Quabbin to Cardigan Conservation Plan

Technical Report
2008

Prepared for the Quabbin to Cardigan Partnership by
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Introduction

This document chronicles the development of the Quabbin to Cardigan strategic conservation plan. It begins in the early days of the Quabbin to Cardigan project in 2003 when an overarching vision was crafted by the stakeholders that distilled the shared goal of the Q2C conservation plan: "*to identify and protect large forest blocks with significant embedded ecological features*." In other words, the region's mosaic of intact forest blocks would provide the underlying structure for the plan, and that to the extent that other important natural resources co-occur within that mosaic, certain forest blocks would be elevated in priority as target areas for concerted conservation efforts. This later led to the delineation of final "conservation focus areas" and "supporting landscapes" – which were adopted by the Q2C Partnership in June 2007 -- that reflect actual, on-the-ground geographies within which Q2C land protection projects should be focused.

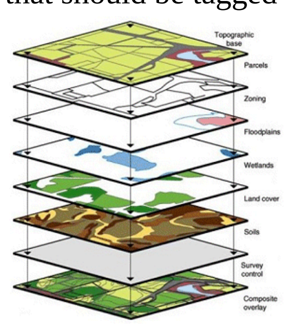
PHASE I: Natural Resource Co-Occurrence Mapping, 2004-2005

Overview of GIS Method

The regional scale study of important natural resources in the Q2C involved several discrete steps.

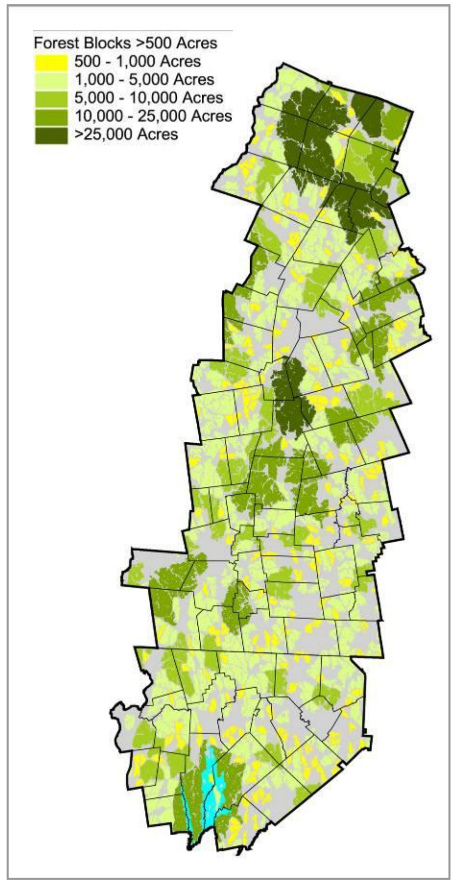
First, wide-ranging research was conducted to develop a database of digital information that could be used in the GIS for mapping and analysis purposes. It is important to note that funding and time limits did not permit the development of new and unique datasets; rather, the group agreed that "best available" data would be used as building blocks in this study. Data was obtained from both the Massachusetts and New Hampshire GIS data libraries (MassGIS and GRANIT, respectively), as well as from participating organizations with specialized data, e.g., The Nature Conservancy, and various state agencies. The data was evaluated for content and accuracy, and then was assembled into a list by resource type for review by the stakeholder group.

Second, from the list of potential data and illustrative mapping, the group selected a set of resource factors that best reflected the study goal above, and which are described in detail below. Some data, such as regional recreation trails, were deemed important to the planning effort, but not suitable for the next step in the study: the resource co-occurrence analysis. These datasets were set aside as reference datasets to be overlaid and compared to the results of the co-occurrence analysis in planning specific projects, or project approaches in the smaller regional venues within the Q2C. In fact, the regional trails were subsequently analyzed to identify trail segments that should be tagged as conservation priority targets; this study is detailed later in this report.



The third step in the process was to conduct a co- occurrence analysis of the data. A ***co-occurrence model*** is used in landscape-scale conservation planning to determine where a variety of natural resource factors are co-located, thus implying potentially higher conservation values. The diagram at the right shows schematically how this process works to build a database of spatial information about any particular location on the ground. This model is run in the GIS, using numerical values associated with each data factor. The key to drafting a valid co-occurrence map is how the many data factors are weighted, especially in terms of the group process used in large stakeholder groups with many areas of natural resource expertise and interests represented. For the Q2C project, a consensus building process of anonymous voting termed a ***Delphi process*** was used to craft both a shared vision of the relative importance values associated with the range of natural resource factors being evaluated, which also results in the numerical values that can be used in the GIS.

Data Factors & Rationale



Unfragmented Forest blocks

A ***forest block*** is an area of intact forest with continuous canopy, without regard to ownership. Thus it functions as a structural matrix for wildlife habitat, with block-to-block connections being important for the movement of wildlife. Large forest blocks are also important for the natural management of water quality and quantity, and as an economic resource to sustainable forestry. Block edges are defined by highways and local roads, non-forest land uses, and/or by large water features.

The map at the right shows the mosaic of forest blocks within the Q2C region, and extending beyond into neighboring communities. The gray background shows where the forest cover is fragmented by transportation corridors and developed land uses, or forest blocks are less than 500 acres. A minimum block size of 500 acres was selected for the regional study in favor of larger blocks which reveal forest structure patterns at landscape scale. A block of 500 acres can also provide adequate wildlife habitat for some species, help protect water quality, allow for long-term economic forest management, and offer a relatively remote recreation experience.

Forest block size classes used in this study are shown in the table below, with the class size ranges approximating the "natural breaks" statistical groupings of all blocks in the study area. The count and total acres of blocks by class are also listed. Note that "total acreage" includes blocks extending beyond the study area boundary, versus acreage within the Q2C which is also included in the table.

Size Class	Count	Total Acreage	Q2C Acres
500 – 1,000 Acres	240	170,372	139,411
1,000 – 5,000 Acres	270	554,987	445,512
5,000 – 10,000 Acres	43	294,793	213,335
10,000 – 25,000 Acres	19	294,671	224,149
>25,000 Acres	5	205,396	136,652

As milestones of significance, blocks of 5,000 acres or more represent a minimum for sustainable economic forest management at regional scale, as well as a minimum size for long-term ecological significance. Blocks greater than 10,000 acres, and especially greater than 25,000 acres, represent the best scale to ensure that ecological structure, function, and processes such as soil nutrient accumulation and formation of old growth forests have sufficient framework to foster true ecological stability over the long term.

Note in the map how the largest forest blocks work to anchor either end of the Q2C study area, with very large blocks to the north that link to the White Mountain National Forest and another large block surrounding the Quabbin Reservoir in Massachusetts. Scattered north to south are series of blocks greater than 10,000 acres in size that follow the height of land between the Connecticut and Merrimack River watersheds. In New Hampshire, four significant mountains -- Mt. Cardigan, Mt. Kearsarge, Mt. Sunapee, Mt. Mondanock – and their associated undeveloped forest blocks, serve as a bio-geographic island chain that links the large anchor blocks north and south.

Intact forest cover of this extent is not common in New Hampshire or Massachusetts, especially east of the Q2C interest area in both states where the influence of metropolitan Boston has pushed suburban and exurban development well west and north,

Land cover data from the USGS National Land Cover Dataset (1998) was used as a starting point to define forest blocks across the two states. This GIS data is developed from satellite imagery using a 30-meter grid; this results in a resolution of about 1/5th of an acre, but is quite suitable for regional land use analysis. The land cover data is classified using remote sensing technology to depict a range of natural land cover types (forest, wetlands, water, etc.) and human uses of the land (transportation, built-up areas, disturbed areas, etc.). However, the land cover grids are only as good as the spectral energy seen in the satellite imagery, and therefore represent best approximations of actual conditions on the ground. An example, important to understanding forest blocks, is that roads with tree canopy overhead will not be "seen" as transportation features. Therefore, the land cover data needed to be further processed to define forest blocks.

To do this, data on the road and highway networks for both Massachusetts and New Hampshire were "burned into" the NLCD land cover grid. To be as accurate as possible, only roads classified as "traveled" were used in processing the data, with the idea that discontinued rural roads which are common in New England, and many private roads (actually driveways) included in the GIS data see little or no disturbance, and therefore do not have a fragmenting effect. However, it was found early on in evaluating and applying these official state road and highway data that mistakes had been made in classifying discontinued (so-called Class 6 roads) as functional segments of the local road system. It was not within the scope of the study to vet the road data in all 3,000 square miles of study area, so it was agreed to work with the existing data. One exception to that was an effort made by the North Quabbin Partnership to review and mark up mapping in the Massachusetts portion of the Q2C study area, and revisions were made to the digital data.

This is an important note because the edges of forest blocks were largely defined by traveled roads and highways, versus other land uses or large water bodies. This in turn effects the calculation of block size and classification in the co-occurrence model. But this is also an example of the limits of best available data in regional studies such as this, and acceptable range of error in the data. Also see the ***Core Focus Area Delineation*** section later in this report for more detail on forested habitat and the role of forest blocks in the *NH Wildlife Action Plan*.

Important Forest Soils

Apart from the obvious economic values noted above, forests are also directly linked to the quality of other natural resources typically considered in natural resource inventory and conservation planning. The structure, composition, and ecological processes at work in forests are critical to a myriad of wildlife habitat values. Forests are also integral to maintaining water quality and regulating water quantity as they relate to both the natural world and to human uses.

While long-term forest management plans seek to maximize all the benefits and uses of our forests, the innate productivity of any forest is dependant in large part on landscape position (elevation, topography, etc.), and especially on soil types. These relationships have been well-studied in New Hampshire, and we are fortunate to have soils mapping that includes groupings of soil types according to general productivity and forest type.

Three important forest soil groupings are of special note, and are described as follows. These soils groupings can be thought of as our "***most productive forest soils***" for the given forest types, although forest management can and does produce significant economic results on less productive soils. The characterization of important forest groups varies by county in New Hampshire. Information on each county soil survey can be found at this link http://www.nh.nrcs.usda.gov/Soil_Data/soil_data.html. Within each soil survey, a "data dictionary" discusses typical soils characteristics and forest cover types for each NH forest soil grouping. The relevant soil surveys for the N.H. portion of the Q2C are Cheshire, Sullivan, Grafton, Hillsborough and Merrimack counties.

New Hampshire Classification System

The most productive forest soils in New Hampshire are characterized as follows:

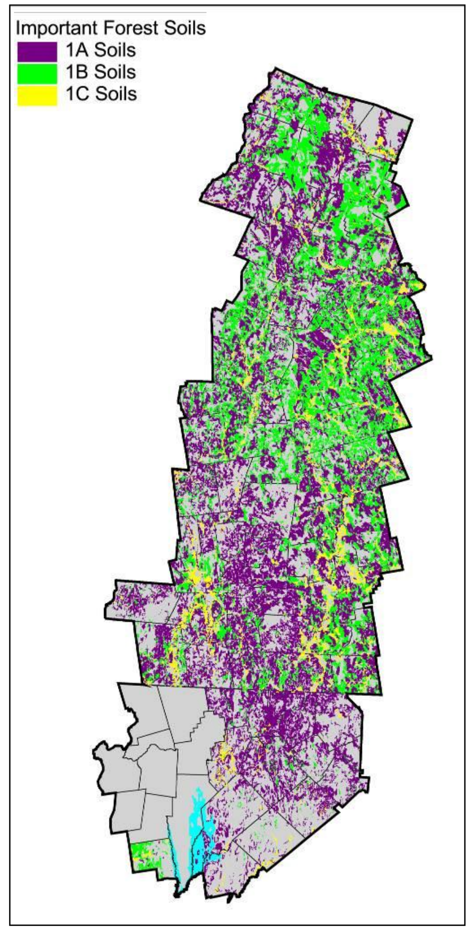
- **Group IA** consists of the deeper, loamy, moderately well drained and well drained soils. Generally, these soils are more fertile and have the most favorable soil moisture relationships. Successional trends on these soils are toward climax stands of shade tolerant hardwoods, such as sugar maple and beech. Early successional stands frequently contain a variety of hardwoods such as sugar maple, beech, red maple, yellow, gray, and white birch, aspen, white ash, and northern red oak in varying combinations with red and white spruce, balsam fir, hemlock, and white pine. The soils in this group are well suited for growing high quality hardwood veneer and saw timber, especially, sugar maple, white ash, yellow birch, and northern red oak.

- **Group IB** generally consists of soils that are moderately well drained and well drained, sandy or loamy over sandy, and slightly less fertile than those in group 1A. Soil moisture is adequate for good tree growth, but may not be quite as abundant as in group1A. Successional trends and the trees common in early successional stands are similar to those in group IA. However, beech is usually more abundant on group IB and is the dominant species in climax stands. Group IB soils are well suited for growing less nutrient and moisture demanding hardwoods such as white birch and northern red oak. Softwoods generally are scarce to moderately abundant and managed in groups or as part of a mixed stand.

- **Group IC** soils are derived from glacial outwash sand and gravel. The soils are coarse textured and are somewhat excessively drained to excessively drained and moderately well drained. Soil moisture and fertility are adequate for good softwood growth but are limiting for hardwoods. Successional trends on these soils are toward stands of shade-tolerant softwoods, such as red spruce and hemlock. White pine, northern red oak, red maple, aspen, gray birch, and paper birch are common in early successional stands. These soils are well suited for high quality softwood saw timber, especially white pine, in nearly pure stands.

Important Forest Soils in Massachusetts

The soil groupings classification described above are unique to New Hampshire, and do not exist in Massachusetts. Therefore, an analysis was made of soils in the Massachusetts portion of the Q2C to approximate the 1A, 1B, and 1C groupings. Digital data for use in the GIS are not yet available for Franklin County, so mapping and analysis in the GIS were not possible; the missing data are evident in the map to the right. A small amount of soils data are also missing within the White Mountain National Forest at the northern end of the Q2C region. Soils in adjacent New Hampshire counties were used as a baseline for comparison in Massachusetts counties since they most closely relate across the state boundary. Where differing soil map units were found state-to-state, the physical characteristics described for N.H. soils was used to classify Massachusetts soils using the N.H. system.



The map at right shows the extent and distribution of the three most important forest soils in the Q2C region, and which are discussed below.

Analysis

Of the soils mapped within the Q2C, approximately 573,000 acres (57%) are classed 1A, 350,000 acres (35%) are in group 1B, and 80,000 acres (8%) are 1C soils. This leaves about 973,000 acres (~50%) of the overall Q2C region either unmapped, or distributed among less productive soils not considered in this analysis.

As a check, in N.H. where the important forest soils groups are complete for most of the Q2C region, about 60% of soils are 1A, 1B, or 1C, with approximately the same shares noted above for soils mapped in this study. Therefore, somewhat less than 40% of soils are rated less productive, allowing for the lack of soils data within the White Mountain National Forest in N.H. The same ratios should apply in the Massachusetts portion of the Q2C if the Franklin County data were available.

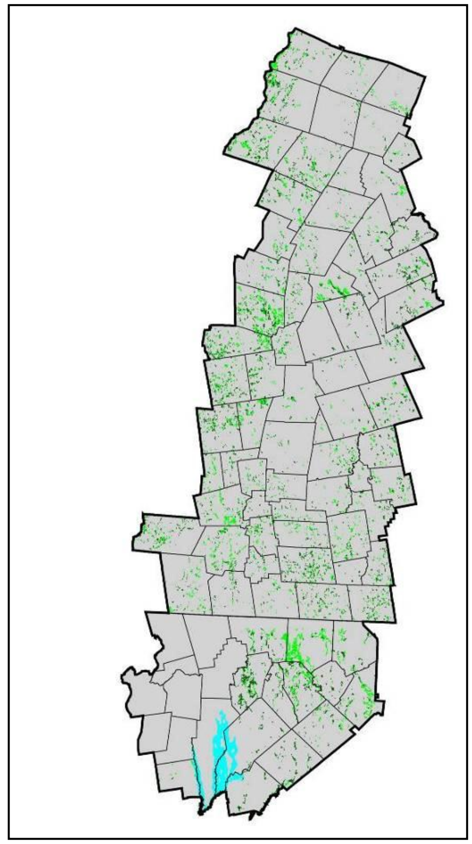
Important Agricultural Soils

The Farmland Protection Policy Act of 1981 was established to assure that Federal programs are administered in a manner that will be compatible with state and local governments and private programs and policies to protect farmland. The NRCS uses the following criteria in New Hampshire for the purpose of carrying out the provisions of this Act.

- Prime agricultural soils: interpreting from technical soils data, prime agricultural soils have sufficient available water capacity to produce the commonly grown cultivated crops adapted to N.H., with high nutrient availability, generally low slope and low landscape position, not frequently flooded, and with less than 10% rock fragments in the top six inches. Corn fields and other row crops would be an example.

- Soils of statewide importance: land that is not prime but is considered farmland of statewide importance for the production of food, feed, fiber, forage or oilseed crops. Hay meadows not normally in row cropping would be an example.

- Soils of local importance: farmland that is not prime or of statewide importance, but has local significance for the production of food, feed, fiber and forage. In The Q2C study area, this includes all land that is in active farm use, but does not qualify as prime or of statewide importance. Pasture land and hay meadows would be examples.



For the purposes of the regional resource analysis in the Q2C interest area, only the first two categories were included due to elevated importance for food and feed production activities typical and important to agriculture in New England.

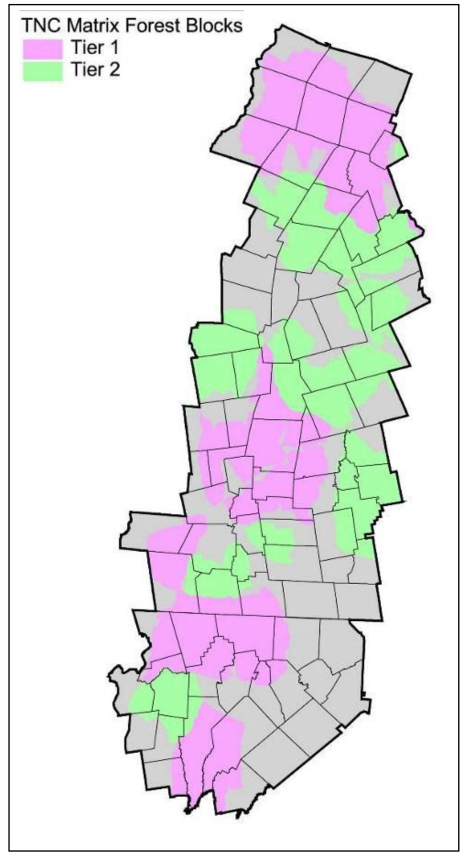
Prime agricultural and soils of statewide importance are classified uniformly in both Masschusetts and New Hampshire, so no interpretation was made state-to-state. However, no soils data were available digitally for Franklin County, as noted above.

It should be noted that no agricultural land use data were considered in this study, for two reasons. First, with the exception of outdated land cover data from the USGS National Land Cover Dataset, no uniform digital data are available across the two states. Second, using the soils data gives a better sense of the potential for agricultural activity, versus actual land use which has been decreasing significantly across New England for decades.[1]

[1] See data in the USDS National Agricultural Statistical Survey available online at _______.

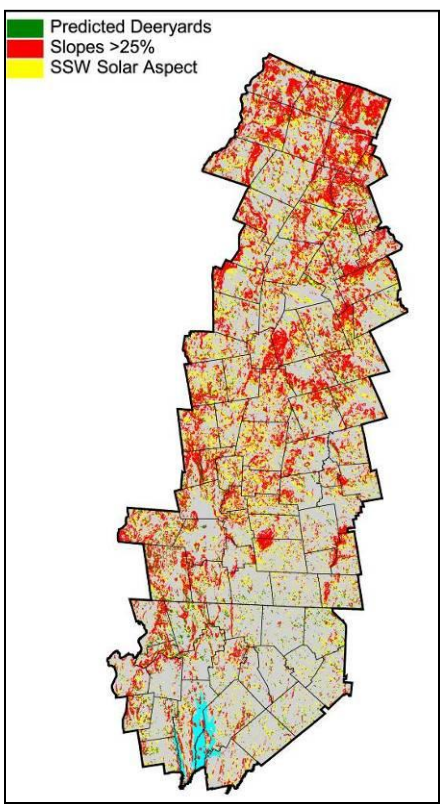
Habitat Factors

TNC Large Matrix Forest Blocks



At the time the regional natural resource study was designed and implemented, no wildlife habitat value ranking had been determined for large forest blocks, except for The Nature Conservancy's large matrix forest block classification system. Intended for a super-regional conservation portfolio planning exercise, the mapping of these blocks by TNC extends from New Brunswick to New Jersey. It is instructive that the length of Q2C interest area extending into Massachusetts is one of the most significant and contiguous southern extensions of this system of scientifically vetted forest block classification.

Tier 1 matrix forest blocks represent the most ecologically viable and best examples of forest occurrences in a particular ecoregion in the TNC analysis and are top-ranked conservation priority areas in TNC's planning portfolio. Tier 2 blocks are also viable matrix forest occurrences, but are not critical to meeting best and most viable conservation goals. However, Tier 2 blocks do serve as protective buffers and connecting structure in many cases. In a sense, these large matrix forests represent the best examples of forest structure upon which the Q2C conservation vision is predicated.



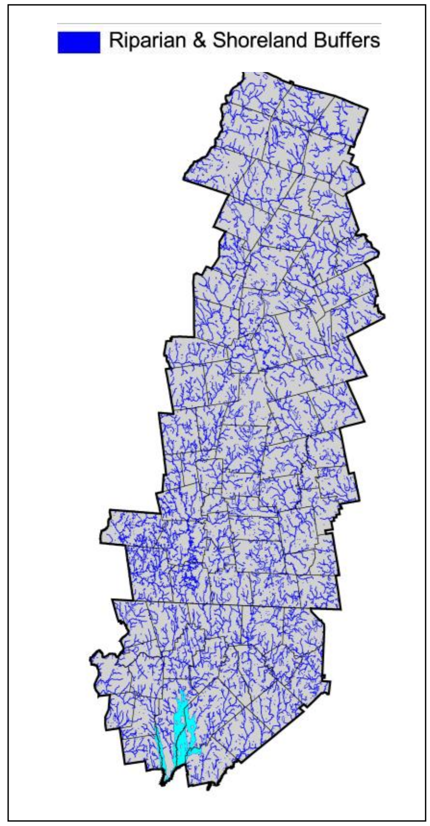
Deeryards, Steep Slopes >25% & South-facing Slopes

Additional proxies for habitat-specific GIS data include predictive modeling for deeryards, and relatedly, steep and south-facing slopes. Steep and sunny slopes are important for many animal species for refuge and winter habitat; bobcat and deer are only two examples. Steep, complex slopes also create nutrient-rich pockets of soil important to certain plant communities. Because much of the terrain of the Q2C region is dominated by steep, hilly-to-mountainous slopes with south-facing slopes, this habitat factor is a significant conservation planning consideration.

Terrain slope and solar aspect data were derived from 30-meter digital elevation models available from USGS. Deeryards were modeled by overlaying hemlock forest land cover data on south-facing slopes of approximately 10% to 25% slope gradient.

The three factors are grouped together in the map at the left. Steep slopes are given precedence in the map over south-facing slopes. The deeryard data display as small, scattered green dots fairly uniformly distributed over the study area.

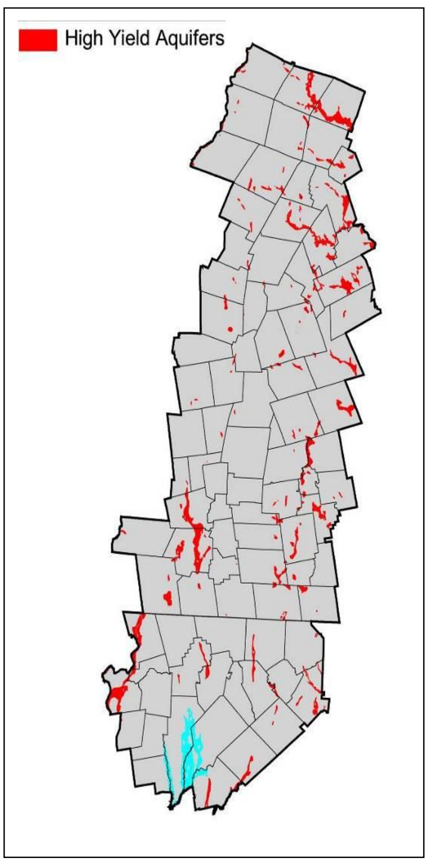
Riparian & Shoreland Zones



It is well known in ecological science that stream networks and shoreline areas functional as critical wildlife corridors and serve a number of habitat functions for wildlife. Obviously, shorelines offer multiple human benefits as well, including aesthetic enjoyment and recreation activities.

For this study, a riparian and shoreland buffer zone has been established around all perennial watercourses (brooks, streams, rivers) as well as ponds and lakes. The buffer zone extends 300' either side of a stream, or back from shorelines along rivers, lakes and ponds. This distance is well established in the scientific literature as a sound working minimum distance within which natural land cover should be maintained in order to function as wildlife corridor and maintain habitat quality, plus act as a filter for soil erosion and control for stream sedimentation.

The map at right shows the entire riparian and shoreland buffer system in the Q2C, including all Order 1 streams and higher, based on the National Hydrography Dataset.



Water Resources

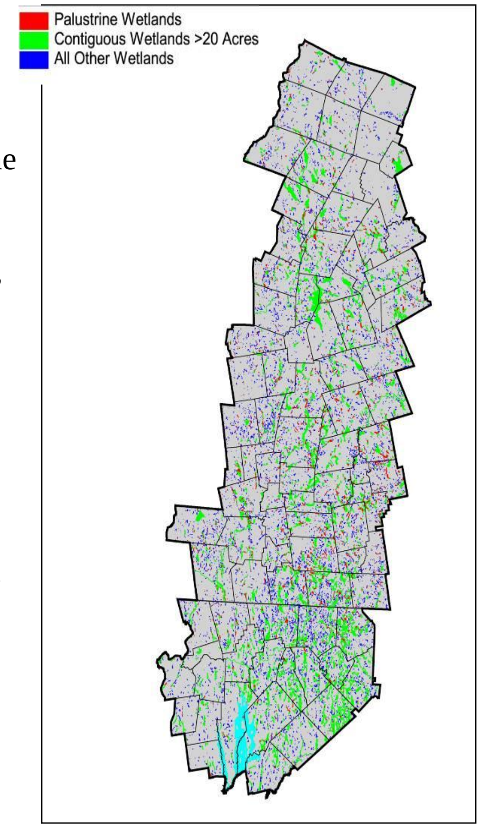
High Yield Aquifers

Underlying many of the major river valleys in the Q2C region are extensive aquifers of sand and gravel layers, also known as a stratified drift aquifer formation. The aquifers are functionally important to many wetlands complexes in terms of maintaining constant groundwater levels, as well as home to several important natural plant communities occurring on river floodplains.

The concept of "high yield" relates to the fact that these aquifers also supply much of the municipal drinking water to public water supplies in Q2C communities. High yield aquifers can deliver adequate water supply to a municipal well over long periods of time. They also tend to enhance the ecological functions noted above simply due to groundwater water flow and primary recharge to the aquifer.

The map at left shows the primary high yield aquifers in the Q2C.

Wetlands



Wetlands of various types are well recognized for multiple habitat values, maintenance of water quality in natural aquatic systems, and flood storage and control. The primary data source for wetlands mapping at regional scale is the National Wetlands Inventory (NWI), which is based on delineations done by the US Fish and Wildlife Service using aerial photography. While some minor inaccuracies are know to exist in these data, they continue to serve as the baseline reference data in locating wetlands. For the purposes of the Q2C regional study, three aspects of the NWI data were considered:

- Any NWI wetland, regardless of size or type;
- Contiguous wetlands greater than 20 acres in size, as a placeholder for large, multi-function wetlands, and;
- Palustrine wetlands (marshes, bogs, fens) which are recognized as limited in size but very important for biodiversity and water quality.

These classifications are shown in the map above, in tiered format since they are all taken from the same master NWI dataset.

Co-Occurrence Model

A ***co-occurrence model*** is used in landscape-scale conservation planning to determine where a variety of natural resource factors are co-located, thus implying potentially higher conservation values. In its most simple form, a co-occurrence model simply overlays all spatial data and records the number of times resource coincide by using an additive arithmetic 1+1+1…n. However, no relative values among resource factors are reflected in this method. To discriminate resource value, the data layers need to be scored in the GIS according to a weighted set of values reflecting more or less importance in the total scheme of factors being considered.

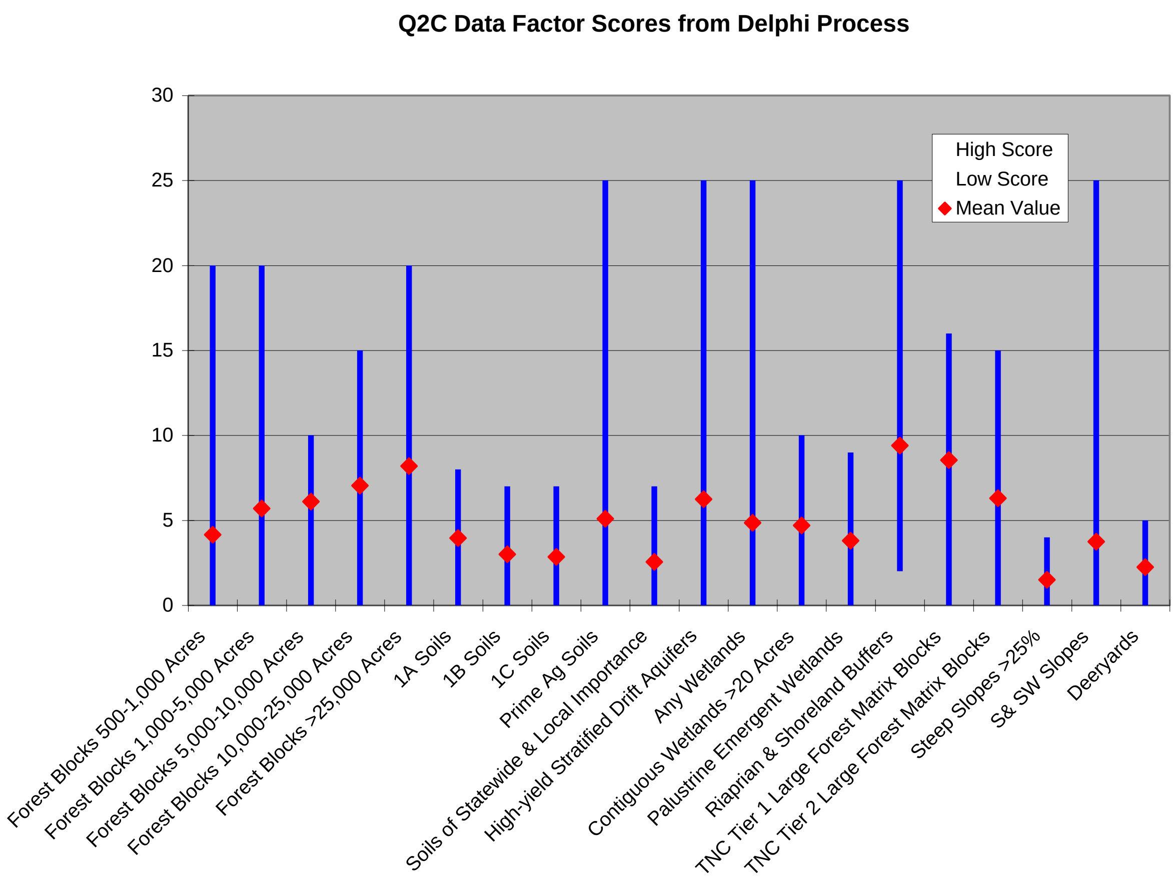
How the weighted values are decided is important. In some co-occurrence models, a team of scientific experts rates and ranks each factor, with an emphasis on mathematic modeling and statistical analysis. Because of the broad group of stakeholders and viewpoints in the Q2C Conservation Collaborative, a “shared vision” of relative values was generated by way of a Delphi process of voting and group consensus-building.

The process is simple once the ground rules are understood. First, the group discusses the list of data layers to be rated; this is to be sure that everyone agrees that what needs to be on the list is there, and that everyone understands the information displayed in the mapping process. Then the group engages in anonymous voting to distribute a budget of 100 points across the data layers in the list, according to their own sense of relative worth and importance to conservation planning. The individual votes are pooled and summarized, ideally by a neutral third party – in this case, Forest

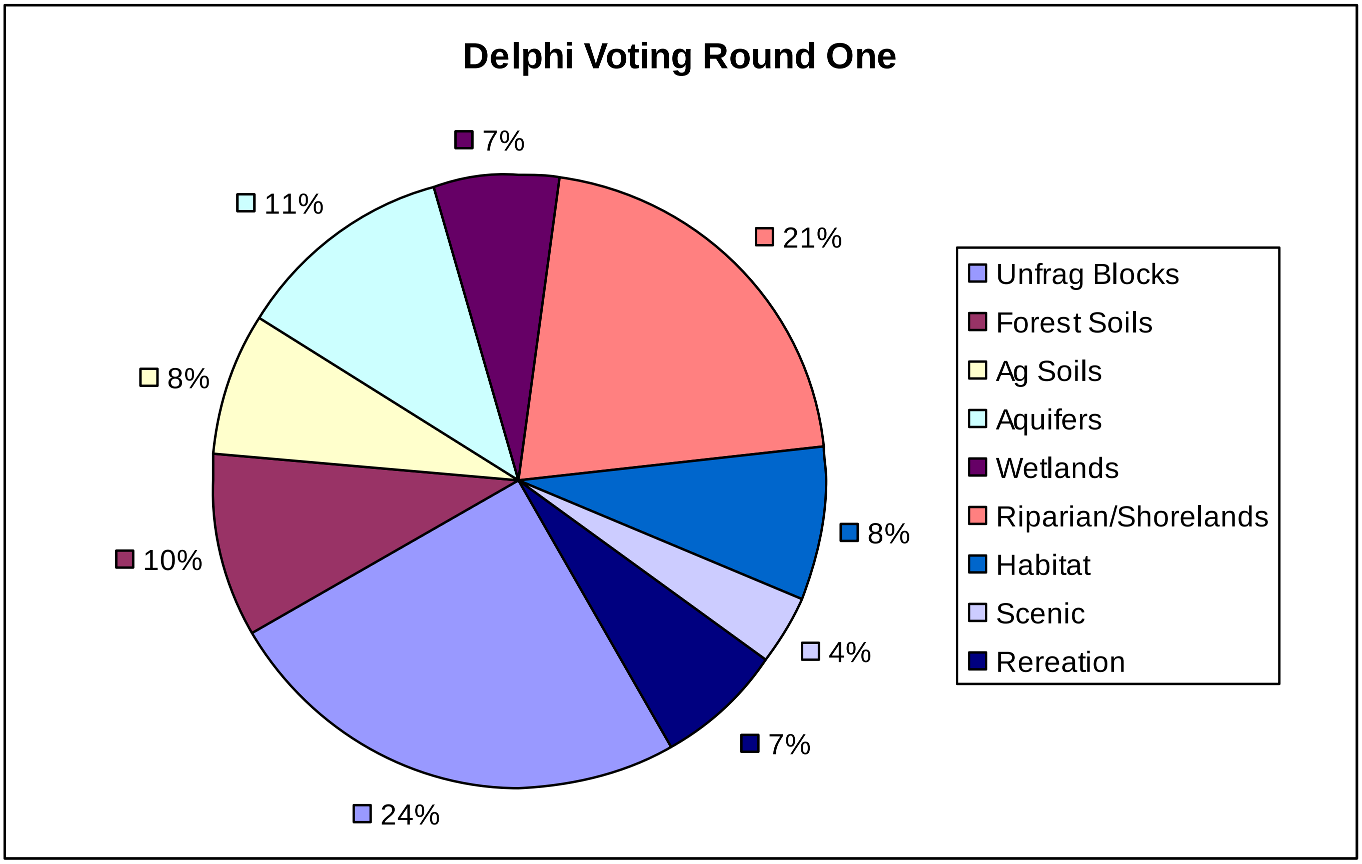
Society staff. A mean (average) value is calculated for each data layer, and fed into the GIS model to produce a first-run co-occurrence map.

At this point, the group has an opportunity to review the anonymous vote/value range, along with the map, and questions or comments can be posed that serve to clarify each person's understanding of the result of the first-round voting. The point of the anonymous voting is to eliminate the usual group dynamic where the most skilled debater wins the point, so the results are not intended to be debated. Each participant then has a second chance to vote, perhaps shifting points with better understanding or changed viewpoint. With the Delphi process, consensus is usually reached in two rounds of voting.

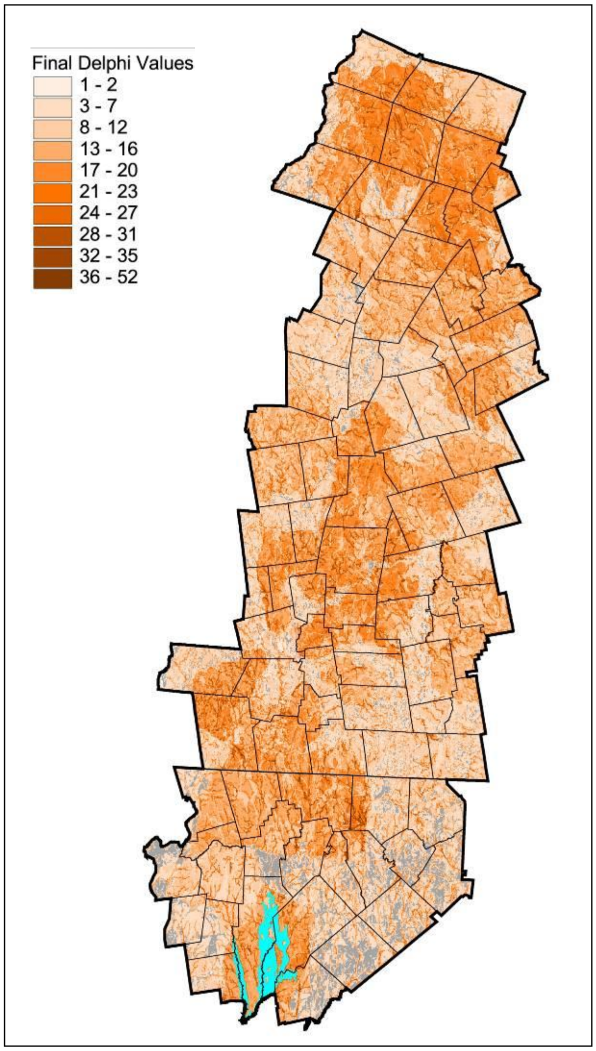
The mean values (red pips) and the high-low range (blue bars) of votes on the Q2C co-occurrence map are shown in the chart and table below. The data factors are grouped by forest blocks, then productive soils groups and important agricultural soils, high-yield aquifers, several wetlands categories, TNC large matrix forest blocks, and habitat features such as steep and south-facing slopes, and deeryards. As can be seen, the group ranked riparian and shoreland buffers highest in conservation value, and emphasized large, intact forest in both the forest block classes and the TNC large matrix forest data factor groups. On the other end of the scale, habitat factors such as steep slopes and deeryards, along with various productive soils evidently hold less value overall to the group.

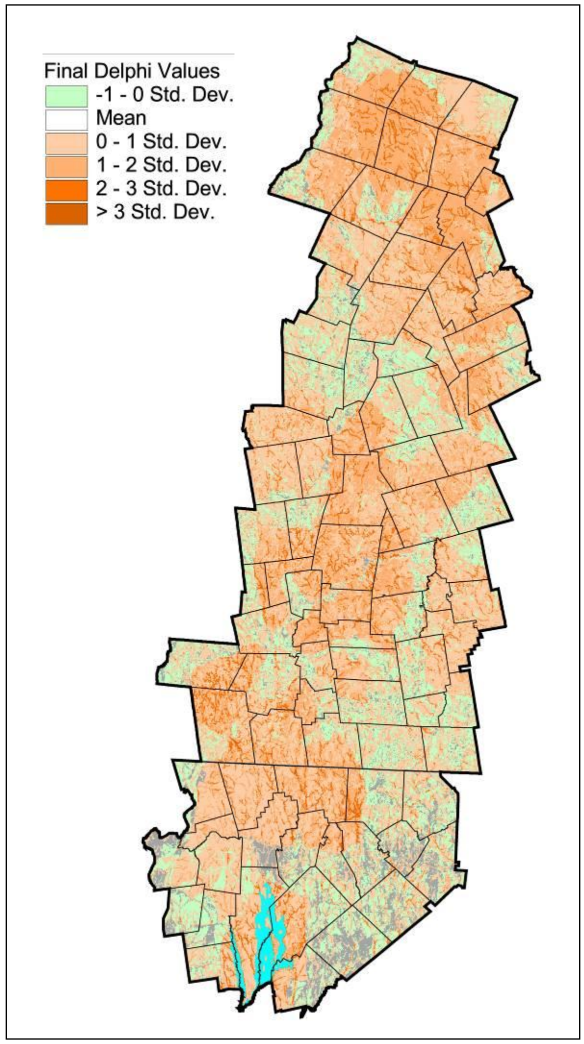


Regional Data Factor Weighting

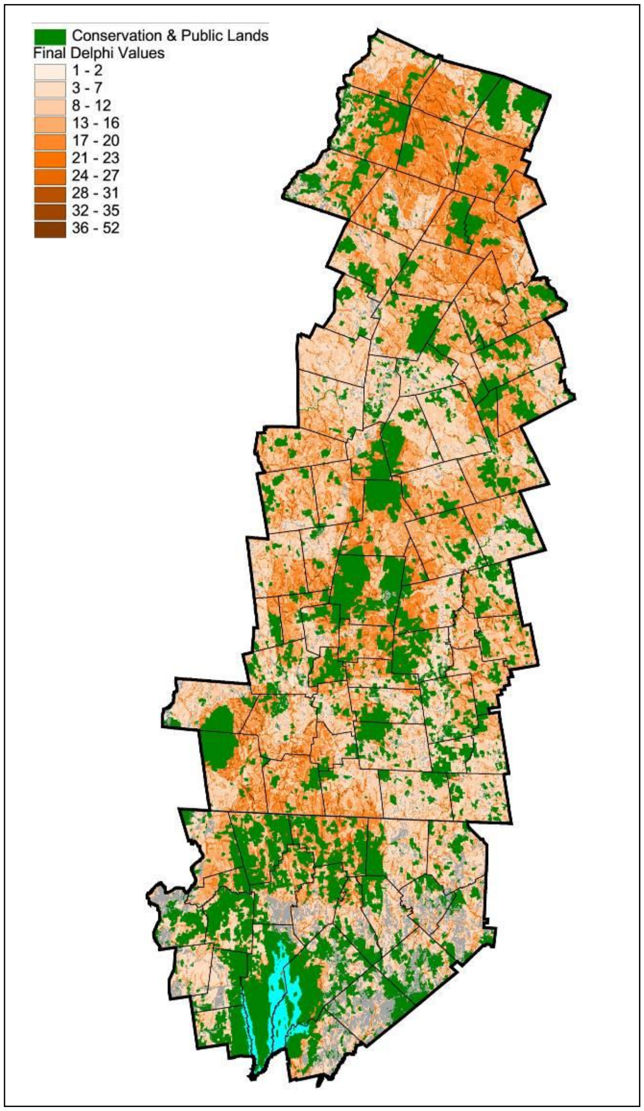


The map below to the left displays the results of the Delphi voting. Note that in this map the data is clipped to the study area boundary to eliminate the effect of data outside the area when using the GIS to classify and display values within the study area. The data in this map are classified along a color gradient of continuous value, i.e., high to low, based on a natural breaks statistical analysis within the GIS. This method display natural groupings of values along a continuum. Gray indicates a non-scoring area due to lack of data factors used in the analysis.





Another way to look at the same data is shown in the map above to the right by classification according to standard deviation, which is a statistical technique translated into the GIS that shows the *average value* of all data, as well as the lowest values versus the highest values with a two-color gradient. The average value here is ~7.7, while the range in points is 0 to 52; the higher the scores rise, though, the fewer grid cells occur, so the average is driven down. As can be seen, the orange color gradient represents the above average scores across all 20 data layers, while the green tones descend down to the lowest scores. As before, gray in this map equal a "0" score. This map is useful to quickly identify where the "best of the best" resources are found.



Protection Status

In the map to the left, conservation and public land is overlaid in green on the value gradient to show relative protection status. It is interesting to note that in certain places, such as northern Massachusetts and the Mt. Monadnock-to-Mt. Sunapee corridor, darker, high-value areas in the co-occurrence analysis are relatively well protected. In other areas, such as the northern Q2C, very sizeable high-value areas appear with low levels of protection.

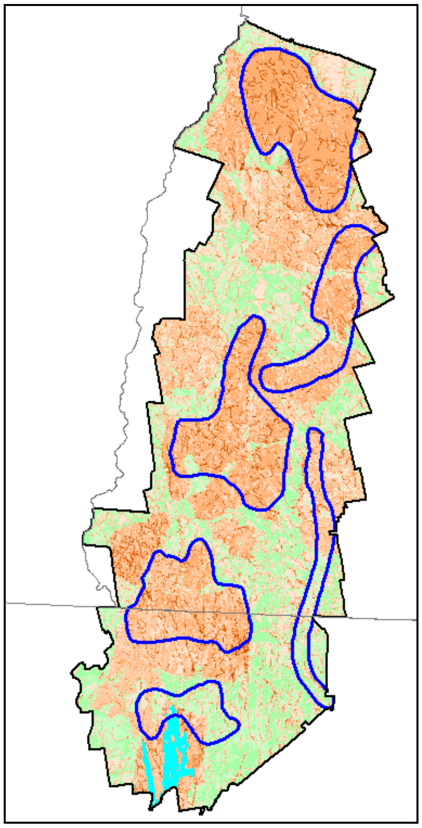
Interpretation

Why do the high-to-low conservation value patterns manifest as they do in these map displays? Referring back to the mean values chart and table of Delphi values, it is important to note that the TNC large forest matrix blocks received very high scores in the voting, as did the larger sized forest blocks. In combination, this boosts the weight of forest blocks in general, and raises the both the actual and the apparent value of the overall forest block structural mosaic in a very visible way in the maps. Keep in mind, however, that the riparian and shoreland buffers received the highest mean value in the voting. While spatially extensive across the Q2C interest area, the impact of that high conservation valuation is not readily apparent until close inspection is made. Other data factors which are spatial scattered and/or small in scale also do not tend to be apparent in the regional scale co-occurrence mapping.

Thus, while the mosaic of high-scoring forest blocks do reflect the strategic emphasis of the Q2C conservation collaborative on protecting large forest blocks with significant embedded ecological features, the patterns apparent in the co-occurrence map are highly complex and risk overlooking smaller elements of high conservation importance. To remedy this situation, a second step of refinement of the co-occurrence analysis has been conducted, using a GIS focal mean analysis and further delineation techniques to identify core conservation focus areas that are both scientifically vetted and practical to protect on-the-ground. This step is detailed in the next section of this report.

PHASE II -- Identifying Conservation Focus Areas, 2005-2006

The Quabbin to Cardigan Conservation Initiative strategic plan has been actively evolving for three years. During 2005 and 2006, the regional planning process has been scaled down from its original 3,000 square mile extent, with the idea of a developing parcel-based conservation focus area (CFA) for each of several generalized "core areas" identified by Q2C collaborators.



As an orientation device and a first step, the Q2C collaborative sought to identify regional plan focus areas by reviewing the results of the co-occurrence analysis and discussing organizational project priorities – both ongoing and planned. This round robin process culminated in a "hot dot" voting process in which each stakeholder placed colored dots on a large map to identify the location of top priority project areas. Then, using transparent acetate overlays, groupings of "votes" were outlined with felt tip pens. Adjustments to boundaries were made based on a second round of group comments and suggestions as to expansion or linkages of areas, was well as discussion of relative importance in terms of large forest blocks with significant embedded ecological features.

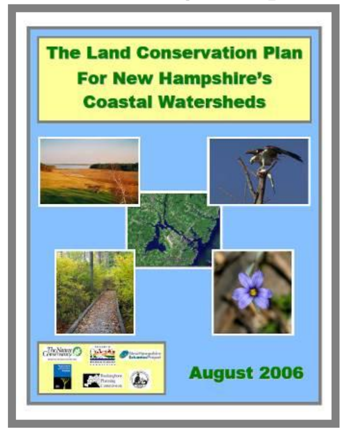
The six first approximation focus areas are shown in the map to the left, with the total hot dot votes within each area. The co-occurrence map has been classified and colored as with a standard deviation scheme which reveals areas of high conservation values (orange) versus area of relatively low values (green). As can be seen, there is a strong match between the blue focus area boundaries and the higher values, but this was intentional in the delineation process.

While a classic approach to selecting focus areas, the process outlined above suffers from a high degree of subjectivity and is prone to individual and group bias. It did serve as a warm-up exercise for a complex GIS-based analytical process which resulted in a more scientific and precise delineation of a series of core focus areas and supporting landscapes within the Q2C interest area, described below.

Integrating New Data and New Approaches

Shortly after the effort outlined above, the science of core focus area selection and prioritization advanced significantly in parallel strategic planning projects in New Hampshire. The first such effort is found in the *Ashuelot River Watershed* study conducted by The Nature Conservancy (TNC) in 2005, which evaluated and ranked the ecological integrity of forest blocks and small watershed catchments across a regional watershed. A majority of this watershed is located within the Q2C study area.

The second, and perhaps more sophisticated approach to delineating core focus areas emerged from the *Coastal Watershed Land Conservation Plan*, released in 2006; for more detail refer to http://www.nhep.unh.edu/programs/community-assistance.htm#lcp
Working with regional resource co-occurrence mapping similar to that of the Q2C regional plan, TNC and the Forest Society developed a more refined methodology for the 1,000 square mile coastal watershed of New Hampshire.



That has now been replicated in the Q2C region, with some modifications appropriate to the goals of the Q2C project, and the particular resources addressed in the study (discussed below). In the case of strategic conservation planning in the Q2C interest area, taking a landscape-scale approach is imperative to the success of the model. While incorporating local knowledge and town-wide data is important when available, at this broad resolution it is not the main focus of this exercise. Taking a "big picture" approach has resulted in the most unbiased and meaningful results.

When the Q2C regional conservation planning project was first conceptualized, the available GIS datasets were limited, especially in the realm of watershed-scale water quality data and wildlife habitat. Since then, two significant additions have been added to the conservation planning toolkit:

- the USGS *SPARROW* water quality model released in 2004, which generated very high resolution watersheds for each stream catchment in New England, and characterized water quality in each catchment; and,

- the release of new ecologically-based wildlife data as part of the generation of *Wildlife Action Plans* in both New Hampshire and Massachusetts.

Instead of revamping the entire regional study to accommodate the availability of new data in 2006, the Q2C collaborative chose to build from the base of the strategic regional plan data developed to date, starting with the Q2C co-occurrence mapping with its weighted resource values, and then bringing in the WAP and *SPARROW* data as overlays and reference datasets. In this way, the integrity of all preceding GIS planning work (and the investment in consensus-building) has been preserved, while leaving open the option to incorporate "value-added" information from more recent sources that reinforces the central goals and mission of the Q2C Partnerhsip.

Definitions

The following working definitions are offered as context in the following discussion. As indicated above, we followed a similar methodology adapted from the recent *Land Conservation Plan for NH's Coastal Watershed* study, so these definitions are adapted from that plan.

Conservation Focus Area (CFA):
An area that is considered to be of exceptional significance for the protection of large forest blocks with significant embedded ecological features (Q2C mission).

Core Area:

A contiguous geographic area that contains a high concentration of natural resource values for which the conservation focus area was identified, typically defined by major natural features such as large forest blocks, near-pristine stream watersheds, and highest-ranked habitat features identified by the NH *Wildlife Action Plan*.

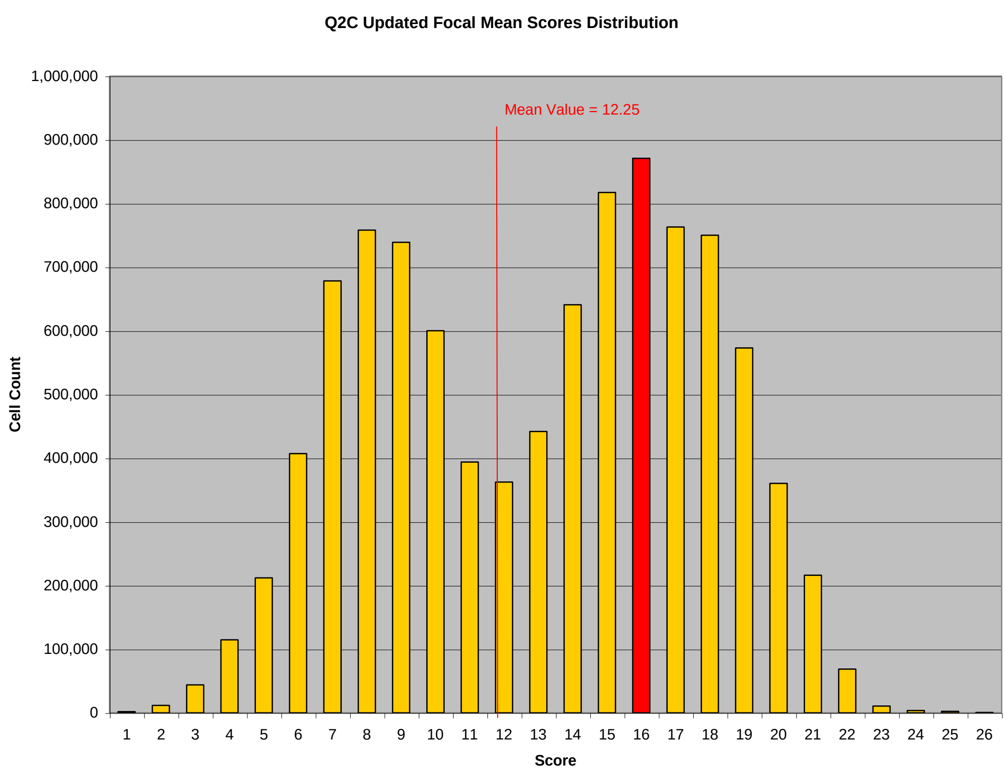
Supporting Landscape:
The surrounding area that helps to safeguard the core area, typically composed of forest blocks >1,000 acres, relatively high quality stream watersheds, and second rank WAP habitat features.

CFA Delineation Process

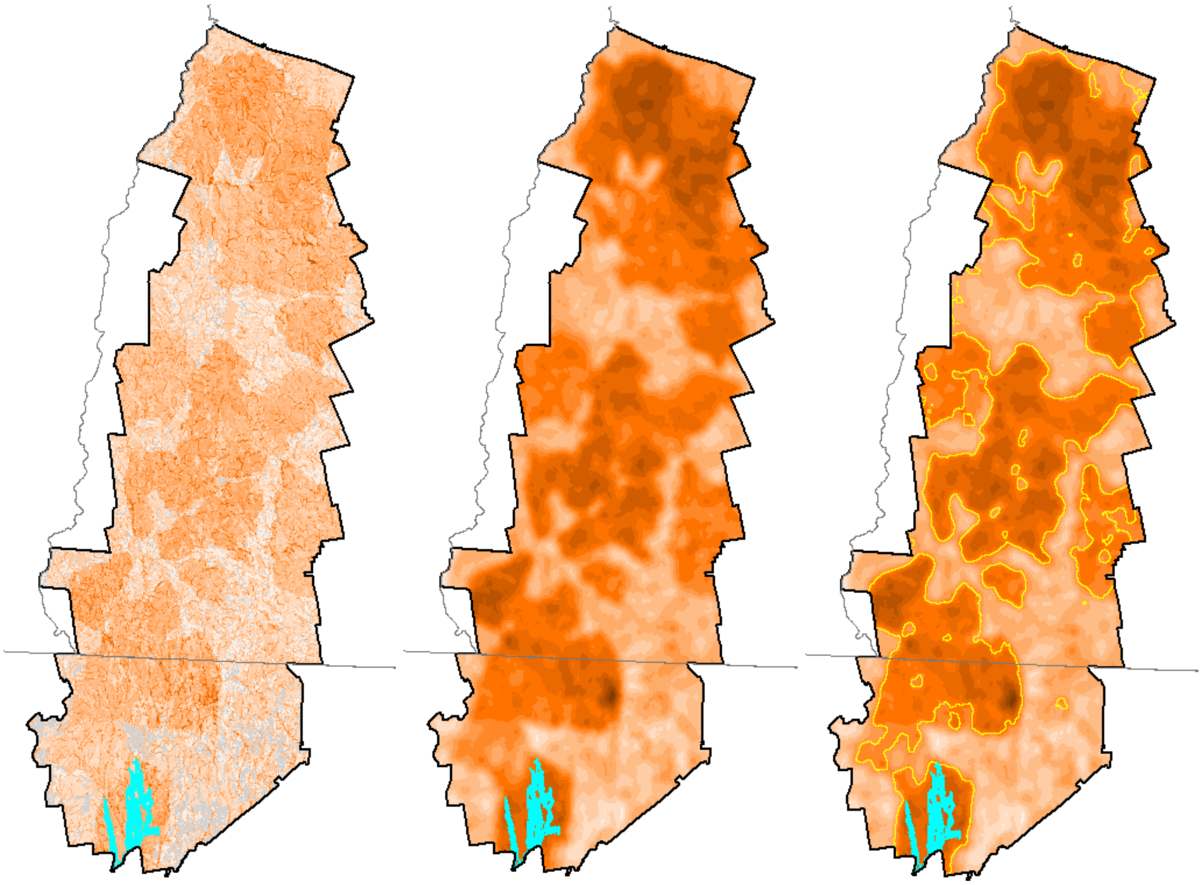
Focal Mean Analysis

As indicated above, we followed a targeting methodology adapted from the recent *Land Conservation Plan for NH's Coastal Watershed* involving feature-based delineation of conservation focus areas. We first generated "statistical contouring" of the regional Q2C co-occurrence mapping, using a focal mean GIS processing technique that averages scores within a moving analytical window. This has the effect of smoothing the complex spatial mosaic of score variances in the original co-occurrence map product by creating a continuous surface of relative values (it is important to keep in mind that these are statistical values, not conservation values).

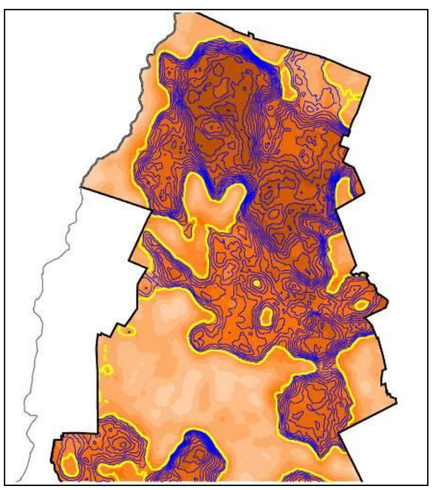
From this intermediate step, contours of the surface are generated and cell counts are analyzed in a histogram to find a logical threshold or break point from which to begin delineating core focus areas. The following histogram shows the contour (point value) distribution for the Q2C focal mean analysis. While the mean value for the entire focal mean analysis is ~12 points, note how the values are distributed in a "camelback" form, and that the mean value occurs in a low-scoring valley in the data. Use of a mean value was set aside in favor of a threshold that embraces a high-scoring set of values, with a target of about 25% to 30% of the Q2C land area set as guidance by the stakeholder group. After testing several focal mean values, contour 16 (shown in red in the histogram) was selected as having the best balance between score and workable land area.



Representing approximately the top 20% of the regional land base, this value served as an initial targeting device for feature selection.



The maps above show the three stages in moving from the regional co-occurrence map to the focal mean surface with smoothed values, and finally, to the initial target areas defined by contour 16.



The accompanying inset map shows the typical contour values associated with contour 16 (yellow) in a large portion of the northern Q2C.   Note the plateau-like topography within the yellow line, with a steep escarpment then a relatively flat summit. This indicates strong edge definition in the data which is desirable for targeting delineation of CFA.

Core Focus Area Structural Elements

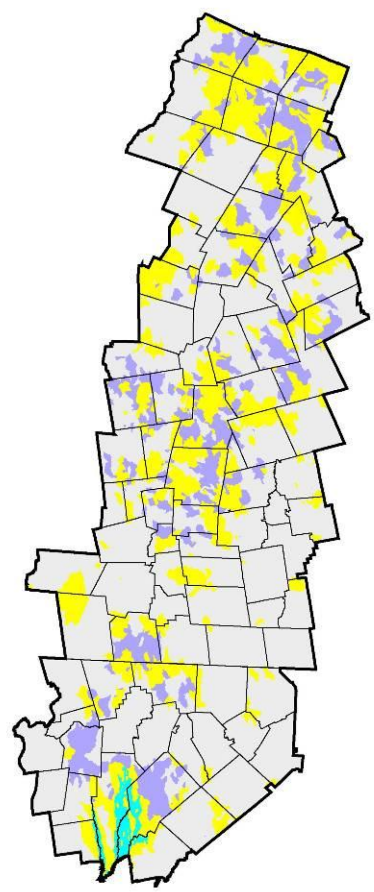
The next step in the processing delineating CFA's was to assemble key datasets in the GIS and begin a process of comparing spatial relationships of key features in the landscape that would allow real edges to be selected as CFA boundaries. These features need to be of relatively large size, given the scale of the Q2C region, and important structural features in the scheme of natural resource values being evaluated. This process was also used in the Coastal Plan, but again was adapted for the scale and natural resource features evaluated in the Q2C interest area.

In New Hampshire:

- Forest Blocks >1,000 acres (from TNC and NH WAP)
- USGS *SPARROW* high quality stream watersheds
- N.H. Fish and Game *Wildlife Action Plan*
- N,H. Natural Heritage Bureau Element Occurrences Database

In Massachusetts:

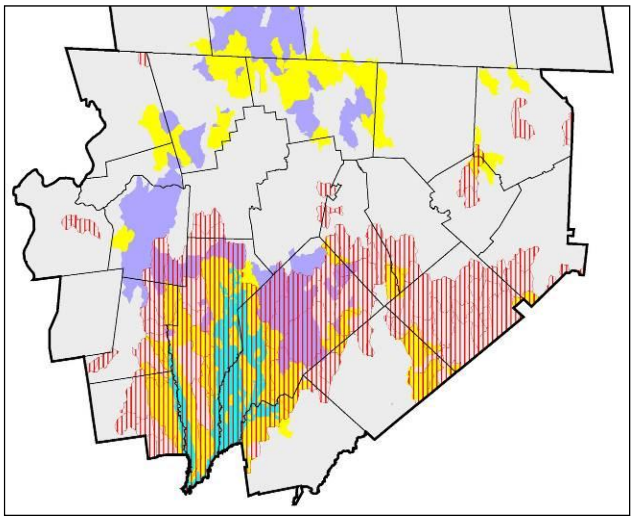
- TNC Roadless Forest Blocks
- USGS *SPARROW* high quality stream watersheds
- *Outstanding Resource Waters* data
- Massachusetts Fisheries and Wildlife *BioMap Project* (MA WAP)



The forest blocks data used in the CFA delineation represent updated and upgraded block data compared to that available at the time the regional co-occurrence model was run. This is largely due to data acquisition and development generated for the N.H. WAP. TNC worked with the N.H. Fish and Game Department to refine forest block data using a newer dataset (GRANIT land cover 2001) and a broader range of fragmenting features, e.g., major transmission lines, railroads, etc.. Due to the statewide scale of the WAP analysis and planning effort, and the fact that habitat values increase typically with block size, a minimum block size of 1,000 acres was used.

New data also became available on high quality stream watersheds, thanks to the USGS *SPARROW* water quality model, after the regional co-occurrence analysis was completed. *SPARROW* was developed to predict where high amounts of phosphorous and nitrogen loading occur, indicating watersheds with low water quality and in need of remediation. As part of the project, small stream catchments, or watersheds, were defined using GIS processing of digital elevation models. The resulting watersheds represent the first high-resolution, statewide watershed database keyed to water quality.

For the purposes of the Q2C CFA delineation, these watersheds were "reverse-engineered" to show the stream catchments that have the highest water quality. The original *SPARROW* data were calibrated using 1992 land cover and 1990 census data. Using 2000 census and land cover data in both NH and MA, we updated the original *SPARROW* thresholds for the three parameters used by USGS to rate watershed quality: population density, percent land cover in agriculture, and percent of developed land. The stream watersheds were then broken into three classes, the highest quality being an "EPA Reference Reach" – developed in the original SPARROW study -- constituting a near pristine wilderness-quality watershed. The other two classes differ from the reference reach only slightly in terms of population density, and are referred to as "low density rural" and "high density rural" watersheds. Taken together, the three classes are taken to mean "high quality stream watersheds". Reference reaches are shown in yellow in the accompanying map; other high quality watersheds are colored purple.



In Massachusetts, we also made use of the *Outstanding Resource Waters (ORW)* data, which served as an important supplement and additive to the updated *SPARROW* model in the Massachusetts portion of the Q2C. The *ORW* classification primarily includes drainage basins contributing to a public surface water supply, but also state-designated areas of critical environmental concern (unique natural and cultural waters) and watersheds feeding protected scenic rivers and protected wetlands areas. *ORW* designation takes many factors into consideration, including: socio-economic, recreational, ecological and aesthetic value. Of particular interest in the southern Q2C, is the Quabbin Reservoir watershed which provides clean drinking water to the City of Boston. *ORW* watersheds are shown in the map inset with red hatch overlaying the USGS *SPARROW* data from the previous map.

The new Wildlife Action Plans (WAP) in both New Hampshire and Massachusetts also added important baseline and priority-setting wildlife habitat data not available in the regional co-occurrence plan. The two plans differ somewhat in the methods and data used in their production, but for the purposes of the CFA delineation process they are considered on par with each other in terms of the intent of the WAP nationally, and in terms of data inputs. In Massachusetts, the *BioMap* project became the core of the Mass WAP, while in New Hampshire a different ranking approach generated tiered habitat condition/quality mapping, and conservation focus areas.

In addition, thanks to the inherent scaling capability of the NH WAP that allows the model to be run for regions and communities, the NH Fish and Game staff graciously re-ran the data using the protocol in the statewide WAP mapping to generate a unique habitat condition analysis for the NH portion of the Q2C. This data has been important in delineating CFA boundaries, and will be integrated in later connectivity studies for the Q2C.

Finally, in New Hampshire, preliminary selection of CFA's were reviewed by TNC to determine whether any significant rare, threatened or endangered plant and animal element occurrences, or exemplary natural communities, appear in the N.H. Natural Heritage Bureau database within those areas. This step was not needed in Massachusetts since the presence of similar element occurrences had already been considered as part of the BioMap evaluation process. A similar review for special habitat feature occurrences was made by the NH Fish and Game staff responsible for the WAP.

Delineation Decision Process

Background

Forest blocks and *SPARROW* watersheds that were contained or mostly contained within the 20% threshold contour discussed above were selected as the basis for CFAs in the Q2C study area. The areas where these two feature types overlapped created the basis for our **core areas**. Abutting forest blocks and high quality watersheds that extended beyond the initial core areas were accounted for as **supporting landscapes.**

The intersection of large roadless blocks with *BioMap* core areas and high quality watersheds created the bulk of the foundation for the core areas in Massachusetts. *BioMap* data was found to be highly precise, extensively ground-truthed, and of the appropriate level resolution for application.

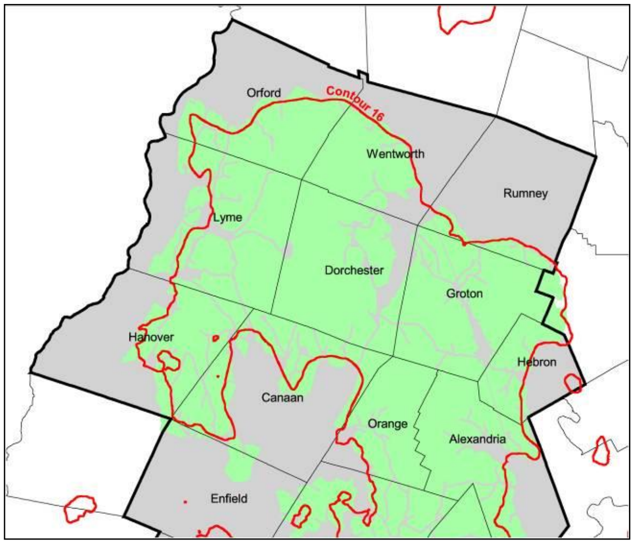
After initial roughing out of CFA's, three refinements added to the CFA delineation methodology were implemented to finalize CFA boundaries:

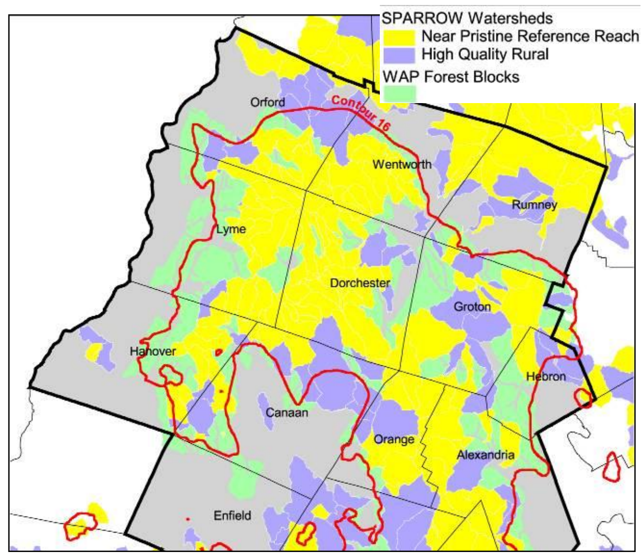
- The presence of NHB element occurrences that fall within forest blocks of any size and that contribute to the greater system of CFA. In New Hampshire, this review was conducted by The Natural Conservancy;
- *BioMap* core areas and other known occurrences in Massachusetts; and,
- Areas of special consideration that fall outside of the forest block thresholds, but were deemed important in a review made by NH and MA Fish and Game Departments, consistent with the NH WAP or the BioMap plan in Massachusetts.

Process Vignette

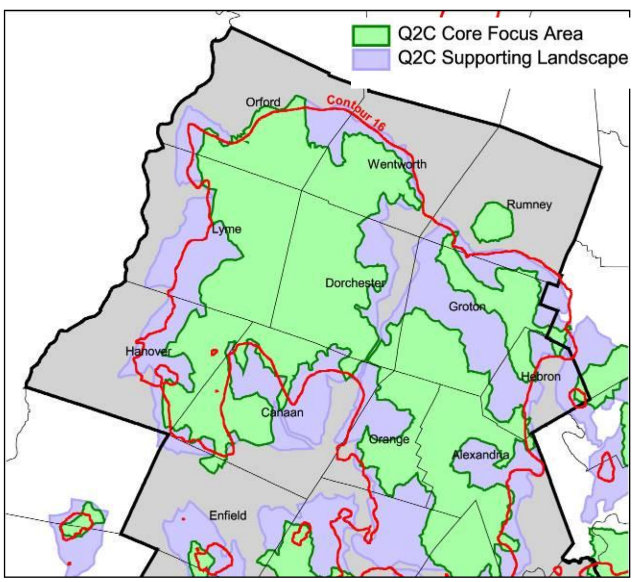
To more fully illustrate the decision model used in delineating CFA and supporting landscapes for the Q2C region, the following series of map insets lay out the series of data factors used for the northern portion of the Q2C study area. The first two maps represent the foundation data factors – forest blocks and high quality stream watersheds -- followed by other important data sets that serve to guide refinement of the CFA and supporting landscape boundaries. The final map points out specific areas where a professional judgment was made in deciding the final outlines.

Contour 16 (the 20% factor) from the focal mean analysis is shown in the first few maps as the starting point for CFA delineation. The later maps shift to the actual CFA boundary.



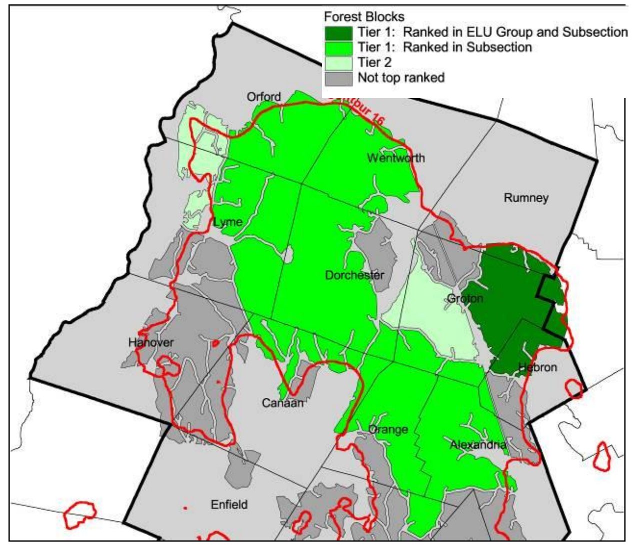


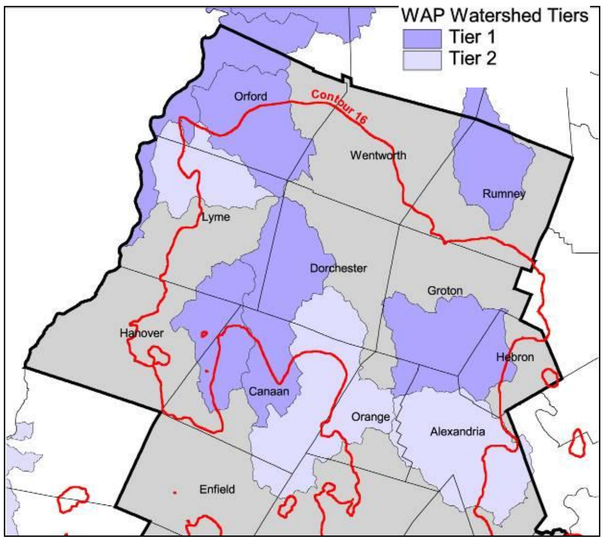
The map above shows the NH WAP forest blocks that intersect contour 16; these blocks form the most basic structure of the CFA. The next map shows USGS *SPARROW* watersheds overlaid on the forest blocks. Near pristine, EPA-defined reference reaches are shown in yellow, with contiguous high quality rural stream watersheds in lavender. Taken together, these watersheds form the core of the CFA where they overlap the forest blocks (see map on following page).



This map shows how the forest blocks and high quality watershed combine to form CFA and supporting landscapes, in green and lavender, respectively. This first step in defining CFA then moves onto secondary, qualitative considerations that may cause adjustments to the preliminary boundaries, typically reaching out to include additional areas. This second step is outlined below.

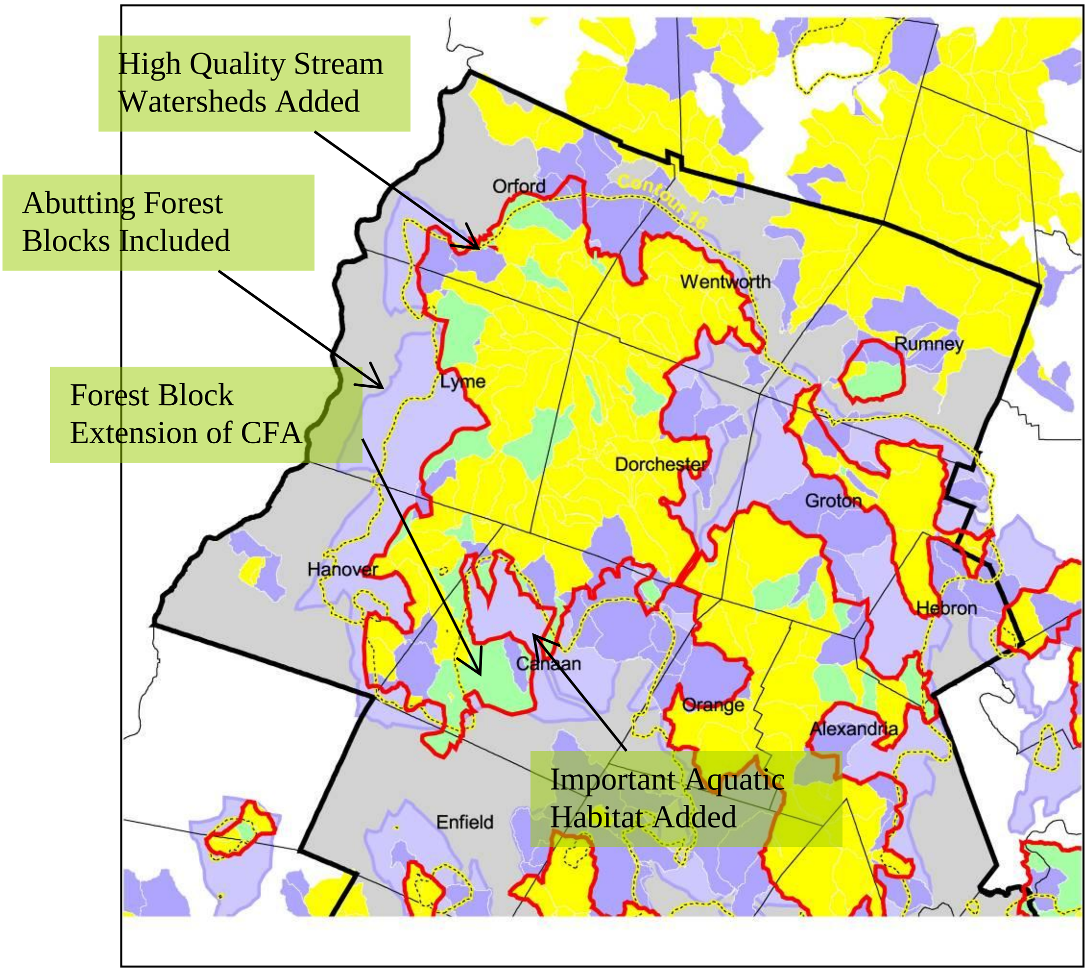
Some forest blocks are ranked more important than others in the WAP process, as shown in the map at the right where tiered ratings are color-coded. The darkest green block holds the highest habitat value ranking in this inset map because it ranked high in its ecological land unit (ELU) group and subsection. The bright green is also ranked Tier 1, and is important within its more narrow ELU subsection definition. These two tier ranks were carried forward in the delineation process, with higher rankings given more consideration in deciding CFA boundaries, especially for core areas.





An additional WAP reference dataset for HUC 12 watersheds was used similar to WAP forest block tier rankings as a consideration in delineating CFA and supporting landscape boundaries. These watersheds are more extensive and lower spatial resolution than the SPARROW stream watersheds, and are based on larger watershed groups with physical characteristics (geology, topography, elevation) and ecological factors (climate, connectivity). Tier 1 watersheds represent entire HUC 12 watersheds ranked in the top 15% by area of a watershed group; Tier 2 watersheds represent the top 30% by area and focus on a 100 meter riparian and shoreland buffer network. These watersheds do not match the SPARROW watersheds due to widely different modeling intent and resolution, but were used in the second step of refinement to identify areas of important water quality where CFA and supporting landscape boundaries should be expanded.

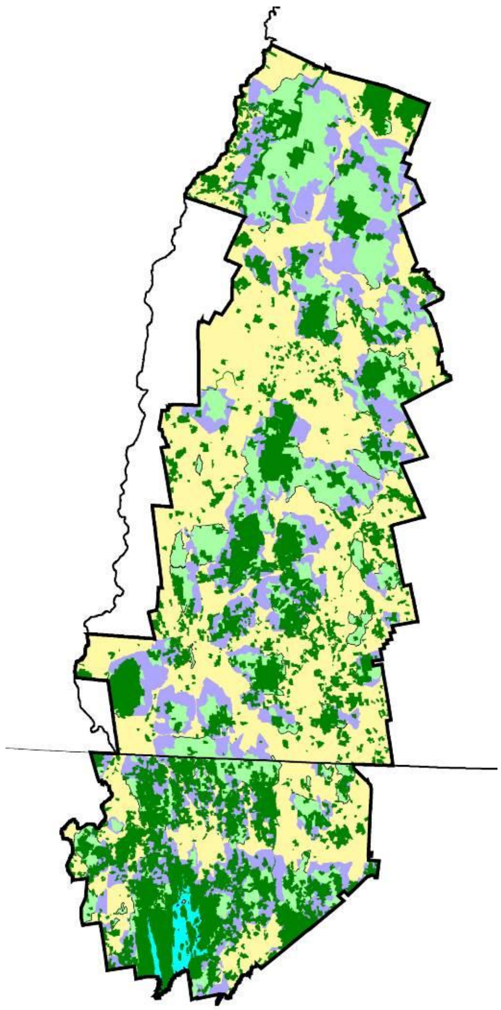
The map below illustrates a few examples of how professional judgment in subsequent steps in refined the delineation of the CFA and supporting landscapes adjusted the boundaries. Contour 16 is shown for reference, and the red outline shows the final CFA. SPARROW watersheds appear in yellow and darker lavender. The green color shows areas of forest blocks not overlaid by high quality stream watersheds. The lighter lavender color polygons are supporting landscape zones.



Regional CFA Statistical Overview

The final delineations yielded a total of 70 core focus areas and 182 supporting landscape polygons for the Q2C database. Of these, 64 core focus areas are totally within the Q2C project area, or overlap significantly into it; 166 supporting landscape polygons do the same. However, due to high conservation values, CFA and supporting landscape were investigated to the immediate northeast and southeast of the Q2C project boundary during the delineation phase, and have been retained in the database.

Core focus areas and supporting landscapes "within" the project boundary total 486,577 acres and 418,347 acres, respectively. All the CFA taken together total 698,560 acres, and all supporting landscapes total 552,007 acres. Within the Q2C project boundary, the mean size of CFA is about 9,810 acres, while the median size is 4,140 acres. Supporting landscapes are more amorphous, and are shared among several CFA, so mean and median data are not significant.

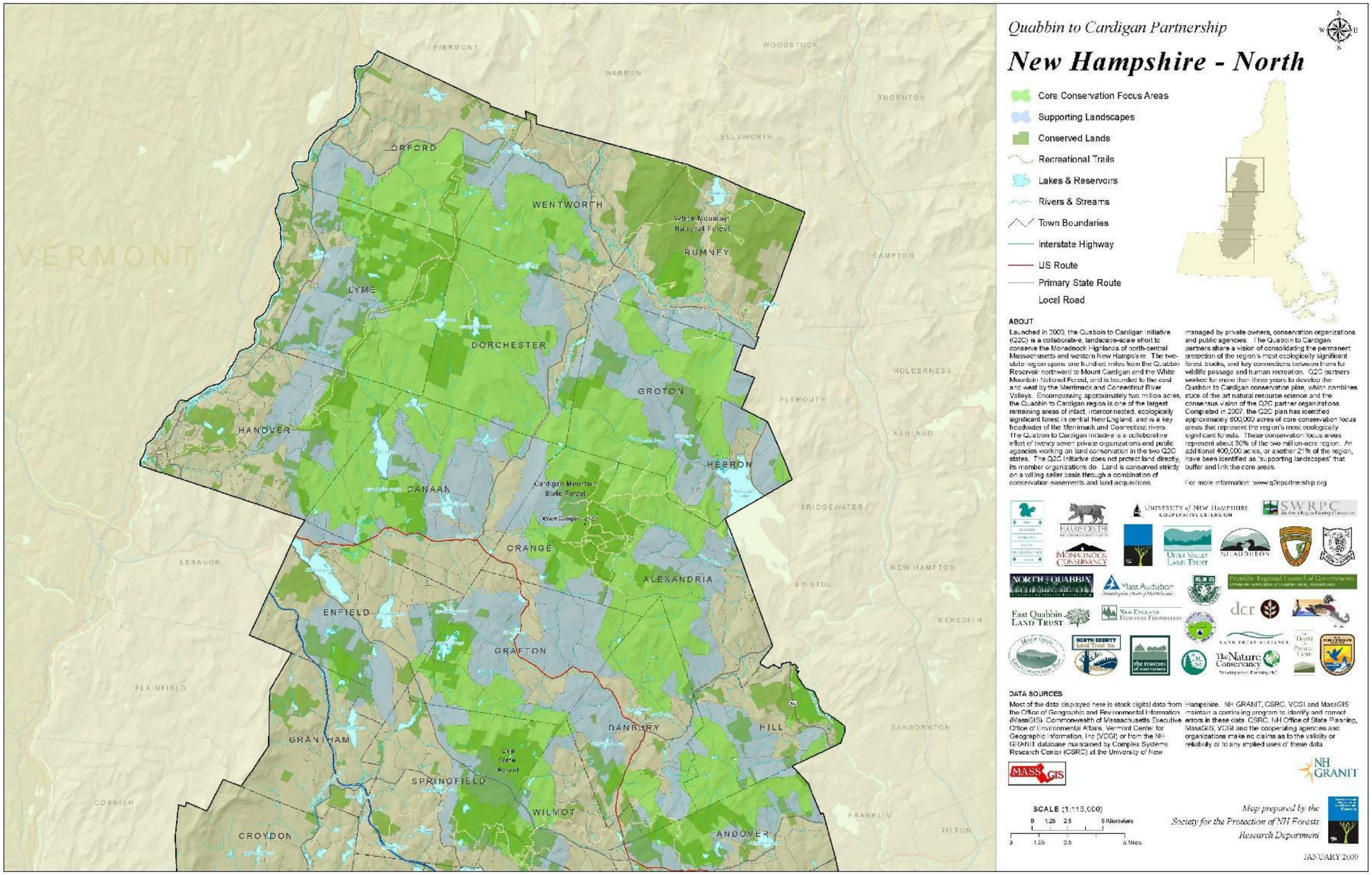


Within the Q2C, about 47%, or 229,776 acres, of the suite of CFA are currently protected, as are 26%, or 108,946 acres, of the associated supporting landscapes. However, as can be seen in the map to the left, the distribution of protected land (dark green) within the combined CFA (light green) and supporting landscapes (lavender) varies considerably along the length and breadth of the project area.

The level of protection in the Massachusetts portion of the Q2C is quite high due to the lands surrounding the Quabbin Reservoir and the extent of land protected recently by the commonwealth and private land trusts in north of the Quabbin Reservoir. In New Hampshire, large areas of protected land exist in the Mt. Monadnock, Mt. Sunapee and Mt. Cardigan regions, and at Pisgah State Park in the southwestern quarter. However, permanently protected land is more scarce in the large CFA in the northern Q2C project area, and in a series of connecting CFA among the mountain peaks noted above.

Maps

Detailed maps of the Q2C project area are provided on the following four pages, broken into four map frames north to south.


Quabbin to Cardigan Partnership
New Hampshire - North
Core Conservation Focus Areas
Supporting Landscapes
Conserved Lands
Recreational Trails
Lakes & Reservoirs
Rivers & Streams
Town Boundaries
Interstate Highway
US Route
Primary State Route
Local Road
ABOUT
Launched in 2003, the Quabbin to Cardigan Initiative (Q2C) is a collaborative, landscape-scale effort to conserve the Monadnock Highlands of north-central Massachusetts and western New Hampshire. The two-state region spans one hundred miles from the Quabbin Reservoir northward to Mount Cardigan and the White Mountain National Forest, and is bounded to the east and west by the Merrimack and Connecticut River Valleys. Encompassing approximately two million acres, the Quabbin to Cardigan region is one of the largest remaining areas of intact, interconnected, ecologically significant forest in central New England, and is a key headwater of the Merrimack and Connecticut rivers. The Quabbin to Cardigan Initiative is a collaborative effort of twenty seven private organizations and public agencies working on land conservation in the two Q2C states. The Q2C Initiative does not protect land directly, its member organizations do. Land is conserved strictly on a willing seller basis through a combination of conservation easements and land acquistions managed by private owners, conservation organizations and public agencies. The Quabbin to Cardigan partners share a vision of consolidating the permanent protection of the region's most ecologically significant forest blocks, and key connections between them for wildlife passage and human recreation. Q2C partners worked for more than three years to develop the Quabbin to Cardigan conservation plan, which combines state-of-the-art natural resource science and the consensus vision of the Q2C partner organizations. Completed in 2007, the Q2C plan has identified approximately 600,000 acres of core conservation focus areas that represent the region's most ecologically significant forests. These conservation focus areas represent about 30% of the two million-acre region. An additional 400,000 acres, or another 21% of the region, have been identified as "supporting landscapes" that buffer and link the core areas.
For more information: www.q2cpartnership.org
DATA SOURCES
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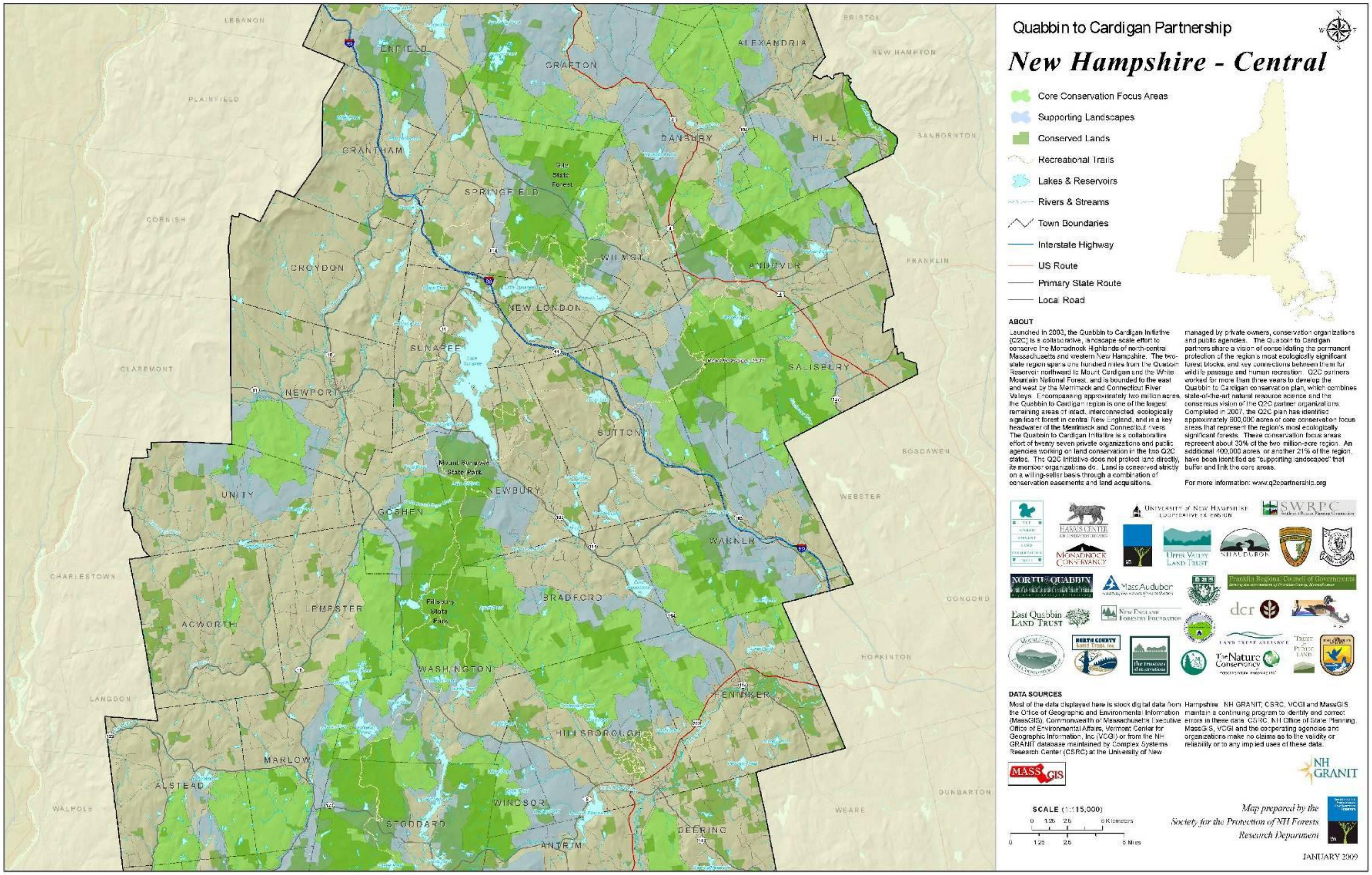
SCALE (1:115,000)
0 1.25 2.5 5 Kilometers
0 1.25 2.5 5 Miles
Map prepared by the
Society for the Protection of NH Forests
Research Department
JANUARY 2009
VERMONT
PIERMONT
WOODSTOCK
WARREN
THORNTON
ELLSWORTH
ORFORD
WENTWORTH
RUMNEY
White Mountain National Forest
CAMPTON
LYME
DORCHESTER
HOLDERNESS
GROTON
PLYMOUTH
HANOVER
ASHLAND
HEBRON
CANAAN
Cardigan Mountain State Forest
BRIDGEWATER
ORANGE
LEBANON
ALEXANDRIA
NEW HAMPTON
BRISTOL
ENFIELD
MEREDITH
GRAFTON
PLAINFIELD
DANBURY
HILL
SANBORNTON
GRANTHAM
SPRINGFIELD
CORNISH
WILMOT
FRANKLIN
CROYDON
ANDOVER
TILTON



Quabbin to Cardigan Partnership
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0 1.25 2.5 5 Kilometers
0 1.25 2.5 5 Miles
Map prepared by the
Society for the Protection of NH Forests
Research Department
JANUARY 2009
LEBANON
PLAINFIELD
CORNISH
CLAREMONT
CHARLESTOWN
LANGDON
WALPOLE
BRISTOL
NEW HAMPTON
ALEXANDRIA
SANBORNTON
FRANKLIN
BOSCAWEN
WEBSTER
CONCORD
HOPKINTON
DUNBARTON
WEARE
ENFIELD
GRAFTON
DANBURY
HILL
GRANTHAM
SPRINGFIELD
Gile State Forest
WILMOT
ANDOVER
CROYDON
NEW LONDON
SUNAPEE
SALISBURY
NEWPORT
SUTTON
Mount Sunapee State Park
UNITY
NEWBURY
GOSHEN
WARNER
LEMPSTER
BRADFORD
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WASHINGTON
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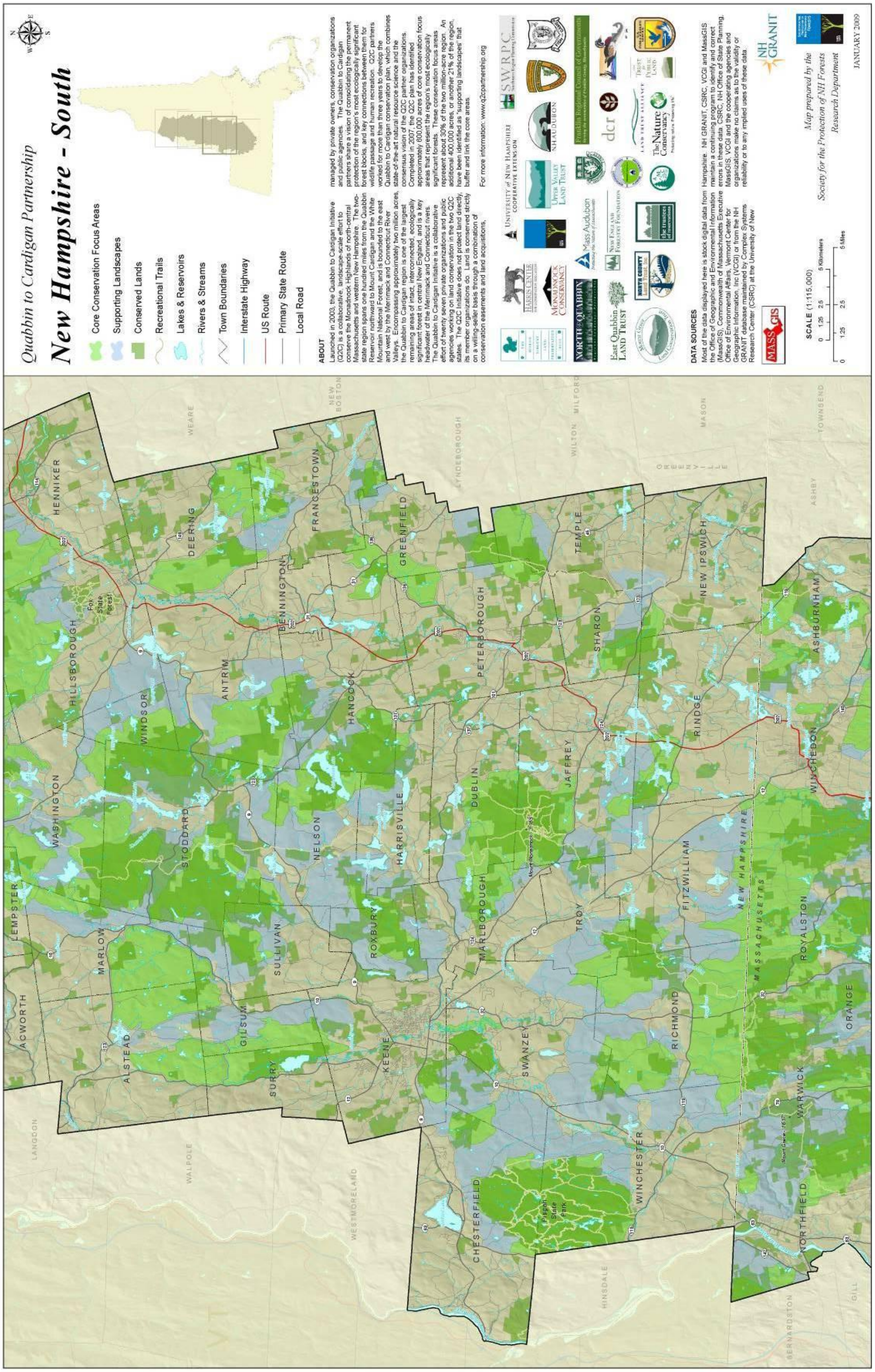
WINDSOR
STODDARD
DEERING
ANTRIM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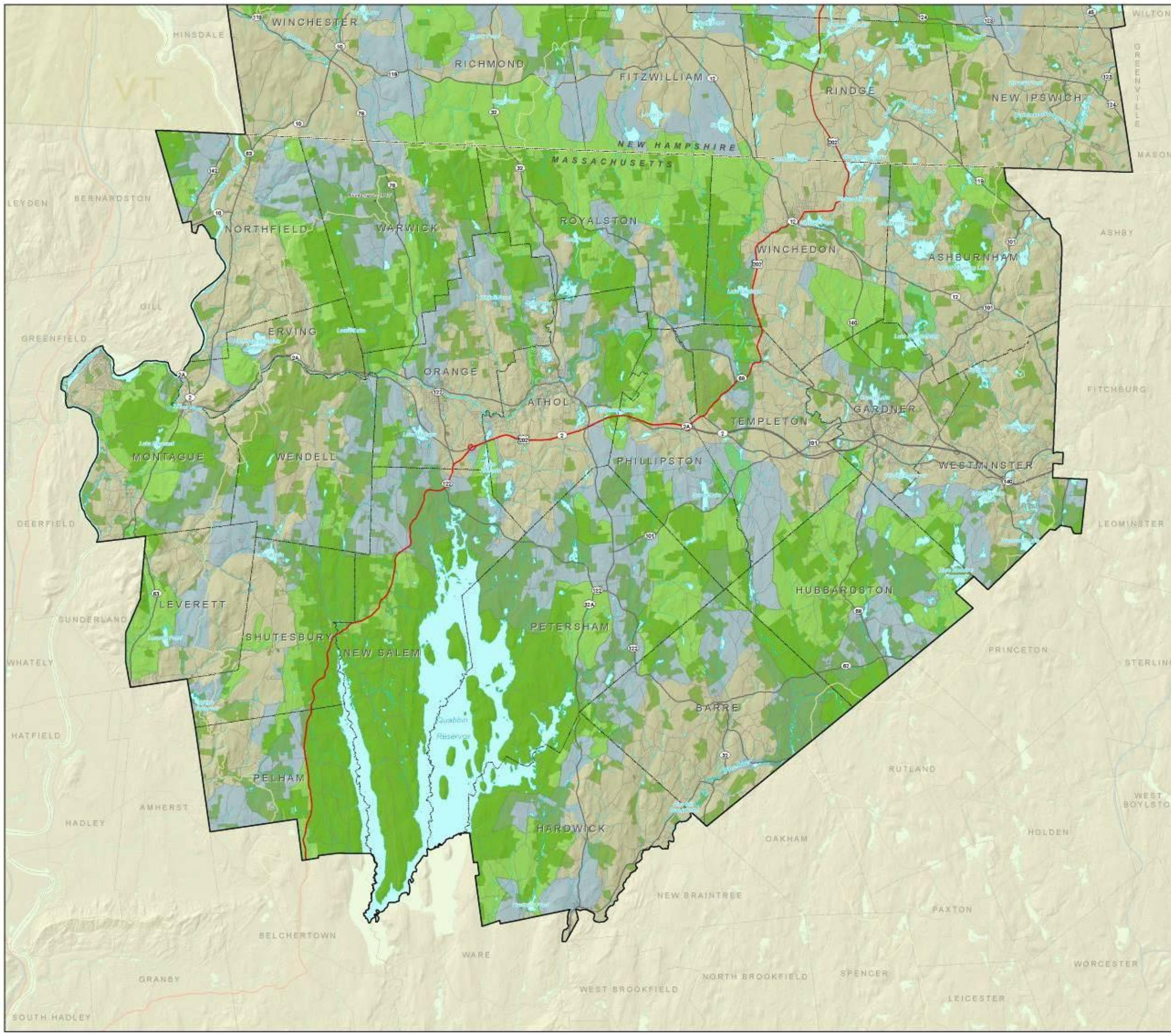
Local Road
ABOUT
Launched in 2003, the Quabbin to Cardigan Initiative (Q2C) is a collaborative, landscape-scale effort to conserve the Monadnock Highlands of north-central Massachusetts and western New Hampshire. The two-state region spans one hundred miles from the Quabbin Reservoir northward to Mount Cardigan and the White Mountain National Forest, and is bounded to the east and west by the Merrimack and Connecticut River Valleys. Encompassing approximately two million acres, the Quabbin to Cardigan region is one of the largest remaining areas of intact, interconnected, ecologically significant forest in central New England, and is a key headwater of the Merrimack and Connecticut rivers. The Quabbin to Cardigan Initiative is a collaborative effort of twenty seven private organizations and public agencies working on land conservation in the two Q2C states. The Q2C Initiative does not protect land directly, its member organizations do. Land is conserved strictly on a willing-seller basis through a combination of conservation easements and land acquisitions, managed by private owners, conservation organizations and public agencies. The Quabbin to Cardigan partners share a vision of consolidating the permanent protection of the region's most ecologically significant forest blocks, and key connections between them for wildlife passage and human recreation. Q2C partners worked for more than three years to develop the Quabbin to Cardigan conservation plan, which combines state-of-the-art natural resource science and the consensus vision of the Q2C partner organizations. Completed in 2007, the Q2C plan has identified approximately 600,000 acres of core conservation focus areas that represent the region's most ecologically significant forests. These conservation focus areas represent about 30% of the two million-acre region. An additional 400,000 acres, or another 21% of the region, have been identified as "supporting landscapes" that buffer and link the core areas.
For more information: www.q2cpartnership.org
DATA SOURCES
Most of the data displayed here is stock digital data from the Office of Geographic and Environmental Information (MassGIS), Commonwealth of Massachusetts Executive Office of Environmental Affairs, Vermont Center for Geographic Information, Inc (VCGI) or from the NH GRANIT database maintained by Complex Systems Research Center (CSRC) at the University of New Hampshire. NH GRANIT, CSRC, VCGI and MassGIS maintain a continuing program to identify and correct errors in these data. CSRC, NH Office of State Planning, MassGIS, VCGI and the cooperating agencies and organizations make no claims as to the validity or reliability or to any implied uses of these data.
SCALE (1:115,000)
0 1.25 2.5 5 Kilometers
0 1.25 2.5 5 Miles
Map prepared by the
Society for the Protection of NH Forests
Research Department
JANUARY 2009



Quabbin to Cardigan Partnership

Massachusetts

- Core Conservation Focus Areas
- Supporting Landscapes
- Conserved Lands
- Recreational Trails
- Lakes & Reservoirs
- Rivers & Streams
- Town Boundaries
- Interstate Highway
- US Route
- Primary State Route
- Local Road

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