0	0	0	0	2	1	2	1	10
2/17/2014	7	3	7	5	0	0	0	0	0	0	3	0	3	0	28
Totals	**23**	**31**	**30**	**18**	**38**	**1**	**9**	**3**	**2**	**1**	**39**	**4**	**13**	**1**	**213**

Table 16. Species counts from Route 23 in the Southern Berkshires displayed by tracking dates.

Date	Beaver	Bobcat	Canid	Cottontail	Coyote	Deer	Gray fox	Mink	Opposum	Raccoon	Red fox	Skunk	Unid	Total
1/20/2014	1	0	14	1	4	2	6	0	0	4	11	0	3	**46**
2/7/2014	0	0	2	1	3	1	0	0	0	0	1	0	2	**10**
2/11/2014, 2/12/2014	0	0	8	2	2	0	3	0	0	0	4	0	0	**19**
2/15/2014, 2/17/2014	0	1	3	5	0	0	3	1	0	0	7	0	0	**20**
Total	**1**	**1**	**27**	**9**	**9**	**3**	**12**	**1**	**0**	**4**	**23**	**0**	**5**	**95**

Table 17. Species counts from Route 7 displayed by tracking dates.

Appendix B: Species data by habitat

Westfield River Watershed

Species	Coniferous	Deciduous	Field	Mixed	River	Shrub	Total
Canid	0	1	1	2	0	0	**4**
Coyote	18	40	2	15	8	0	**83**
Deer	73	21	1	53	4	5	**157**
Fisher	8	9	0	16	4	1	**38**
Mink	1	0	1	3	1	0	**6**
Mustelidae	0	0	0	0	2	0	**2**
Otter	2	0	0	3	14	0	**19**
Porcupine	3	0	0	0	0	0	**3**
Raccoon	0	1	0	0	0	0	**1**
Red fox	1	2	3	1	0	0	**7**
Weasel	13	5	9	19	0	1	**47**
Total	**119**	**79**	**17**	**112**	**33**	**7**	**367**

Table 19. Species counts from Middle Branch transects displayed by habitat type.
Total transect lengths approximately 2.42 miles (3900m). Based on 5 tracking surveys.

Species	Coniferous	Deciduous	Mixed	Total
Bobcat	2	3	4	**9**
Canid	1	0	0	**1**
Coyote	9	6	9	**24**
Deer	68	77	175	**320**
Fisher	6	2	9	**17**
Grouse	2	0	1	**3**
Moose	0	0	1	**1**
Otter	0	0	1	**1**
Porcupine	6	1	0	**7**
Turkey	275	1	14	**290**
Weasel	6	5	9	**20**
Total	**375**	**95**	**223**	**693**

Table 20. Species counts from southern ridge transects displayed by habitat type.
Total transect lengths approximately 1.7 miles (2700m). Based on 5 tracking surveys.

Species	Coniferous	Deciduous	Driveway	Field	Lawn	Mixed	Riparian	River	Total
Bear	0	0	0	0	0	3	2	0	**5**
Bobcat	0	0	0	0	0	4	2	0	**6**
Canid	0	0	0	0	0	3	1	0	**4**
Coyote	0	0	0	0	0	47	9	0	**56**
Deer	0	2	0	0	0	31	1	0	**34**
Fisher	1	0	0	0	1	20	4	0	**26**
Gray fox	0	0	0	0	1	2	2	0	**5**
Mink	0	0	0	0	0	11	9	0	**20**
Moose	0	0	0	0	0	3	0	0	**3**
Mustelidae	0	0	0	0	0	1	0	0	**1**
Otter	0	0	0	0	0	1	3	1	**5**
Racoon	0	0	0	0	0	0	3	0	**3**
Red fox	1	0	1	0	0	31	5	0	**38**
Skunk	0	0	0	0	0	1	0	0	**1**
Unid	0	0	0	0	0	16	5	0	**21**
Weasel	1	0	0	0	0	44	5	0	**50**
Total	**3**	**2**	**1**	**1**	**2**	**218**	**51**	**1**	**278**

Table 21. Species counts from route 112 inside predicted corridor displayed by habitat type. Based on 6 tracking surveys.

Southern Berkshires

Species	Cliffs	Coniferous	Deciduous	Driveway	Field	Field edge	Hedge trees	Lawn	Mixed	Orchard	Parking lot	Riparian	Roadside	Scrub	Stream	Wetland	Yard	Total
Bobcat	1	1	13	1	1	1	0	4	9	0	0	0	0	3	0	1	0	35
Canid	0	5	8	3	6	0	0	9	11	1	0	0	1	1	0	0	0	45
Cottontail	0	0	8	0	0	1	1	8	11	0	0	0	0	1	0	0	0	30
Coyote	0	2	4	0	9	0	0	3	7	0	0	0	0	0	0	1	0	26
Deer	0	1	1	0	15	1	0	3	20	1	0	0	0	2	0	2	0	46
Fisher	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Gray fox	0	1	2	0	0	0	1	0	6	0	0	0	0	0	0	0	0	10
Mink	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	3
Opossum	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Porcupine	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Red fox	0	5	6	2	2	1	0	10	16	1	1	0	0	1	0	2	1	48
Turkey	0	1	1	0	0	0	0	2	1	0	0	0	0	0	0	0	0	5
Unid	0	0	6	0	0	1	0	4	1	0	0	1	0	0	1	1	0	15
Weasel	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	**1**	**16**	**50**	**6**	**33**	**5**	**2**	**43**	**86**	**3**	**1**	**3**	**1**	**8**	**2**	**7**	**1**	268

Table 22. Species counts from route 23 displayed by habitat type. Based on 6 tracking surveys.

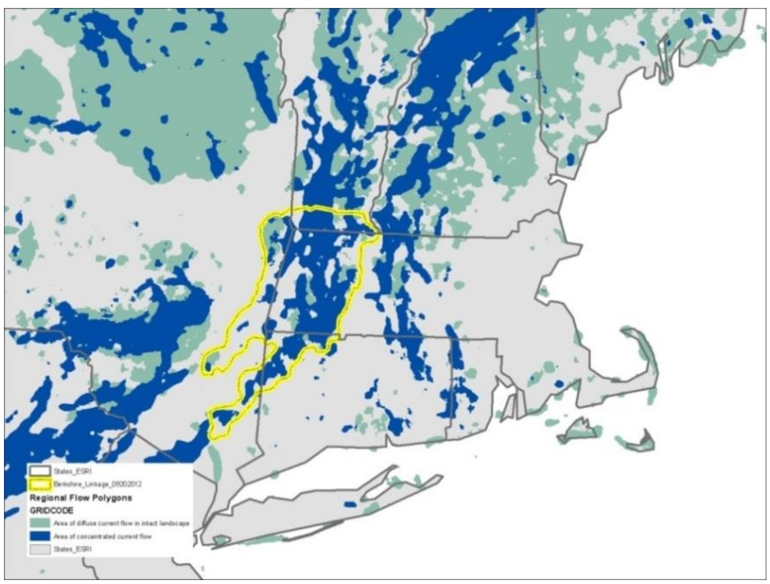
Species	Agriculture	Cemetery	Deciduous	Deciduous floodplain	Driveway	Field	Hedge	Lawn	Mixed	Oxbow	Riparian	Roadside	Scrub	Wetland	Total
Beaver	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Bobcat	0	1	0	0	0	0	0	0	1	0	0	0	3	0	**5**
Canid	19	1	4	0	5	8	2	12	1	0	1	0	3	5	**61**
Cottontail	0	0	1	1	0	0	1	2	1	0	2	0	8	1	**17**
Coyote	8	3	1	0	0	3	1	4	0	1	0	0	2	1	**24**
Deer	2	2	0	0	2	2	0	0	0	0	0	0	1	0	**9**
Gray fox	2	1	5	1	1	2	0	4	0	0	2	1	1	3	**23**
Mink	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Racoon	1	0	1	0	1	0	0	1	0	0	3	0	0	0	**7**
Red fox	6	4	7	1	4	22	1	16	1	3	1	0	5	0	**71**
Unid	0	0	1	0	2	4	0	12	1	0	0	0	1	1	**22**
Total	**38**	**12**	**20**	**3**	**15**	**41**	**5**	**51**	**5**	**4**	**11**	**1**	**24**	**11**	**241**

Table 23. Species counts from Route 7 displayed by habitat type. Based on 5 tracking surveys.

Appendix C: Methodology for defining Linkage and corridor boundaries

The linkage boundary (refer to Map 1 in the introduction) is defined at a coarse and broad scale, intended to reflect the regional scope of our goal and the spatial extent of our analysis, particularly for calculating metrics related to landscape structure. The linkage was delineated using TNC matrix forest blocks identified in the Lower New England Ecoregional Plan (Barbour et al., 2003), ecoregional boundaries, and TNC's regional resistant kernel analysis (Anderson et al., 2012). We also looked at orthoimagery and base data layers like roads and rivers to understand the landscape context, especially in the Hudson River valley. The boundary is intended to capture within its northern and southern boundaries a portion of the areas that we are trying to connect – the Green Mts. in Vermont and the Hudson Highlands in New York.

The Nature Conservancy's regional flow dataset, part of the resilient sites analysis (Anderson et al., 2012) identifies broad patterns of habitat connectivity across the entire eastern region and indicates where landscape structure is most permeable to wildlife. The areas in dark blue in the map below (also included in main text) show that Western Massachusetts is an important link between the Green Mountains and Hudson Highlands, and indicates that the broadest continuous pathway between these areas falls within the central part of the Linkage.



Regional flow patterns indicate concentrations of well-connected habitat in dark blue.

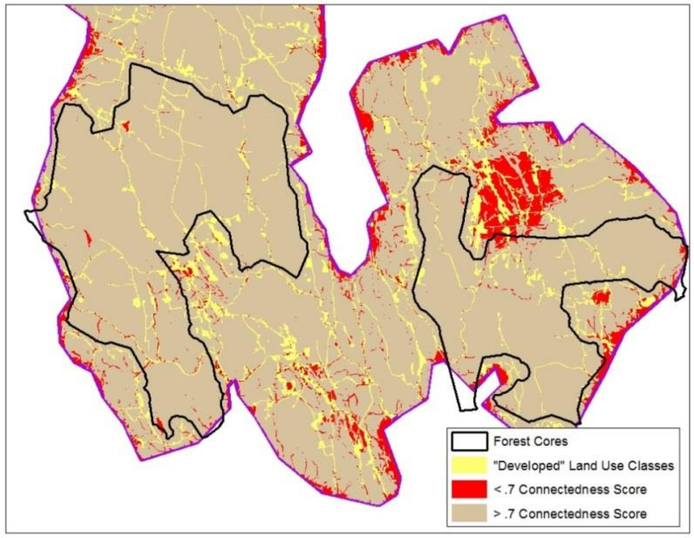
The regional flow and ecoregional plan data cover all of the eastern states. Within the portion of the Berkshire Wildlife Linkage that falls within the Massachusetts state boundary, we have finer scale information about intact core habitats and landscape connectivity. That enables us to narrow down within the Linkage which core habitats and corridors between them are most critical for connecting at all spatial scales. Perhaps the most powerful of these state-specific datasets is the University of Massachusetts-Amherst's Critical Linkages model (http://www.umasscaps.org/applications/critical-linkages.html). Within the Berkshire Linkage, 136 habitat "nodes" were included in the Critical Linkages model. Critical Linkages indicates core habitats (nodes – often overlapping forest cores but defined differently, see the UMass Critical Linkages report) that are most important to maintaining connectivity across the state. This ranking takes into account the location of the node within the network, how well it is connected to its neighbors, and its size and ecological integrity (including level of fragmentation and how similar portions of the node are to nearby portions). Losing these nodes will disrupt animal movement the most if they are converted or otherwise removed from the connected network of habitat across Massachusetts. Similarly, Critical Linkages models the impact of severing the connection between each pair of habitat nodes, and identifies links where a loss of connectivity would most impact the entire network of habitat nodes.

Critical Linkages is also helpful in placing the corridors we studied into a broader context. Our Westfield corridor connects the East Branch and Middlefield-Peru forest cores. Of the 136 nodes assessed within the linkage, the largest node within the East Branch forest core ranks 6th and the largest node within the Middlefield Peru forest core ranks 10th. Our Berkshires corridor connects the Mt. Washington and Beartown forest cores. The main node in the Beartown forest core ranks 5th out of 136 nodes. The main node within the Mt Washington core ranks 14th. This is a reflection both that it is isolated by the route 7 corridor, and its position at the corner of the state. The regional flow model does extend beyond Massachusetts borders, and corroborates our interpretation of Critical Linkages, indicating that the Mt Washington forest core is currently not well connected to the rest of the Berkshires, and is even more isolated to the west and south beyond Massachusetts borders.

Corridors:

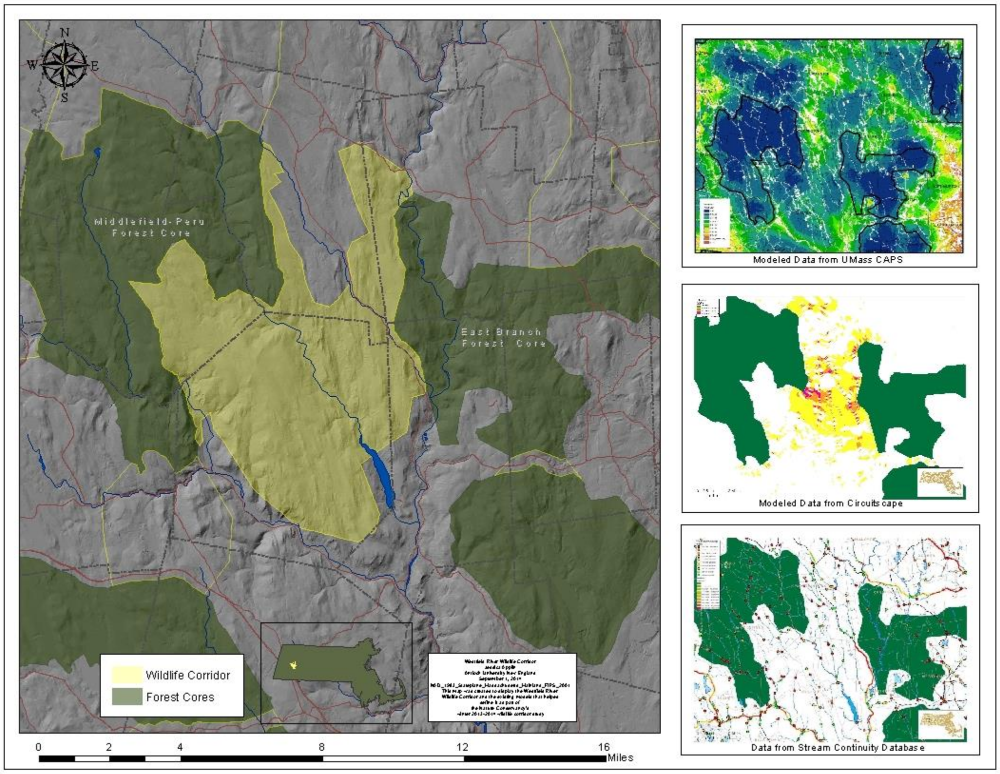
Critical Linkages, an additional model from UMass-Amherst called CAPS (Conservation Assessment and Prioritization System), Circuitscape, and information about where road-stream crossings are located and their condition were used to identify the corridors in this study. Our hope is that this methodology could also be used by others interested in identifying and/or studying corridors throughout Massachusetts. Detailed explanations of CAPS and Critical Linkages are available at: http://www.umasscaps.org/applications/critical-linkages.html.

Our general approach was to start with the area between the closest boundaries of two nodes, and further refine the pathway using specific data as follows. We first defined nodes as forest cores. We used the CAPS connectedness analysis to identify areas of high local connectivity between the two cores. The top right inset map shows the connectedness metric by decile for the Westfield corridor. We use the top 3 deciles of the metric to identify the most connected habitat between the two cores. We chose this threshold based on looking at the underlying land cover shown in recent orthoimagery. This threshold seemed to capture land cover that appears intact and in good condition. Below this threshold, the landscape appears more fragmented and areas of agriculture and residential development are evident in the imagery. We drew a rough boundary around the areas that met this threshold and overlapped with the two cores and the intervening area between them.



Within this purple boundary, there are areas of lower connectedness as well as areas of developed land uses. The brown areas in the map below are the high connectedness areas selected for inclusion in the structural pathway. In red are areas below the .7 threshold, and in yellow are areas that are considered “developed” land use classes in the CAPS analysis (these land use classes are listed below). As an artifact of the CAPS analysis, all the developed land classes are already removed from the structural pathway GIS layer. In a separate step we clipped out large water bodies from the structural pathway layer to ensure that the final layer is solely areas of high connectedness, with no developed lands or large water bodies within it.

Our final step was to exclude areas to the north of both cores that would not serve to connect them. The final structural pathway layer is shown in yellow shading in the main Westfield corridor map below.



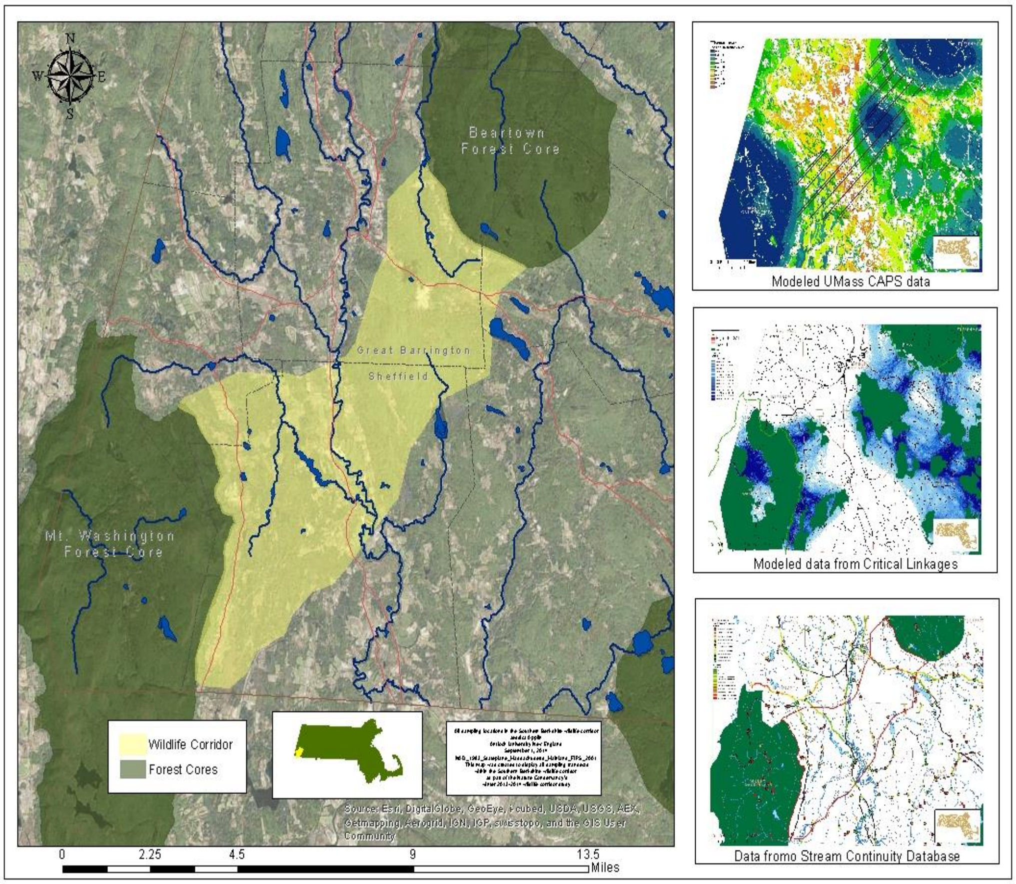
Westfield River wildlife corridor showing supporting data from UMass CAPS and Circuitscape models, as well as Stream Continuity Database.

The methodology used to define the Westfield corridor would likely work in any area that is largely in natural cover. While we looked at protected land, road-stream crossings, and Circuitscape models as filters, in the Westfield we did not need to alter the corridor boundaries based on these data. Several ground-truthing trips, one by vehicle and foot and one during the winter before the study by snowshoe, confirmed that we had captured a seemingly well-connected path between the two cores.

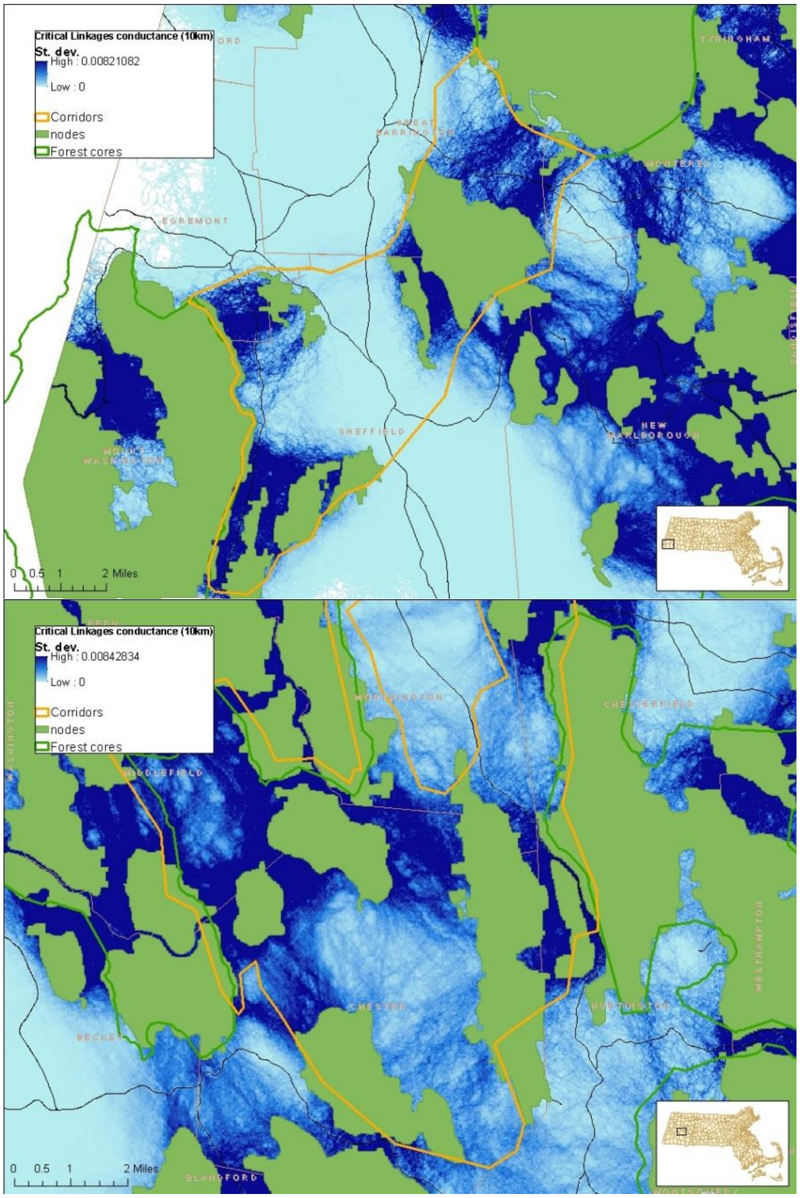
This same methodology was our starting point for defining the southern Berkshires corridor as well. UMass CAPS was helpful in indicating a stepping-stone between the two forest cores here, East Mountain State Forest. We drew our initial corridor boundaries by hand to attempt to include the highest-scoring CAPS areas, including East Mountain (top right inset map). However, CAPS did not provide us with much area between the Mt. Washington forest core and East Mountain that was in the top 3 deciles of connectedness, forcing us to alter our methods from the Westfield corridor delineation.

In this area of more developed land, we used Critical Linkages, Circuitscape, and protected land as filters. Our corridor in the southern Berkshires is less easily defined by its ecological criteria, and over time we have found that there are some areas to the south of our boundary that may be important to include in the corridor, especially wetlands around Schenob Brook and the Housatonic River just outside of the southern corridor boundary. Ground-truthing in this area was essential.

We expect that the methods used in the southern Berkshires could also be exported to other areas. In a corridor where the two nodes (forest cores, in this case) are currently not well-connected to each other, CAPS in combination with Critical Linkages can identify important stepping stones and give a starting point for including the most likely paths for wildlife between the two cores. However, thresholds for all data sets will need to be set based on the conditions in the corridor – land that would have been too fragmented to include in the Westfield corridor was some of the best-connected area around route 7. Ground-truthing or consultation with local landowners and groups can help to double-check the chosen thresholds and methodology.



Southern Berkshire wildlife corridor showing supporting data from UMass CAPS and Critical Linkage Models, as well as the Stream Continuity Database.



Critical Linkages II 10km conductance results for the Berkshires and Westfield corridors. In these maps, green nodes are the habitat areas used in the model. Lighter blue areas between nodes indicate that it is more difficult for animals to move between these nodes than nodes which have dark blue areas and lines between them. Note the slightly different scales in each map; the range of conductance is scaled to the area shown in each map, rather than an absolute scale based on the entire state.

<u>Reports cited</u>:

Anderson, M.G., M. Clark, and A. Olivero Sheldon. (2012). Resilient Sites for Terrestrial Conservation in the Northeast and Mid-Atlantic Region. The Nature Conservancy, Eastern Conservation Science. 168 pp.

Barbour, H., M.G. Anderson et al. (2003). Lower New England – Northern Piedmont Ecoregional Conservation Plan; First Iteration, Edited. The Nature Conservancy, Northeast & Caribbean Division, Boston, MA

Appendix D: Winter tracking – justification of methodology and data collected

Understanding mammal species communities and how often they are using an area can be done on multiple scales and the overall understanding can be aided by small-scale inquiries (Van de Poll 1996). Gathering information on mammals is important because of their varied roles and significant impacts in the ecosystems they inhabit (Schipper et al. 2008). The reforestation of New England has influenced the expansion of large mammals such as moose, coyote, deer, bear, and beaver, and is causing a need for effective conservation and management plans (Foster et al. 2002). As human populations continue to increase and expand, we are starting to see that landscape change again. Research done in Massachusetts by Foster et al. (2002) shows that wildlife populations across the state have been rapidly changing due to these human alterations to the landscape In light of this information, it becomes increasingly important to catalogue information on multiple scales, including small areas like private lands, which can be compiled or added to a larger understanding of wildlife populations, habitats or land-use (Van de Poll 1996).

In the northeast, winter mammal tracking is an effective way to collect information on species' presence, frequency of occurrence and relative activity or movement through a landscape (Thompson, Davidson, O'Donnell, & Brazeau 1989; Van de Poll 1996; Brower, Zar and von Ende 1998). Wildlife population census techniques often rely on relative indices rather than total abundance or diversity. Total counts are not a feasible or practical option due to budget, time, skill or equipment restraints, especially when looking at smaller, privately owned land (Van de Poll 1996). For the private landowner with a property of less than 100-200 acres, indirect methods for terrestrial sampling can reveal important information such as frequency of encounter and relative indices of activity of various mammal species.

Sampling Location________________________________DATE______________________

Transect	Waypoint	Species	Sign	Movement	Direction	Forest type	Forest cover	Location	Photo #

Movement - away, toward, parallel, avoid, cross, enter, exit
F. cover- I sapling, II middle age/mixed age, III mature F.type - C, D, M
Location - meters along transect

Figure 6. Sample of data collection sheet used in the field by wildlife trackers.

The line-intercept technique as outlined by Van de Poll (1996) has been shown to be an effective means of gauging frequency of occurrence of mammals within a given area. A study conducted by Thompson et al. (1989) in an Ontario, Canada boreal forest utilized the line-intercept technique combined with tracking in snow substrate to measure habitat preferences of marten (*Martes americana),* lynx (*Felix lynx)*, red fox (*Vulpes vulpes)*, ermine weasel (*Mustela erminae),* snowshoe hair (*Lepus americanus),* and red squirrel *(Tamiasciurus hudsonicus)* across varying states of forest succession following timber harvesting. When compared to live capture of marten, hare, and red squirrel, the tracking survey was significantly correlated with those results (Thompson, Davidson, O'Donnell, & Brazeau, 1989). The study also suggested that track abundance can be utilized to indicate habitat preference and population trends with these species (Thompson, Davidson, O'Donnell, & Brazeau, 1989; Van de Poll, 1996). These methods have also been widely used in combination with sophisticated GIS modeling as part of the Nature Conservancy's Staying Connected Initiative in the Northern Appalachian/Acadian region. Staying Connected has initiated several different studies focusing on restoring the connectivity of landscapes for wildlife. Information on these studies as well as ways the public can become part of this work is available on their website (*www.stayingconnectedinitiative.org)*.

Appendix E: - 4 Strategies for prioritizing land protection sites from the Staying Connected in the Northern Appalachians 2013 report (Steckler & Bechtel, 2013)

Prioritizing Land Protection Sites:

We recommend using four considerations for prioritizing land protection sites within structural pathways. These considerations provide partners and conservation professionals with a framework to strategically develop a long-term approach for protecting permeability within structural pathways. This approach includes developing a range of land protection priorities, from short-term where a site has high connectivity value but is also currently highly threatened, to longer-term where the connectivity value of a site is not threatened. The considerations are discussed in more detail below and include assessments of:

- Functional connectivity
- Threats to connectivity values
- Land ownership patterns and feasibility
- Valuable wildlife habitat features

Functional Connectivity

Places where wildlife use is documented are considered functionally connected. In these areas we have the highest level of confidence that the habitat is suitable for dispersal because of confirmation through field observations. In areas where functional connectivity overlaps with structural pathway modeling results, we feel strongly that investments in land protection will be effective at maintaining permeability for wildlife. These places, when combined with high threat by development, represent the highest priorities for initiating land protection. Partner organizations and agencies have started to compile functional connectivity datasets including wildlife tracking data, roadkill locations, and wildlife use areas, all of which can be used in concert with the structural pathway mapping.

Threat

We define threat in terms of a parcel's potential to be converted (i.e. developed) from its current condition to a condition less permeable to wildlife movement. Threat assessments should take into consideration parcel location, which includes proximity to roads by road class, and the area and distribution of steep slopes and wetlands, among other development constraints and appealing site attributes.

The NEK-NNH Linkage is sparsely populated outside of town and village centers and has limited highway networks, making undeveloped parcels with frontage on federal or state roads good options for easy access and development. Roads, especially those that accommodate high speeds and traffic volumes, are significant habitat fragmenting features and barriers for wildlife (see Road Barrier Mitigation Strategies). Undeveloped road frontage lots, with their higher threat of conversion and mitigating effect to the barrier of roads, are especially important to prioritize for land protection. Other site characteristics such as steep slopes and wetlands are generally more difficult to develop and reduce the threat of development.

An example of a highly threatened tract might be one that is undeveloped, relatively flat, and well drained, with road frontage along a major road. An example of a low-threat parcel is one that is located along a mountain side, landlocked by other parcels, and has no roads that lead to it. In general, the threat level diminishes upslope and away from the major transportation corridors in the Linkage's river valleys. Investing conservation resources in the highly threatened tracts in the near-term is more likely to ensure connectivity across the Linkage over the long-term.

Land Ownership Patterns & Feasibility

The configuration of parcels can significantly influence the feasibility of securing a protected network of lands within a structural pathway. For example, if a 100-acre priority area is composed of two or three tracts, the feasibility of protecting those tracts is much higher than if that same area has a larger number of tracts. This is because of variations in landowners' willingness toward conservation, higher per-acreage costs for smaller tracts, and higher transaction costs and investments in staff time to complete many projects. Some smaller parcels are critical to completing a network of connecting lands so parcel size and configuration should be assessed on a site by site basis rather than excluding smaller parcels from consideration all together. Overlaying parcel boundaries with structural pathways allows for evaluating land ownership patterns and parcel configuration.

Valuable Wildlife Habitat Features

Multiple structural pathway areas coincide with valuable wildlife habitat features identified in natural resource studies or planning efforts. Parcels that include such habitat features should be appropriately prioritized when taken into account with other prioritization measures, such as proximity to roads, development pressure, and land ownership patterns. For example, if there is an immediate opportunity 16 to protect two tracts of land and both tracts are very similar in their connectivity value, a tract with a valuable wildlife habitat feature such as a lowland spruce-fir forest should be prioritized for its unique habitat value.

Sources of information and locations of valuable wildlife habitat features include areas identified by wildlife experts, Wildlife Action Plan priority areas (New Hampshire Fish and Game Department, 2010), deer wintering areas (Vermont Fish & Wildlife Department, 2010 and New Hampshire Fish and Game Department, 2012), locations of intact and restorable floodplain forest priority areas along the Connecticut River (Marks, 2010), and the Natural Heritage databases in both Vermont and New Hampshire.

Appendix F: Road kill percentages

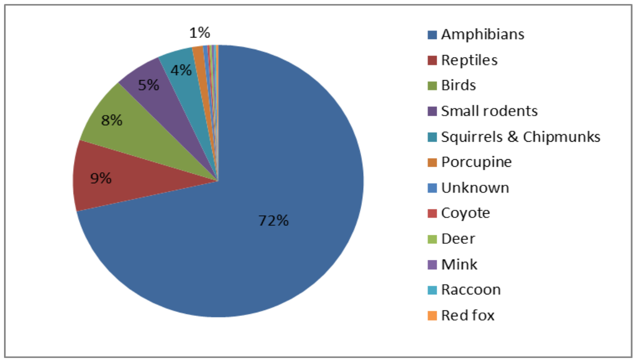


Figure 7. Route 112 road kill percentages by species and species groups found from December 2013 through August 2014

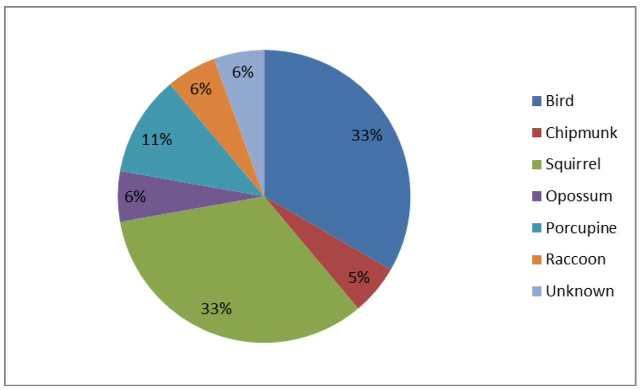


Figure 8 . Percentage of road kill by species and species groups found along Route 23 from December2013 through August 2014

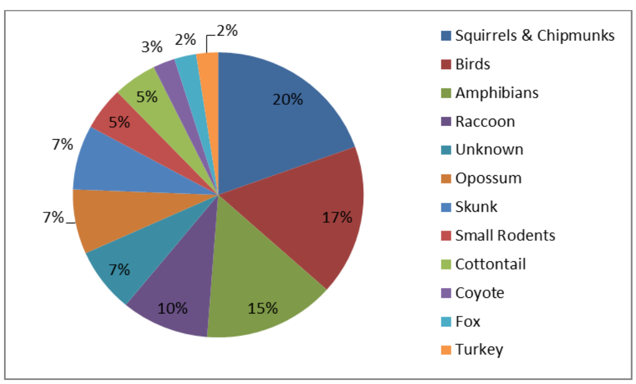
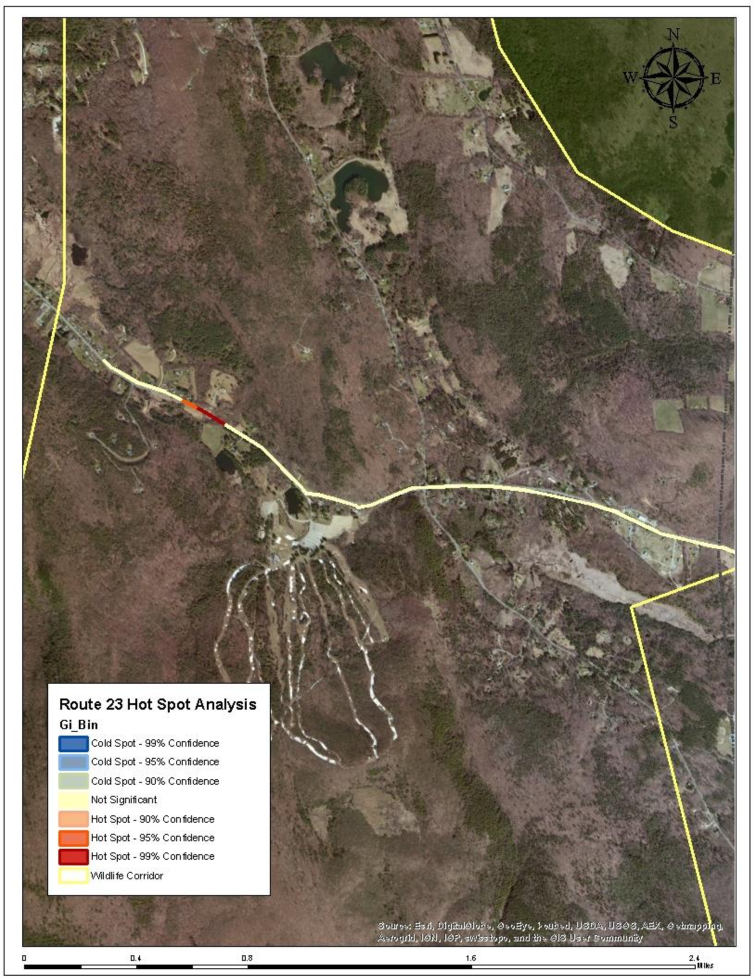


Figure 9 . Percentage of road kill by species and species groups found along Route 7 from December 2013 through August 2014

Appendix G. Statistical analysis of hotspots

To test the statistical significance of concentrations of road crossings across routes 7, 112 and 23, we used the GIS hot spot analysis tool (ESRI ArcMap 10.2.2). We input the average number of successful road crossings by mammals, per storm, for each 100-meter road segment. Previous exploratory analysis in which the tool chose the length of road segments determined that the segment lengths were close to 100 meters, so we felt confident in setting them manually to 100 meter lengths to prevent the need for creating a new road crossing densities dataset. The results of this analysis indicate areas where there is a statistically significant amount of clustering of crossings. On route 112 and on route 7, there were no significant hot spots, and those maps are not shown. On route 23, shown below, a concentration of segments with high average road crossings to the west of Butternut Ski Resort was highly significant. In this location, a statistical analysis of hot spots, interpretation of the conductance layer from UMass' Critical Linkages II model, and our tracking results all supported the importance of this area for wildlife moving across route 23. Suggested actions in this area are detailed in the conclusion section of the text, and indicated on Map 26.



Appendix H. Corrections

An earlier version of this report contained an error that was corrected in December 2014. In the original version, an incorrect corridor boundary (a boundary from before Critical Linkages II was available) was used in portions of the data analysis for the southern Berkshires. This led to a section of the tracking transect being considered "outside" of the corridor, and separated as such in tables and text referencing activity levels, tracks, and road crossings. The text and tables have been updated to reflect that the entirety of the route 7 transect (save for 100-200 meters on either side) is within the corridor. The conclusions and suggested actions to maintain and improve wildlife connectivity were not affected by this error.

Acknowledgements

We would like to acknowledge the contributions made by the following. Without your incredible support and encouragement, we would not been able to accomplish all that we did.

Westfield River Wild and Scenic

Your generous funding of this project and your dedication to the health and wellbeing of the Westfield River, and all the plant, animal and human life that call it home is greatly appreciated.

Berkshire Environmental Action Team

You brought so much to this partnership and continue to move the needle in Berkshire County when it comes to keeping animals safe and able to move. Your efforts to found a Keeping Track group years ago are what made the scope of this work in the Berkshires corridor possible.

Our incredible volunteers

The tireless hours you spent with us tromping though the snow and cold did not go unnoticed or unappreciated.

Thanks to Hannah Chamberlain, Tessa Dowling, Ann Jon, Karen Karlburg, Leslie Keller, Kathy Kessler, Amy Pulley, Laura Stinette, Bill Warren, Michael Wolski,Frederica Chick, Alison Dixon, Collin Adkins, Danika Padilla, Doreen Forney, Hannah Goodnow, Hillary Filios, Jim Pelletier, Linda Huebner, Lynn Meehan, Marie Raftery, Pat Liddle, Richard Greene, Steve and JoAnne Hodgin, Cath Whicomb, Charles Kaminski, Irmgard Schrempp-Arruda, JoAnne Larsen, Judy Williams, Leslie Keller, Sue Seppa, Tess Reed, Barbara Phillips, and Sandra Wymth

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Our landowner neighbors

Without your generosity this study could not have happened. Allowing us into your backyards, sharing your homes, watching out for us in the field, and your genuine interest and excitement in this project is what keep us going.

Additional supporters:

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For all the extra hard work, support and encouragement along the way.

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