A Measures Framework for Staying Connected in the Northern Appalachians

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Acknowledgements

The Measures Framework for the Staying Connected Initiative (SCI) was a major undertaking that would not have been successfully completed without the active engagement and hard work of many dedicated people. We would particularly like to acknowledge the members of the SCI Measures and Evaluation Group (MEG) whose critical thinking forms the backbone of this report. The MEG is composed of representatives from the U.S. states and Canadian provinces covered by the geography of Staying Connected. As of December 2012, there are 27 individuals representing state fish and wildlife agencies, state chapters of The Nature Conservancy (TNC), provincial chapters of the Nature Conservancy of Canada (NCC), Wildlands Network, Wildlife Conservation Society (WCS) Canada, and other organizations.

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Summary

This document presents a system for measuring the status of landscape connectivity in eight *landscape linkage areas* across the Northern Appalachian – Acadian ecoregion. These linkages were identified by the Staying Connected Initiative (SCI) as part of its mission to protect and maintain landscape connectivity across the Northern Appalachians for the benefit of wide-ranging, forest dwelling wildlife such as bear, moose, lynx, marten and bobcat.

The framework provides a compact set of relatively simple, inexpensive, and repeatable GIS-based status measures, as well as an initial snapshot of the status of structural connectivity (with baseline numbers and maps), for each linkage area and the important *pathways* – fine-scale landscape connections – they contain. It should be viewed as a living document; as our understanding of wildlife movements and habitat connectivity in this region improves and better and more detailed information becomes available, this framework should evolve.

The terms "measure" and "metric" are used interchangeably within this framework. Each measure/metric is comprised of three elements*: an Attribute, Objective and Indicator(s)*. In addition to full explanations of the proposed attributes, objectives, and indicators for each measure, GIS analyses and datasets are described and referenced. There are four sets of connectivity measures for each linkage: two relate to habitat composition and distribution, and derive from land use-land cover data; one describes the state of land protection and is derived from regional datasets maintained by TNC; and one attempts to describe the status of existing road-barrier effects and is derived from road lengths and traffic volume counts. Because of gaps in appropriate data needed for some indicators, not all proposed status measures were run. In addition, because of our lack of knowledge of *thresholds* for structural connectivity in the northeast, specific objectives are not always articulated for all measures.

The GIS data used in this initial snapshot was the best and most recent available across the region, but publication and currentness dates vary considerably across the region. For example, the land cover data used for the U.S. portion of the linkage areas was derived from 2006 NLCD, but the Canadian land cover data varied in vintage from 1999-2006. As new data become available, the framework can be updated relatively simply. But, it is inevitable that not all data needed will be available for a desired time period. For example, NLCD data is scheduled to be updated every 5 years, protected lands data as maintained by TNC is updated yearly, and state roads datasets are updated on schedules that vary by state. In any event, the combined

metrics can provide a ready "dashboard" for evaluating conservation status and trends in these critical landscapes.

It is important to stress that each linkage and structural pathway was defined by a group of local experts, and that they vary greatly in size, status of structural connectivity, appropriate conservation strategies, and ecological, economic and social contexts. Because of these differences, this measures framework is set up so that baselines and on-going monitoring will occur on a linkage-by-linkage and pathway-by-pathway basis. It is most instructive to compare and evaluate individual linkages over time and not to compare each linkage to other linkages. The same holds true for structural pathways – they should only be compared to themselves through time and not compared to other structural pathways.

Nevertheless, describing the status of structural connectivity across all the linkages can give us a flavor for the variety inherent in the linkage areas. Overall, the eight linkages encompass over 12 million acres, nearly 50,000 km^2, out of a total ecoregion area of about 88 million acres (356,000 km^2). On the whole, nearly 92% of the area of all the linkages remains in natural cover, though this varies greatly across the region, from a low of 76% in the Adirondacks-Greens linkage – an area of rich farmland and a long history of agriculture – to 95% in the rugged Western Maine linkage with its few permanent residents. Another measure, habitat distribution, provides insights into how clumped or fragmented a landscape is, via the Resistant Kernel (RK) indicator. We used a RK score of 50 or higher to generally indicate a relatively unfragmented landscape. The average RK score ranges from 34 in the Taconics-Greens linkage, which is long and narrow and has a major road running its length, to 67 in Western Maine, where there are few paved roads. Of the eight linkages, four have RK scores below 50, four above. The amount of land in some form of protection also varies greatly among the linkages, from 14% in the Tug Hill-Adirondacks linkage to nearly 50% in the 3-Borders-Northern Maine-Gaspe linkage (much of this is Crown land).

Assessing the negative effects roads have on animal movement and habitat connectivity at both the linkage and structural pathway scale is a particular challenge. Given the lack of detailed data at the scale of the linkage area, we were forced to use the simple indicators of the number of miles of roads in four general classes and in each of three different traffic volume categories where the data were available. The number of miles of different road types varies greatly by linkage area. Some linkages are bisected by high traffic, major roads while others contain mostly low volume, local roads. As a result, future conservation and evaluation strategies involving transportation infrastructure will need to vary by linkage area.

This framework uses data that are readily available across the region for the four connectivity measures. What it doesn't do – and we readily acknowledge that this is a limitation of the current framework that needs to be addressed – is present the wide range of other regulatory and non-regulatory conservation measures in place that are helping to keep land undeveloped and landscapes connected. These include programs such as:

- The Use Value Appraisal (or "current use") program in Vermont[1] (and similar programs elsewhere) that assess lower taxes on parcels that remain undeveloped;
- The local regulatory (i.e., zoning bylaws, subdivision regulations) process that permits or restricts what can happen on a given piece of land[2];
- Federal programs such as the US Department of Agriculture's Natural Resources Conservation Service (NRCS) Farm Bill conservation cost-share programs, such as Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP), which now incorporate connectivity criteria in the evaluation of land parcels and project for funding in some states and;
- State-sponsored programs such as Maine's Beginning with Habitat[3] that provide guidance to towns on non-regulatory approaches to conserving important habitats and the connections between them.

All of these important programs have a significant effect on conservation – hundreds of thousands of acres/hectares likely remain undeveloped across the region because of them. But many of them produce results that are arguably not permanent, nor readily measurable. Only the most measurable and permanent of these means (land protection) is used as a measure in this report.

Finally, this is the first iteration of the SCI measures framework. The following next steps could greatly improve both our understanding and ability to evaluate the state of connectivity in the region:

- Identify priority road segments within pathways (or linkages if pathways have not been identified) wherever possible.
- Encourage expansion of Annual Average Daily Traffic (AADT) data collection in New Hampshire, Vermont, Maine and New York, and further investigate availability and coverage of AADT data in New Brunswick and Quebec
- Carry out comprehensive inventories of culverts and other structures along priority road segments in pathways.

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[1] http://www.state.vt.us/tax/pvrcurrentuse.shtml

[2] See Krestser et al. (2013) for a review of Best Practices and Land Use Planning Tools in the US portion of the Northern Appalachian/Acadian region.

[3] http://www.beginningwithhabitat.org/

- Assess and document evidence of use by species of interest by tracking, remote cameras, and/or other methods.
- Establish specific, quantitative objectives for each measure.
- Re-run the Resistant Kernel analysis using updated land cover and roads data, at 30 meter resolution.
- Incorporate regulatory and non-regulatory conservation measures into the framework.
- Incorporate all of the above into a new version of the measures framework by the end of 2015, and include updated information derived from 2011 NLCD data in that next iteration if possible.

Introduction

As on-the-ground conditions change in the Northern Appalachians, conservation practitioners need ways to evaluate and quantify the status of landscape connectivity -- defined as the *degree to which similar landscape elements, such as habitat patches or natural vegetation, are connected to each other so as to facilitate the movements of target organisms and ecological processes between them.* They also need a method to evaluate whether their conservation strategies are having a positive effect on landscape connectivity. This document details a proposed framework for measuring the status of landscape connectivity in eight *landscape linkages* located in four U.S. states and two Canadian Provinces (Figure 1). The Staying Connected Initiative defines a Landscape Linkage – or Landscape Linkage Area – as a *broad region of comparatively greater or more concentrated connectivity important to facilitate the landscape or regional-scale movement of multiple species and to maintain ecological processes between core areas, and where structural connectivity is at risk*[4]. Starting in 2009, these linkages were defined as part of the Staying Connected Initiative (SCI)[5]. The eight linkages vary widely in their size and ecological condition.

This framework provides a compact set of relatively simple, inexpensive, and repeatable GIS-based status measures, as well as baseline numbers, for each linkage area and the important *pathways*[6] they contain. It should be viewed as a living document; as our understanding of

[4] See Appendix A for this and other connectivity measures terms and definitions.

[5] The Staying Connected Initiative (SCI) began in 2009 to protect and maintain landscape connectivity across the Northern Appalachians for the benefit of wide-ranging, forest dwelling wildlife such as bear, moose, lynx, marten and bobcat. SCI brings together more than 20 NGO and governmental organizations in the US and Canada with a great breadth of experience in conservation science, community outreach, land use planning, transportation, and land protection to address the problems of habitat fragmentation and climate change on many levels.

[6] The “Structural Pathway” is the secondary, smaller, more focused geographic unit for which connectivity status measures were developed. We define a structural pathway as a location where components of the landscape

wildlife movements and habitat connectivity improves and better and more detailed information becomes available, this framework should evolve.

The measures framework is one facet of the Staying Connected Initiative's implementation strategy. Ideally, the framework would have evolved out of a plan that articulated the overall vision, mission, goals, and strategies of the initiative; in reality the framework was developed before many of these facets were established. We are confident, however, that this measures framework will provide a useful and informative tool as we evaluate the current and future condition of connectivity across the region and that it will fit in well with the overall vision, goals, and strategies of the initiative.

In some cases, the GIS datasets to support our proposed measures do not yet exist or are incomplete. In these cases, we make recommendations of additional datasets that would facilitate more precise, comprehensive, and meaningful connectivity measures.

<u>How this framework was developed</u>

This measures framework was developed by the Measures and Evaluation Group (MEG) of the Staying Connected Initiative. The MEG is composed of representatives from each of the four U.S. states and two Canadian provinces covered by the geography of Staying Connected. As of December 2012, there are 24 individuals representing state fish and wildlife agencies, state chapters of The Nature Conservancy (TNC), provincial chapters of the Nature Conservancy of Canada (NCC), Wildlands Network, Wildlife Conservation Society (WCS) Canada, and other organizations. The group held an initial meeting in May 2010 to begin developing the framework. After this initial meeting a number of subgroups were formed to do the work of developing and assembling the background terms and definitions, datasets, and analyses that make up the framework. These subgroups met by phone and web conference over the next two years. The final framework was assembled by TNC Maine and Wildlands Network staff with significant input and review from the MEG team. All GIS data assembly, mapping, and analyses were performed by TNC Maine staff.

<u>How this framework document is organized</u>

This document is organized into the following sections:

- **Section 1**: Provides some **key terms, definitions and explanations**.
- **Section 2**: Details the **objectives, measures, and indicators** that apply to the **SCI Linkage Areas**

provide a continuous or near continuous pathway that may facilitate the movement of target organisms or ecological processes between areas of core habitat.

- **Section 3**: Details the **objectives, measures, and indicators** that apply to **Structural Pathways** within the SCI Linkage areas
- **Section 4**: Contains a table that **summarizes all measures, objectives, and indicators** for both Linkage Areas and Structural Pathways
- **Section 5**: Baselines: Contains Linkage-specific reports on **current condition, including maps and tables** for each Linkage Area and its Structural Pathways (if they were mapped)
- **Section 6**: Provides a **discussion of results, conclusions and next steps.**
- **Appendix A**: Contains the complete Terms and Definitions document developed by the SCI terms and definitions team.
- **Appendix B**: Contains details about the datasets used in each indicator

Section 1: Some key terms and definitions

The following terms are used throughout the document. Many were defined by the Terms and Definitions workgroup, and more details are available in Appendix A.

Structural vs. Functional Connectivity

The framework is designed to establish a baseline for, and monitor changes in, structural connectivity, defined as the *degree to which similar landscape elements, such as habitat patches or natural vegetation, are physically connected to each other*. Structural connectivity is distinct from Functional Connectivity, which we define as the *degree to which landscapes facilitate or impede the movement of a target organism or ecological process assuming all other conditions for movement are met*[7]*.* Because of the focus on structural connectivity, for the most part the proposed measures in this framework are generic, rather than species or species-group specific.

Status Measures vs. Effectiveness Measures

It is important to distinguish between status measurement and effectiveness measurement:

- **Status measures**: Objectives and indicators used to assess how species or their habitats are doing over time, without reference to specific conservation actions.
- **Effectiveness measures**: Objectives and indicators used to assess whether a given conservation action is leading to its desired objectives and ultimate impacts.

This measures framework focuses on **Status Measurement**.

Linkage Area

The "Linkage Area" is the primary geographic unit for which connectivity status measures were developed. We define a linkage area as a broad region of comparatively greater or more concentrated connectivity important to facilitate the landscape or regional-scale movement of multiple species and to maintain ecological processes between core areas, and where structural connectivity is at risk. Eight priority linkage areas were defined at the outset of the Staying Connected Initiative and their boundaries were mapped and refined by a subcommittee of the measures and evaluation working group. **See Figure 1. Map of Staying Connected Linkage Areas and the Human Footprint.**

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[7] These definitions were established by the SCI Terms and Definitions group and are included in the Terms and Definitions document in Appendix A.

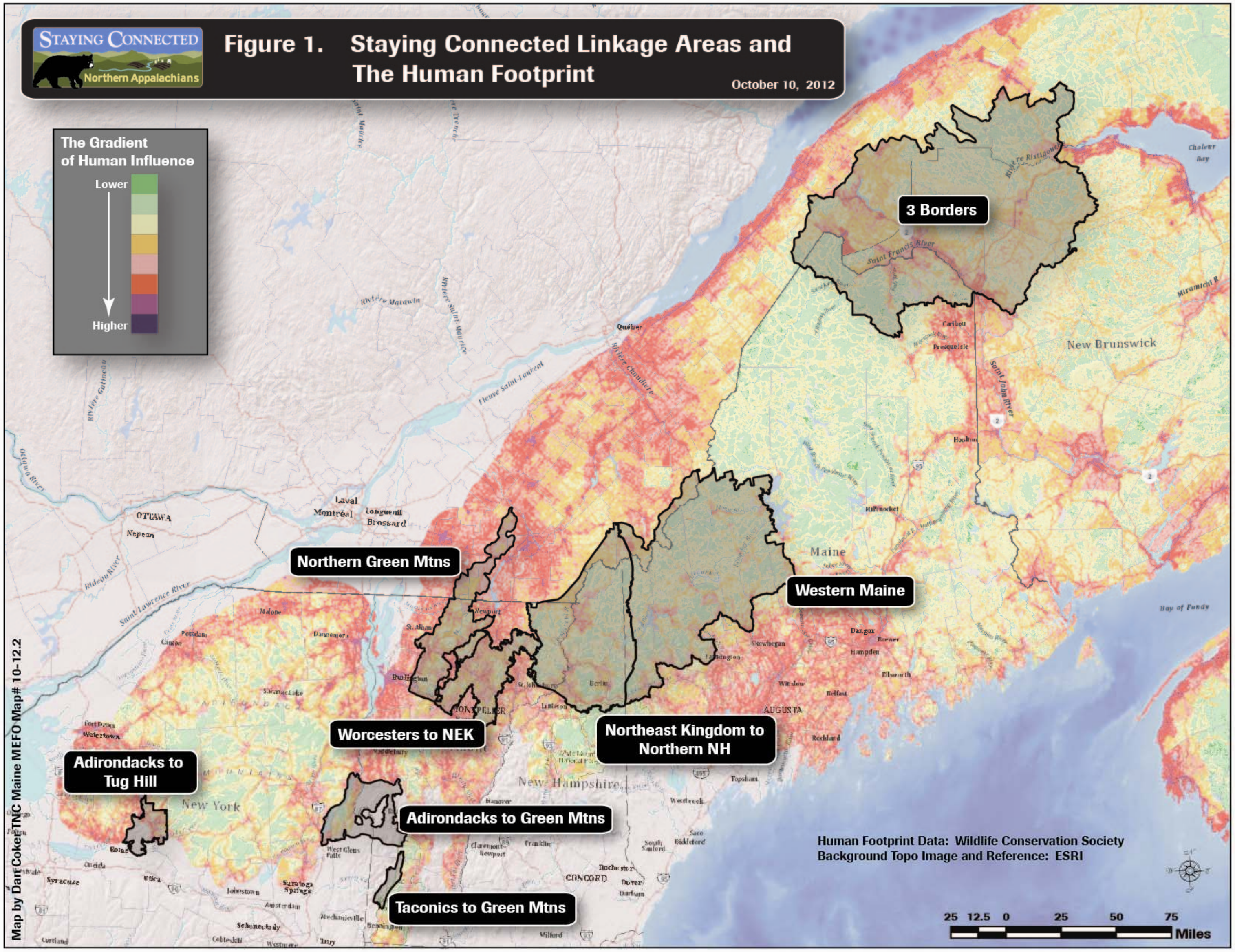

Figure 1. Staying Connected Linkage Areas and The Human Footprint

Structural Pathways

The "Structural Pathway" is the secondary, smaller, more focused geographic unit for which connectivity status measures were developed. For SCI's work, structural pathways are contained in priority linkage areas. We define a structural pathway as a location where components of the landscape provide a continuous or near continuous pathway that *may* facilitate the movement of target organisms or ecological processes between areas of core habitat. Not all linkage area teams developed structural pathways and it is important to note that the ones that did used a host of different methodologies and developed them with different conservation strategies in mind. As a result, not all measures in this framework will be meaningful to the ongoing work in every structural pathway.

Important Note on Comparing Linkages and Structural Pathways*:* Each linkage and structural pathway boundary was defined by a group of local experts, and they vary greatly in size, status of structural connectivity, and ecological, economic and social contexts. Because of these differences, this measures framework is set up so that baselines and on-going monitoring will occur on a linkage-by-linkage and pathway-by-pathway basis. Linkages should only be compared to themselves at different periods in time and not compared to other linkages. The same holds true for structural pathways – they should only be compared to themselves through time and not compared to other structural pathways.

Measure, Metric, Attribute, Indicators, and Objectives

Each Measure within the framework is made up of three elements*: Attributes, Objectives and Indicators*, described in more detail below. The terms "measure" and "metric" are used interchangeably.

Attribute:

An Attribute (or Key Ecological Attribute - KEA) is an Identifiable feature of an ecosystem, species or process that is particularly critical to maintaining viability / stability over centuries and vulnerable to human action.

Example: *Habitat composition* within linkages, which provides the landscape context for structural pathways, stepping stones and corridors within a linkage area

Indicator

An indicator is:

- A measurable entity used to assess the status of progress toward meeting Objectives;

- Usually expressed in level of threat and/or status of key attributes;
- Sometimes a proxy for those attributes or predictors – in a sense they are hypotheses;
- Mutable: their utility should be tested and the indicators refined with more knowledge.

Example: Percentage of the linkage area in natural, agricultural, and developed land use/land cover classes.

<u>Objective:</u>

An Objective is a concise and formal statement detailing a desired outcome and has the following characteristics:

- A good objective should be outcome oriented;
- An objective is not what we'll be doing;
- An objective is not how we will be doing it;
- An objective is a description of the specific conservation outcome towards which we are aiming and what the OUTCOME looks like if we are successful:
- An objective specifies necessary changes in critical threats and KEAs

There are two possible types of Objectives:

1. Abated critical threat and/or
2. Enhanced viability of, and/or restored conservation target (improved KEA(s))

Examples:

- General Objective: To maintain or enhance current overall levels of natural land cover in the linkage areas.
- Specific Objectives:
  - By 2015, no less than 90% of the linkage area is in natural land cover.
  - By 2015, less than 5% of the current agricultural lands within the linkage area have been lost to development.

An important note about Objectives in this Framework: At the outset of the Measures Framework project, the team intended to set specific, quantitative objectives for each measure. We now realize that connectivity science, at least in this landscape, has not yet evolved to the point where we have the knowledge to confidently set numeric objectives at this time. In other words, we don't have a clear picture of what a 'good' or 'very good' rating for each of the proposed indicators looks like. We are confident that the measures-indicators we propose are appropriate and meaningful, but we don't yet know all the meaningful and appropriate thresholds for ensuring wildlife connectivity. That is to say, we don't have a clear picture of the scale on which to grade many of the proposed measures and indicators.

We have therefore, in most instances, NOT set specific numeric objectives for each measure-indicator. As connectivity research continues within the northern Appalachian – Acadian region, and our knowledge of connectivity thresholds grows, we expect that meaningful and appropriate numeric objectives can and will be set. Indeed, a goal of the next phase of a SCI monitoring project will be to set these goals to the extent possible.

Section 2: Linkage-Area Measures (Group A)

There are two distinct groups of Measures detailed in this Framework:

- **Group A** relates to permeability/connectivity and barriers for each **Linkage as a whole**;
- **Group B** relates to permeability/connectivity and barriers of the **Structural Pathways** within each Linkage.

Complete References for the GIS Datasets used to develop the indicators can be found in **Appendix B**.

This section of the report details the **Group A** measures: those developed for each Linkage area as a whole.

Linkages range in size from tens of thousands of acres (hectares) to millions of acres (hectares), so this set of measures provides the "macro" view of what is going on within a given linkage. The measures cover both landscape-level permeability/connectivity and measures of barriers to connectivity. Barriers measures are particularly limited at this macro scale, and consist of measures of miles of various categories of roads (e.g. highways, secondary roads) and miles (km) of roads in three categories of Annual Average Daily Traffic volume (AADT) where such AADT data are available.

There are four measures for each Linkage area. The attributes, objectives and indicators for each measure are described below.

A.1. Attribute*:* Habitat composition within linkages, which provides the landscape context for structural pathways, stepping stones and corridors within the linkage

General Objective: To maintain or enhance current overall levels of natural land cover in the linkage areas

Specific Objectives[8] (actual percentages should be specific to each linkage)**:**

a) By 2015, *no less than* x% of the linkage area is in natural land cover.
b) By 2015, *less than* x% of the current agricultural lands within the linkage area have been lost to development.

Indicator:

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[8] As noted above, we have not set specific numeric objectives. These will be set before the next round of measures assessment occurs.

- Percentage of the linkage area in natural, agricultural, and developed land use/cover class

GIS Dataset utilized

- A **Northern Appalachian (NAP)-wide Land Cover** dataset was assembled as part of the development of these measures. It is comprised of the following (see Appendix B for more details on the data sources):
  - United States: NLCD06 (National Land Cover Dataset, 2006) for baseline with reliance on future NLCD land cover products and change detection analyses.
  - Canadian land cover – Multiple Sources that vary by province:
    - Southern Quebec: 2004 Canadian Wildlife Service
    - Northern Quebec: 1994 Canadian Wildlife Service
    - New Brunswick: 2009 Department of Natural Resources & Environment

A.2. Attribute: Patterns of habitat distribution within the linkages.

General Objective: To maintain or improve habitat distributions that foster the structural connectivity of the linkage area as a whole.

Specific Objective:

a. By 2015, the overall local connectivity of the linkage area has not been significantly degraded. Specific thresholds will be provided at a later date.

Indicators:

- Average Resistant Kernel (RK) score of the linkage area
- Percentage of the linkage area with RK score of at least 50

Specific Objective:

b. By 2015, no Large Blocks of currently highly connected habitat have been lost. (Size to qualify will vary by linkage. RK score to qualify will ***not*** vary by linkage – set to 50+)

Indicators:

- Number of contiguous areas of at least XX acres with Resistant Kernel value >=50

- Average size of contiguous areas with RK>=50
- Minimum size of contiguous areas with RK>=50
- Maximum size of contiguous areas with RK >=50

GIS Data and analyses

- The Resistant Kernel (RK) Analysis for the Northern Appalachians region is the primary dataset used in all indicators for this attribute. It was developed by Brad Compton, UMASS CAPS program (www.umasscaps.org) for The Nature Conservancy's Eastern Resource Office and plays a central role in TNC's recent Resilience analysis (Anderson and Sheldon 2012). The Resistant Kernel dataset is a wall-to-wall raster assessment that is based on the arrangement and contrasts of land uses. In its simplest form, as it is used here, it is a measure of how alike or different (in land cover) each pixel is from its surrounding neighborhood of pixels. Examining the patterns in this raster dataset gives us an indication of how clumped or fragmented a landscape is. The resistant kernel dataset used in this analysis has a 90-meter (m) raster cell size and a 3-kilometer (km) radius circle of evaluation. For more information, see the "Resilient Sites for Terrestrial Conservation in the Northeast and Mid-Atlantic Region" report available here: http://conserveonline.org/workspaces/ecs/documents/resilient-sites-for-terrestrial-conservation-1.

  To create 'blocks' of highly connected habitat, RK raster 90-meter pixels with values of 50+ were extracted and polygons (blocks) were created from groups of these pixels. The score of '50' used as the threshold for many of our RK-based indicators was chosen by examining how different RK scores were expressed on recent aerial photography from around the region.

A.3. Attribute: Land Protection

While Land Protection / Conservation status is not a direct measure of structural connectivity, it is included here because it provides an easy indicator of the permanence of current landscape conditions and helps directly indicate how generally protected each linkage area is.

General Objective: To Increase the amount of conservation land within the linkage area

Specific Objective:

a. By 2015, at least **X** acres (**Y%**) of the linkage area are permanently secured from development

Indicators:

- Acres of permanently protected land (by level of protection) within Linkage Area

GIS Data and analyses

- The primary GIS dataset used to assess current protection status was the 2011 (released in November 2012) regional secured lands datasets assembled and maintained by The Nature Conservancy's Eastern Resource Office. For more information about this dataset and its availability, please contact Melissa Clark, TNC regional data manager (Melissa_clark@tnc.org)

A.4. Attribute: Road-barrier effects with Linkage Area

Assessing the negative effects roads have on animal movement and habitat connectivity at both the linkage and structural pathway scale is a particular challenge for a variety of reasons. Barrier effects can be highly variable and seem to be dependent on a host of parameters which may interact in complex ways. Some of these parameters are well suited for coarse scale assessment by GIS and others need finer scale assessment and require detailed field work that is not currently feasible across entire linkage areas. In addition to the scale-dependent nature of these indicators, the data coverage, even for coarse-scale indicators like traffic volume is incomplete and inconsistent across linkage areas.

Therefore, we present our best recommendations for assessing the barrier effects of roads at both the linkage and structural pathway scale with the strong acknowledgement that there is both incomplete knowledge of the regional and local factors that influence barrier effects and that there are major gaps in the data we feel are necessary to confidently assess barrier effects.

Our recommendations for measuring barrier effects should be viewed as *starting points* or *hypotheses* on which to base more detailed, higher resolution GIS and field studies.

In general, we recommend barrier metrics that are a combination of:

- Traffic Volume of road Segments
- Habitat surrounding road segments
- A comprehensive assessment of existing crossing structures (bridges, culverts, etc.)
- Protection status of lands surrounding road segments

In addition, because species responses to various traffic volumes, crossing structures, and road-side features varies greatly, we also recommend, where possible, that road-barrier metrics for different species groups or movement guilds (e.g. wide-ranging mammals vs. reptiles and amphibians) be assessed separately.

Given the lack of detailed data at the scale of the Linkage Area, we defaulted to the simple indicators of the number of miles of roads in four general classes and in each of three different traffic volume categories where the data were available. Our recommendations for assessing barrier effects at the structural pathway and individual road segment level are more complex and are detailed in the next section of this document.

General Objective for Linkage Area: To maintain or enhance the permeability of existing roads within Linkage Areas.

Specific Objectives

a. Discourage new road construction and keep traffic distributions stable. Keep traffic distributions from shifting upwards.

Indicator:

- Number of Miles of Roads in each of four General Classes (e.g., highways, primary roads)
- Number of miles within each of three traffic volume categories (Average Annual Daily Traffic [AADT)]: 1) < 2,500 AADT; 2) 2,500-10,000 AADT; 3) > 10,000 AADT)

GIS Data and analyses:

- ESRI StreetMap North America 10.1 and
- State (ME, NH, VT, NY) DOT roads datasets with traffic volume (U.S. only)

Key Recommendation: Encourage expansion of AADT data collection in NH, VT, and NY, and further investigate availability and coverage of AADT data in New Brunswick and Québec.

Section 3: Structural Pathway Measures (Group B)

Within several of the linkages, “Structural Pathways” have been identified. SCI defines these pathways as ***areas with sufficient structural connectivity to function as a habitat corridor**,* with a habitat corridor defined as those ***components of the landscape that provide a continuous or near continuous pathway that may facilitate the movement of target organisms or ecological processes between areas of core habitat**.* Structural Pathways have not been defined in every linkage, and methods of delineation vary from linkage to linkage. However delineated, pathways play broadly the same habitat corridor function within any given linkage.

As in the linkages, there are four general measures for pathways, two for permeability/connectivity, one for conservation status and one for barriers. Several of the datasets used, such as 30m NLCD data, are shared by the linkage and pathways measures, though the objectives and indicators vary.

B.1. Attribute*:* Habitat composition within structural pathways

General Objective: To maintain or enhance current overall levels of natural land cover in the pathways

Specific Objectives:

a. By 2015, ***no less*** than x% of the pathways as a whole is in natural land cover.
b. By 2015, ***less than*** x% of the current agricultural lands within the pathways as a whole has been lost to development.

Indicator:

- Percentage of the pathways in natural, agricultural, and developed land use/cover class

GIS Data

- A **Northern Appalachian-wide Land Cover** dataset was assembled as part of the development of these measures. It is comprised of the following (see Appendix B for more details on data sources):
    - United States: NLCD06 (National Land Cover Dataset, 2006) for baseline with reliance on future NLCD land cover products and change detection analyses.
    - Canadian land cover – Multiple Sources that vary by province:
        - Southern Quebec: 2004 Canadian Wildlife Service
        - Northern Quebec: 1994 Canadian Wildlife Service
        - New Brunswick: 2009 Department of Natural Resources & Environment

Key Recommendation: High-resolution land cover data developed from other sources such as recent aerial photography more appropriate for the scale of analysis could greatly improve the precision and accuracy of this indicator.

B.2. Attribute: Patterns of habitat distribution within the pathways.

General Objective: To maintain or improve habitat distributions that foster the structural connectivity of the structural pathways.

Specific Objectives

a. By 2015, natural and agricultural lands have not experienced significant additional fragmentation

Indicator:

- Average size of contiguous Undeveloped Habitat Blocks within pathways.

b. By 2015, no large blocks of currently undeveloped habitat have been lost – size to qualify as "large" will vary by linkage area

Indicator:

- Number of undeveloped habitat blocks of at least XX acres within pathways.

GIS Data and analyses:

- For these indicators, an Undeveloped Habitat Blocks dataset was developed from the Northern Appalachian land cover dataset and ESRI StreetMap NA 10.1 roads. First, natural and agricultural lands were extracted from the NAP land cover dataset. The ESRI StreetMap roads were then rasterized (30 meter cell size) and added to the land cover dataset. These roads along with developed land cover classes were then erased out of the dataset and the resultant blocks of natural and agricultural lands were then converted to polygons. These polygons formed the bases of the undeveloped habitat block indicators. The choice to develop these habitat block polygons rather than used Resistant Kernel (RK)-based polygons for the pathway indicators was based on the need to restrict our pathway indicators to what was going on *within* the defined boundaries of the pathways. The pathways, are, in some instances, quite narrow and, as detailed above, the RK score is based on an evaluation radius of 3km. Use of the RK as an indicator of condition within the narrow pathways would have produced results that were not as focused as desired.

B.3. Attribute: <u>Land Protection</u>

While Land Protection - Conservation status is not a direct measure of structural connectivity, it is included here because it provides an easy indicator of the permanence of current landscape conditions and helps directly indicate how generally protected each linkage area is.

General Objective: To Increase the amount of protected land within the structural pathways.

Specific Objective: By 2015, at least **X** acres (**Y%**) of the structural pathways are permanently secured from development

Indicator:

- Acres of permanently protected land (by level of protection) within Linkage Area

GIS Data and analyses

- TNC regional secured lands dataset (2011)

B.4. Attribute: <u>Degree of Permeability of *priority* road segments within Structural Pathways.</u>

General Objective: To maintain or enhance the permeability of *priority* road segments within Structural Pathways. Priority road segments are those stretches of road where, because of their relatively high use by target species and/or their key position in the landscape, efforts to prevent or mitigate road-barrier effects should be focused. **Note:** it is anticipated that further work to prioritize road segments within pathways is needed in many of the linkage areas. In this framework, we therefore report baseline indicator values for ***all*** road segments within mapped structural pathways.

Specific Objective a): At least X% of natural land cover within 100 meters of Priority Road Segments is maintained with no more than y% developed lands by 2015.

Indicator:

- Percentage of the area within 100 meters of Priority Road Segments in natural, agricultural, and developed land use/cover class

GIS Data and Analysis:

- **This indicator was NOT run. Detailed land cover at the appropriate scale is not yet widely available. Some detailed data are available for some road segments in some linkage areas.**

Specific Objective b): By 2015, at least y (#) acres or x% are permanently secured from development within 100 meters of priority road segments in the pathways.

Indicator:

- Acres of Conserved Lands within 100 meters of roads within structural pathways

GIS Data:

- TNC regional secured lands dataset (2011) and ESRI StreetMap NA 10.1

Specific Objective c): Traffic volume and speed along Priority Road Segments is maintained or reduced

Indicator:

- Average Annual Daily Traffic (AADT) counts and speed data

GIS Data:

- **This indicator was NOT run. Traffic Volume data are not consistently available enough for pathway-level analysis.**

Specific Objective d): X% of road crossing structures (e.g. bridges, culverts) and other infrastructure (e.g. fencing) are permeable by 2015 in order to facilitate passage of target wildlife.

Indicator:

- Characteristics of structures within Priority Road Segments, which would then be updated on a periodic basis.

GIS Data:

- **This indicator was NOT run due to a lack of comprehensive data on wildlife crossing structures.**

Key recommendations for improving Barrier metrics:

- Comprehensive inventories of culverts and other structures are needed along priority road segments in pathways.
- Evidence of use by species of interest should be assessed, either by tracking, remote cameras, and/or other methods.

Section 4: Summary of Attributes, Objectives, and Indicators

This section provides a summary of the framework in the form a table that organizes the measures into two groups:

- **Group A** relates to permeability/connectivity and barriers for each **Linkage as a whole**;
- **Group B** relates to permeability/connectivity and barriers of the **Structural Pathways** within each Linkage.

Table 1. Staying Connected Initiative Measures Framework

Note: Baseline Map #'s repeat for each linkage area (e.g. 1-10) and do not correspond to overall Figure #'s.

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
Group A: Attributes, Objective and indicators related to overall Linkage Permeability/Connectivity						
A.1	Habitat composition within linkages	To maintain or enhance current overall levels of natural land cover in the linkage areas	a. By 2015, **no less** than x% of the linkage area is in natural land cover.	% of the linkage area in natural, agricultural, and developed land use/cover class	**Data**: 1. NAP land cover dataset 2. Future - USGS NLCD-conducted change analysis (U.S.)	**Baseline Map #1**
			b. By 2015, **less than** x% of the current agricultural lands within the linkage area has been lost to development.	*Same as above*	*Same as above*	**Baseline Map #1**
A.2	Patterns of habitat distribution within the linkages	To maintain or improve habitat distributions that foster the structural connectivity of the	a. By 2015, the overall local connectivity of the linkage area as a whole has not been significantly degraded.	i. Average RK score for the linkage area.	**Data**: Resistant Kernel Dataset	**Baseline Map #2**

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
		linkage area as a whole.				
				ii. % of the linkage area with RK score of at least 50	*Same as above*	**Baseline Map #2**
			b. By 2015, no large blocks of currently highly connected habitat have been lost	i. Number of contiguous areas of at least XX acres with RK >=50.	*Same as above*	**Baseline Map #3** Size of blocks to qualify will vary by linkage. RK score to qualify will not vary by linkage – set to >= 50.
				ii. Average size of contiguous areas with RK >= 50.	*Same as above*	**Baseline Map #3**
				iii. Minimum size of contiguous areas with RK >= 50	*Same as above*	**Baseline Map #3**
				iv. Maximum size of contiguous areas with RK >= 50	*Same as above*	**Baseline Map #3**

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
A.3	Land Protection	Increase the amount of conservation land within the linkage	a. By 2015 at least y (#) are x% permanently secured	Acres of permanently protected lands within Linkages	**Data**: TNC Regional Secured Areas Dataset	**Not a direct measure of connectivity status, but an important measure for overall conservation and permanence of current landscape conditions.** Baseline Map #4
A.4	Road-barrier effects within Linkage Area	To maintain or enhance the permeability of roads within Linkages.	a. Discourage new road construction and keep traffic distributions consistent. Don't want distributions to shift upwards.	Number of Miles of Roads: In each of 4 General Classes and In each of 3 Traffic Volume Categories) – where data available	**Data**: ESRI StreetMap NA 10.1 and state DOT roads datasets with traffic volume (U.S. Only)	**Traffic Volume data coverage is varies greatly by geography and is not available for many roads.** Baseline Maps #5 and #6

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
Group B: Attributes, Objectives and indicators related to Structural Pathways within the Linkage (if pathways are defined). NOTE that Structural Pathways were NOT defined for all Linkage Areas. **Note: The pathway measures below are reported as aggregates for all pathways within each linkage and not reported on a pathway-by-pathway basis.**						
B.1	Habitat composition within structural pathways	To maintain or enhance current overall levels of natural land cover in the pathways.	a. By 2015, **no less** than x% of the pathways as a whole is in natural land cover.	Percentage of the pathways in natural, agricultural, and developed land use/cover class	**Data**: 1. NAP land cover dataset 2. Future - USGS NLCD-conducted change analysis (U.S.)	Baseline Map #7
			b. By 2015, **less than** x% of the current agricultural lands within the pathway has been lost to development.	*Same as above*	*Same as above*	
B.2	Patterns of habitat distribution within the pathways	To maintain or improve habitat distributions that foster the structural connectivity of the pathways.	a. By 2015, natural and agricultural lands in the pathways have not experienced significant additional fragmentation.	Average size of contiguous undeveloped habitat blocks within pathways.	**Data / Analysis**: Undeveloped Habitat Blocks dataset – see text in Section 3 and reference in Appendix B.	Baseline Map #8
			b. By 2015, no large blocks of currently undeveloped habitat have been lost.	Number of undeveloped habitat blocks of at least XX acres within pathways.	*Same as above*	**Size to qualify will vary by linkage area.** Baseline Map #8

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
B.3	Land Protection	Increase the amount of protected land within the structural pathways	By 2015, at least **X** acres (**Y%**) of the structural pathways are permanently secured from development	Acres of Conserved Lands (in various protection status) within structural pathways	**Data**: TNC Regional Secured Areas Dataset	**Not a direct measure of connectivity status, but an important measure for overall conservation and permanence of current land use.** **Baseline Map #9**
B.4	Degree of permeability of *priority* road segments within a Structural Pathway.	To maintain or enhance the permeability of priority road segments within pathways	a. At least X % of natural land cover within 100 meters of Priority Road Segments maintained with no more than y % of developed land by 2015	% of area within 100m of road segments in general land use categories.	**NOT RUN – LAND COVER DATA OF APPROPRIATE SCALE NOT WIDELY AVAILABLE**	**NO MAP**
			b. By 2015, at least y (#) or x % are permanently secured from development within 100 meters of Priority Road Segments	Acres of protected Lands within 100 meters of roads within structural pathways	**Data**: TNC Regional Secured Areas Dataset and ESRI StreetMap NA 10.1	**Further prioritization of roads within pathways needs to occur to develop sets of Priority Road segments. This measure was**

	Attribute	General Objective	Specific Objective	Indicator	GIS Data and/or analyses	Map Number and Notes
						run for *ALL* road segments within pathways **Baseline Map #10**
			c. Traffic volume and speed along Priority Road Segments is maintained or reduced	Average Annual Daily Traffic (AADT) counts and speed data.	**NOT RUN – Traffic Volume data not consistently available enough for pathway-level analysis**	**NO MAP**
			d. By 2015, X% of road crossing structures and other infrastructure are permeable in order to facilitate passage of target wildlife species	Characteristics of structures within priority road segments, which would then be updated on a regular basis	**NOT RUN – No comprehensive data on wildlife crossing structures (culverts, bridges, etc.) currently available.**	**NO MAP**

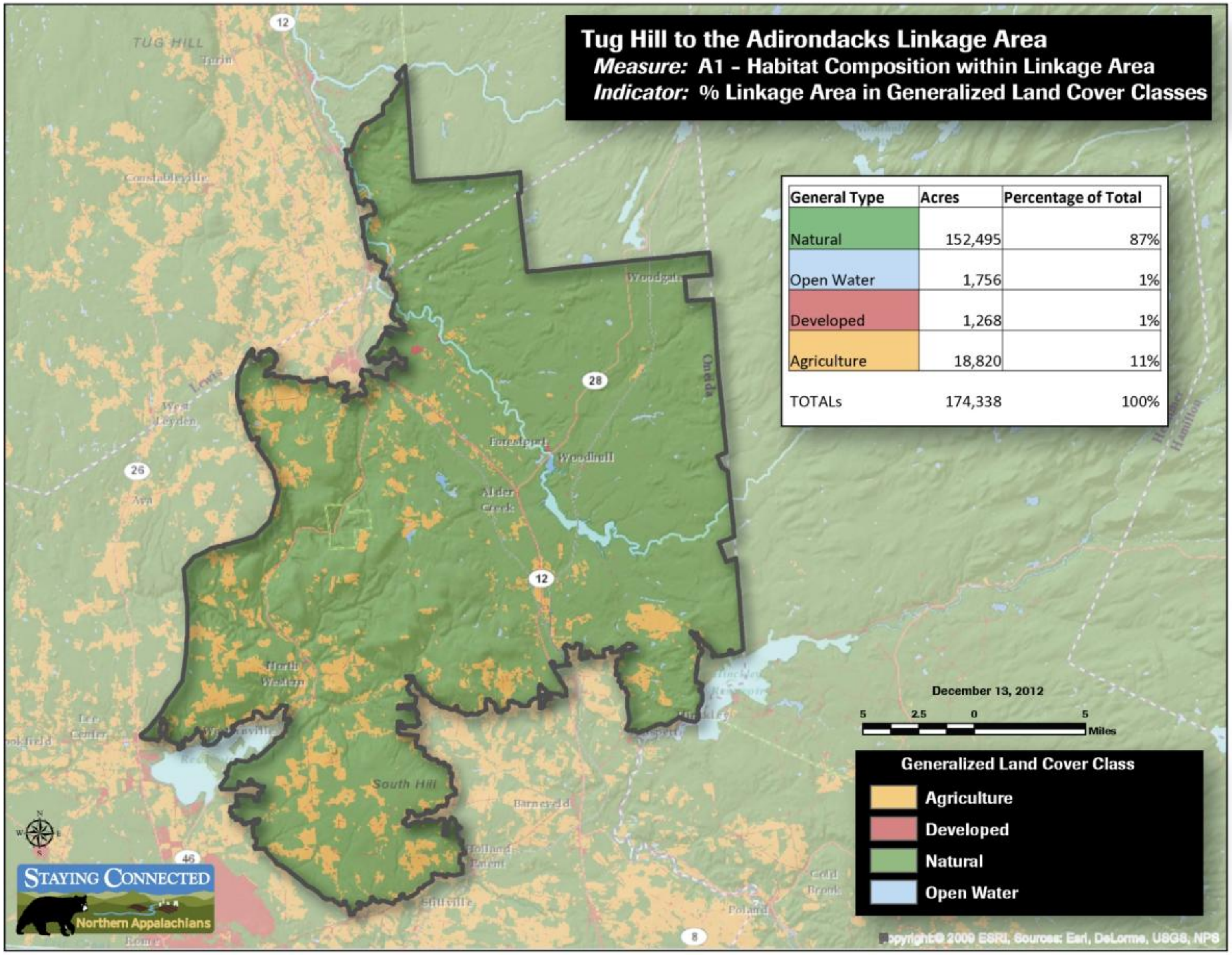
Section 5 Baselines: Linkage-specific reports on current condition, including statistics, and maps for each Linkage Area and its Structural Pathways

This section contains reports on each linkage area, including short descriptions of the natural and cultural landscape of each linkage and maps and descriptive statistics that detail each structural connectivity measure. Each measure/metric and associated attributes and indicators are referenced with the code as indicated in Table 1. Not all measures were run for every linkage area, primarily because of data limitations. We include suggestions for data needs and improvements with each linkage area measure. Some data needs apply to all linkage areas (e.g. more current land cover, higher resolution resistant kernel analyses) and some are linkage-specific (e.g. more complete traffic volume-road data for the Adirondacks-Tug Hill linkage)

Linkage 1: The Tug Hill to Adirondacks Linkage Area

The Black River Valley is located between the 6-million acre (24,280 km^2) Adirondack Park and 1.2-million acre (4,856 km^2) Tug Hill region, two of the largest forested areas in New York. Most conservation work is focused on 174,338 acres (706 km^2) in the southern portion of the valley. Viewed from satellite images, this section of river valley stands out as a natural funnel for wildlife – a largely forested stretch between the Adirondacks and Tug Hill, surrounded by agricultural and residential lands. The Black River, a moderate sized waterway popular with anglers and paddlers, winds through the valley. State routes 12 and 28 are significant state travel corridors crossing the linkage, but remain two-lane roads in places. Boonville, with approximately 2,000 residents, is the largest settlement in this rural landscape. Wide-ranging species like bear and bobcat are currently able to move between the Adirondacks and Tug Hill, and once extirpated species like moose and marten are returning to the area.

As detailed in Figure 2, most of the linkage (87%) retains its natural vegetation, with 11% in agriculture and 1% as developed land. The resistant kernel statistics show, however, that a good part of the linkage is relatively fragmented (Figure 3), as shown by the low RK scores in the southwestern portion of the linkage, and an overall average RK score of 40 (an area with an RK score of 50 or greater is generally considered to be relatively unfragmented). Larger blocks with RK scores of 50 or above are mostly located near the Adirondack Park, with a smaller block just to the west of Route 12 (Figure 4). About 14% of the linkage is in some form of conservation (Figure 5). Routes 12 and 28 are moderate barriers to mammal movement, with a combined 31 miles (50 km) of road with an Average Annual Daily Traffic (AADT) volume of between 2,500 and 10,000 (Figure 7).



General Type	Acres	Percentage of Total
Natural	152,495	87%
Open Water	1,756	1%
Developed	1,268	1%
Agriculture	18,820	11%
TOTALs	174,338	100%

Figure 2. Tug Hill to the Adirondacks Linkage Area - ***Baseline Map #1: Habitat composition within linkage***

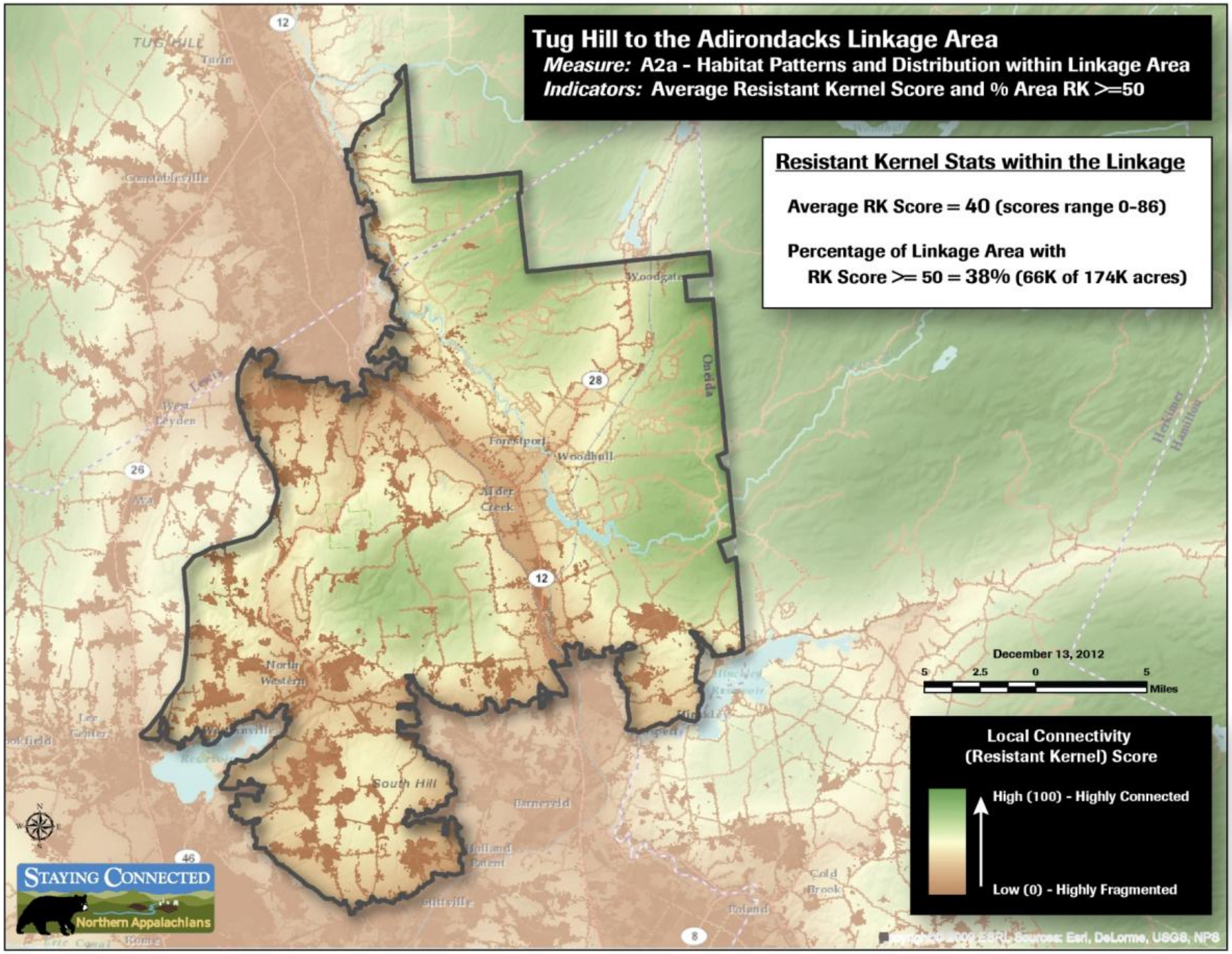


Figure 3. Tug Hill to the Adirondacks Linkage Area - *Baseline Map #2: Patterns of habitat distribution within linkage*

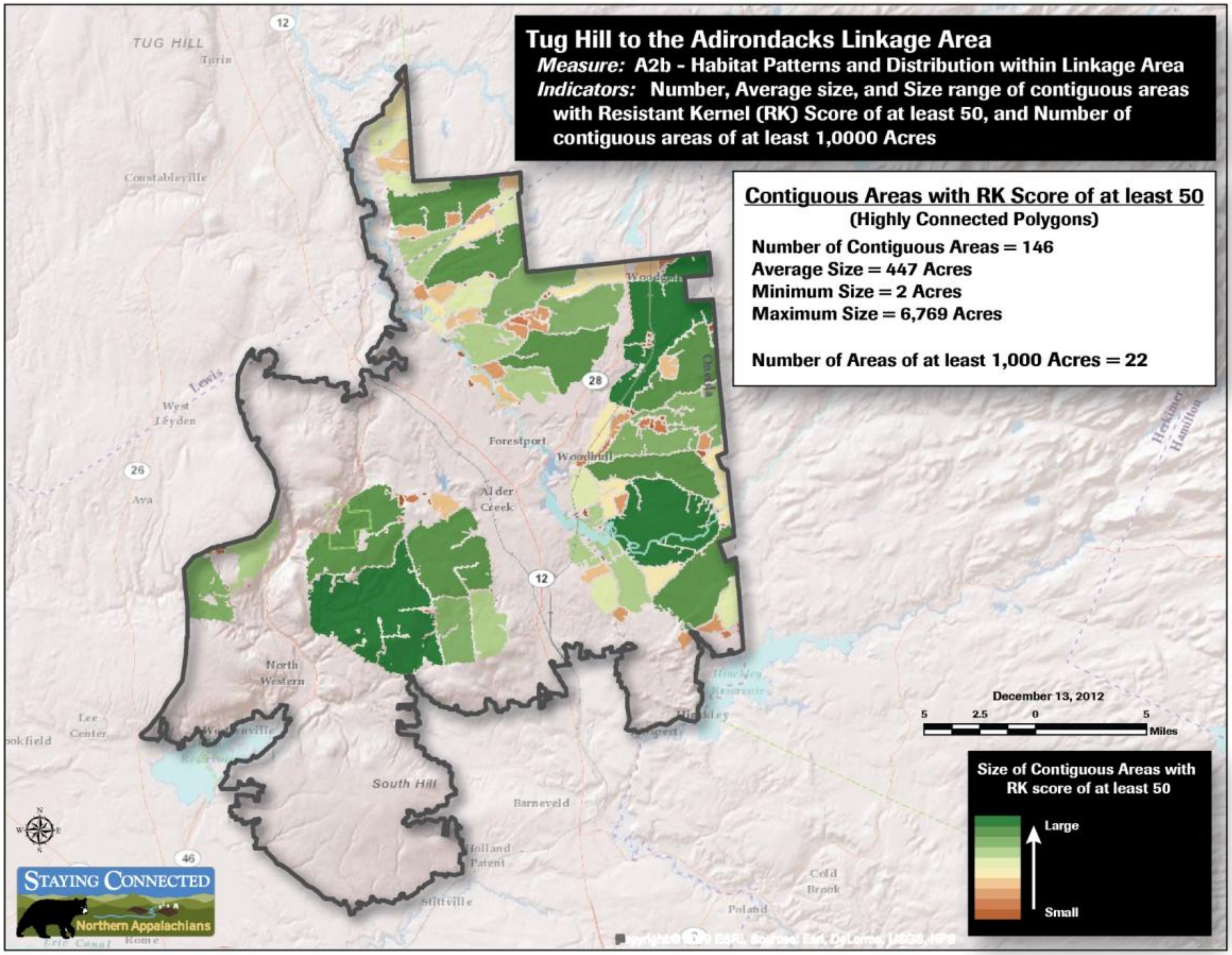


Figure 4. Tug Hill to the Adirondacks Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

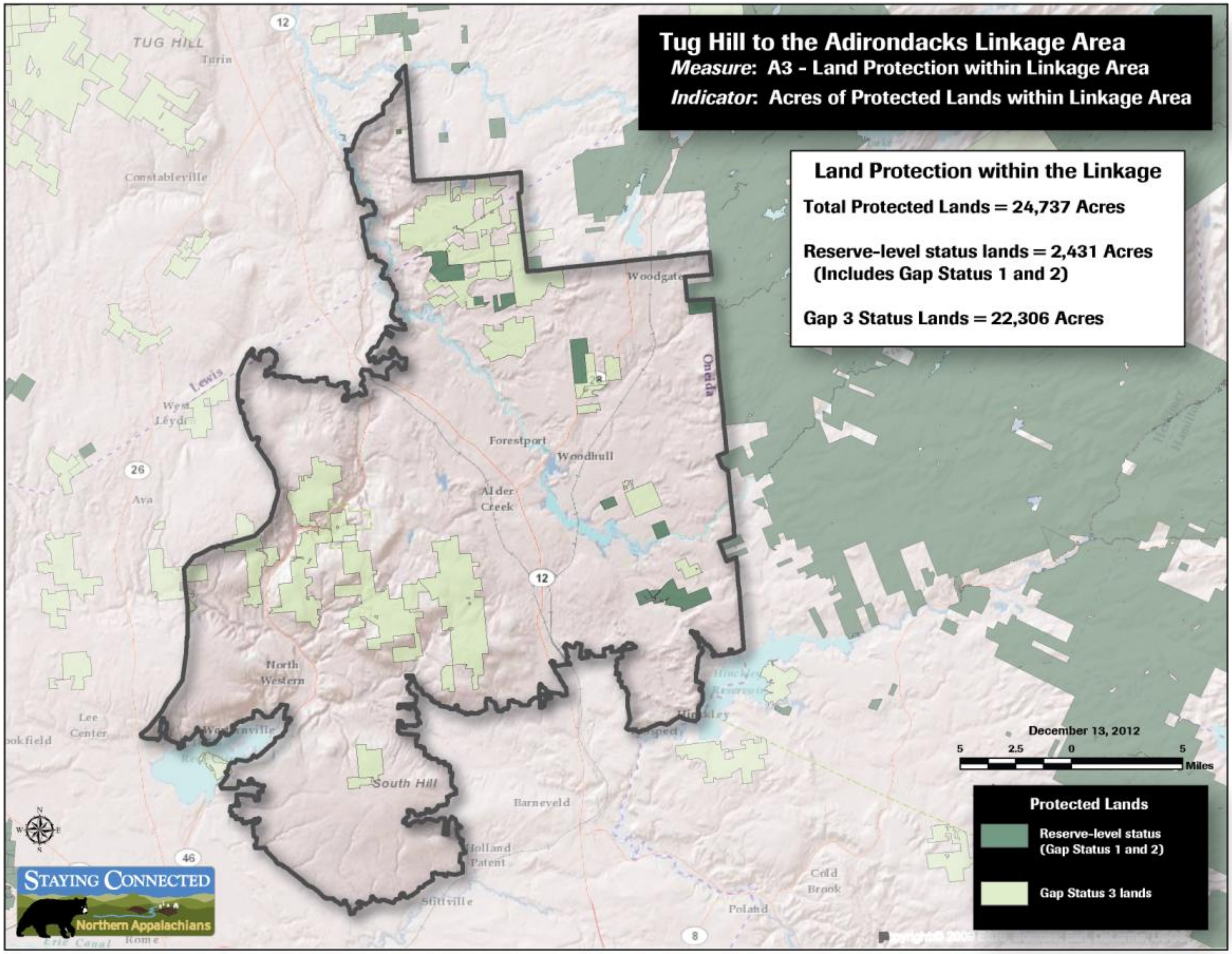


Figure 5. Tug Hill to the Adirondacks Linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

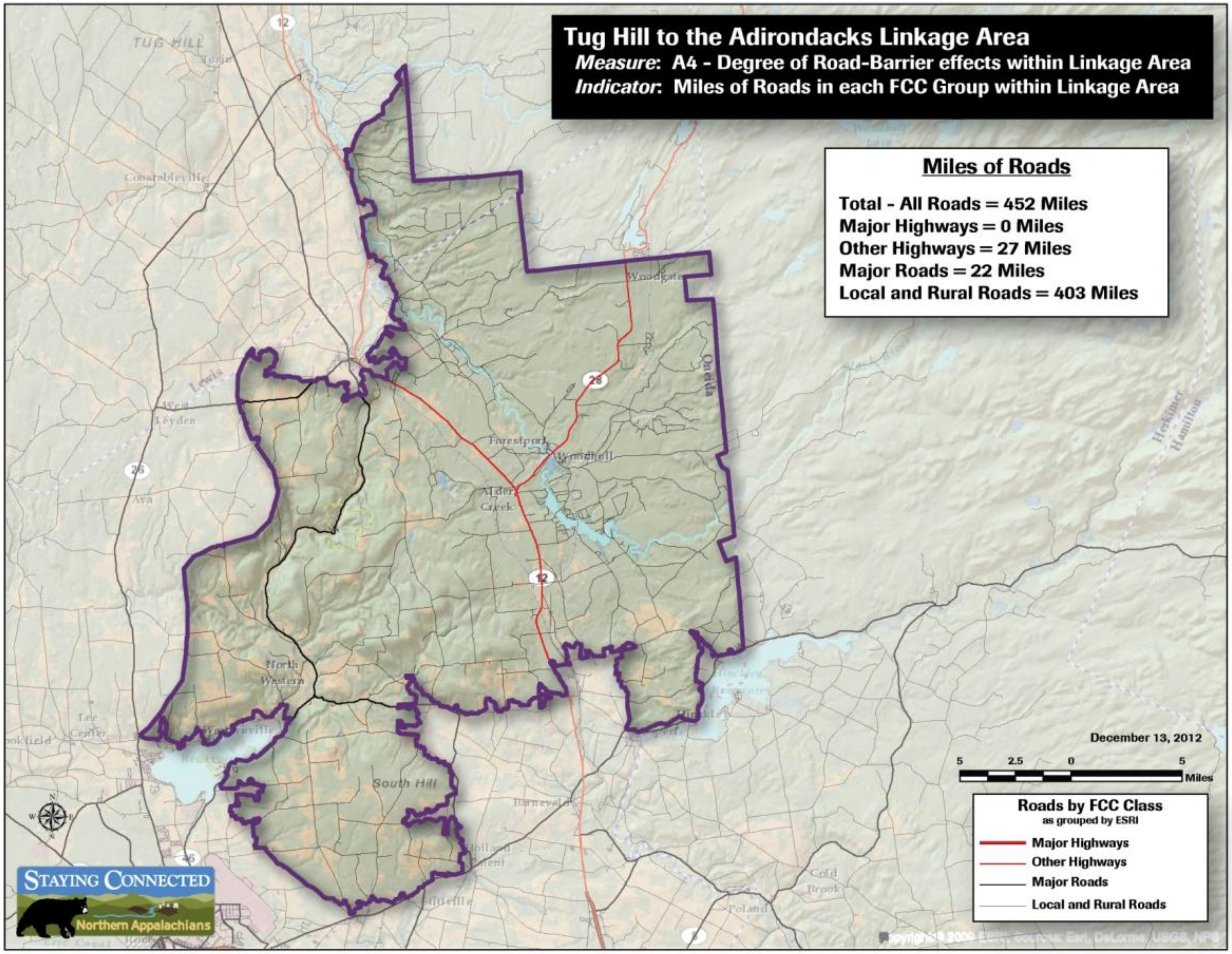


Figure 6. Tug Hill to the Adirondacks Linkage Area - ***Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes***

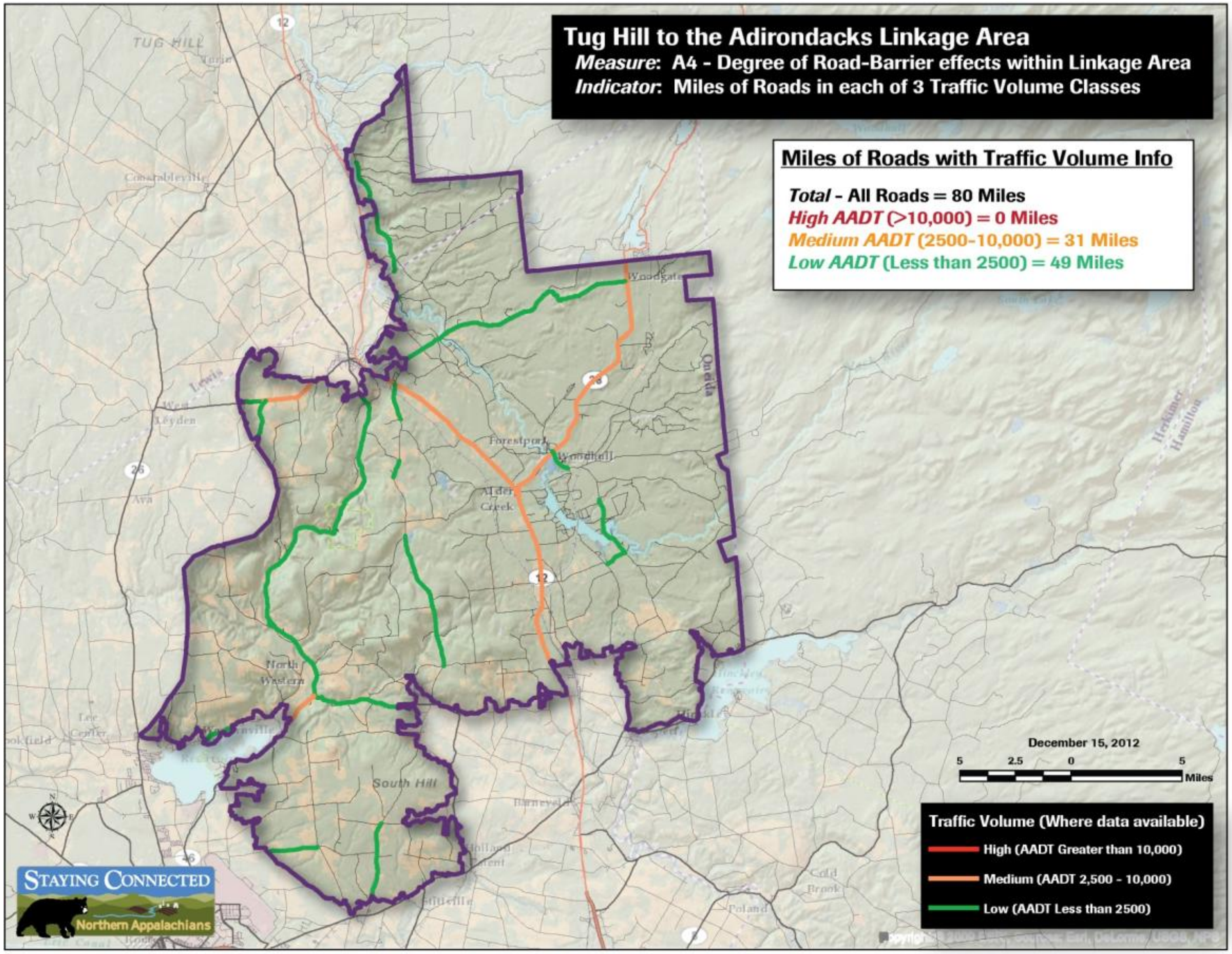


Figure 7. Tug Hill to the Adirondacks Linkage Area - *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*

Linkage 2: Adirondacks to Green Mountains Linkage

The Adirondacks to Green Mountains habitat linkage consists of a mosaic of 689 square miles (440,681 acres, 1,783 km^2) of forested ridges, farms, towns and small cities, wetlands, river valleys, and lakes of all sizes. In addition to its high quality natural habitats, its spectrum of human communities span from Vermont's second largest city (Rutland) to the tourist destination of Lake George, New York, with a myriad of small, rural towns that dot the landscape in between. This area is a "linkage" because of the character of the landscape – it is the most heavily forested part of the valley that separates the Green Mountains from the Adirondacks: north of Orwell, VT, Lake Champlain dramatically broadens, and agricultural land use predominates, while south of Ft Ann, New York, development becomes more intensive, and agriculture becomes much more prevalent. As such, it is crucial that the needs of both wildlife and human communities be met in this area.

As shown in Figure 8, a relatively large portion (76%) of the linkage is in natural vegetation, with 11% in agriculture and 4% developed. Because of Lake George, a relatively high proportion (9%) of the linkage is open water. As with the Tug Hill-Adirondacks linkage, the Adirondacks to Greens linkage is relatively fragmented, with an average RK score of 41, and substantial amounts of highly fragmented land along routes 22, 30 and 4 (Figure 9). The largest blocks of relatively unfragmented habitat, with RK scores of 50 or above, are mostly located near Lake George and the Green Mountains (Figure 10). Over 19% of the linkage is in some form of conservation (Figure 11). Routes 22, 30 and 4 present moderate to high barriers to movement of mammals, with 9 miles (14.5 km) having AADT values above 10,000 and 87 miles (140 km) having AADT values between 2,500 and 10,000 (Figure 13). Structural pathways comprise about 128,606 acres (520 km^2), or 29% of the linkage (Figure 14). While the pathways contain relatively large blocks of natural habitat, with an average of 344 acres per block and 35 blocks of 1,000 acres or larger (Figure 15), only about 10%, or 12,706 acres (51 km^2) of the pathways are conserved in any way (Figure 16). About 29,586 acres (120 km^2) fall within 100 meters of the road segments within the pathways. Of this area, only about 7% (2,085 acres or 8 km^2) is conserved (Figure 17).

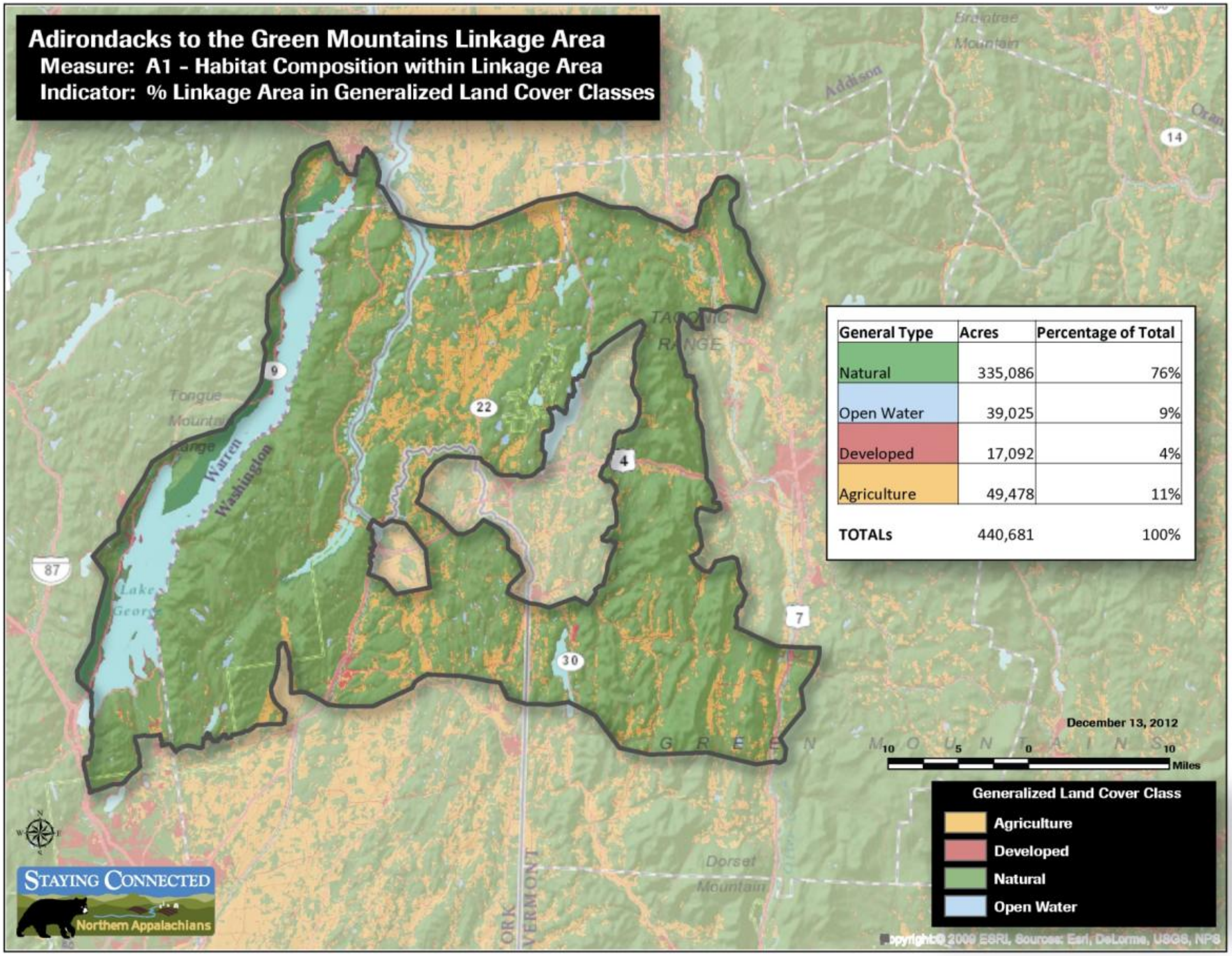


Figure 8. Adirondacks to the Green Mountains Linkage Area *Baseline Map #1: Habitat composition within linkage*

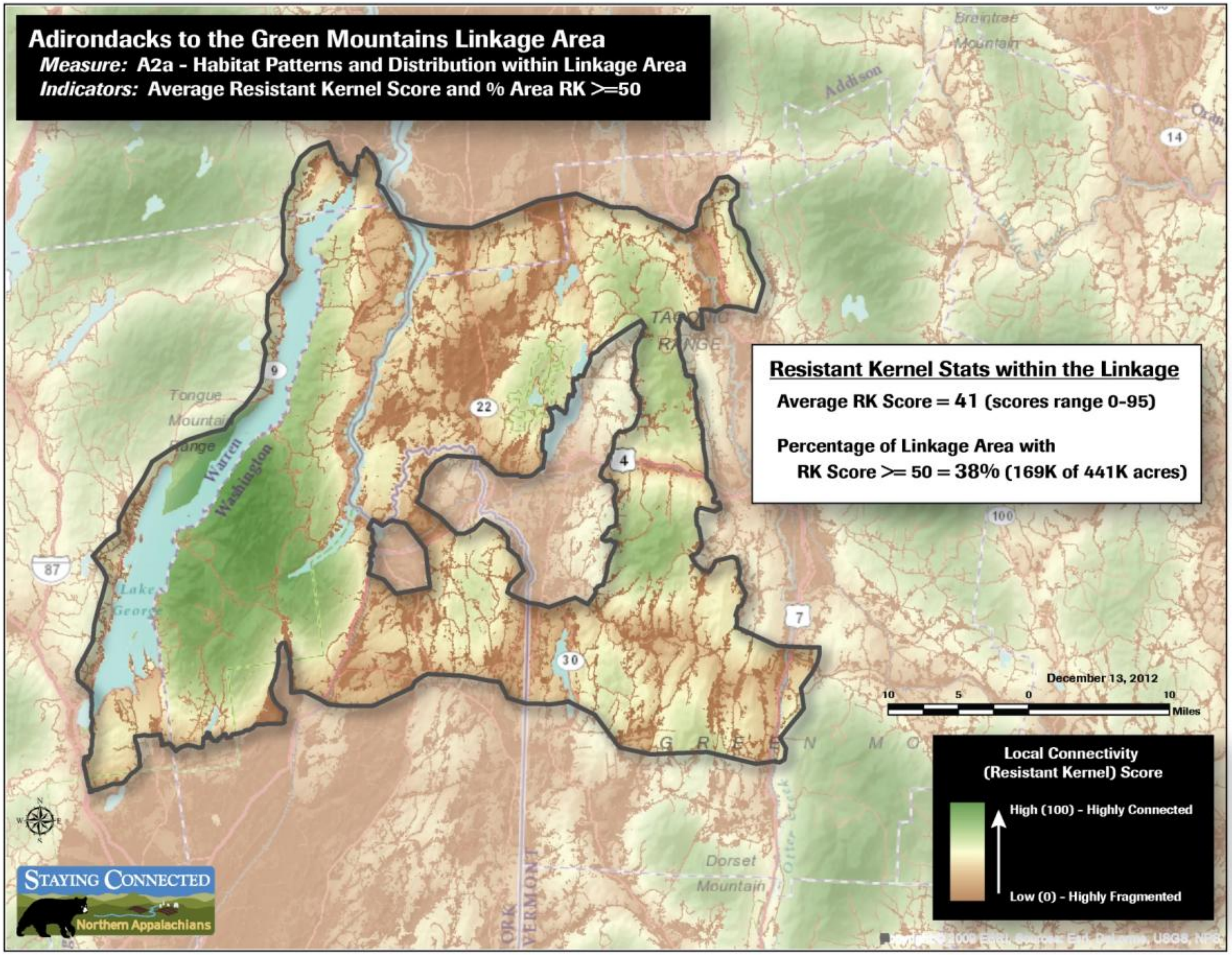


Figure 9. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #2: Patterns of habitat distribution within linkage*

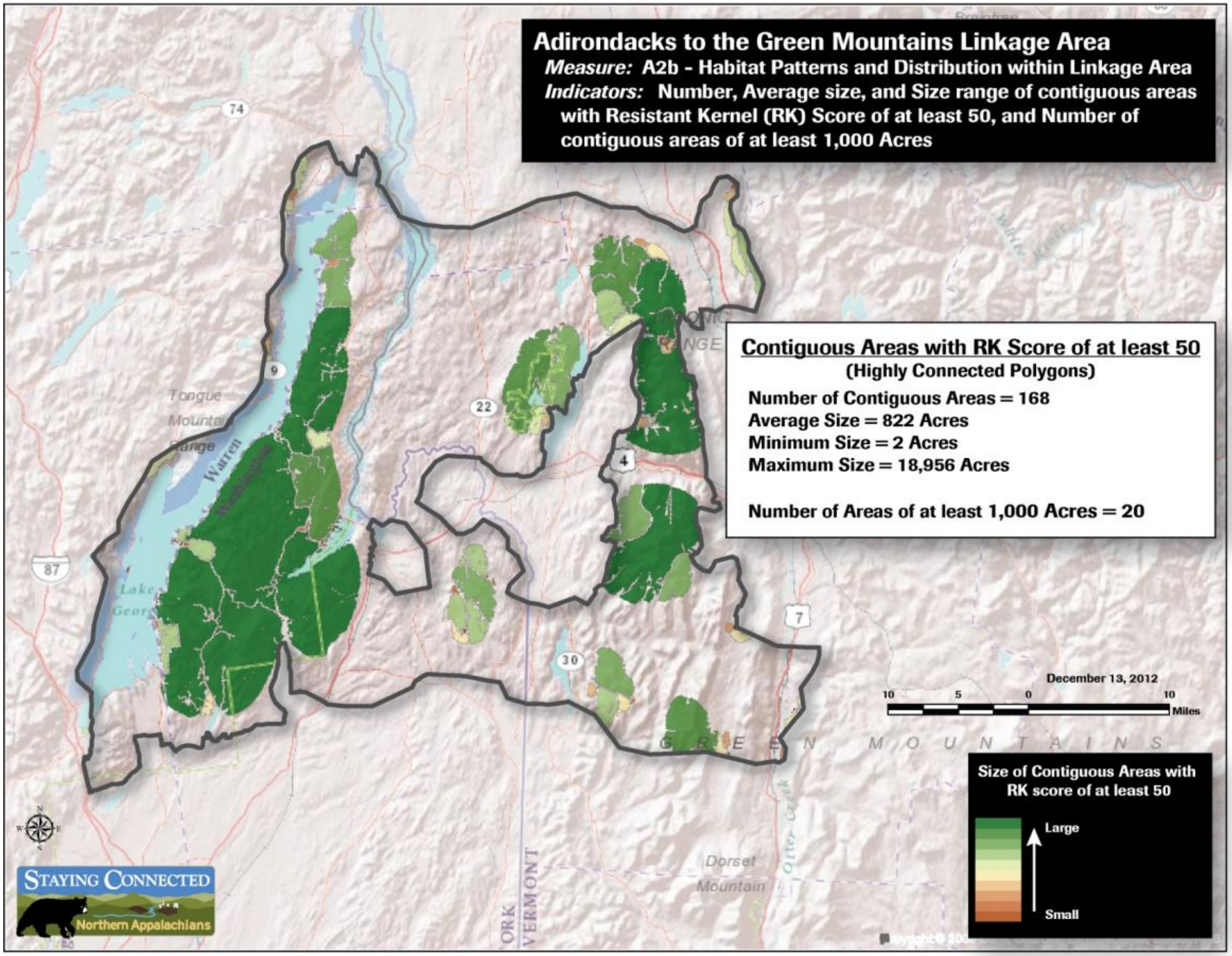


Figure 10. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

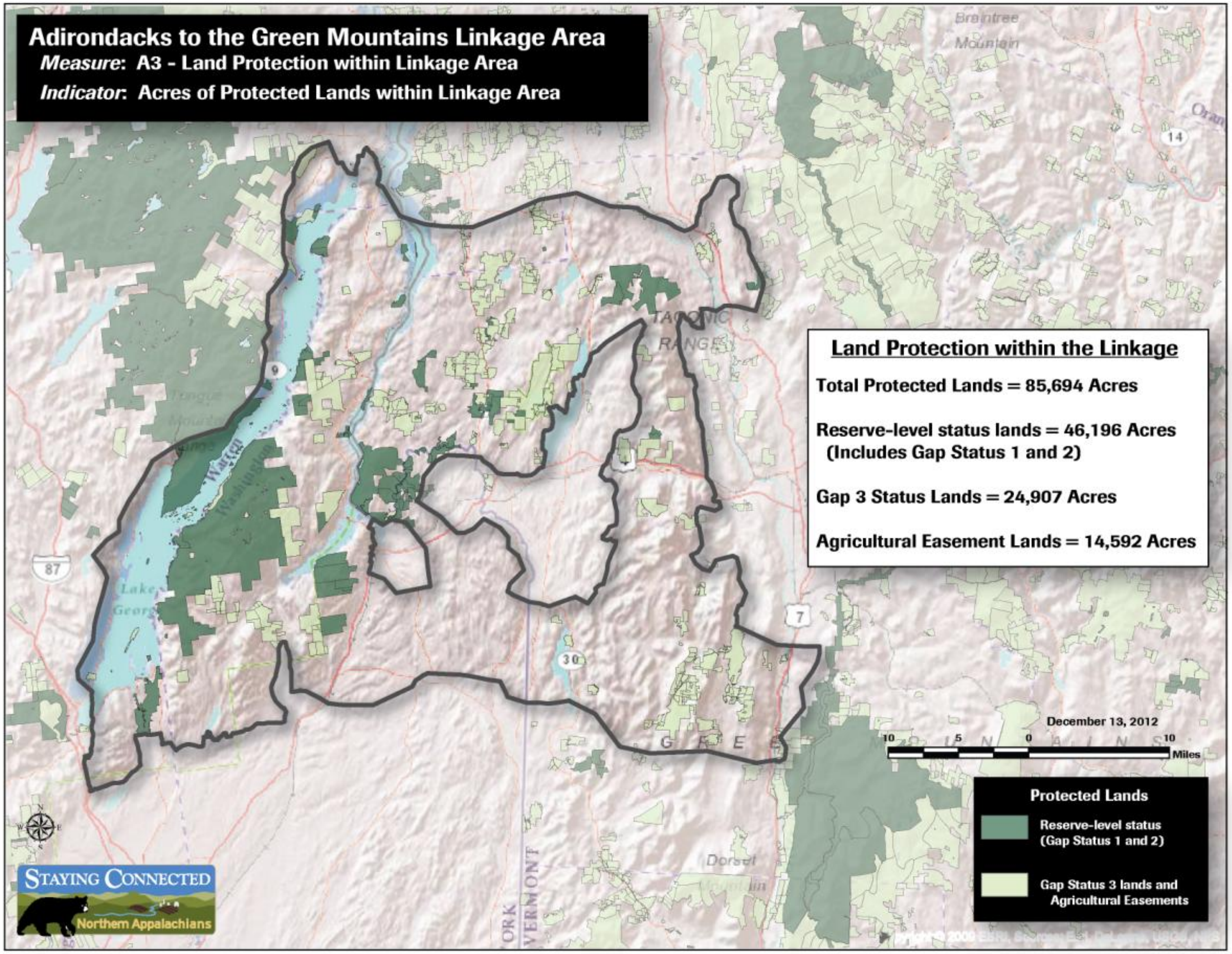


Figure 11. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

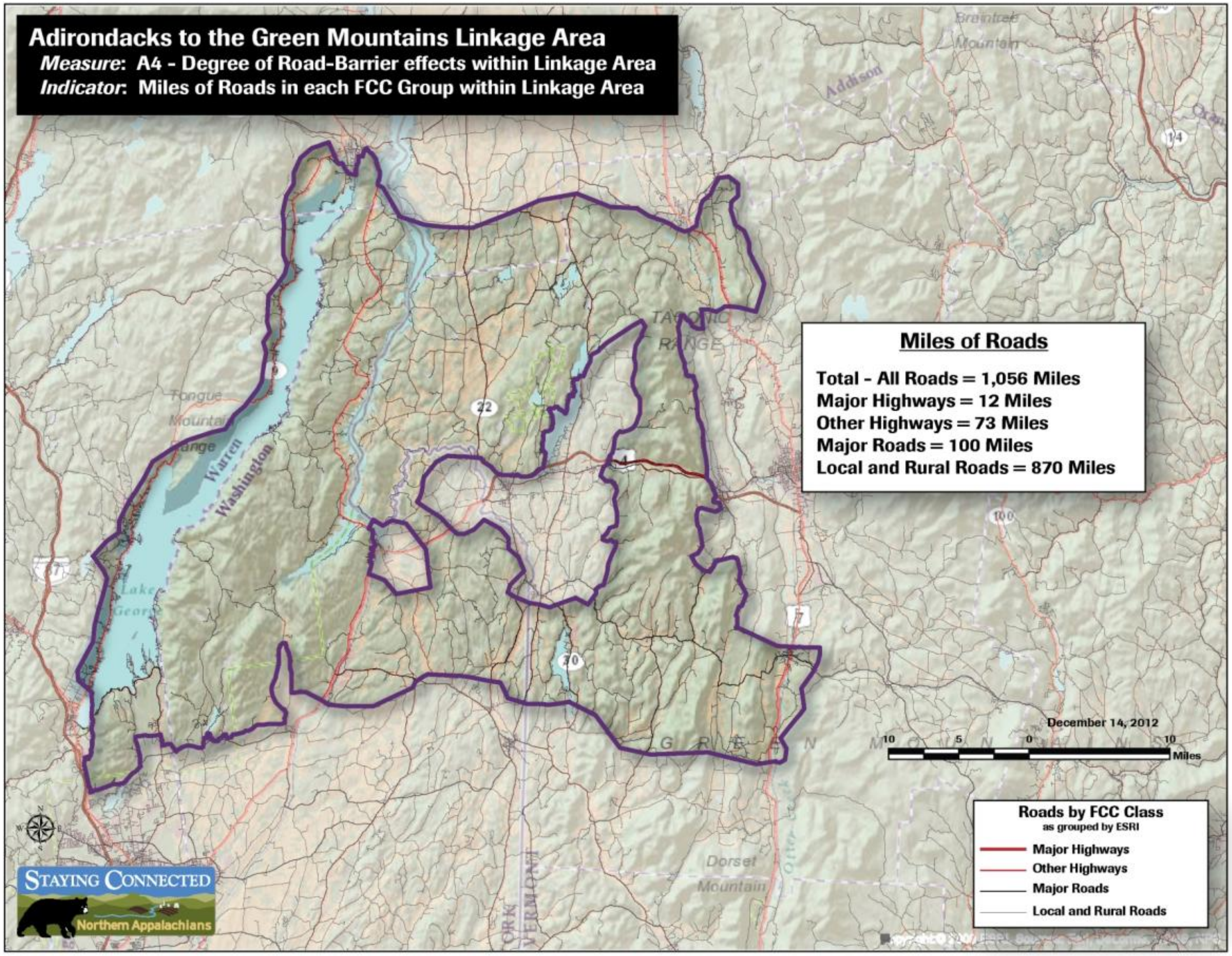


Figure 12. Adirondacks to the Green Mountains Linkage Area - *Baseline Map#5: Road barrier effects – Miles of Roads in 4 General Classes*

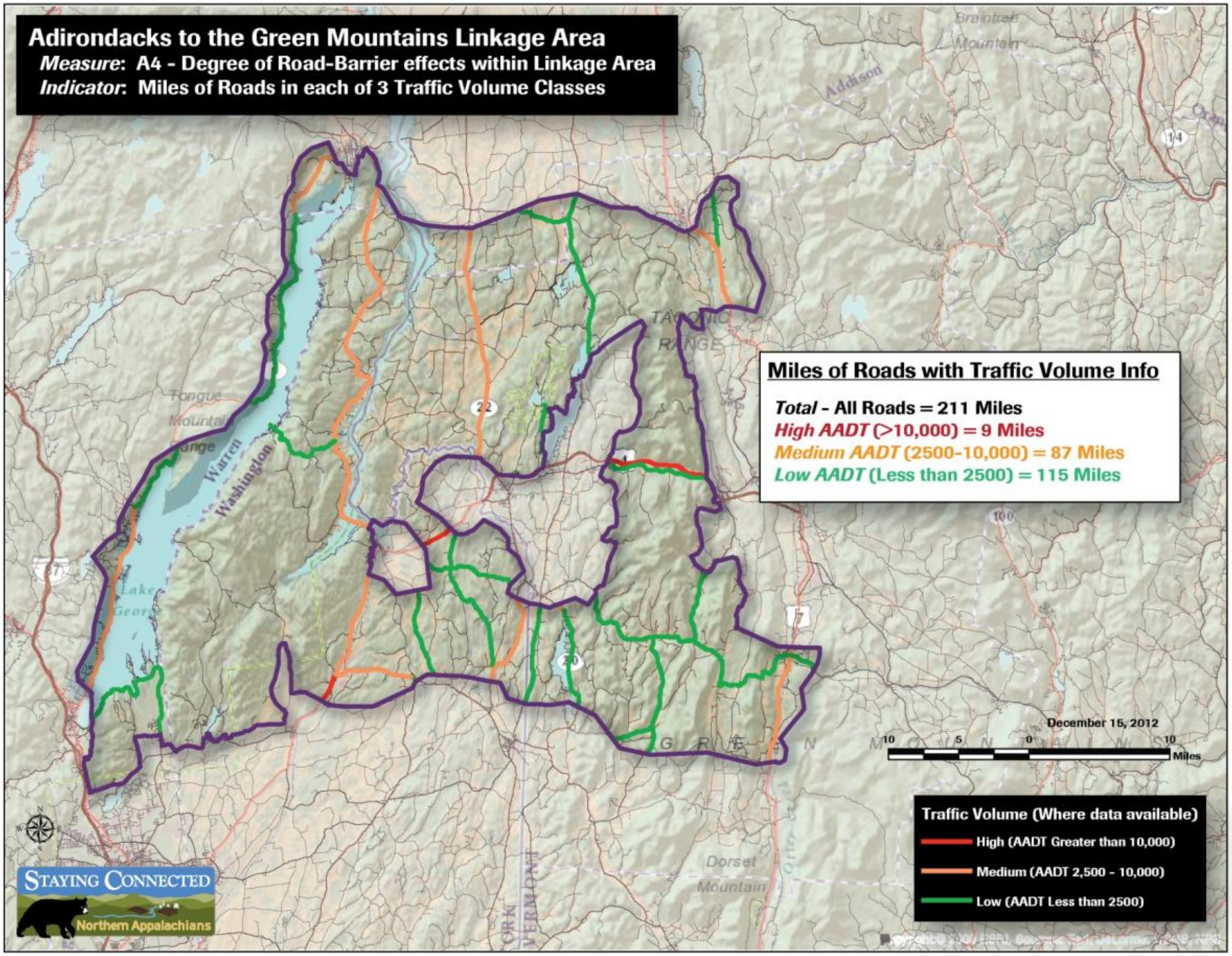


Figure 13. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*

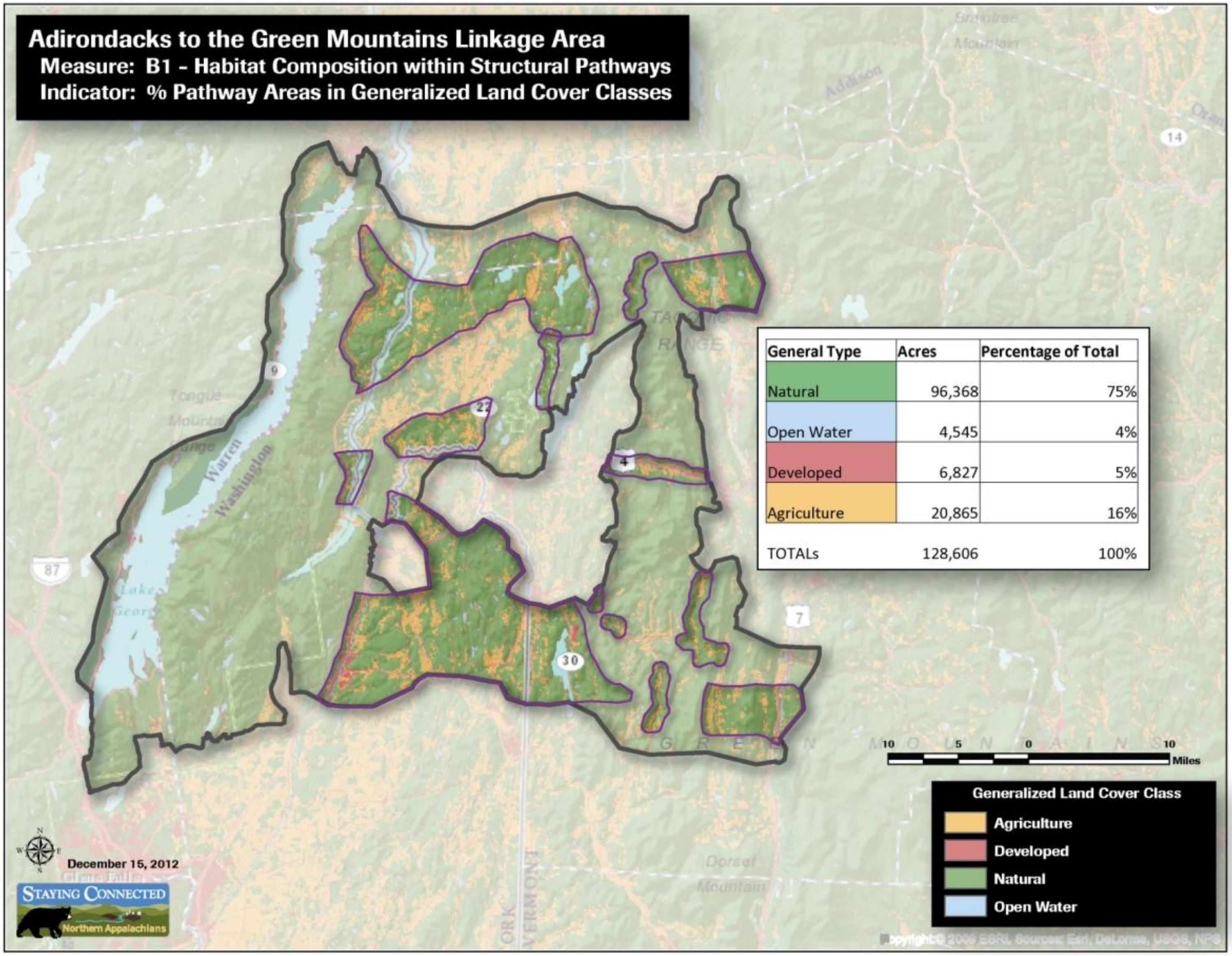


Figure 14. Adirondacks to the Green Mountains Linkage Area - ***Baseline Map #7: Habitat Composition within Structural Pathways***

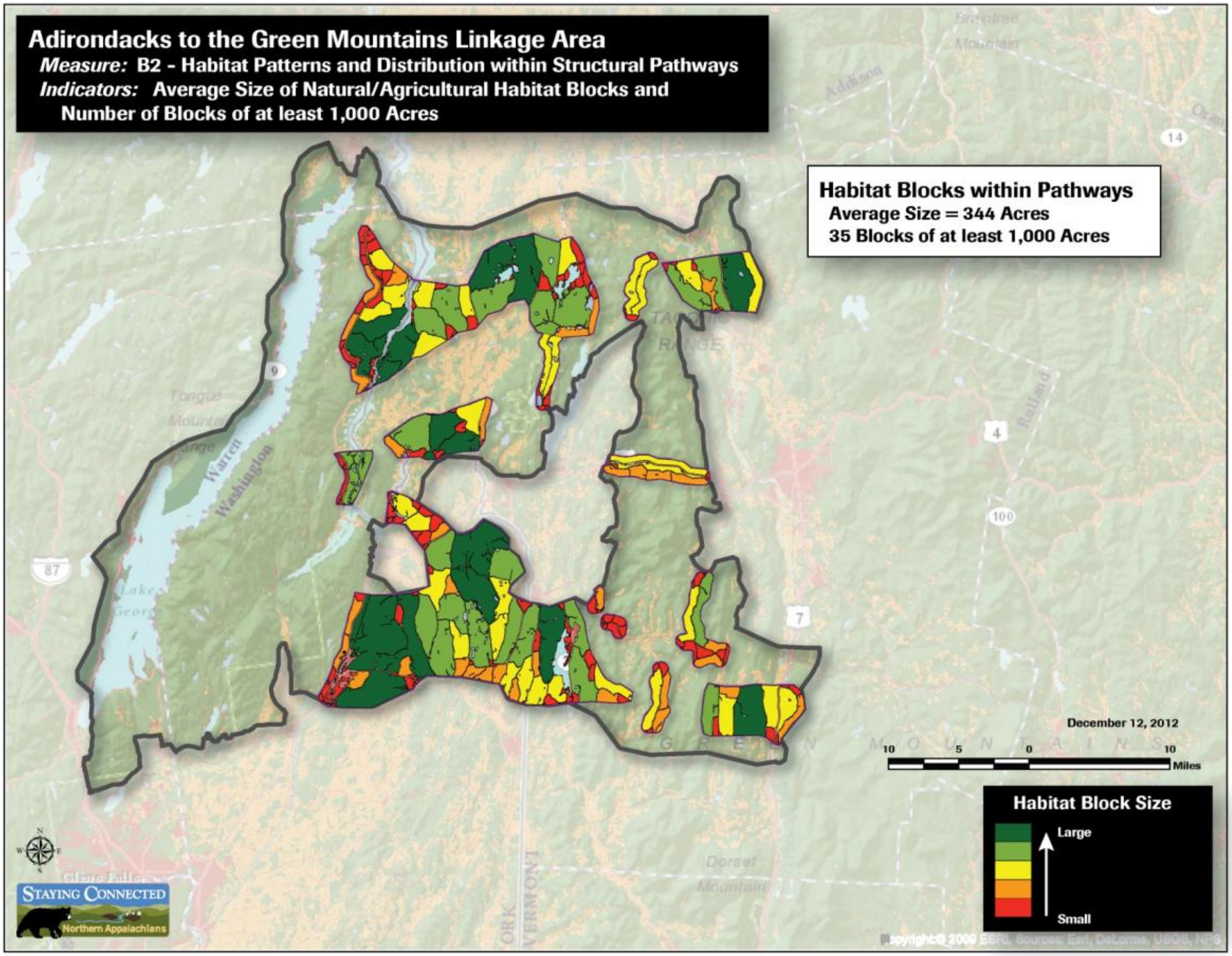


Figure 15. Adirondacks to the Green Mountains Linkage Area - ***Baseline Map #8: Patterns of Habitat Distribution within Structural Pathways***

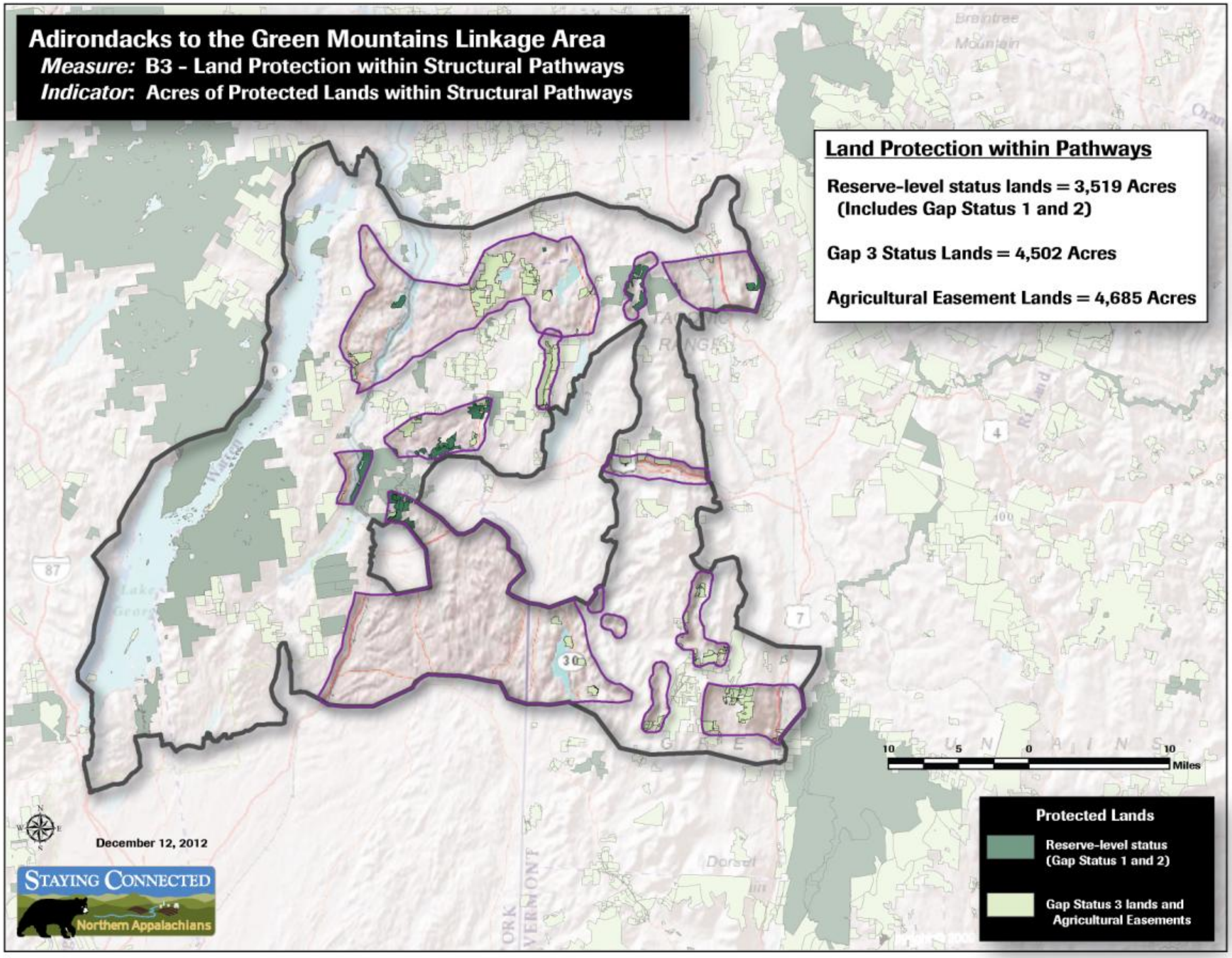


Figure 16. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #9: Land Protection within Structural Pathways*

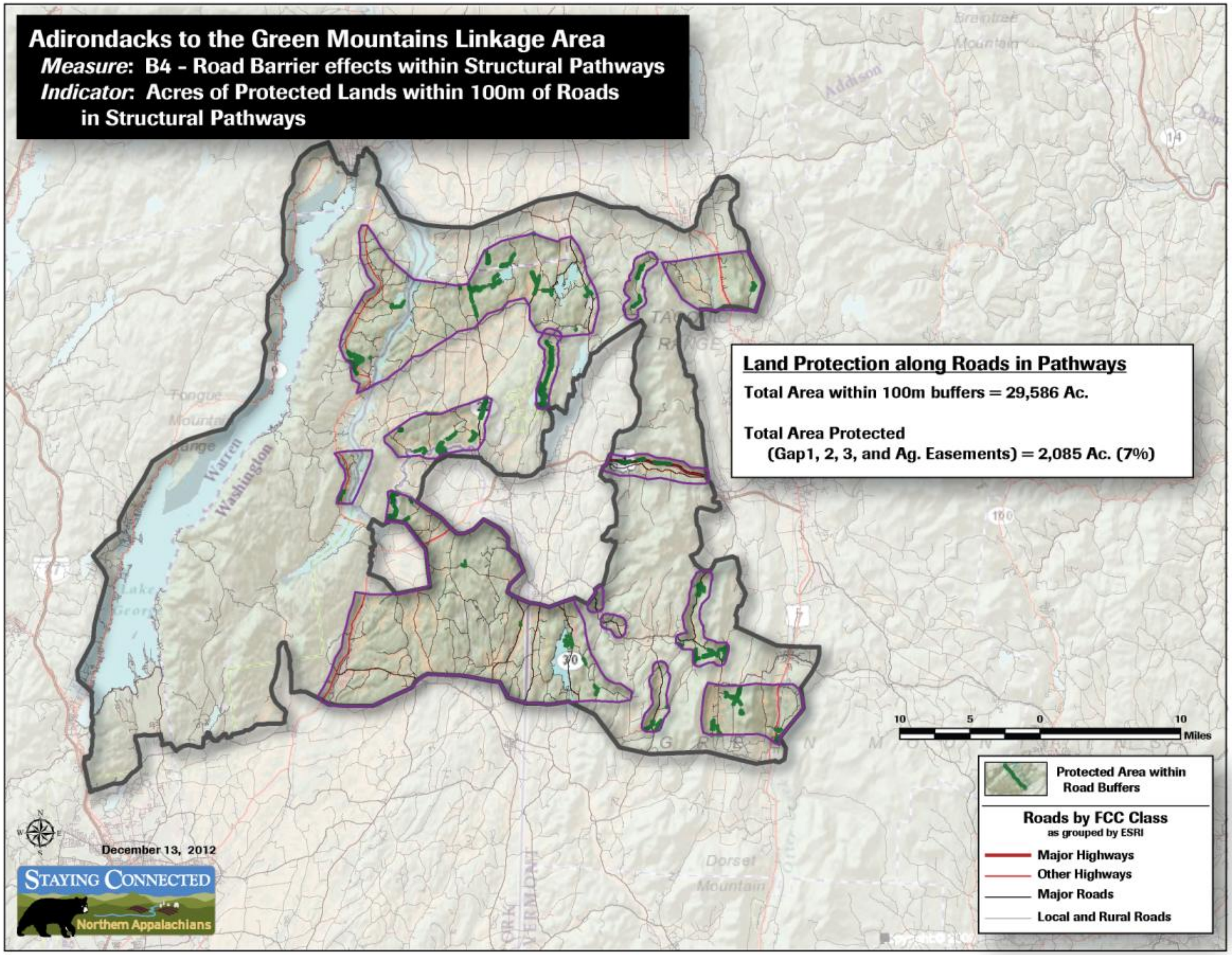


Figure 17. Adirondacks to the Green Mountains Linkage Area - *Baseline Map #10: Road Barrier effects within Structural Pathways*

Linkage 3: Taconic Mountains to the Southern Green Mountains Linkage

The Southern Green Mountains to Taconic Mountains linkage is an area of nearly 70,000 acres (69,283 acres, 283 km^2) in the Vermont towns of Mount Tabor, Dorset, Manchester, Arlington, Sunderland, and Shaftsbury that connects some 500,000 acres (2,023 km^2) of core forest in the Taconics to the west and the Green Mountains to the east. The linkage is primarily considered to be the Valley of Vermont biophysical region, a narrow valley of different climate, bedrock and landforms, than the mountains on either side. This area has seen significant sprawl development in recent years and the forested connections from one range to the next are narrow and threatened. The Battenkill River and the upper portion of Otter Creek are prominent natural features that bring this area together and set it apart from the rugged uplands, with the mix of developed, agricultural, and forested land cover that form a patchwork mosaic along their lengths.

As shown in Figure 18, a remarkably large portion (83%) of the linkage is in natural vegetation, with 10% in agriculture and 7% developed. Despite the relatively high percentage in natural vegetation, the sprawl along Route 7 magnifies the effects of development, and results in low and widespread RK values in the core of the linkage (Figure 19). Areas with RK scores of 50 or above are only found along the edges of the linkage (Figure 20). More than 26% of the linkage is in some form of conservation (Figure 21), but these areas are also concentrated along the edges of the linkage. Routes 7, 11 and 313 present moderate to high barriers to movement of mammals, with 1 mile (1.6 km) having an AADT value above 10,000 and 57 miles (91 km) having AADT values between 2,500 and 10,000 (Figure 23). Structural pathways comprise only 6,727 acres (27 km^2), or about 10% of the linkage (Figure 24). Despite the small size of the pathways, there are some promising blocks of unfragmented habitat within the pathways (Figure 25). Yet over 93% of the area of the pathways remains unprotected, with only about 6.9%, or 465 acres (2 km^2) of the pathways conserved in any way (Figure 26). About 2800 acres (11 km^2) fall within 100 meters of the road segments within the pathways. Of this area, only about 5% (139 acres or 1 km^2) is conserved (Figure 27).

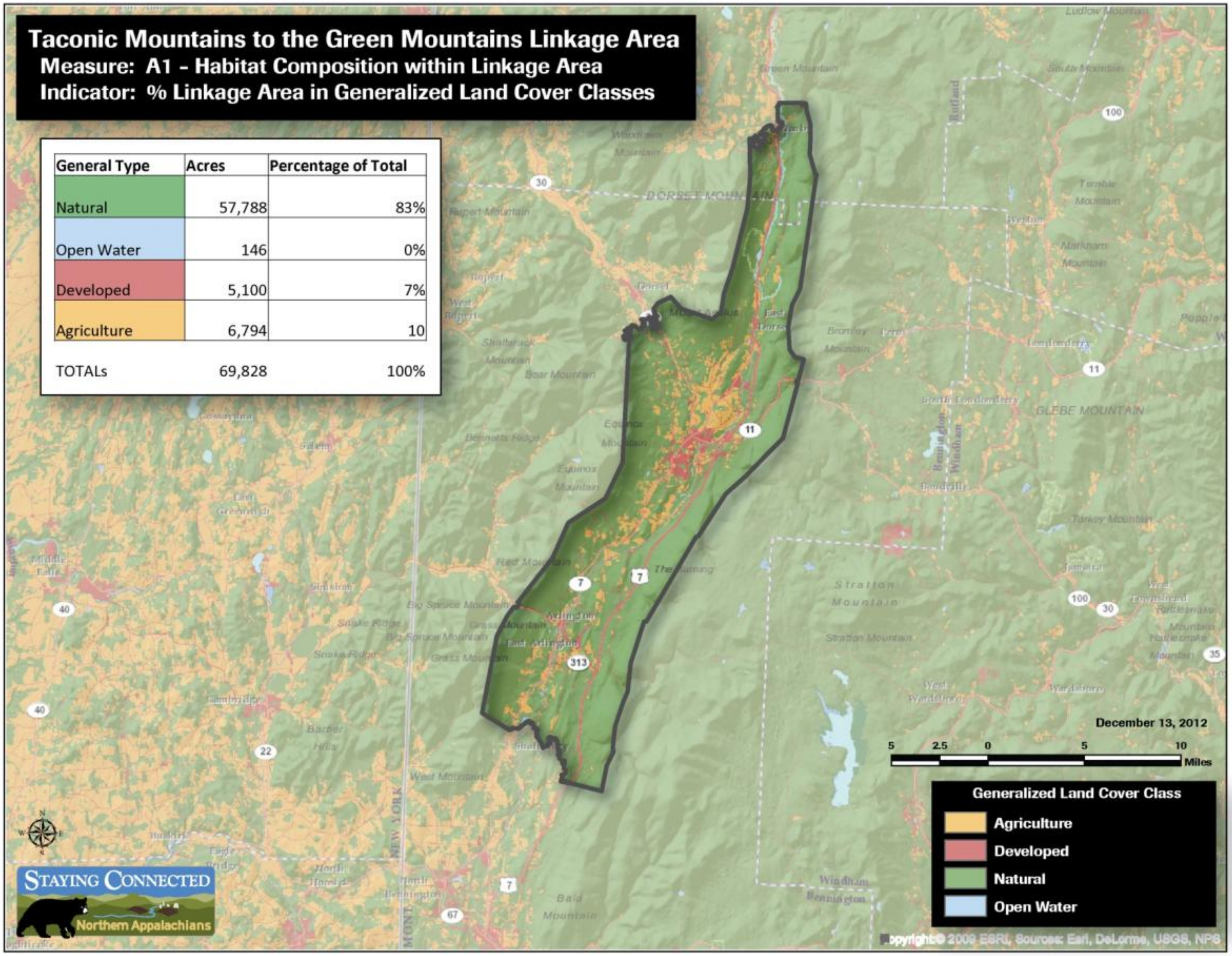


Figure 18. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #1: Habitat composition within linkage*

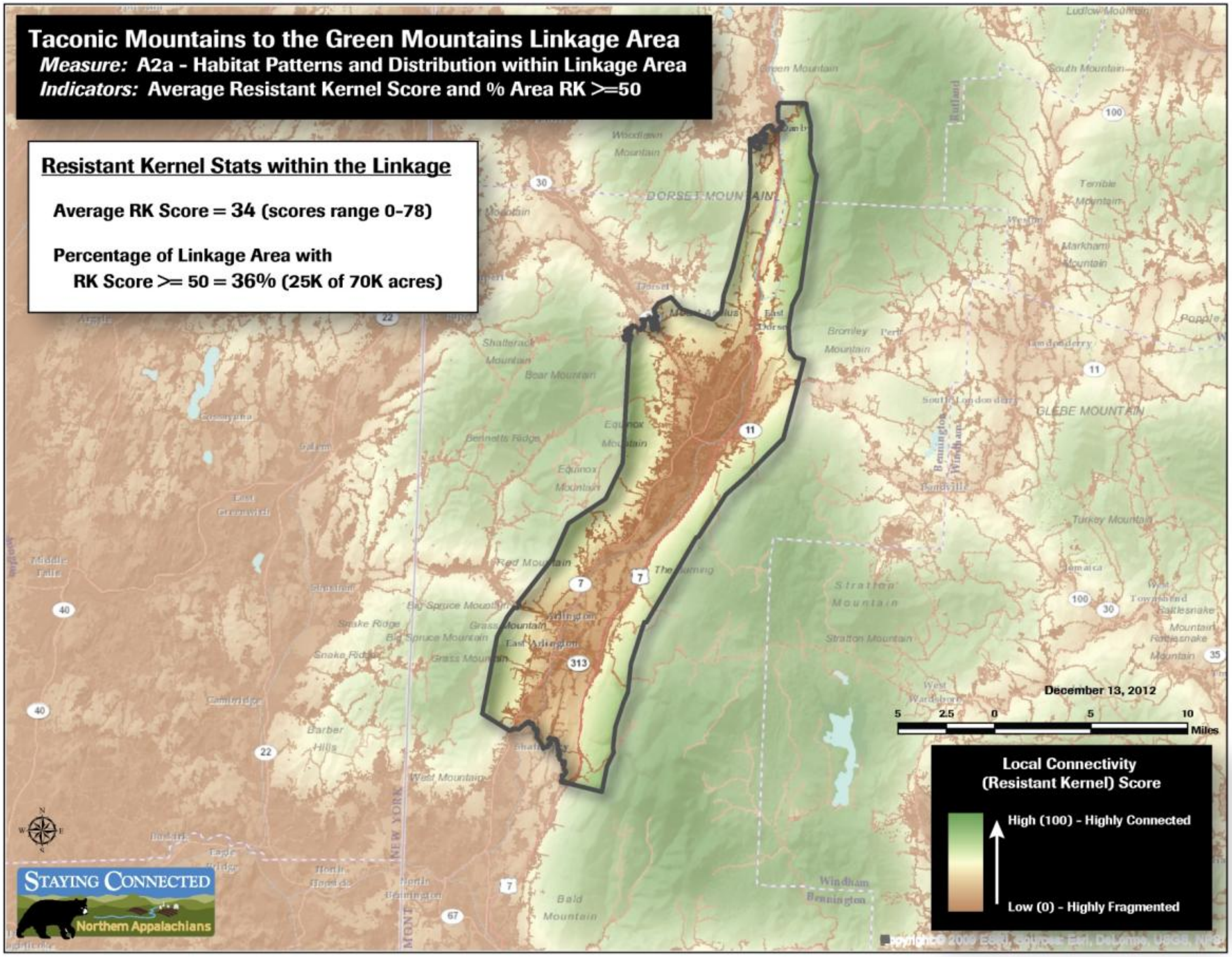


Figure 19. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #2: Patterns of habitat distribution within linkage*

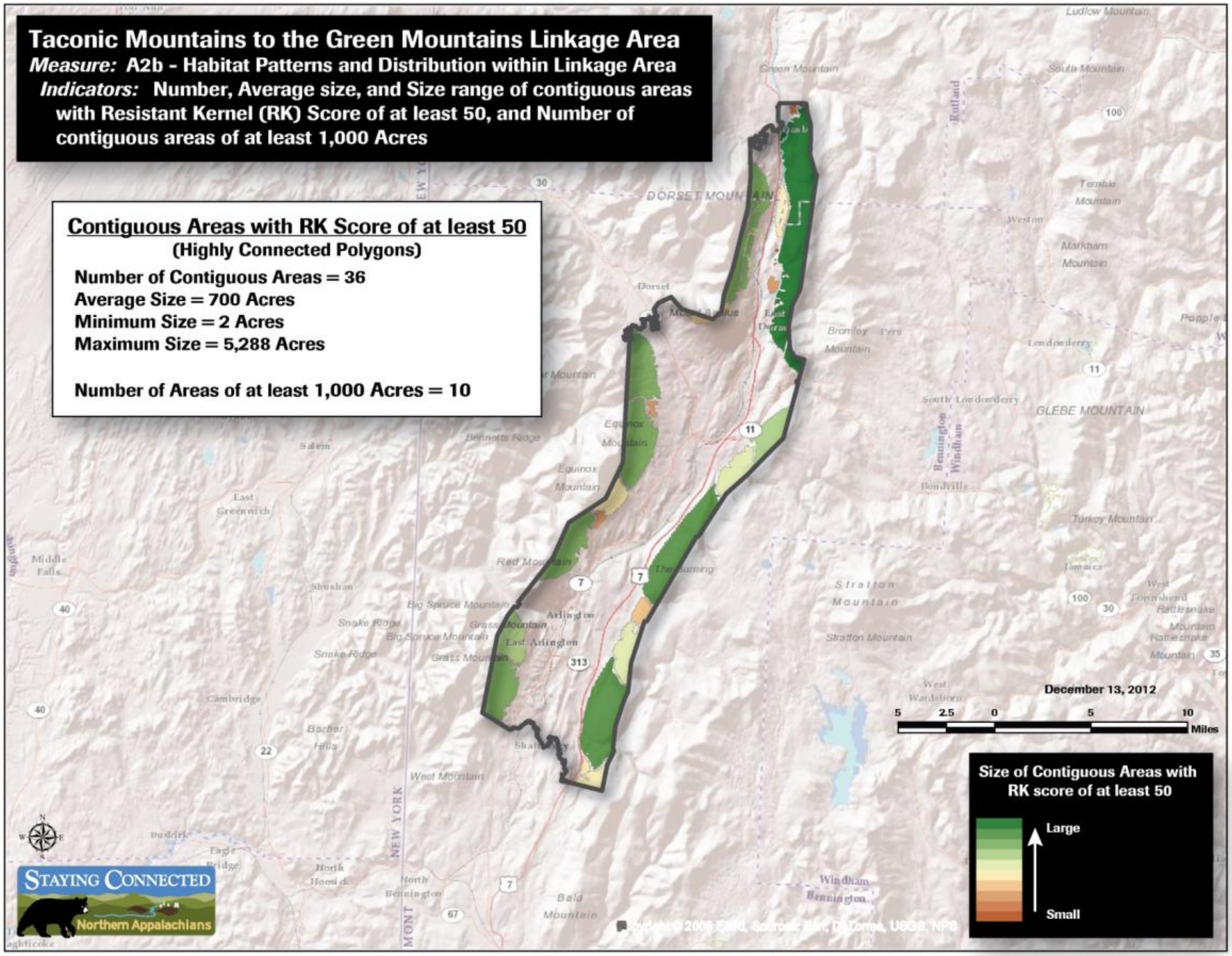


Figure 20. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

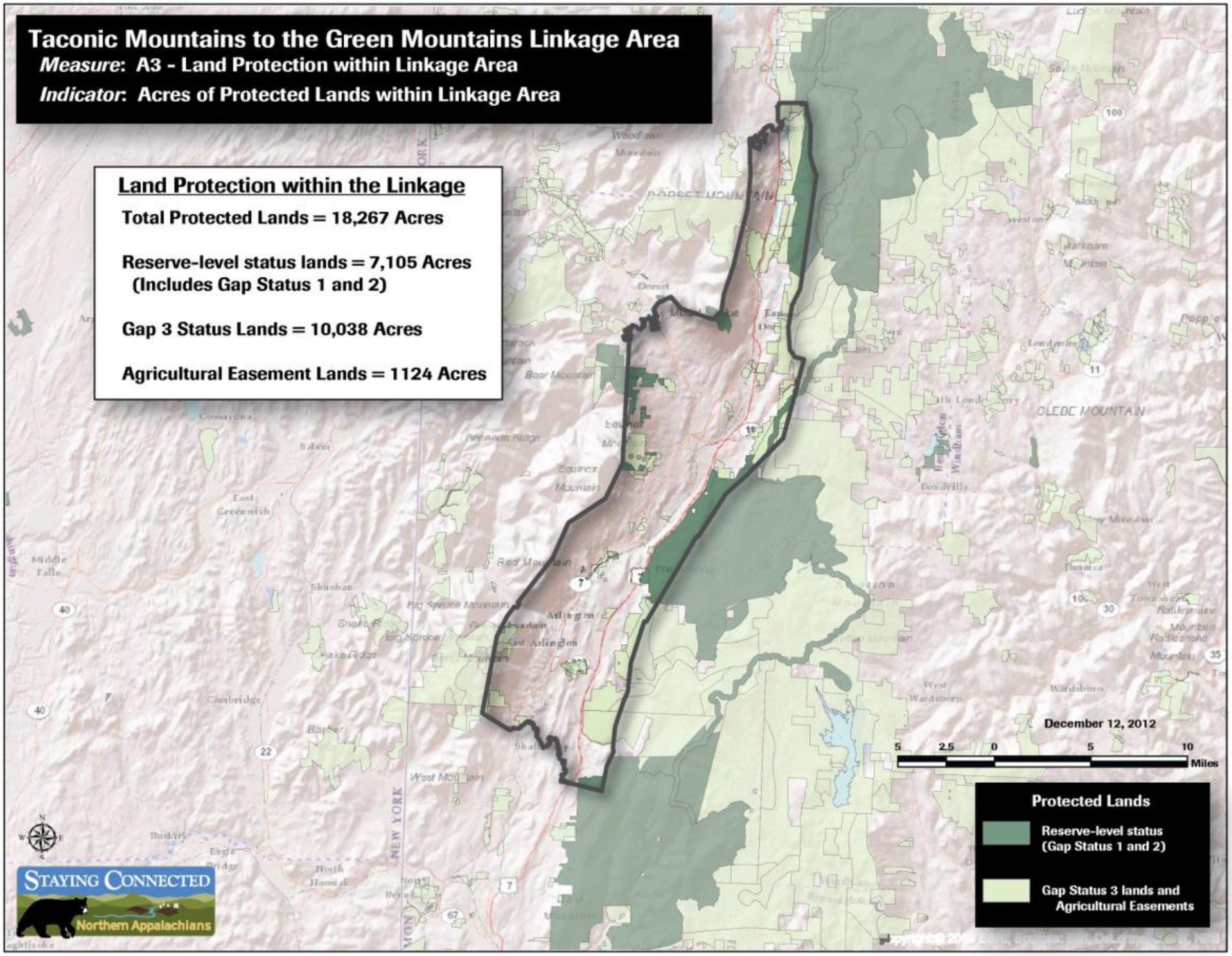


Figure 21. Taconic Mountains to the Green Mountains Linkage Area - ***Baseline Map #4: Land Protection – Conservation within the Linkage Area***

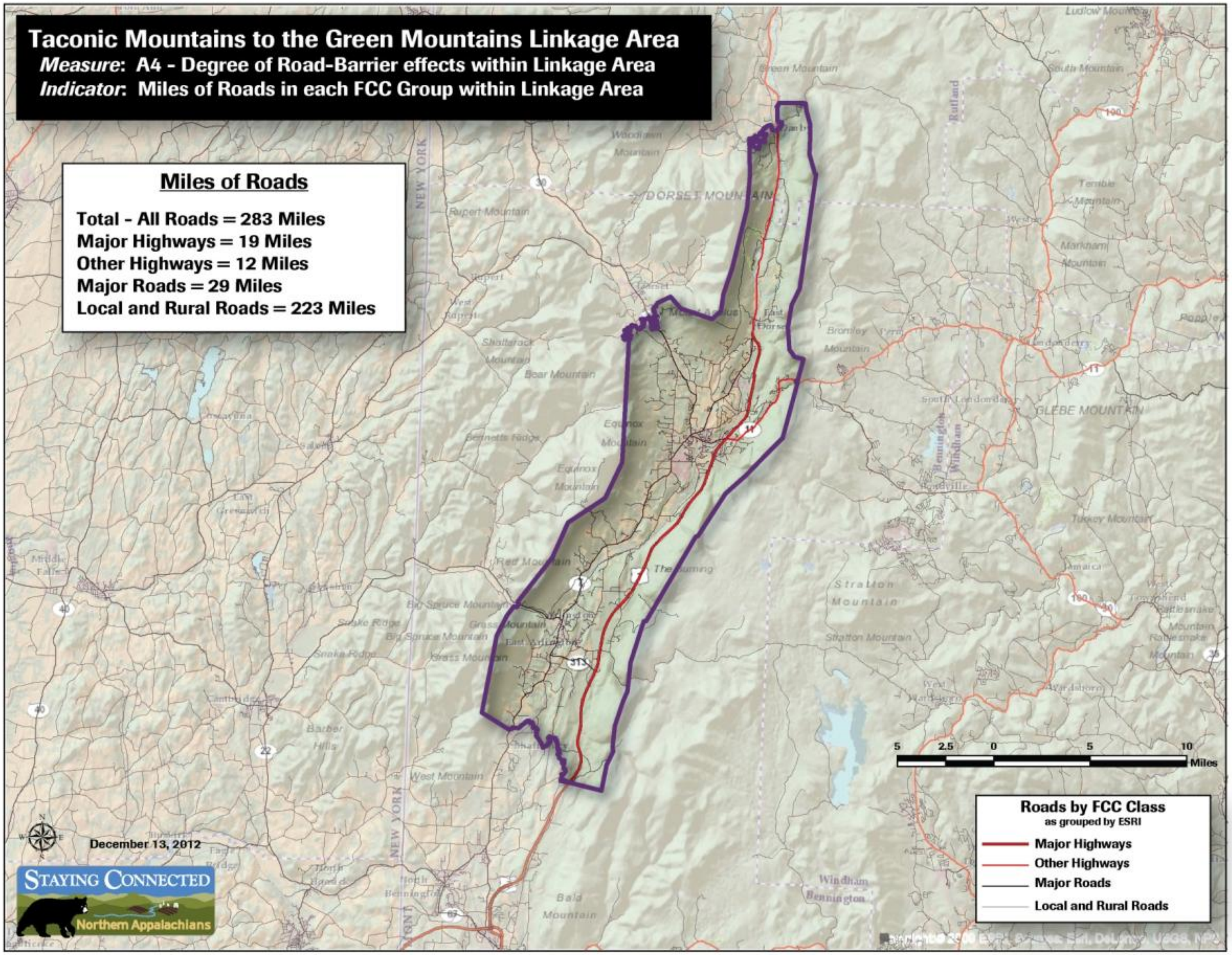


Figure 22. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes*

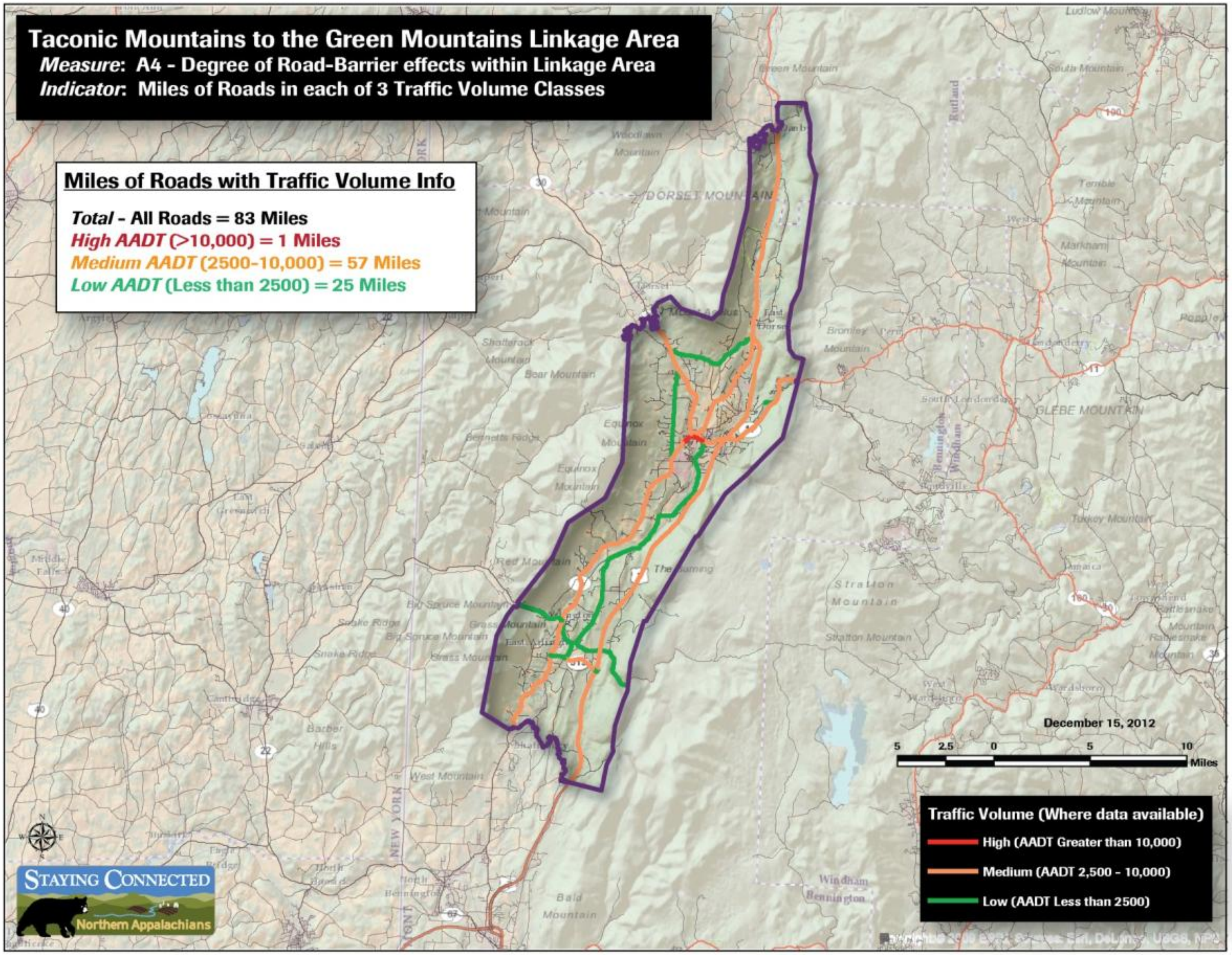


Figure 23. Taconic Mountains to the Green Mountains Linkage Area - ***Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume***

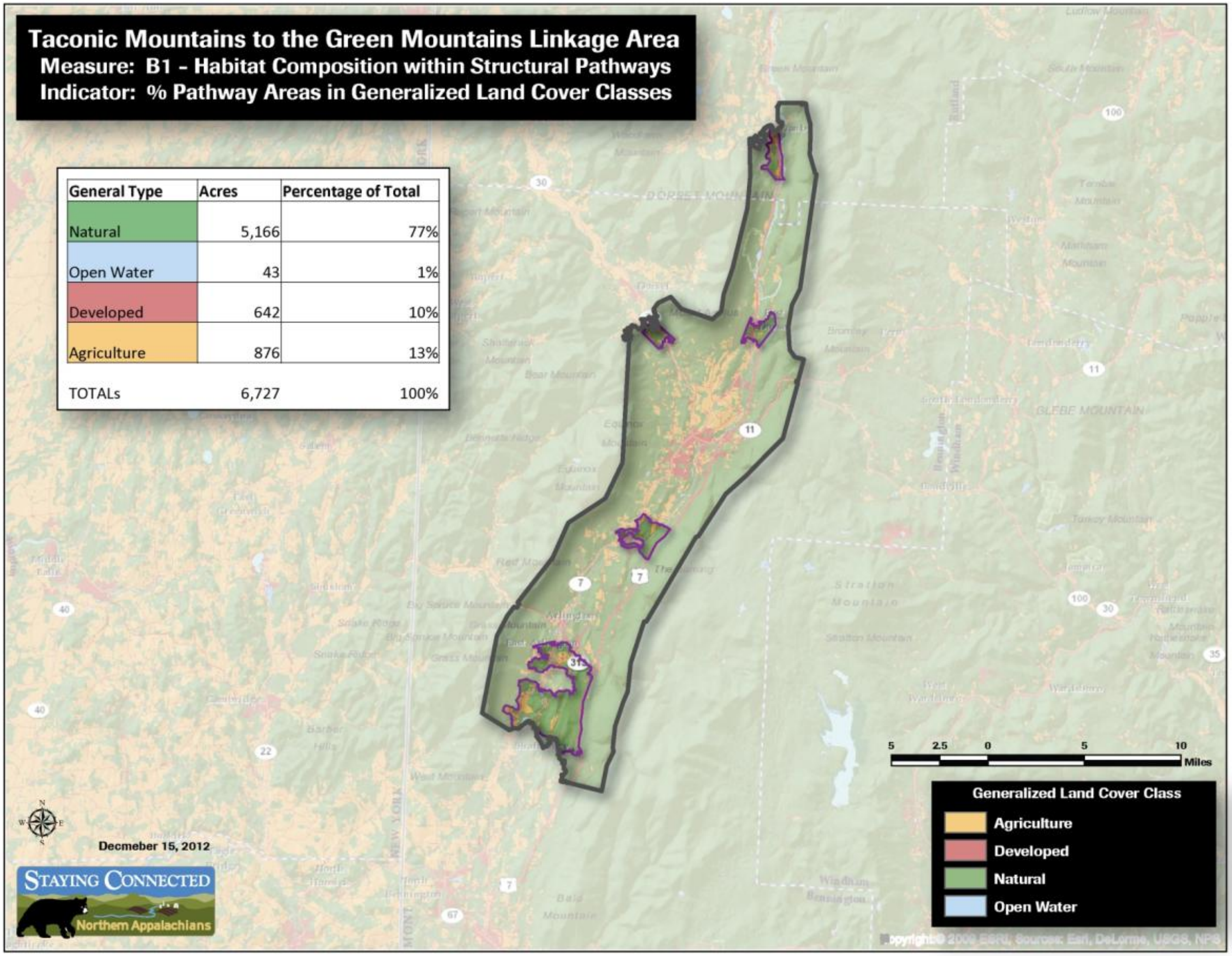


Figure 24. Taconic Mountains to the Green Mountains Linkage Area - ***Baseline Map #7: Habitat Composition within Structural Pathways***

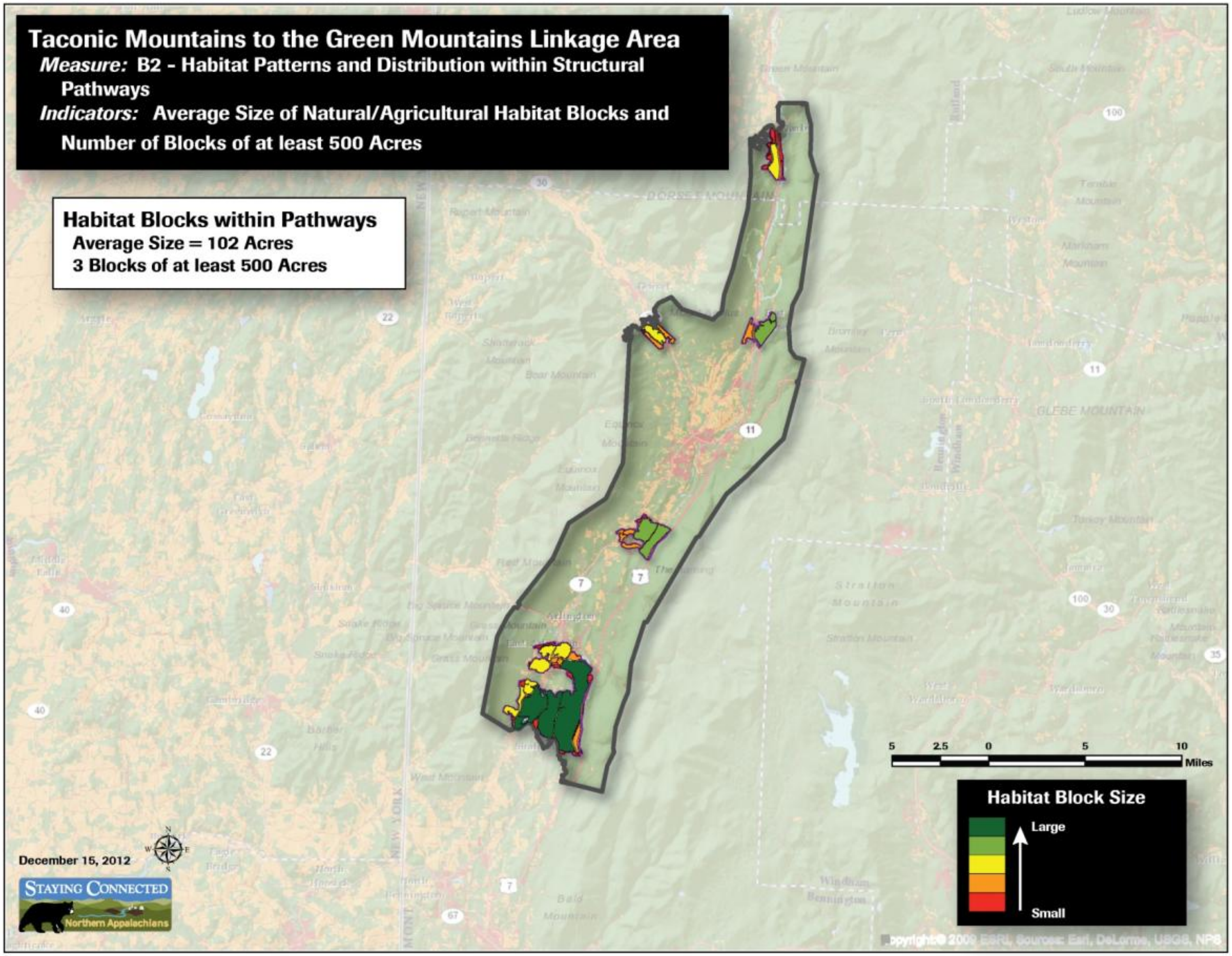


Figure 25. Taconic Mountains to the Green Mountains Linkage Area - ***Baseline Map #8: Patterns of Habitat Distribution within Structural Pathways***

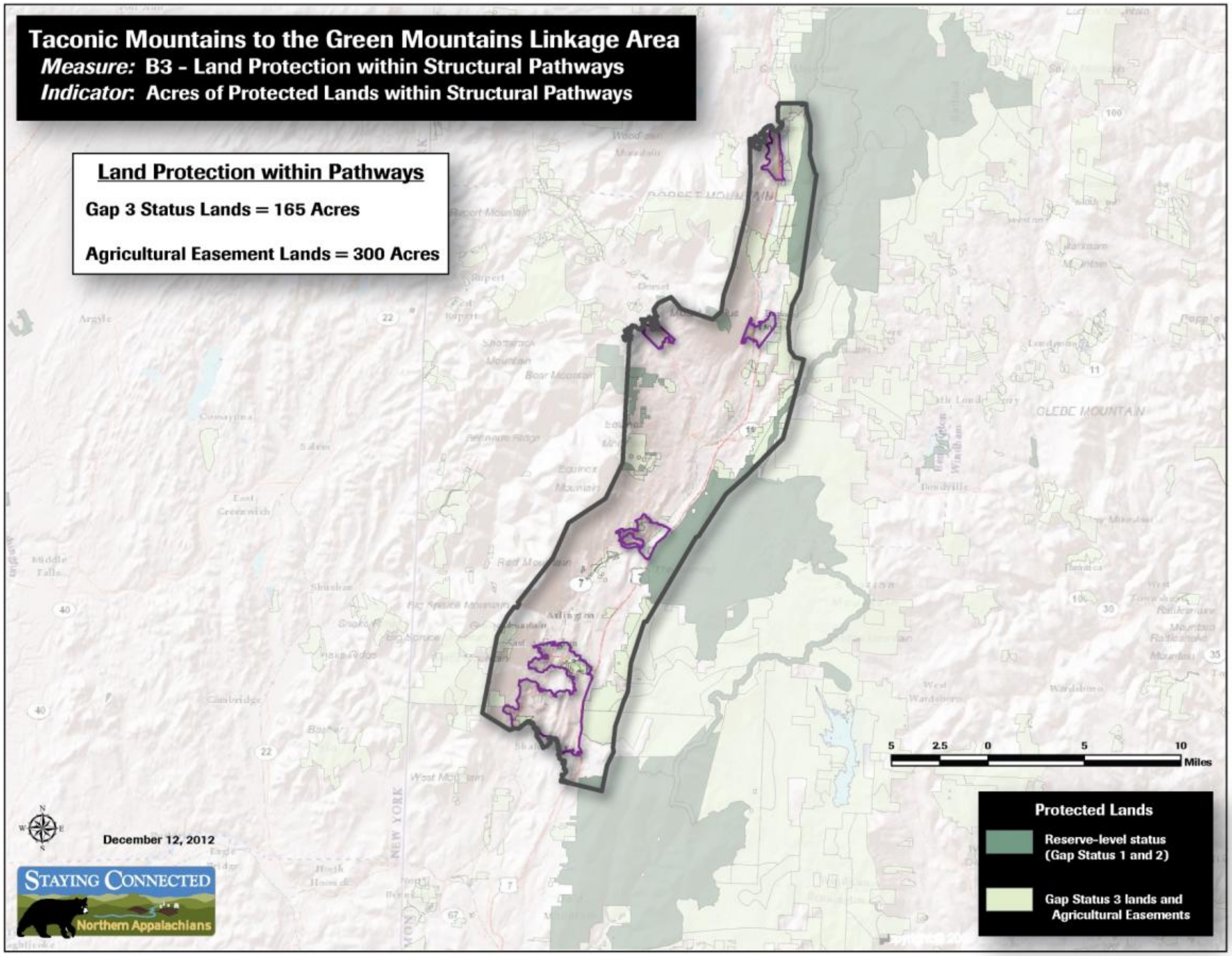


Figure 26. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #9: Land Protection* within Structural Pathways

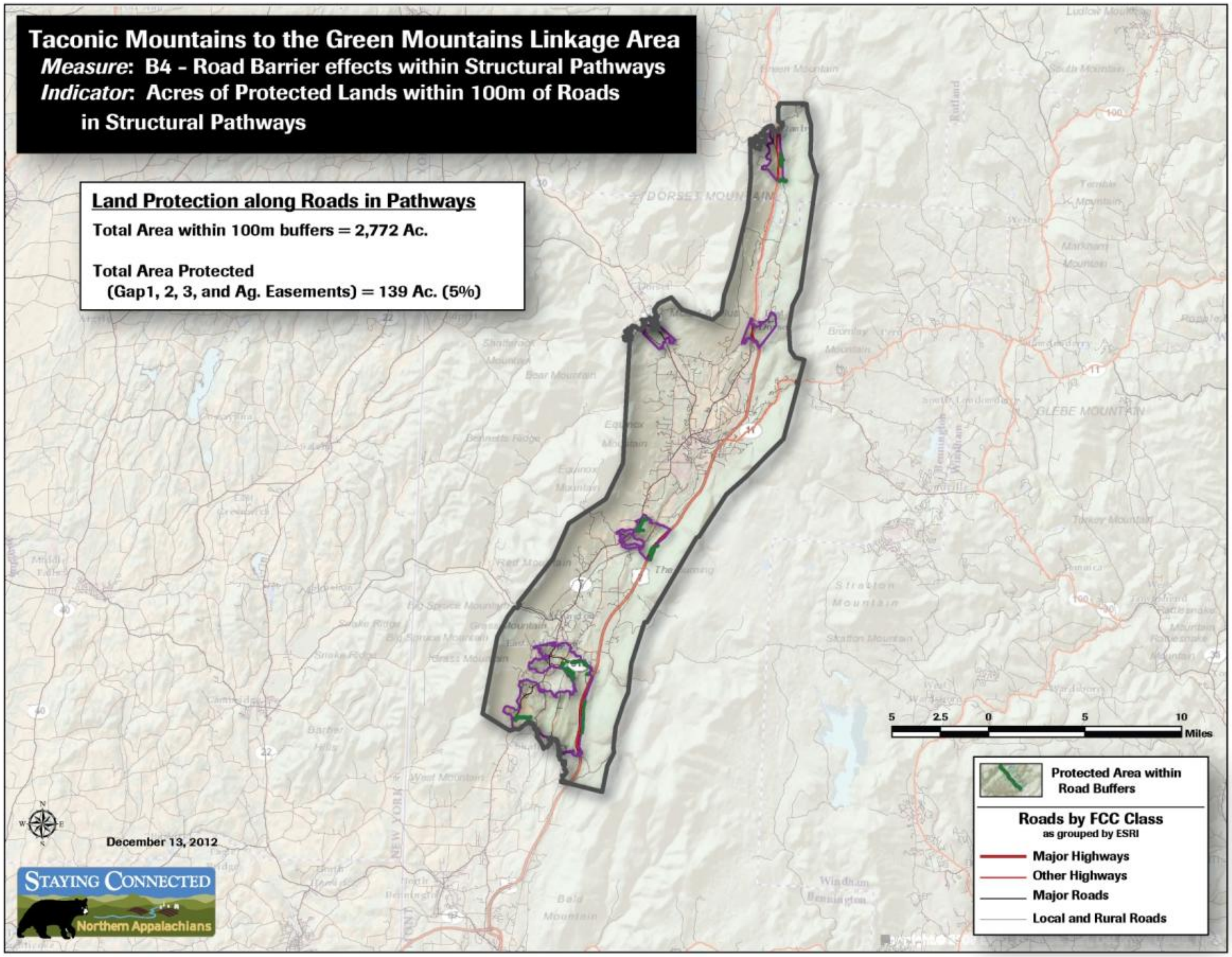


Figure 27. Taconic Mountains to the Green Mountains Linkage Area - *Baseline Map #10: Road Barrier effects within Structural Pathways*

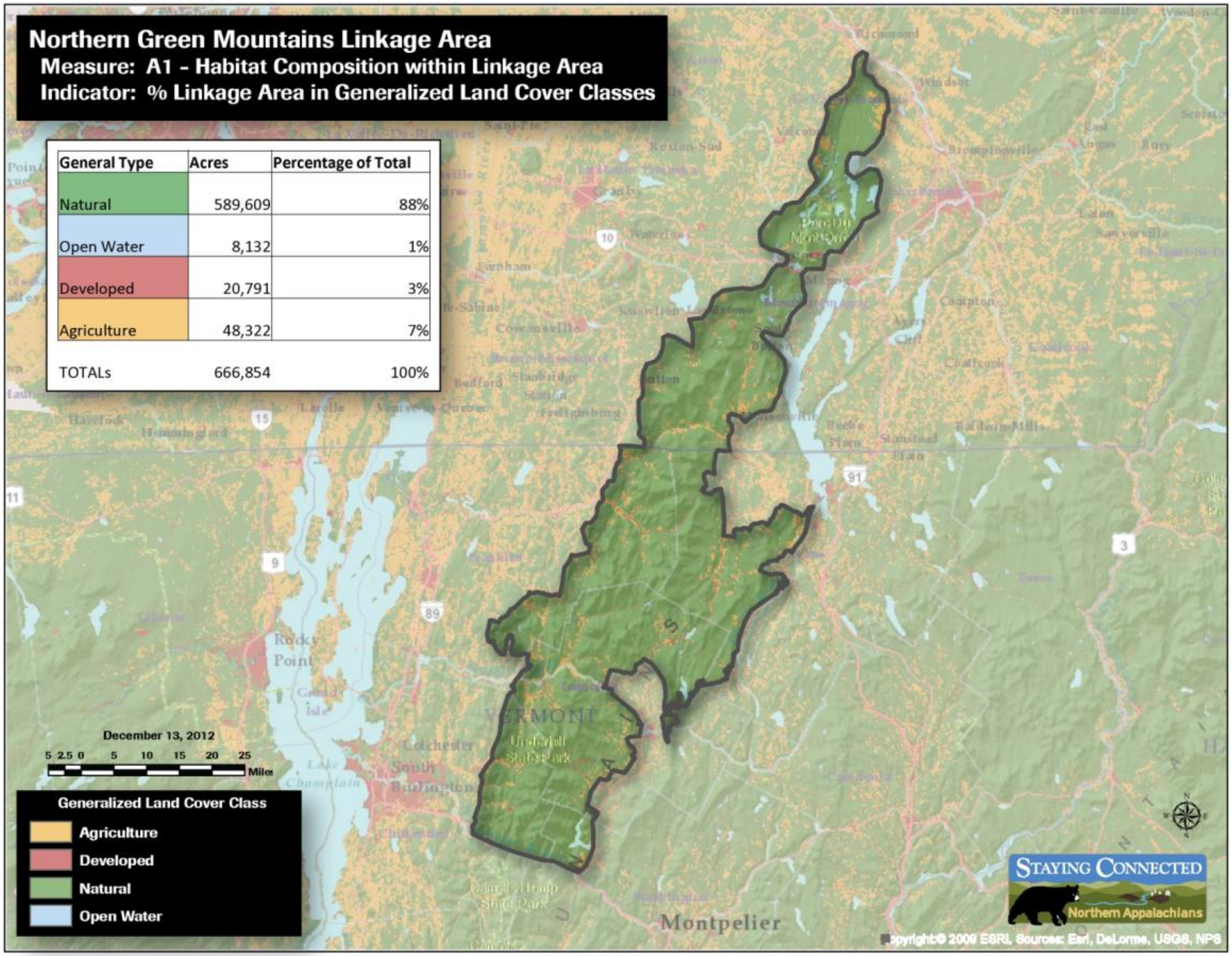
Linkage 4: Northern Green Mountains Linkage

The Northern Green Mountains may be among the wildest, yet least protected landscape in the Northern Appalachian/Acadian region. Ranging from Mount Mansfield, Vermont's highest peak, in the south, to Mount Orford, Québec, in the north, these mountains and their slopes are remarkably diverse, containing all the major ecosystem types of the Northern Appalachians. The Northern Green Mountain Linkage encompasses 722,183 acres (2,923 km2) and is centered on the spine of the Green Mountains. Most of the linkage area is forested, with agriculture and small towns and villages in the many valleys that bisect the mountain spine. Most roads are secondary one or two-lane gravel or asphalt, though Interstate 89 forms the southern border of the linkage and Autoroute 10 effectively bisects the Québec portion of the linkage. The economy of the region is dominated by wood products, agriculture and tourism, and includes several large ski areas, such as Jay Peak, and Stowe in Vermont and Mounts Sutton and Orford in Québec.

Unlike the Taconics to Southern Greens linkage, a mostly undeveloped mountain ridge dominates the Northern Green Mountains linkage, and thus a larger portion (88%) of the linkage is in natural vegetation, with only 7% in agriculture and 3% developed (Figure 28). Low levels of development yield relatively high average RK values of 56, with 63% of the linkage having an RK score of 50 or above (Figure 28). Blocks of unfragmented habitat form distinctive patches of uplands separated by rural valleys with low to moderate levels of development (Figure 30). About 20% of the linkage, 144,353 acres (584 km^2), is in some form of conservation (Figure 31), mostly in upland portions. Most of the roads within the US portion of the linkage[9] present relatively low barriers to the passage of mammals, with 53 miles (85 km) having AADT values between 2,500 and 10,000 and 136 miles (218 km) having AADT values of 2,500 or less (Figure 33). Eight miles (13 km) along Interstate 89, at the far southern end of the linkage, show AADT values above 10,000. The interstate, and a parallel state highway and railroad line, are formidable barriers to movement and require mitigation to reduce their impacts. A recent study by Samuel Schlepphorst (2012) proposes several mitigation options for this area. Autoroute 10 in Canada probably has traffic volumes similar to those of I-89.

Over two-dozen relatively small structural pathways have been identified within the linkage. Pathways have not yet been identified for the southernmost portion of the linkage. The pathways comprise about 55,000 acres (223 km^2), or 7.6% of the linkage (Figure 34). About 10%, or 5,639 acres (23 km^2) of the pathways are conserved in any way (Figure 36). About 10,174 acres (41 km^2) fall within 100 meters of the road segments within the pathways. Of this area, about 11% (1,096 acres or 4 km^2) is conserved (Figure 37).

[9] Traffic volumes are only available for the US at time of report preparation.



General Type	Acres	Percentage of Total
Natural	589,609	88%
Open Water	8,132	1%
Developed	20,791	3%
Agriculture	48,322	7%
TOTALs	666,854	100%

Figure 28. Northern Green Mountains Linkage Area - ***Baseline Map #1: Habitat composition within linkage***

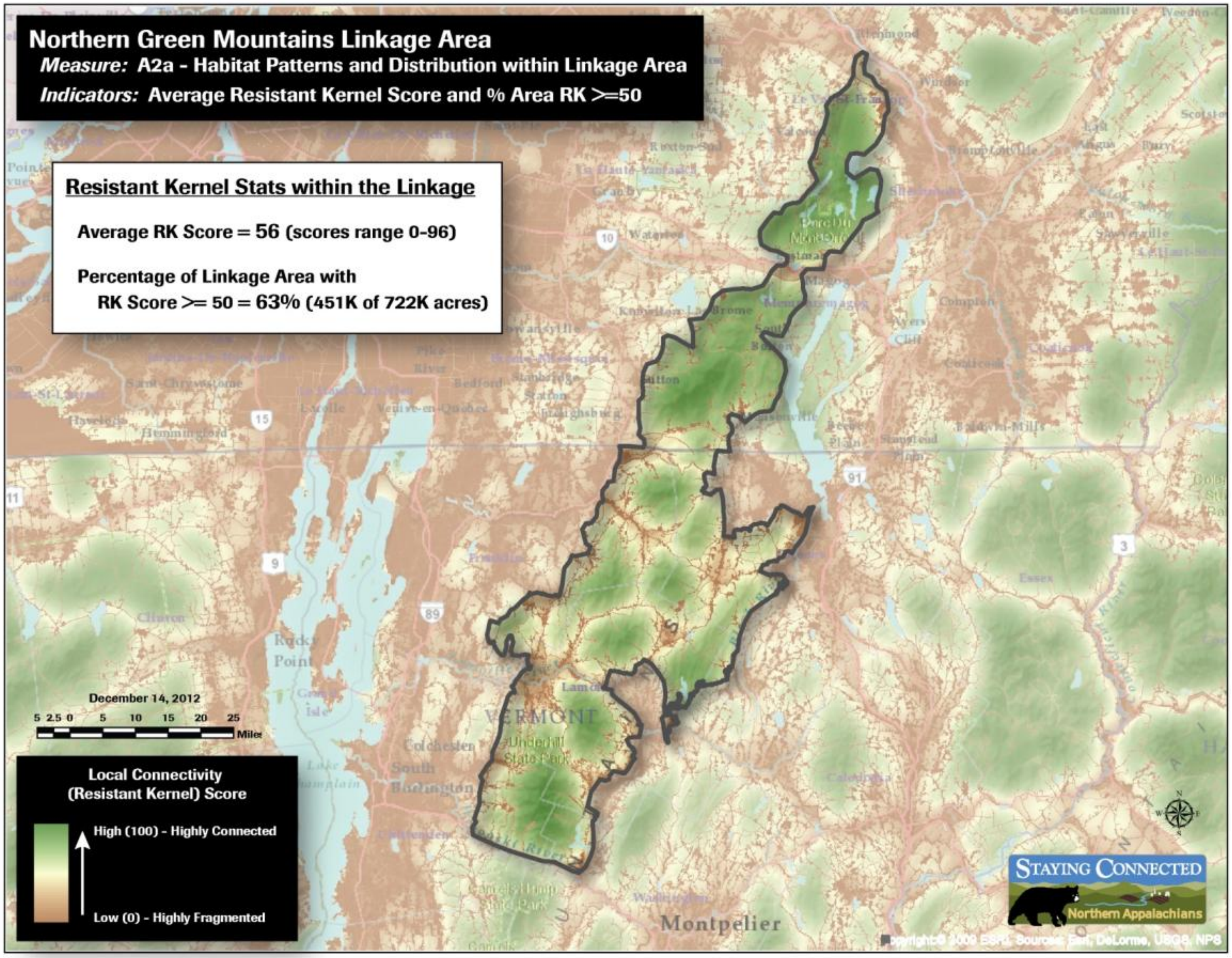


Figure 29. Northern Green Mountains Linkage Area - Baseline *Map #2: Patterns of habitat distribution within linkage*

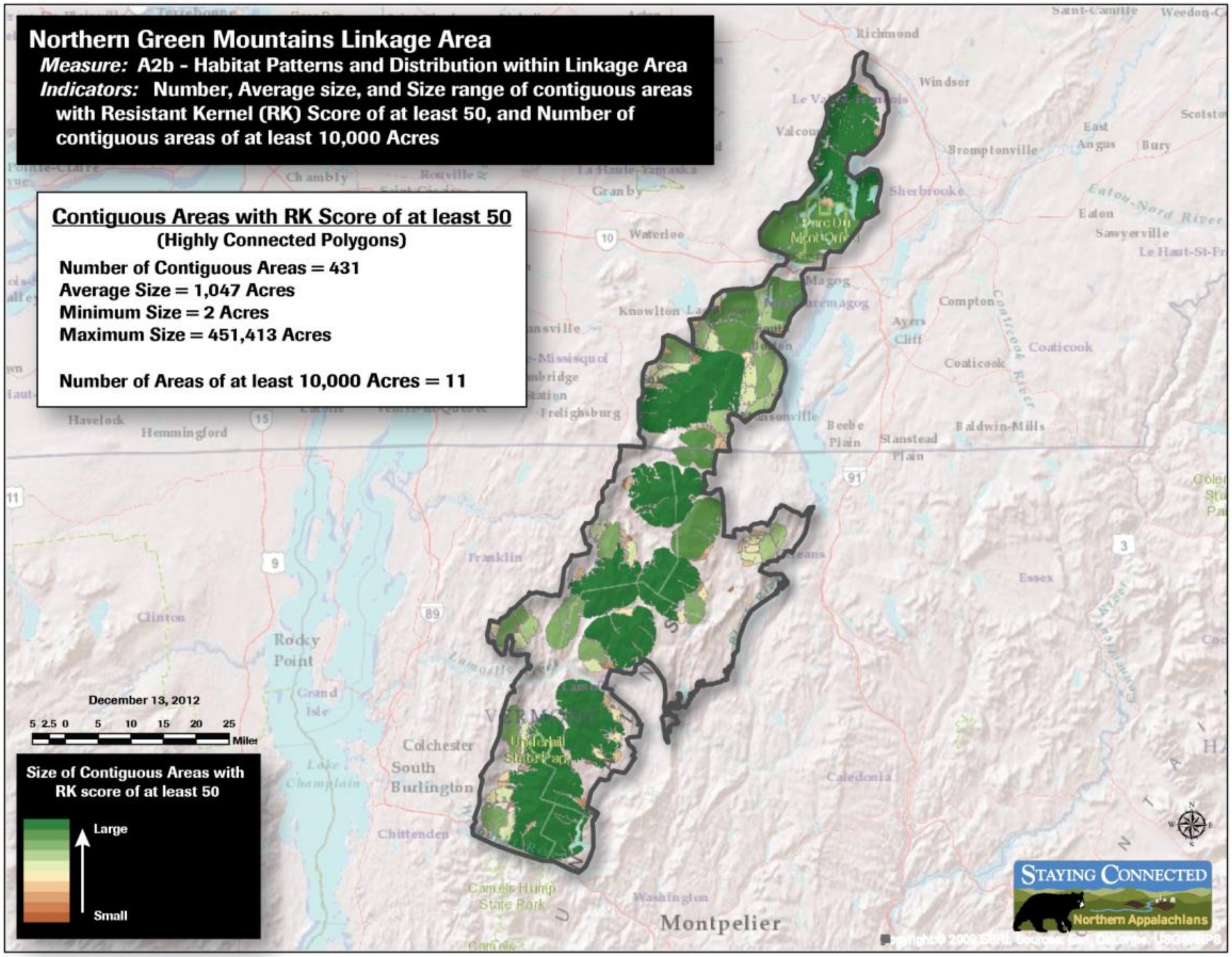


Figure 30. Northern Green Mountains Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

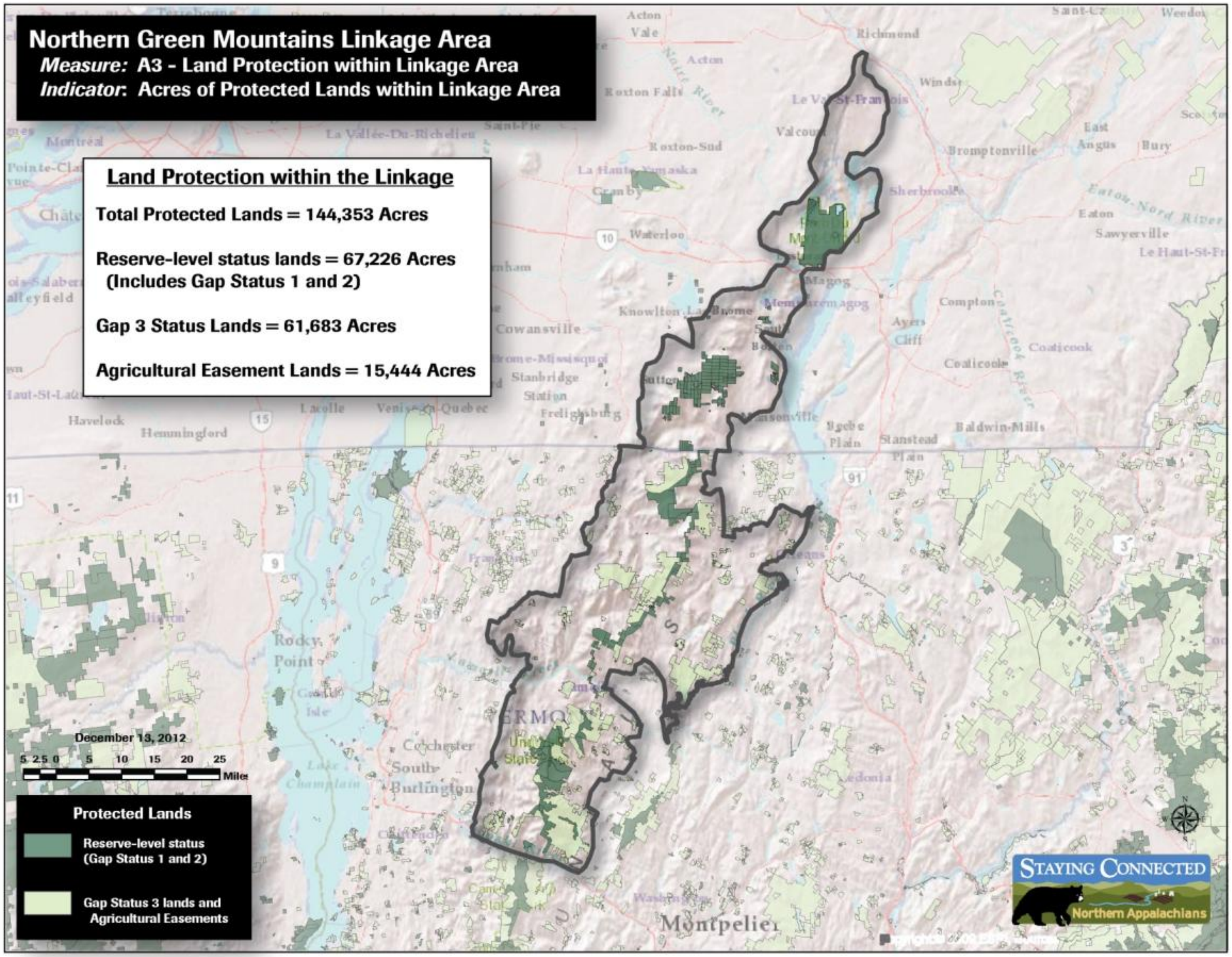


Figure 31. Northern Green Mountains Linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

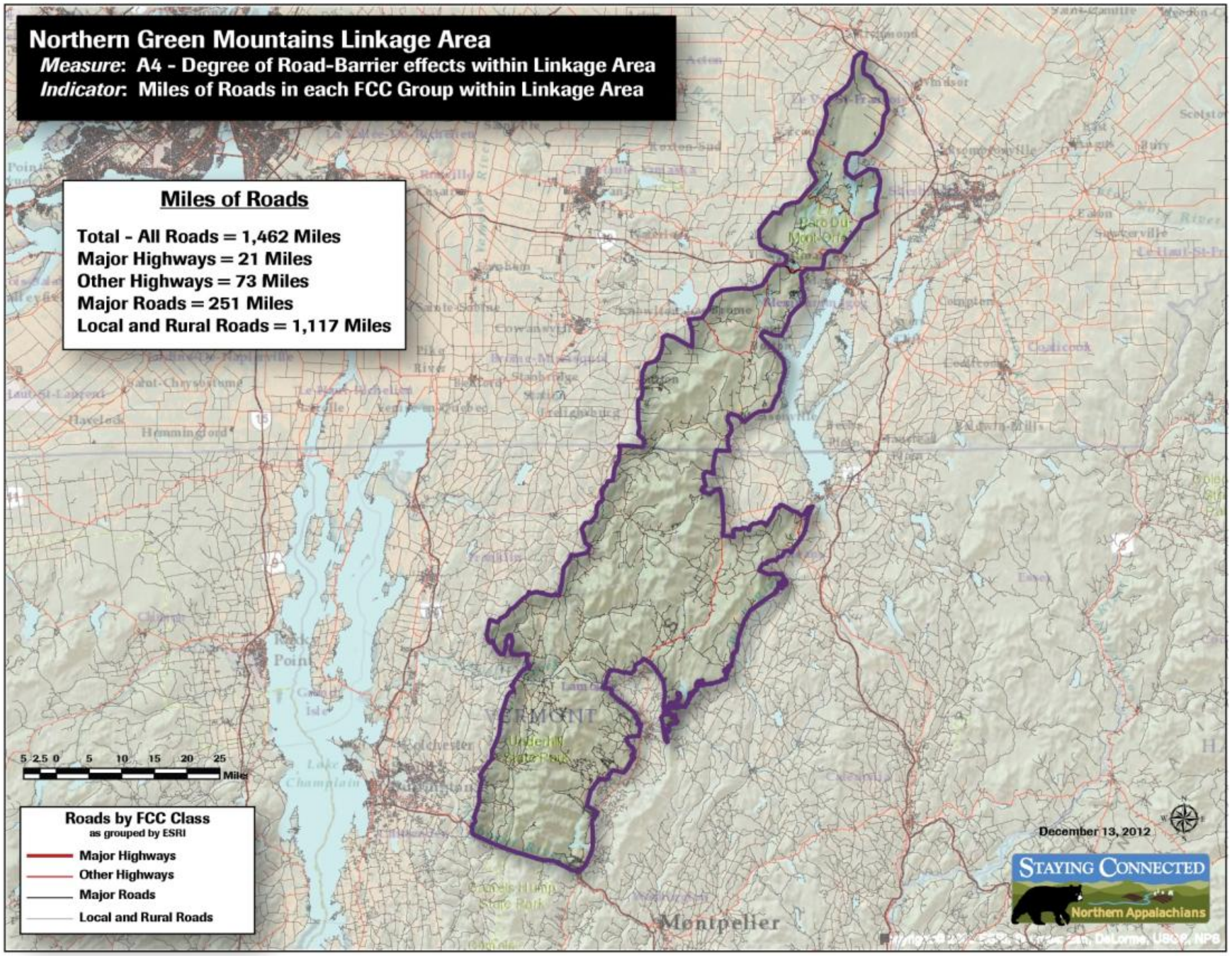


Figure 32. Northern Green Mountains Linkage Area - *Baseline Map#5: Road barrier effects – Miles of Roads in 4 General Classes*

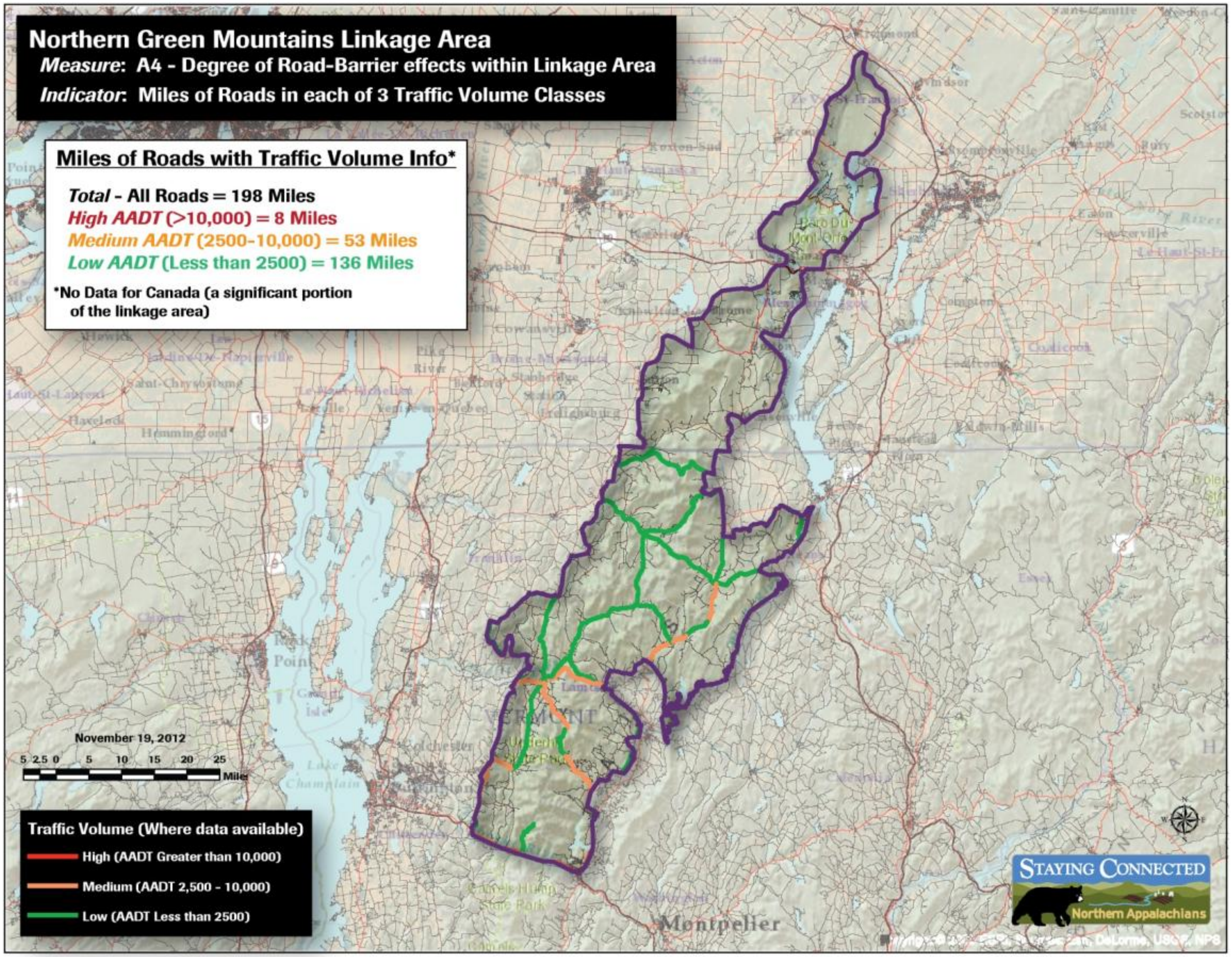


Figure 33. Northern Green Mountains Linkage Area *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*

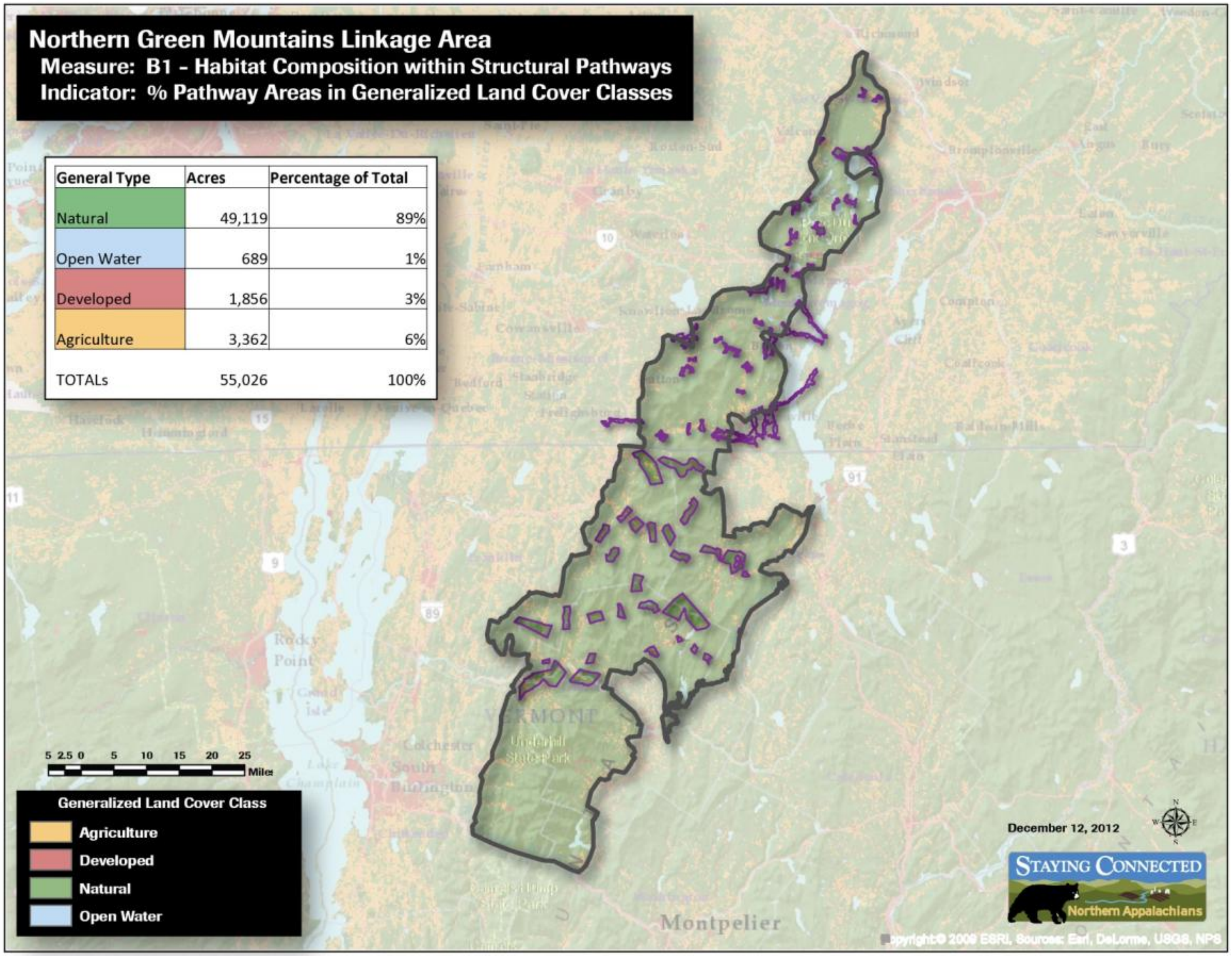


Figure 34. Northern Green Mountains Linkage Area - *Baseline Map # 7: Habitat Composition within Structural Pathways*

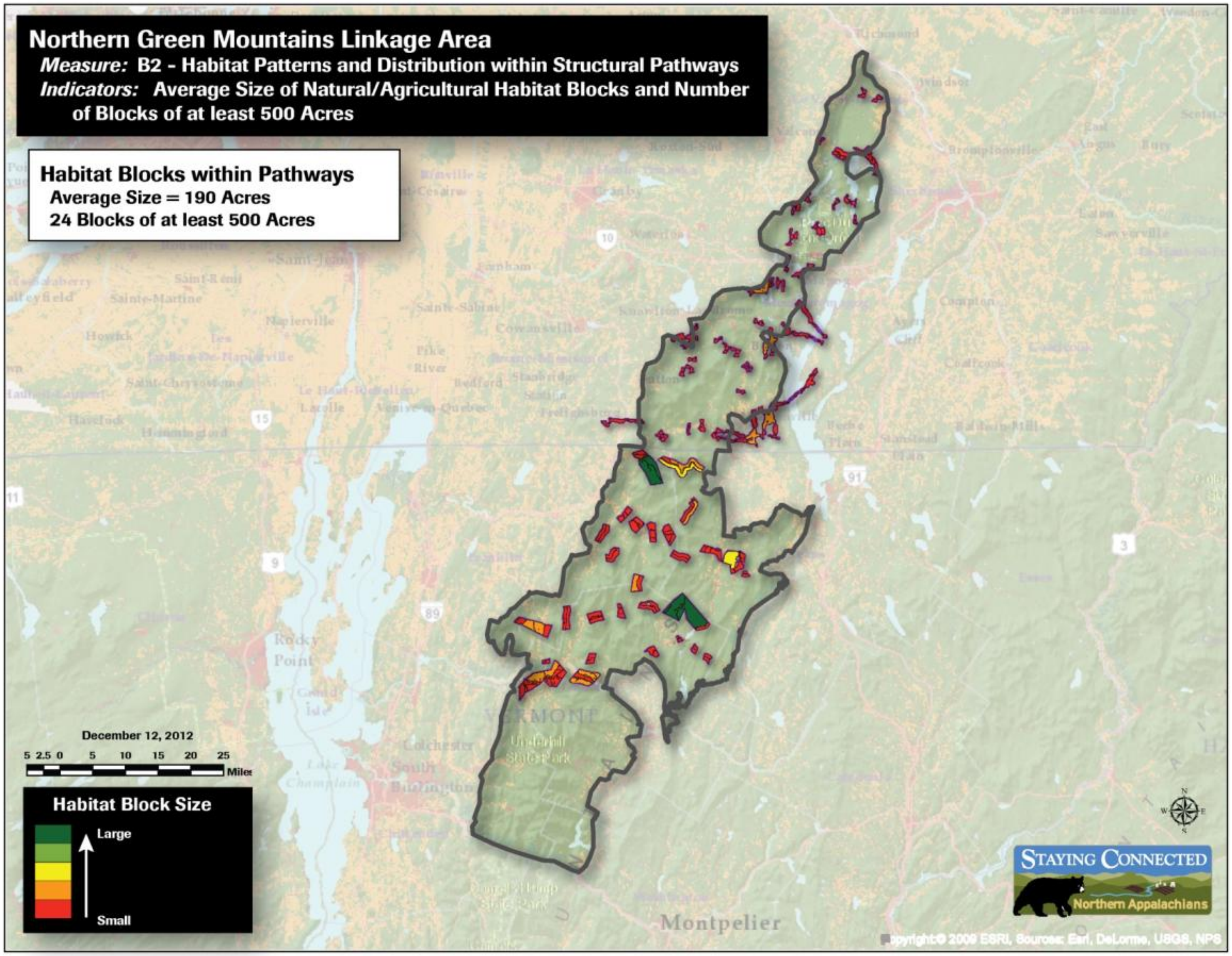


Figure 35. Northern Green Mountains Linkage Area - *Baseline Map # 8: Habitat Composition within Structural Pathways*

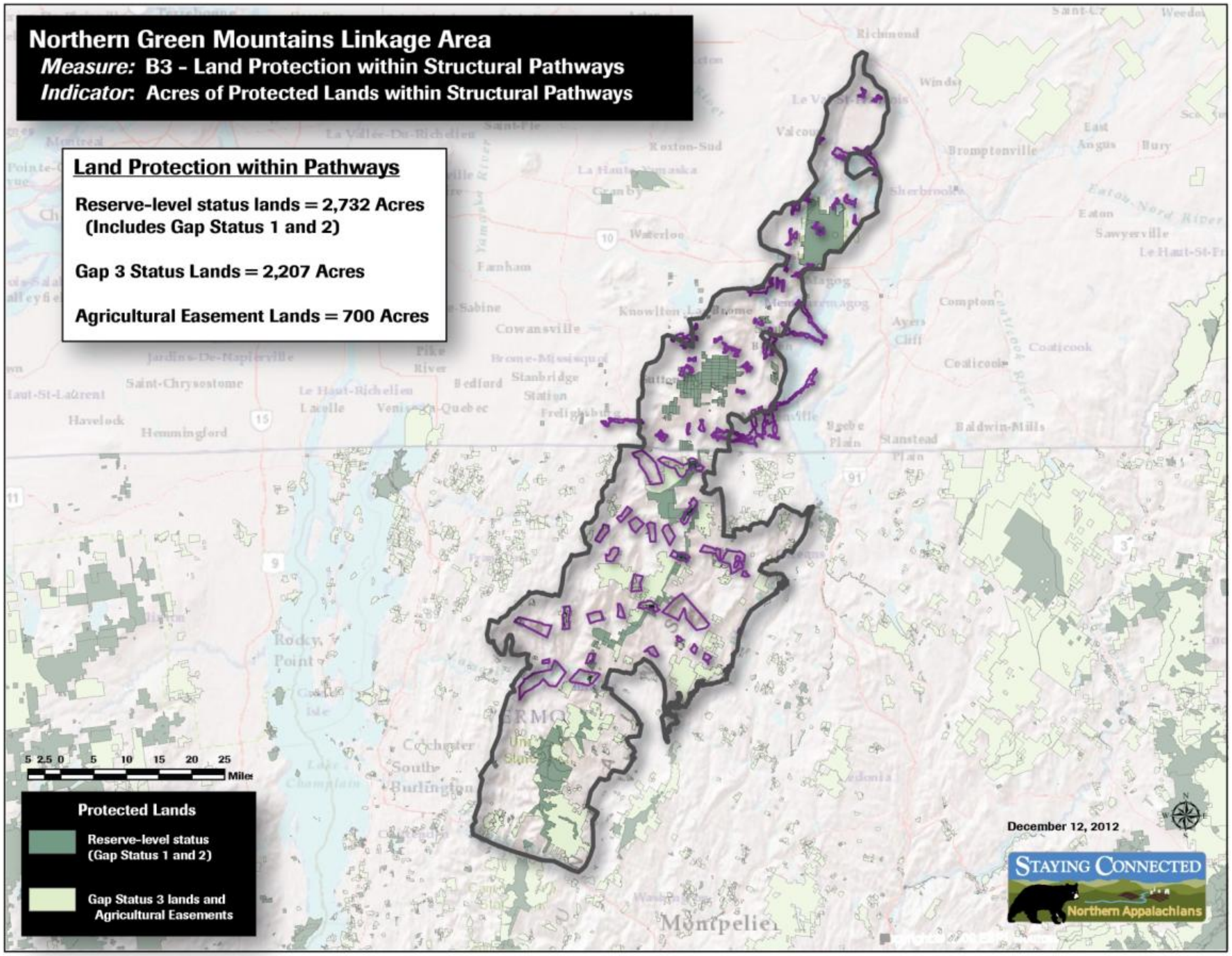


Figure 36. Northern Green Mountains Linkage Area - *Baseline Map # 9: Land Protection with Structural Pathways*

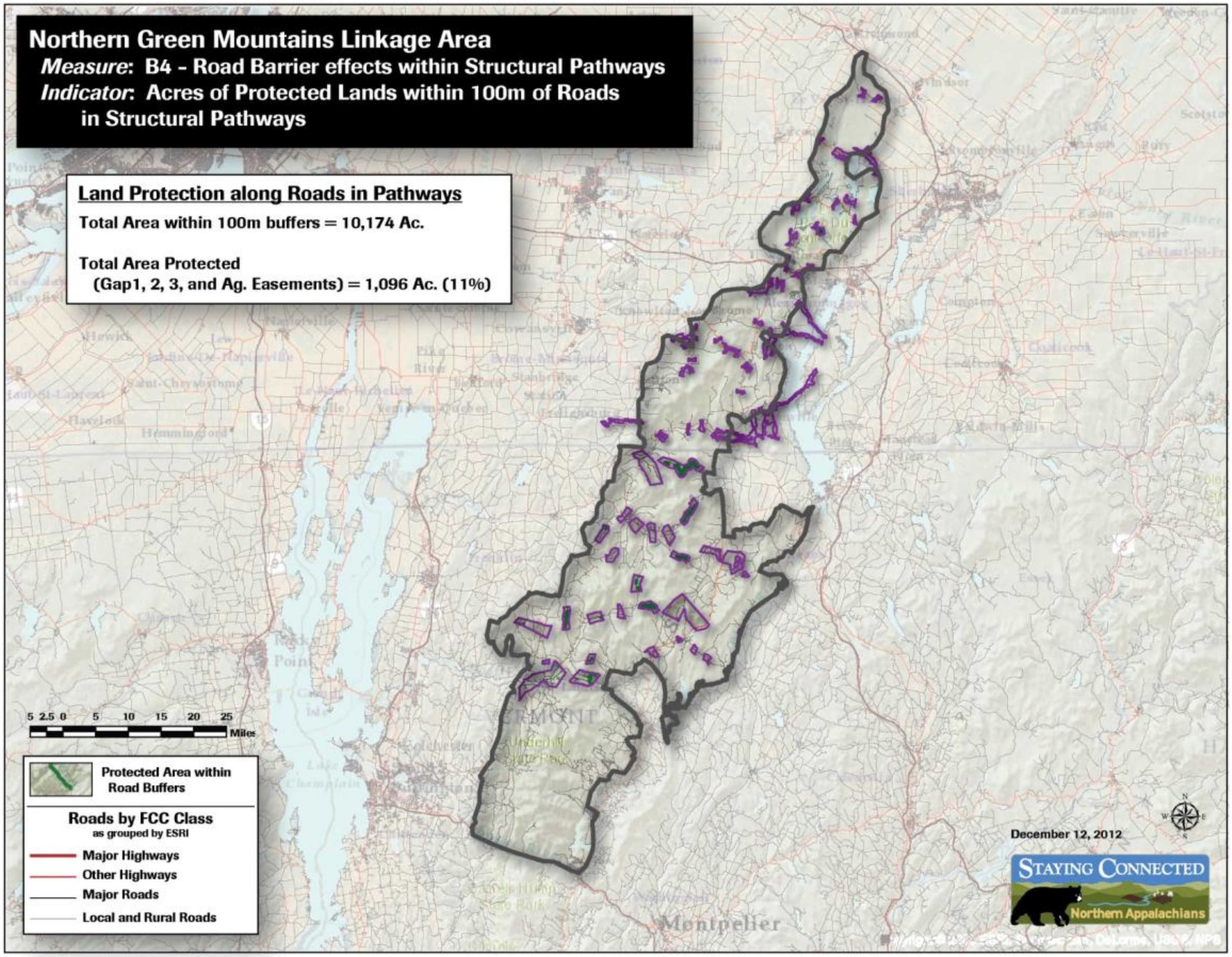


Figure 37. Northern Green Mountains Linkage Area - *Baseline Map# 10: Road Barrier effects within Structural Pathways*

Linkage 5: Worcester Range to the Northeast Kingdom Linkage

This linkage covers nearly 600,000 acres (2,412 km^2) from the Northern Green Mountains and Worcester Ranges northeastward through the Northeastern Highlands of Vermont. Within this area there are three distinct biophysical regions, each one contributing to the sense of identity of regions within the linkage. These are the Green Mountains, the Piedmont, and the Northeastern Highlands of Vermont. Many watersheds are involved, from the Winooski and Lamoille in the west to the St, Francis, Passumpsic and Connecticut River systems in the east. Interspersed among these are fantastic, wild places like the Nulhegan Basin, Lake Willoughby, Green River and Waterbury Reservoirs. Politically, this area includes 30 Vermont towns from Stowe and Waterbury to Newark, Ferdinand and Brunswick - each with its own culture and yet broadly sharing many similarities and connections to the land. Lifestyles vary from traditional land-related professions of agriculture, sugaring and logging, to ecotourism and outdoor recreation.

Like the Northern Greens linkage, a large portion (89%) of the Worcesters to NEK linkage is in natural vegetation, with only 6% in agriculture and 3% developed (Figure 38). With larger river valleys than the Northern Greens, the development patterns differ, yielding a lower overall average RK score of 46 for the linkage, with 53% of the linkage having an RK score of 50 or above (Figure 39). As with the Northern Greens, blocks of unfragmented habitat form distinctive patches of uplands separated by (wider) rural valleys with moderate levels of development (Figures 39 and 40).

About 18% of the linkage, 106,089 acres (429 km^2), is in some form of conservation (Figure 41), mostly in upland areas. Most of the roads present relatively low barriers to the passage of mammals, with only 5 miles (8 km) of the 1,403 miles (2,245 km) of roads in the linkage having AADT values above 10,000. An additional 58 miles (93 km) have AADT values between 2,500 and 10,000 and 164 miles (262 km) have AADT values of 2,500 or less (Figure 43).

The structural pathways in the Worcester to NEK linkage are fewer and larger in area than those in the Northern Greens. The pathways comprise about 120,510 acres (48 km^2), or 20.6% of the linkage (Figure 44). About 7%, or 8,430 acres (34 km^2) of the pathways are conserved in some way (Figure 46). Because the pathways are relatively large, about 44,078 acres (178 km^2) fall within 100 meters of the road segments within the pathways. Of this area, about 7% (3,052 acres or 12 km^2) is conserved (Figure 47.)

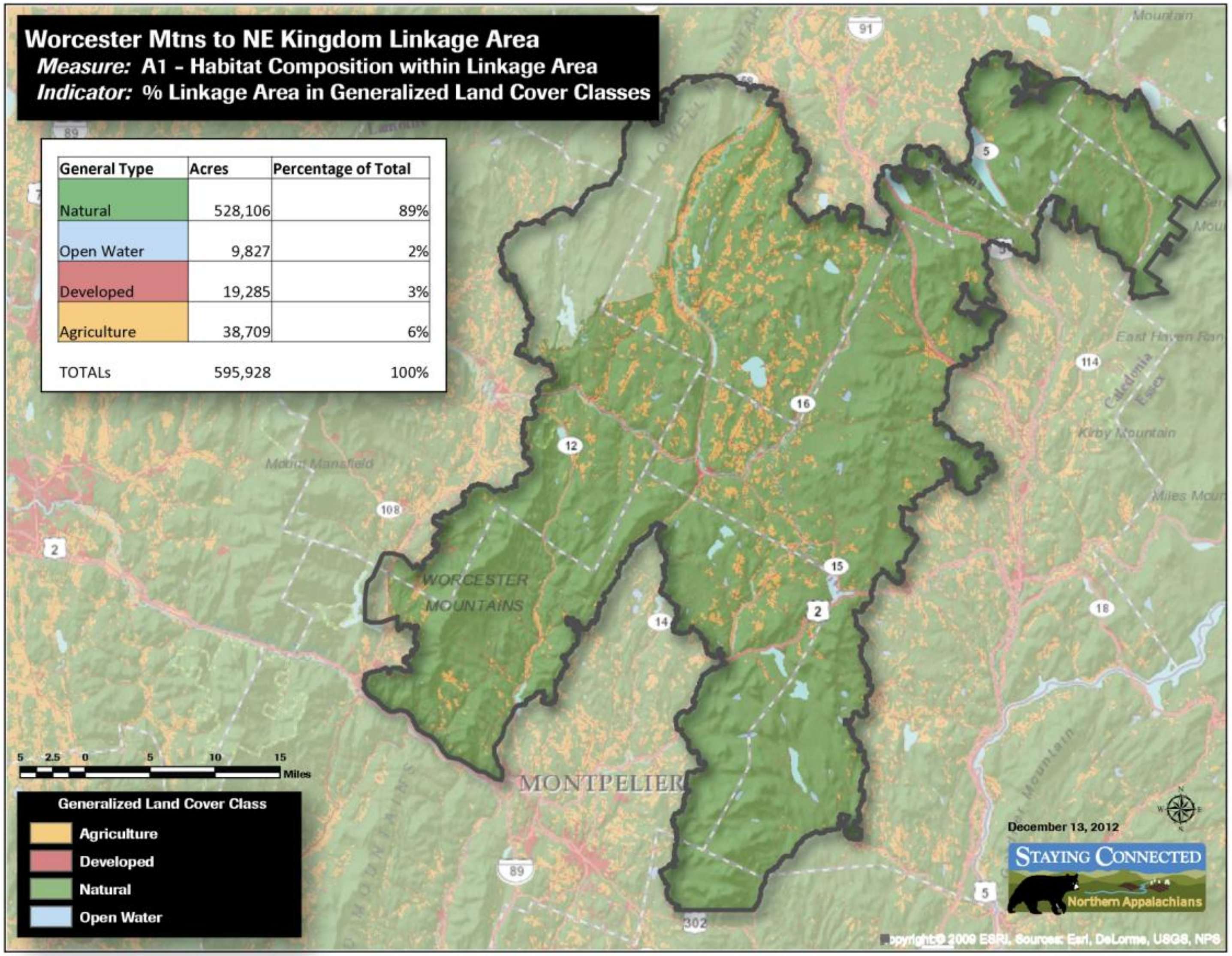


Figure 38. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #1: Habitat composition within linkage*

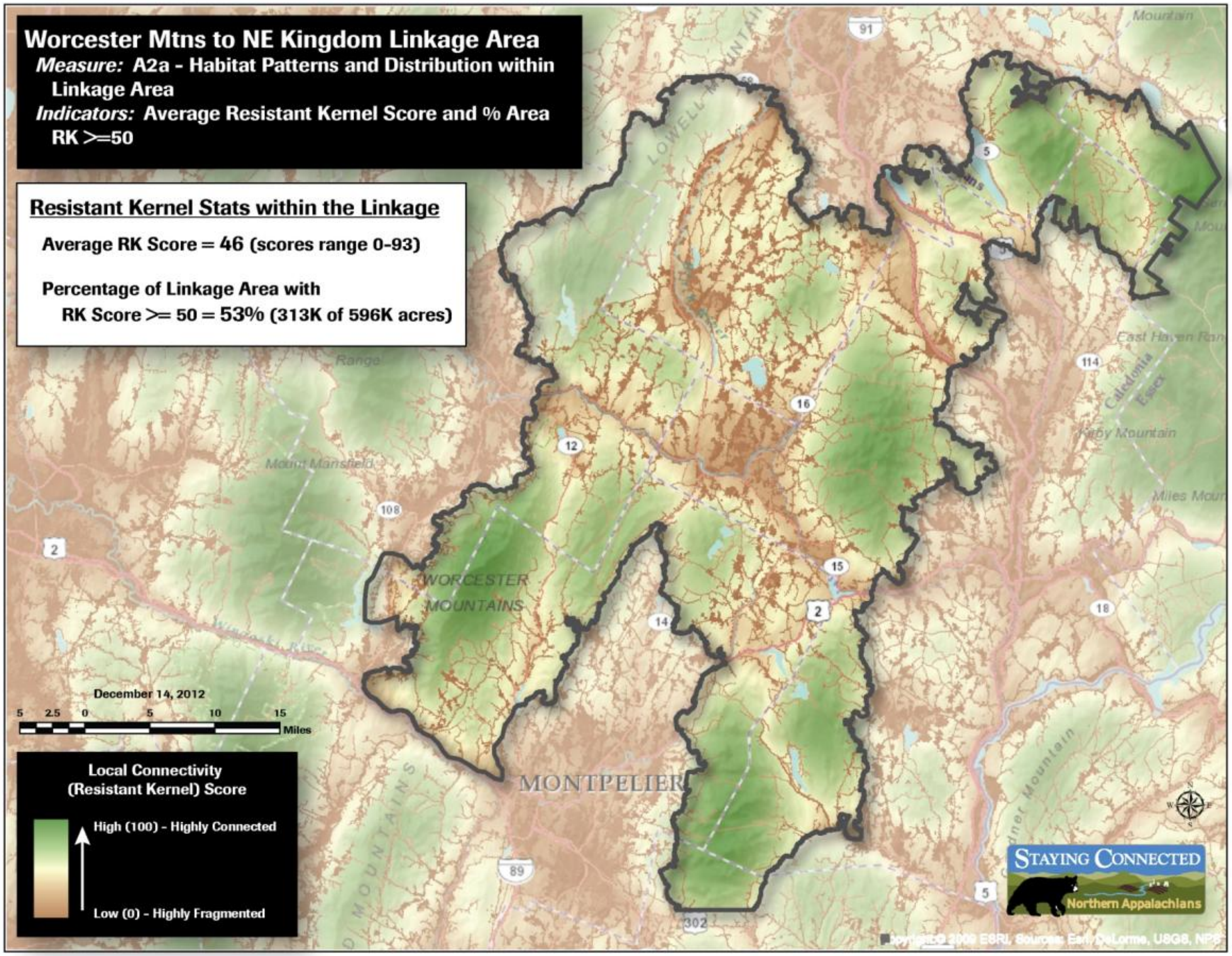


Figure 39. Worcester Mountains to Northeast Kingdom Linkage Area - Baseline *Map #2: Patterns of habitat distribution within linkage*

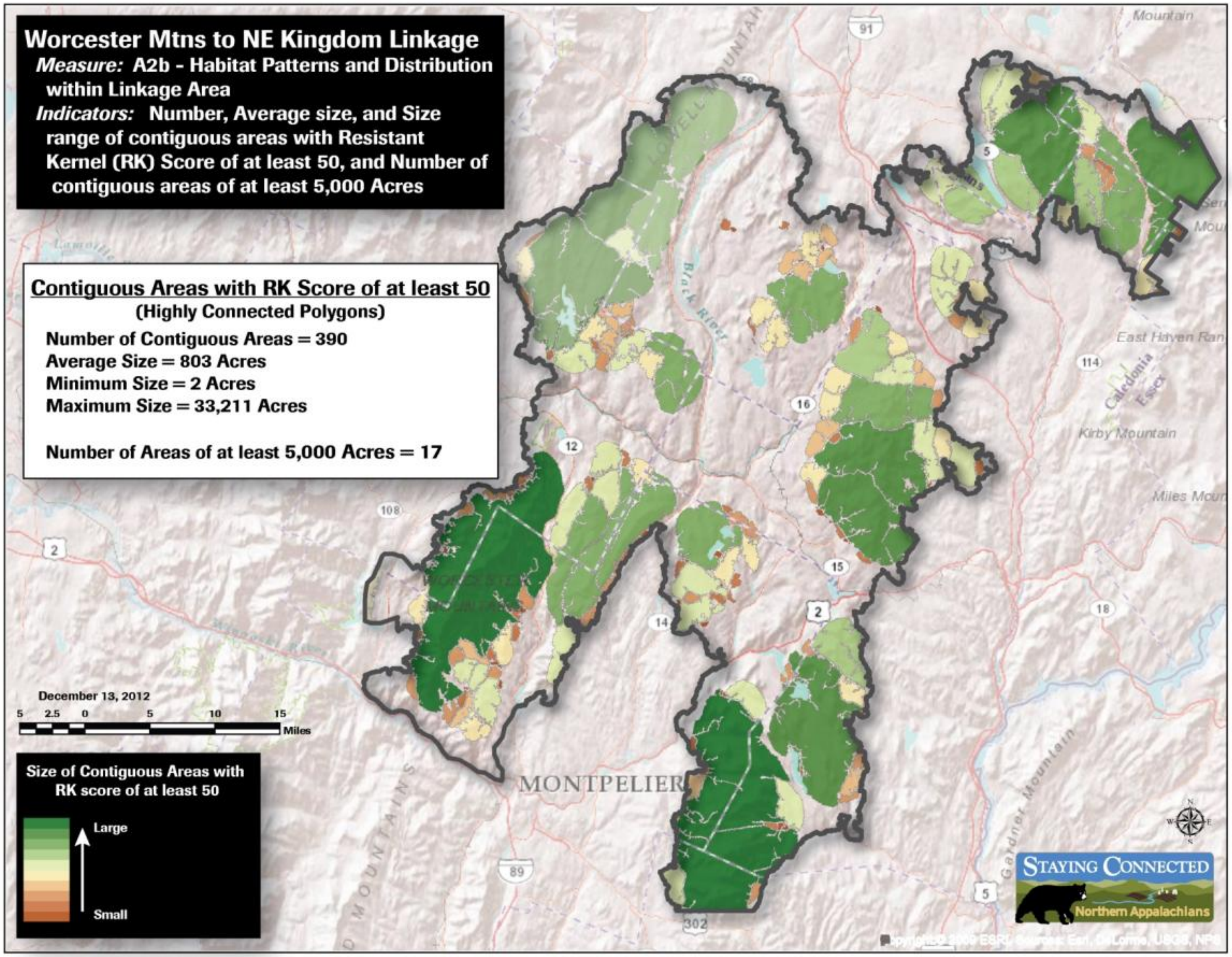


Figure 40. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

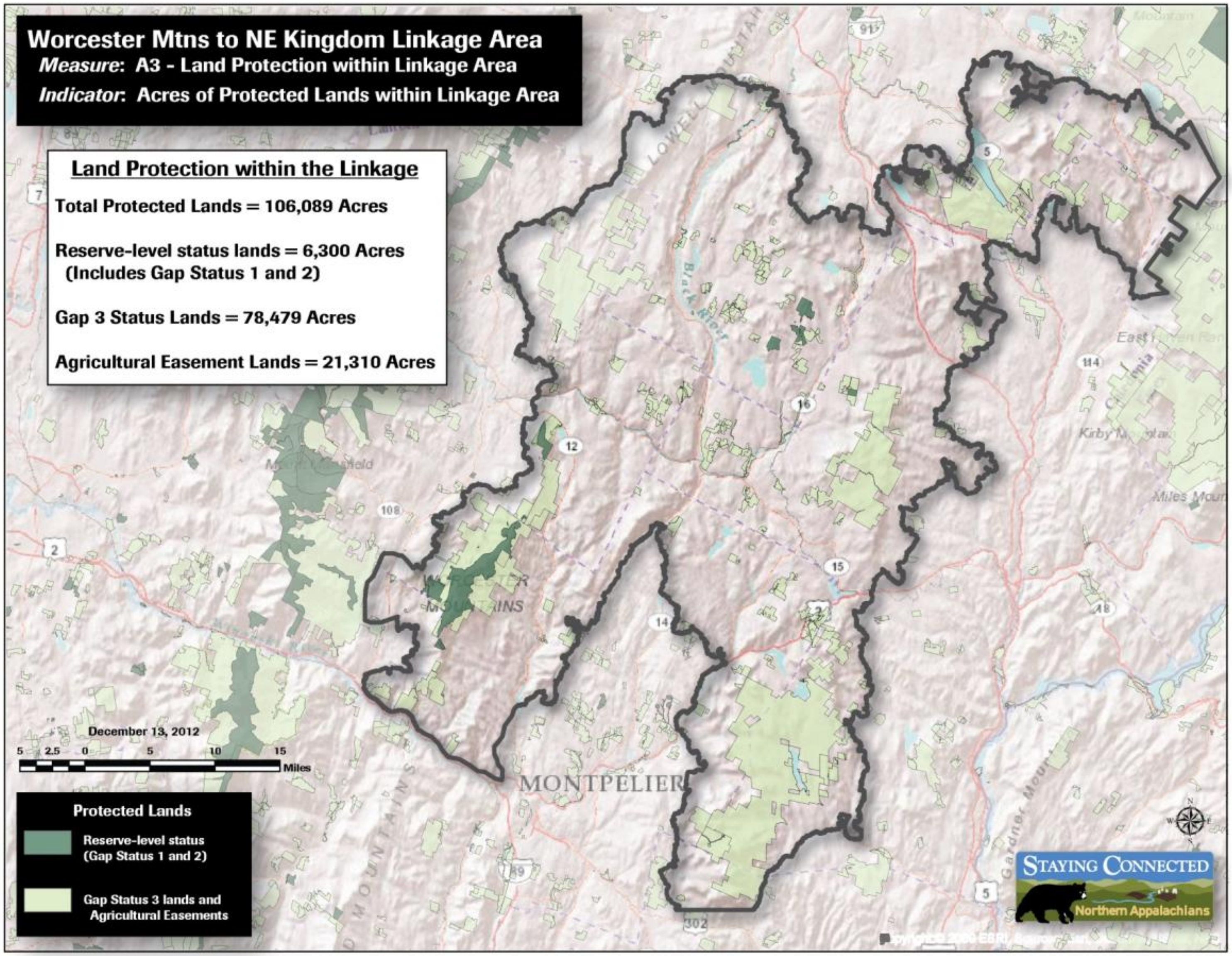


Figure 41. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

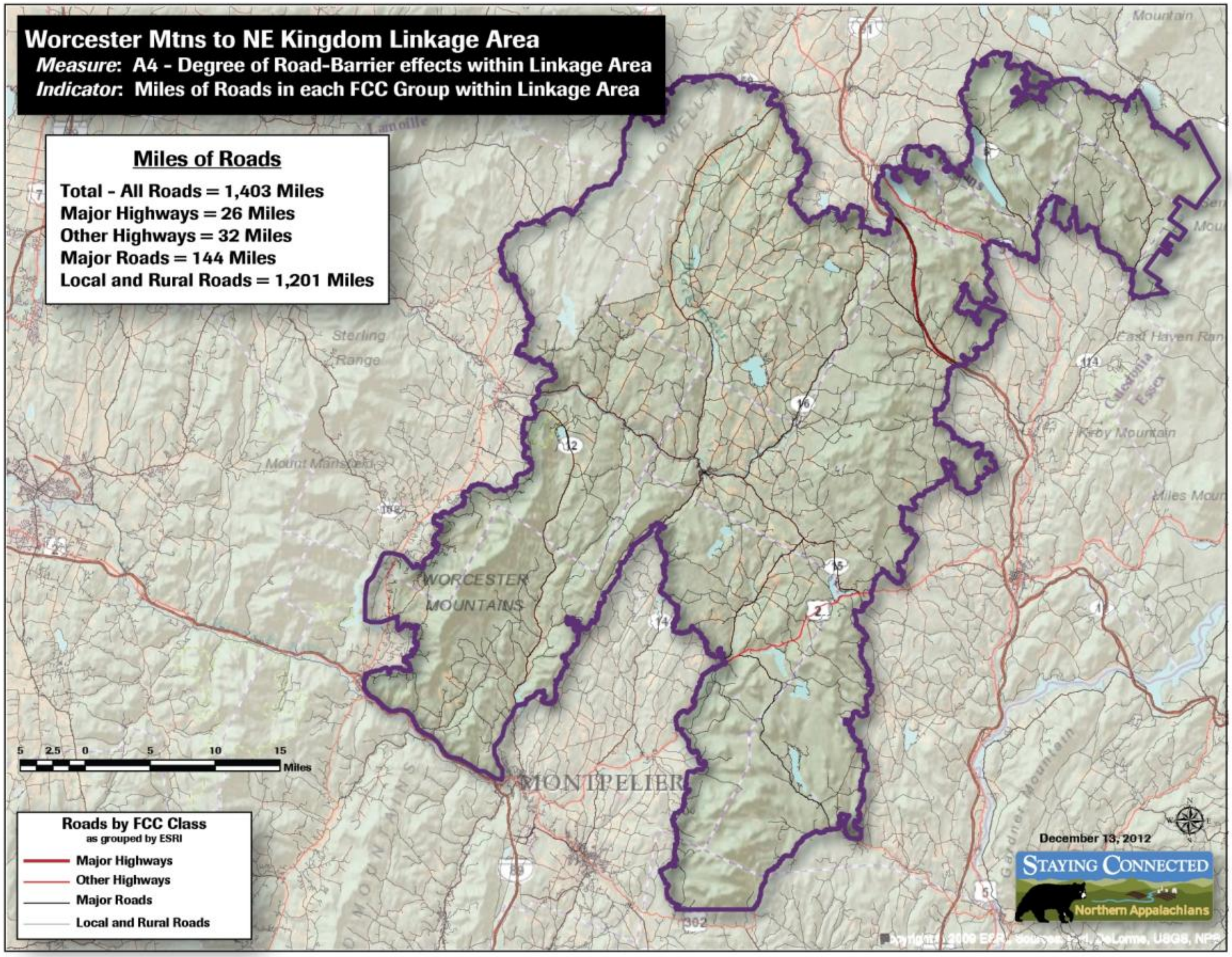


Figure 42. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes*

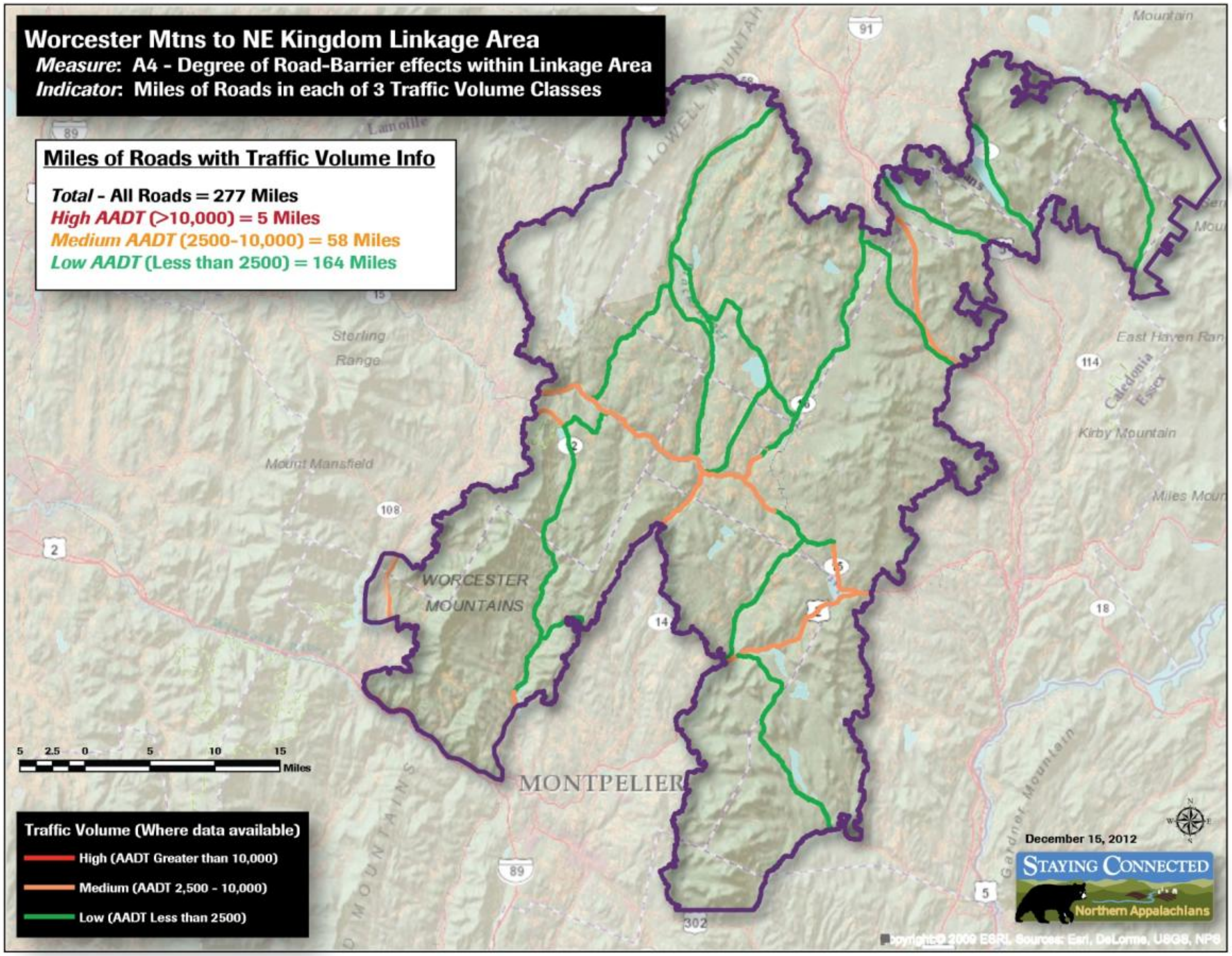
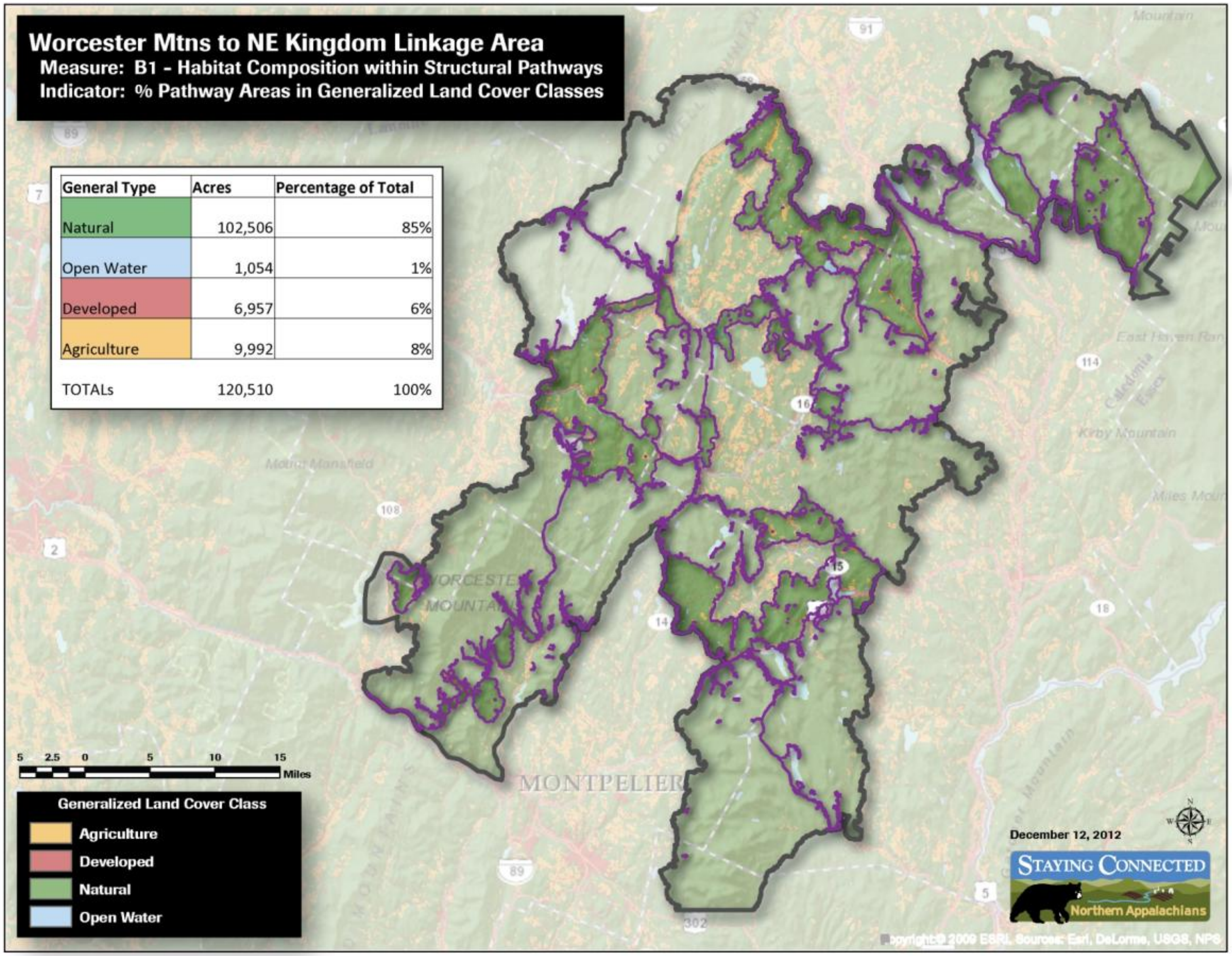


Figure 43. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*



General Type	Acres	Percentage of Total
Natural	102,506	85%
Open Water	1,054	1%
Developed	6,957	6%
Agriculture	9,992	8%
TOTALs	120,510	100%

Figure 44. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #7: Habitat Composition within Structural Pathways*

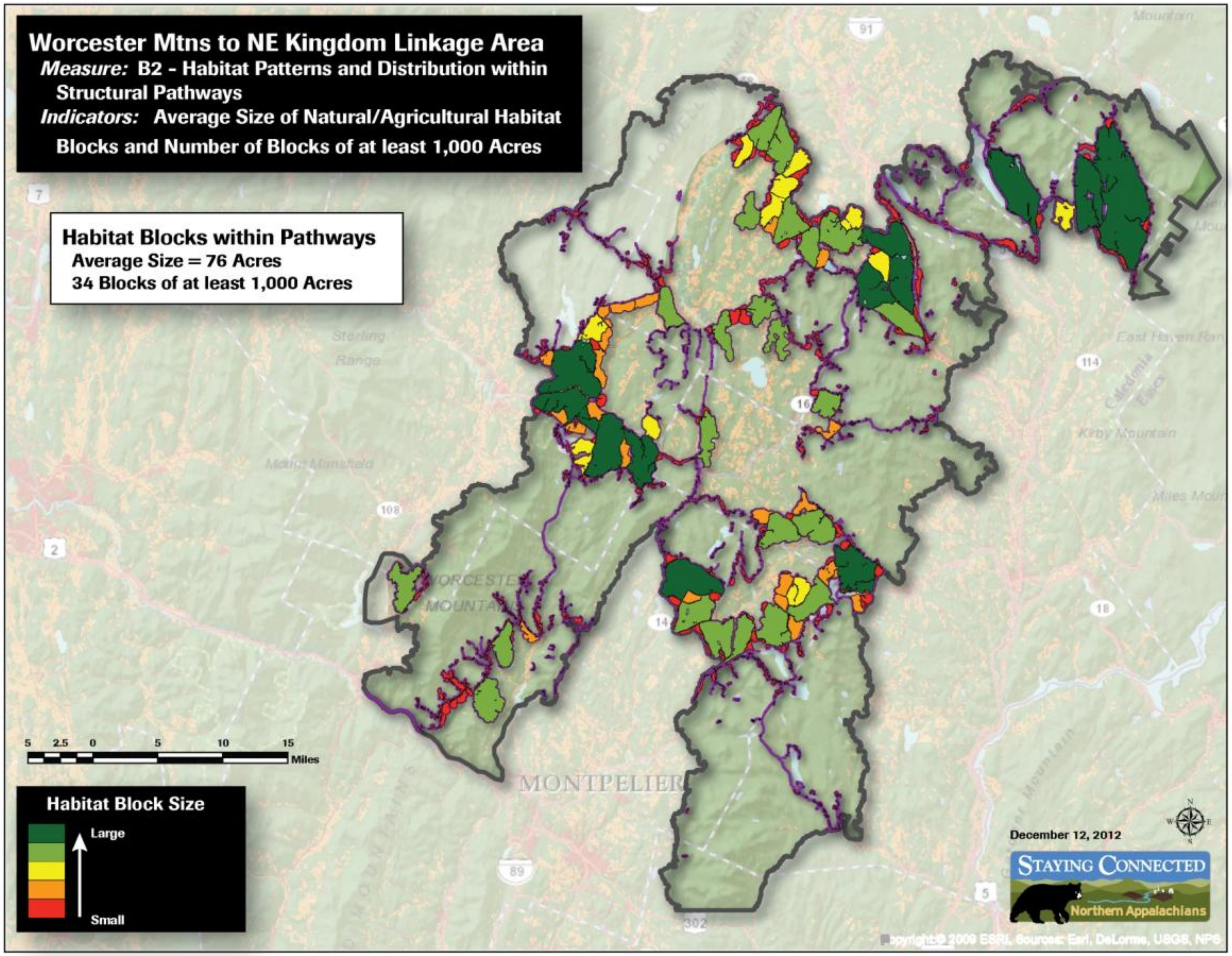


Figure 45. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #8: Patterns of Habitat Distribution within Structural Pathways*

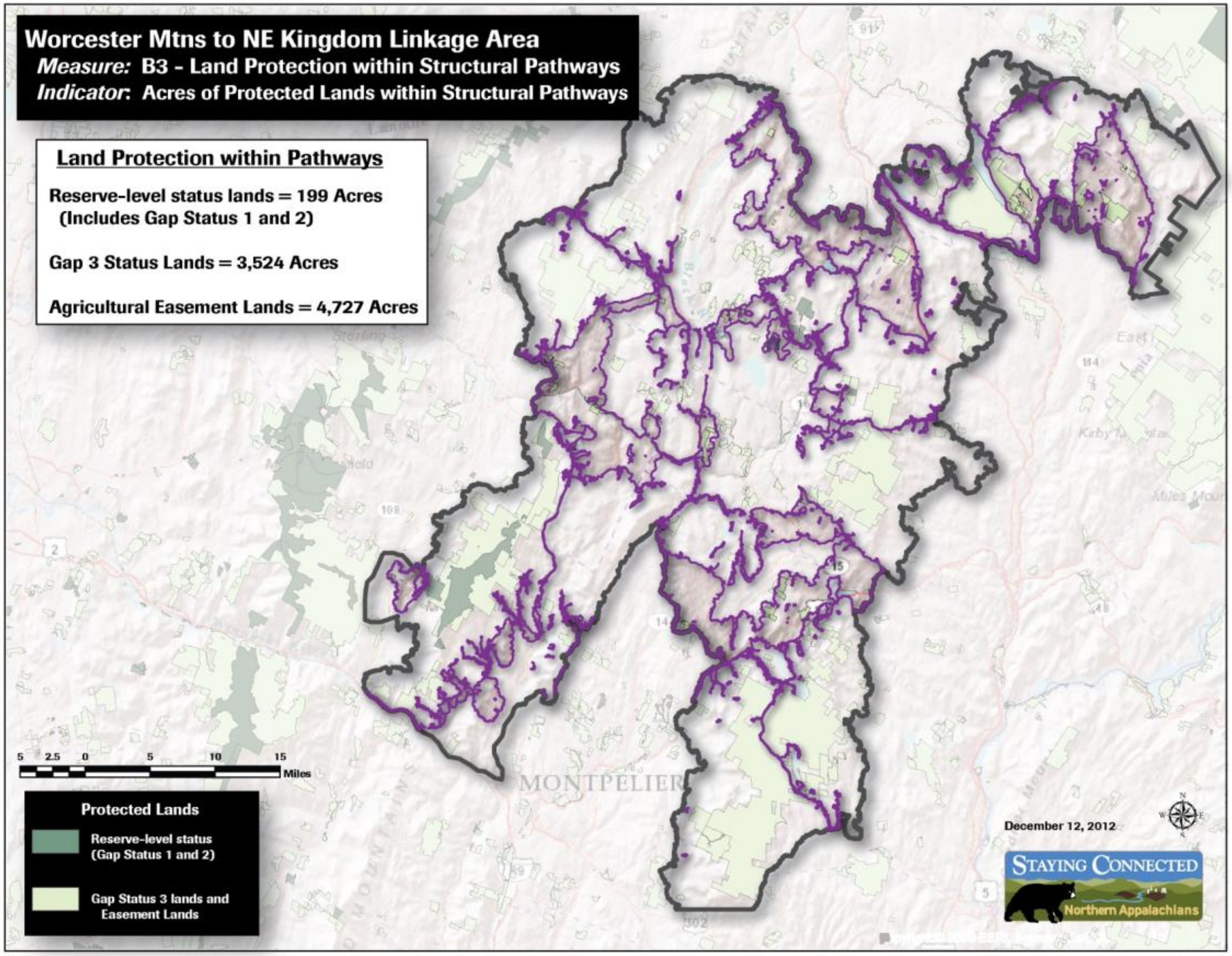


Figure 46. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #9: Land protection within Structural Pathways*

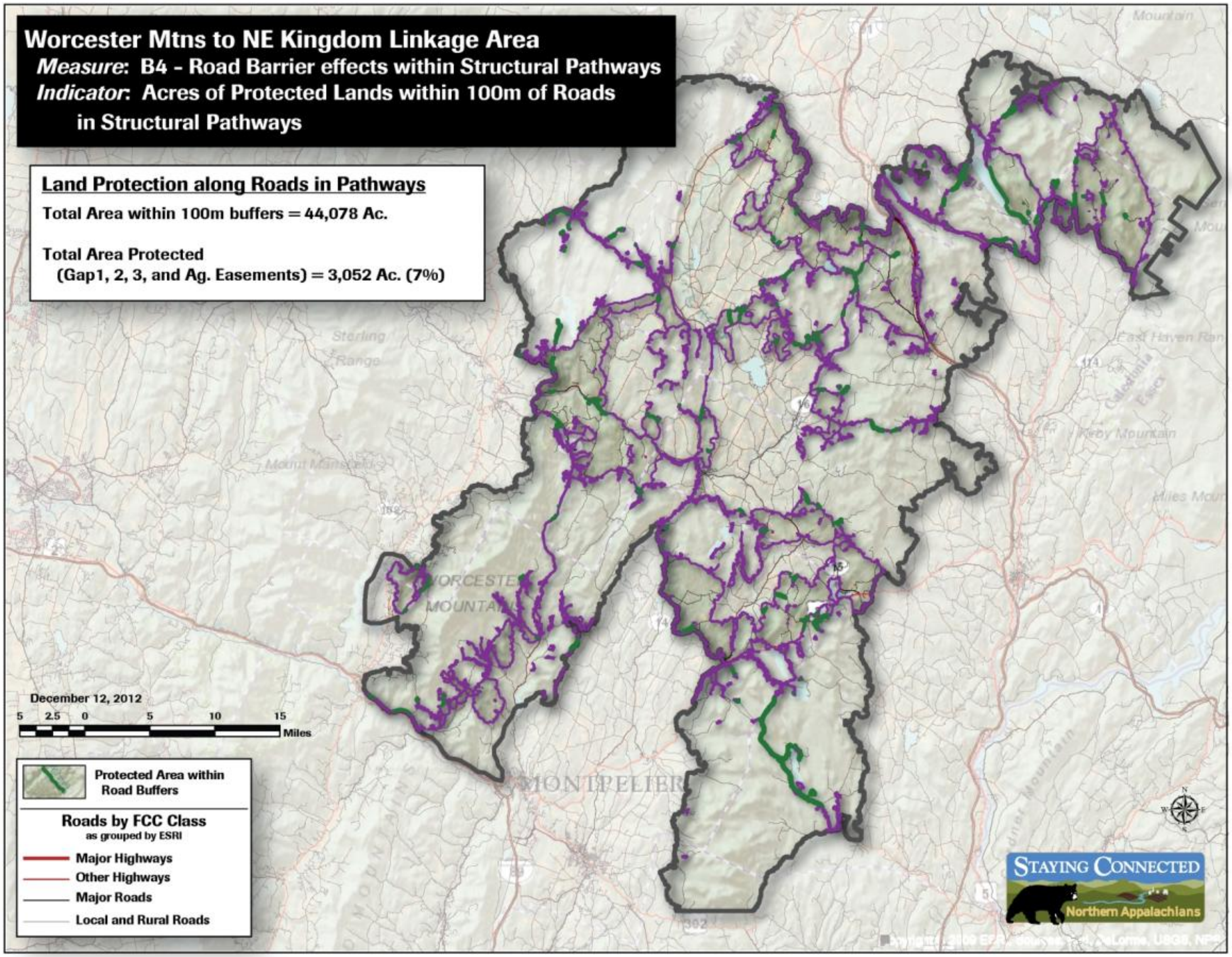


Figure 47. Worcester Mountains to Northeast Kingdom Linkage Area - *Baseline Map #10: Road Barrier effects within Structural Pathways*

Linkage 6: Northeast Kingdom to Northern New Hampshire Linkage

Characterized by extensive forests, rugged mountains and remote lakes, this linkage reaches from the northeast corner of Vermont and across much of northern New Hampshire to connect with Mount Megantic in southern Québec. While largely permeable for wildlife, the fertile river valleys of the region, with a pattern of intensive agricultural use and scattered communities, present the biggest challenge to maintaining connectivity for wildlife. Over half a million acres of conserved land within the linkage, including the Nulhegan Basin and West Mountain WMA in Vermont, the Connecticut Lakes Headwaters, the Kilkenny district of the White Mountain National Forest in New Hampshire, and Mount Megantic National Park in Québec provide high-quality habitat for wildlife. Maintaining connectivity between these conserved lands is a high priority for the Staying Connected partnership.

The Northeast Kingdom to Northern New Hampshire (NEK-NNH) linkage has lower levels of development than linkages discussed previously. Nearly 94% of the linkage is in natural vegetation, with only 2% in agriculture and 2% developed (Figure 48). The undeveloped nature of the linkage is reflected in a high average RK score of 64, with 76% of the linkage having an RK score of 50 or above (Figure 49).

This area has been the focus of many large conservation projects over the last 20 years. Consequently, 731,609 acres (2,961 km^2), nearly 44% of the linkage, is in some form of conservation (Figure 51). Most of the roads present low barriers to the passage of mammals, with only 7 miles (11 km) of the 2,489 miles (3,982 km) of roads in the linkage having AADT values above 10,000. An additional 128 miles (205 km) have AADT values between 2,500 and 10,000 and 309 miles (494 km) have AADT values of 2,500 or less (Figure 53).

The structural pathways in the NEK-NNH linkage make up a relatively modest 14.5% of the linkage as whole, though the absolute area of the pathways is substantial: 242,523 acres (981 km^2; Figure 54). In keeping with the overall high degree of conservation land in the linkage, nearly 16% of the land in the pathways is conserved (Figure 56). About 34,798 acres (141 km^2) fall within 100 meters of the road segments within the pathways. Of this area, about 16% (5,708 acres or 23 km^2) is conserved (Figure 57).

During the first phase of the Staying Connected Initiative, the Northeast Kingdom to Northern New Hampshire linkage and the Western Maine to Moosehead linkage were viewed as separate linkages, and that is reflected in this measures report. However, as the Initiative moves into its second phase, the Staying Connected partners recognize that it makes sense to combine these two halves into a single whole, which is called the Northeast Kingdom, Northern New Hampshire to Western Maine Linkage.

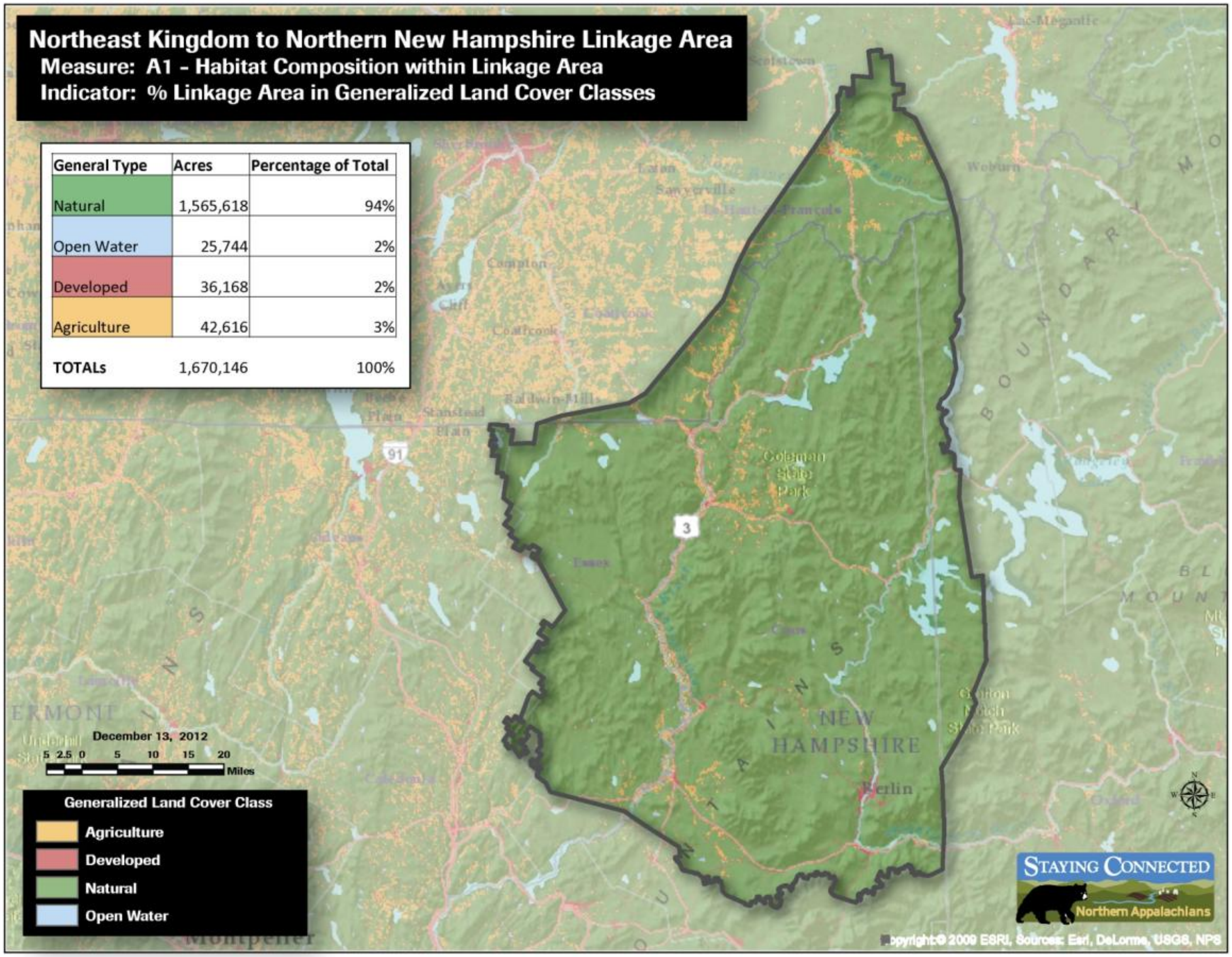


Figure 48. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #1: Habitat composition within linkage area*

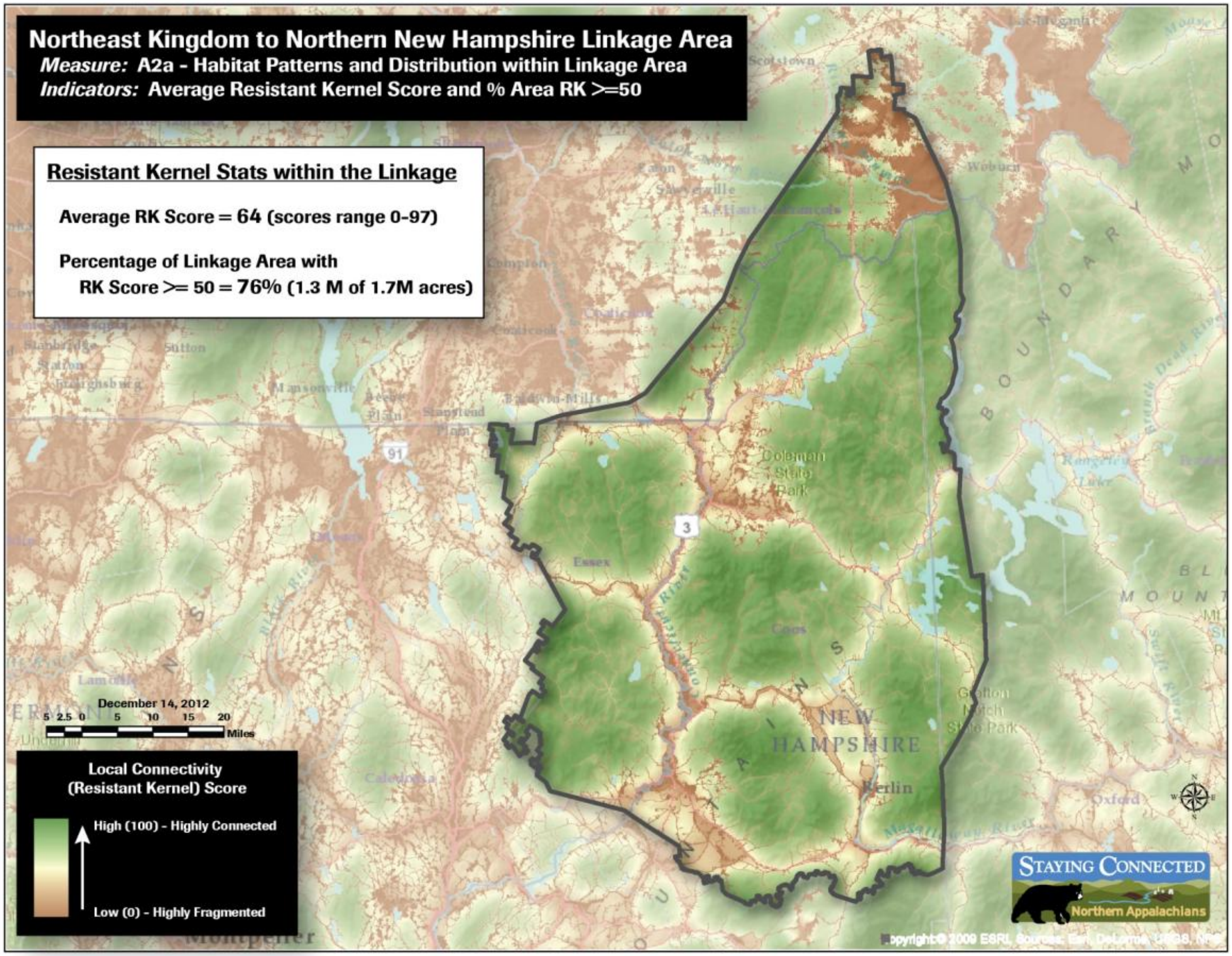


Figure 49. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #2: Patterns of habitat distribution within linkage*

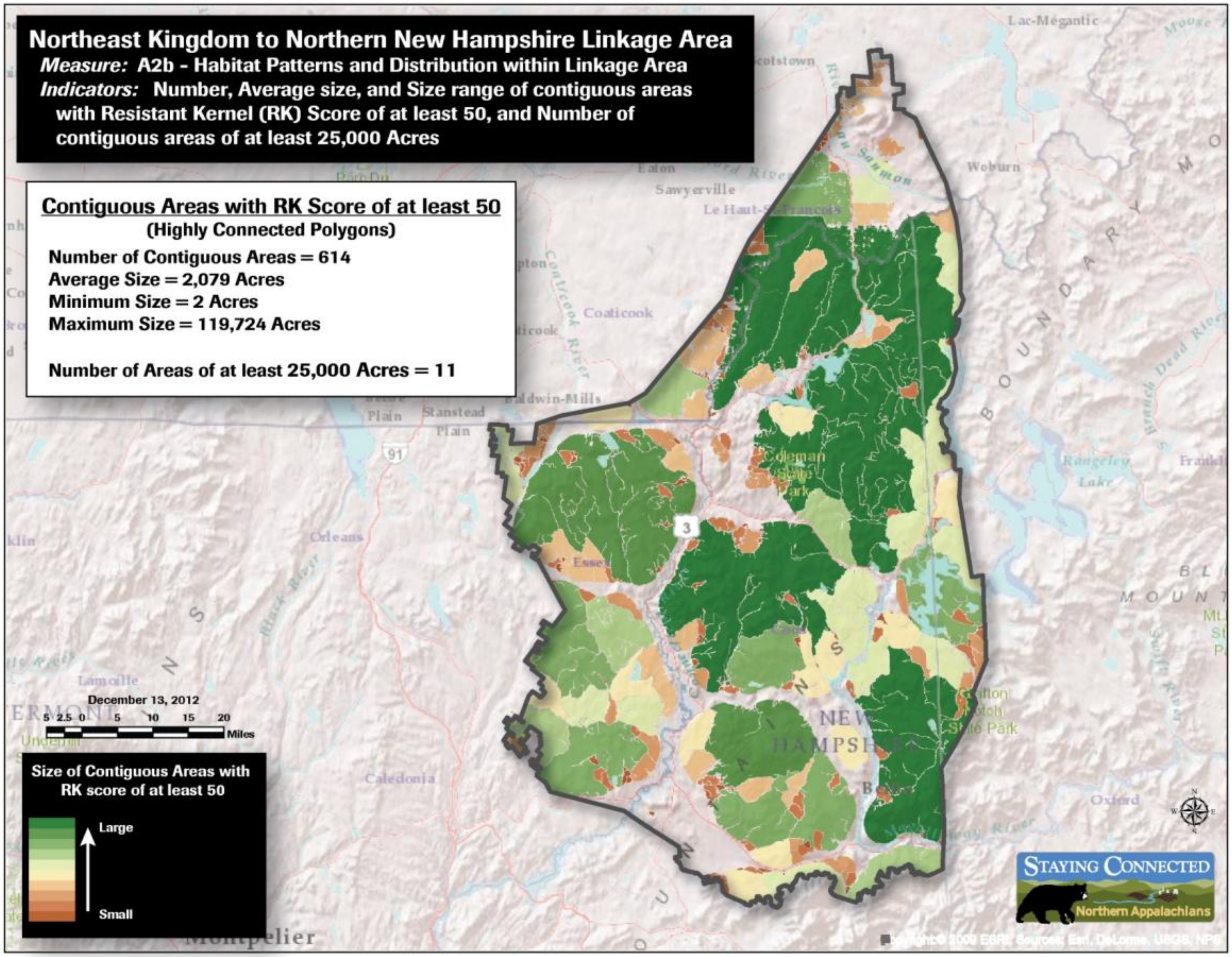


Figure 50. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #3: Patterns of habitat distribution within linkage*

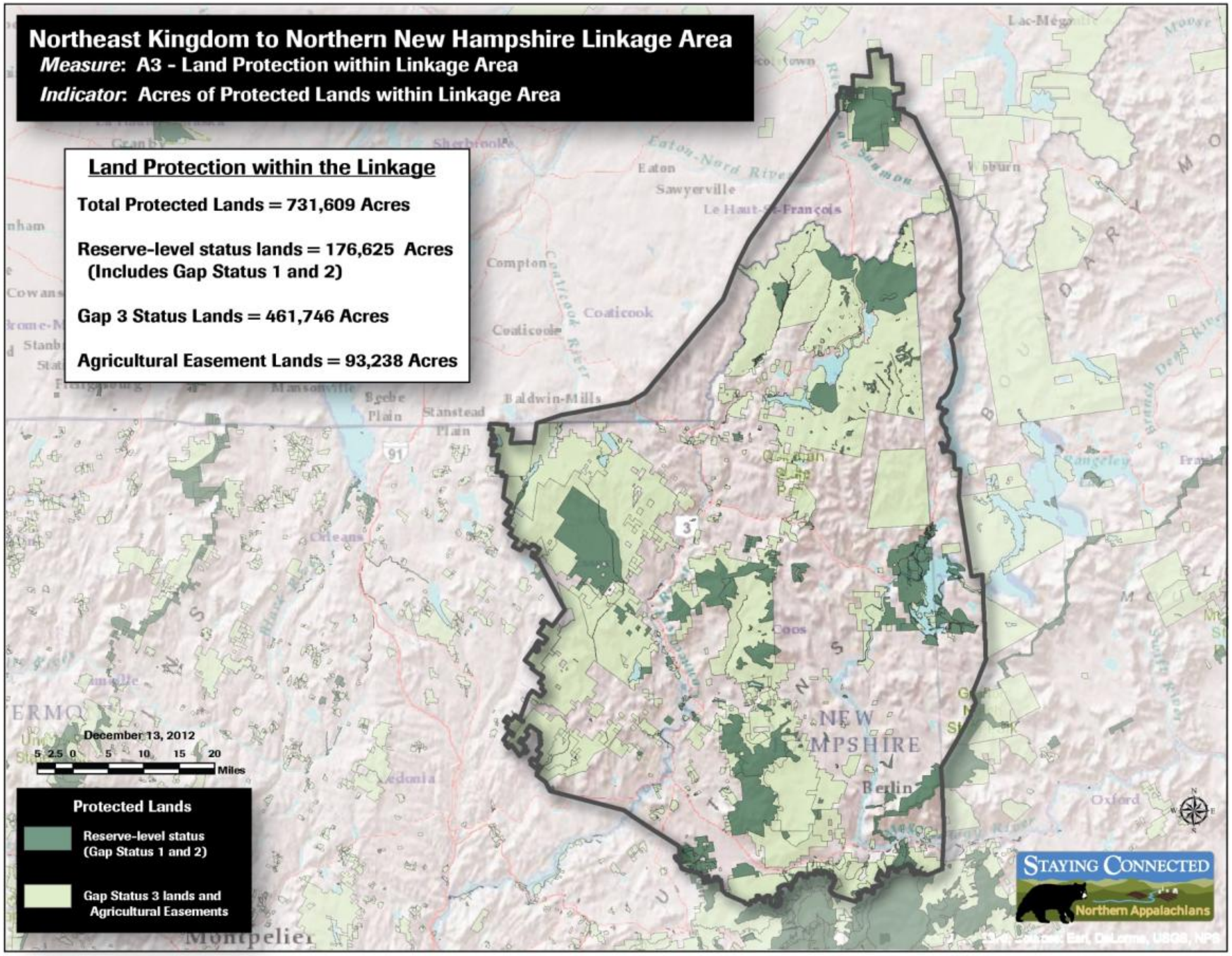


Figure 51. Northeast Kingdom to Northern New Hampshire Linkage Area – Baseline *Map #4: Land Protection – Conservation within the Linkage Area*

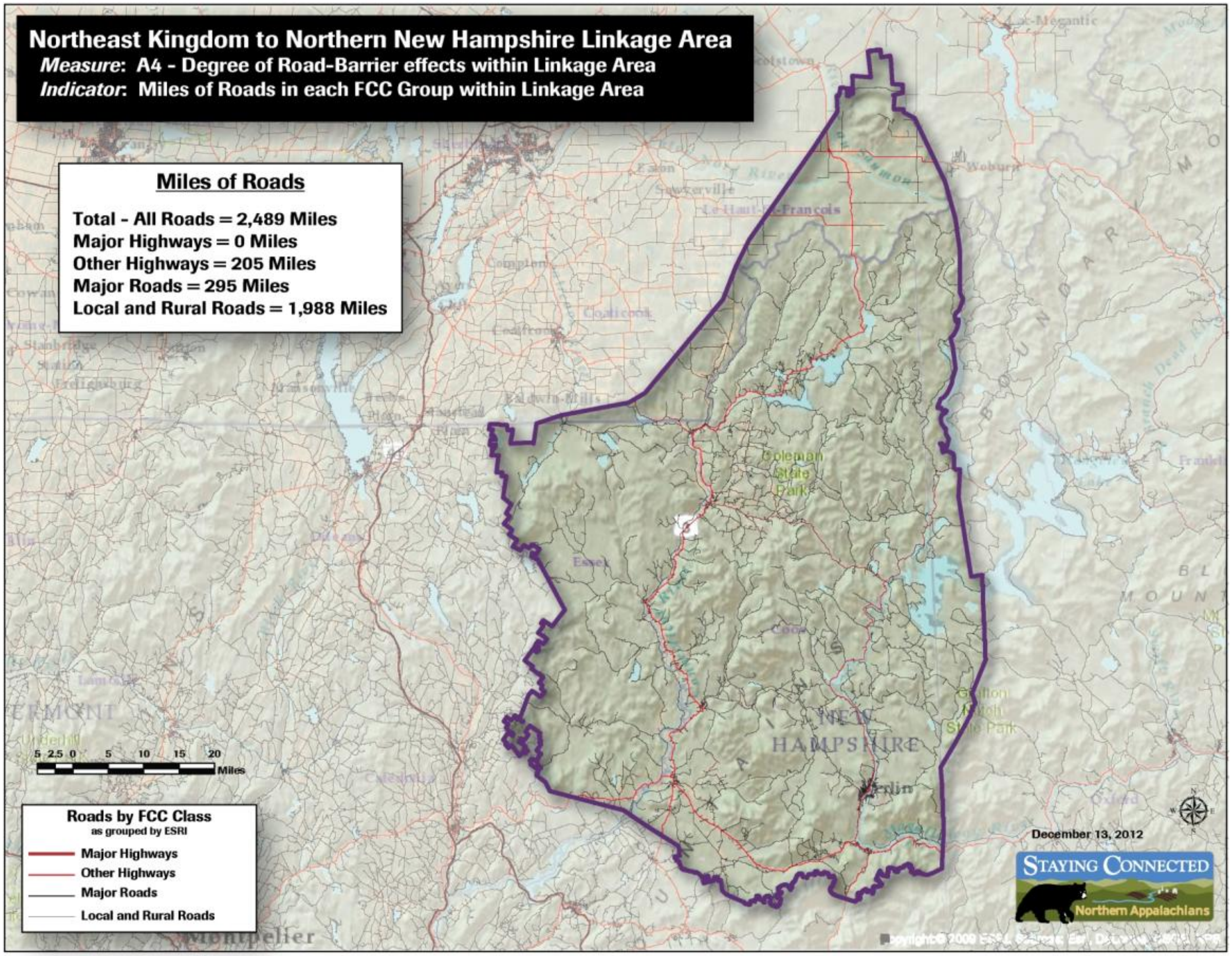


Figure 52. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes*

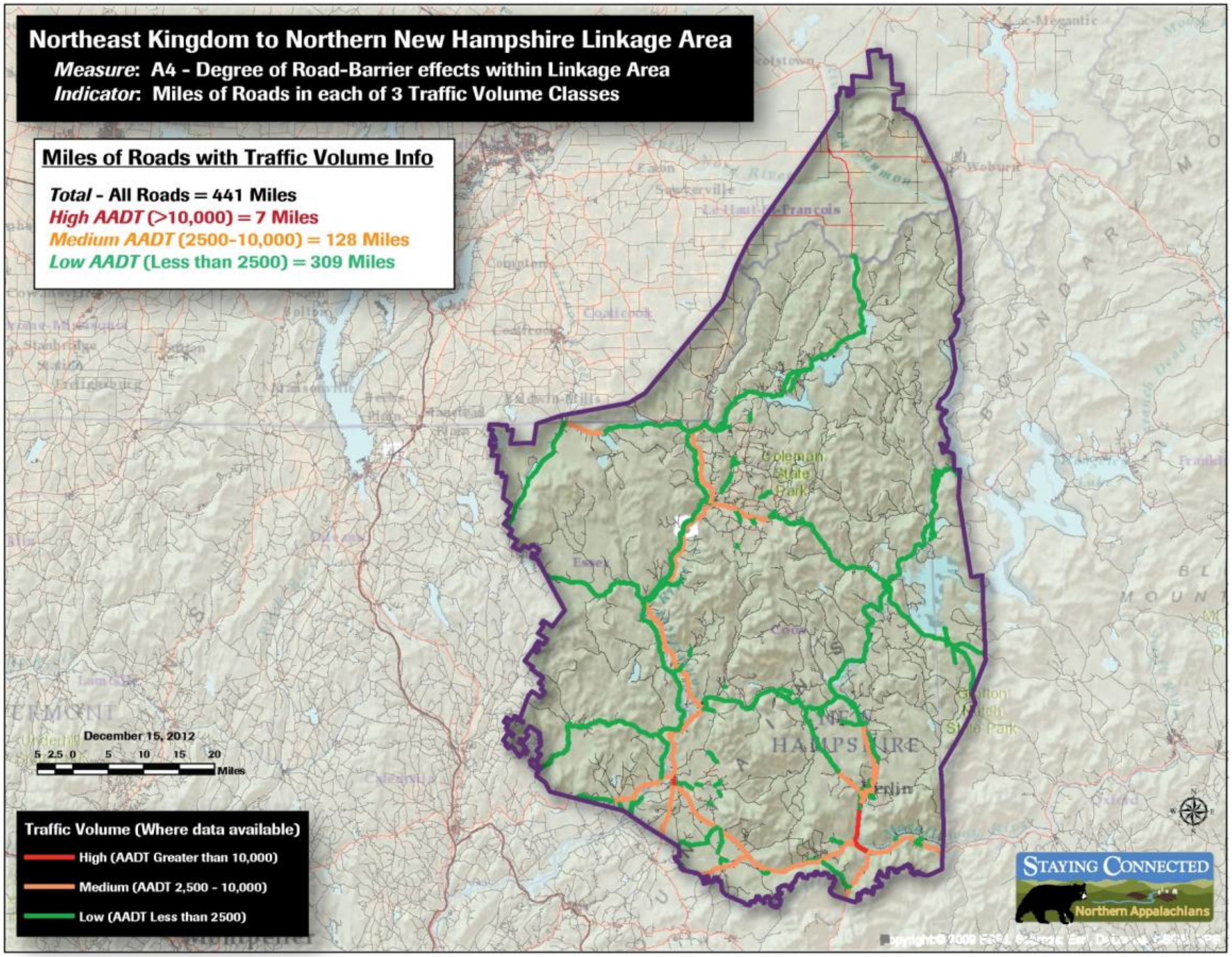


Figure 53. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*

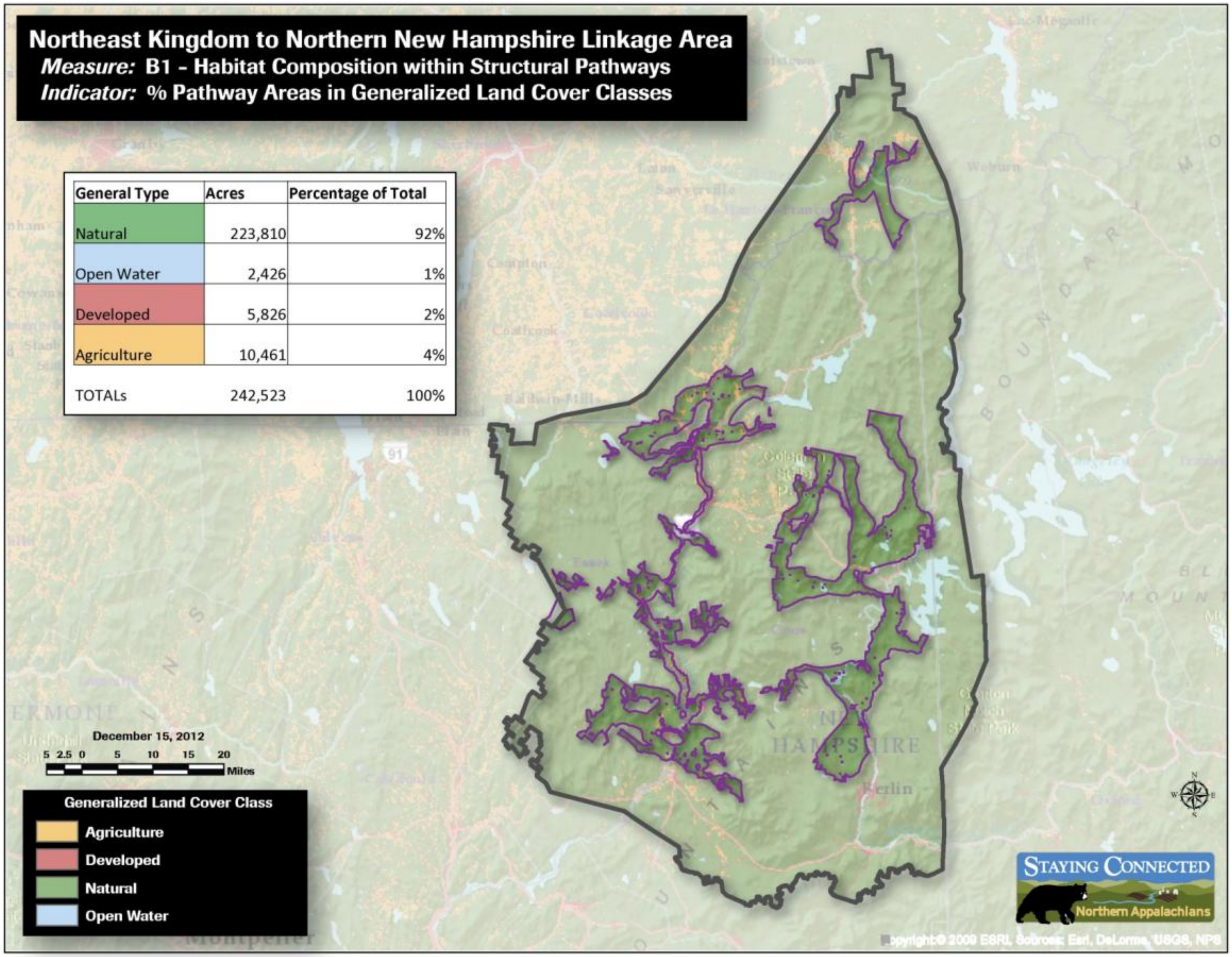


Figure 54. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #7: Habitat Composition within Structural Pathways*

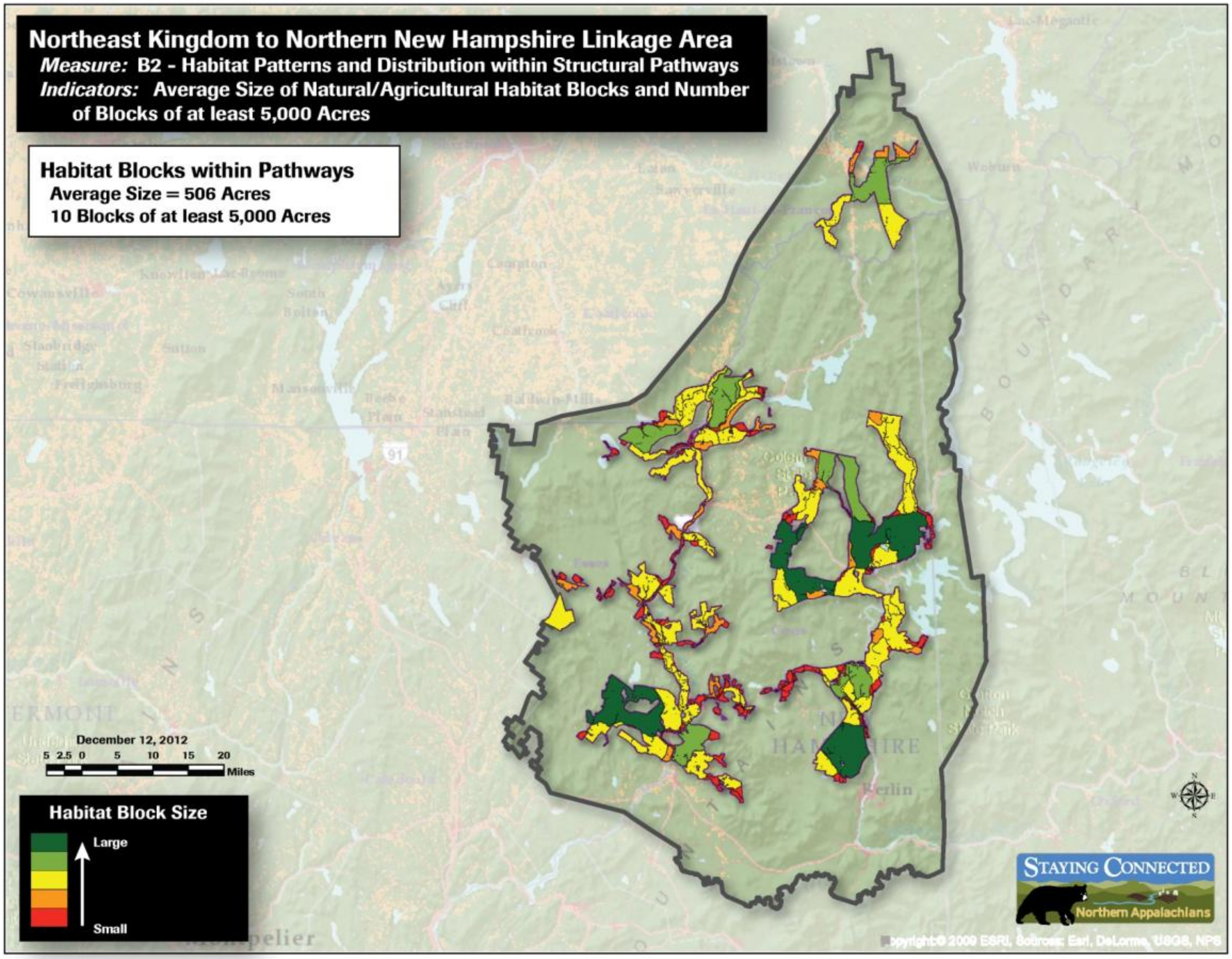


Figure 55. Northeast Kingdom to Northern New Hampshire Linkage Area - ***Baseline Map #:8 Patterns of Habitat Distribution within Structural Pathways***

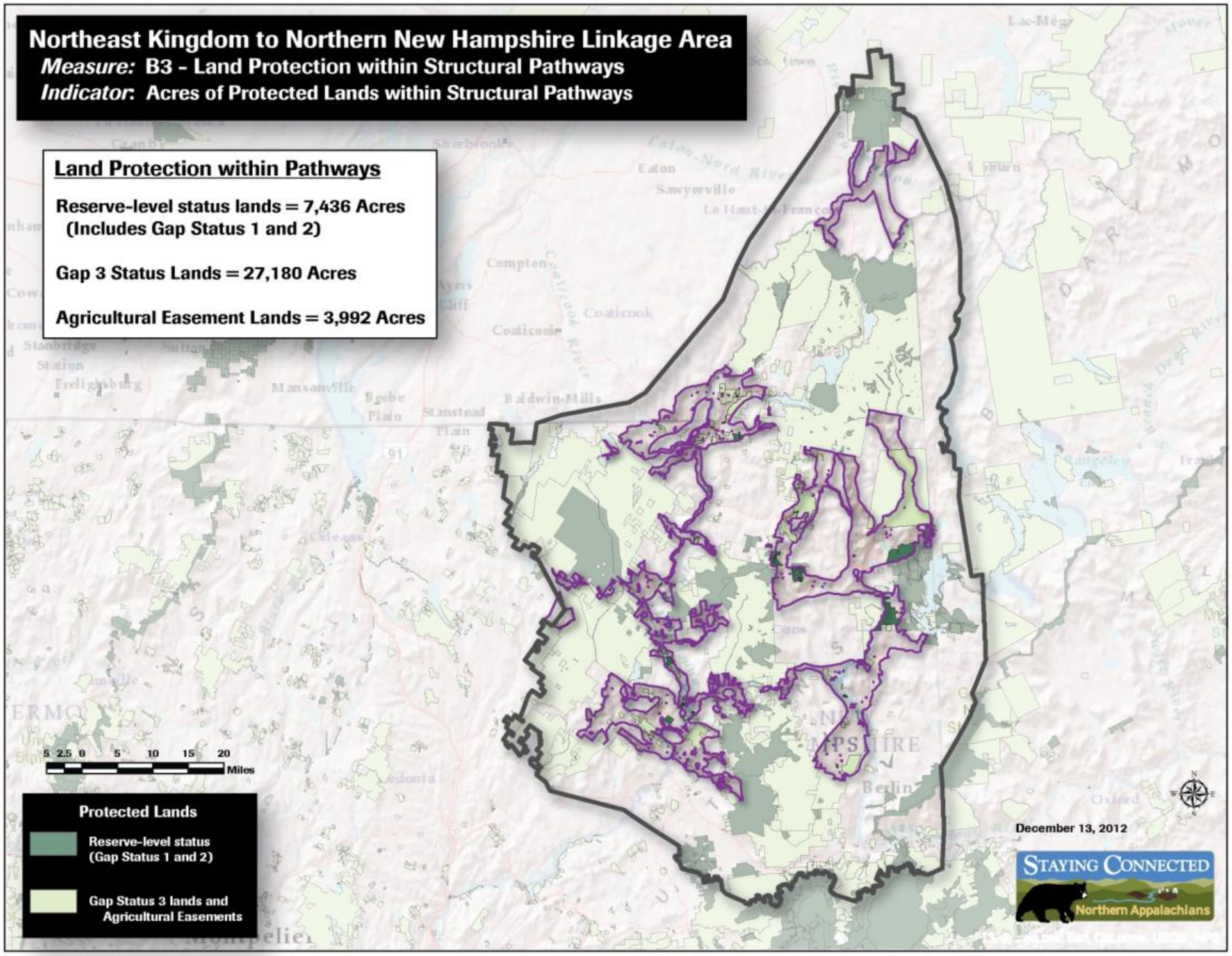


Figure 56. Northeast Kingdom to Northern New Hampshire Linkage Area - *Baseline Map #9: Land Protection within Structural Pathways*

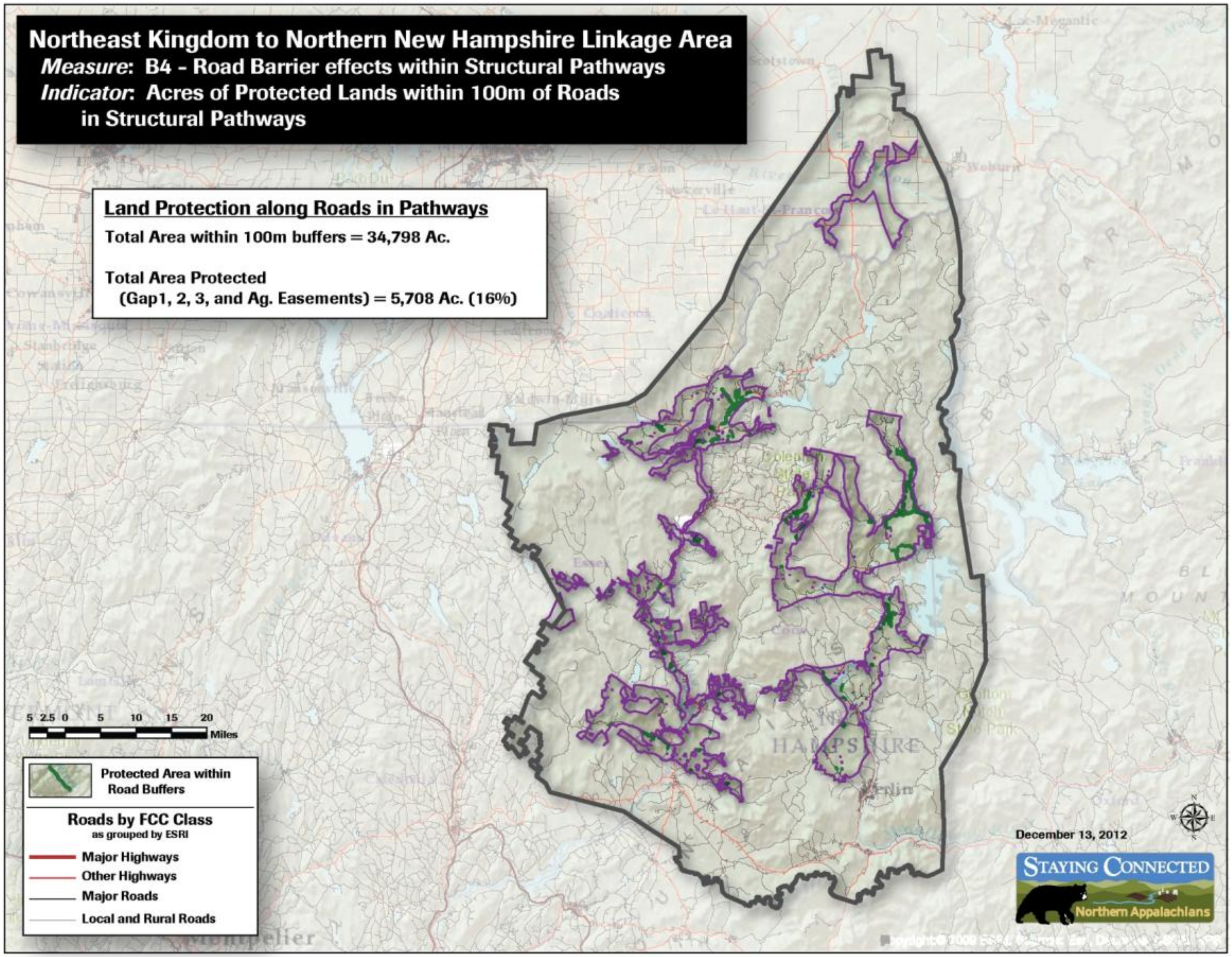


Figure 57. Northeast Kingdom to Northern New Hampshire Linkage Area - ***Baseline Map #10: Road Barrier effects within Structural Pathway***

Linkage 7: Western Maine to Moosehead Linkage

The Western Maine to Moosehead linkage area is a broad, rugged, region of nearly 3 million forested acres (2,923,855 acres; 11,832 km^2) that stretches from northern New Hampshire and southern Quebec to Moosehead Lake of north-central Maine. It is characterized by extensive forests, rugged mountains, large lakes, and small towns that are centers for winter recreation. The great majority (about 93%) of the linkage area is in Maine. The remainder, about 7%, includes the border mountain region of southern Quebec. Western Maine is the regional link between the White Mountains and Connecticut Lakes region of NH and the large expansive core forest of northern Maine. There is significant conservation land on both sides of the border and several conservation groups are active in this area, including Beginning with Habitat (BwH), Forest Society of Maine, Rangeley Lakes Heritage Trust, The Mahoosucs Land Trust, and the Trust for Public Land.

The Western Maine to Moosehead linkage (WMM) has the lowest levels of development of all the linkages, with only 1% developed (Figure 58). As with the adjoining Northeast Kingdom to Northern New Hampshire (NEK-NNH) linkage to the west, the WMM linkage has a very high average RK score, in this case 67, with 83% of the linkage having an RK score of 50 or above (Figure 59). The average size of a habitat block with an RK score of 50 or above is 1,648 acres (about 7 km^2) and there are 11 blocks with such a score that are at least 50,000 acres (about 200 km^2) in size (Figure 60).

As this area has been the focus of many large conservation projects over the last 20 years, it contains 780,423 acres (3,153 km^2) of conservation lands (Figure 61), though this is a smaller percentage (26.7%) than the NEK-NNH linkage to the west. There are no roads with AADT values above 10,000, and only 81 miles (130 km), of a total of 2,161 miles of roads in the linkage, with AADT values between 2,500 and 10,000. About 816 miles (1,306 km) of road have AADT values of 2,500 or less (Figure 63).

Because the linkage is so heavily and contiguously forested, there has been no need to delineate structural pathways between large habitat blocks as in other linkages. Work is now underway to assess whether certain sections of roads pose particular impediments to wildlife movement.

During the first phase of the Staying Connected Initiative, the Northeast Kingdom to Northern New Hampshire linkage and the Western Maine to Moosehead linkage were viewed as separate linkages, and that is reflected in this measures report. However, as the Initiative moves into its second phase, the Staying Connected partners recognize that it makes sense to combine these two halves into a single whole, which will be called the Northeast Kingdom, Northern New Hampshire to Western Maine Linkage.

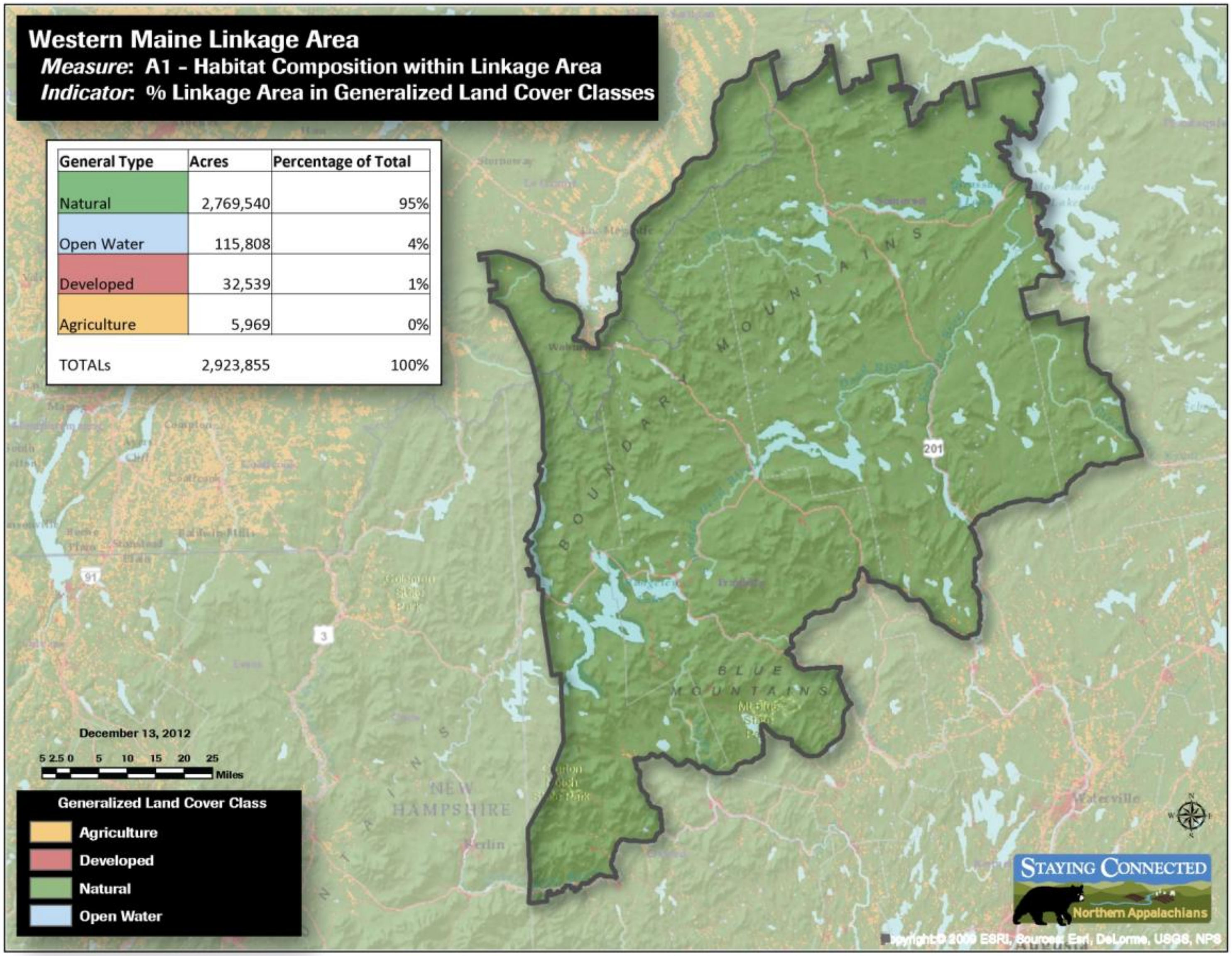


Figure 58. Western Maine Linkage Area *Baseline Map #1: Habitat composition within linkage*

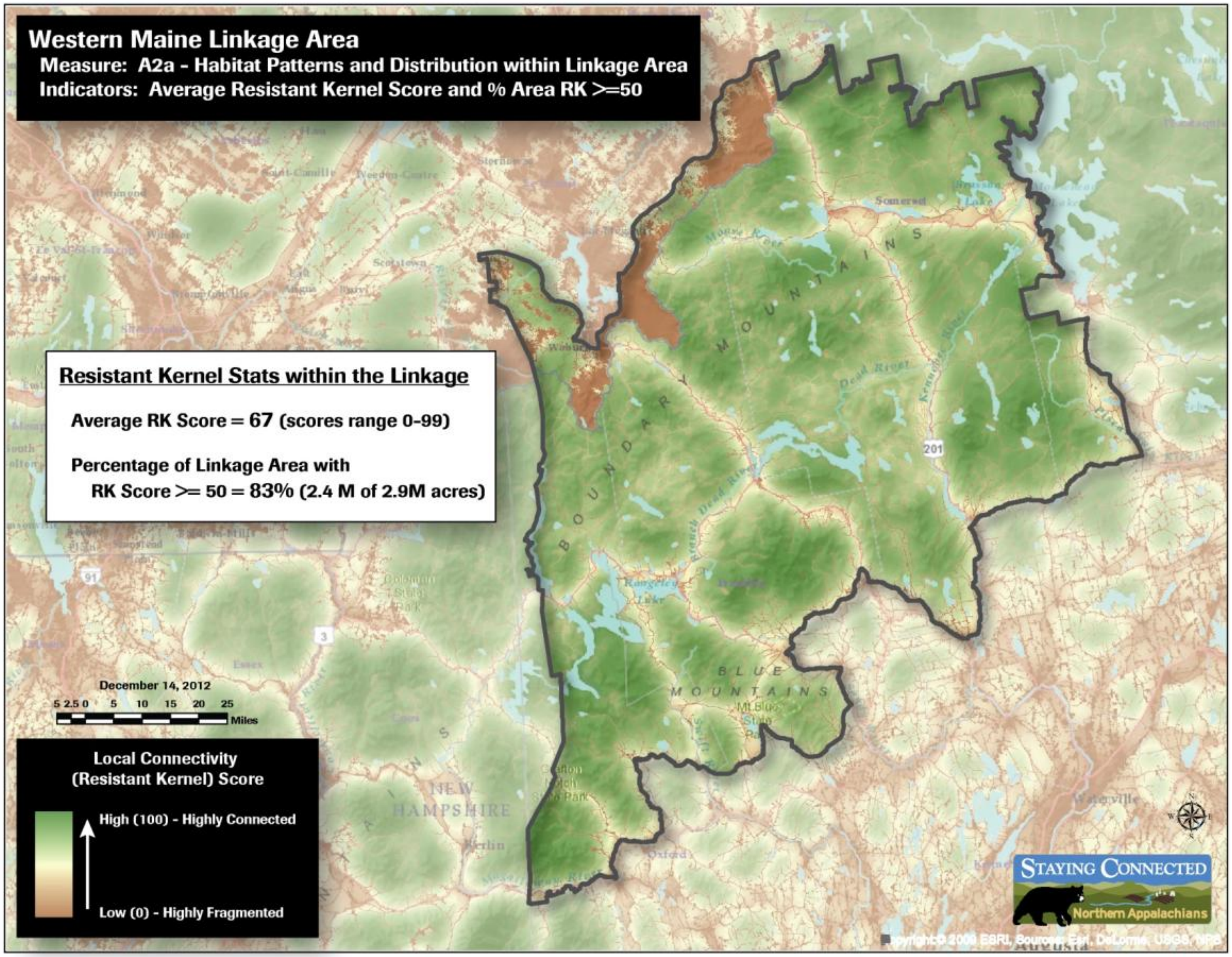


Figure 59. Western Maine Linkage Area *Baseline Map #2: Patterns of habitat distribution within linkage*

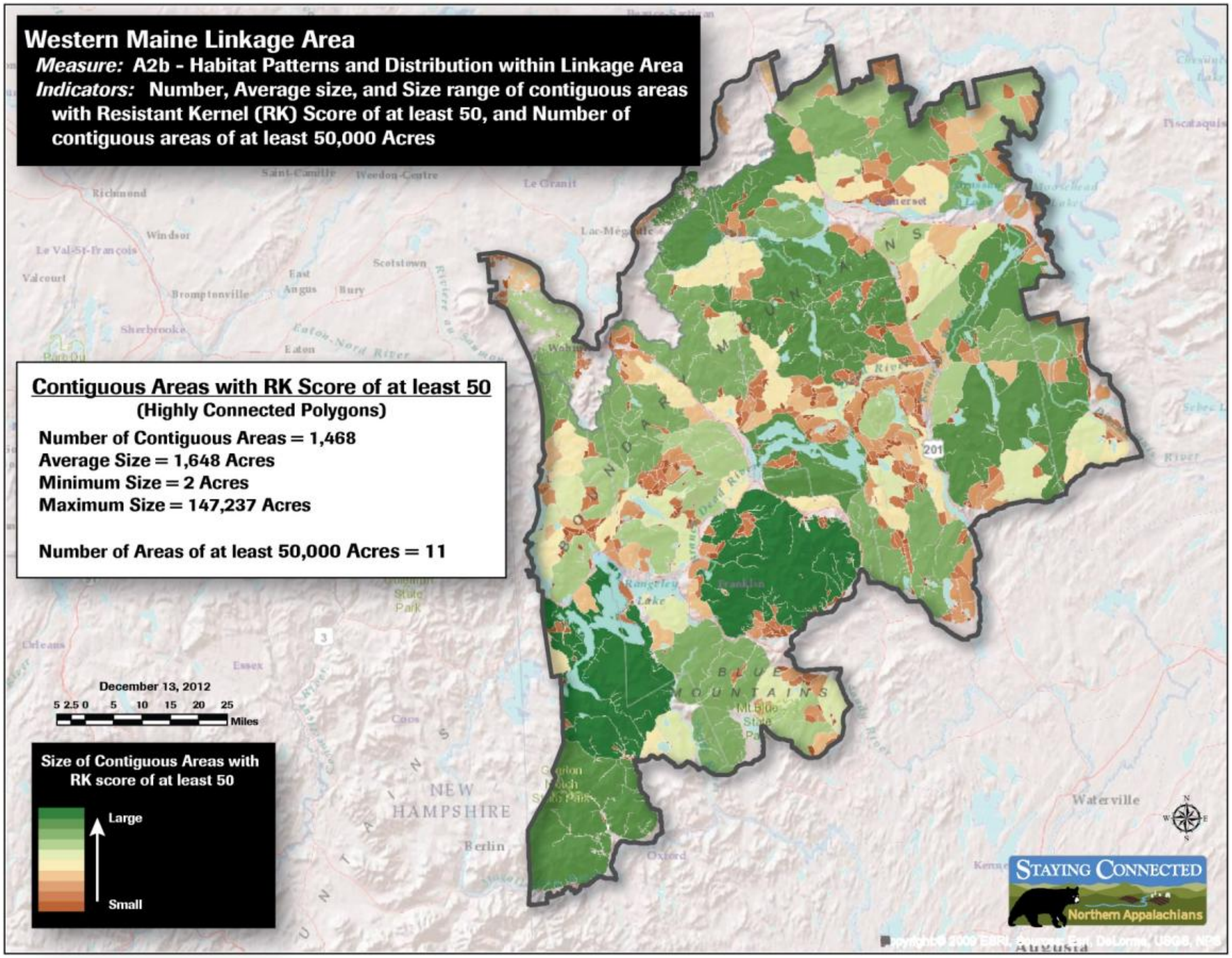


Figure 60. Western Maine Linkage Area - *Baseline Map#3: Patterns of habitat distribution within linkage*

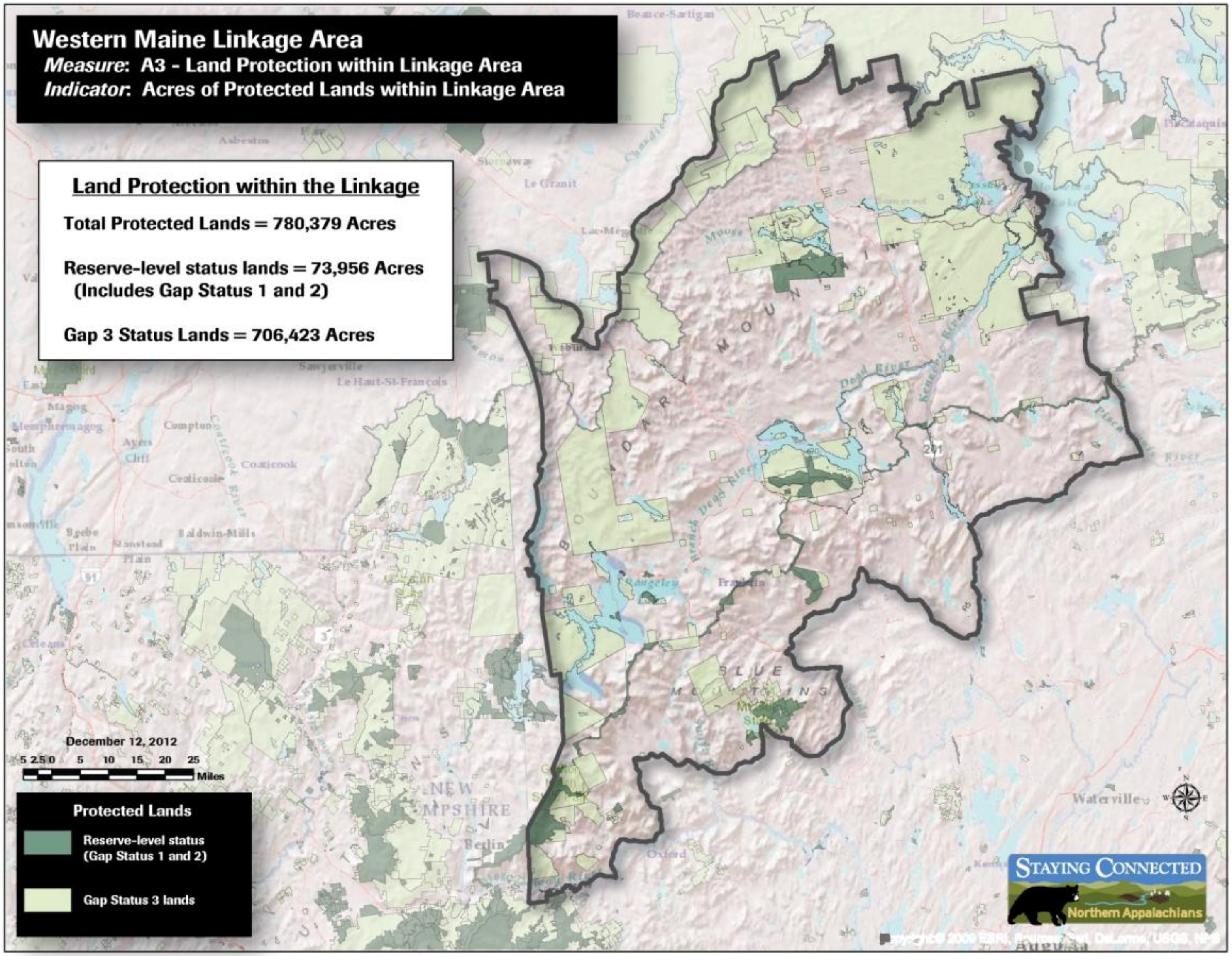


Figure 61. Western Maine Linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

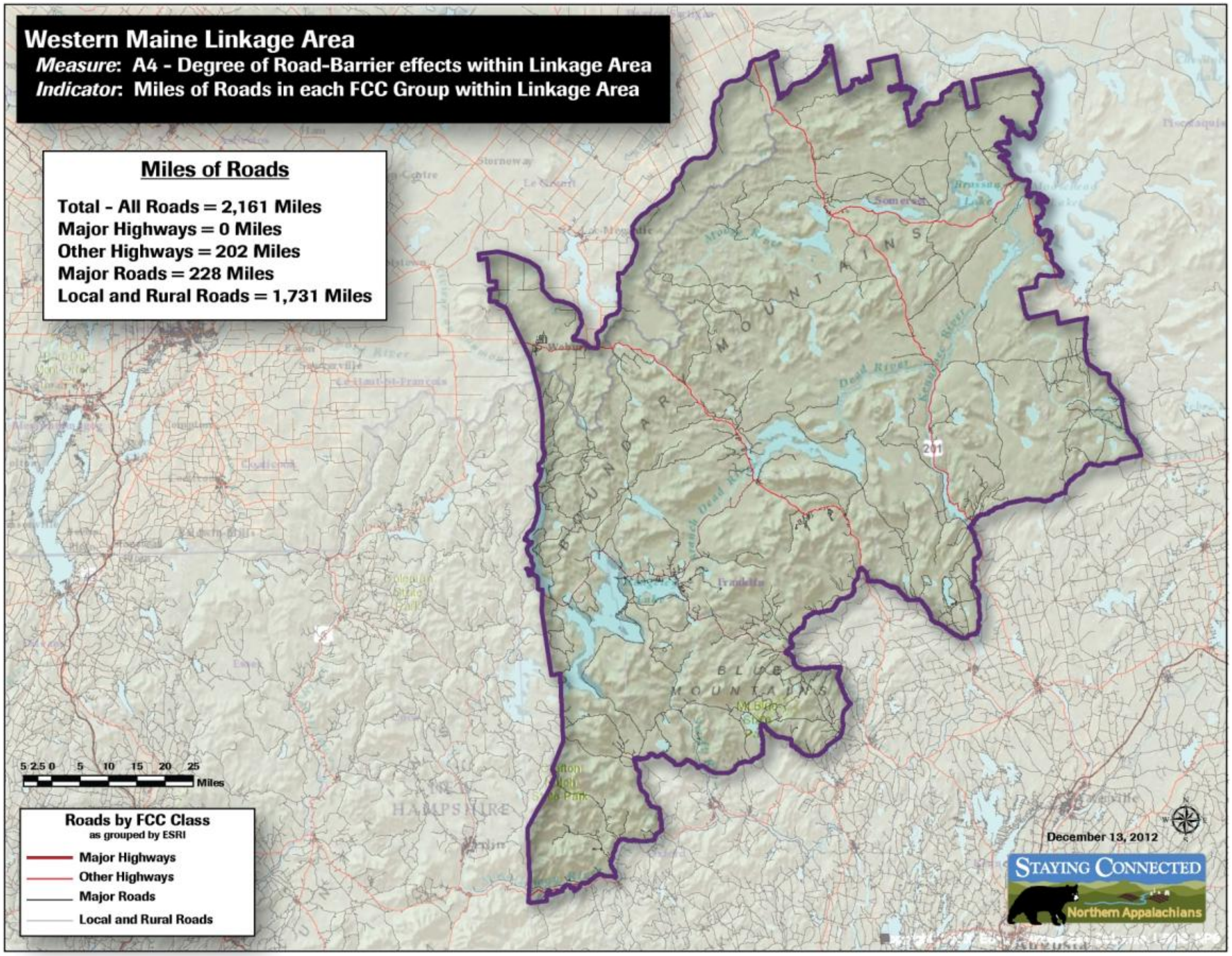


Figure 62. Western Maine Linkage Area - *Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes*

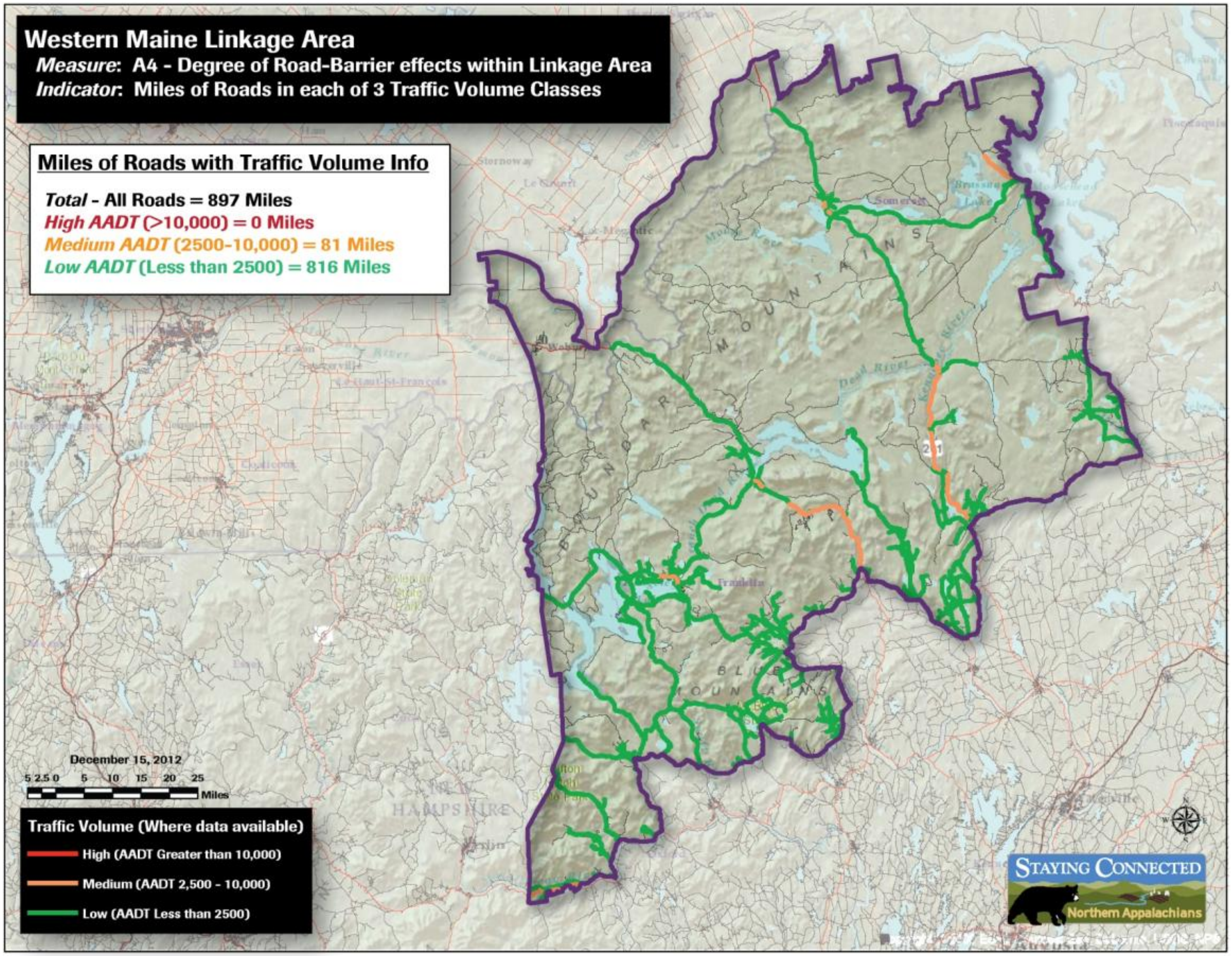


Figure 63. Western Maine Linkage Area - *Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume*

Linkage 8: Three-Borders: Northern Maine to the Gaspé Linkage Area

The Three Borders linkage area is the large region (5,741,998 acres, 23,237 km^2) that includes the 'top' of Maine and portions of western New Brunswick and eastern Quebec. It is key to regional connectivity, linking northern Maine and the rest of the Northern Appalachians to the southwest with the extensive forests of the Gaspe Peninsula to the north and New Brunswick to the east. The St. John River forms the majority of the border between Maine and Canada in this linkage area. The Maine side is mostly forested, especially in the western and central portion of the linkage area. The eastern portion of the Maine side is characterized by more agriculture and settlements along the river. The Quebec portion is more heavily populated and fragmented by roads than the New Brunswick portion, but the great majority of forest land in the linkage area is actively managed.

The Three Borders Linkage has relatively low levels of development overall, with only 2% in development and another 4% in agriculture (Figure 64). The linkage has a high average RK score, in this case 64, with 76% of the linkage having an RK score of 50 or above (Figure 65). There are thousands of contiguous blocks with RK score of 50 or above, including one of 357,153 acres (1,445 km^2) (Figure 66).

This linkage contains a large amount of land that is protected in some fashion – 2,865,737 acres (11,597 km^2) -- nearly 50% of the linkage. However, only 118,201 acres (478 km^2) are strictly protected (Figure 67). The vast majority of the protected lands are public or "Crown Land" in Canada, and because these lands may be subject to intensive silvicultural practices that include plantations, genetically engineered trees, and liberal use of pesticides, there is some question within the Canadian conservation community as whether they should be considered protected lands.

In the US portion of the linkage, the roads present low barriers to the passage of mammals, with the vast majority of roads for which there are AADT values -- 504 miles (806 km) out of 532 miles (852 km) – having AADT values of 2,500 or less (Figure 69). However, this tells only a small part of the story because traffic volume data for the major Canadian roads, such as the Trans-Canada Highway that runs right through the linkage, could not be obtained for this phase of the framework. Collecting such data will be an important part of the next phase of monitoring work.

Five relatively large structural pathways, totaling 547,674 acres (2,216 km^2) and making up 9.5% of the linkage, have been identified Figure 70). In keeping with the overall high degree of secured land in the linkage, over 32% of the land in the pathways is secured (Figure 72). About 26,514 acres (107 km^2) fall within 100 meters of the road segments within the pathways. Of this area, about 14% (3,650 acres or 15 km^2) is conserved (Figure 73).

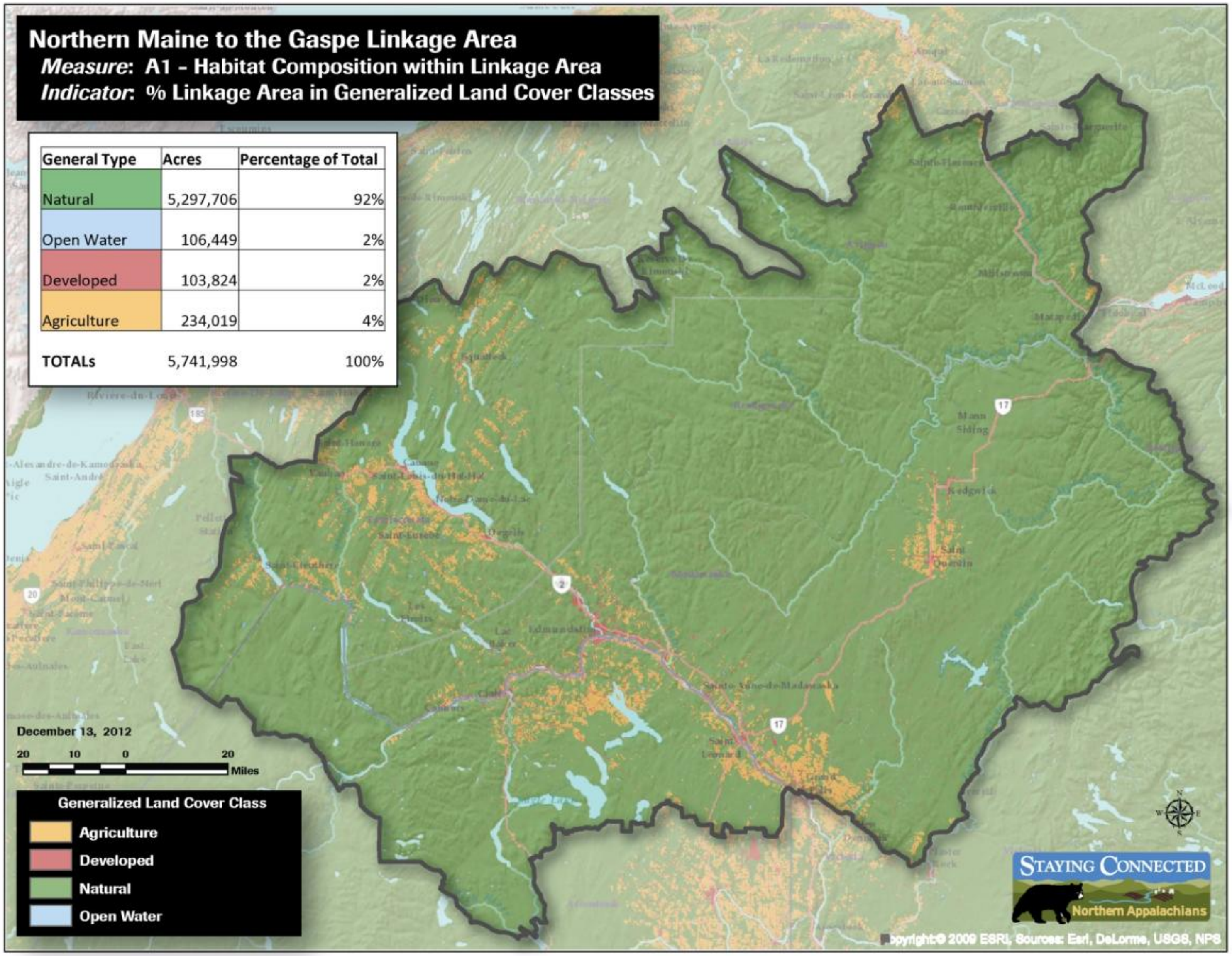


Figure 64. Northern Maine to the Gaspe linkage Area - *Baseline Map #1: Habitat composition within linkage*

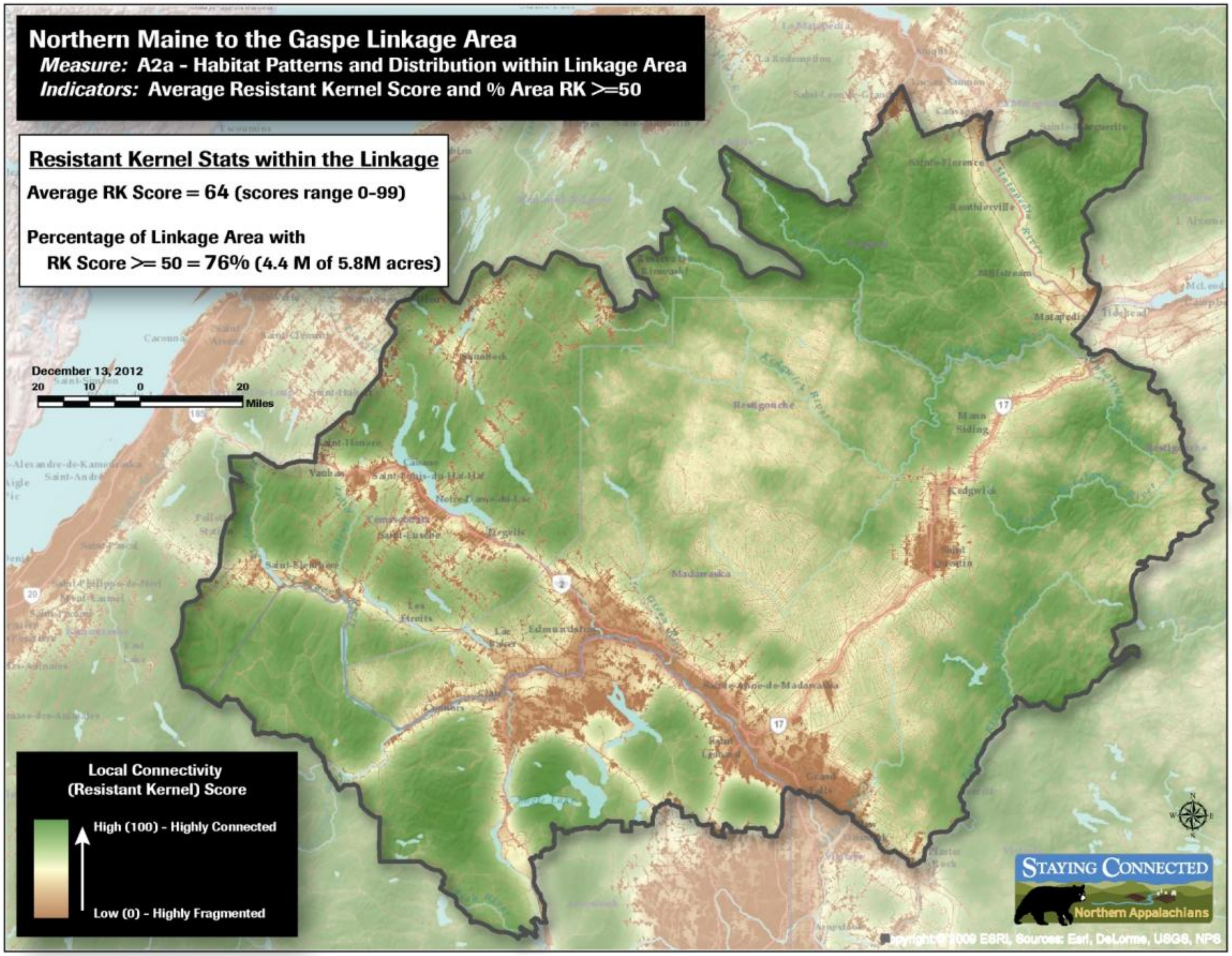


Figure 65. Northern Maine to the Gaspe linkage Area - *Baseline Map #2: Patterns of habitat distribution within linkage*

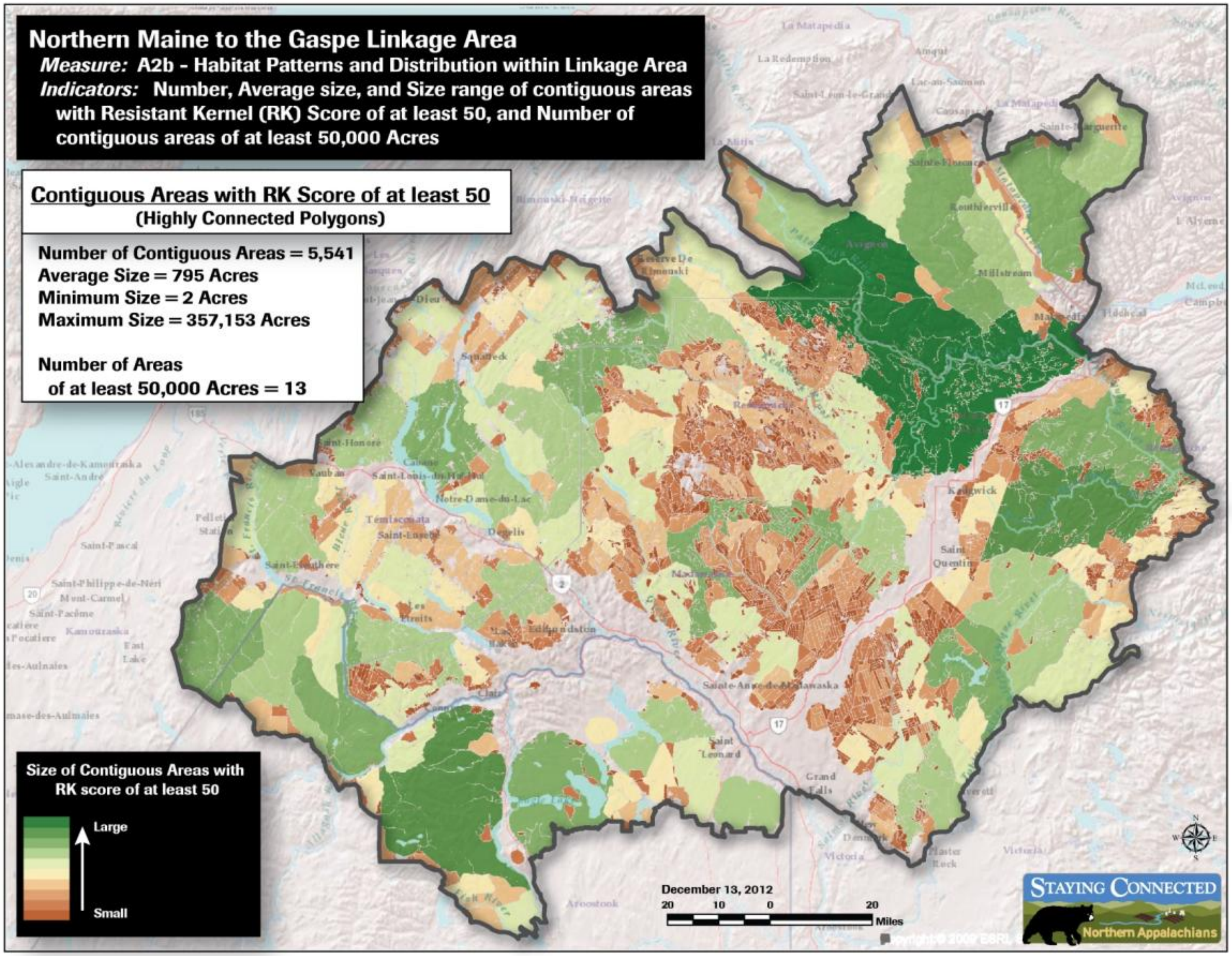


Figure 66. Northern Maine to the Gaspe linkage Area - ***Baseline Map #3: Patterns of habitat distribution within linkage***

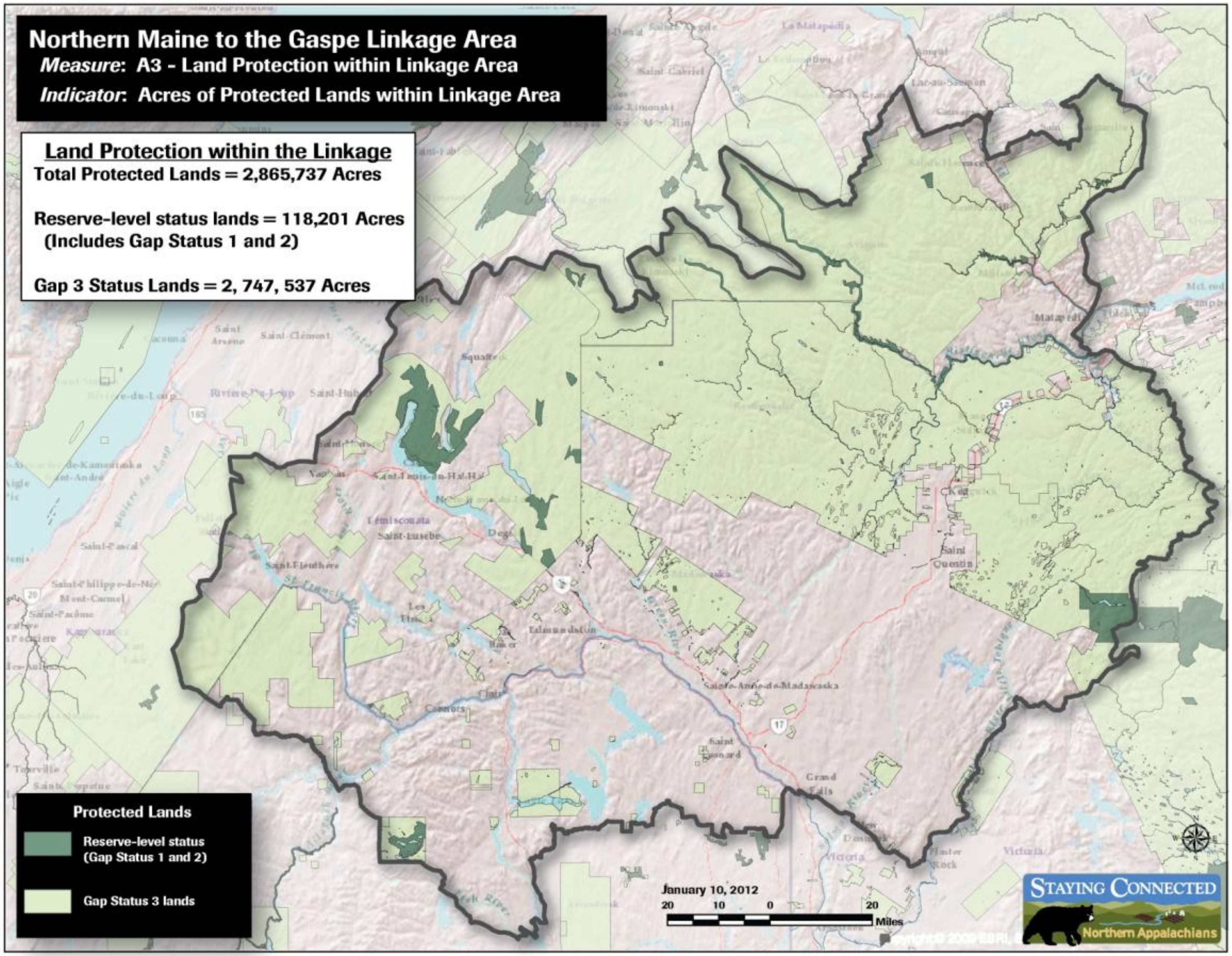


Figure 67. Northern Maine to the Gaspe linkage Area - *Baseline Map #4: Land Protection – Conservation within the Linkage Area*

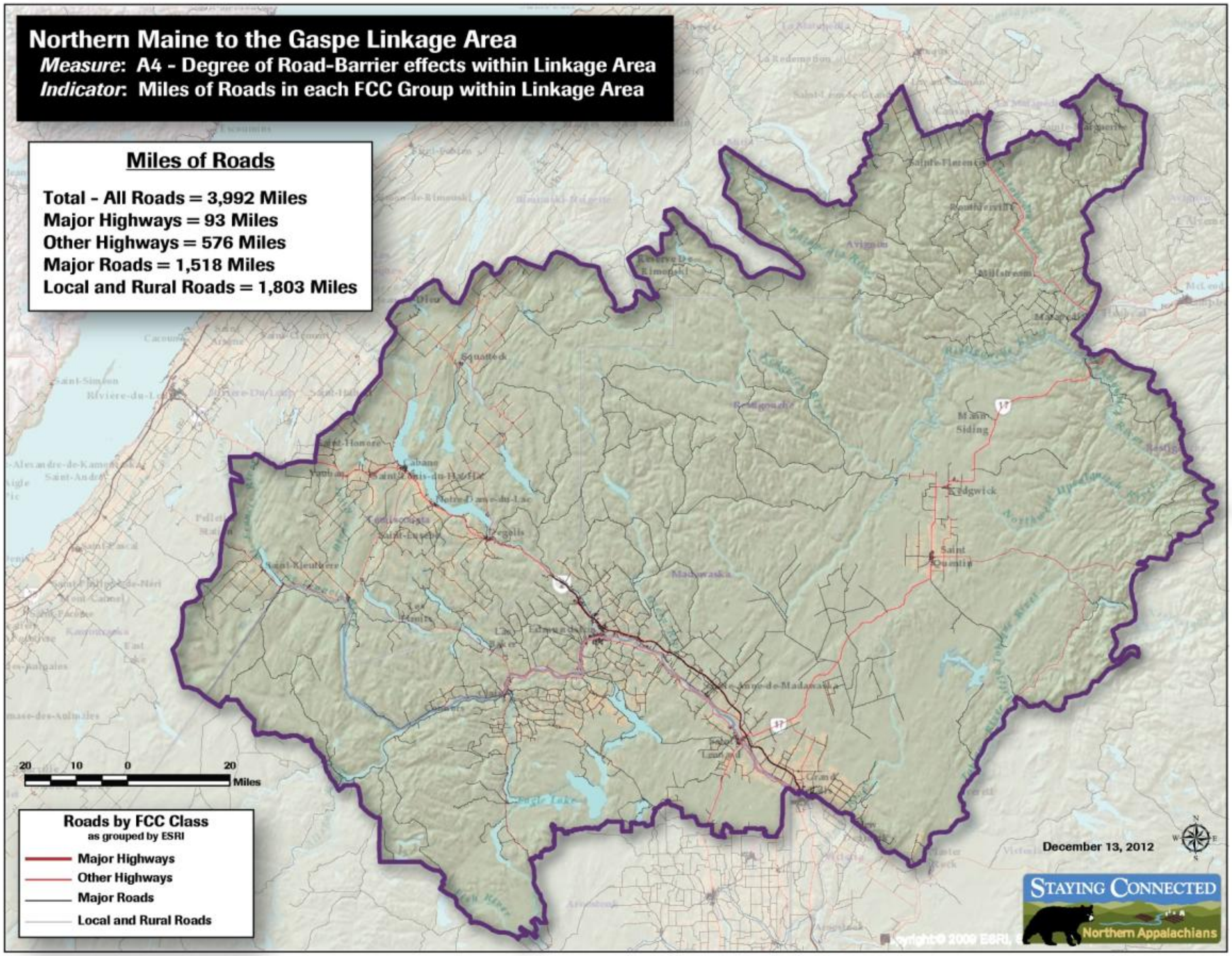


Figure 68. Northern Maine to the Gaspe linkage Area - *Baseline Map #5: Road barrier effects – Miles of Roads in 4 General Classes*

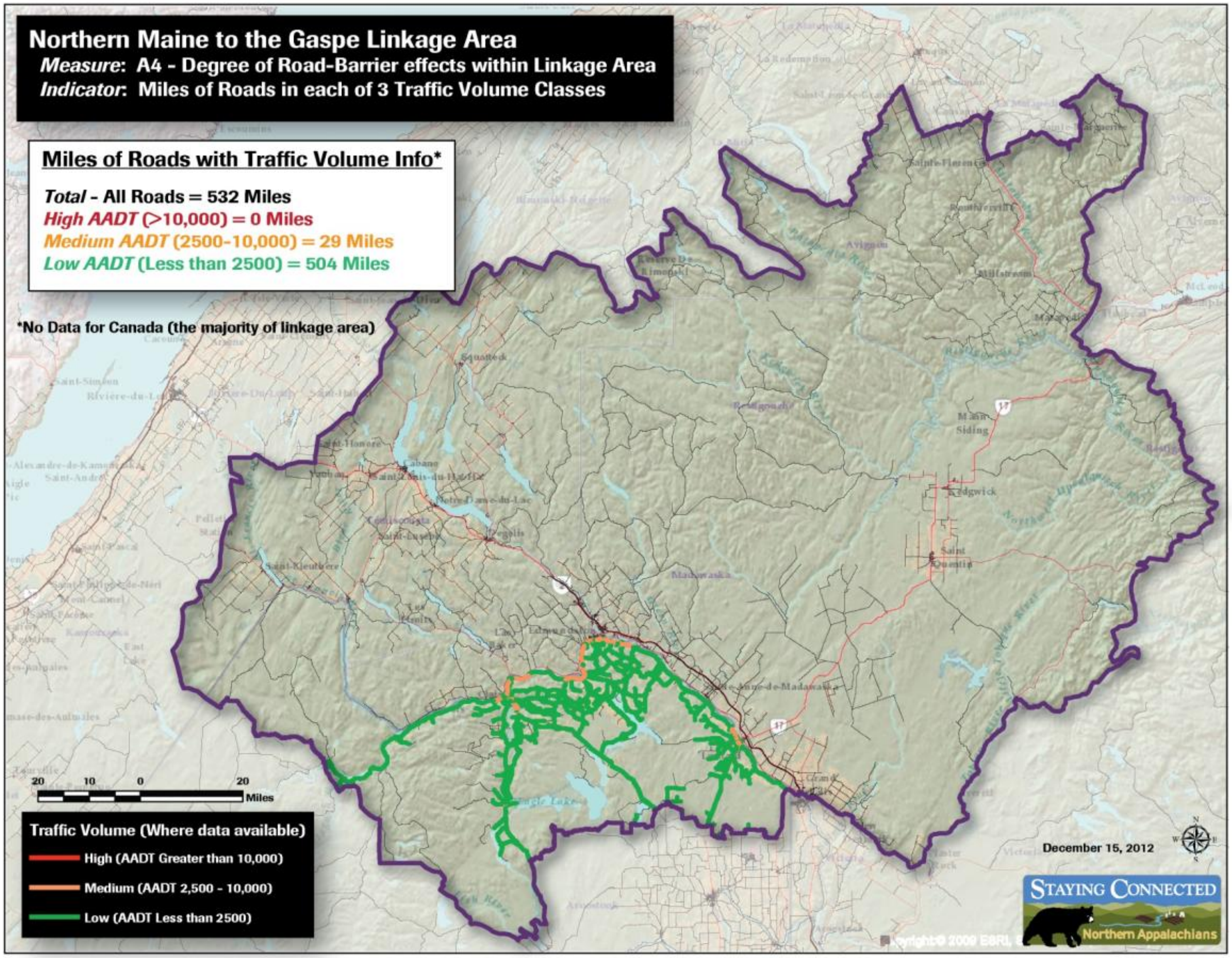
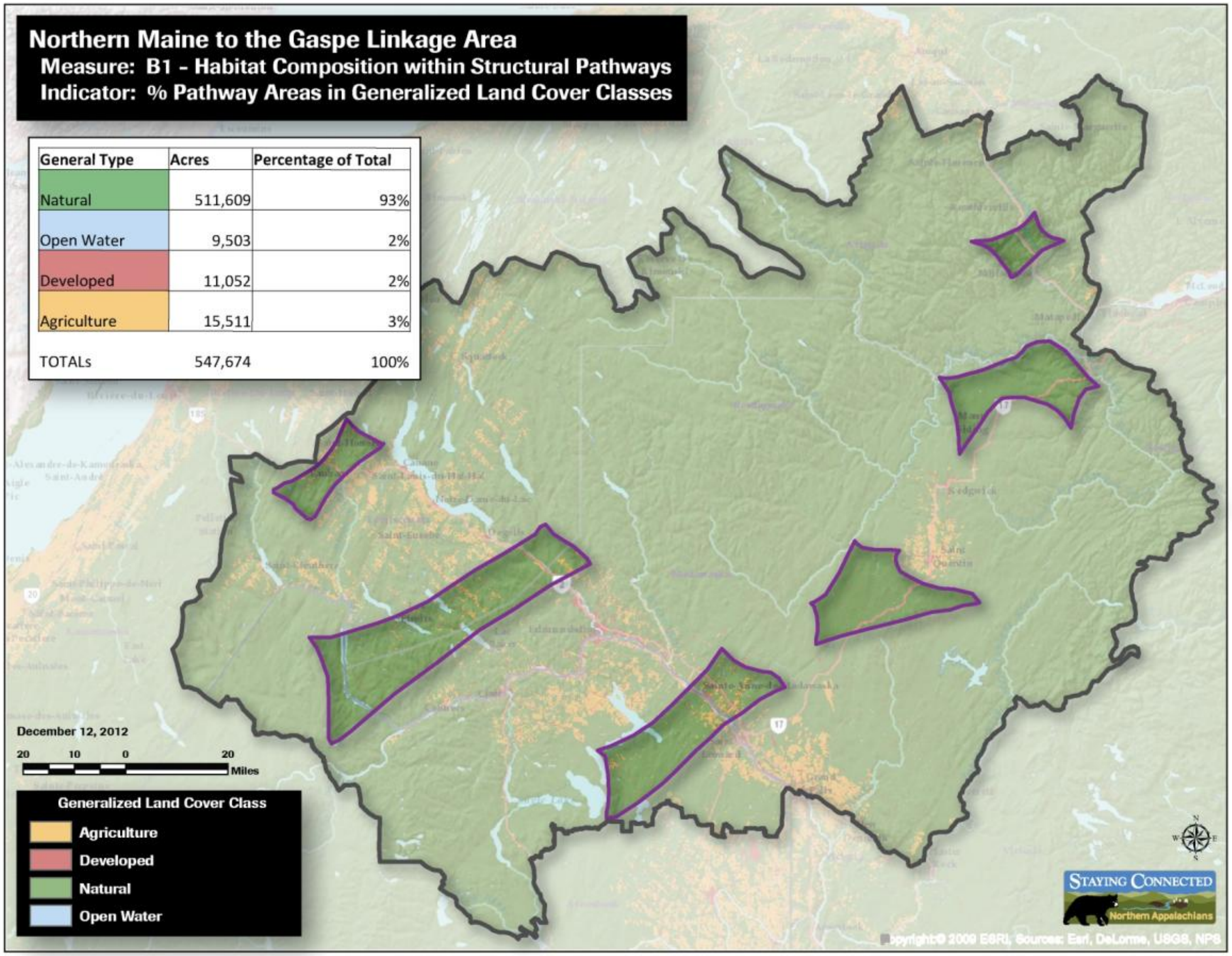


Figure 69. Northern Maine to the Gaspe linkage Area - ***Baseline Map #6: Road barrier effects – Miles of Roads in 3 Categories of Traffic Volume***



General Type	Acres	Percentage of Total
Natural	511,609	93%
Open Water	9,503	2%
Developed	11,052	2%
Agriculture	15,511	3%
TOTALs	547,674	100%

Figure 70. Northern Maine to the Gaspe linkage Area - *Baseline Map #7: Habitat Composition within Structural Pathways*

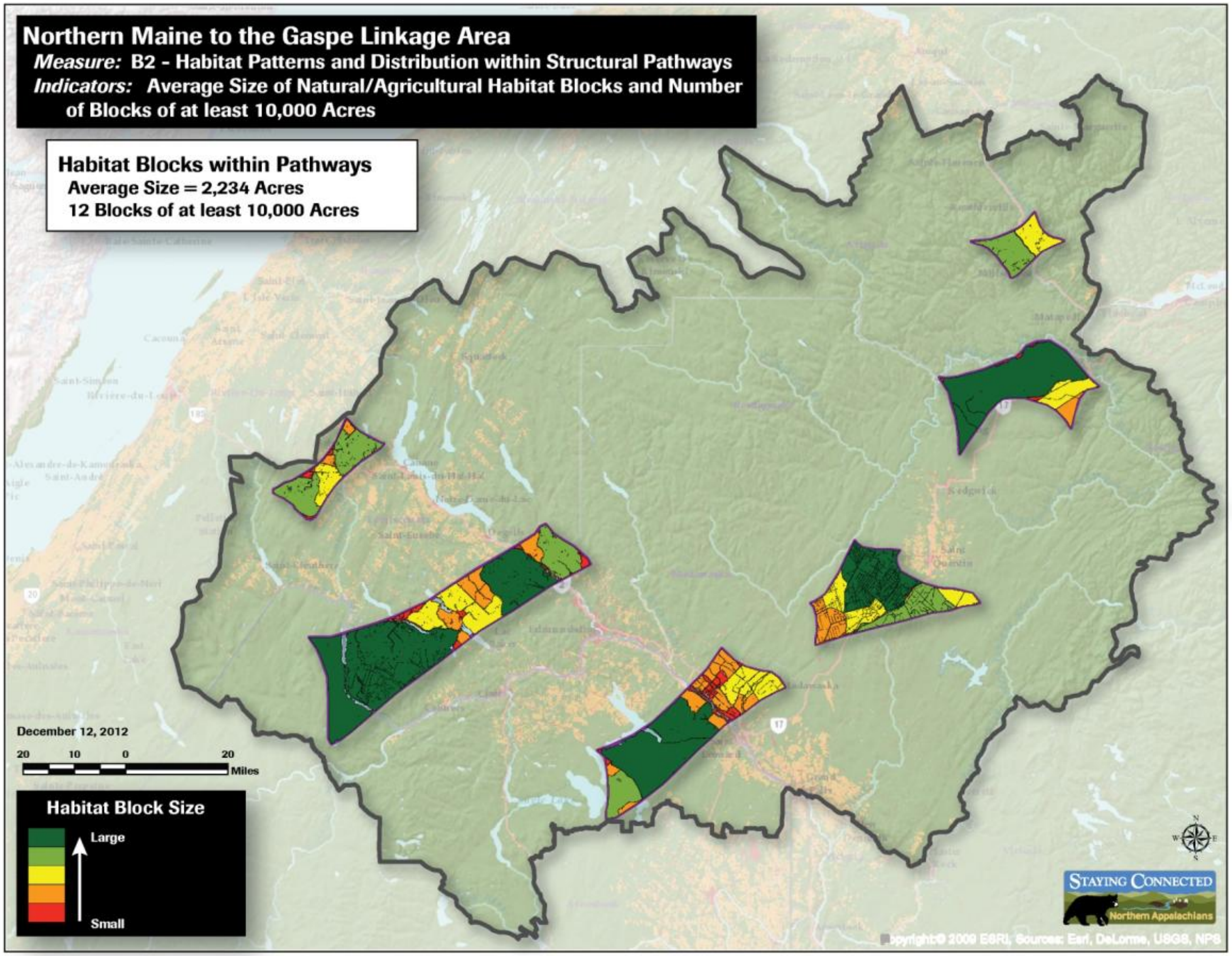


Figure 71. Northern Maine to the Gaspe linkage Area - ***Baseline Map #8: Patterns of Habitat Distribution within Structural Pathways***

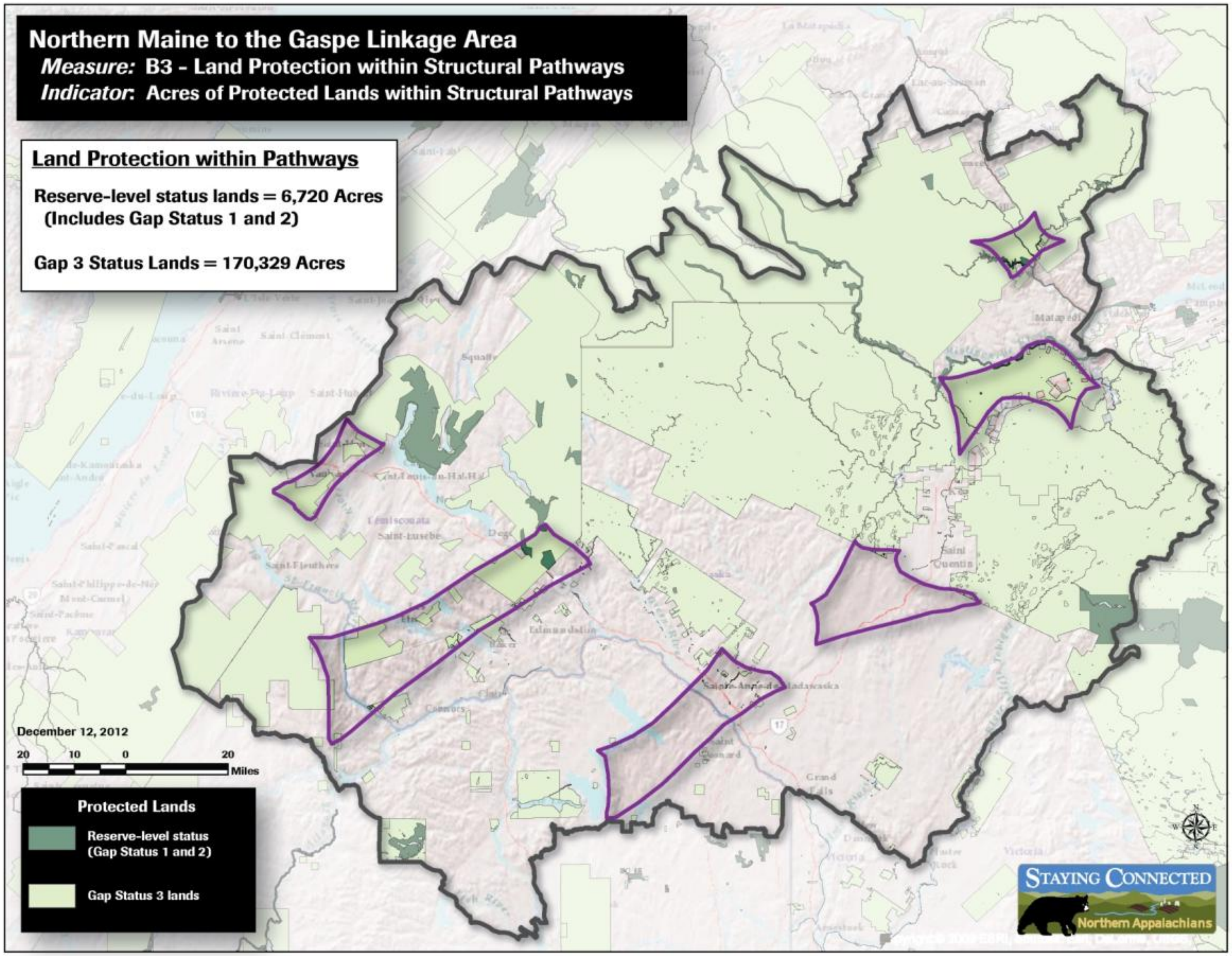


Figure 72. Northern Maine to the Gaspe linkage Area - *Baseline Map #9: Land Protection within Structural Pathways*

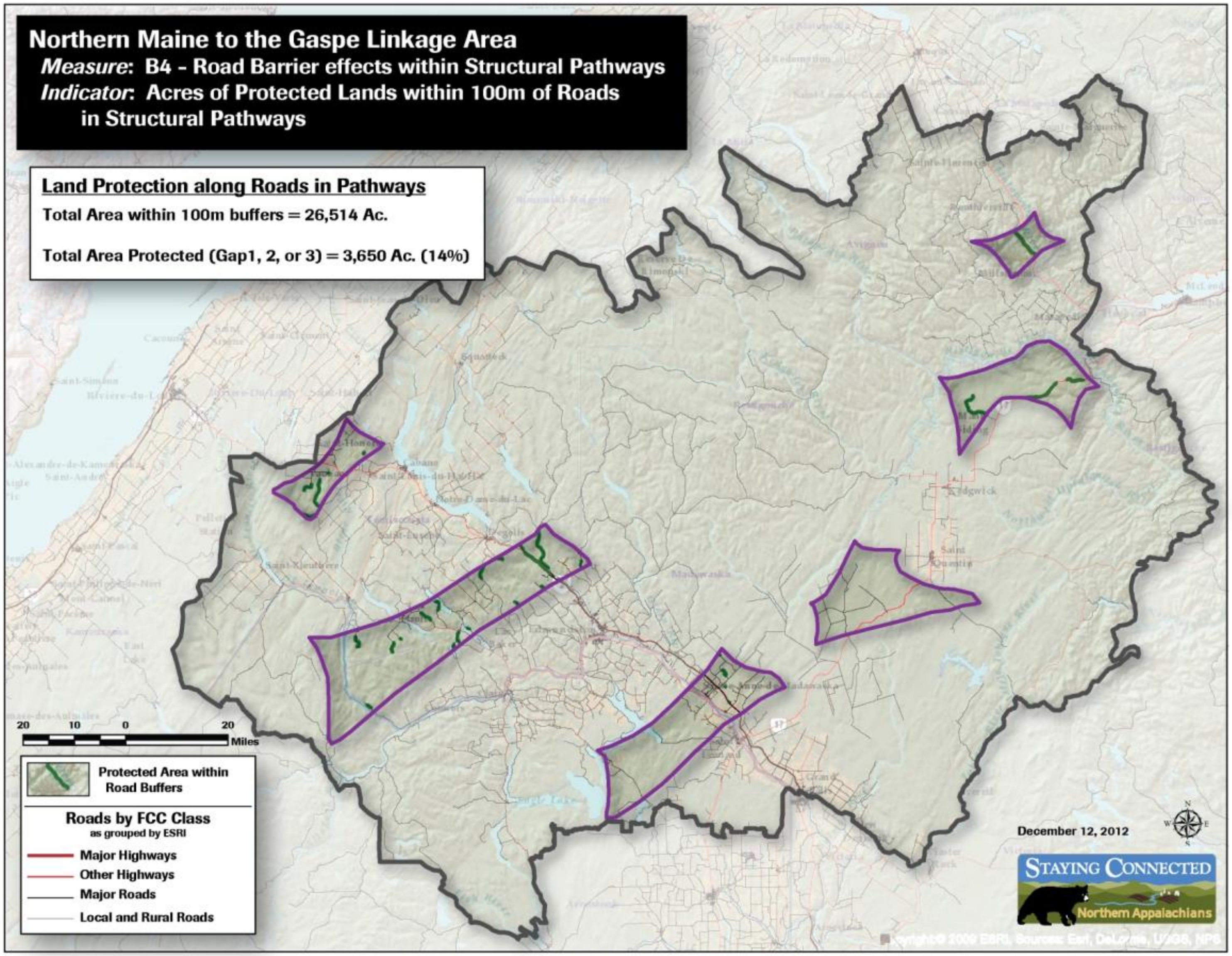


Figure 73. Northern Maine to the Gaspe linkage Area - *Baseline Map #10: Road Barrier effects within Structural Pathway*

Section 6: Discussion

The measures framework presented in this report provides a comprehensive system for measuring the state of structural connectivity in eight key landscape linkages in the Northern Appalachian/Acadian region. This report also provides a baseline for most, though not all, the measures in the framework. The framework is designed to be relatively simple and readily updated as new data become available. We acknowledge that not all datasets required will be available for the same time periods – for example, the baseline year for Land Use/Land Cover data for the US is 2006, and updated data are likely to be available for every five years from that date, while Land Protection data is generally updated every year, and the baseline year is 2012. Nevertheless, the combined metrics provide a ready “dashboard” for evaluating conservation status and trends in these critical landscapes.

Overall, the eight linkages encompass over 12 million acres, nearly 50,000 km^2, out of a total ecoregion area of about 88 million acres (356,000 km^2). On the whole, nearly 92% of the area of all the linkages remains in natural cover, though this varies greatly across the region, from a low of 76% in the Adirondacks-Greens linkage – an area of rich farmland and a long history of agriculture – to 95% in the rugged Western Maine linkage with its few permanent residents. Another measure, habitat distribution, provides insights into how clumped or fragmented a landscape is, via the Resistant Kernel (RK) indicator. We used a RK score of 50 or higher to generally indicate a relatively unfragmented landscape. The average RK score ranges from 34 in the Taconics-Greens linkage, which is long and narrow and has a major road running its length, to 67 in Western Maine, where there are few paved roads. Of the eight linkages, four have average RK scores below 50, four above. The amount of land in some form of protection also varies greatly among the linkages, from 14% in the Tug Hill-Adirondacks linkage to nearly 50% in the 3-Borders-Northern Maine-Gaspe linkage (though much of this is Crown land subject to timber harvest).

The linkages range greatly in size, from the relatively small Taconics-Greens linkage, at just under 70,000 acres (about 280 km^2), to the enormous 3-Borders linkage, which, at nearly 6 million acres (a bit more than 23,000 km^2), is only a little smaller than the entire state of Vermont. They also vary greatly in their landscape context and the current state of conservation. As noted earlier, because each linkage, and its associated pathways, were delineated independently, one should use caution when comparing one linkage to another. All linkages are not created equally. The linkages also play fundamentally different roles in their respective landscapes. The Tug Hill to Adirondacks linkage in New York, the second smallest linkage, connects two very large mountainous habitat blocks across an agricultural valley. It is essentially one large structural pathway, and for this reason no additional pathways have been defined within it. In contrast, the 3-Borders linkage connects two major relatively less mountainous forest masses – the Maine North Woods to the southwest and the Gaspé Peninsula and the northern New Brunswick forests to the northeast. The forest masses being connected are less well defined than in New York and the agricultural valleys being traversed are less developed. The result is a much larger linkage with several smaller defined pathways that are the primary focus of connectivity conservation in the 3-Borders area.

Assessing the negative effects roads have on animal movement and habitat connectivity at both the linkage and structural pathway scale is a particular challenge, and the chief limitation of the current iteration of this measures framework. Given the lack of detailed data at the scale of the linkage area, we were forced to use the simple indicators of the number of miles of roads in four general classes and in each of three different traffic volume categories where the data were available. The number of miles of different road types varies greatly by linkage area. Some linkages are bisected by high traffic, major roads while others contain mostly low volume, local roads. As a result, future conservation and evaluation strategies involving transportation infrastructure will need to vary by linkage area.

To guide barrier mitigation strategies at the linkage and pathway scale, several types of data are still needed for several indicators, including:

1. Detailed landcover data around Priority Road Segments (PRS).
2. AADT counts and speed data for PRSs
3. Key characteristics of road structures (culverts, bridges, fencing, etc.) within PRSs

Although we include these indicators in the overall measures framework, we do not provide information for them at this time precisely because these data are so fine-scale and linkage specific.

The Nature Conservancy, in their study of selected roadways in the Tug Hill to Adirondacks linkage, provides a model for how to obtain these data (Adirondack Nature Conservancy 2012). The goal of the study was to develop data, tools, and strategies that can be used to mitigate the negative impacts of barriers, particularly roads, on habitat connectivity in the Black River Valley. The study identifies high probability wildlife crossing locations on priority road segments using field-collected animal track data; evaluates the importance of variables such as road infrastructure, land use, and topography on crossing probabilities to inform mitigation efforts; establishes a model prototype that can be used as a rapid assessment tool throughout the linkage to identify priorities on other road segments; and examines metrics to track changes to connectivity over time using remote datasets. As part of the study, high-resolution spatially referenced photos were digitized into habitat categories (e.g. residential, forest, road surface etc.) within a 100m buffer of the road center. In addition to animal track data, fieldworkers also obtained detailed information on the physical infrastructure of the study roads. This included the location and length of guard rails and fences, width of the roadway, the location, size, and condition of culverts and bridges, as well as validating terrain features (e.g. cliffs and canals) that were mapped remotely. Other efforts of similar scope are currently underway in other linkage areas.

It is clear from reviewing the linkage maps and data that there is much conservation work that still needs to be done to ensure that these landscapes remain intact and permeable over the long term. The degree of conservation in the pathways where they have been defined – and at the two linkages as whole where pathways have not been defined – ranges from 5% and 7% in the Taconics-Greens and Adirondacks to Greens linkages, respectively, to just under 27% in the Western Maine linkage. There are large gaps in the conservation map that need to be addressed in every linkage, and there are many organizations inside and outside the Staying Connected Initiative partnership that are working hard every day to close these gaps.

What the maps and data don't convey – and we readily acknowledge that this is a limitation of the current framework that needs to be addressed – is that there is a wide range of other regulatory and non-regulatory conservation measures in place that are helping to keep land undeveloped and landscapes connected. These include programs such as:

- The Use Value Appraisal (or "current use") program in Vermont[10] (and similar programs elsewhere) that assess lower taxes on parcels that remain undeveloped;
- The local regulatory (i.e., zoning bylaws, subdivision regulations) process that permits or restricts what can happen on a given piece of land[11];
- Federal programs such as the US Department of Agriculture's Natural Resources Conservation Service (NRCS) Farm Bill conservation cost-share programs, such as Wildlife Habitat Incentives Program (WHIP) and Environmental Quality Incentives Program (EQIP), which now incorporate connectivity criteria in the evaluation of land parcels and project for funding in some states and;
- State-sponsored programs such as Maine's Beginning with Habitat[12] that provide guidance to towns on non-regulatory approaches to conserving important habitats and the connections between them.

All of these important programs have a significant effect on conservation – hundreds of thousands of acres/hectares likely remain undeveloped across the region because of them. But

[10] http://www.state.vt.us/tax/pvrcurrentuse.shtml

[11] See Krestser et al. (2013) for a review of Best Practices and Land Use Planning Tools in the US portion of the Northern Appalachian/Acadian region.

[12] http://www.beginningwithhabitat.org/

many of them produce results that are arguably not permanent, nor readily measurable. Only the most measurable and permanent of these means (land protection) is used as a measure in this report.

Recommendations and Next Steps

This is the first iteration of the SCI measures framework. The following next steps could greatly improve both our understanding and ability to evaluate the state of connectivity in the region:

- Identify priority road segments within pathways (or linkages if pathways have not been identified) wherever possible.
- Encourage expansion of Annual Average Daily Traffic (AADT) data collection in New Hampshire, Vermont, Maine and New York, and further investigate availability and coverage of AADT data in New Brunswick and Quebec
- Carry out comprehensive inventories of culverts and other structures along priority road segments in pathways.
- Assess and document evidence of use by species of interest by tracking, remote cameras, and/or other methods.
- Establish specific, quantitative objectives for each measure.
- Re-run the Resistant Kernel analysis using updated land cover and roads data, at 30-meter resolution.
- Incorporate all of the above into a new version of the measures framework by the end of 2015, and include updated information derived from 2011 NLCD data in that next iteration if possible.
- Determine the most practical and cost-effective frequency for updating the monitoring framework, perhaps every five years, corresponding to the issue of updated NLCD data

References

Adirondack Nature Conservancy. 2012. Securing permeable roadways for wide-ranging wildlife in the Black River Valley. Draft report, May 2012.

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

Anderson, M.G. and A. Olivero Sheldon. 2011. Conservation Status of Fish, Wildlife, and Natural Habitats in the Northeast Landscape: Implementation of the Northeast Monitoring Framework. The Nature Conservancy, Eastern Conservation Science. 289 pp.

Kretser, H., L. Karasin, M. Glennon, and S. Reed. 2013. Best Practices and Land Use Planning Tools. A deport developed as part of the Staying Connected Initiative. Wildlife Conservation Society.

Schlepphorst, S. 2012. The Green Mountain wildway: reconnecting the habitat of the northern Green Mountains (Senior thesis project). Burlington, VT: University of Vermont.

Appendix A: Staying Connected – Connectivity Measures

Terms and Definitions Workgroup

Workgroup Members: Mark Anderson, Dan Coker, Gillian Woolmer, Barbara Vickery, Mark Zankel (lead)

The charge to the Terms and Definitions Workgroup is to ensure that we are using common language and consistent definitions of words and phrases that are considered essential for the development of a connectivity measures framework. As our starting point, we are drawing from the excellent document written by Meiklejohn et al. for the Center for Large Landscape Conservation.[13] We also reviewed and incorporated elements from the Glossary of Connectivity Terms contained in Worboys et al.[14] As needed for our purposes, we have revised their definitions and included and defined additional terms deemed to be key for our purposes.

Landscape connectivity:

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

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

Functional connectivity:

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

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

Structural connectivity:

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

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

Habitat corridor:

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

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

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

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

Landscape Linkage (or Landscape Linkage Area):

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

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

Landscape (or Landscape linkage) permeability:

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

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

Core (or Core Area):

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

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

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

Matrix:

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

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

Buffer:

Meiklejohn et al. definition: None

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

Ecological network:

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

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

(Structural) Pathways:

Meiklejohn et al. definition: None

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

Pinch points (or concentration areas):

Meiklejohn et al. definition: None

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

Priority road segment:

Meiklejohn et al. definition: None

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

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

Stepping Stones:

Meiklejohn et al. definition: None

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

Appendix B: List of GIS Datasets used in SCI Measures Framework Analyses

Linkage Areas – As developed by the Staying Connected Initiative Measures and Evaluation Group, boundary committee.

Structural Pathways – As developed by teams in each linkage area. Methods of pathways development vary by linkage areas.

Northern Appalachian / Acadian 30 meter Composite Land Cover dataset assembled by TNC Maine and WCS Canada from:

> **NLCD06** – U.S. National Land Cover Dataset 2006. 30m Landsat ETM+ images circa 2006. http://www.mrlc.gov/nlcd2006.php
>
> **New Brunswick Land Cover** – NB Department of Natural Resources & Environment. Generalized 1:10,000 forest stand data – published 2009, most stand data updated 2006. Data for large industrial ownerships taken from original TNC land cover dataset assembled 2003.
>
> **Southern Quebec Land Cover –** Ecosystems conservation Section**,** Canadian Wildlife Service, Environment Canada. Land use from Landsat-7 classified 25m images, Southern Quebec, 1999-2003, CWS-Quebec Region, FauneQubec, DUC, MRNFP, MAPAQ, AAC, SLC
>
> **Northern Quebec Land Cover –** as assembled by TNC 2003. Canadian Wildlife Service, Environment Canada. Classified 30m Landsat TM data. 1993-1994.

Resistant Kernel dataset for the Northern Appalachian / Acadian region – Clipped from rcloccon100 developed by University of Massachusetts Conservation Assessment and Prioritization System (CAPS) for The Nature Conservancy Eastern Resource Office for TNC's resiliency analysis. More information available from 'Resilience to Climate Change and Landscape Permeability by The Nature Conservancy' report and other downloads at: http://www.2c1forest.org/atlas/datawarehouse.html

The Nature Conservancy regional secured lands – U.S. Published November 2011 by TNC Eastern Resource Office.

Quebec Secured lands – SA2009_Canada_12_07. Published December 2009 by The Nature Conservancy Eastern Resource Office.

New Brunswick protected lands dataset – extracted from 'holder' dataset. Published in 2012 by New Brunswick Department of Natural Resources. Made available to TNC by Nature Conservancy Canada.

ESRI StreetMap North America 10.1 – U.S. and Canada Detailed Streets, 2012 Edition. Publication Date March 1, 2012.

Maine Department of Transportation public roads dataset – GISVIEW.MEDOT.medotpubrds , updated August 2012, 1:24,000 scale based on ME DOT's Transportation Information for Decision Enhancement. Available from Maine Office of GIS: http://geolibportal.usm.maine.edu/geonetwork/srv/en/metadata.show?id=996

New Hampshire DOT roads dataset – NH Public Roads, Published November 2005, NH Department of Transportation, Bureau of Planning & Community Assistance. Available from NH GRANIT: http://www.granit.unh.edu/data/metadata?file=roads_dot/nh/roads_dot.html

Vermont DOT roads dataset – TransStats_AADT2010**.** Published October 2011. Available from The Vermont Center for GIS: http://www.vcgi.org/dataware/default.cfm?layer=TransStats_AADT

New York DOT roads dataset – 2010_AADT_Line. Published 2010. Available from NYDOT Traffic Data Viewer: https://www.dot.ny.gov/tdv

Undeveloped Habitat Blocks for structural pathways – based on Northern Appalachian/Acadian 30 meter composite land cover dataset and ESRI StreetMap North America 10.1

Appendix C: List of Members of the SCI Measures and Evaluation Group (MEG)

First Name	Last Name	Organization
Mark	Anderson	The Nature Conservancy
Douglas	Bechtel	The Nature Conservancy, New Hampshire Chapter
Michelle	Brown	Adirondack Nature Conservancy and Land Trust
Emily	Brunkhurst	New Hampshire Fish and Game Department
Dirk	Bryant	Adirondack Nature Conservancy and Land Trust
Barbara	Charry	Maine Audubon
Roberta	Clowater	Canadian Parks and Wilderness Society, New Brunswick Chapter
Dan	Coker	The Nature Conservancy, Maine Chapter
Jessica	Dyson	The Nature Conservancy, Massachusetts Chapter
Andy	Finton	The Nature Conservancy, Massachusetts Chapter
Carol	Foss	New Hampshire Audubon
Steve	Fuller	Wildlife Management Institute/North Atlantic Landscape Conservation Cooperative
Louise	Gratton	Nature Conservancy of Canada
Jens	Hilke	Vermont Fish and Wildlife Department
Phil	Huffman	The Nature Conservancy, Vermont Chapter
Jon	Kart	Vermont Fish and Wildlife Department
Paul	Marangelo	The Nature Conservancy, Vermont Chapter
Laura	Marx	The Nature Conservancy, Massachusetts Chapter
Margo	Morrison	Nature Conservancy of Canada
Rose	Paul	The Nature Conservancy, Vermont Chapter
Conrad	Reining	Wildlands Network
Peter	Steckler	The Nature Conservancy, New Hampshire Chapter
Tim	Tear	The Nature Conservancy, New York Chapter
Liz	Thompson	Vermont Land Trust
Barbara	Vickery	The Nature Conservancy, Maine Chapter
Gillian	Woolmer	Wildlife Conservation Society Canada
Mark	Zankel	The Nature Conservancy, New Hampshire Chapter