Staying Connected in the Northern Green Mountains:

Identifying Structural Pathways and other Areas of High Conservation Priority

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Summary

This paper describes the process of identifying critical areas of fine-scale wildlife connectivity, or structural pathways, within the Northern Green Mountains of Vermont, as well as the process used to refine the Northern Green Mountain landscape linkage boundary.

The Northern Green Mountains constitute one of eight large-scale, regionally significant, wildlife linkages in the Northern Appalachian Ecoregion. The analyses focused on road crossing areas connecting large habitat blocks of unfragmented forest greater than 3,000 acres in the US portion of the Northern Green Mountains. Thirty-four pathways were identified and categorized, and the landowner parcels within them identified and ranked for importance of connectivity within the pathway. In addition, parcels within the habitat blocks themselves were identified and ranked for importance in contributing to *regional* connectivity.

The Staying Connected Initiative

The Staying Connected Initiative (SCI) was formed in 2009 to protect and maintain landscape connectivity across the Northern Appalachians of the United States and Canada for the benefit of wide-ranging, forest dwelling wildlife such as bear, moose, lynx, marten and bobcat. SCI is an innovative 21-member, multi-state partnership that includes 13 non-profit organizations and eight state agencies from Vermont, New Hampshire, Maine, and New York. The initiative focuses on eight priority landscape linkages (Figure 1), most of which were identified by Two Countries, One Forest (www.2C1forest.org; Trombulak et al., 2008) as important for ecoregional connectivity. Due to initial funding source requirements, the first phase of the SCI project was implemented only in the US portions of the Northern Appalachian Ecoregion.

Within each linkage, SCI partners are pursuing a suite of conservation strategies designed to succeed in a region dominated by private lands. These include: 1) using conservation science and GIS modeling analyses to identify critical areas of fine-scale connectivity within each linkage (this paper is a key part of that analysis); 2) providing outreach, education, and assistance to individuals, landowners, municipalities, and community groups to better understand and protect wildlife connectivity; 3) providing technical assistance for municipal land use planning to safeguard wildlife and other conservation values; 4) collaborating with state and local transportation departments to facilitate better, safer wildlife movement across important crossing areas; and 5) protecting land in targeted areas.

Definitions

SCI defines a landscape linkage as a *broad region of comparatively greater or more concentrated connectivity important to facilitate the landscape or regional-scale movement of multiple species and to maintain ecological processes between core areas*. Structural connectivity occurs when *similar landscape elements, such as habitat patches or natural vegetation, are physically connected to each other* (these terms and others related to connectivity are found in Appendix 1). The structural connectivity in many of these linkages is threatened by fragmenting features such as roads and development.

Regional scale habitat connectivity, a course-scale perspective, is dependent on thousands of smaller structural pathways, a fine-scale perspective, that allow for movement across one road at a time. Thus the regional network of connected land is to some extent the summation of thousands of road crossings and the stepping stone and anchor blocks that these pathways connect.

SCI defines a structural pathway as an *area with sufficient structural connectivity to function as a habitat corridor*. A habitat corridor occurs when those *components of the landscape provide a continuous or near continuous pathway that may facilitate the movement of target organisms or ecological processes between areas of core habitat.*

It is imperative to note that structural pathways are not synonymous with *actual* wildlife crossings, known as *functional pathways*. SCI defines functional connectivity as t*he degree to which landscapes facilitate or impede the movement of a target organism or ecological process assuming all other conditions for movement are met.*

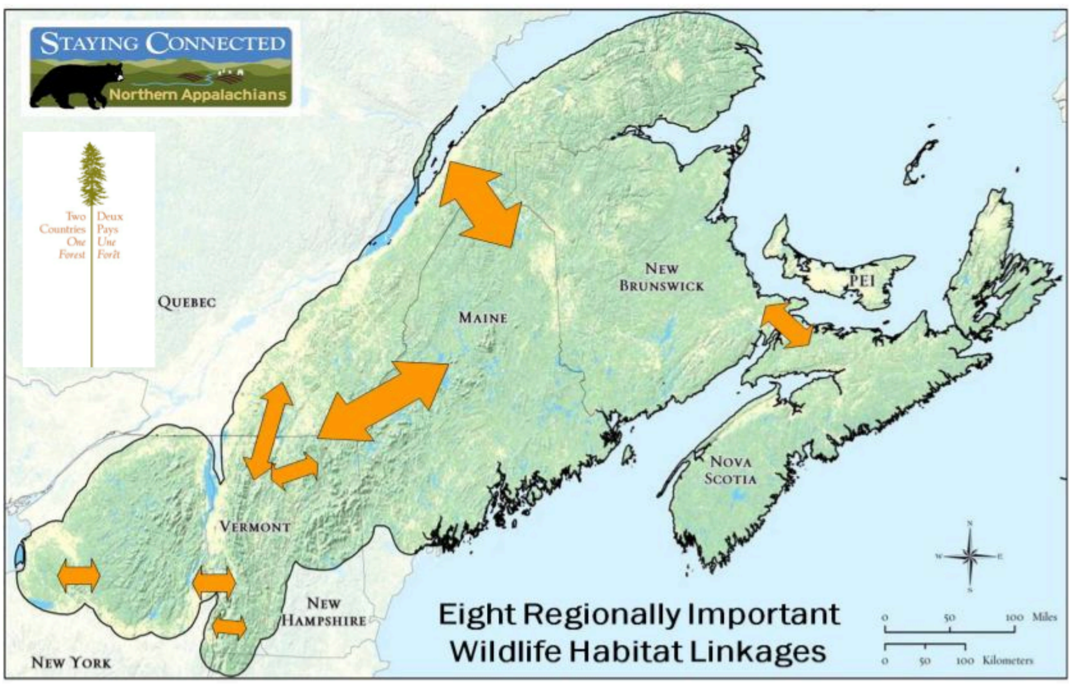

Figure 1. The eight priority landscape linkages originally identified by the Staying Connected Initiative and Two Countries, One Forest (2C1Forest) in response to 2C1Forest's report on conservation priorities in the Northern Appalachians (Trombulak et al., 2008). Northern Appalachian Ecoregion is outlined in black.

The Northern Green Mountains Landscape Linkage

The Northern Green Mountains may be among the wildest, yet least protected, landscapes in the Northern Appalachians. Ranging from Mount Mansfield, Vermont, in the south to Mount Orford, Québec, in the north (Figure 2), these mountains and their slopes are remarkably diverse, containing all major ecosystem types of the Northern Appalachians.

The Northern Green Mountains serve a crucial role in regional landscape connectivity, tying the southern Green Mountains and the Berkshires to the Northern Appalachians of Maine and Canada, thus providing an important north-south and east-west corridor for wildlife. The complexity of the terrain in the Northern Greens, and the relatively large elevation gain over the surrounding Champlain Valley and Piedmont, provide species with flexibility to move and adapt in face of climate change (Anderson et al. 2011).

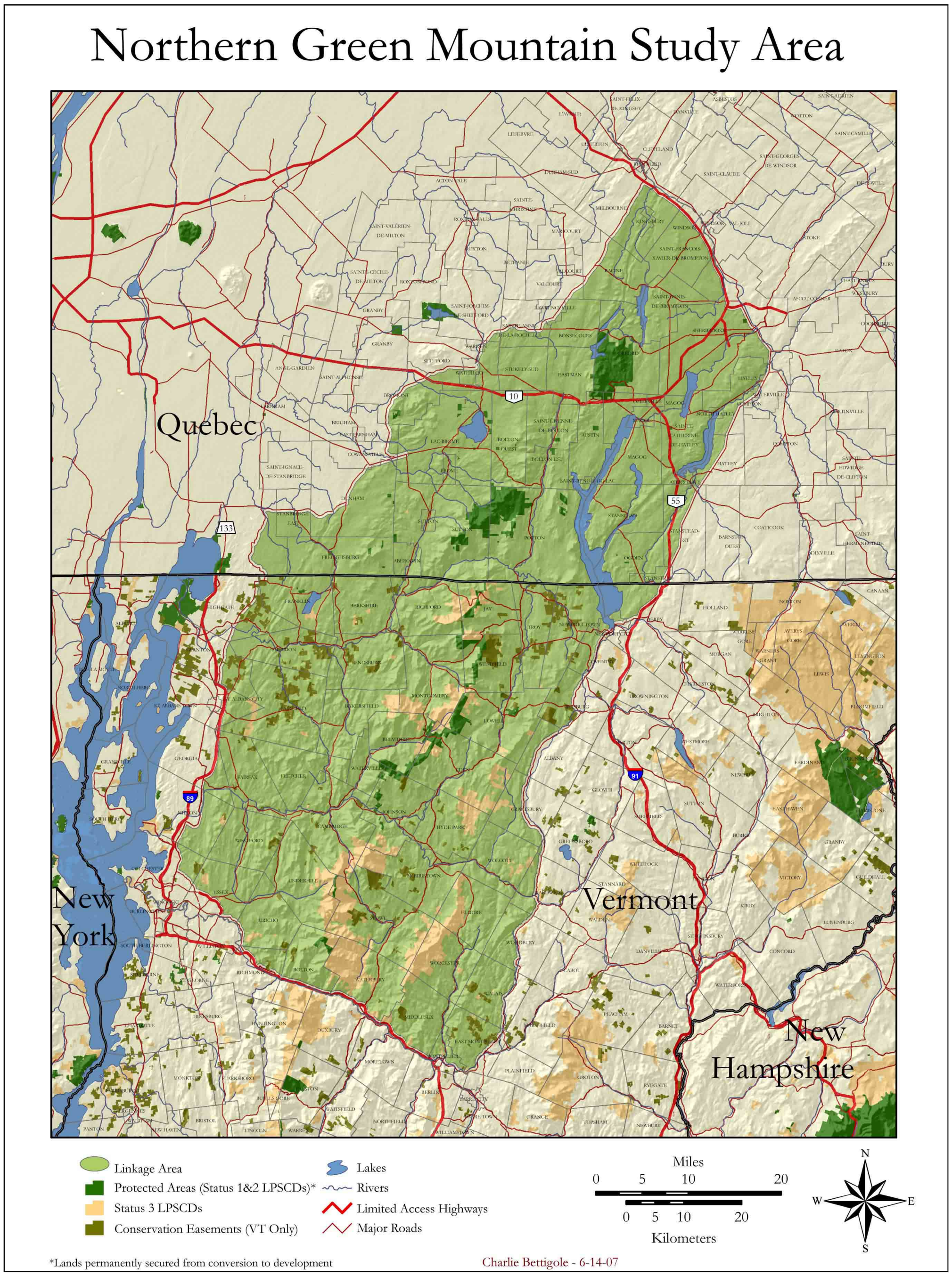

Figure 2. Initial Northern Green Mountain Study Area at outset of process to identify critical areas of fine-scale wildlife connectivity, or structural pathways.

Identifying Structural Pathways in the Northern Green Mountains

To delineate structural pathways, the authors (hereafter "we") first determined the location of existing unfragmented areas. The Vermont Fish and Wildlife Department (VFWD) and the Vermont Land Trust (VLT) had previously conducted a study to improve the understanding of the statewide distribution of contiguous habitat blocks. (Sorenson and Osborne, 2011) Specific undertakings of the study (see Appendix #2 for further details) included:

- Identification of habitat blocks (contiguous areas of natural cover that are undeveloped, uncultivated, greater than 20 acres, and lacking class 1 – 3 roads) based on land cover data from the Coastal Change Analysis Program of the National Oceanic and Atmospheric Administration (Figure 3);
- Creation of a "cost" grid for Vermont that models difficulty of wildlife movement (cost) across the landscape;
- Ranking statewide importance of habitat blocks for their contribution to biological and conservation value and the potential threat to them.

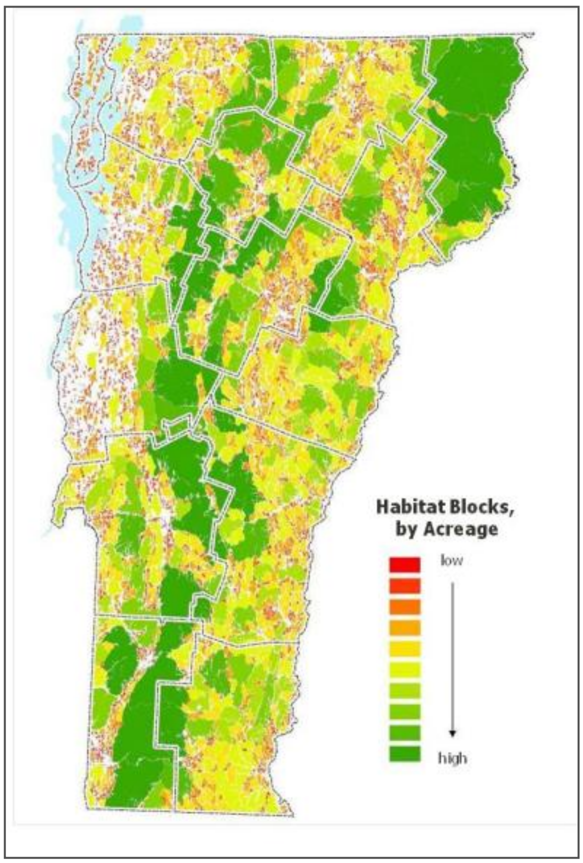

Figure 3. Habitat Blocks across Vermont, colored according to acreage (Sorenson and Osborne, 2011)

We symbolized the habitat block data by acreage in the U.S portion of the Northern Green Mountains Landscape Linkage area. After experimenting with various acreage thresholds, we selected those habitat blocks greater than or equal to 3,000 acres (Figure 4). We consider these large habitat blocks to be the core forested areas in the Northern Greens, but are aware that appropriate size thresholds depend largely on landscape context.

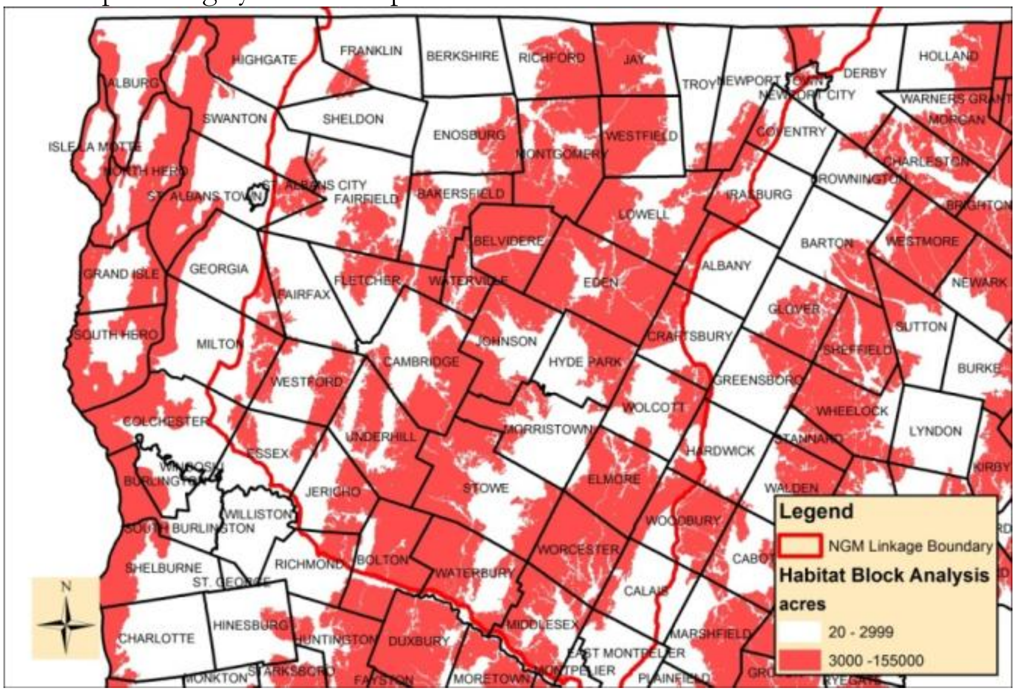

Figure 4. Habitat blocks 3,000 acres or larger are shown in red.

Jens Hilke, a Conservation Biologist with VFWD had used Sorenson and Osborne's results to develop a "Habitat Network" of habitat blocks and the lands connecting them, by overlaying a series of Cost-weighted distance analyses from several anchor blocks across the region to show potential movement in multiple directions rather than a single linear feature. (Figure 5).

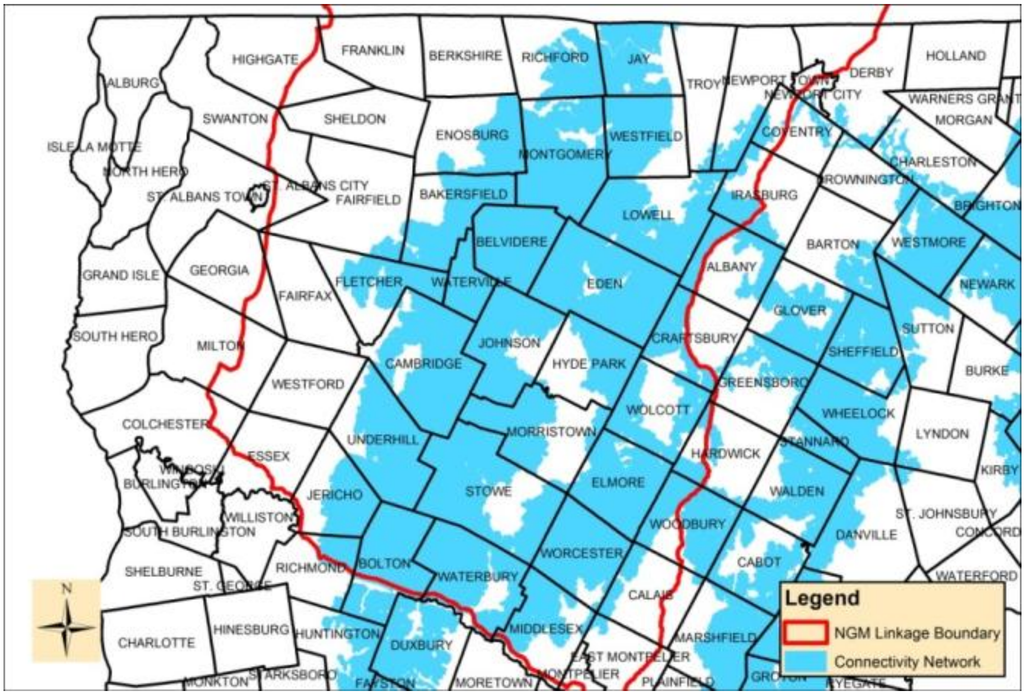

Figure 5. "Habitat Network" as developed by Jens Hilke of VFWD in 2010

To highlight areas of connectivity, we overlaid Hilke's Habitat Network with identified habitat blocks greater than 3,000 acres (Figure 6). In Figure 6, areas where such habitat blocks overlap Hilke's Habitat Network are purple, while light blue represents areas of potential connectivity among habitat blocks that we call connecting lands.

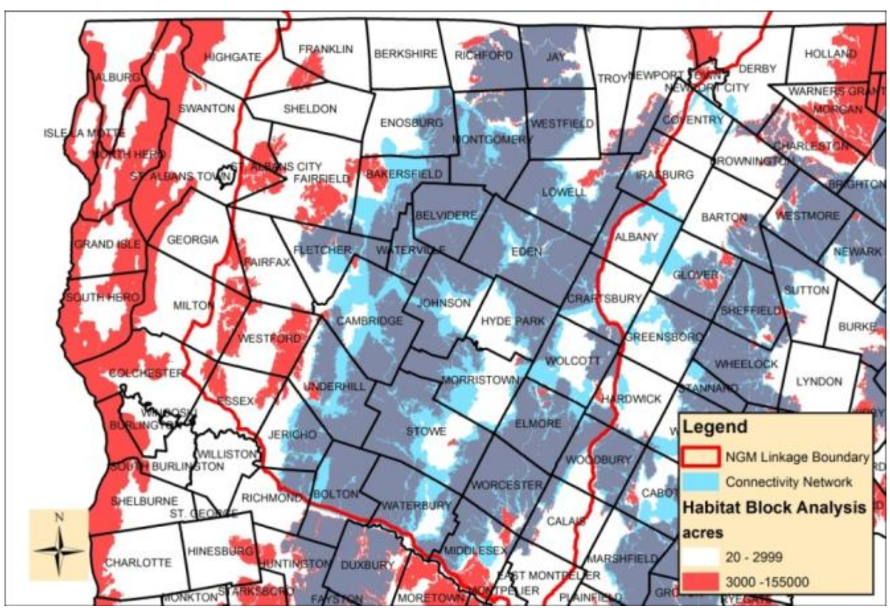

Figure 6. US portion of the Northern Greens showing Habitat Blocks (in red and purple) and areas of potential connectivity (light blue).

To broaden the geography that Hilke covered and to refine his analysis for the Northern Greens, we ran additional cost-weighted distance analyses. We employed various "start" and "end" points in the analyses, acknowledging the region's value for both east-west and north-south connectivity. Eric Sorenson of VFWD assisted in these analyses (Figure 7).

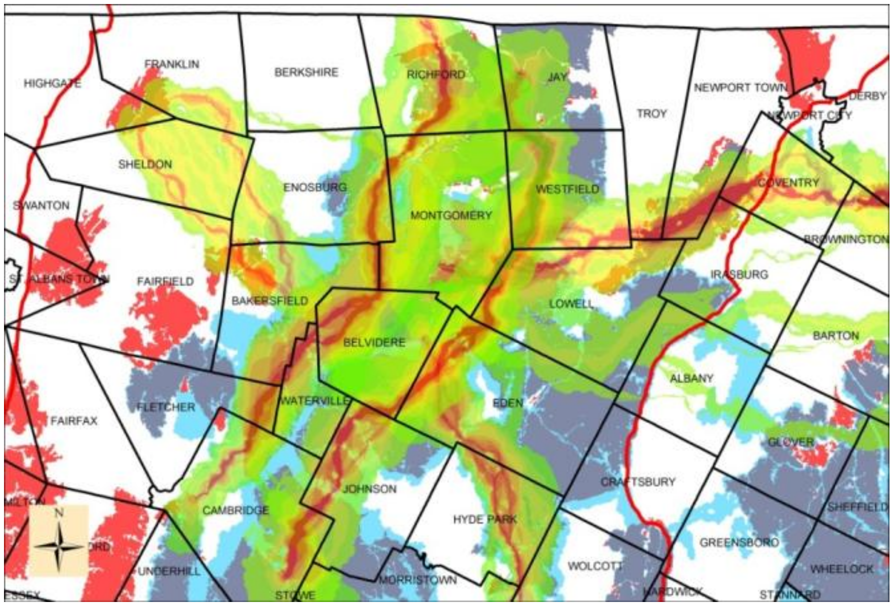

Figure 7. Combined Least Cost Path analyses: red, yellow, green, and no coloration show the paths of increasing resistance between two habitat blocks. Habitat Blocks and Habitat Network symbolized as in Figure 6

Modeling results were cross referenced with field data from the Critical Paths Project (Leoniak et al., 2009), which surveyed 38 sites throughout the state where east-west roads cross the spine of the Green Mountains. A team of state biologists and conservation organizations assessed the physical features of the crossings and the natural features of adjacent landscapes. They also tracked and monitored wildlife movement patterns at each crossing, three times each during one winter and one spring. From this work they were able to identify 11 critical "Priority Crossing Zones" along the spine of the Green Mountains that are essential to north-south wildlife movement. Detailed strategies are being developed for road mitigation, roadside improvements for traffic safety and wildlife crossing, land conservation, and local land use planning for these zones. We considered it in our analysis the Priority Crossing Zones that occur in the Northern Green Mountain Linkage area. Leoniak et al. (2009) is the only study to date that assessed *functional* connectivity.

We next identified general connecting lands — a subset of the connecting lands (light blue in Figures 6 – 8) — with *best available* current structural connectivity between habitat blocks (Figure 8). These are areas where it is particularly important to maintain connectivity so that blocks stay structurally connected.

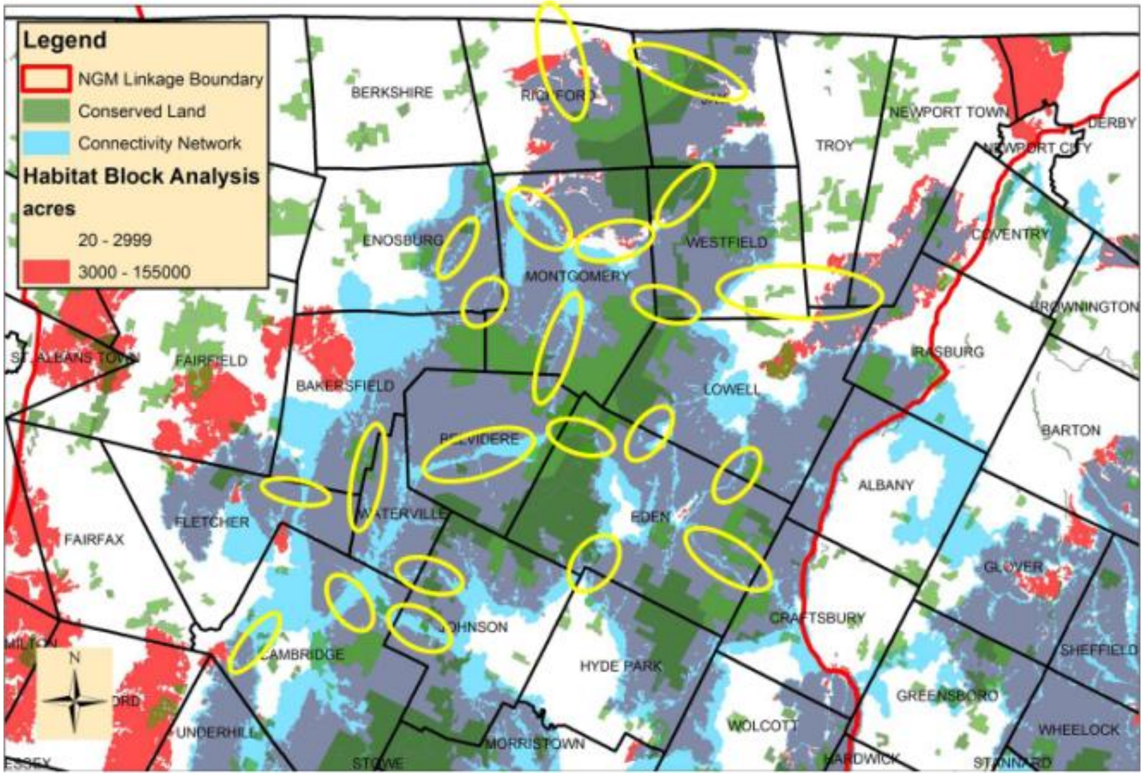

Figure 8. General "Connecting Lands," indicated by yellow ellipses, between habitat blocks.

Although roads fragment the landscape, certain landscape features contribute to or weaken the structural connectivity between large blocks across road corridors. In order to further refine the general connecting lands areas, we took into account the presence of these features. Features that promote structural connectivity in our refinement process included: forest cover on both sides of the road, hedgerows, riparian buffers, culverts, bridges, and wetlands. (Identification by the Critical Paths or Least Cost Path analyses of likely road crossings also highlighted specific areas). Features that weaken structural connectivity include human development, roads, agricultural fields, and sometimes guardrails.

With the General Connecting Lands defined, we took a systematic approach to delineating the structural pathways. The first step was to isolate a given connecting area and then identify the large habitat blocks and conserved lands around the connecting area (Figure 9).

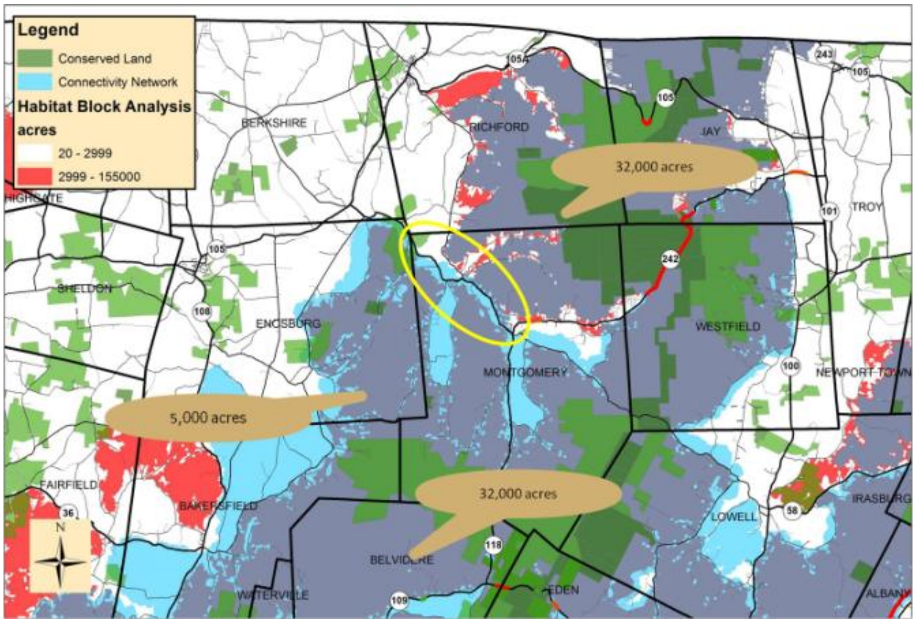

Figure 9. A closer look at a general "Connecting Lands" area in Montgomery, VT. shows surrounding large habitat blocks and conserved land.

We then reviewed high-resolution ortho photos. (Figure 10)

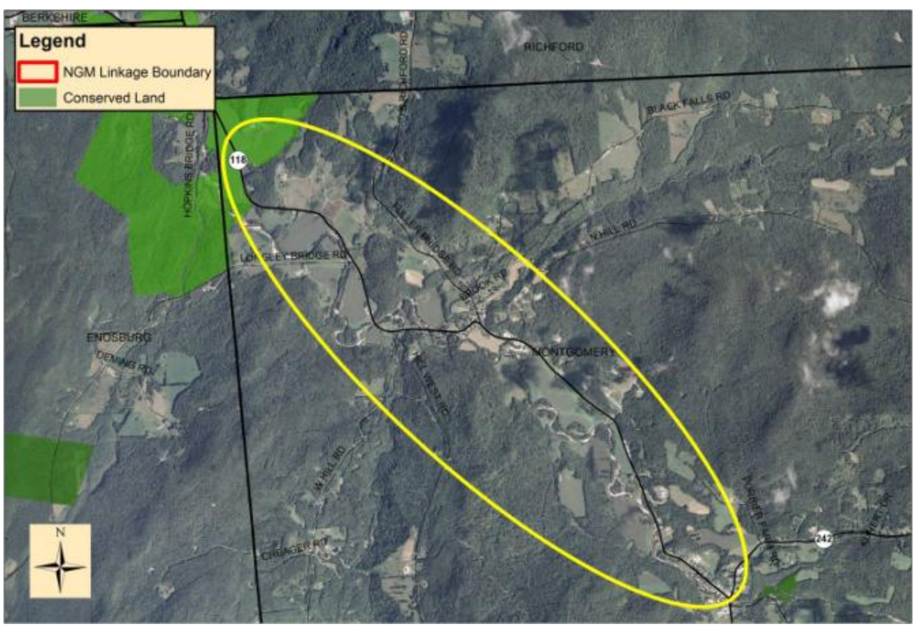

Figure 10. Montgomery, VT, General Connecting Lands Area shown on ortho photograph overlaid with nearby conserved land.

The ortho photos allowed us to "zoom in" on the connecting area to explore connecting features in more detail. Figure 11 shows the general connections between two sets of habitat blocks, as illustrated by the double-headed arrows below. These arrows will be the basis for the delineation of a structural pathway. Within the arrows can be seen forested and riparian cover that connects the blocks.

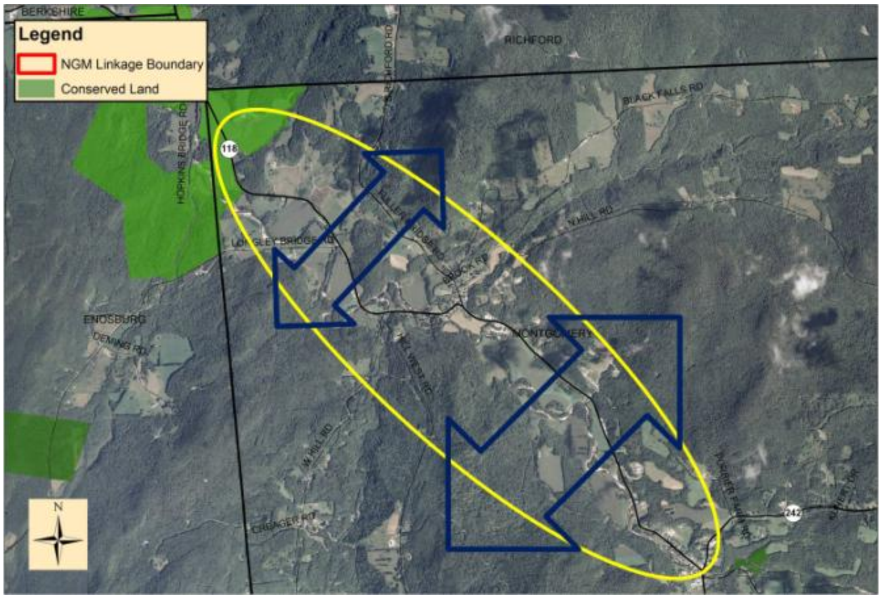

Figure 11. Montgomery, VT. General connections between two sets of habitat blocks shown by dark blue arrows.

Specific features that aid movement, such as hedgerows and riparian buffers, or hinder movement such as agricultural fields, can be tagged at this fine scale of analysis. Figure 12 shows this analysis for one of the double-headed arrows, with red stars highlighting important features.

Figure 12. Montgomery, VT. Features that aid movement shown with red stars, including, top to bottom: forest up to both sides of a road, riparian buffers, a forested "stepping stone," and a bridge underpass.

Some of those specific features are highlighted in Figures 13 and 14.

Figure 13. Route 118 bridge over Trout River in Montgomery, VT looking north from West Hill Road. (photo: Bob Hawk, 5/7/12)

Figure 14. Route 118 looking north toward Longley Bridge (on left behind trees). Note riparian buffer on upper left (photo: Bob Hawk, 5/7/12).

Once the connectivity-supporting features were identified, we delineated structural pathway polygons with boundaries 500 meters into the forest (from the road or from the forest edge, whichever was greater). See example in Figure 15.

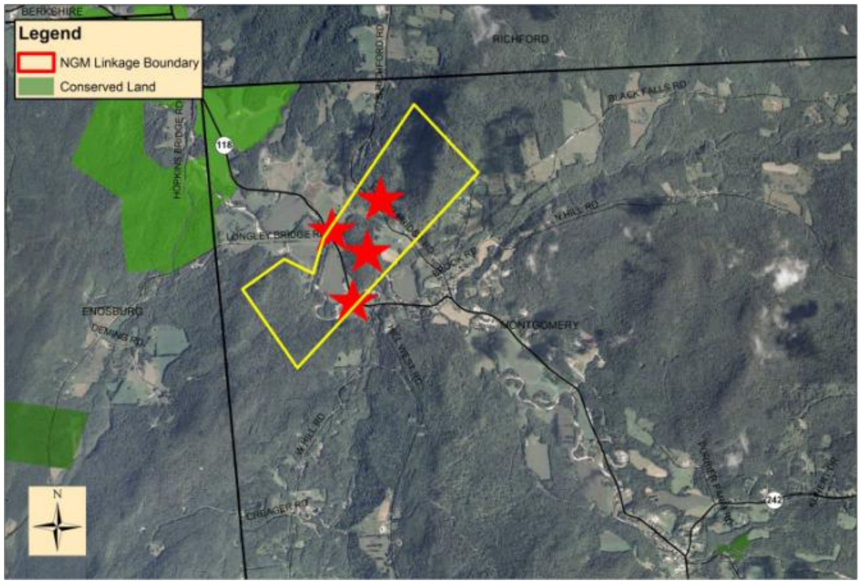

Figure 15. Montgomery, VT. An example of a Structural Pathway polygon extending 500 meters into the habitat block on either side, encompassing connectivity supporting landscape features, and representing the most structurally connected pathway between the two larger blocks.

Using a combination of fieldwork and GIS analysis (described above) we assigned each polygon (ID 1-34) to one of four categories that represent levels of structural connectivity based on the presence or absence of the connectivity promoting and weakening features (Figure 16):

1. Existing Connectivity with *Mostly Intact* Forest Cover (16 total)
2. Existing Connectivity with *Moderately Fragmented* Forest Cover (7 total)
3. Potential Connectivity – *Potential for Improved* Forest Cover, with remediation (e.g. riparian plantings, hedgerow development) (4 total)
4. Possible Future Focus – areas that may be at risk of future disconnection (7 total)

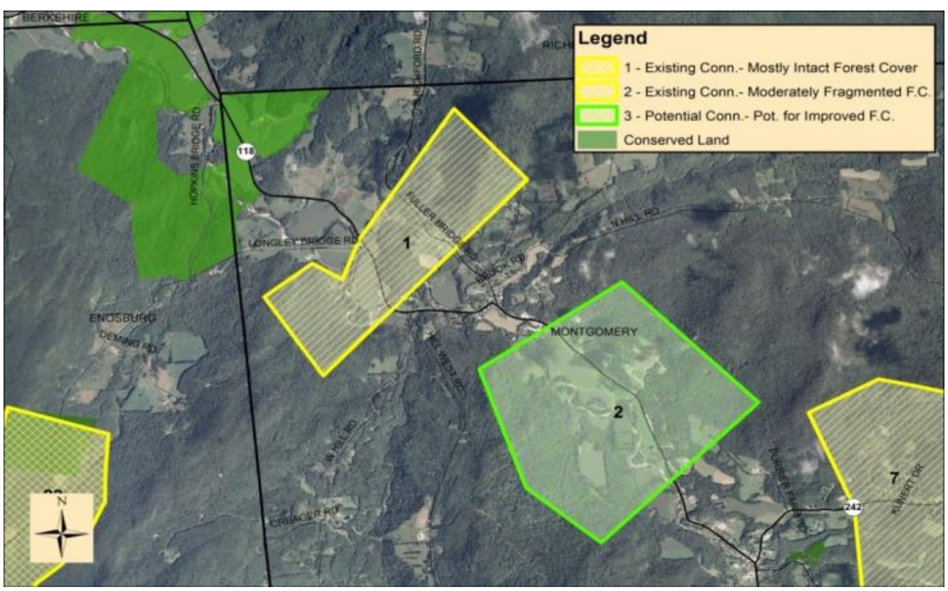

Figure 16. Structural Pathways of varied levels of structural connectivity. The number at the center of the polygon is the ID number (1-34).

We chose to narrow the final analyses to the 27 Structural Pathways with Existing or Potential Connectivity (categories 1-3 above). The final suite of Structural Pathways is shown in Figure 17.

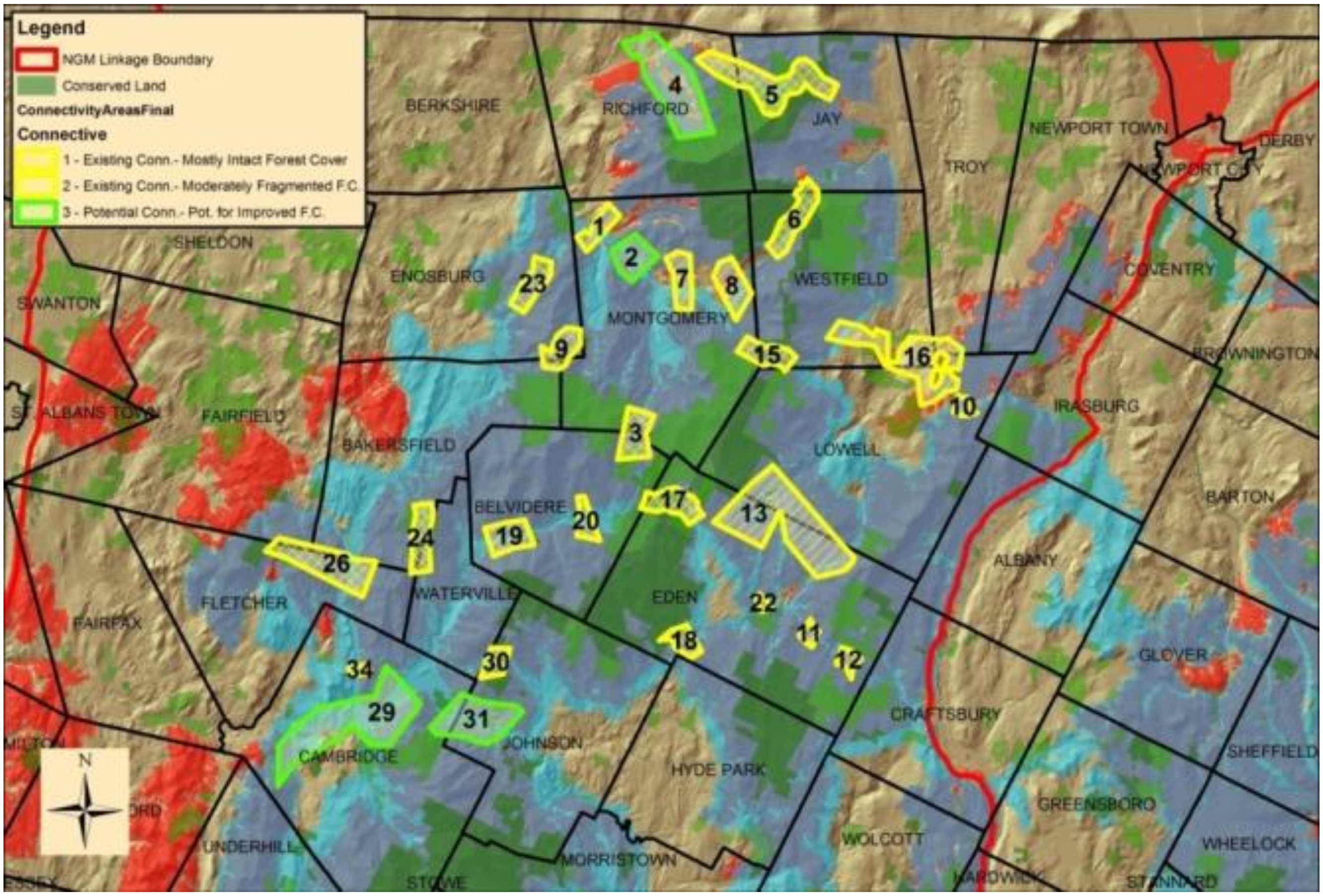

Figure 17. Northern Green Mountain Structural Pathways. Again, the number in the center of the polygon refers to that polygon's ID number and are for identification purposes only, and do not indicate rank.

We then further assigned each Pathway a Regional Ranking of Highest, High, Medium, or Low, to prioritize Structural Pathways at the linkage-level. This ranking was based on:

- Acreage of habitat blocks connected by Structural Pathway (larger acreage scored higher);
- Proximity to conserved lands (closer to large areas of conserved land scored higher);
- Distance between habitat blocks (smaller distances scored higher);
- Critical Paths crossing presence within Structural Pathway (increased score);
- Proximity to spine of Northern Greens (closer to spine scored higher).

Those Pathways scoring "Highest" are outlined in bright yellow and green in Figure 18.

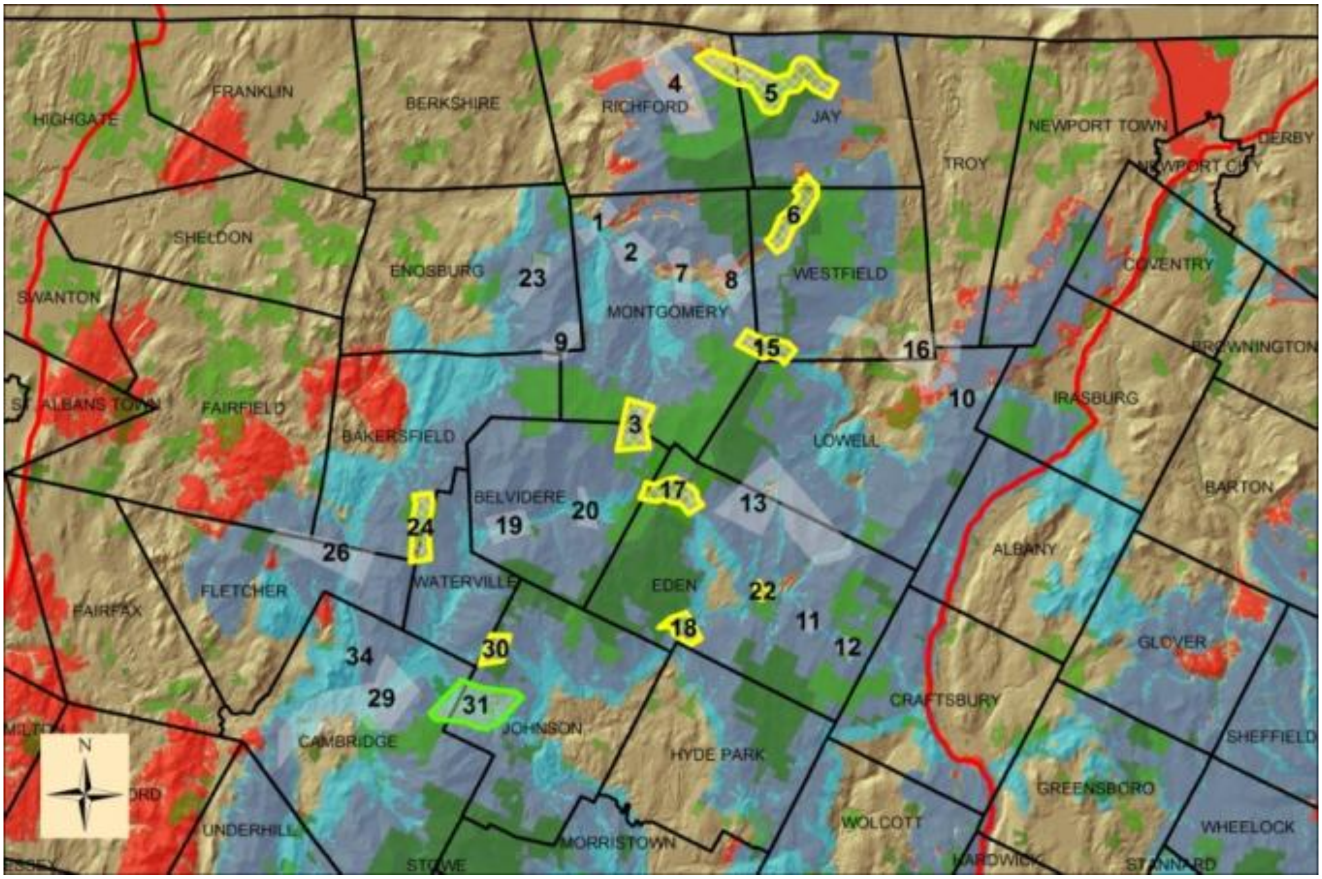

Figure 18. Structural Pathways with "Highest" Regional Rank (outlined in yellow or green).

<u>In summary, we took the following steps to define structural pathways</u>:

1) Identified the area's large habitat blocks, among which wide ranging mammals need to be able to travel.
2) Identified areas of connecting lands between habitat blocks.
3) Identified the sections within these connecting lands with best current structural connectivity (considering land cover, culverts and bridge data, topography, wetlands).
4) Created polygons extending 500 meters into the connected habitat blocks in the areas most conducive – in current state – for wildlife crossing. These polygons are the Structural Pathways.
5) Assigned each Structural Pathway polygon to a category representing its level of structural connectivity.
6) Assigned each Structural Pathway a Regional Rank –Highest, High, Medium, Low.

Identifying Unprotected Land Parcels Within Structural Pathways

With the Structural Pathways established we could then overlay parcel data with the boundaries of each Pathway and view all the unprotected land parcels within each Structural Pathway.

We entered the ID # of Structural Pathways that at least partially overlapped parcels into the corresponding fields in the attribute table of the parcel layer.

Each parcel was then assigned a value, based on its contribution to the structural connectivity across that Pathway. Factors that increased a parcel's value included: predominance of forest cover, the shape of the parcel, large acreage, forested road frontage, spanning across a road (same owner on each side of road), and high habitat value (wetland, riparian area, saddle, ridgeline, beech stand, etc…). Although the assigned value reflects a subjective decision of the authors, specific factors guided the ranking of each parcel. Generally, this scoring method can be described:

- Three or more factors → **High**
- Two or more factors → **Med**
- One factor → **Low**
- No factors → **Un-scored or Lowest**

An example of High and Medium Priority Parcels in the Route 105 Structural Pathway are shown in Figure 19.

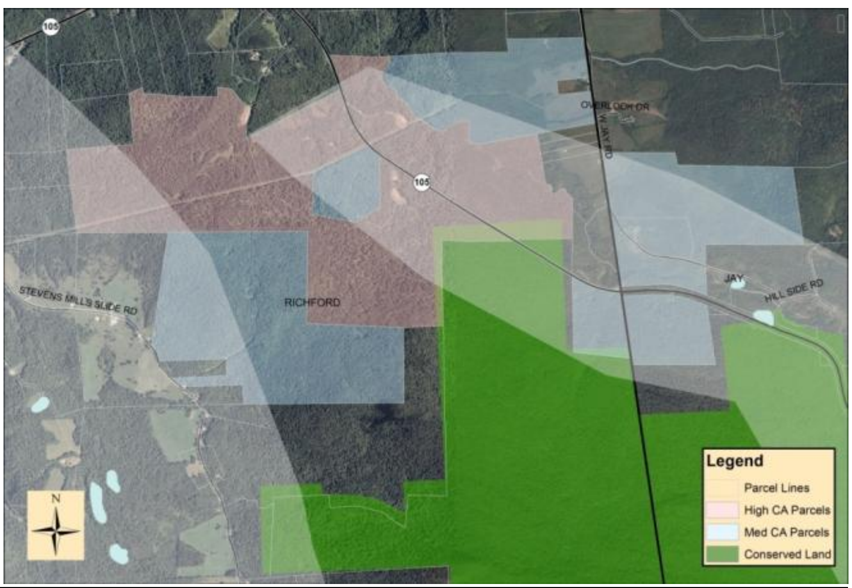

Figure 19. Example of High and Medium Priority Parcels in the Route 105 Structural Pathway. The high scoring pink parcel is large, spans across the landscape, crosses the road, and encompasses wetlands. Structural pathways are shown in transparent white.

We identified a total of 1,084 unprotected parcels within the 27 structural pathways, 175 of which were deemed "High" or "Med" priority.

Avoiding "Bridges to Nowhere:" Identifying Habitat Block Core Areas (HBCA)

Having delineated structural pathways and important associated parcels we were faced with the question of whether we had created "bridges to nowhere" by not considering the conservation status of habitat blocks that are linked together by the pathways. To address this issue, we examined the Sorenson and Osborne habitat blocks themselves to identify priority parcels for conservation. Our goal was to ensure *regional* connectivity by identifying areas, and ultimately parcels within them, that best connect the Structural Pathways to each other and to currently conserved lands within the habitat blocks. As a means to this end (with the end goal being the identification of important parcels in the core habitat blocks), we delineated structurally connected areas of unprotected land (within habitat blocks) between Structural Pathways, and called them Habitat Block Core Areas (HBCA). HBCA boundaries were loosely drawn using a combination of structural pathway boundaries; roads, parcel lines, and forest cover (Figure 20).

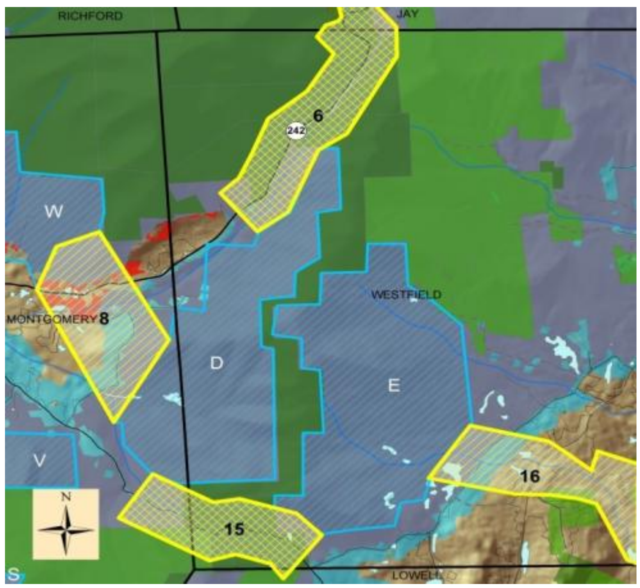

Figure 20. Examples of Habitat Block Core Areas (outlined in light blue) and associated structural pathways (outlined in yellow). Note how HBCAs represent the general area of land connecting Structural Pathways with each other and with conserved land.

As was done within Structural Pathways, we associated all parcels within each HBCA with that area's ID letter (A-Z). The parcels were given a subjective rank of "high," "medium," or "low." Factors that increased a parcel's value included: proximity to conserved land, proximity to a Structural Pathway, predominance of forest cover, shape of the parcel, large acreage, spanning across a road (same owner on each side of the fragmenting road), and high habitat value (wetland, riparian area, saddle, ridgeline, beech stand, etc…). The goal was to explain visually how to best connect the Structural Pathways to each other through the Sorenson and Osborne habitat blocks. See Figure 21for the final set of Structural Pathways and HBCAs, but keep in mind the HBCAs were only a means to identify important parcels within habitat blocks and do not necessarily have additional meaning for connectivity.

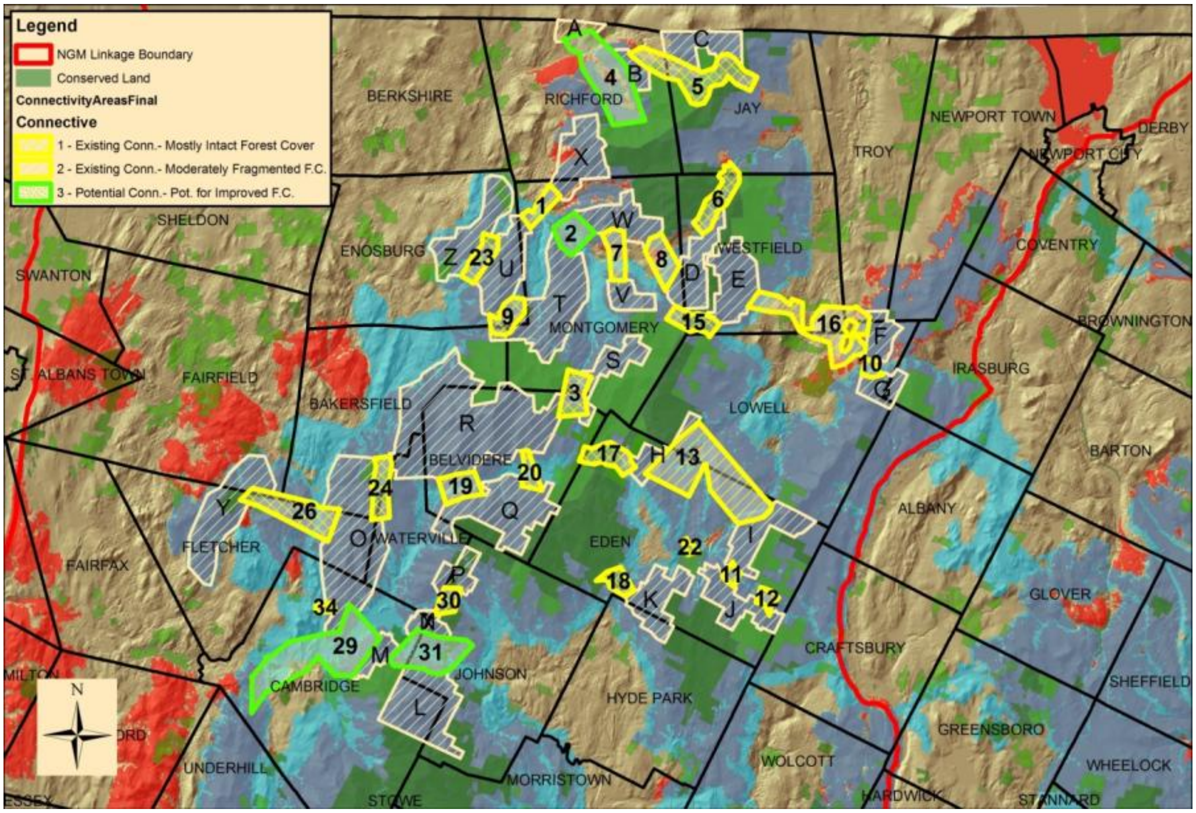

Figure 21. Final set of 27 Structural Pathways (ID=1-34) and 26 Habitat Block Core Areas (ID=A-Z). Together with conserved land, they make up critical network of connectivity in the Northern Greens.

Final Step: Parcel Attributes

We have so far described how we developed two types of spatial polygons: 1) Structural Pathway polygons and 2) HBCA polygons. We have also described how we assigned connectivity values to individual parcels within Northern Greens parcel database to provide information most applicable to land conservation efforts. As a final product, we developed a GIS layer containing all Northern Greens parcels with associated attribute data related to connectivity (see Appendix 3). This product can be used to prioritize and narrow down important parcels based upon the interests of a given user. Within the attribute table of this shapefile, a parcel can be associated with:

- A Structural Pathway or HBCA that encompasses it – the specific Structural Pathway or HBCA will be identified by ID number or letter;
- The Regional Rank value of the Structural Pathway or HBCA encompassing it;
- Current landowner feasibility (a subjective ranking of a landowner's attitude in the CHC 7-town area toward conservation based on anecdotal information provided by CHC members);
- 2C1Forest Threat/Importance Value for hexagon encompassing it;
- "Cost" for wide-ranging mammals to travel through a parcel (from Sorenson and Osborne, 2011, Habitat Block Analysis cost surface);
- Identification as a "Phase 1 parcel" – identified on Jan 26, 2011 at priority setting meeting (~88 parcels) among SCI partners. A landowner address is included for approximately 68 parcels;

- Identification as a "Phase 2 parcel" – identified as a priority after Jan 2011 meeting. These are all parcels that scored a "High," "Med," or "Low" (low is still of value, as lowest value parcels were not scored at all) priority within Structural Pathway or HBCA and include about 365 parcels. Of these parcels:
    - About 178 are in Structural Pathway polygons;
    - About 159 are in an HBCA polygon;
    - About 28 are in both Structural Pathway and HBCA polygons.

Refining the Linkage Boundary

During the process of identifying polygons of significance for connecting the habitat network and sustaining its core, it became clear that our original Northern Greens Landscape Linkage boundary was too broad. To refine the boundary, we followed edges of habitat blocks greater than 3,000 acres as well as connecting lands identified by Hilke (Figure 22). We focused on the spine of the Northern Greens, as opposed to "outlying" large blocks. To capture potential restoration opportunities and to simplify the boundary of our resulting dataset, parcels that were apparently disconnected were not excluded from the final polygon

The same methodology was used by the Canadian NGO, Appalachian Corridor Appalachien (ACA; www.appalachiancorridor.ca) in the Quebec portion of the Northern Greens Landscape to identify habitat blocks that delineate the linkage boundary in their area. Structural pathways shown in Figure 22, and in greater detail in Figure 23 ("Corridor naturel"), were identified by Least Cost Path analysis followed by field work to ground proof their actual potential (Robidoux and Guérin, 2010). Validating their use by wildlife is ongoing by Canadian tracking teams (Robidoux and Bouthot, 2011).

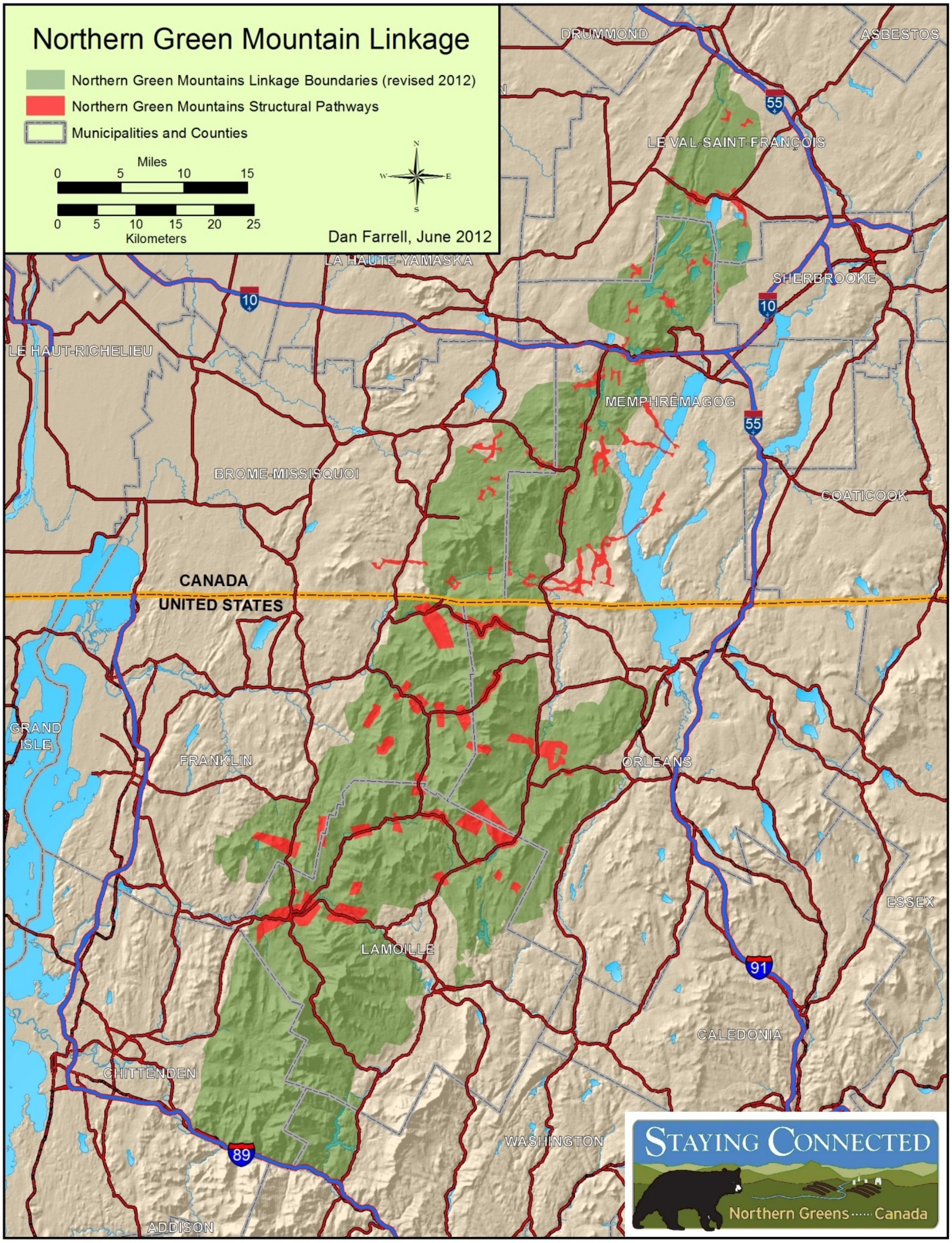

Figure 22. Final, refined boundary of the bi-national Northern Green Mountains Linkage colored green, with Structural Pathways colored red.

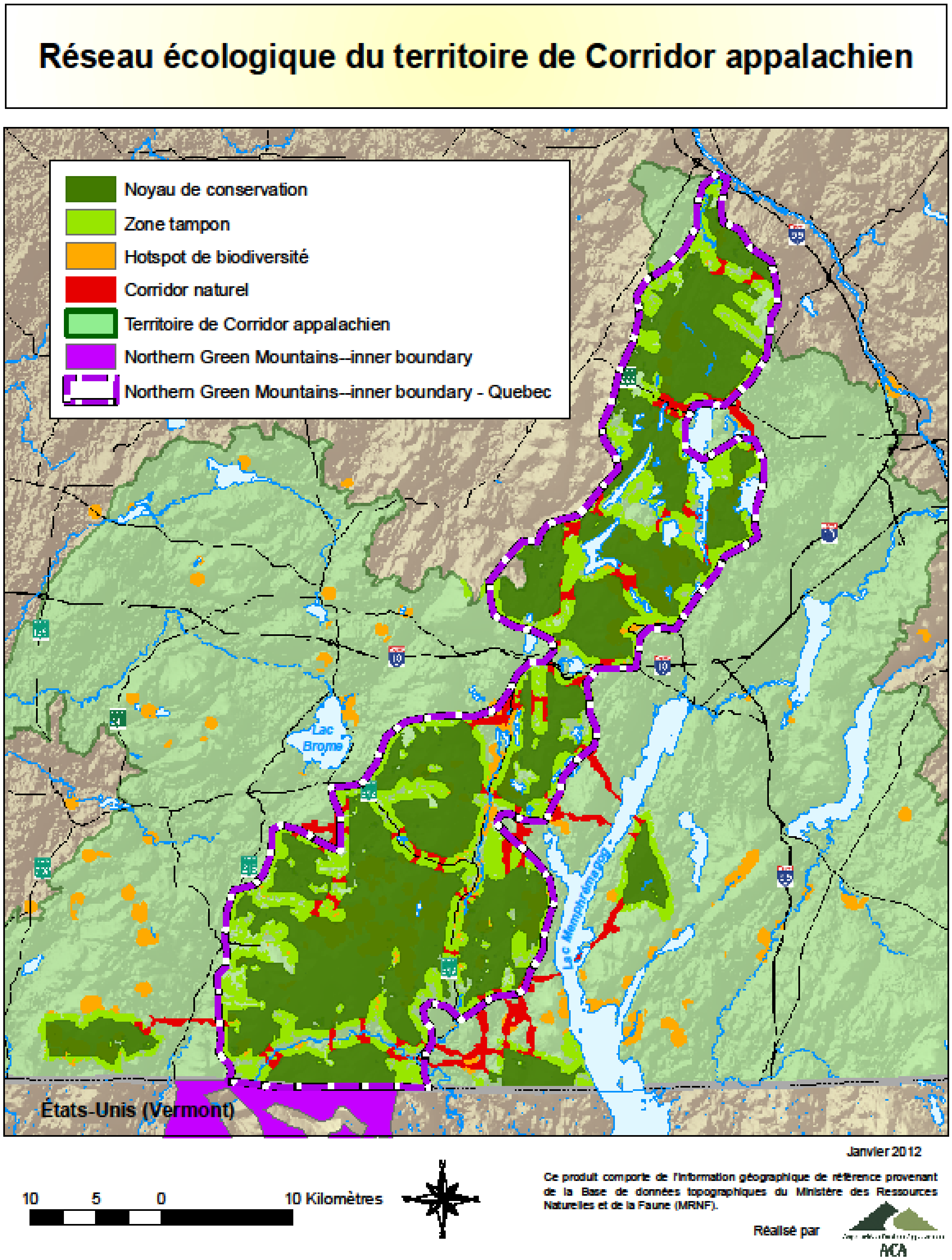

Figure 23. Structural Pathways ("Corridor naturel") in the Canadian section of the Northern Green Mountains.

Discussion and Recommendations

This analysis was developed to give local communities, land trusts, town and regional planning entities, the Vermont Fish and Wildlife Department and the Vermont Agency of Transportation information on those places in the Northern Green Mountains that could contribute most significantly to the conservation of landscape connectivity at local and regional scales. We identify a set of Structural Pathways that tie together relatively large habitat blocks in a strategic and efficient manner, as well as those parcels within the pathways whose conservation, and in some cases restoration, would contribute the most to ensuring the long-term structural integrity of those pathways. We also sought to identify those places – the Habitat Block Core Areas – whose conservation would contribute to the long-term viability of the region's network of wildlife habitat.

Many of the Structural Pathways span roads with traffic volumes that exceed 1,000 vehicles per day and three that well exceed 3,000 per day (VAOT 2010). Emerging scientific studies about traffic volumes indicate that elevated Average Annual Daily Traffic (AADT) counts may be detrimental to wildlife movement, and that species groups such as reptiles and amphibians are more sensitive to eleveated traffic volumes than are mammals. (Clevenger and Huijser 2011; Seiler 2005). The road segments that fall within the structural pathways need further study to understand just how much of a barrier the roads associated infrastructure constitute, and what might be done to mitigate their effects. A wildlife monitoring system should be established that includes cameras, track plates, GPS/radio collar data, DNA analysis and other tools to provide the validating evidence transportation agencies and conservation organizations will likely need before investing millions of dollars to improve infrastructure or buy conservation land and easements. Such a system can be designed to incorporate data generated by citizen scientists and professionals alike. This could add the functional connectivity information that is presently missing from the puzzle.

The authors acknowledge that this document is a work in progress. Unresolved issues include:

- Where to "stop" the analyses along the edges in East/West connectivity (e.g., towns of Fletcher and Lowell).
- Different analysis necessary on both sides of the border because Habitat Block Analysis data is only available for Vermont.
- Border complications using cost-weighted distance analyses for start/end points in Richford and Jay because of lack of compatible data from Canada.
- Subjectivity of "high," "med," and "low" categories.
- Whether this analysis leaves out important terrain/habitat in lower elevations because those habitats aren't available or are underrepresented in blocks of 3,000 acres or greater. Some species may prefer or need lower elevation areas, even if they are relatively small, for their life cycles. This study does not capture these smaller, lower elevation blocks.
- Generalization of connectivity habitat needs that are generally species specific into a data layer that hypothetically characterizes conservation needs for wide ranging mammal connectivity was a concession needed to produce data that is readily interpretable.

Despite these issues, we hope that this work contributes to the establishment of a healthy and resilient network of wildlife habitat in the region, and that this network will in turn allow for the movement, migration, and dispersal of wide-ranging mammals.

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APPENDIX 1

Staying Connected – Connectivity Measures Terms and Definitions Workgroup

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The charge to the Terms and Definitions Workgroup is to ensure that we are using common language and consistent definitions of words and phrases that are considered essential for the development of a connectivity measures framework. As our starting point, we are drawing from the excellent document written by Meiklejohn et al. for the Center for Large Landscape Conservation.[1] We also reviewed and incorporated elements from the Glossary of Connectivity Terms contained in Worboys et al. (2010)[2] As needed for our purposes, we have revised their definitions and included and defined additional terms deemed to be key for our purposes.

Landscape connectivity:

Meiklejohn et al. definition: *The capacity of individual species to move between areas of habitat via corridors and linkage zones.*

Proposed Staying Connected definition: ***The degree to which similar landscape elements, such as habitat patches or natural vegetation, are connected to each other so as to facilitate the movements of target organisms and ecological processes between them.***

Functional connectivity:

Meiklejohn et al. definition: *The degree to which landscapes actually facilitate or impede the movement of organisms and processes.*

Proposed Staying Connected definition: ***The degree to which landscapes facilitate or impede the movement of a target organism or ecological process assuming all other conditions for movement are met.***

Structural connectivity:

Meiklejohn et al. definition: *The physical relationship between landscape elements.*

Proposed Staying Connected definition: ***The degree to which similar landscape elements, such as habitat patches or natural vegetation, are physically connected to each other.***

Habitat corridor:

Meiklejohn et al. definition: *Components of the landscape that facilitate the movement of organisms and processes between areas of intact habitat.*

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[1] Meiklejohn, K., R. Ament, and G. Tabor. Habitat Corridors & Landscape Connectivity: Clarifying the Terminology. Center for Large Landscape Conservation, Bozeman, MT.

[2] Worboys, Graeme L., W. L. Francis, and M. Lockwood, ed. 2010. Connectivity Conservation Management: A Global Guide.

Proposed Staying Connected definition: ***Components of the landscape that provide a continuous or near continuous pathway that may facilitate the movement of target organisms or ecological processes between areas of core habitat.***

Landscape Linkage (or Landscape Linkage Area):

Meiklejohn et al. definition: *Broader region of connectivity important to facilitate the movement of multiple species and maintain ecological processes.*

Proposed Staying Connected definition: ***Broad region of comparatively greater or more concentrated connectivity important to facilitate the landscape or regional-scale movement of multiple species and to maintain ecological processes between core areas, and where structural connectivity is at risk.***

Landscape (or Landscape linkage) permeability:

Meiklejohn et al. definition: *The degree to which regional landscapes, encompassing a variety of natural, semi-natural and developed land cover types, are conducive to wildlife movement and sustain ecological processes.*

Proposed Staying Connected definition: ***The degree to which a regional landscape (or landscape linkage), encompassing a variety of natural, semi-natural and developed land cover types, sustains natural ecological processes and is conducive to the movement of many types of organisms. Landscape permeability is a function of the connectedness of natural cover, the hardness of barriers, and the spatial arrangement of land uses.***

Core (or Core Area):

Meiklejohn et al. definition: None, but equivalent to what Meiklejohn et al. refer to as "Habitat patches" and "intact habitat."

Proposed Staying Connected definition: ***An area with sufficient size, suitable intact cover type(s), and sufficient condition to serve as source habitat for all or most species characteristic of the region.***

(*Note: an issue has been raised about the potential confusion of landscape ecology terms and conservation management terms. Core (and buffer) are management terms and do not describe conditions of the landscape, per se, but conditions of how the landscape is being managed. As such, core area implies an area protected and/or managed for biodiversity. Worboys et al include this distinction in their definition. So, an alternate definition that more explicitly makes this connection would be:* ***A protected area which is thought to include suitable intact cover types of sufficient size and condition to serve as source habitat for all or most species characteristic of the region.****)*

Matrix:

Meiklejohn et al. definition: *A component of the landscape, altered from its original state by human land use, which may vary in cover from human-dominated to semi-natural and in which corridors and habitat patches are embedded.*

Proposed Staying Connected definition: ***The landscape around and between core areas, which may be altered from its original state by human land use and may vary in cover from human-dominated to semi-natural and in which corridors and habitat patches are embedded.***

Buffer:

Meiklejohn et al. definition: None

Proposed Staying Connected definition: **Areas of managed, multiple use forest lands that serve to shield core areas against the direct impacts and influences of human activities and reduce contrast between core forest and surrounding more human altered matrix. Buffer may serve as breeding habitat for some species and as dispersal habitat for many organisms.**

Ecological network:

Meiklejohn et al. definition: *Coherent systems of natural or semi-natural landscape elements configured and managed with the objective of maintaining or restoring ecological functions as a means of conserving biodiversity while also providing appropriate opportunities for the sustainable use of natural resources.*

Proposed Staying Connected definition: ***A coherent system of interconnected natural and semi-natural landscape elements including protected core areas, buffers, and habitat corridors, configured and managed to maintain or restore ecological functions as a means of conserving biodiversity.***

(Structural) Pathways:

Meiklejohn et al. definition: None

Proposed Staying Connected definition: ***An area with sufficient structural connectivity to function as a habitat corridor.***

Pinch points (or concentration areas):

Meiklejohn et al. definition: None

Proposed Staying Connected definition: ***A relatively narrow area or location where wildlife movement is likely to be funneled or concentrated because of the configuration of inhospitable land uses, physical barriers, and natural cover constraints in the landscape.***

Priority road segment:

Meiklejohn et al. definition: None

Proposed Staying Connected Definition: ***A section of road that crosses a structural pathway or habitat corridor where the landscape quality and permeability are high and the road is the primary potential impediment to animal movement, and which is a higher priority for restoration or mitigation because of its current degree of impermeability and its known or modeled importance for multiple species.***

(Note: it has been suggested that we also define the term "Intersecting Road Segment" as "A section of road that crosses a structural pathway or habitat corridor where the landscape quality and permeability are high and the road is the primary potential impediment to animal movement". If we choose to do so, then the definition of "Priority Road Segment" would be modified to be "A particular intersecting road segment that is a higher priority for restoration or mitigation because of its current degree of impermeability and its known or modeled importance for multiple species."

Stepping Stones:

Meiklejohn et al. definition: None

Proposed Staying Connected Definition: ***Small patches of intact habitat, located within the intervening space between core areas, that provide resources and refuge that assist a target species moving through the landscape but lack sufficient size or condition to function as core for those species.*** **(Stepping stones may be configured to provide structural pathways or corridors when they are separated only by roads or other permeable land uses**.)

APPENDIX 2

Habitat Block Weights in Sorenson and Osborne (2011).

Habitat blocks were evaluated using 11 factors to assess their contribution to biological and physical diversity and given a weighted score (see Figure 3):

- Cost distance to core area – 15%
- ELU Weighted Average – 15%
- Element Occurrence count – 10%
- Percent core (250 acre blocks = core) – 15%
- Block size – 15%
- Roads (miles of roads/square miles of habitat block) – 10%
- Percent ponds – 5%
- Percent wetlands – 5%
- Exemplary aquatic features – 5%
- Rivers/Streams (miles) – 5%
- Percent TNC Matrix block – 5%

APPENDIX 3

Description of GIS Shapefiles and Attributes for Structural Pathways, Habitat Block Core Areas and Priority Parcels

Connectivity Areas – "ConnectivityAreasFinal" shapefile

Attributes:

- "ID" = 1:34
- "Connective" =
  - "1 - Existing Conn.- Mostly Intact Forest Cover" (16 total)
  - "2 - Existing Conn.- Moderately Fragmented F.C." (7 total)
  - "3 - Potential Conn.- Pot. for Improved F.C." (4 total)
  - In "ConnectivityAreaFull" shapefile there is also "Connective" = "4 - Future Threat?" (7 total)
- Regional Rank – "RegionRank" =
  - Highest
  - High
  - Med
  - Low

Habitat Block Core Areas – "HabitatBlockCoreArea" shapefile

Attribute:

- "CoreAreaID" = A:Z (26 total)
- Regional Rank
  - High
  - Med
  - Low

Parcels of Interest – "NG_CombinedParcelsFinal"

Attributes:

- *Related to Connectivity Areas*
    - "Focus_2" refers to parcel's location within Connectivity Area and is marked with the Identification Number of that Connectivity Area ("ID" attribute in "ConnectivityAreasFinal" shapefile; "Focus_2" = "1": "34")
    - "Phase1_Par" = "Yes" identifies this parcel as a conservation priority for SCI partnership; determined at meeting on January 24, 2011. We have determined ownership data for these parcels, as possible (80%). "Discarded" refers to parcels that were determined important on January 24, but because location of some Connectivity Areas changed, they are no longer inside a Connectivity Area. 88 of these. 20 with unknown addresses.
    - "Phase2_Par" = "Yes" identifies this parcel as a conservation priority for connectivity in the Northern Greens, at both scales – CA and HBCA; determined by Corrie Miller and Bob Hawk in GIS analysis during Spring 2011. 365 of these (178 CA value only, 159 HBCA value only, 28 that are valuable at both scales).
    - "ConnPriori"- "Phase2_Par" and "Phase1_Par"= "Yes" parcels can have a connectivity priority of either "high," "med," "low," or "lowest." Parcels that made it to Phase 1 list but were determined to be of lowest significance upon a second look are labeled "lowest." "Low" parcels are still important, just lowest tier importance of important parcels.
- *Related to Habitat Block Core Areas*
    - "Focus_3" refers to parcel's location within a Habitat Block Core Area and is marked with the Identification Letter of that Habitat Block Core Area ("CoreAreaID" attribute in "HabitatBlockCoreArea" shapefile; "Focus_3" = "A": "Z")
    - "CorePriori" – all "Focus_3" parcels were determined to have a habitat area core priority of "high," (had 2 or more attributes) "med,"(had 1 attribute) or a blank field (low). If "Focus_3"places parcel in a Habitat Block Core Area, but this field is blank, that's when priority is lowest (note: attributes included adjacent to already conserved, adjacent to connectivity area, large area, good geometry for connectivity, landscape features that would support wildlife (wetlands, ridge top, beech stand, etc…)
- Feasible – Yes Maybe No, blank = unknown; based on Nancy Patch's dataset.
- 2C1Fthreat – Two Countries, One Forest threat and importance value of hexagon containing parcel