Adirondack – Tug Hill Connectivity Project
Planning Phase – Final Report
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Photo: Susan Morse

Project leads: Michelle Brown, Craig Cheeseman, Linda Garrett, Todd Dunham and Dirk Bryant

Contributors: Michale Glennon and Robert Long

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Executive Summary

The Nature Conservancy (TNC) and other groups have a long track record of working with government agencies, local land trusts and other partners in the Adirondacks and Tug Hill regions of New York to protect 'core' tracts (those critical to biodiversity conservation) and to prevent fragmentation of surrounding 'buffer' lands through conservation easements. To date, however, TNC has not treated these two areas as an interconnected entity; yet, the long-term viability of wide-ranging species inhabiting them (especially Tug Hill populations) will likely depend on maintaining connectivity across the intervening and relatively unprotected Black River Valley. Maintaining and enhancing this connectivity will be especially important in the future, to allow for species dispersal in response to climate change.

In collaboration with the Tug Hill Tomorrow Land Trust (THTLT) and the Wildlife Conservation Society (WCS), we launched the planning phase of a proposed long term connectivity initiative within the Black River Valley. This entailed:

i. Engaging potential partners: we assembled a steering committee to provide guidance on connectivity modeling work described below and to develop a strategic plan for enhancing and restoring connectivity. The committee included representatives from State and local government agencies, environmental organizations and landowners active in the Black River Valley.

ii. Identifying priority geographies: we applied spatial connectivity models to identify priority habitat patches for protection and areas on which to focus barrier mitigation work within the Black River Valley—where land conversion, second home development, roads, etc. threaten to fragment the landscape. We mapped connectivity priorities using Least Cost Path and FunConn models for seven focal species. We then generated an integrated coverage for remaining species and identified two priority linkages to focus work on---one at the northern end of the valley near Loweville and one in the Southern end of the Valley near Forestport.

iii. Outlining potential strategies for securing/enhancing connectivity. These fall within four broad categories: land protection to secure habitat 'stepping stones', local land use planning/zoning, increasing the permeability of roads for wildlife, and education/outreach to 'brand' the importance of connectivity so that it is addressed within resource management decision-making.

iv. Raising funds for proposed work: We have secured $293,900 in US Fish and Wildlife Funding to implement the strategic plan over the next three years, which will leverage an additional $480,400 in match for this effort. Additional fundraising is underway.

Acknowledgements

We would like to sincerely thank the many individuals and organizations that made this project possible. Many thanks to the NYS Biodiversity Research Institute, the Land Trust Alliance and the Switzer Foundation for their generous financial support. A mountain of gratitude is extended to the many experts that volunteered their time to improve our project, especially: Lou Berchielli, Doug Blodgett, Polly Buotte, Sudie Davis, Karl Didier, Kathy Fleming, Paul Jensen, Ken Kogut, Andy MacDuff, Ray Masters, Susan Morse, Clay Nielsen, Justina Ray, Ed Reed, Toni Ruth, Ben Tabor, and Benjamin Zuckerberg. Special thanks to Susan Morse for donating beautiful photos and to three anonymous donors of Keeping Track for supporting her time.

We would particularly like to thank the Steering Committee for their strategic thinking and commitment to this project: Tom Brown, Don Carbone, Edward Franz, Linda Gibbs, Michale Glennon, Richard Hill, Robert Keller, Scott LaPoint, Katie Malinowski, Fred Munk, Geraldine Ridder, Angelena Ross, and Zoe Smith.

Introduction:

Temperate deciduous forests rank among the most fragmented and degraded of the planet's major forest ecosystem types. New York State is home to one of the largest expanses of remaining, unfragmented deciduous forest east of the Mississippi - in a swathe extending from Tug Hill across the Adirondacks. As such, this area offers a rare opportunity to restore a representative, intact temperate forest system at a scale sufficient for maintaining ecosystem processes and supporting viable populations of indigenous species.

The Nature Conservancy (TNC) has been working with the Department of Environmental Conservation (DEC) and other partners in the Adirondacks and on Tug Hill, to protect 'core' tracts of forest. These large, intact forests are critical to biodiversity conservation and to preserving ecosystem function (The Nature Conservancy and Sweet Water Trust 2004). Much work in the Adirondack and Tug Hill landscapes has also centered on maintaining canopy cover and minimizing fragmentation surrounding the forest cores, largely through the application of conservation easements. However, little attention has been focused on the intervening Black River Valley.

Maintaining and enhancing the connectivity between these two large, forested landscapes is important for biodiversity conservation across the region, for the following reasons:

1. *Promoting genetic exchange between populations of resident species, particularly those with large home ranges*: Free exchange between populations in Tug Hill and the Adirondacks allows for successful genetic (and behavioral) adaptations to take hold, and prevents genetic isolation and inbreeding. Species need populations that consist of many thousands of adult individuals if they are to persist over the long term (Reed et al. 2003). This suggests that connectivity will be especially important for securing 'source' populations of resident species with large home ranges, such as bobcat (average home range for males in the Adirondacks is ~125 $miles^2$) and black bear (average home range for males in the central Adirondacks is ~65 $miles^2$). This point is particularly relevant for populations on Tug Hill given its smaller size. Maintaining connectivity between the Adirondacks and Tug Hill also preserves the option of supporting viable populations of some extirpated species should these naturally re-colonize the region (as moose are currently doing).

2. *Mitigating the negative effects of exurban development:* Low density rural residential development is a primary cause of habitat loss in the United States. Negative consequences for wildlife include ecosystem fragmentation, edge effects and nest predation, creation of source-sink dynamics, disruption of wildlife dispersal and movement patterns and changes in community composition and structure, among others (Glennon and Kretser 2005). Efforts to maintain areas of natural habitat in the Black River Valley will help to mitigate some of these broader, system-level impacts, as exurban development is a primary driver behind land use change in this region.

3. *Mitigating the effects of climate change:* Modeling work indicates that summer temperatures in the Northeast could rise by 6-14 degrees by the end of the century unless carbon emissions are significantly curtailed (Frumhoff et al. 2007). US Forest Service maps show the ranges of dominant tree species shifting northward in response to climate change, with maple-beech-birch forests replaced by oak-hickory dominants more typical of the mid-Atlantic (Prasad and Iverson 1999). Even if carbon emissions were capped today, scientists predict significant increases in growing season length, declines in winter snowfall and other effects over coming decades because of elevated greenhouse gas levels already in the atmosphere. That suggests mitigation efforts will be needed, along with those aimed at emissions reduction. From a conservation perspective, opportunities include protecting areas at a large enough scale to allow species and communities to shift and adapt to climate change. Preserving the natural cover (i.e., connectivity) between Tug Hill and the Adirondacks will significantly further this objective, as species need to move east-west as well as north-south.

Recognizing the importance of connectivity in the Black River Valley, we wanted to: 1) identify where important connectivity zones exist; and: 2) develop strategies describing what actions we should implement in these high priority zones to maintain or enhance connectivity.

PROJECT OBJECTIVES

Long term objective: to maintain or enhance landscape permeability across the Black River Valley for all species, natural communities, and ecological processes. We envision a landscape where all native species can move freely and persist in the face of threats like climate change.

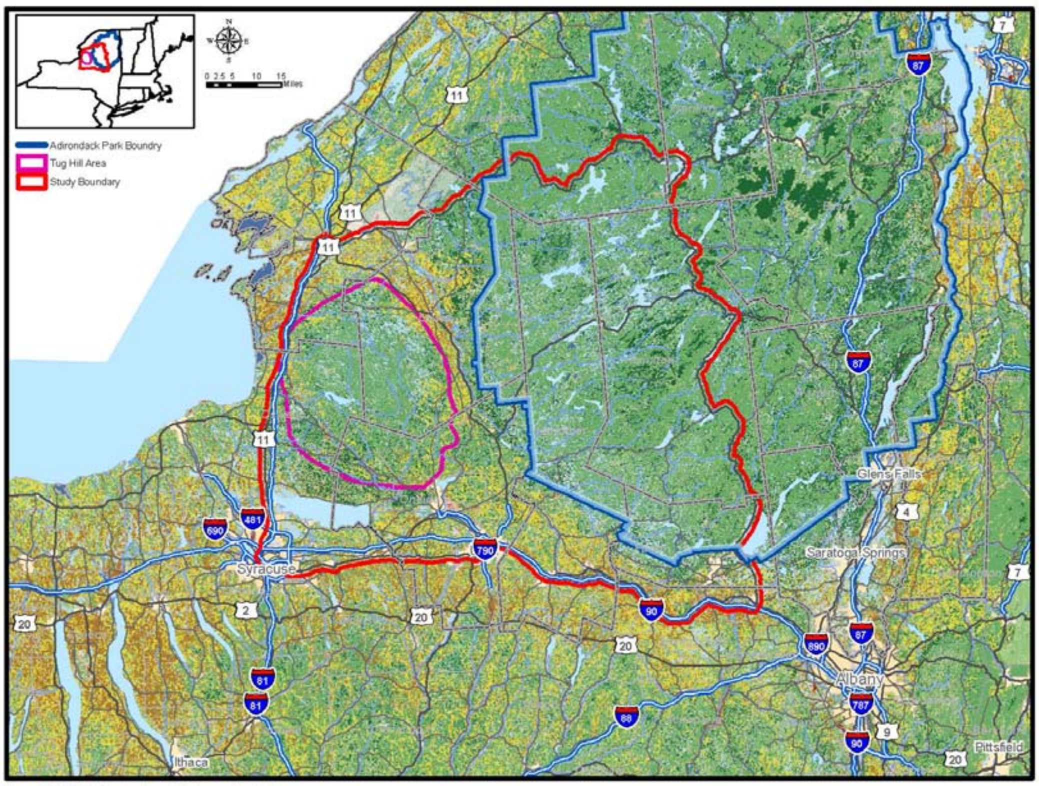
Immediate (planning) objective: to develop a set of place-based strategies to address functional and genetic connectivity for a suite of wide-ranging focal species that currently or historically move between the Adirondacks and Tug Hill (and whose long-term population viability needs capture those of many other species present in the region).

Study Area:

The Black River begins in the foothills of the western Adirondacks, flows through Tug Hill, and eventually dumps into the eastern side of Lake Ontario. A mix of flat and white water, the Black River is known for its beauty and recreational attributes. Our study area consists of the Black River Valley and surrounding uplands in both the Adirondacks and Tug Hill, an area of about 4 million acres (Fig. 1). The boundaries of this area was defined according to the presence of existing major roads and urban areas, and included large contiguous forest blocks (e.g. Tug Hill Plateau, Five Ponds Wilderness area) to capture habitat that might house source populations for species moving between the Adirondacks and Tug Hill.

Within the study area, we primarily focused on the valley between the Adirondacks and Tug Hill, an area of about 650,000 acres (Fig. 1). The focal area is roughly 50% forested, 11% wetlands, 25% agriculture, and 3% developed. Expansion of metropolitan areas, along with the paved roads that link them, and demand for second homes and vacation retreats threaten to isolate the Adirondacks and Tug Hill as separate, 'forested islands.'

Figure 1. Adirondack and Tug Hill reference map.



Tug Hill Plateau to Adirondacks

External Input

Given the technical complexity of the modeling/assessment work and need for stakeholder guidance in developing implementation strategies we relied on external input at every stage of this project. This included:

1. Project Steering Committee

We recruited a steering committee to guide modeling and planning work at the onset of this project (See Table 1 for list of members). Specifically, we were looking for individuals who could provide input on one or more of the following:

- The science underpinning the spatial modeling work

- Implementation strategies (factoring in local political and socio-economic opportunities and constraints)
- Communications and outreach in order to engage key partners, constituencies, and potential funders for implementation work.

The steering committee met during two day-long workshops, and we consulted with individuals in the interim on specific issues (for example, on model inputs and initial results). The first workshop was held January 23, 2007. This covered the model assessment approach, communications and outreach and project outcomes/products (we also got valuable input on potential connectivity strategies). The second workshop was held September 15, 2008 and focused largely on a strategic plan to secure/enhance connectivity, in light of modeling results. Prior to the second steering committee meeting we hosted a conference call to review model outputs in detail.

Table 1. Steering committee members and affiliations.

NYS Department of Transportation
- Edward Franz, Utica

NYS – Department of Environmental Conservation
- Fred Munk – Region 6 Lands & Forests, Lowville
- Angelena Ross – Region 6 Fish & Wildlife, Watertown

NYS Tug Hill Commission
- Katie Malinowski – Natural Resources Associate Director, Watertown
- Linda Gibbs – Natural Resource Specialist, Watertown

Northern Oneida County Council of Governments
- Geraldine Ritter – Circuit Rider, Forestport

State University of New York – College of Environmental Science and Forestry
- Scott LaPoint

Wildlife Conservation Society
- Michale Glennon, Associate Conservation Scientist, Saranac Lake
- Zoe Smith, Director - Adirondack Program, Saranac Lake

Landowners & Other
- Don Carbone, Landowner – Boonville
- Robert Keller, Landowner - Boonville & Tug Hill Tomorrow Land Trust – Vice Chair
- Tom Brown, Retired NYS Region 6 Regional Director, Cape Vincent
- Richard Hill, Trustee-The Nature Conservancy Central & Western NY Chapter, Board Member-Tug Hill Tomorrow Land Trust

Note: in addition, project team staff served on this committee.

2. Expert interviews:
As described below, we relied extensively on species-specific expert advice in order to develop model parameters

3. Connectivity modeling technical workshops
The Nature Conservancy-Adirondack Chapter hosted two technical workshops on connectivity modeling, bringing together 20-25 technical experts across the Northeast region. These provided opportunities to solicit input on assessment methodology and preliminary model results. At the first meeting (September 2006) we reviewed connectivity modeling approaches, their advantages and limitations. The second meeting (September 2008) was spent reviewing results of a number of modeling initiatives, and discussing their applicability and limitations in guiding conservation work on the ground.

Modeling Approaches: Connectivity for what?

Numerous modeling approaches exist to determine connectivity pathways. Our challenge was to select an approach that was broad enough to capture a range of connectivity values, but specific enough to be clear and manageable.

We considered approaches that targeted broad ecological integrity, environmental gradients, and environmental processes, but decided on a focal species approach. We selected the focal species approach because it factors in the needs of a specific suite of species (more tangible) and relies on data and local expertise which were available. Within the realm of focal species approaches, there are many models available. To determine what models were appropriate for this analysis, we wrestled with many questions: What plant and animal taxa are important for connectivity? What types of dispersers need focus? How do different species move through this landscape? Are individual species sensitive to particular threats? We examined six models in detail, ranging from specific connectivity models to habitat suitability tools (Table 2).

Table 2. Focal species models.

Model	Description
PATH (Pathway Analysis Through Habitat) (Hargrove et al. 2004)	This is a “dynamic” type of model that uses simulated “walkers” to assess how permeable landscapes are to animal movement. Each “walker” is given a set of characteristics (e.g., how far it can go without food, how likely it is to find food or die within a particular habitat type) and then their movement path is recorded. Can identify landscape permeability and the most used linkages. Constraints: based on simulation that may/may not accurately represent the focal species; must be run on a supercomputer at Oak Ridge

	National Laboratory.
Graph-theoretic (Urban & Keitt 2001)	A mathematical approach that takes advantage of tools used to design and assess networks (e.g., computer networks, road networks). Constraints: use may be limited in regions with large, fairly well-connected patches; availability and performance are still being assessed.
Least-cost path (Walker & Craighead 1997)	A formal analysis that asks: "Given underlying information concerning how easily an animal might move through different habitat types or land-use types, what is the most likely path that an individual would take to move between two locations?" Constraints: the origin and destination of the path must be chosen; a "path" will be generated regardless of the true permeability of the landscape.
Assessment of habitat suitability (Carroll et al. 1999)	Although not a formal connectivity analysis, some metrics of habitat suitability or probability of animal use can be used to assess how much connectivity there might be within a region of interest.
Functional Connectivity (FunConn) (Theobold 2006)	A toolset designed to assess how animals actually perceive patches. Based on a graph-theoretic approach, users can evaluate landscape-level connectivity, network linkages and corridors.
PatchMorph (Girvitz 2007)	This is a patch-delineation tool that can identify organism-specific habitat patches at multiple scales. Land cover density, habitat gap maximum, and habitat minimum thickness are focal parameters used to produce habitat patches. Can be used to identify suitable habitat patches for inputs into connectivity models.

All of these models represent simplified versions of how systems work. They rely on our ability to predict how individual animals will move. We decided to use two models in our landscape in an attempt to reduce the uncertainly associated with each model. We hypothesized that we would have more confidence in the resulting priority geography if two separate models overlapped. Based on availability of data, species expertise, modeling expertise, resources available, and feasibility, we selected least-cost path and FunConn as the connectivity models to apply within our landscape.

Selection of Focal Species:

To determine the suite of focal species to model we developed the following selection criteria (Beazley and Cardinal, 2004, Hilty et al, 2006, Soule et al, 2003, Weaver et al. 1996, Woodroffe et al. 1998):

Primary criteria:

1. Extant or extirpated **wide-ranging species** with large home range requirements. We gave a preference for:

- Keystone or foundation species whose loss or recovery would have broad ecological effects (e.g., apex predator, important prey species, species that transforms landscapes/waterways).

2. **Umbrella species** whose spatial and connectivity requirements encompass those of a suite of other species. We gave a preference for:
   - Habitat specialist(s) requiring specific forest composition and structure characteristics.
   - Species whose requirements include the aquatic/terrestrial interface.
3. **Species sensitive to barriers/human disturbance.**

Secondary criteria:

4. **Rarity/population status:** Species listed as a species of greatest conservation need in the NYS State Comprehensive Wildlife Conservation Strategy.
5. **Information availability:** Species for which literature and expert knowledge is available relating to local/regional habitat preferences, home range and dispersal characteristics, and behavior (e.g., human avoidance and response to disturbance/barriers).
6. **Social acceptance:** Species that can serve as a flagship to help communicate the importance of connectivity to local audiences.

Six species emerged after applying the criteria: 1) black bear, 2) American marten, 3) cougar, 4) Canada lynx, 5) moose, and 6) river otter. Based on input from the Steering Committee we decided to add a seventh species, scarlet tanager, to test whether or not the connectivity models could be used for birds. The scarlet tanager was chosen because of its sensitivity to fragmentation and preference for interior forest (Mowbray 1999). Appendix 1 contains a table showing the application of the focal species criteria to all species considered for modeling.

Methodology:

The project methodology is described below. For more details on how the models work, please refer to Appendix 2.

We identified the quantitative parameters needed to run the FunConn and Least Cost Path models (e.g. home range size), and created species profiles from literature and personal communications (Appendix 3). We then interviewed between two and four wildlife experts per species to review the parameters we culled from the literature. Experts were chosen based on input from the authors and contributors. We were particularly interested in wildlife biologists with local knowledge of the Tug Hill and Adirondack landscapes. We also targeted species experts in other geographies.

The literature review and expert interviews resulted in between three and five sets of quantitative parameters for each species. In most cases, the parameters were similar for each model input. However, where differences existed rules were developed for reconciling the quantitative inputs. If the parameters were > 20% different we considered quantitative inputs from the literature, local experts, and experts outside the region, in that order. Where a great discrepancy existed, we consulted the experts for clarification and explanation. The resulting parameters were used as inputs into the connectivity models (Appendix 5 to come).

Results:

FunConn and least-cost path models were developed for each species and run between three and ten times. The seven species models were combined for each model type, which resulted in a cumulative species map for both the least-cost path model and the FunConn model. Finally we combined the results of the cumulative species models.

The least-cost path maps represent the probability of the target species occurring at (or using) a particular location (Figs. 2-8). The darkest green linkages represent the top 7% of the predicted results. The FunConn maps illustrate suitable habitat patches (in green), and connected corridors and linkages (in orange and yellow respectively) (Figs. 9-15). Habitat patches represent an area functionally defined by habitat quality, size, and proximity. Corridors represent the optimal movement pathway between adjacent habitat patches, and linkages represent the least-cost path between habitat patches.

The results of the least-cost path analyses have many similarities between species. The lynx, moose, scarlet tananger, black bear, river otter, and marten all outputs suggest preferred linkages in the northern part of the Black River Valley near Carthage. River otter results, however, more clearly follows stream and river features. Least cost results indicated a second linkage area near Lyons Falls, in the middle of the Valley. Here, the data show higher movement probabilities for black bear, lynx and cougar.

The FunConn results were more disparate, but a few patterns did emerge. The otter and moose results both illustrated habitat patches in the southern end of the valley near Forestport, and corridors toward the northern end of the valley near Lowville. The black bear model resulted in one very large patch, therefore no corridors were identified in the main Black River Valley. The patch was connected, however, near Forestport. The lynx and marten models resulted in much smaller habitat patches than the other species, but many corridors and linkages. Nearly the entire landscape for the scarlet tanager is identified as a habitat patch or linkage area, suggesting good landscape connectivity for this species.

We ran into problems running the cougar models because of the project area defined for the analysis (in retrospect, we should have looked at the Adirondacks and Tug Hill as a whole). That is because the species minimum home range requirements are so large there wasn't enough preferred habitat within Tug Hill alone to meet model thresholds.

When the results of each model are compiled, an overlap in preferred geographies becomes even more apparent. Figure 16 shows the species density per pixel that were identified in the high probability linkages for the least-cost path analyses (the cumulative number of focal species predicted to use a given 30x30 meter pixel, when individual model outputs are integrated). The northern part of the valley near Carthage stands out as a potential linkage for multiple species. Figure 17 illustrates the species density per pixel for the habitat patches identified in FunConn. Because the corridors were so species-specific and variable, we used the resultant habitat patches to show the overlap between species. In Figures 16 and 17 the highest number of species per pixel depicted is six as we did not include results for scarlet tanager. Given FunConn results can be interpreted to suggest tanager movement is not an issue within this landscape it was more informative to focus on results from the other six focal species. Figure 18 illustrates the highest probability least-cost path linkages with the highest probability habitat patches results from FunConn.

Figure 2: Bear Least Cost Path Output

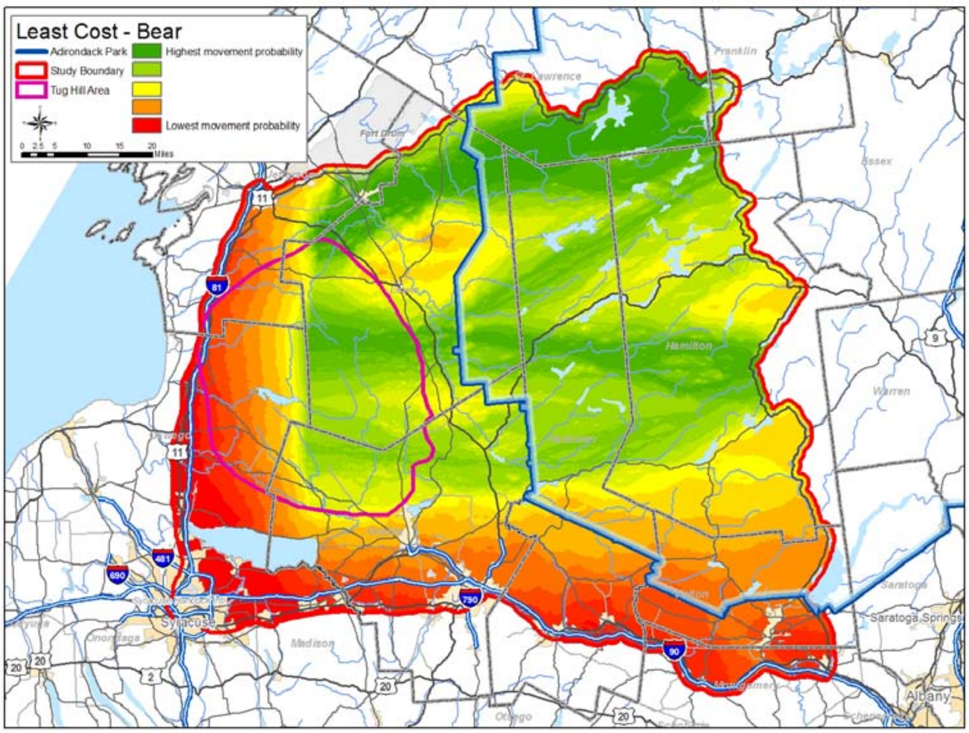


Figure 3: Cougar Least Cost Path Output

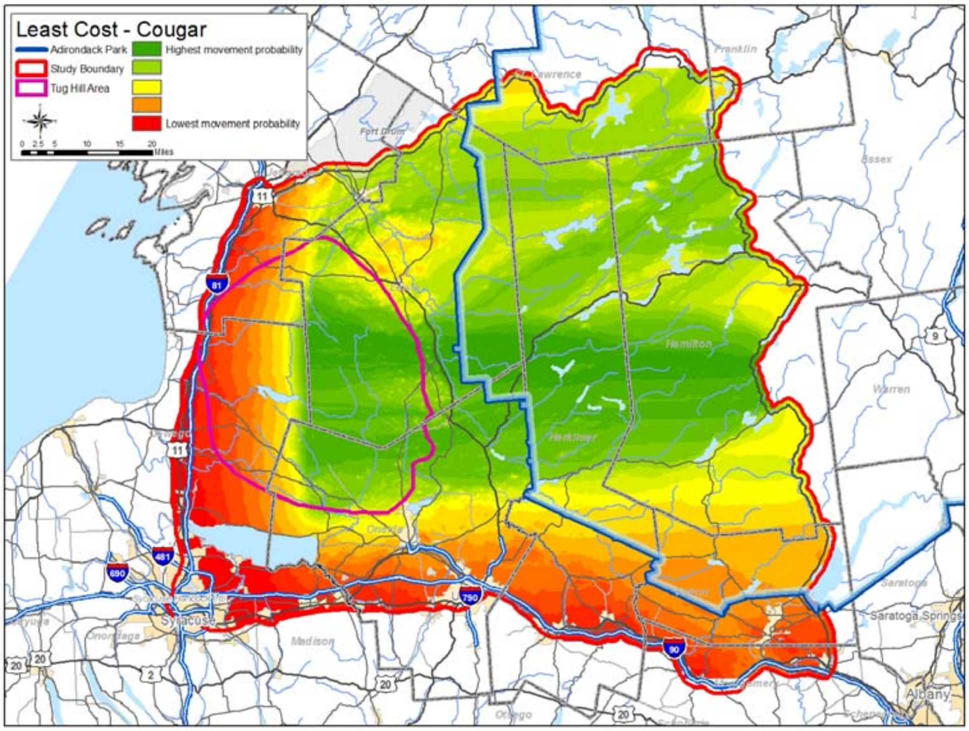


Figure 4: Lynx Least Cost Path Output

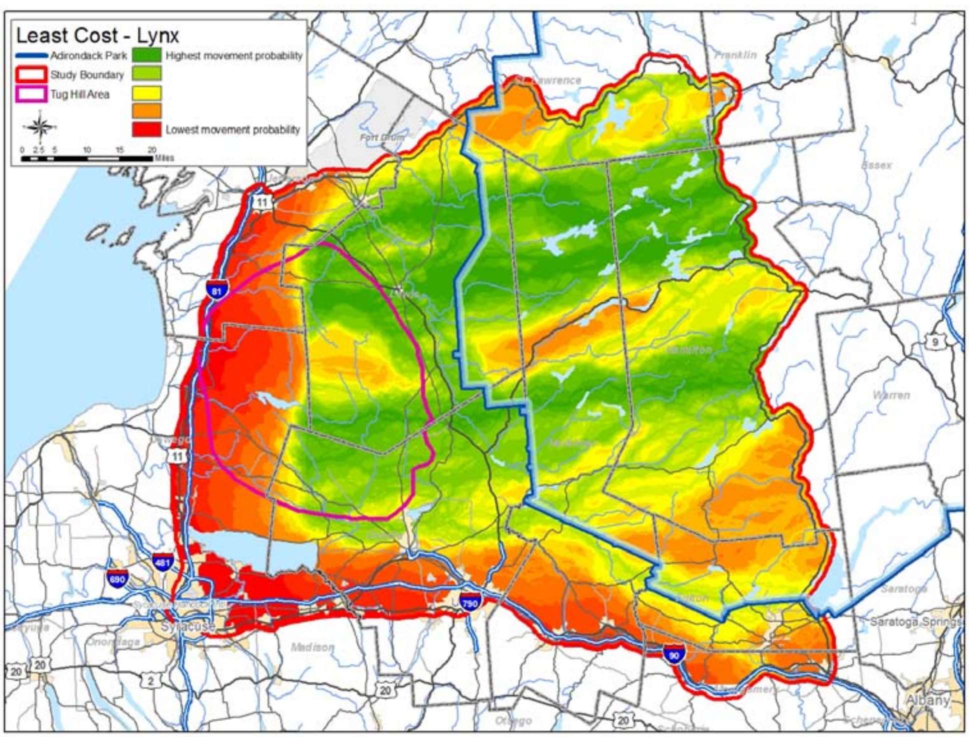


Figure 5: Marten Least Cost Path Output

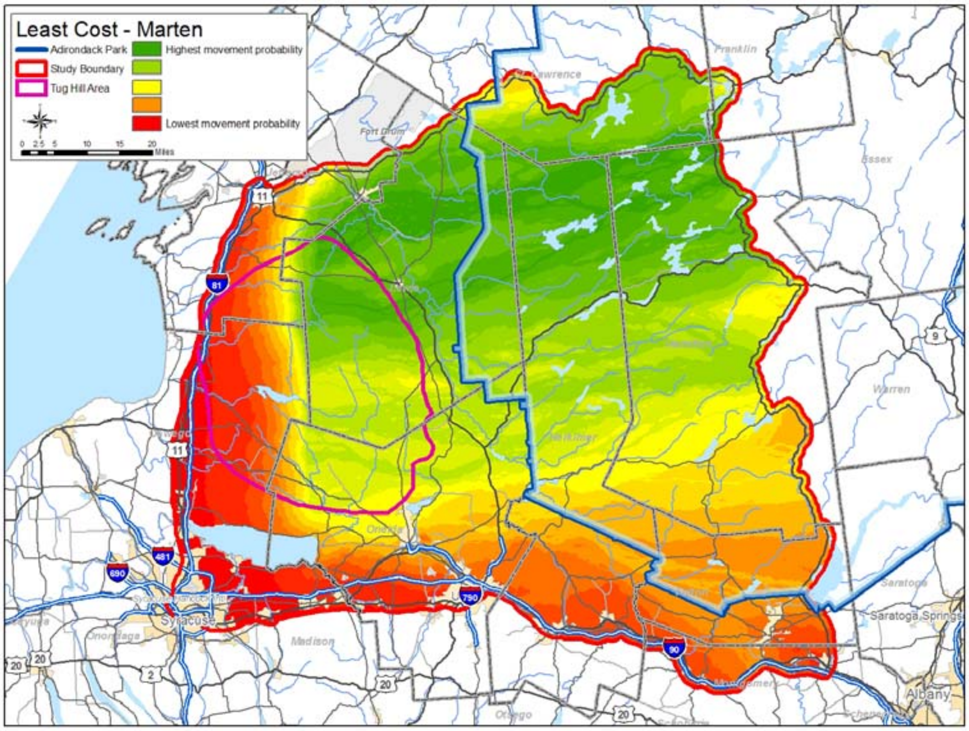


Figure 6: Moose Least Cost Path Output

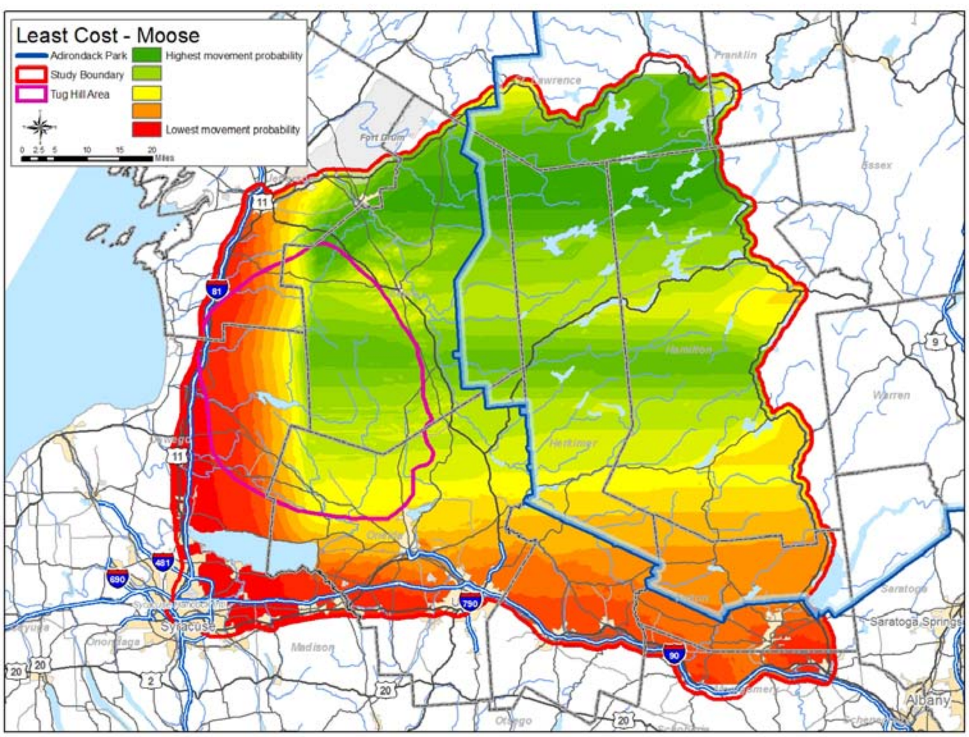


Figure 7: Otter Least Cost Path Output

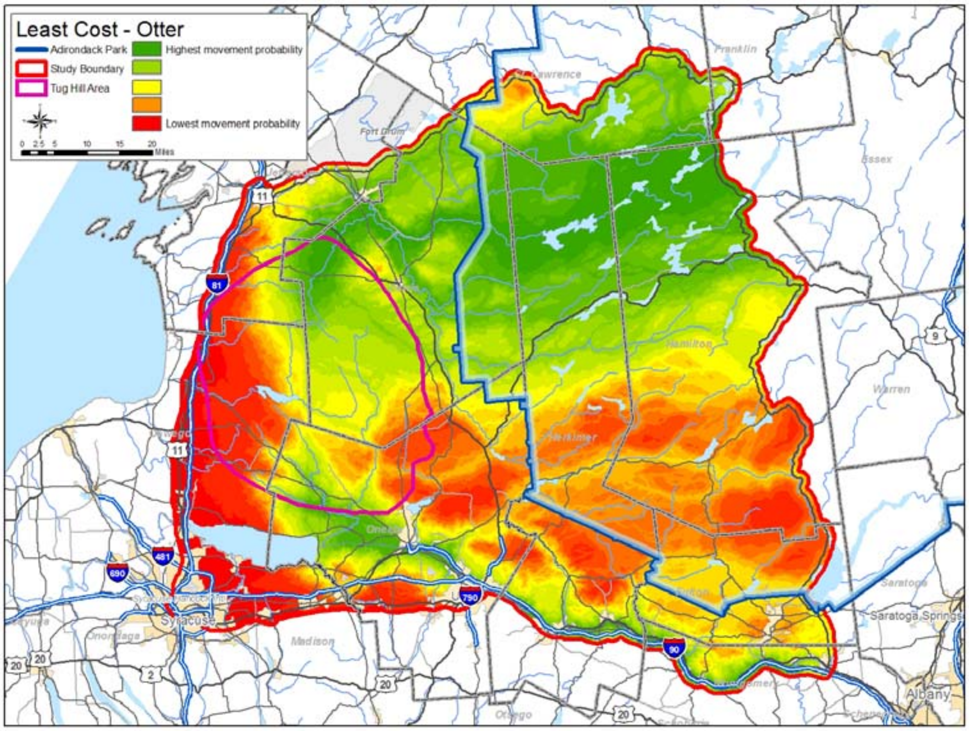


Figure 8: Tanager Least Cost Path Output

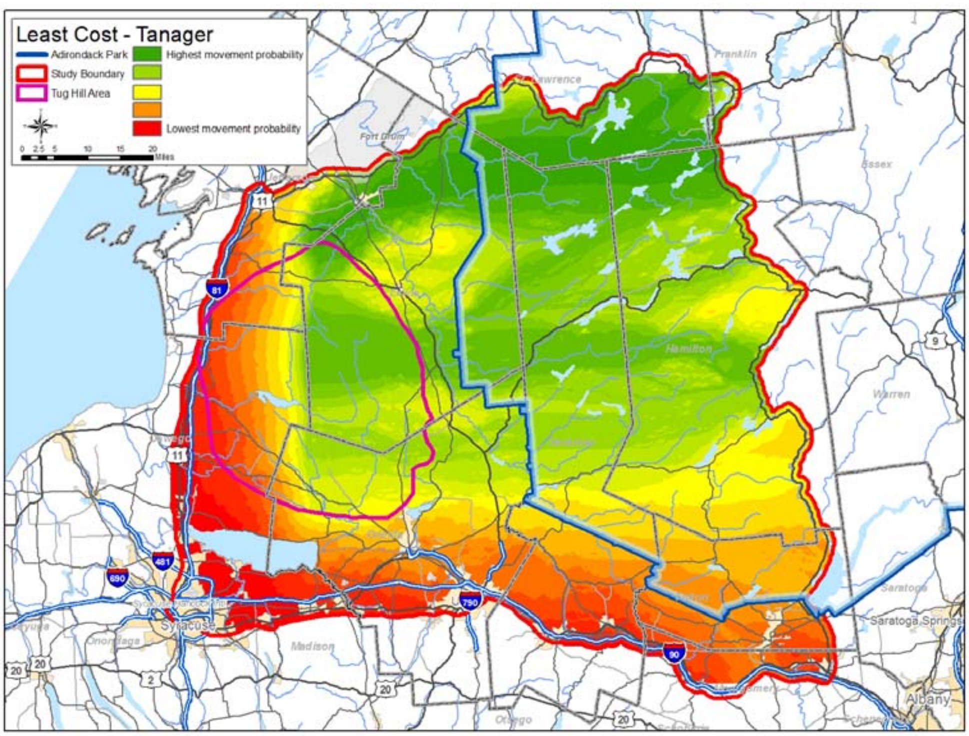


Figure 9: Bear FunConn Output

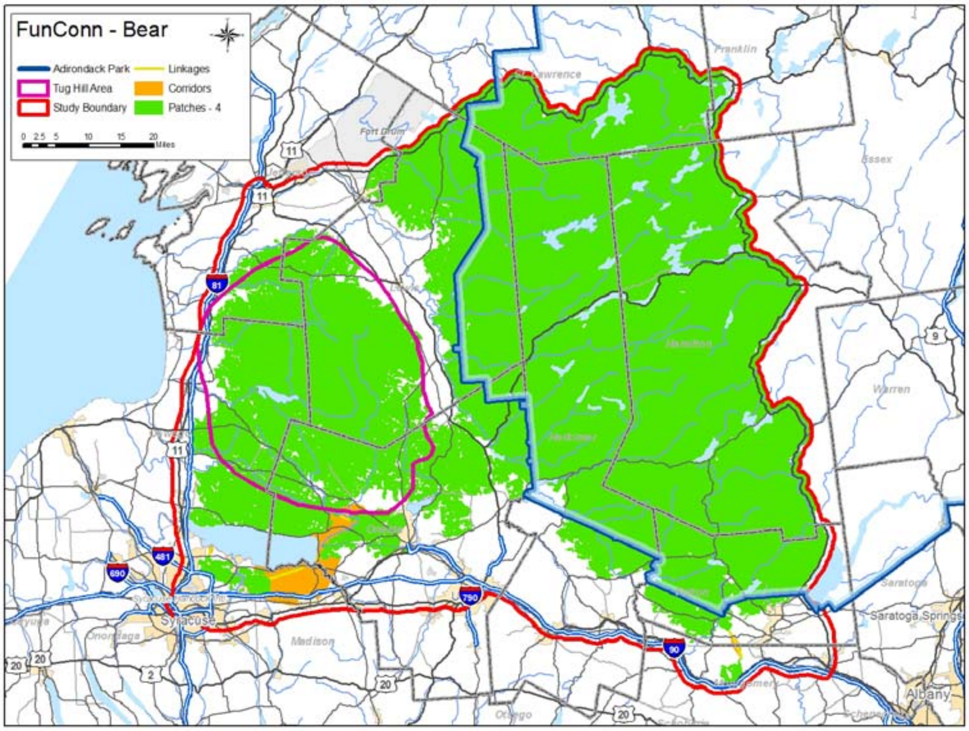


Figure 10: Cougar FunConn Output

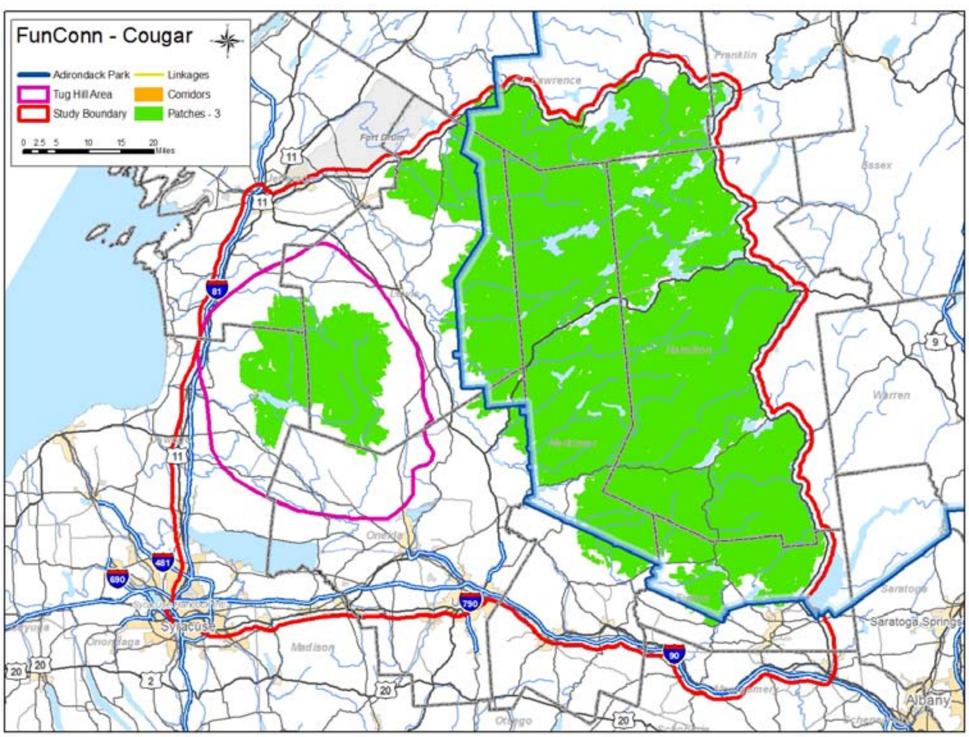


Figure 11: Lynx FunConn Output

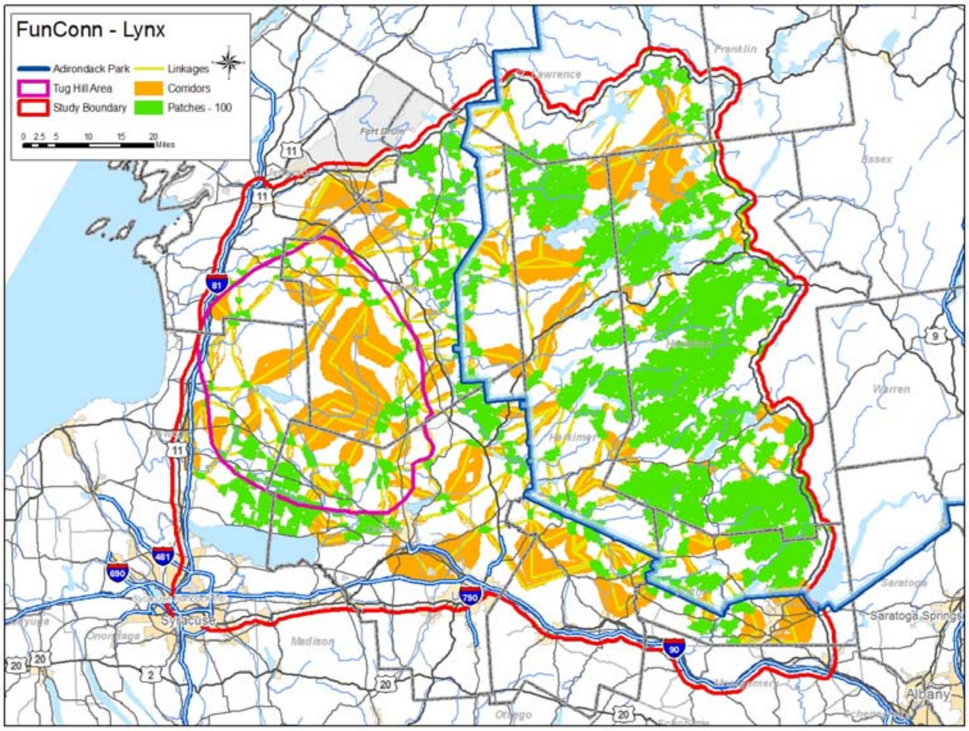


Figure 12: Marten FunConn Output

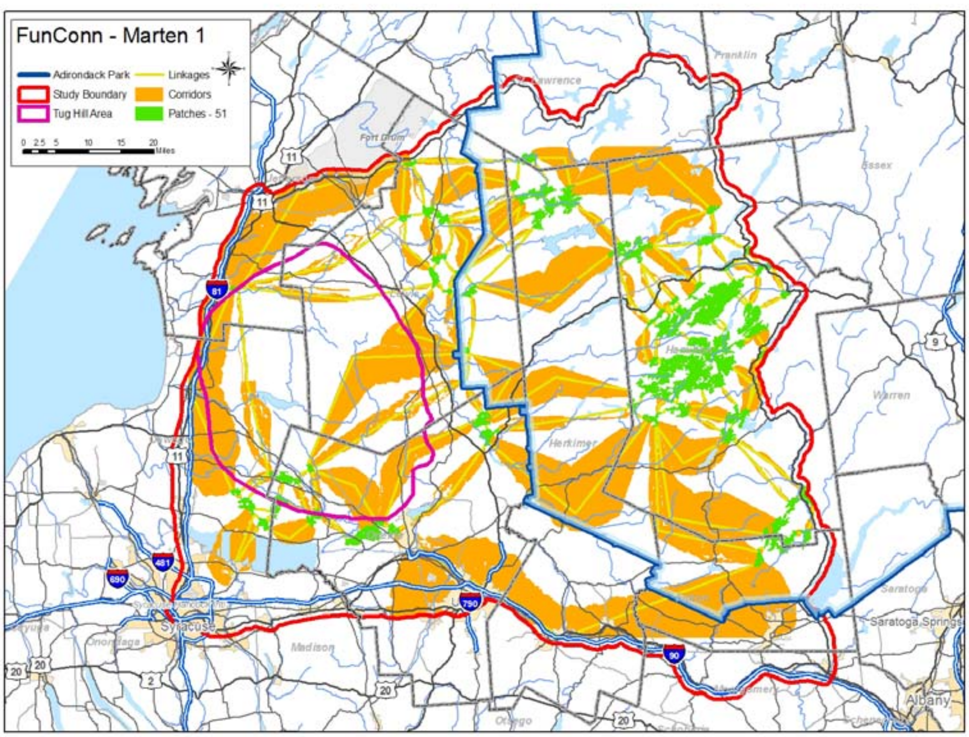


Figure 13: Moose FunConn Output

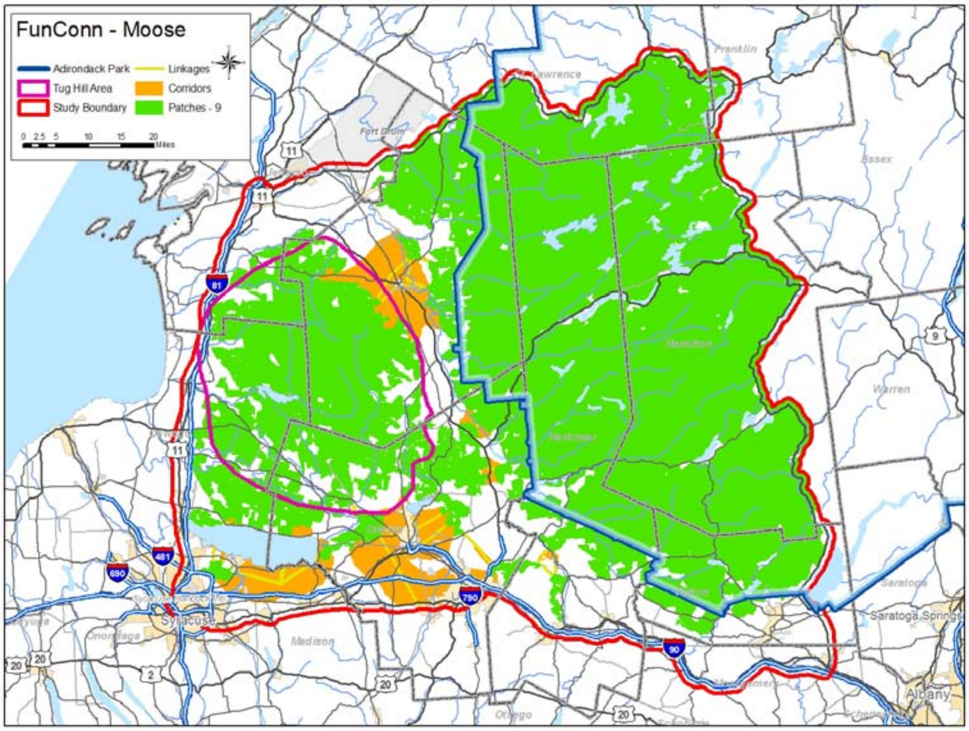


Figure 14: Otter FunConn Output

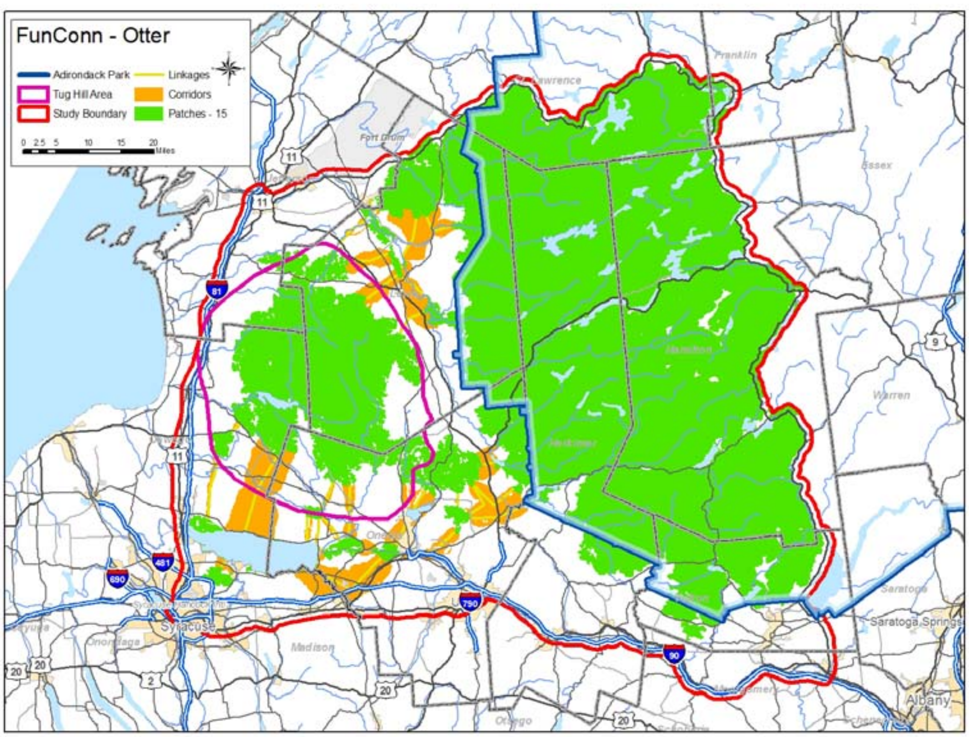


Figure 15: Tanager FunConn Output

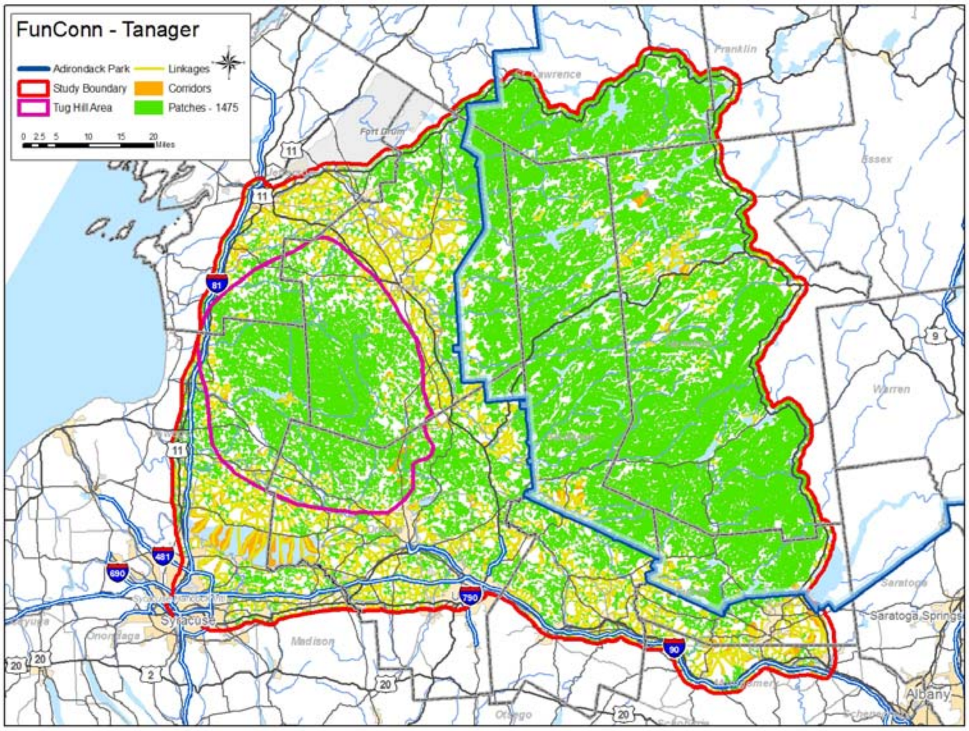


Figure 16: Species Density per Pixel – Least Cost Path Model.

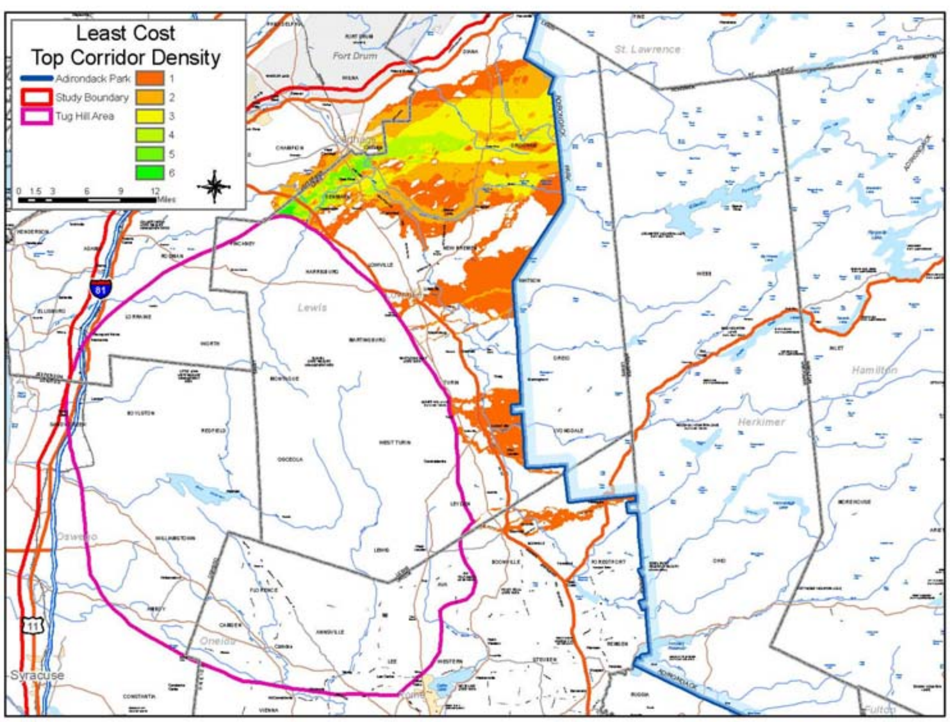


Figure 17: Species Density per Pixel – FunConn Model.

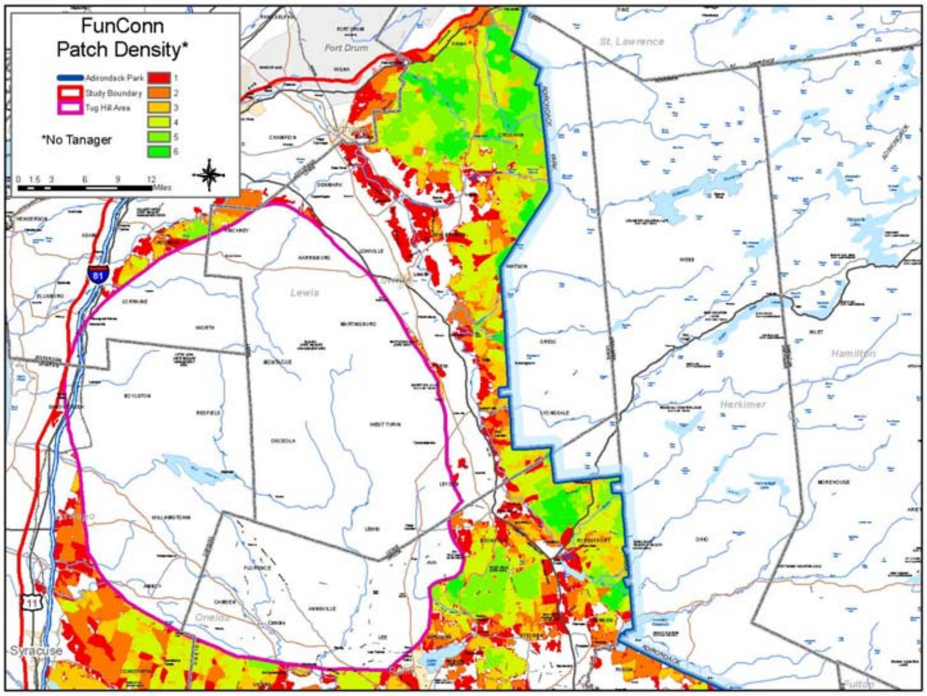
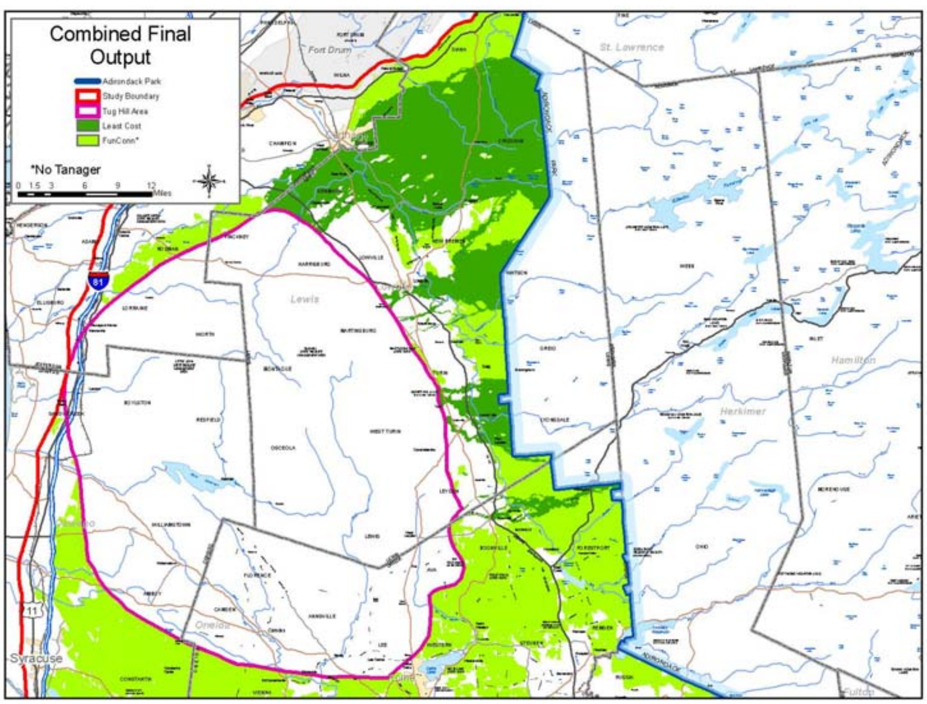


Figure 18: Species Density per Pixel – Models Combined.



Discussion:

Roughly 23% of the focal study area occurs where a priority linkage (least-cost path result) overlaps with a priority habitat patch (FunConn result). We are more confident that these areas of overlap have high potential connectivity values for the suite of species modeled. Of the roughly 200,000 acres of linkages identified in the least-cost path results, 57% is forest and 17% is agriculture, suggesting opportunities for restoration.

The models worked well for some species, and not for other species. According to FunConn, the Black River Valley is completely permeable for the movement of the scarlet tanager. In contrast, the least-cost path model showed a tanager preference for the northern portion of the valley. We suggest this disparity can be attributed to the models, as they were not created to represent species that move primarily through flight. Based on results from our expert review, it appears scarlet tanager can move through this landscape with ease.

As noted above, we were not able to manipulate the FunConn model to create a linkage for the cougar between the two landscapes. Using the smallest possible home range size, we were able to create two habitat patches: one in Tug Hill and one in the Adirondacks. Using the quantitative parameter we developed during our literature and expert review process however, resulted in only one habitat patch in the Adirondacks. We think this result suggests that our landscape in itself is simply not big enough to support cougars moving through it. However, we strongly suspect that if examined at a larger scale like the entire northern Appalachians, probable connections may result.

Two substantial linkages resulted from the compilation of all of the results: 1) A northern linkage through Carthage and south of Fort Drum, and 2) A southern linkage through Forestport. There is also evidence for two other smaller linkages in the middle of the valley near Lowville and Lyons Falls.

Limiting factors

It is critical to keep the limiting factors of all modeling efforts in the forefront of one's mind when interpreting results. These limiting factors include:

- Least-cost path models will generate a linkage regardless of the true permeability of the landscape.
- The graph-theory approach utilized in FunConn may be limited in regions with large, fairly well-connected patches; performance is still being assessed.
- Many factors contribute to an individual animal's use of habitat: food availability, den sites, intra and inter species competition, safety. Most of these factors are not captured within existing spatial data and cannot be mapped without extensive on-the-ground surveys or higher resolution data.
- The models correlate species biological requirements to available digital data to the extent possible, which necessarily introduces errors and unknowns.

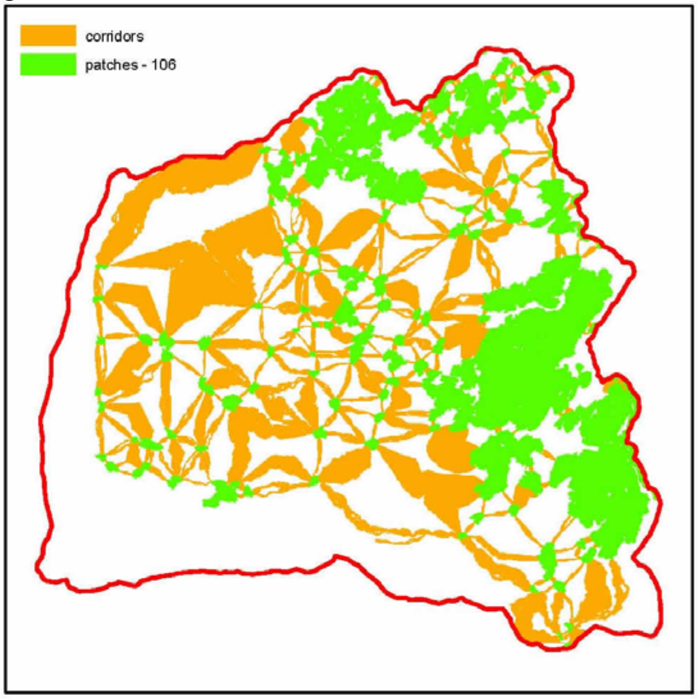
- The models sometimes require users to quantify parameters that haven't been documented through scientific literature. For example, we rarely had information on the smallest size patch an individual animal would be likely to move through.
- We did not have any on the ground data documenting behavior for any of the focal species specific to our project area (we had to rely on studies from other places to help quantify model parameters). Other modeling assessments have relied on setting habitat preference values based on empirical data for species within their study areas. 'Local' empirical data for species use of, and movement within, habitat types in our landscape would greatly improve our ability to select habitat values (Beier 2008). We think these values introduce some of the greatest error.

Sensitivity analysis

To better understand how some of our decisions regarding model inputs impacted the results we conducted two sensitivity analyses based on feedback from the steering committee. Sensitivity analyses try to identify what source of uncertainty weights more on the models outputs. For example, in Figures 19 and 20, we examined the deciduous forest model input for marten. We altered the value of deciduous forest from 50 to 75 (out of 100). This value represents a marten's preference for deciduous forest habitat. Through the literature search and expert interview, we valued the deciduous forest parameter at 50, which resulted in 51 habitat patches (Figure 19). Feedback on the outputs suggested there was more habitat available to martens than the results were showing. We increased the marten's preference for deciduous forest habitat to 75, which resulted in 106 habitat patches (Figure 20). This example illustrates the impact of one model input and reminds us why it is critically important to consider model limitations when interpreting the results.

Figure 19: FunConn Results for Marten - Deciduous Forest Value of 50

Figure 20: FunConn Results for Marten - Deciduous Forest Value of 75



Modeling results – implications for where we work

Modeling results identified two primary linkages (Figure 21). Table 3 summarizes the land cover characteristics of these two linkages. Descriptions of these linkages follow:

Northern linkage: located just south of Fort Drum, this linkage covers approximately 148,000 acres. East of the Black River it remains relatively forested, as it encompasses several large tracts of protected lands (15% of the linkage is protected as state forest). West of the river it is highly fragmented and dominated by residential and agricultural lands. All told, the linkage includes about 300 miles of primary, secondary and local roads.

Despite the patchy land cover in the linkage, credible bear and marten sightings are not unusual. To maintain and improve the condition of this linkage - not only for wide-ranging species, but also for less motile species - increasing the amount of natural cover would need to be part of a conservation strategy aimed at enhancing connectivity. Close to a fifth of all unprotected lands are in ownerships at least 250 acres in size (51 owners). Many of these bigger ownerships are farms. A restoration strategy might include protecting these areas through conservation easements which provide incentives for reforestation---for example, along riparian areas.

Figure 21. Primary linkages resulting from FunConn and least-cost path models.

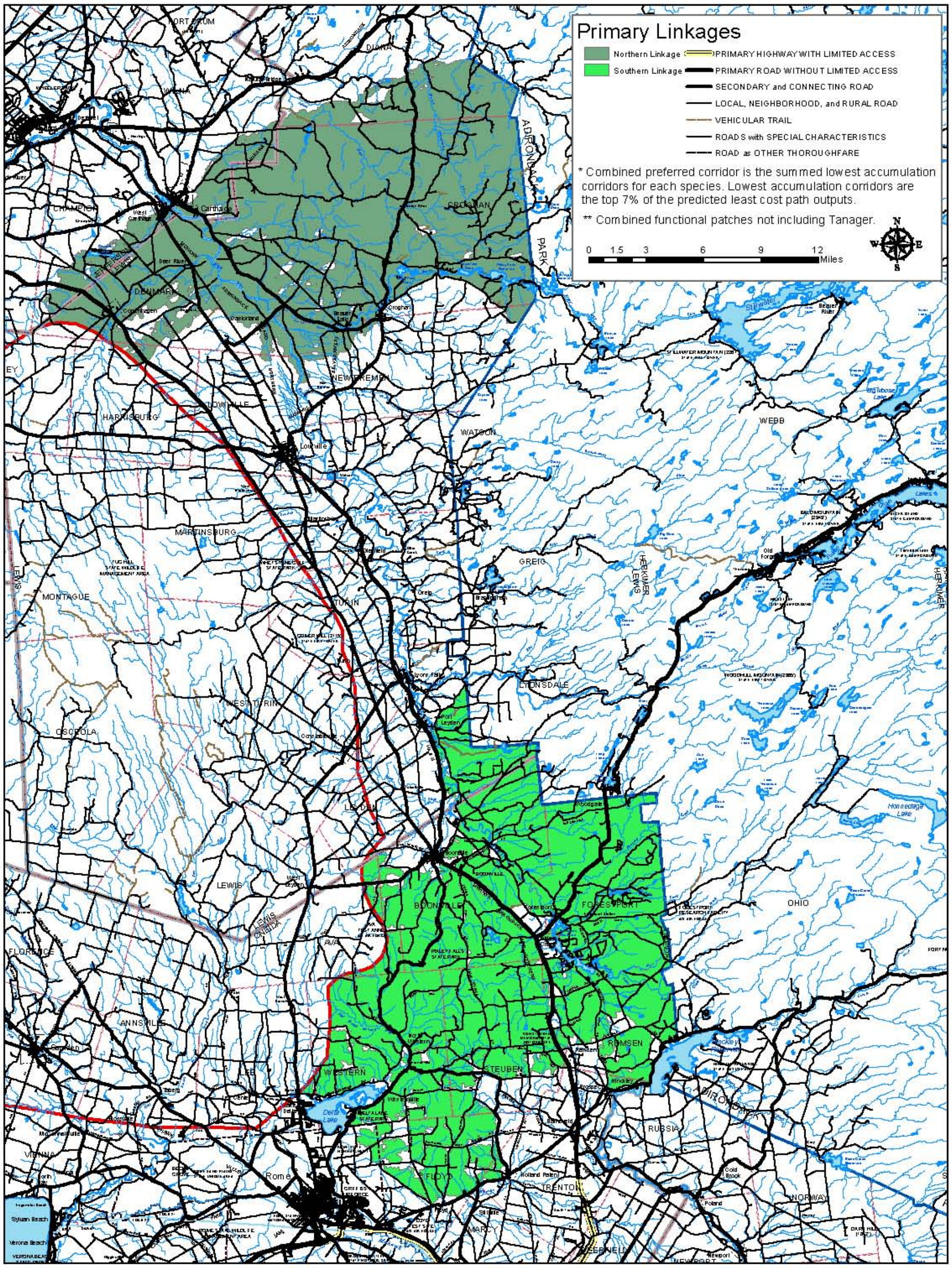


Table 3. Land cover characteristics of the two key linkages

Land cover	**Northern Linkage** *acres (and percent of total area)*	**Southern Linkage** *acres (and percent of total area)*
Total area	148,258	163,084
Natural/semi-natural (forest, scrub, wetlands and water)	118,299 (80%)	145,401 (89%)
Forested	102,110 (69%)	126,664 (78%)
Residential	2,149 (1%)	735 (0.5%)
Agriculture/pasture	27,806 (19%)	16,947 (10%)

The Southern Linkage: covering roughly 163,000 acres this linkage is located primarily within six townships, including Forestport and Booneville. As Table 3 indicates, it remains largely forested. About 11% of the area is protected as state forest and forest preserve. Connectivity may be improved or maintained simply by protecting the existing habitat patches. A land protection strategy targeted at protecting habitat 'stepping stones' across this linkage could be enough to keep this portion of the landscape permeable without expensive restoration work. About 14,560 acres is in private ownerships at least 250 acres in size (41 owners).

One other important strategy would be increasing the 'permeability' of roads to wildlife (i.e. assuring animals can move across roads successfully). This has been done elsewhere by incorporating road crossing structures such as culverts and underpasses, posting warning signs for motorists, and through strategic placement of guard rails and fencing. The linkage includes ~360 miles of public roads, of which 14 miles is classified as primary road (in particular, routes 28 and 12).

Implementation Plan

The focus of our second steering committee meeting was to identify strategies for implementing the results of the connectivity modeling. Four general strategies were identified: land protection, barrier mitigation, outreach, and land use planning.

Protection Strategy: *Develop and implement a protection plan to prioritize parcels for improving or maintaining connectivity in the Black River Valley.*

To accomplish this goal, the following actions were identified:

- Package results so they can inform land protection decision-making. Integrate connectivity modeling results with tax map parcel data and other datasets that can help flag conservation priorities and key land owners to reach out to. Funding permitted, conduct (or contract for) a study projecting future land use change to identify important connectivity areas at greatest risk for conversion.

- Identify opportunities for enhancing both recreational and connectivity objectives through land protection work (for example, greenways that maintain natural cover while providing new hiking, skiing and other outdoor recreational use). This would open new doors in terms of partners and funding opportunities.
- Explore the potential for creating a revolving land protection fund that Tug Hill Tomorrow, The Nature Conservancy and others could tap when opportunities arise within priority areas. At a minimum this could provide a partial match for project costs. We estimate this would require a minimum of $1 million.
- Agency outreach: more is work needed to encourage resource management agencies to incorporate and prioritize connectivity in project work, in particular:
    - Department of Conservation (note that connectivity has been adopted as a new criteria within the Region 6 Open Space Plan)
    - Department of Agriculture and Markets, given their role administering the farmland protection program (there is potential to secure/restore riparian corridors on key farmland tracts).
- Develop model conservation easement standards that specifically address connectivity – this would require an iterative process starting with generic standards, then species-specific standards.

Two observations:

i. Our assumption is that given cost of fee acquisition, a land protection strategy aimed at protecting key habitat 'stepping stones' would focus largely on securing conservation easements with willing land owners.
ii. A land protection strategy would likely focus on the southernmost linkage identified in the modeling analysis, given this is where Tug Hill Tomorrow and The Nature Conservancy are currently active. In order to engage within the northern priority linkages we would need to partner with other groups. There is an opportunity for focused farmland protection program work here.

Potential partners: Tug Hill Tomorrow and The Nature Conservancy

Barrier Mitigation Strategy: *Identify critical road segments for increasing the permeability for wildlife species.*

To accomplish this goal, the following actions were identified:

- Integrate modeling results with NY Department of Transportation's 5-year maintenance plan data to identify priority road segments to focus field assessment work.
- Along priority road segments, collect field data on species movements (winter tracking and collection of road kill data) to identify key wildlife crossing areas. Explore opportunities to enlist volunteer monitors for this work.

- Based on revised results, work with DOT on low-cost barrier mitigation work that can be incorporated through planned routine maintenance – culvert repair/replacement, signage etc.

Potential partners: The Nature Conservancy and NY Department of Transportation

<u>Outreach Strategy</u>: *Create communication pieces to educate the public, decision-makers, and donors on why connectivity is important and where to focus efforts in the Black River Valley.*

This has been described as a 'branding' effort, given limited public awareness about Adirondack-Tug Hill connectivity needs. We discussed key messages and opportunities at our first Steering Committee meeting. These included the need to engage local outdoor recreation interests and promoting connectivity strategies that furthered additional community objectives (for example, 'greenways' that serve wildlife movement while also providing through-trails for hiking, skiing and other recreational uses, where these are compatible).

Potential partners: WCS and Tug Hill Commission

<u>Land Use Planning Strategy</u>: *Integrate connectivity modeling results in local land use planning efforts.*

To accomplish this goal, the following actions were identified:

- Package results so they can inform land protection decision-making. Integrate connectivity modeling results with other datasets that can help flag conservation priorities.
- Develop recommendations on what zoning could do to secure/enhance connectivity
- Conduct outreach and training with town planning boards and officials

Potential partners: Tug Hill Commission, Wildlife Conservation Society, Tug Hill Tomorrow

Each of these strategies requires the integration of the connectivity modeling results with other data to make informed decisions. For example, as we move forward with land protection work outlined above we have begun comparing the two priority linkages with data on protected area location, land ownership and New York Natural Heritage data (see figures 22 and 23). This will help us prioritize where we should focus landowner outreach: for example, favoring large ownerships, especially where these fill gaps between protected areas (to round out habitat 'stepping stones') and where additional protection can address multiple conservation objectives.

Figure 22: Protected lands and private parcels at least 250 acres in size within the two primary linkages.

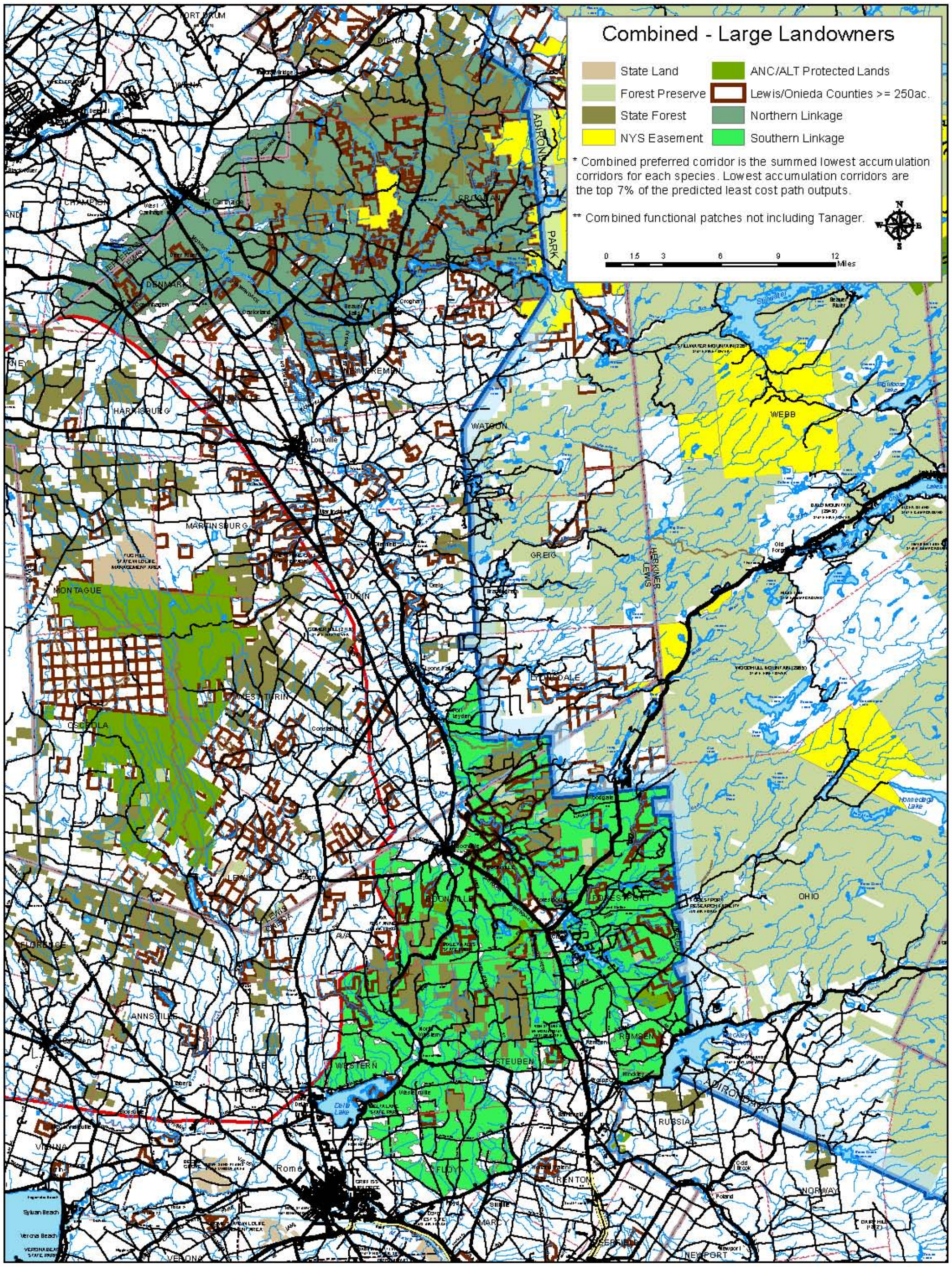
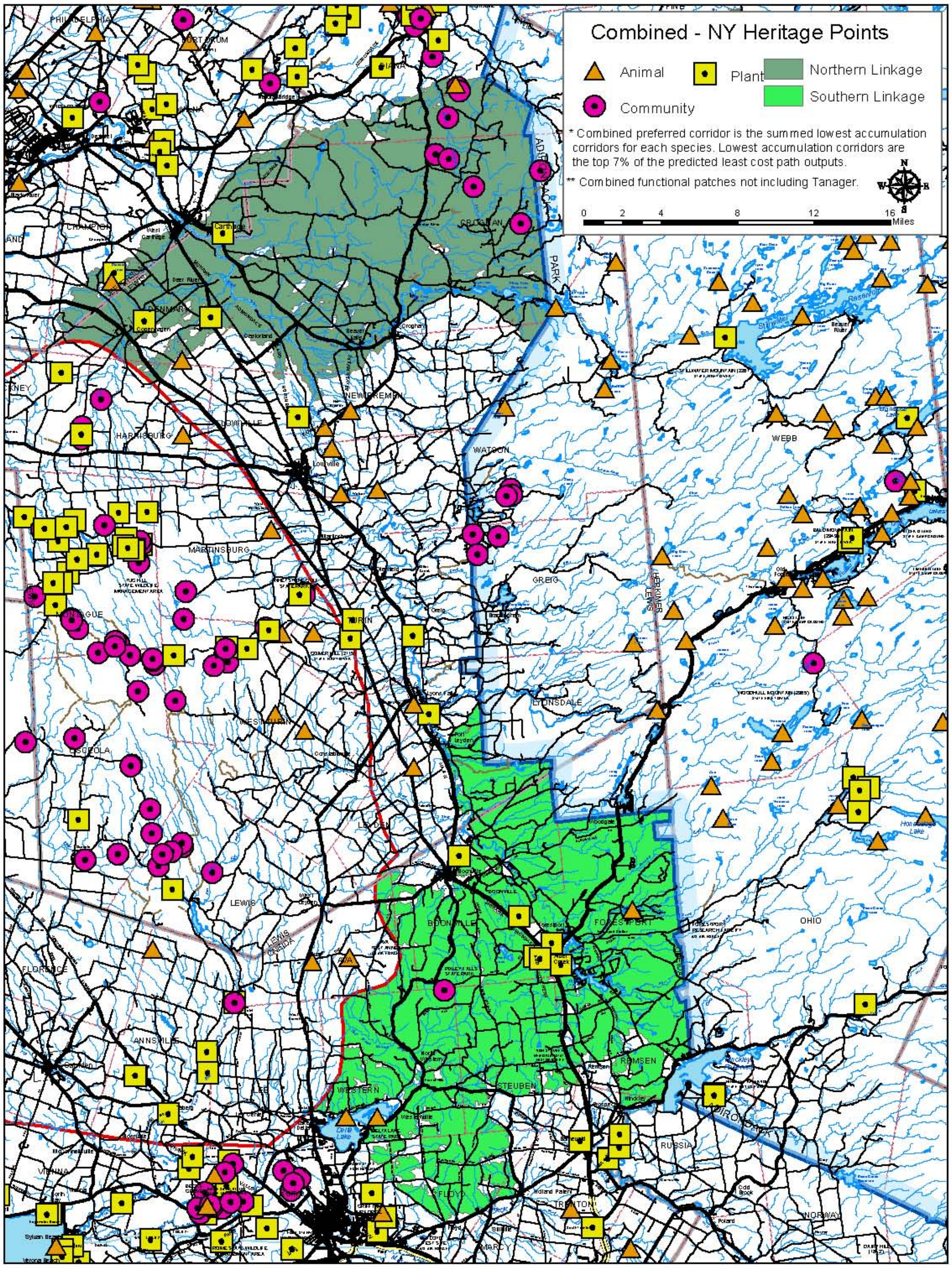


Figure 23: New York Natural Heritage plant, animal and community occurrences within primary linkages.



Next Steps:

Since the September 2008 Steering Committee meeting, TNC has been actively seeking funding for implementation of Adirondack-Tug Hill connectivity work. We have secured $293,900 in funding for this to date, as part of regional connectivity initiative funded by the US Fish and Wildlife Service's State Wildlife Competitive Grants (SWG) Program. That grant includes $$293,900 to implement strategies outlined above within the Adirondack-Tug Hill project area and additional funds for development of tools such as model easement standards and land use planning tools. We expect to leverage an additional ~$480,000 in match (total project costs for implementation were estimated at $774,300 not counting capital costs associated with land protection work).

The SWG funded project will involve TNC, Tug Hill Tomorrow, Wildlife Conservation Society, the Tug Hill Commission, NY Department of Transportation and NY Department of Environmental Conservation. Project objectives and activities are based on results of the spatial modeling work and strategic plan outlined in this document. We are indebted to the Steering Committee and supporters for their help on the connectivity plan, which has resulted in significant funding for implementation work.

Glossary:

Least Cost Terms

Least Cost Path: The Cost Path function determines the path from a destination point to a source. Once you have performed the Cost Distance or Path Distance functions, you can output the least-cost (shortest) path from a chosen destination to your source point. Aside from the destination, the path analysis function uses two rasters derived from the Cost Distance function: the least-cost distance and back link raster. Cost Path uses the back link raster to retrace the least-costly route from the destination to the source over the cost distance surface. (ESRI 2009)

Least Cost Corridors: The Corridor function is another member of the cost path family. Instead of returning an output raster with the least-cost paths, Corridor returns a raster in which, for each cell location, the sum of the cost distances (accumulative costs) for two input accumulative cost rasters is calculated. The sum of the two raster costs identifies for each cell location the least-cost path from one source to another source that passes through the cell location.
You can use the Corridor function instead of the Cost Path function to connect two patches of deer habitat in a conservation plan and want to conserve the optimal corridor for the deer instead of just buffering a single path. To create a corridor, two cost accumulative rasters, one for each source (or set of sources), must be created using Cost Distance (or another cost-surface function that produces an accumulative cost surface). The diagrams below show the cost surfaces being created from a single cell location for demonstration purposes. The procedure actually occurs for each cell location on the input rasters. (ESRI 2009)

Reclass: The reclassification functions reclassify or change cell values to alternative values using a variety of methods. You can reclass one value at a time or groups of values at once using alternative fields; based on a criteria, such as specified intervals (for example, group the values into 10 intervals); or by area (for example, group the values into 10 groups containing the same number of cells). The functions are designed to allow you to easily change many values on an input raster to desired, specified, or alternative values. (ESRI 2009)

FunConn Terms (Taken from FunConn user manual (Theobold 2006)***)***

Cluster: A group of patches that function as a single patch.

Core Habitat Percentage: This value is multiplied by the area of the foraging radius (∏ r2). For lynx, it is {0.1 * (∏ * 9172)}. Any high quality habitat area that is larger than this area is retained as core seeds from which to grow functional patches. The default value is 0.1, which, unless you are performing advanced modeling, you don't need to alter. Increasing this value will reduce the number of seeds by increasing the minimum size requirement.

Core Seed: An area of high-quality habitat from which the functional patches originate. From the seed, the patches are 'grown' across a cost surface to a distance equal to the units of the foraging radius. See Define Functional Patches tool.

Corridor: A representation of the optimal movement pathway between adjacent habitat patches. Corridors have a one-to-many relationship between node pairs; one corridor can connect several patches. The geometry of the corridors reveals potential geographic "bottlenecks" or other shape characteristics that might enhance or inhibit the traversability of a habitat network.

Edge: While the two definitions for 'edge' are similar, the second is specific to the FunConn Tools.
1) In graph theory, edges connect adjacent nodes. See graph definition.
2) The edges generated by the FunConn Tools are stored within the Landscape Network connect nodes centroid-to-centroid, are not straight-line, and have a one to many relationship with node pairs (multi-edge). Also, each edge is represented twice in the relationship table to account for directionality. The Landscape Network edges contain the following attributes: edge length, effective distances, centroid-to-centroid angle, and mean angle vector.

FunConn: (pronounced 'funkin') Is an ArcGIS modeling toolbox created by Colorado State University which provides graph theoretic-based analysis methods for landscape connectivity. The set of tools offers more flexibility and efficiency to traditional least-cost path approaches.

Graph: A graph is a data structure comprised of a set of points (nodes) functionally joined by lines (edges). The set of nodes is typically defined as V(G) = {v1, v2, v3, ….vp} and the edges as E(G) = {e1, e2, e3, …eq}. Therefore, the graph G has p nodes (order) and q edges (value): G(p,q). Edge eij connects adjacent nodes vi and vj. In this application, nodes represent habitat patches and edges represent lines of movement. For classic literature on graph theory, refer to Harary's 1969 text, Graph Theory. Otherwise, Urban and Keitt (2001) provide a comprehensive overview of the application of graph theory to landscape ecology. A basic understanding of graph terminology is helpful before using FunConn.

Landscape Network: A Landscape Network is a type of graph that recognizes spatial context and relationships with additional geographic information. The data structure of a Landscape Network is stored within a ESRI personal geodatabase. Landscape Networks have four distinguishing features (Theobald 2005):

1. The Landscape Network stores both the topology of a graph and the geometry of the nodes and edges (possibly multi-edges).

2. Nodes represent functionally-defined patches that represent an organism's behavioral response to landscape structure: size, shape, quality, directionality between nodes.

3. Effective distance is an attribute of an edge; multiple-pathways can be unique edges.

4. Planar graph algorithms allow for important responses to be modeled, such as an organism's use of 'stepping stones' while moving between primary patches.

Linkage: Linkages are the least-cost pathways between patch edges defined by cost allocation boundaries and a certain threshold that allows for multiple-linkages to be defined. This threshold is set through the qn value which is user-defined in the Create Landscape Network tool. Also, each linkage is represented twice in the relationship table to account for directionality.

Minimum Patch Size (ha): This threshold is the smallest biologically relevant patch size for the target organism. It may be based on known home range sizes or by estimating home range size using allometric relationships between body mass and home range size (Jetz et al. 2004). To ensure that the full range of possible home range sizes is covered, we recommend running the model at an order of magnitude less than and greater than the estimated home range size. The minimum patch size for the example lynx is 264 ha.

Model: The definition of a 'model' depends on its context: 1) Simulation of a process or response at a given scale. For example, lynx natal dispersal across a landscape, i.e.: lynx habitat model. v., modeling. 2) In ArcGIS geoprocessing, a process or series of linked processes represented by a flow diagram in Modelbuilder.

Node: In a graph, a node is a point functionally connected to other points via edges. Nodes are stored in the Landscape Network as a point feature class. However, patches defined by a polygon feature class can also serve as nodes in the FunConn Landscape Network Analysis tools.

Patch: A habitat area functionally defined by habitat quality, size, and proximity constraints. In a traditional graph, patch centers serve as the nodes connected by straight-line edges. In a Landscape Network, the patches are stored as a polygon feature class, and linkages originate at the patch perimeter.

Patch/Foraging Radius: This user-defined parameter is the distance that an animal moves on the landscape seeking out forage, and is influenced by the organism's perceptual ability. Map units are typically in meters.

Path: A walk in which all nodes and edges are unique. If a path has more than 3 nodes, with no cycles, it is a tree.

qn Value: Specify the n value: the cost allocation values that fall in the nth percentile. For example, if you specify q10, the values falling in the lowest 10th percentile, or .10 quantile, will be used to assemble the initial linkages between patches. This choice will change the number of linkages generated between patches, however it can be counter-intuitive. That is, more linkages might result from using a value of q10 than a value of q20. Here's why: From the patches, allocation zones are grown outward across the cost surface until the meet. The area where zones meet is the allocation boundary, which is actually 2-cells wide. Each boundary cell location has a cost value associated with it. Collectively, they form a distribution of cost values along the allocation boundary. q10 is the lowest 10% of the cost values, q20 is the lowest 20% of cost values, and even though q20 includes the q10 cells, fewer groups might be formed after regiongrouping.

Resource Quality Threshold: The resource quality threshold is the minimum habitat quality value acceptable to the target organism to define patches. The threshold value will typically fall near 75-80 (range 0-100), and is based on the QUALITY values from the Resource Quality Reclass Table. The default value is 75 and represents a minimum habitat quality of 75% acceptability to the organism, where 100% is the best possible habitat. This does not mean that any land cover cell that is below the threshold will be eliminated (see next paragraph).
The resource quality threshold is used twice in the Habitat Modeling processes. The first use establishes the primary habitat areas from which to base smaller 'stepping-stone' habitat areas and ultimately the seeds for defining functional patches. While you are setting a threshold for retaining areas of a certain habitat quality, areas of lower habitat quality will not be eliminated until their relationship (based on distance) to the primary patches is evaluated. This is done through the patch structure reclass table.

Walk: A sequence of nodes connected by edges. If a walk ends at the first node, it is a cycle.

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Appendix 1: Focal Species Selection Table

	Bobcat	Marten	Black bear	Otter	Moose	Lynx	Wolf	Cougar
Extant wide-ranging species – terrestrial	X	X	X		X			
Extant wide-ranging species – aquatic				X				
Extirpated wide-ranging species						X	X	X
Keystone species		X		X		X	X	X
Foundation species					X			
Umbrella species	X	X	X	X	X	X	X	X
Habitat specialist		X		?		X		
Sensitive to human disturbance (e.g. road density over given threshold) - LOW, MED, HIGH	MED	MED	LOW/MED	MED	LOW	HIGH	HIGH	HIGH
Vulnerable - NY Species of Greatest Conservation Need		X		X		X	X	X
Information availability - LOW, MED, HIGH	MED	HIGH	HIGH	?	MED	MED/HIGH	MED	LOW
Social acceptance - LOW, MED, HIGH	MED	MED	MED	HIGH	HIGH	MED/LOW	LOW	LOW

Appendix 2: Model Methodologies

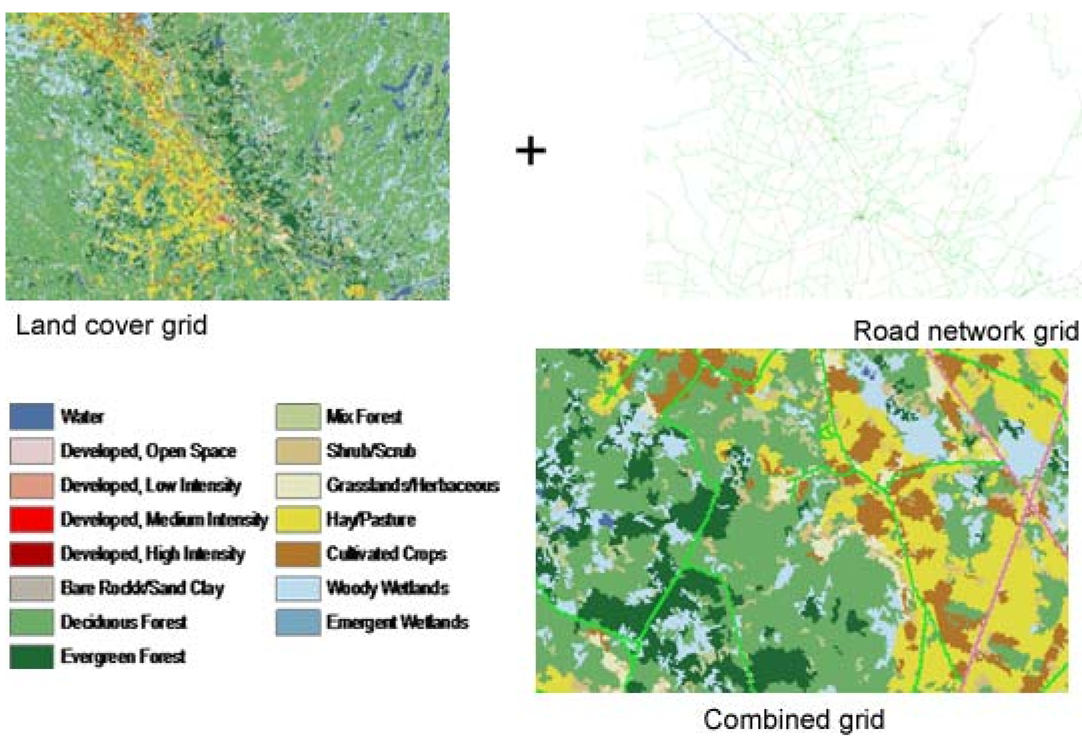
Least Cost Path:

Least cost path is a raster function that finds the route from an origin to a destination that accumulates the least amount of cost. This route is based upon an input cost raster that defines the weighted distance from a point or points of origin. In the case of our species based grids this cost raster is the amount of preference/low friction or the barrier/high friction when moving across the surface. A least cost corridor is the summation of the cost distance rasters traveling in both directions (east to west and west to east) across the surface. The corridor grid will then show areas where the cost surface has the lowest accumulated values across the surface.

Methods:

The first step with any least cost path analysis is to create a cost grid. For each of our seven species we combined US Geological Survey National Land Cover Database (NLCD) land cover, USGS Digital Elevation Models and New York State Accident Location Information System (ALIS) transportation layers to create a new grid layer. We then, specific to each species, assigned new values to each pixel according to how each species may prefer a particular type of land cover. Figure 1 shows the initial combination of land cover and road networks

Figure 1: Addition of land cover and road network grids



The combined grid then has the values shown in Table 1 for each new unique grid value.

Table 1: Grid Values for Combined Grid

GRIDCODE	DESCRIPTION
21	Developed Open Space
31	Bare Rockk/Sand Clay
41	Decid Forest – Low
42	Ev Forest – Low
43	Mix Forest – Low
52	Shrub/Scub
71	Grassland/Herbaceous
81	Hay/Pasture
82	Cultivated Crops
90	Woody Wetlands
95	Em Wet – Low
10000	Open Water – Small
20000	Open Water – Medium
30000	Open Water – Large
90001	Highway
90002	State Route
90003	County Road
90004	Large Street
90005	Residential Street
90006	High Intensity Developed

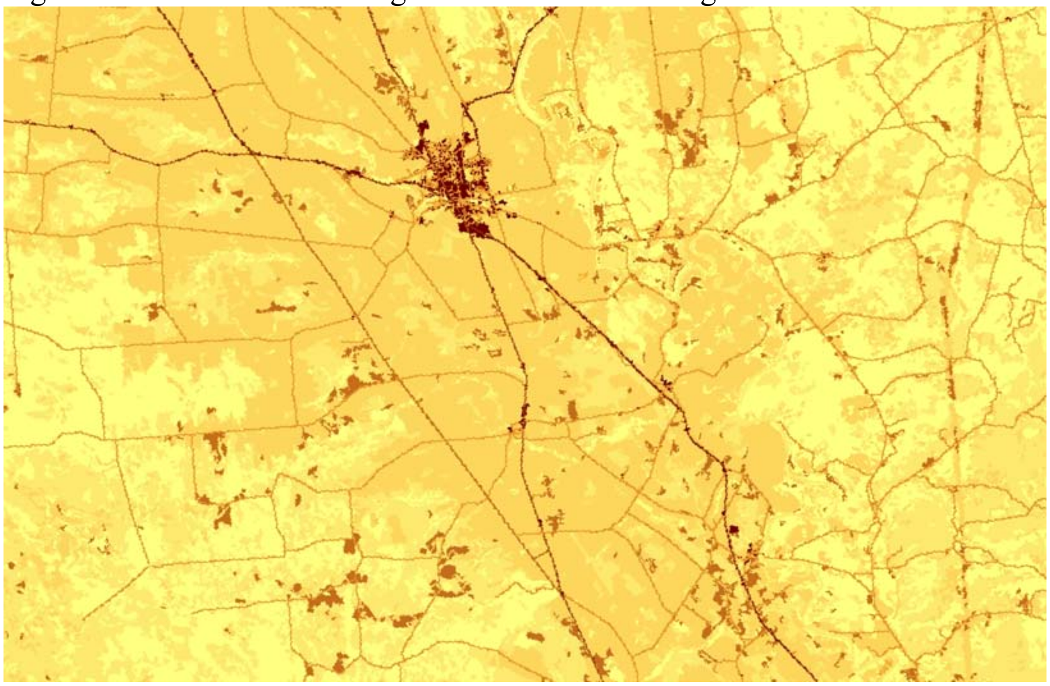
Once we had our grid completed the grid codes were reclassed to represent our cost values. The lower the cost value the easier/more preferable the habitat type. The following table displays the cost value with the grid code for marten.

Table 2: Cost Values for Marten

GRIDCODE	DESCRIPTION	Cost Value
21	Developed Open Space	4
31	Bare Rockk/Sand Clay	5
41	Decid Forest – Low	2
42	Ev Forest – Low	1
43	Mix Forest – Low	1
52	Shrub/Scub	3
71	Grassland/Herbaceous	7
81	Hay/Pasture	3
82	Cultivated Crops	3
90	Woody Wetlands	1
95	Em Wet – Low	1
10000	Open Water – Small	2
20000	Open Water – Medium	3
30000	Open Water – Large	5
90001	Highway	10

90002	State Route	9
90003	County Road	8
90004	Large Street	7
90005	Residential Street	6
90006	High Intensity Developed	10

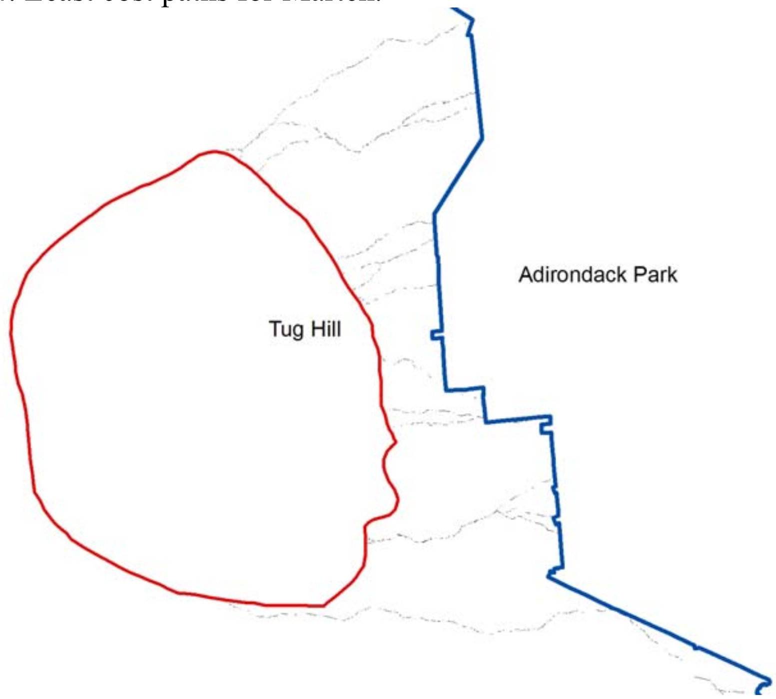
Figure 3: Marten Cost Grid Light lower cost – Dark higher cost



In order to calculate a path over the grid a source and a destination for each species in the study area must be defined, and these need to extend in both directions (west to east and east to west). A cost distance and back link grid were created for our eastern source locations for each species. The cost distance calculation finds the distances from a source across the grid that accumulates the least amount of cost over that distance. The back link cost raster allows the tracking (by direction) of the neighbor cell that is the next cell on the least accumulative path to the nearest source.

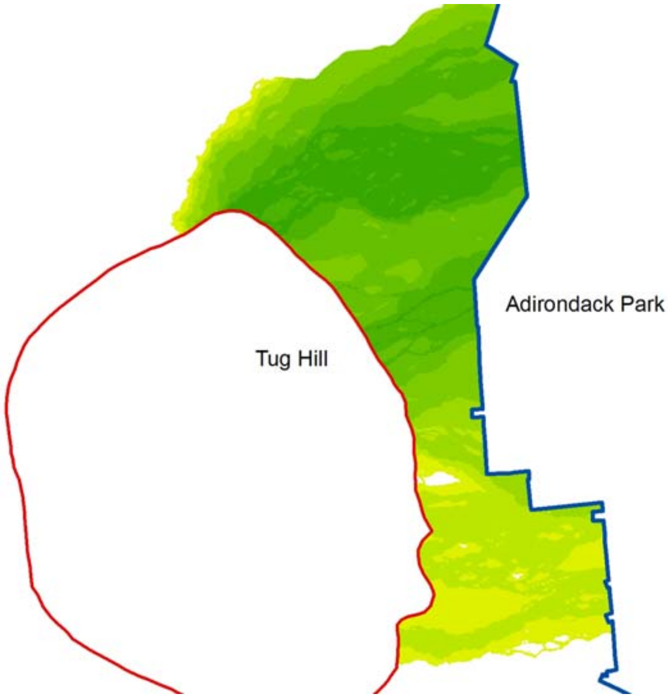
Once the distance and direction grids were created from the source, a path was defined to a destination. The destination, like the source, can be a single point or many points that make up a line. Because we are interested in the animals traveling in both directions across the grid we made a second distance and direction grid to find paths going the opposite direction. The graphic below displays the least cost paths defined across the focus area within our study site.

Figure 4: Least cost paths for Marten.



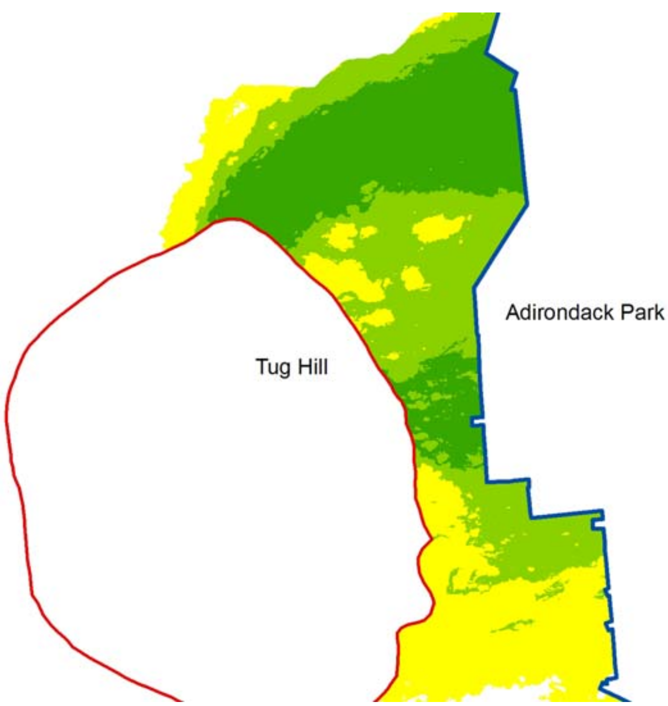
The final step in our least cost analysis was applying the corridor function. The corridor is the summation of the two distance grids we created. This grid shows a gradient of areas of least cost accumulation. We examined the accumulation values to identify the appropriate places to break the data into categories. This was necessary to enable easier interpretation of the data. We found that using a 15 class quantile classification worked best to distribute the accumulation values for our purposes, but this break can be changed to illustrate smaller or larger preferred areas based on objectives. The grid below shows the distribution of values where the darkest green represents the top 7% of the least accumulated distance for the marten to the reds that display the maximum accumulated distance. In other words, according to our model and analyses, marten may prefer the habitat in the green to other places in the study area.

Figure 5: Least cost corridor for Marten



These “preferred” places for each of the seven species were combined to display the areas of highest ease of movement to cross the Black River Valley.

Figure 6: Top preferred corridor for all species.



FunConn Methodology:

FunConn is an Arc Info Toolbox and offers graph theoretic based tools for modeling landscape connectivity. The toolset we used was the habitat modeling which allowed us to build a model from our existing datasets and interviewing experts. The tools include creating a habitat quality raster, functional patches and a landscape network. The advantage of this model is that it: 1) assesses the landscape based on animal perception; 2) provides graph theoretic-based methods to evaluate landscape-level connectivity; and that: 3) graph theory considers all habitat patches and distance/barriers between them to identify most important connections and patches.

Methods

To begin the analysis we needed to create a number of base layers and tables used for reclassing the intermediate grids. The spatial datasets necessary to begin the analysis are a land cover dataset such as the National Land Cover Database (NLCD) and a second land cover layer with disturbance barriers such as roads that impact the species ease of movement across the landscape.

The other necessary inputs are a group of reclass tables used during the analysis process. Reclass tables are simply the tables containing the input values like habitat preference or home range size. These values were determined through literature and expert interview.

The first input was the Habitat Quality reclass table determining the quality of habitat for each of the land cover types. The marten habitat quality table is shown below:

Table 1: Habitat Quality reclass table for marten.

GRIDCODE	DESCRIPTION	QUALITY
11	Open Water	10
21	Developed Open Space	30
22	Developed Low Intensity	20
23	Developed Med Intensity	20
24	Developed High Intensity	0
31	Bare Rock/Sand Clay	0
41	Deciduous Forest	50
42	Evergreen Forest	100
43	Mixed Forest	90
52	Shrub/Scub	30
71	Grassland/Herbaceous	0
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	30
95	Emergent Wetlands	10

The next two inputs addressed the resource quality threshold and minimum patch size. We kept the default threshold of 75 for the habitat quality which does not eliminate values below that number, rather it simply defines where the primary areas should be established. The next input was the minimum patch size. This is “the smallest biologically relevant patch size for the target organism.” This value could be the home range size or a relationship of body mass to home range size. We tested the results using an order of magnitude above and below our expert-derived parameters to understand the effect of the minimum patch size input on the model results.

The patch structure reclass table helped to define how the species will respond to a patch. The values in this table can vary widely by species, for example when one species prefers core areas versus others that prefer the edge of a patch. Marten are an edge negative species so the habitat quality levels drop as the animal reaches and goes beyond the edge of a patch. The table below displays our inputs for marten:

Table 2: Patch structure relass table for marten.

FROMVAL	TOVAL	QUALITY
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	75
-50	0	50
0	10	35
10	50	30
50	100	25
100	200	10
200	300	0
300	400	0
400	500	0
500	750	0
750	1000	0
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	0
5000	7500	0
7500	10000	0
10000	999999999	0

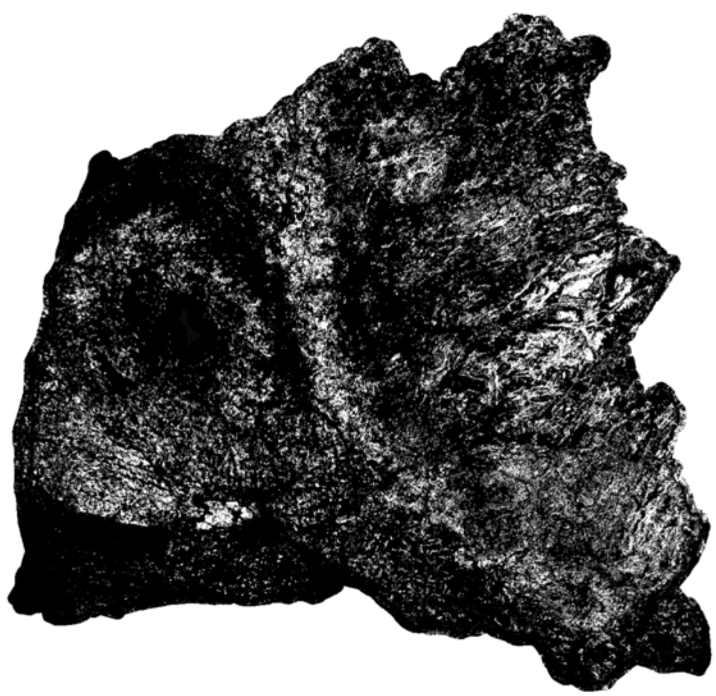
The habitat quality function also required a disturbance raster and reclass table. The disturbance raster is the land cover raster with disturbances embedded into the grid. In our model these disturbances captured roads and areas of high development. The reclass table was used to address the impacts of these disturbances at a variety of distances. Values in the table range from 0 (total habitat loss) to 100 (no habitat loss) and are shown at increasing distances for each disturbance. Our table below displays the roads (90001 – 90005) of decreasing size and high development (90006):

Table 3: Disturbance reclass table for marten.

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0.0000
0	10	0	1	5	5	25	0.0000
10	50	1	2	25	25	75	1.0000
50	100	2	10	50	50	90	2.0000
100	200	10	25	75	75	100	5.0000
200	300	25	50	90	90	100	15.0000
300	400	50	75	100	100	100	50.0000
400	500	60	80	100	100	100	60.0000
500	750	75	90	100	100	100	75.0000
750	1000	90	100	100	100	100	90.0000
1000	1500	100	100	100	100	100	100.0000
1500	2000	100	100	100	100	100	100.0000
2000	3000	100	100	100	100	100	100.0000
3000	4000	100	100	100	100	100	100.0000
4000	5000	100	100	100	100	100	100.0000
5000	7500	100	100	100	100	100	100.0000
7500	10000	100	100	100	100	100	100.0000
10000	999999999	100	100	100	100	100	100.0000

The output grid for habitat quality has a value range from 0 – 100 of increasing habitat quality. The figure below depicts the marten habitat quality grid:

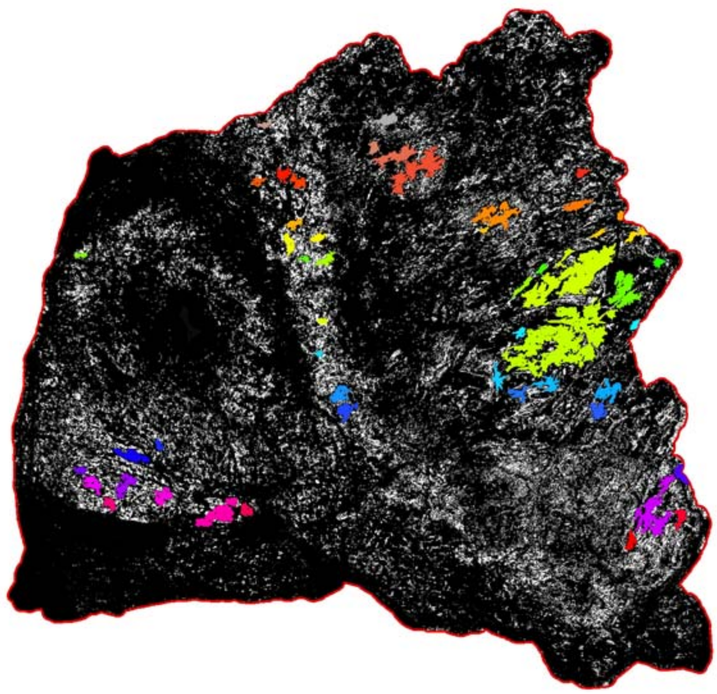
Figure 1: Habitat quality grid for marten. Values of quality range from 0(light) – 100 (dark).



The habitat quality raster provided our first input in implementing the second step of the habitat modeling process. The other inputs for this function were the minimum patch size, patch/foraging radius, core habitat percentage and the resource quality threshold. The patch/foraging radius is defined as the distance an animal moves in search of food on a daily basis. Core habitat percentage was multiplied by the patch/foraging radius and was used for seeds in creating functional patches.

The functional patches from this analysis totaled 51 unique polygons. The graphic below shows the output over the habitat quality grid to get an understanding of how there may be good quality habitat but due to the patch size and foraging distance may not be enough to be a functional patch:

Figure 2: Functional patches for marten. Colors represent individual patches.

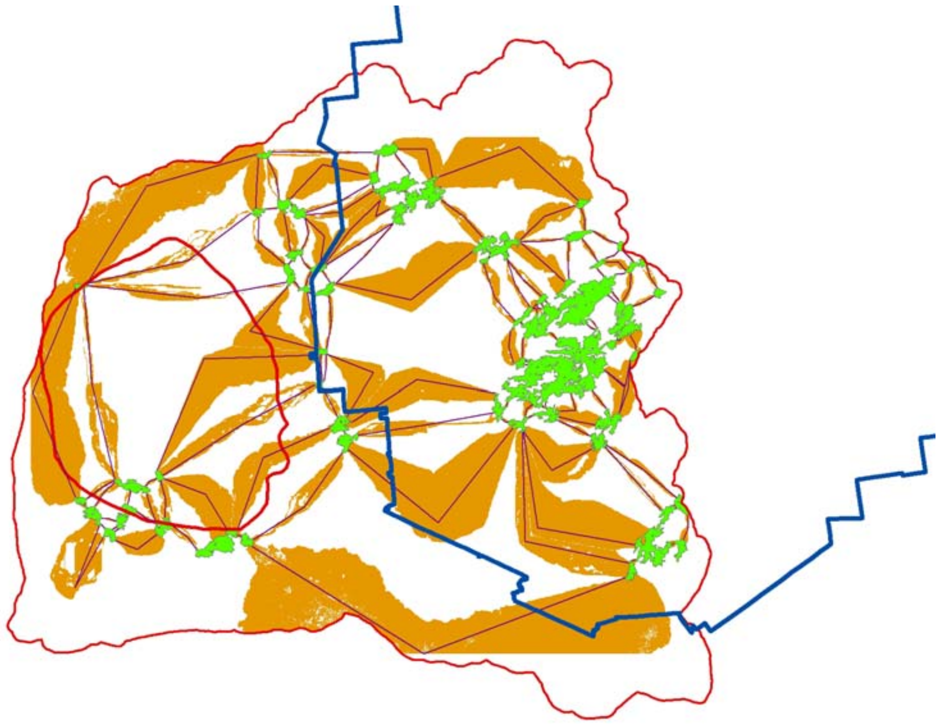


The final tool we used in this suite is the Build Landscape Network. The tool uses the functional patches as source areas and the land cover data as the friction surface. The landscape network produces a Geodatabase containing nodes, patches, edges, linkages, corridors and relationship tables. In order to run this tool we supplied a permeability table to reclass the land cover dataset. This table defines how easily an animal can move through a particular land cover type.

The last value supplied is the n value for the cost allocation that fall in the nth percentile. We used the default of 10 which uses the lowest 10^{th} percentile of the cost surface. This number affects the number of linkages generated between each patch.

The final output for marten is below. The corridors are depicted in orange connecting the functional patches shown in green.

Figure 3: Final output for marten. 51 functional patches(green) which totals 198,000 acres.



Appendix 3: Species Profiles

Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

American Marten (*Martes Americana*) Profile

Habitat Preferences

- In Broquet et al's (2006) least cost model in Ontario, forest of any kind was considered the preferred habitat type and given a friction value of 1. All other habitats were assigned a friction value of 50, except for narrow elements (riparian/riverine and roads), which were given an intermediate value.
- Marten prefer older forests, mixed or softwood, with hollow trees and logs for denning (Chapman 1991).
- During leaf-on, martens selected against regenerating forests and for second growth or partially harvested stands; during leaf-off martens use more second growth and less partially harvested stands (Fuller and Harrison 2005)
- Marten are positively associated with snowfall, though there is a threshold at 3000mm/year (Carroll 2005)
- In Maine marten are associated with frequent (6.5/month) and deep (>48cm/month) snowfall, possibly because of competition with fisher in less snowy environments. Few adult marten were harvested in core fisher habitat (Krohn et al 1995).
- Vertical and horizontal structure may be more important than stand age or species composition (Chapin et al 1997)

Disturbance Sensitivity

- In a winter study, Robitaille and Aubry (2000) found that marten tracks are more common and denser 800 – 100m from roads than 300 - 400m from roads.
- In Utah martens respond poorly to habitat fragmentation, even when forest connectivity is still present; Martens were nearly absent from landscapes with >25% non-forest cover, even with connectivity (Hargis et al 1999).
- Marten were found more frequently in larger forest patches (median = 27ha) than smaller patches (median = 1.5ha), ,patches that were closer to the nearest patch larger than 2.7 ha (38 m versus 55 m; p = 0.057) and to an adjacent forest preserve (2.5 km versus 3.5 km; p = 0.075) (Chapin et al 1998)
- Martin will use road crossing structures, especially as the noise associated with the road increases (Clevenger et al 2001)
- Martens avoid openings, especially in the winter though some small openings are predicted to be beneficial b/c of increasing prey abundance (Hargis et al 1999).

Movement and Home Range

- Male Home Range—Leaf-on with partial harvest: 4.33 km2; Leaf-on without partial harvest: 4.42km2; Leaf-off with partial harvest 6.29 km2; Leaf-off without partial harvest 3.45 km2. Female Home Range—Leaf-on with partial harvest: 2.76 km2; Leaf-on without partial harvest: 2.65; Leaf-off with partial harvest: 3.10 km2; Leaf-off without partial harvest: 1.70 km2 (Fuller and Harrison 2005)

- Burskirk et at (1989) have a summary of mean home range size for marten from 11 different studies that showed female sizes were fairly consistent but male home range size varied.
- Maximum dispersal distance = 40km (Carroll 2005)
- Daily movements of 22 km and dispersal movements of 163 km have been recorded, however reintroduced populations expand 8 – 16 km/decade (Broquet et al 2006)
- Mean dispersal distance in as season in Ontario was 5.14 km in a logged and 5.11 km in an unlogged landscape (Broquet et al 2006)
- Foraging - Not specific, but Hagis et al (1999) found that although prey densities were highest in clear-cut areas, marten captures were not correlated with prey abundance.

Mortality and Fecundity

- .32 (poor year) - .87 (good year) survival rate for year 1 young; .87 (good or poor) survival rate for subadult/adult > 1 year; .40 (good or poor) survival rate at senescence, > 7 years (Carroll 2005)
- Do not reproduce until >2 years of age at which point fecundity rates are .93 (poor year) – 3.3 (good year). When females are >7 years fecundity rates drop to .32 (poor year) - .87 (good year) (Carroll 2005)
- Median age of martens in Main population was 2 (Fuller and Harrison 2005)

NYS History

- Marten, mostly of the boreal forest, are limited to the central mountains in the Adirondacks. The Adirondack population is the southernmost population known and are separated by over a hundred miles from other martens to the west and north (Jenkins 2004)

Additional Considerations

- Range: Boreal forest species
- Use of study area resources: Prey on small mammals, so small mammal density is a key factor in population success (Fuller and Harrison 2005)

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Black bear (*Ursus americanus*) Profile

Habitat Preferences

- Hammond 2002: In New England, beechnuts are held to be the most important food in the fall (citing Schooley 1990, McLaughlin et al, 1992). Bears also eat crops like corn, and these populations are more productive and individuals are heavier (citing McLaughlin 1998). At Stratton Mountain in Vermont, the mean elevation of telemetry observations of black bears was 626m in spring, 607m in summer, 660m in fall, and males tended to be found at slightly higher elevations in summer and fall. The three food items for bears in Vermont which were consistently available and heavily utilized were *Carex gynandra,* Jewelweed, and Jack-in-the-pulpit. The first two are found in wet, disturbed sites and the third is found in moist, mature hardwood forests at lower elevations and deeper soils. It also is associated with disturbance of soils and soil hydrology. When available, beechnuts, red oak acorns, apples, and berries of various species where preferred food items. In other parts of the eastern US, skunk cabbage and squaw root are important foods.
- Black bears are regarded as a species that has the ability to adapt to anthropogenic changes in the landscape. Bears are usually regarded as a "landscape species", or a species that requires a mosaic of habitats that feature the interspersion of various vegetation associations, rather than a specific type of vegetation (Rodgers and Allen, 1987; Schoen, 1990).
- Given the differing patterns of human land use in suitable black bear habitat in North America, black bear populations have apparently developed localized behavioral patterns in response to human land use patterns and hunting pressures. Moreover, since some behavioral attributes with respect to how bears respond to humans and human-related landscape alterations are learned, these attributes can change over time in accordance with changes in hunting pressures and landscape alterations.

Disturbance Sensitivity

- Hammond 2002: On Stratton Mountain, 7/13 female bears had home ranges with both seasonally occupied homes and year-round homes. Nearly all males had both types in their range. Adult males generally had 1.64 houses/km^2 and 0.61 km roads /km^2 in their home range. Adult females, 3.53 houses/km^2 and 0.84 km roads/km^2. Subadults, 3.80 houses/km^2 and 0.92 km roads/km^2. Adult bears demonstrated significant avoidance of houses of all types, to varying degrees, at all times during the year. Avoidance of the houses was about 400m.
- Hammond 2002: Stratton Mt VT, barriers include heavy vehicle traffic, fences, open landscapes, steel guardrails, and clustered houses.
- Hammond 2002: Recommends a quarter mile buffer to protect high-quality bear habitat, and a half mile buffer for beech stands receiving intense bear use.

- Hammond 2002: Vermont: major highways (i.e. Rt 7, 9, 11) did not act as barriers for most male bears. Roads were crossed to gain access to crops and edge plants. Female bears also would undertake travels but stopped at highways and did not cross. Females were observed to travel away from their home ranges in a direction that took them away from the highway. Class 1 roads, paved with more than 1000 vehicles/day seemed to be hard barriers for females and semi permeable/partial barriers for males.
- Kasworm and Manley 1990: In northwest Montana black bears avoided habitat that was within 274m of open roads. Trails had less impact on habitat choice than roads for black bears.
- Hammond 2002: In the Stratton Mountain study (VT) bears do not cross roads at random, but seem to choose selected points. These sites primarily were forested on both sides, had dense concealment cover, nearby food patches, on road curves, and where roads intersected wetlands, streams, or ridge tops.
- While most literature points to the negative influence of roads on bear habitat and restriction of home ranges, there is some ambiguity over the exact influence of roads on bear populations. Bears have been documented using roads for travel lanes, and foraging on the numerous roadside fruiting plants in late summer and autumn (Manville, 1983), and may also be important habitats for bears that frequently use them (Hellgren et al. 1991). Female bears in Maryland avoided only highways, but were less impacted by roads of other classes (Fecske, 2002). In Vermont, roads are considered to be the most important landscape feature that impedes the movement of bears (Doug Blodgett and John Austin, pers. comm.). In particular, bears (almost all females and some males) appear to avoid crossing high-volume roads, and cross only in specific locations that appear to feature certain vegetative attributes that make a given location an attractive crossing opportunity. Roads that surpass 1000 vehicles/day appear to elicit avoidance behavior in Vermont bears (Hammond, 2002; Doug Blodgett, VT F&W, pers. comm.). Road crossing is a deliberate act, and bears learn to cross roads in specific locations that feature specific attributes that cover that facilitates crossing. This alone is considered the single most important feature in assessing habitat connectivity for black bears in Vermont, and is a key piece of data that is used to perform landscape scale assessments of bear habitat in the state (John Austin, VT F&W, pers. comm.). Large lakes and rivers do not appear to be hard barriers to bears. Black bears have been observed regularly swimming across the southern portion of the Hudson River (Dick Henry, pers. comm.).
- The tendency for bears to seasonally shift habitat with respect to food availability is well documented in a broad range of geographical areas (Amstrup and Beecham, 1976; Grenfell and Brody, 1986; Hellgren et al, 1991; Jonkell and Mc Cowan, 1971; Kelley house, D. G. 1980; Lindzey and Meslow, 1977; Meddleton and Litivaitis, 1990; Pelchat and Ruff, 1986). In areas proximate to the Southern Lake Champlain Valley (southern Quebec), early successional stands that produced soft mast and beechnuts were correlated with home ranges of female black bears (Samson and Huot, 1998). In another Quebec study, black bears tend to shift habitat use in accordance with seasonal food availability, and tended to avoid mature hardwood stands where little food was available (Boileau *et al*

1994). In the central Adirondacks, bears selected habitat based on seasonal food availability, from managed timberlands in the spring and summer, to non-managed hardwood stands and uneven aged managed stands in the fall (Costello, 1992). In Vermont, shifting patterns of food availability between years can cause different annual patterns of habitat use (Hammond, 2002). In general, Vermont bears consumed a large variety of food items, but few food items were consistently abundant enough to be considered of major importance. When available, late summer and fall foods sought after by bears were beech and red oak mast, apples, black and choke cherries, blackberries, raspberries, mountain ash berries, blueberries, and shad berries. Spring food items were limited to a particular species of sedge (*Carex gynandra*), along with various leaves, grasses, roots, and nuts, foods which were located in a variety of habitats within the study area. Many spring foods were abundant on disturbed wet sites (log landings, skid trails, beaver dams, artificial wastewater treatment wetlands) (Hammond, 2002). In Massachusetts, bears relied on skunk cabbage growing in wetland areas for spring foraging (Elowe, 1984, 1989).

- Black bears on a densely roaded military reserve preferred to cross roads during low traffic volume times. Black bears preferred to cross at major drainages and at areas of dense vegetation (Forman 2003).
- Among roads that black bears negotiated, low-traffic-volume roads were crossed relatively more frequently than high volume roads. Also - the frequency of road crossing was not affected by age, sex, or season (Forman 2003).

Movement and Home Range

- Hammond 2002: home range size is dependent on food availability (citing Garshelis and Pelton, 1981), and most studies have observed large range changes due to the variable fall hard and soft mast production. Vermont: median home range size of adult females was 36.2 km^2, and ranged from 12.4 to 72.6 km^2. Adult males had a mean range of 158.1 km^2, with the largest observed at 391.5 km^2. Greatest range sizes observed in a year with poor food production. The greatest straight line distance travel, >27.5 km, was observed in this low food year.
- Smith and Pelton 1990: in Arkansas, in a study of home range sizes for a variety of age classes of both genders, the largest mean home range (103 km^2) was held by male, subadults during the summer.
- Black bear home ranges vary substantially with respect to food availability and sex. In the central Adirondacks, mean home range size for male black bears was 170 km^2 for males and 31 km^2 for females (Costello, 1992). In one Vermont study adult male home ranges averaged 158 km^2, while females averaged 36 km^2 (Hammond, 2002). In western Nevada, home ranges for males in wildland habitats averaged 519 km^2, while bears living in urban-interface habitats had home ranges that averaged 52 km^2. The differences in female home range size for wildland versus urban-interface bears were less than males: 55 km^2 for urban-interface females vs. 173 km^2 for wildland females (Beckman and Berger 2003). On the Gaspe Peninsula in Quebec, summer home ranges averaged 125 km^2 for

males and 47 km^2 for females (Boileau et al 1994). Female bears in the Ozarks had a mean home range diameter of 6.7 km (Clark 1991).

- Sub-adult males typically disperse from family groups, and their proclivity to move long distances is well known. Schwartz and Franzmann (1992) observed that 100% of sub-adult males dispersed away from the habitat occupied by their mothers. In a six-year Vermont study, sub-adult males moved between 3.6 – 27.1km away from their home range (Hammond, 2002). In New York, one sub adult male captured in Rockland County, NY moved 49 miles northwest, and several months later was recaptured in Westhaven, CT, 115 miles to the east. Several months later this same bear was shot 124 miles southwest of Westhaven in Pennsylvania (NYDEC, 2003). While males exhibit the greatest tendency to disperse long distances, road kill data from Florida suggests that females also occasionally disperse long distances as well (Wooding and Brady, 1987).
- Adult bears can also move large distances to search for food in years of scarcity. In Vermont, movement of adult males away from home ranges ranged between 8.2 – 28.9 km. Distances for females were similar (5 – 27 km), but females generally did not cross major highways (e.g. Route 7), while males did (Hammond, 2002).
- Vermont bears denned mostly within home ranges, though males tended to choose den sites that were more remote from concentrated human activities than females and did not exhibit complete fidelity to home ranges. Females denned exclusively within home ranges. A variety of den types were used, some of which were slash from logging activities (Hammond 2002).

<u>Mortality and Fecundity</u>

<u>NYS History</u>

- Populations have recently increased in the northeastern U.S.

<u>Additional Considerations</u>

- Smith and Pelton 1990: in Arkansas, over a three year study, the authors found no evidence of dispersal by black bears. Radio-tagged bears did not leave the White River National Wildlife Refuge or stray far from their natal ranges. This was observed for both males and females across age-classes.

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Canada Lynx (*Lynx canadensis*) Profile

Habitat Preferences

- Hoving et al. 2005: (NE America) Lynx is a boreal forest species. Found that the best model for predicting lynx presence/absence was based on snowfall and deciduous forest. Lynx most likely to be present in areas with high mean annual snowfall and relatively low % deciduous forest in the habitat. Snowfall is likely to have indirect effects on the lynx and may be an indicator of prey abundance and predator competition. Lynx not likely in areas with less than 2.7 m snowfall/year.
- Carroll et al. 2001: In the Rockies, positive correlation with canopy closure and lynx occurrence until closure > 40%. Lynx occurrence negatively correlated with topographic complexity greater than 35%. Lynx habitat model included normalized differenced vegetation index, brightness, topographic complexity and a low road density threshold. The model tailored to the US incorporated snowfall.
- Hoving et al. 2004: (Maine) Created a model which is 63% accurate, and predicts that lynx will occur in habitat with relatively large amounts of regenerating forest, and are less likely to occur in areas that have been recently clear-cut, partially harvested, or contain forested wetlands. Lynx more closely associated with younger forests than mature forests, although old-growth forests were absent in the study region. No positive or negative correlation between lynx and mature coniferous forests.
- Homyack et al. 2007: Lynx is a early successional habitat specialist
- Poole 2003: (Canada) lynx is most common in boreal, sub-boreal, and western montane forests. Prefers older (>20 years) regenerating forests and avoids younger stands
- Gonzalez 2006: lynx need boreal forest habitat, late successional sites for den sites, early stands for prey, deep snow.
- Singleton et al. 2002: intermediate stages may serve as travel habitat. (citing Koehler and Aubry, 1994).
- Ray et al. 2002: lynx presence associated with snow depth greater than 2.6m annual snowfall, and less than 27% deciduous cover (Citing Hoving et al. 2001).
- Mowat and Slough, 2003: Lynx habitat highly correlated with snowshoe hare habitat. Understory more important determinant of habitat for lynx than overstory.
- Hodges 2000 in Ruggiero et al, 2000: Hares use stands of 10-17 years old Picea species more than uncut stands or stands younger than 10 years (New Brunswick: citing Parker 1984). Newfoundland: prefer stands of Balsam fir 40 years old more than 60 year and uncut stands (citing Thompson and Curran, 1995). Prefer dense stands of Balsam (32,000 stems/ha) more than open stands (7,000 stems/ha) (citing Lloyd-Smith and Piene 1981, unpublished). New Hampshire (citing Brocke et al, 1993, unpublished): in spruce-fir-ash-maple habitats, hares

were most abundant when stem density was high and primarily coniferous (1.34 hares/ha when 9,221 stems/ha (90% conifer) and 1.27 hares/ha when 26,028 stems/ha (99% conifer) vs. 0.74 hares/ha when 8,512 stems/ha (82% conifer) and 0.40 hares/ha when 6,533 stems/ha (90% conifer). Similar results observed in Maine (citing Litvaitis et al, 1985b): Density of hares highest in high density, primarily coniferous stands (1.7 hares/ha when 20,350 (16,150 of which were conifer) stems/ha vs. 0.6 hares/ha when 31,490 (2,580 conifer) stems/ha).

- Mowat et al, 2000 in Ruggiero et al 2000: lynx and hares exhibit similar patterns of habitat selection with two exceptions. Hares select denser stands than lynx (citing O'Donoghue et al, 1998a), and hares select dense shrubs with little aerial cover, stands that are often avoided by lynx (citing Keith, 1990).
- Singleton et al. 2002: lynx avoid steep habitat (>40% grade) in the Canadian Rockies. Only 4 of nearly 4000 observations were more than 100 km from interior coniferous forests. Areas with moderately low slopes and high stream density preferred.
- McKelvey et al. 2000 in Ruggiero et al 2000. Historic distribution of lynx in the Northeast based on elevation, highest (77% of occurrences) at mid-elevations (250-750m, which comprise 59% of the total area). 20% of the occurrences were below 250m (39% of the total area). Based on vegetation, 88% occurrences in Mixed Forest-Coniferous Forest-Tundra (29% of total area). On a finer scale, red spruce-balsam fir/sugar maple-birch-beech forest had the highest frequency (53% occurrences). This forest type and red spruce-balsam fir forest and sugar maple-birch-beech forest accounted for 84% of all occurrences and compose 29% of the total area.

<u>Disturbance Sensitivity</u>

- Hoving et al. 2005: In Rockies lynx seemed to avoid crossing divided highways or including them in their home range (citing Apps 2000). The Hoving model was not conclusive on the effects of road density on lynx occupancy.
- Squires and Oakleaf 2005. (Yellowstone) observed a radio-tagged lynx explore habitat and crosses several two-lane highways, one on a few occasions.
- Homyack et al. 2007: (Maine) forest stands treated with pre-commercial thinning support half as many snowshoe hares for at least 11 years
- Singleton et al. 2002: lynx observed to cross major highways and large rivers during long distance movements and forest roads seem to have little effect on habitat use (citing Aubry et al. 2000).
- Mowat et al, 2000 in Ruggiero et al, 2000: Lynx exhibit both functional and numerical responses to snowshoe hare cycles.
- Apps 2000 in Ruggiero et al 2000. Southern Canadian Rock Mountains. Lynx crossed highways less frequently than predicted by a model of random lynx movements.
- Aubry et al in Ruggiero et al 2000: Lynx observed to follow road edges and forest trails in Nova Scotia, as well as in Washington for roads less than 15m wide (citing Parker 1981; Koehler and Brittell, 1990, respectively)
- Mowat et al 2000 in Ruggiero et al 2000: anecdotally, lynx tolerate moderate snowmobile traffic however these trails may allow coyotes to intrude on lynx

habitat and exclude lynx. Lynx are also moderately tolerant of humans, and several studies (Brand and Keith, 1979, and Fortin and Huot, 1995) occur in relatively densely populated rural areas and dispersed agricultural land use.

Movement and Home Range

- Hoving et al. 2005: at the southern extent of the range of lynx: 100 km^2 (citing Aubry et al. 2000a).
- Aubry et al, 2000 in Ruggiero et al. 2000: Mean home range size of lynx varies greatly throughout its range. On Cape Breton Island, Nova Scotia a male lynx had a 12km^2 range in summer, 26 km^2 in winter and a female had 19 km^2 in summer and 32km^2 in winter (citing Parker et al 1983).
- Singleton et al. 2002: lynx will cross open meadows as long as the opening is smaller than 100m (citing Koehler and Brittell, 1990).
- Carroll et al. 2005; Poole 2003: maximum dispersal distance 1,100 km.
- Mowat et al 2000 in Ruggiero et al. 2000: information on long distance lynx migration must be considered biased because it typically comes from trappers and lynx vary in susceptibility to trapping by age class and sex.
- Schwartz et al. 2002 : Lynx populations separated by as much as 3,100 km still show no evidence of genetic drift. Peripheral populations of lynx are heavily influenced by periodic diffusion of individuals from the core.
- Aubry et al 2000 in Ruggiero et al 2000: no successful dispersals (breeding after movement) have been observed in the southern boreal forest, however there is little available data on lynx dispersal in this area and there may be under-reporting of these type of events.
- Singleton et al, 2002: exploratory movements within 40-74 km (citing Apps, 2000). Daily movements within 2-4 km (citing Squires and Laurion, 2000).
- Mowat et al. 2000 in Ruggiero et al 2000. Daily movements vary greatly within range, and are influenced heavily by prey density and snow pack. “Daily cruising distance” averages 5-9km, however, a study of lynx on Cape Breton Island, Nova Scotia observed greater average daily travel distances in the summer (9 km) than in the winter (8 km). Declining populations in the Yukon were observed to have much larger daily movements (about 13 km in summer, 20.5 km in winter).

Mortality and Fecundity

NYS History

- Extirpated from the Adirondacks between 1850 – 1900. There were lynx in the Adirondacks, however it is unknown whether they were permanent and breeding or how abundant they were. A reintroduction was attempted unsuccessfully in the late 1980’s (Jenkins 2004).

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Cougar (*Puma concolor*) Profile

Habitat Preferences

- Habitat generalist – key needs large wilderness areas and prey base (USFWS Division of Endangered Species).
- British Columbia: depends on prey distribution and movement (e.g. lower elevations where deer over winter during that season) (MoE, 1994).
- Kautz et al 2006 Florida panther study found preference for forest cover over other habitat types, small patches ranked higher probably because of natural habitat patchiness and congregation of prey (earlier studies sited suggested preference for patches at least 500 ha in size).
- California: use riparian areas to move between core habitat, use rocky areas/ledges/cliffs in more open country, Oregon study suggests preference for areas with rocks and downed logs where they bed up (MSHCP Clearinghouse – various citations).

Disturbance Sensitivity

- Selected home ranges in areas w/lower road densities, no recent timber sales and few or no human residences. However, study in Sheep River Alberta found lions 'relatively unaffected by summertime human activity (vehicular traffic, camping hiking' (MSHCP Clearinghouse)
- Study of cougar movement in Santa Ana Mountain range of Southern California found aversion to paved roads and human-modified vegetation types, but not dirt roads (appears they may use them as travel paths). Highways a major mortality factor. Two lane paved roads avoided, but not hard barriers (they will cross them). Traveling cougars appear to show preference for riparian vegetation and other types that provide cover, and prefer gentler terrain i.e. 'travel paths less rugged than general surroundings' (Dickson et al)

Movement and Home Range

- Range: male cougars 25+ square miles, females 5-20 square miles (USFWS Division of Endangered Species).
- Northern Rockies (BC and Washington State (Lambert el al, 2006) N.B. heavily hunted population:
  - average home range adult females ~653 km^2
  - density in study area: 1.09 cougars per 100 km^2 compared to a range of 0.44 to 13.03 cougars per 100 km^2 found elsewhere, reported by Smallwood in 1997.
- Average patch size for Florida panther encircled by paved highways: 53,320 ha (Maehr et al, 2002)
- Mean home range size used in modeling of potential Florida panther habitat (Thatcher et al, 2006):
  - 243.6 km^2 for females

- 767.3 km^2 for males

- dispersal corridor width: 0.5-1 km wide over a dispersal distance of 6 km. CA recommendations corridors less than .8 km wide should be more than 100 m wide, those 1-7 km long should be over 400m wide, regional corridors should be at least 1.6 km wide with no bottlenecks less than 400m wide – various citations from Kautz et al, 2006 which mapped a dispersal zone of 3-7.8 km wide for Fla panthers.
- Florida panthers (Maehr et al, 2002):
  - Mean dispersal age (male and female) ~ 14 months
  - Mean maximum juvenile dispersal distance: 20.3 km (females), 68.4 km (males).
  - Mean effective juvenile dispersal distance (survived to establish home ranges) 11.3 km (females), 37.3 km (males)
  - 1 male in study covered 224 km in 7 months.
- Foraging distance - SC Idaho and NW Utah – males move about 10 miles a day and females 12 miles a day (MSHCP Clearinghouse)
- Florida work indicates rivers a barrier to movement, though animals will cross them with sufficient dispersal pressure. Also, lights associated with development (Maehr et al, 2002)

<u>Mortality and Fecundity</u>

- Northern Rockies (BC and Washington State (Lambert el al, 2006):
  - Mean litter size: 2.53 (probably higher than normal because of hunting pressure)
  - Average annual survival rate: 59% +/- 20%, higher for adult females
  - density in study area: 1.09 cougars per 100 km^2

<u>NYS history</u>

- Last documented cougar in Adirondacks about 1903 (Vos, 1964)
- In 1800 cougar were found throughout the Adirondacks, though always scarce (Jenkins 2004)
- About 1980 increased credible sightings were reported in the Adirondacks starting in a cluster north of the High Peaks (Jenkins 2004).

<u>Additional Considerations</u>

- Historic range of eastern cougar – eastern Canada to South Carolina. National Park Service study in 1975 estimated small population (3-6 individuals) in the Smokies. Recent sightings in Minnesota and Michigan probably originated from Canada (USFWS Division of Endangered Species)
- Manitoba – documented as a resident in the province in the 1970s, two cougar shot in 2004 north and west of Lake Manitoba according to Manitoba Conservation Dept zoologist Bill Watkins (www.cougarnet.org)
- **Use of study area resources:**
  BC fact sheet on cougar prey preferences (MoE, 1994):
  - capable of killing a 600 lb moose
  - opportunistic, will feed on grouse, porcupine

- mule deer staple food, adult cougar needs 14-20 mule deer/year (less if diet supplemented with other foods)

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Moose (*Alces alces*) Profile

Habitat Preferences

- Moose need a diverse, heterogeneous habitat; food producing areas, water bodies, and patches of dense, mature forest are critical; small scale patch dynamics where open areas are scattered within dense, mature forest are most beneficial for selective feeding (Snaith et al 2002)
- Forest cover is critical for refuge from snow, wind, cold and heat (Snaith et al 2002); mid- to late winter moose use mature, dense conifer stands near suitable forage sites (Pullock et al 1996)
- Early successional vegetation is primary source of food, but moose avoid foraging in large open areas. (Snaith et al 2002)
- Intolerant of prolonged temperatures above 24°C (75°F) (Saunders 1988)
- Proximity to wetlands and early stages of successional vegetation are important (Saunders 1988); wet areas like bogs and swamps provide excellent summer habitat (Chapman 1991); wetland habitat may not be crucial in Nova Scotia given paucity of wetlands (Snaith et al 2002)
- Snow >102 cm (40 in) inhibits movement (Saunders 1988); 65 cm snow depths restrict movement of cow and calf and 95 cm is considered critical depth (Romito et al 1999)
- May be limited by white-tailed deer density because of brainworm spread (Saunders 1988)
- Consumes 16 – 27 kg (35 – 60 lb) of plant materials daily (Saunders 1988); willows, aspen, birch, alder, maple, dogwood, cherry, yew, balsam fir, white cedar and eastern hemlock are preferred plants; red maple and striped maple bark and branches constitute principal winter food (Merriam 1886)
- Spring/summer = preference for aquatic habitats and aquatic plants; summer = early successional trees like trembling aspen, paper birch, and willow are preferred food source; winter = same preferred browse but limited availability because of snow so hemlock also browsed (Puttock et al 1996).
- Preference for aquatic plants during the summer (especially roots of pond lily); maybe because of higher sodium content (Saunders 1988)
- Habitat Suitability Index Models identify 4 critical habitat types: open forage-producing areas (shrub or forest <20 years in Lake Superior; any forest type <20 years in Nova Scotia), softwood cover (spruce-fir forest ≥20 years in Lake Superior, softwood forest ≥20 years in Nova Scotia), hardwood or mixed cover (upland deciduous in Lake Superior, deciduous or mixed forest ≥20 years in Nova Scotia), and wetlands (riverine, palustrine or lacustrine wetlands not dominated by trees in Lake Superior, wetlands not dominate by trees and not including acidic unproductive wetlands in Nova Scotia); suitability indices (0 – 1) were determined based on optimal habitat assumptions of 40 – 50% forage, 5 – 15% softwood cover, 35 – 55% deciduous or mixed forest cover, and 5 – 10% wetlands (Snaith et al 2002)

- Significant habitat variables in Algonquin were browse producing habitat (% area of stands 1 – 20 years old and stands with ≤30% stocking), barren and scattered areas (% area of barren and scattered habitats), late winter habitat (% area with conifer stands >20 years old and ≥50% cover), early winter conifer (% area of conifer stands >20 years old and <50% cover) and deciduous habitats (% area of stands with 30-50% hardwoods by basal area), the area of open muskeg (% area open muskeg), and snow depth (average snow depth) (Puttock et al 1996).

Disturbance Sensitivity

- Road density is correlated with lower moose population density, as measured by moose pellet surveys (Beazley et al 2005 and Snaith et al 2002)
- Decreases in moose populations are correlated with hunter success and hunter access by roads (Beazley et al 2005)
- Successive clear-cut's was not any worse for moose populations than a harvest strategy of dispersed block cuts in Ontario—possibly because dispersed block cuts resulted in more road and hunter access; hunting can be a threat to population viability (Rempel et al 1997)
- Moose appear to avoid roads, but I have not yet found a quantifiable measure of that
- Impacts of forest management activities could be provided if necessary
- Can swim up to 19.3 km (12 mi)

Movement and Home Range

- Densities in habitat comparable to Adirondacks are 1- 2 moose/256 ha (1 sq. mi.)
- Algonquin park population density stable at .8/km2
- .5 moose/km2 (Beazley et al 2005)
- Average home range is 20.7 – 38.8 km (8 – 15 sq. mi.) (Saunders 1988)
- 30 – 55 km2 = average home range size (Beazely et al 2005)
- Minimum path width defined as 10 km for Nova Scotia model (Beazley et al 2005)
- In the fall males range up to 50 miles/day in search of mate (Chapman 1991)
- Mean rate of movement for ADK bull moose in summer = .4 km/day, winter = .2 km/day, and fall = 4.4 km/day. Max range in fall = 9.7 km/day. Fall is highest b/c of mate searching, but possibly unusually high in ADK pop b/c of low cow density (Garner and Porter 1990)
- Foraging - Generally will not move more than 80 – 200 m from cover, esp. in winter (Snaith et al 2002)

Mortality and Fecundity

- Cows usually give birth to 1 calf but 2-3 is possible depending on cows state of nutrition and age (Saunders 1988)
- Prime reproduction is from 6 – 10 years but may extend much longer. (Saunders 1988)
- Longevity is 18 – 23 years (Saunders 1988)

- Black bear is the only potential predator of moose calves in Adirondacks (Saunders 1988)

<u>NYS History</u>

- Extirpated from Adirondacks around 1861 (cow shot then at Raquette Lake); some restoration attempts around 1900; occasional in-migration between 1935 and 1980; Permanent residents again since at least 1980 (Saunders 1988)
- As of 1991, most moose in NY are males b/c dispersers from CA or VT are more likely to be males. It can not yet be claimed that a permanent breeding base has been established (Chapman 1991)

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

River Otter (*Lontra canadensis*) Profile

Habitat Preferences

- Riverine (rivers, creeks, low – moderate gradient, pools); lacustrine (deep and shallow water); palustrine (forested wetlands, herbaceous wetlands, riparian, scrub-shrub wetlands) (NatureServe).
- Soil and fallen log/debris for burrowing (NatureServe).
- Streams, lakes, ponds, swamps, marshes, estuaries (in some areas), beaver flowages, exposed outer coast (Pacific Northwest, Alaska). When inactive, occupies hollow log, space under roots, log, or overhang, abandoned beaver lodge, dense thicket near water, or burrow of other animal; such sites also are used for rearing young. Highly associated with beaver on Mount Desert Island, Maine (Dubuc et al. 1990, in NatureServe). Uses traditional haul-out sites along the banks of aquatic habitats.
- In coastal Maine, river otters select habitat associated with beaver flowages, which provided abundant food, stable water levels, escape cover, and resting and dens sites. These areas also are relatively free from human disturbance. Habitat use by river otter in Maine is positively correlated with the length of the stream and the average shoreline diversity (e.g., the amount of shallow habitat available for foraging). River otters in coastal Maine avoid watersheds within mixed hardwood-softwood communities, which are typically less productive, headwater streams (Dubuc *et al.* 1990, in U.S. EPA).
- Prey availability appears to be the primary factor affecting habitat selection (Melquist and Hornocker 1983, in U.S. EPA). Also of importance is the presence of adequate shelter and limited human activity. Habitat use varies during the course of the year based on accessibility and food availability (U.S. EPA).
- In New England, river otters will preferentially select riverine and lacustrine systems, but will also use estuaries, salt marshes, and most palustrine wetlands. They may also be present in a variety of forest cover types provided a water body is nearby (DeGraaf and Yamasaki 2001).
- In Massachusetts, river otters use a variety of palustrine, riverine and lacustrine wetland systems with no particular preference for any one community type (Newman and Griffin 1994, in U.S. EPA).
- In Idaho, river otters use a variety of habitats throughout the course of the year, including mudflats, open marshes, forest streams, swamps and backwater sloughs, large lakes and reservoirs, and smaller ponds. Idaho river otters preferred stream-associated habitats to lakes, reservoirs, and ponds (Melquist and Hornocker 1983, in U.S. EPA).
- Within any given habitat, river otters select locations referred to as latrines, where they leave the water to defecate, urinate, scent mark, and groom (Newman and Griffin 1994, in U.S. EPA). Habitat characteristics specifically associated with otter latrines include the presence of rock formations, backwater sloughs, fallen logs, vertical banks, large conifers, points of land, beaver bank dens and lodges,

isthmuses, and the mouths of permanent streams (Newman and Griffin 1994, Swimley *et al.* 1998, in U.S. EPA).

- River otters also have numerous den and resting sites within their home range that they use over the course of a year. These sites provide river otters with protection as well as isolation (Melquist and Hornocker 1983, in U.S. EPA). Den and resting sites may be located in logjams, riparian vegetation, snow or ice cavities, rip-rap, talus rock, boulders, brush and log piles, undercut banks, boat docks, abandoned dam spillways, and dens constructed by other animals (e.g., beaver, muskrat, woodchuck, fox, or coyote) (Liers 1951, Melquist and Hornocker 1983, in U.S.EPA). Melquist and Hornocker (1983) found that river otters used active and abandoned beaver bank dens and lodges more often than any other den or resting site, probably because they provide shelter as well as underwater egress (in U.S. EPA).
- Tend to live within about 100 meters of rivers, streams, and lakes (need to check reference)

<u>Disturbance Sensitivity</u>

- Separation barriers include rugged mountain ridges (NatureServe).
- Otter observed using urban pond in Minnesota December – April. Area described as "heavily populated residential, industrial, and business area interlaced with paved streets, highways, and parking lots, and a golf course. The only nearby natural vegetation is an embankment up to 15 m wide along each side of a railroad track. The only water is a pond of 1.1 ha (Walsh Lake) surrounded by a golf course and residential yards. A storm sewer feeds the pond. The nearest natural Mink habitat is 3.3-5.7 km away, with houses, yards, businesses, and six to eight lanes of interstate highway intervening. The nearest extensive waterways where otters might be expected are 3.5-6.0 km away, also separated from the area by the same type of surroundings (Mech 2003).

<u>Movement and Home Range</u>

- Typically linear, 20-30 miles for a pair or male; less for females with young (Jackson 1961, in NatureServe).
- Individual otters regularly move large distances. Home ranges are large and often generally linear along streams and shorelines, typically 30-50 kilometers long for males or pairs (Jackson 1961 in NatureServe)….Thus populations and metapopulations generally occupy large areas. For this and other wide-ranging, low density mammals, it seems most reasonable to base occurrences (and conservation efforts) on major occupied landscape features rather than on specific prescribed separation distances (NatureServe).
- May travel long distances over land, particularly in snow (NatureServe).
- May hunt over as much as 80-100 km of stream during the course of one year (NatureServe).
- Home range lengths at all seasons were 10-81 kilometers in Idaho (Melquist and Hornocker 1983, in NatureServe); 20 kilometers of marine shoreline for males in Alaska, 10 kilometers for females (Bowyer et al. 1995); average of 32 km for 10 radio-tagged individuals in Colorado (Mack 1985).

- Young may disperse up to 200 km (Melquist and Hornocker 1983, in NatureServe).
- NatureServe **"**Inferred Minimum Extent of Habitat Use (when actual extent is unknown): 12 km"
- Non-migratory, but will travel between different foraging locations throughout the course of the year. In Idaho, conservative estimates of average daily distance traveled by otters (including family groups) ranged from 0.4 to 3.1 miles. During dispersal and exploration of their home ranges, river otters will travel much greater distances in a single day (i.e., up to 26 miles) (Melquist and Hornocker 1983 as cited in U.S. EPA).
- River otters do not hibernate. They remain active throughout the year and actually show an increase in activity level during the winter. Although activity levels generally increase during the winter, travel may be restricted by snow and ice cover. During much of the year river otters are primarily nocturnal, with peak activity occurring around midnight and just before dawn. During the winter, however, river otters appear to be more diurnal (Melquist and Hornocker 1983, in U.S. EPA).
- Population densities have been reported from 1 otter per 2.3 miles of waterway to 1 otter per 6 – 11 miles of waterway (Melquist and Hornocker 1983, Melquist and Dronkert 1987 as cited in DeGraaf and Yamasaki 2001, in U.S. EPA).
- The diet of the river otter varies during the course of the year with changing prey availability. For example, in areas where spawning runs of fish occur, river otters will shift their hunting efforts to these concentrated prey items when they are available (Melquist and Hornocker 1983, in U.S. EPA).
- In U.S. EPA: Melquist and Hornocker (1983) reported home ranges from 5 – 50 linear miles for a population in Idaho. Area home ranges have been estimated from 448 – 14,080 acres (0.7 – 22 sq. mi.) (Melquist and Dronkert 1987, as cited in DeGraaf and Yamasaki 2001). Male river otters typically occupy larger home ranges than females (DeGraaf and Yamasaki 2001). River otter display a high degree of individual and seasonal variation in home range size. Home range size in Idaho was somewhat influenced by the age, sex, and social status (i.e., solitary versus family group), although no clear association was evident. Adult females with pups are generally restricted to the area around the natal dens in the spring while pups are young.
- In U.S. EPA: Home ranges in this species have been shown to overlap extensively, with some otters sharing essentially the same home range. Separation appears to occur at the activity centers, with individuals or family groups using different activity centers within the home range or using the same activity centers, but at different times throughout the day (Melquist and Hornocker 1983). When a food source is abundant and concentrated, such as during a spawning run of fish, river otters may use the same activity center at the same time. River otters do not appear to defend a defined area within their home range that would represent a territory, but rather will defend an area surrounding their immediate physical location (Melquist and Hornocker 1983). Animals using overlapping home ranges or activity centers prevent confrontation through mutual avoidance.
- May move 3 mi a day on land (Seneca Zoo, need to check reference).

Mortality and Fecundity

- In many areas, births peak in late winter-early spring; parturition dates may not be closely synchronized within a given population. Litter size is 1-6 (average 2-3); 1 litter per year. Young may first enter water at about 7 weeks, are weaned at about 3 months, stay with mother for about a year. Male may rejoin family after young leave den. Females breed for the first time at 2 years. Males become sexually mature at 2 years, but may not breed successfully until 5-7 years old (Toweill and Tabor 1982, in NatureServe).
- Directly from U.S. EPA "Trapping has historically been one of the primary causes of mortality for the river otter. Direct trapping of river otters still occurs in some states, and some may be incidentally caught in beaver traps (Melquist and Hornocker 1983, Chilelli *et al.* 1996). In addition, river otters may be killed by hunters and in collisions with vehicles and watercraft (Melquist and Hornocker 1983). Because of their upper position in the food chain and their aquatic habits, river otter are susceptible to environmental contaminants, including dioxin, mercury, and polychlorinated biphenyls (PCBs) that are present in the lakes and rivers (Foley *et al.* 1988, Sloan and Brown 1988, Organ 1989, Sample and Suter 1999). Though relatively little is known about the specific effects of PCB contamination on river otter, PCBs have been found to impair reproduction and cause death in the closely-related mink (Platonow and Karstad 1973). Organ (1989) compared PCB and mercury residues in river otters from 20 different Massachusetts watersheds. While variability y was high in all watersheds, individuals from the Housatonic River watershed had the highest mean PCB residues. He also found a correlation between mercury residues in river otters and those in whole-body fish from the same watershed, and suggested that river otters could be used to assess the general background levels on a watershed basis. Mercury levels in adults were higher than those in juveniles, implying bioaccumulation over the animal's lifetime. Studies in Europe also report high levels of PCBs in river otters and suggest that population declines there are due to PCB accumulations in this species (Leonards *et al.* 1997, Traas *et al.* 2001). One study of Eurasian otters (Kruuk and Conroy 1996), however, found no evidence that PCBs accumulated in otters with age.

NYS History

- Adirondacks – seem to be most common in the northwestern watersheds where beavers are now abundant (Jenkins 2004). Harvested in low numbers throughout the park and in much higher numbers in the St. Lawrence Valley (Jenkins 2004). In general otter populations were greatly decreased between 1800-1900 largely due to over trapping and populations recovered between 1900-2000 (Jenkins 2004).
- Large range in much of North America north of Mexico; population trend is relatively stable (NatureServe).

Additional Considerations

- Sensitive to pollution

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Species Profile and Modeling Summary
Adirondack-Tug Hill Connectivity Project

Scarlet tanager (*Piranga olivacea*) Profile

Habitat Preferences

- In eastern North America, its breeding range corresponds with the boundaries of the eastern deciduous forest biome (Mowbray 1999).
- Prefers mature deciduous woodland, less common in mixed woods (American Ornithologists Union 1998).
- Inhabits a wide variety of deciduous and mixed deciduous/coniferous forest types. Prefers mature forests, especially where oaks are common, but may occur in young successional woodlands. Occasionally occurs in extensive plantings of shade trees (American Ornithologists' Union 1998, Isler and Isler 1999).
- In northeast US occurs in a wide variety of forest types. Occasionally extends into the boreal forest where it occurs in stands of aspen, balsam poplar, and birch or in mixed deciduous-coniferous stands (Erksine 1977, Peck and James 1987, Gauthier and Aubry 1996).
- Occurs in a variety of wooded habitats with tall trees during migration, similar to during breeding but also occurs in more open habitats (Isler and Isler 1999).
- Infrequently observed and poorly known in South America on wintering range (Mowbray 1999).

Disturbance Sensitivity

- Species of the forest interior, sensitive to forest fragmentation, suffering high rates of predation and brood parasitism in small forest plots and often absent completely from plots less than a minimum size (Mowbray 1999).
- During the breeding season, SCTA prefers mature deciduous forest and shows a marked dependency on size of forest tract. Estimated minimum forest area needed to sustain a viable population 10-12ha (Galli et al. 1976, Robbins 1980, Robbins et al. 1989, Roberts and Norment 1999).
- Breeding densities vary geographically as well as among forest plots of differing size (Price et al. 1995). At Hubbard Brook, mean density of 4.25 individuals/10 ha. In w. NY, mean density ranged from 1.8 birds/10ha in plots 10-50ha to 3 birds/10ha in plots >1000ha (Holmes and Sherry 1988).
- In Wisconsin, SCTA completely disappeared from small forests 0-5ha; forest area and openness of canopy/density of shrub layer accounted for 77% of variation in abundance (Ambuel and Temple 1983).
- Across its entire breeding range, its occurrence is significantly affected by the amount of fragmentation (Mowbray 1999).
- Presence depends on amount of fragmentation, size of forest patch, forest configuration, and degree of patch isolation. Throughout e. North America, occurrence significantly correlated with overall amount of fragmentation. The probability of finding breeding tanagers <0.5 in highly fragmented sites (Rosenberg et al. 1999). In w. NY, breeding success significantly correlated with forest patch area and presence of forest within 1km of patch (Roberts and

Norment 1999). In NJ, SCTA found only in wooded areas >3ha, while forest patches <0.2 ha contained only edge species (Galli et al. 1976).
- Disturbance to the forest canopy during the breeding season (logging) was found to negatively impact SCTA in central MI (Porter 1996).
- Parasitized by brown-headed cowbird throughout range. In Ontario, 19.4% of nests parasitized (Peck and James 1987). Variability in rates due in part to geography (more cowbirds in Midwest than North or Northeast; Rosenberg et al. 1999) and size of breeding area (less parasitism in larger, less fragmented forest tracts; Robinson et al. 1995, Brawn and Robinson 1996).
- When a nest is parasitized, tanager clutch size decreases. Presence of cowbirds does not appear to affect tanager survival however.
- Fragmented forests in central Illinois with 75% SCTA nest predation and 89% brood parasitism considered to be sink habitats.
- In w. New York, pairing success differed significantly among forest size classes. Pairing success high in all forest size classes containing tanagers and was 100% in continuous forest plots <1000ha. Fledging success increased significantly with area of forest patch and differed significantly among forest patch classes; no fledglings present in forest patches <10ha, 22% fledging success in forest patches 10-50ha, 39% fledging success in patches 50-150ha, and 64% in sites <1000ha (Roberts and Norment 1999).
- In Leon County, FL, 153 SCTA killed in one year at television tower during migration, 28 in spring, 125 in fall (Stevenson and Anderson 1994). SCTA reported dead along highway in MN as a result of collisions with cars while snatching recently hatched insects (Longley 1981).

Movement and Home Range

- Complete, long distance Neotropical migrant.
- Territory size not often measured. The few data available suggest that birds use relatively large areas for foraging (Mowbray 1999).
- On breeding grounds males defend mating, nesting, and foraging areas. Territory boundaries not rigid; area used for foraging is largest, but nesting area is most vigorously defended. Size of territory varies substantially with size of forest area, location, and vegetation type. In late successional hemlock/hardwood forest at Hubbard Brook, territories were 2.5 to 5ha (Zumeta and Holmes 1978). In hardwood forests of different sizes in western NY, from 6.1 – 7.6 ha (Roberts and Norment 1999).
- No details on home range size available, just those above on territory size.

Mortality and Fecundity

- Predation on SCTA adults observed by eastern screech owl, short-eared owl, and merlin. Common avian nest predators include blue jay, common grackle, and American crow.
- Cold, wet conditions upon arrival at breeding grounds may result in high mortality/starvation.

- Few data on overall rates of predation. In Illinois, in 8 woodlots <200 ha, 69-68% of nests were depredated (Brawn and Robinson 1996).
- No information on initial dispersal from natal site.
- Males and females both breed at one year, first summer after fledging (Gauthier and Aubry 1996). No data on the percentage of first years that breed.
- Clutch usually 4 eggs, sometimes 3 or 5 (Prescott 1965, Baicich and Harrison 1997). Little information on hatching or fledging success. In s.-central Michigan, of 16 nests observed, parasitized and unparasitized, 50% were successful in hatching ≥1 young; of 30 tanager eggs laid, 8 hatched and fledged, an egg success of 26.6% (Prescott 1965).
- In w. New York, pairing success differed significantly among forest size classes. Pairing success high in all forest size classes containing tanagers and was 100% in continuous forest plots <1000ha. Fledging success increased significantly with area of forest patch and differed significantly among forest patch classes; no fledglings present in forest patches <10ha, 22% fledging success in forest patches 10-50ha, 39% fledging success in patches 50-150ha, and 64% in sites <1000ha (Roberts and Norment 1999).

<u>NYS History</u>

- Breeding distribution encompasses all of New York State and much of the eastern US. Native to US; assumed to be continuously present in the State, no indication otherwise.

<u>Additional Considerations</u>

- In many fragmented landscapes, reproductive rates are low enough to suggest that SCTA populations function as reproductive sinks (Robinson et al. 1995, Brawn and Robinson 1996, Bollinger et al. 1997). In these areas, the source-sink metaphor of population dynamics appears applicable. Though the bird is widely distributed in the state, it is possible that a place like the Black River Valley may function as a population sink – unsure how this may affect model parameters.

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Appendix 4: Expert Interview Form and Experts

Expert:
Date:
Interviewer:
Species:

1. What habitats are preferred? Scale: 100 = most preferred; 0 = least preferred

Habitat type	Preference
Open water	
Perennial Ice/Snow	
Open space developed	
Low intensity developed	
Med intensity developed	
High intensity developed	
Barren land	
Deciduous forest	
Evergreen forest	
Mixed forest	
Shrub/scrub	
Grassland/ herbaceous	
Hay/ pasture	
Cultivated crops	
Woody wetlands	
Emergent herbaceous wetlands	

2. What features are barriers to movement? Do thresholds exist? Scale: 100 = complete barrier; 0 = no barrier

Example: a pond that is 30 m wide is not a barrier to movement, but a pond that is 60 m wide is a barrier. At 30 m the pond's hardness ranking may be 50, whereas at 60m it is ranked 100.

Barrier	Hardness of barrier	Threshold
Roads – 4 lane		
Roads – 2 lane		
Roads - unpaved		
Open water		
Rivers		
Elevation		
Land form		
Topography		
Snowfall		
Slope		
Aspect		

3. What is the range of possible home range sizes?

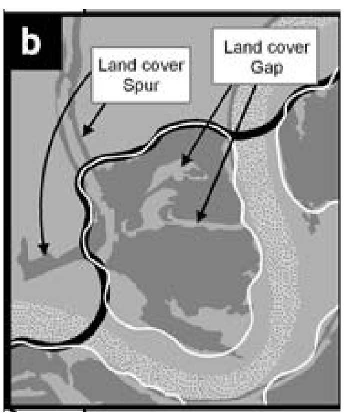
4. What is the smallest patch size an animal will move through?

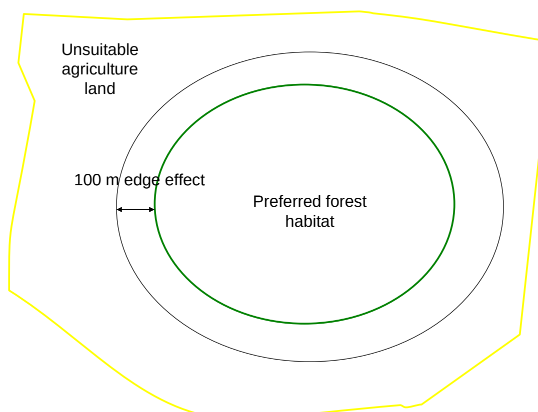
5. How far will an animal disperse (on average and at most)?

6. How far will an animal move in search of food resources?

7. Edge effects: how far will an animal move into or cross undesirable habitat?

Examples:





8. What is the likelihood of mortality in each habitat? Scale: 100 = mortality imminent, 0 = no likelihood of mortality

Habitat type	Likelihood of mortality
Open water	
Perennial Ice/Snow	
Open space developed	
Low intensity developed	
Med intensity developed	
High intensity developed	
Barren land	
Deciduous forest	
Evergreen forest	
Mixed forest	
Shrub/scrub	
Grassland/ herbaceous	
Hay/ pasture	
Cultivated crops	
Woody wetlands	
Emergent herbaceous wetlands	

OPTIONAL:

9. What is the likelihood of finding food in each habitat? Scale: 100 = will find food, 0 = no likelihood of finding food

Habitat type	Likelihood of finding food
Open water	
Perennial Ice/Snow	
Open space developed	
Low intensity developed	
Med intensity developed	
High intensity developed	
Barren land	
Deciduous forest	
Evergreen forest	
Mixed forest	
Shrub/scrub	
Grassland/ herbaceous	
Hay/ pasture	
Cultivated crops	
Woody wetlands	
Emergent herbaceous wetlands	

10. How easily can an animal move through each habitat type? Scale: 100 = will through easily, 0 = will not move through

Habitat type	**Ease of movement through habitat**
Open water	
Perennial Ice/Snow	
Open space developed	
Low intensity developed	
Med intensity developed	
High intensity developed	
Barren land	
Deciduous forest	
Evergreen forest	
Mixed forest	
Shrub/scrub	
Grassland/ herbaceous	
Hay/ pasture	
Cultivated crops	
Woody wetlands	
Emergent herbaceous wetlands	

Experts consulted for species review:

Species	Expert	Affiliation
American marten	Paul Jensen	NYS DEC
American marten	Justina Ray	WCS Canada
American marten	Andy MacDuff	NYS DEC
Black bear	Lou Berchielli	NYS DEC
Black bear	Ben Tabor	NYS DEC
Black bear	Susan Morse	Keeping Track
Cougar	Doug Blodgett	VT Fish and Wildlife
Cougar	Clay Nielsen	Southern Illinois University Carbondale
Cougar	Toni Ruth and Polly Buotte	WCS
Cougar	Susan Morse	Keeping Track
Lynx	Susan Morse	Keeping Track
Lynx	Justina Ray	WCS Canada
Lynx	Andy MacDuff	NYS DEC
Moose	Karl Didier	WCS
Moose	Ray Masters	Adirondack Ecological Center
Moose	Susan Morse	Keeping Track
Moose	Ed Reed	NYS DEC
River otter	Susan Morse	Keeping Track
River otter	Andy MacDuff	NYS DEC
Scarlet tanager	Sudie Daves	Natural Resources Conservation Service, USDA
Scarlet tanager	Kathy Fleming	USFWS
Scarlet tanager	Benjamin Zuckerberg	SUNY ESF

Appendix 5: Model Inputs

FunConn: Bear

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	30
21	Developed Open Space	40
22	Developed Low Intens	40
23	Developed Med Intens	30
24	Developed High Inten	10
31	Bare Rockk/Sand Clay	0
52	Shrub/Scub	90
71	Grassland/Herbaceous	30
81	Pasture/Hay	10
82	Cultivated Crops	50
90	Woody Wetlands	80
141	Decid Forest - Low	100
241	Decid Forest - High	100
142	Ev Forest - Low	90
242	Ev Forest - High	80
143	Mix Forest - Low	70
243	Mix Forest - High	90
195	Em Wet - Low	70
295	Em Wet - High	70

Resource Quality Threshold: 75
Minimum Patch Size: 30ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 8000
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	85
-50	0	70
0	10	50
10	50	44
50	100	38
100	200	32
200	300	26
300	400	20
400	500	16
500	750	10
750	1000	5
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	0
5000	7500	0
7500	10000	0
10000	1E+09	0

FunConn: Bear

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006	V90007
-99999999	0	0	0	0	0	0	0	0
0	10	5	10	10	10	15	10	20
10	50	20	20	30	30	25	20	30
50	100	30	30	40	50	50	30	60
100	200	40	50	60	70	75	40	90
200	300	50	70	80	90	100	50	100
300	400	60	80	100	100	100	60	100
400	500	70	90	100	100	100	70	100
500	750	80	100	100	100	100	80	100
750	1000	90	100	100	100	100	90	100
1000	1500	100	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	Quality
11	Open Water	0.6
21	Developed Open Space	0.8
31	Bare Rockk/Sand Clay	0.6
52	Shrub/Scub	1
71	Grassland/Herbaceous	0.9
81	Pasture/Hay	0.9
82	Cultivated Crops	1
90	Woody Wetlands	1
141	Low Decidious Forest	1
142	Low Evergreen Forest	1
143	Low Mixed Forest	1
195	Low Emergent Wet	1
241	High Decid Forest	1
242	High Everg Forest	1
243	High Mixed Forest	1
295	High Emergent Wet	1
90,001.00	Major Rd.	0.3
90,002.00	State. Rd.	0.5
90,003.00	County Rd.	0.6
90,004.00	Local Rd. 1	0.7
90,005.00	Local Rd. 2	0.8
90,006.00	Highest Development	0.1
90,007.00	River Road Intersect	0.9

FunConn: Cougar

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	5
21	Developed Open Space	30
22	Developed Low Intens	30
23	Developed Med Intens	20
24	Developed High Inten	10
31	Bare Rockk/Sand Clay	0
41	Decidious Forest	100
42	Evergreen Forest	100
43	Mixed Forest	100
52	Shrub/Scub	70
71	Grassland/Herbaceous	50
81	Pasture/Hay	20
82	Cultivated Crops	10
90	Woody Wetlands	50
95	Emergent Wetlands	50

Resource Quality Threshold: 75
Minimum Patch Size: 6500ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 4500m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	80
-50	0	75
0	10	70
10	50	60
50	100	50
100	200	40
200	300	30
300	400	25
400	500	20
500	750	15
750	1000	10
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	5
5000	7500	0
7500	10000	0
10000	999999999	0

FunConn: Cougar

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	0	0	1	1	1	0
10	50	1	1	5	5	5	1
50	100	2	5	10	10	15	2
100	200	5	10	25	25	50	5
200	300	15	25	50	50	75	15
300	400	50	60	75	75	100	50
400	500	60	75	90	90	100	60
500	750	75	90	100	100	100	75
750	1000	90	100	100	100	100	90
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	0.3
21	Developed Open Space	0.2
31	Bare Rockk/Sand Clay	0.2
41	Decidious Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	1
71	Grassland/Herbaceous	0.6
81	Pasture/Hay	0.4
82	Cultivated Crops	0.4
90	Woody Wetlands	0.5
95	Emergent Wetlands	0.5
90,001.00	Major Rd.	0.05
90,002.00	State. Rd.	0.07
90,003.00	County Rd.	0.08
90,004.00	Local Rd. 1	0.09
90,005.00	Local Rd. 2	0.2
90,006.00	Highest Development	0.05

FunConn: Lynx

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	10
21	Developed Open Space	30
22	Developed Low Intens	30
23	Developed Med Intens	20
24	Developed High Inten	10
31	Bare Rockk/Sand Clay	40
41	Decidious Forest	50
42	Evergreen Forest	100
43	Mixed Forest	80
52	Shrub/Scub	60
71	Grassland/Herbaceous	20
81	Pasture/Hay	10
82	Cultivated Crops	10
90	Woody Wetlands	50
95	Emergent Wetlands	30

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	100
-50	0	100
0	10	90
10	50	70
50	100	60
100	200	50
200	300	40
300	400	30
400	500	20
500	750	10
750	1000	5
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	0
5000	7500	0
7500	10000	0
10000	999999999	0

Resource Quality Threshold: 75
Minimum Patch Size: 1ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 1500m
Core Habitat Percentage: 0.1
Links Qn Value: 10

FunConn: Lynx

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	0	10	50	60	70	0
10	50	5	10	40	50	60	10
50	100	10	30	50	60	50	20
100	200	30	40	60	75	100	30
200	300	40	50	75	90	100	40
300	400	50	60	90	100	100	50
400	500	70	80	100	100	100	60
500	750	80	90	100	100	100	75
750	1000	90	100	100	100	100	90
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	0.6
21	Developed Open Space	0.4
31	Bare Rockk/Sand Clay	0.2
41	Decidious Forest	0.5
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	1
71	Grassland/Herbaceous	1
81	Pasture/Hay	1
82	Cultivated Crops	1
90	Woody Wetlands	0.7
95	Emergent Wetlands	1
90,001.00	Major Rd.	0.05
90,002.00	State. Rd.	0.1
90,003.00	County Rd.	0.15
90,004.00	Local Rd. 1	0.2
90,005.00	Local Rd. 2	0.2
90,006.00	Highest Development	0.1

FunConn: Marten 1

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	10
21	Developed Open Space	30
22	Developed Low Intens	20
23	Developed Med Intens	20
24	Developed High Inten	0
31	Bare Rockk/Sand Clay	0
41	Decidious Forest	50
42	Evergreen Forest	100
43	Mixed Forest	90
52	Shrub/Scub	30
71	Grassland/Herbaceous	0
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	30
95	Emergent Wetlands	10

Resource Quality Threshold: 65
Minimum Patch Size: 5ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 1200m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	75
-50	0	50
0	10	35
10	50	30
50	100	25
100	200	10
200	300	0
300	400	0
400	500	0
500	750	0
750	1000	0
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	5
5000	7500	0
7500	10000	0
10000	999999999	0

FunConn: Marten 1

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	0	1	5	5	25	0
10	50	1	2	25	25	75	1
50	100	2	10	50	50	90	2
100	200	10	25	75	75	100	5
200	300	25	50	90	90	100	15
300	400	50	75	100	100	100	50
400	500	60	80	100	100	100	60
500	750	75	90	100	100	100	75
750	1000	90	100	100	100	100	90
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	0.2
21	Developed Open Space	0.4
31	Bare Rockk/Sand Clay	0.5
41	Decidious Forest	0.9
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	0.7
71	Grassland/Herbaceous	0.3
81	Pasture/Hay	0.3
82	Cultivated Crops	0.3
90	Woody Wetlands	1
95	Emergent Wetlands	1
90,001.00	Major Rd.	0.05
90,002.00	State. Rd.	0.1
90,003.00	County Rd.	0.2
90,004.00	Local Rd. 1	0.2
90,005.00	Local Rd. 2	0.2
90,006.00	Highest Development	0.001

FunConn: Marten 2

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	10
21	Developed Open Space	30
22	Developed Low Intens	20
23	Developed Med Intens	20
24	Developed High Inten	0
31	Bare Rockk/Sand Clay	0
41	Decidious Forest	75
42	Evergreen Forest	100
43	Mixed Forest	90
52	Shrub/Scub	30
71	Grassland/Herbaceous	0
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	30
95	Emergent Wetlands	10

Resource Quality Threshold: 65
Minimum Patch Size: 5ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 1200m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	75
-50	0	50
0	10	35
10	50	30
50	100	25
100	200	10
200	300	0
300	400	0
400	500	0
500	750	0
750	1000	0
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	5
5000	7500	0
7500	10000	0
10000	999999999	0

FunConn: Marten 2

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	0	1	5	5	25	0
10	50	1	2	25	25	75	1
50	100	2	10	50	50	90	2
100	200	10	25	75	75	100	5
200	300	25	50	90	90	100	15
300	400	50	75	100	100	100	50
400	500	60	80	100	100	100	60
500	750	75	90	100	100	100	75
750	1000	90	100	100	100	100	90
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	0.2
21	Developed Open Space	0.4
31	Bare Rockk/Sand Clay	0.5
41	Decidious Forest	0.9
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	0.7
71	Grassland/Herbaceous	0.3
81	Pasture/Hay	0.3
82	Cultivated Crops	0.3
90	Woody Wetlands	1
95	Emergent Wetlands	1
90,001.00	Major Rd.	0.05
90,002.00	State. Rd.	0.1
90,003.00	County Rd.	0.2
90,004.00	Local Rd. 1	0.2
90,005.00	Local Rd. 2	0.2
90,006.00	Highest Development	0.001

FunConn: Moose

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	65
21	Developed Open Space	10
22	Developed Low Intens	20
23	Developed Med Intens	10
24	Developed High Inten	5
31	Bare Rockk/Sand Clay	10
41	Decidious Forest	75
42	Evergreen Forest	85
43	Mixed Forest	100
52	Shrub/Scub	75
71	Grassland/Herbaceous	20
81	Pasture/Hay	10
82	Cultivated Crops	10
90	Woody Wetlands	80
95	Emergent Wetlands	75

Resource Quality Threshold: 75
Minimum Patch Size: 2000ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 2500m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	75
-50	0	50
0	10	49
10	50	47
50	100	45
100	200	43
200	300	41
300	400	40
400	500	39
500	750	37
750	1000	35
1000	1500	33
1500	2000	31
2000	3000	30
3000	4000	29
4000	5000	27
5000	7500	25
7500	10000	23
10000	999999999	10

FunConn: Moose

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	1	1	1	5	5	0
10	50	15	25	30	40	50	5
50	100	50	60	70	80	90	20
100	200	75	80	85	90	100	50
200	300	85	90	100	100	100	65
300	400	100	100	100	100	100	75
400	500	100	100	100	100	100	85
500	750	100	100	100	100	100	95
750	1000	100	100	100	100	100	100
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	1
21	Developed Open Space	0.5
31	Bare Rockk/Sand Clay	0.1
41	Decidious Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	1
71	Grassland/Herbaceous	0.8
81	Pasture/Hay	0.8
82	Cultivated Crops	0.7
90	Woody Wetlands	1
95	Emergent Wetlands	1
90,001.00	Major Rd.	0.4
90,002.00	State. Rd.	0.5
90,003.00	County Rd.	0.6
90,004.00	Local Rd. 1	0.7
90,005.00	Local Rd. 2	0.8
90,006.00	Highest Development	0.2

FunConn: Otter

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	90
21	Developed Open Space	20
22	Developed Low Intens	20
23	Developed Med Intens	10
24	Developed High Inten	0
31	Bare Rockk/Sand Clay	0
41	Decidious Forest	80
42	Evergreen Forest	50
43	Mixed Forest	60
52	Shrub/Scub	50
71	Grassland/Herbaceous	10
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	80
95	Emergent Wetlands	50
500	Floodplain	100

Resource Quality Threshold: 75
Minimum Patch Size: 180ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 4000m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	100
-50	0	100
0	10	90
10	50	80
50	100	70
100	200	60
200	300	55
300	400	50
400	500	45
500	750	40
750	1000	37
1000	1500	35
1500	2000	32
2000	3000	30
3000	4000	25
4000	5000	22
5000	7500	20
7500	10000	10
10000	999999999	0

FunConn: Otter

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	0	0	0	0	0
0	10	0	0	1	5	50	0
10	50	0	0	5	20	75	0
50	100	0	5	15	50	100	0
100	200	0	15	50	75	100	5
200	300	5	30	75	90	100	10
300	400	15	50	100	100	100	50
400	500	30	75	100	100	100	30
500	750	50	100	100	100	100	50
750	1000	75	100	100	100	100	75
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	1
21	Developed Open Space	0.4
31	Bare Rockk/Sand Clay	0.4
41	Decidious Forest	0.8
42	Evergreen Forest	0.8
43	Mixed Forest	0.8
52	Shrub/Scub	0.8
71	Grassland/Herbaceous	0.8
81	Pasture/Hay	0.4
82	Cultivated Crops	0.4
90	Woody Wetlands	1
95	Emergent Wetlands	1
500	Floodplain	1
90,001.00	Major Rd.	0.01
90,002.00	State. Rd.	0.05
90,003.00	County Rd.	0.08
90,004.00	Local Rd. 1	0.09
90,005.00	Local Rd. 2	0.2
90,006.00	Highest Development	0.01

FunConn: Tanager

Table 1: Habitat Quality

GridCode	Description	Quality
11	Open Water	0
21	Developed Open Space	5
22	Developed Low Intens	10
23	Developed Med Intens	5
24	Developed High Inten	0
31	Bare Rockk/Sand Clay	0
41	Decidious Forest	100
42	Evergreen Forest	50
43	Mixed Forest	80
52	Shrub/Scub	40
71	Grassland/Herbaceous	0
81	Pasture/Hay	0
82	Cultivated Crops	0
90	Woody Wetlands	30
95	Emergent Wetlands	0

Resource Quality Threshold: 75
Minimum Patch Size: 10ha
Aggregation Factor: 1

Patch/Foraging Radius (meters): 234m
Core Habitat Percentage: 0.1
Links Qn Value: 10

Table 2: Patch Structure

FROMVAL	TOVAL	Quality
-99999999	-2000	100
-2000	-1000	100
-1000	-500	100
-500	-400	100
-400	-300	100
-300	-200	100
-200	-100	100
-100	-50	100
-50	0	90
0	10	80
10	50	75
50	100	70
100	200	65
200	300	60
300	400	55
400	500	50
500	750	25
750	1000	10
1000	1500	0
1500	2000	0
2000	3000	0
3000	4000	0
4000	5000	5
5000	7500	0
7500	10000	0
10000	999999999	0

FunConn: Tanager

Table 3: Disturbance Reclass Table

FROMVAL	TOVAL	V90001	V90002	V90003	V90004	V90005	V90006
-99999999	0	0	70	80	80	90	40
0	10	60	80	85	90	95	50
10	50	75	85	90	95	100	65
50	100	100	100	100	100	100	80
100	200	100	100	100	100	100	100
200	300	100	100	100	100	100	100
300	400	100	100	100	100	100	100
400	500	100	100	100	100	100	100
500	750	100	100	100	100	100	100
750	1000	100	100	100	100	100	100
1000	1500	100	100	100	100	100	100
1500	2000	100	100	100	100	100	100
2000	3000	100	100	100	100	100	100
3000	4000	100	100	100	100	100	100
4000	5000	100	100	100	100	100	100
5000	7500	100	100	100	100	100	100
7500	10000	100	100	100	100	100	100
10000	999999999	100	100	100	100	100	100

Table 4: Permeability

GridCode	Description	PermValue
11	Open Water	0.4
21	Developed Open Space	0.8
31	Bare Rockk/Sand Clay	0.8
41	Decidious Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	0.8
71	Grassland/Herbaceous	0.7
81	Pasture/Hay	0.7
82	Cultivated Crops	0.7
90	Woody Wetlands	1
95	Emergent Wetlands	0.7
90,001.00	Major Rd.	0.5
90,002.00	State. Rd.	0.7
90,003.00	County Rd.	0.7
90,004.00	Local Rd. 1	0.7
90,005.00	Local Rd. 2	0.7
90,006.00	Highest Development	0.3

Least Cost: Bear

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
21	Developed Open Space	5
22	Developed Low Intens	6
23	Developed Med Intens	7
31	Bare Rockk/Sand Clay	10
52	Shrub/Scub	2
71	Grassland/Herbaceous	4
81	Hay/Pasture	4
82	Cultivated Crops	4
90	Woody Wetlands	2
141	Decid Forest - Low	1
241	Decid Forest - High	1
142	Ev Forest - Low	4
242	Ev Forest - High	2
143	Mix Forest - Low	4
243	Mix Forest - High	2
195	Em Wet - Low	5
295	Em Wet - High	5
10000	Open Water - Small	5
20000	Open Water - Medium	6
30000	Open Water - Large	7
90001	Highway	10
90002	State Route	9
90003	County Road	8
90004	Large Street	7
90005	Residential Street	6
90006	High Intensity Developed	10
90007	Medium Intensity Development	6

Least Cost: Cougar

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
11	Water	5
21	Developed Open Space	7
31	Bare Rockk/Sand Clay	7
41	Decid Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	2
71	Grassland/Herbaceous	3
81	Hay/Pasture	6
82	Cultivated Crops	6
90	Woody Wetlands	4
95	Emergent Wetland	5
90001	Highway	10
90002	State Route	9
90003	County Road	8
90004	Large Street	4
90005	Residential Street	4
90006	Medium/High Intensity Development	10

Least Cost: Lynx

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
11	Water	9
21	Developed Open Space	7
31	Bare Rockk/Sand Clay	6
41	Decid Forest	4
42	Evergreen Forest	1
43	Mixed Forest	2
52	Shrub/Scub	4
71	Grassland/Herbaceous	8
81	Hay/Pasture	9
82	Cultivated Crops	9
90	Woody Wetlands	5
95	Emergent Wetland	7
90001	Highway	10
90002	State Route	6
90003	County Road	6
90004	Large Street	5
90005	Residential Street	3
90006	Medium/High Intensity Development	10

Least Cost: Marten

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
21	Developed Open Space	4
31	Bare Rockk/Sand Clay	5
41	Decid Forest	2
42	Ev Forest	1
43	Mix Forest	1
52	Shrub/Scub	3
71	Grassland/Herbaceous	7
81	Hay/Pasture	3
82	Cultivated Crops	3
90	Woody Wetlands	1
95	Em Wet - Low	1
10000	Open Water - Small	2
20000	Open Water - Medium	3
30000	Open Water - Large	5
90001	Highway	10
90002	State Route	9
90003	County Road	8
90004	Large Street	7
90005	Residential Street	6
90006	High Intensity Developed	10

Least Cost: Moose

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
11	Water	3
21	Developed Open Space	5
31	Bare Rockk/Sand Clay	10
41	Decid Forest	1
42	Evergreen Forest	1
43	Mixed Forest	1
52	Shrub/Scub	1
71	Grassland/Herbaceous	2
81	Hay/Pasture	3
82	Cultivated Crops	4
90	Woody Wetlands	1
95	Emergent Wetland	1
90001	Highway	10
90002	State Route	9
90003	County Road	8
90004	Large Street	7
90005	Residential Street	6
90006	Medium/High Intensity Development	4

Least Cost: Otter

Table 1: Cost Surface Values

GRIDCODI	DESCRIPTION	Cost Value
21	Developed Open Space	7
31	Bare Rockk/Sand Clay	10
41	Decid Forest	4
42	Ev Forest	5
43	Mix Forest	4
52	Shrub/Scub	6
71	Grassland/Herbaceous	9
81	Hay/Pasture	10
82	Cultivated Crops	10
90	Woody Wetlands	1
95	Em Wet - Low	1
10000	Open Water - Small	1
20000	Open Water - Medium	3
30000	Open Water - Large	6
90001	Highway	10
90002	State Route	8
90003	County Road	8
90004	Large Street	7
90005	Residential Street	6
90006	High Intensity Developed	8

Least Cost: Tanager

Table 1: Cost Surface Values

GRIDCODE	DESCRIPTION	Cost Value
11	Water	6
21	Developed Open Space	6
31	Bare Rockk/Sand Clay	4
41	Decid Forest	1
42	Evergreen Forest	3
43	Mixed Forest	2
52	Shrub/Scub	4
71	Grassland/Herbaceous	4
81	Hay/Pasture	4
82	Cultivated Crops	4
90	Woody Wetlands	1
95	Emergent Wetland	3
90001	Highway	10
90002	State Route	9
90003	County Road	8
90004	Large Street	7
90005	Residential Street	3
90006	Medium/High Intensity Development	5