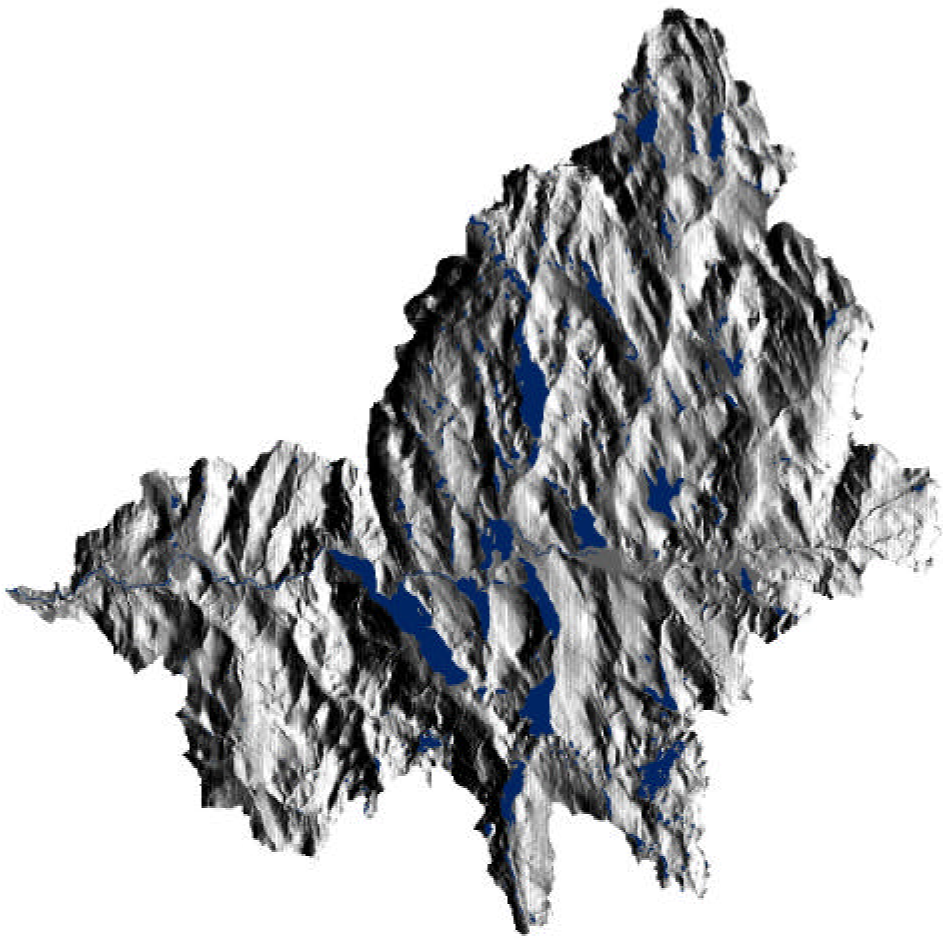
Mascoma River Watershed
Natural Resource Inventory



Prepared for:

The Mascoma Watershed Conservation Council

Prepared by:

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1. Introduction

In October of 2002, The Society for the Protection of New Hampshire Forests (SPNHF) entered into an agreement with the Mascoma Watershed Conservation Council (MWCC) to complete a natural resource inventory (NRI) for the 195 square mile Mascoma River watershed, located in west-central New Hampshire (**Figure 1, Mascoma Watershed Study Area)**. This report details the findings from that NRI and presents recommendations for further work.

The goals of the NRI were to:

1. Map and describe significant natural resources;
2. Examine land use / natural resource relationships;
3. Identify areas of high ecological value based on co-occurrence of significant features;
4. Develop strategic options for natural resources protection.

MWCC, SPNHF, and the Upper Valley Lake Sunapee Regional Planning Commission (UVLSRPC) cooperated to develop a project scope which included the following mapping and analysis products:

1. Conservation Lands Basemap
2. Land Cover
3. Soils
4. Unfragmented Lands
5. Water Resources
6. Wildlife Habitat
7. Co-occurrence Model

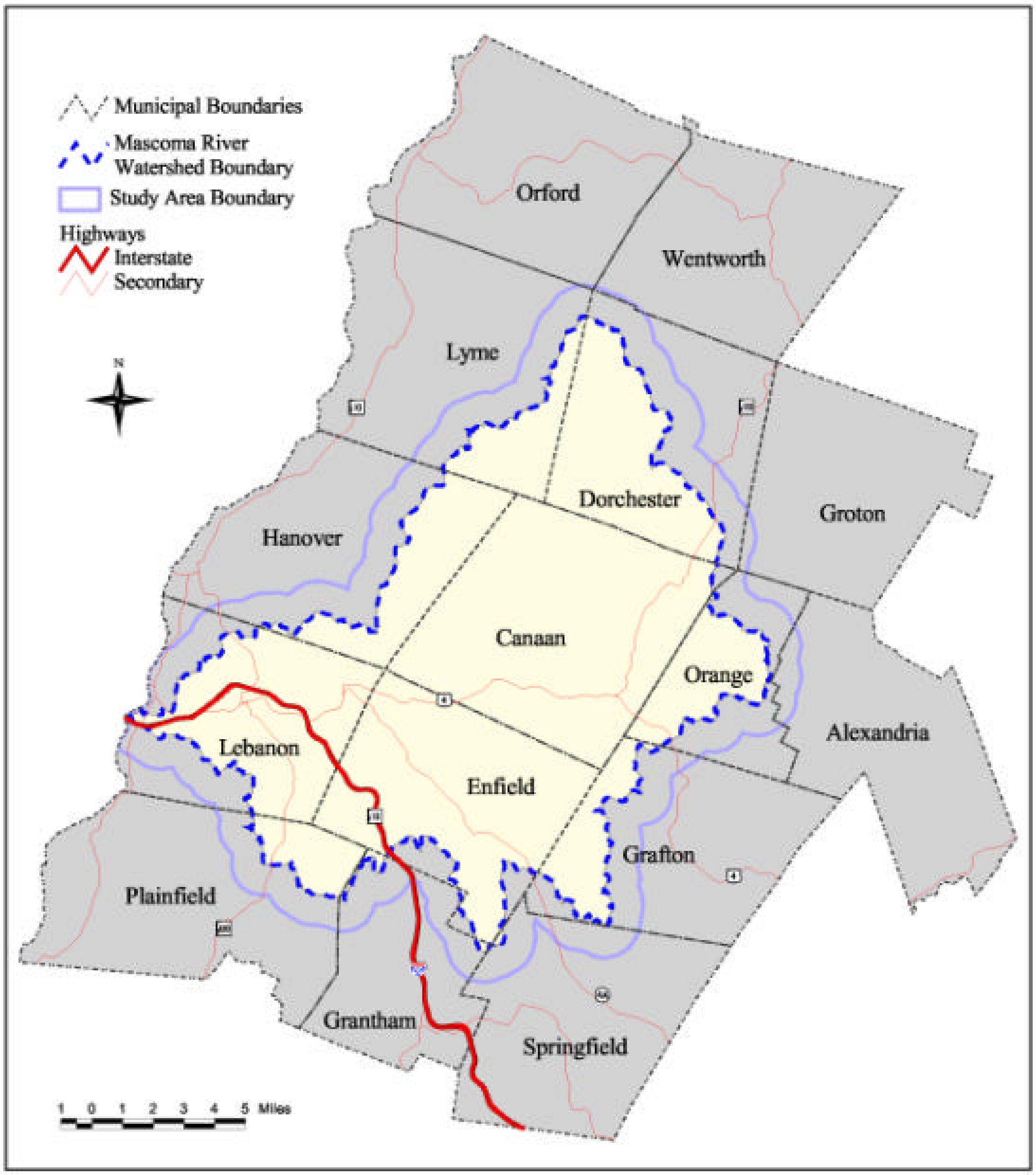
Each map displays the appropriate and "best available" data for its portion of the natural resources analysis. The maps are intended as planning tools, and are designed to present a landscape scale picture of the watershed in such a way that patterns of natural resource occurrence are clearly evident to decision makers. It should be emphasized that these are broad scale planning tools and as such are not meant for specific navigation or for parcel-specific land protection or management.

SPNHF staff carried out the NRI analysis using geographic information systems (GIS). Many of the analysis techniques were adapted from the 2001 University of New Hampshire Cooperative Extension publication Natural Resource Inventories; A Guide for New Hampshire Communities and Conservation Groups. SPNHF staff have developed and applied new approaches to these techniques and in some cases have developed new methods of analysis. For example the approach to creating the undeveloped shorelines and riparian zones layer (see **Wildlife Habitat** below) was developed by SPNHF staff.

SPNHF staff carried out data acquisition, analysis, and cartographic production. UVLSRPC collaborated with MWCC and SPNHF through funding from the Connecticut River Joint Commission Partnership Program. UVLSRPC provided assistance with project design, data updates, and map critique. UVLSRPC staff also organized public outreach and presentation of the project.

Stock data layers were provided by New Hampshire GRANIT (Geographically Referenced Analysis and Information Transfer System). A full technical description of data can be found in the **Technical Report on GIS Data** in **Appendix 1**.

Figure 1: Mascoma Watershed Study Area



2. Maps and Analyses

Seven maps / analyses were completed for this NRI. This section briefly describes the first six maps which display the various natural resources of the watershed. The final map / analysis product, the co-occurrence model, is described in a subsequent section. Each map displays a unique natural resource category in detail. They are designed to be used for planning particular land protection strategies or land management options.

Each map is drawn at the same scale, and includes a 1 mile buffer around the entire watershed for context. Also, several reference data features displayed are common to all of the maps. They include:

- Municipal boundaries
- Roads
- Railroads
- Hydrography (lakes, ponds, rivers, streams, and wetlands)
- Watershed boundaries
- Conservation and Public lands

Conservation Lands

Map 1, Conservation Lands, shows protected conservation and public lands in the watershed. This layer was released by GRANIT in February, 2002, and updated by SPNHF and UVLSRPC in January, 2003. These lands include Federal, State, Municipal, and privately owned conservation lands under a variety of protection types (e.g. conservation easements, fee-ownership, deed restrictions, or some combination of types). The vast majority (99.7% by acreage) of conservation lands in the watershed are under level 1 protection as defined by GRANIT. That is, these properties may be considered "permanent" conservation lands and will remain undeveloped.

This map is designed to give an overall picture of the watershed and the conservation lands which fall within the study area. Conservation Lands are displayed by categories of protecting agency (i.e. that agency which achieved the conserved status of that property; not to be confused with ownership).

The map reveals that there are some significant conservation properties in the Mascoma River watershed, most notably the Cardigan Mountain State Forest on the eastern edge of the region, and various large, state-protected wildlife management areas in Dorchester and Enfield. There are also significant complexes of conservation land protected largely by non-profit entities[1] such as those around Grafton, Spectacle, and Bear Ponds. **Table 1** shows conserved acreage within each town within the watershed.

[1] Non-profit land trusts in the study area include the Appalachian Mountain Club, the Grafton Pond Land Trust, the Mascoma Watershed Conservation Council, the Society for the Protection of New Hampshire Forests, and the Upper Valley Land Trust.

Table 1: Acreage of Protected Lands within the Mascoma River Watershed[2]

Town	Conserved Acres	Total Acres	% Protected
Grafton	1,812.2	5,281.4	34.3
Orange	1,617.7	6,907.1	23.4
Dorchester	2,679.0	14,588.4	18.4
Hanover	1,718.8	9,591.3	17.9
Enfield	4,127.9	25,379.4	16.3
Grantham	43.4	384.1	11.3
Lebanon	1,127.0	17,777.6	6.3
Canaan	2,069.3	35,030.5	5.9
Lyme	222.3	5,878.4	3.8
Plainfield	102.3	3,702.3	2.8
Springfield	0	76.9	0
Mascoma Watershed	**15,519.9**	**124,597.4**	**12.5**

At 12.5%[3], a relatively small fraction of the Mascoma River watershed is permanently protected. This is much less than the statewide percentage of 23.1%[4] (though it should be noted that approximately half of that figure comes from the White Mountain National Forest). However, significant portions of the watershed remain relatively undeveloped and sparsely settled (see next section, Land Cover), so many future conservation opportunities exist here.

[2] Source: GRANIT Conservation Lands data layer; issued April 2002, updated by SPNHF as of January, 2003

[3] We considered the GRANIT designated level 1 lands to be "permanently protected"

[4] Source: GRANIT Conservation Lands data layer; issued April 2002, updated by SPNHF as of January, 2003

Land Cover

Map 2, Land Cover, shows various land use and land cover types in the watershed. GRANIT developed this layer in 2001 from satellite imagery / remote sensing data ranging from 1990 to 2000. The map displays natural cover types such as forests, wetlands, and water, as well as types more intensively used by humans such as developed or agricultural lands.

This map is a useful reference in terms of describing the natural and land-use character of the watershed. What is immediately obvious is that there is extensive, unbroken forest cover within the watershed, totaling over 99,491 acres[5], or about 80% of the total land area of the watershed (see **Table 2**).

What is most striking about the Land Cover map is that it shows the relatively insignificant extent of development in the Mascoma River watershed, only about 5.5%. However, it should be noted that there are emerging development pressures in this watershed. The historical and recent patterns of settlement and transportation systems indicate that growth will likely increase in the Connecticut River valley, and along the Interstate Route 89 and Route 4 corridors.

The map also reveals something about the physical character of the region. A look at the topographic contours shows steep relief in many areas, particularly toward the upper reaches of the watershed in the north and east, in Dorchester, Canaan, and Orange. This region forms the south-western boundary of the White Mountains, where the classic glaciated mountain landscape extends into this watershed.

Patterns of human settlement can also be seen to some extent here through the road network. The transportation network tends to be more dense in the Connecticut River Valley, e.g. Lebanon, and through the central valley where Route 4 follows the Mascoma River. Areas towards the north and east tend to see less traveled roadways, and are more sparsely settled.

[5] Includes the GRANIT Land cover category group, 400 to 499, “Forested”, and 610, “Forested Wetlands”

Table 2: Land Cover of the Mascoma River Watershed[6]

Land Cover Type	Acreage	% Watershed
Developed Cover Types		
Residential, commercial, or industrial	1,810	1.45
Transportation[7]	5,076	4.07
Total Developed:	**6,886**	**5.52**
Agricultural Cover Types		
Row crops	185	0.15
Hay/rotation/permanent pasture	5,770	4.63
Fruit orchards	57	0.05
Total Agricultural:	**6,012**	**4.83**
Forested Cover Types		
Beech/oak	18,900	15.17
Paper birch/aspen	2,431	1.95
Other hardwoods	18,406	14.77
White/red pine	10,887	8.74
Spruce/fir	11,333	9.10
Hemlock	5,879	4.72
Mixed forest	30,374	24.38
Forested Wetlands	1,281	1.03
Total Forested:	**99,491**	**79.86**
Water Cover Types		
Open water	4,288	3.44
Non-forested wetlands	2,197	1.76
Total Water:	**6,485**	**5.20**
Other Cover Types		
Disturbed	103	0.08
Bedrock/vegetated	47	0.04
Cleared/other open	5,569	4.47
Total Other:	**5,719**	**4.59**
Total Watershed Acreage:	**124,593**	**100.00**

[6] For accuracy assessment see Appendix 1
[7] "Transportation" category (140) amended from NH DOT "Roads" vector layer; Satellite derived transportation data is considered to underestimate the extent and effects of roads.

Unfragmented Lands

Map 3, Unfragmented Lands describes the degree of "land fragmentation" in the watershed. Undeveloped land becomes fragmented over time as new roads and intensive human land use convert the natural landscape. This data layer was created in several steps. First, traveled roadways were identified (those roads which are paved or in regular use; discontinued and class 6 roads were not included as their effects on wildlife habitat are assumed to be negligible). Next a 500-foot buffer was applied to the identified roads to account for frontage development (primarily residential) not included in the land cover classification or assumed likely in the future. These buffers were then erased from the surrounding land mass.

The result is unbroken "blocks" of land, largely in natural land cover including forests, wetlands, or open water. These unfragmented blocks therefore describe land that is likely to be high quality wildlife habitat. For forest interior species such as Black Bear, Bobcat, or Moose, the larger the block, the more likely that species will be found there. These unfragmented blocks are also another visual way to interpret the degree and extent of development in the watershed. Where large blocks of unfragmented land are found, development is obviously not as widespread, and thus, human disturbances in the natural landscape are minimized.

The Mascoma River watershed includes portions of some very large unfragmented areas, more than 25,000 acres, most significantly, large blocks in Dorchester, Orange, and Plainfield on the highest ridges of the watershed divide. The largest blocks falling entirely within the watershed are the Lovejoy Brook and Goose Pond West blocks in Canaan and Hanover.

Table 3, Unfragmented Lands (> 1000 acres) shows unfragmented blocks by size and conserved status. This table, like **Table 1**, shows that there is significant conservation potential for some of the larger unfragmented blocks.

Table 3: Unfragmented Lands (> 1000 acres)[8]

Block Name	Total Acreage	Acreage within Watershed	% Conserved Total	% Conserved within Watershed
Mascoma River Headwaters	59287	22296	11.5	11.7
Mount Cardigan	33417	5524	19.8	28.1
Snow Mountain	18130	3441	7.0	0.0
Smith Pond	8205	6056	53.8	50.6
Moose Mountain	7693	4430	32.2	33.4
Grafton Pond	4888	2683	40.5	66.0
Marshall Brook	4414	2047	20.8	3.3
Great Brook	3887	1374	16.4	7.4
Prescott Hill	3475	1214	10.6	24.8
Goose Pond West	3461	3461	3.5	3.5
Boston Lot Lake	3150	1330	16.8	0.2
Lovejoy Brook	2911	2911	2.1	2.1
Mirror Lake	2464	737	15.8	1.1
Bear Pond	2461	2461	49.6	49.6
McDaniels Marsh	2201	116	36.1	16.9
Half Moon	2116	87	0.0	0.0
Methodist Hill	2101	2101	0.0	0.0
Apple	1917	116	1.7	2.2
Mud Pond	1453	1453	12.4	12.4
George Pond	1380	1340	0.5	0.5
Mount Tug	1370	1270	5.0	1.3
Canaan Lake	1362	1362	3.2	3.2
Signal Hill	1270	1182	3.6	3.8
Indian River	1251	1251	0.0	0.0
Gulf Brook	1245	1245	0.0	0.0
Farnum	1225	628	58.1	46.3
Goodwin	1160	1153	30.9	31.1
Height of Land	1106	808	0.0	0.0
Hoyt Brook	1099	1099	0.0	0.0
Rix Ledge	1008	275	3.9	5.3

[8] Unfragmented Lands names chosen for this study by the MWCC board

Important Soils

The soils map (**Map 4, Important Soils**) displays four classes of soil as defined by the USDA Natural Resources Conservation Service.

- *Prime farmland soils* are considered to have the best properties for high yield agricultural use.
- *Farmland soils of statewide importance* are essentially second tier agricultural soils; those soils which are not prime or unique, but are still important for production in New Hampshire.
- *Hydric soils* are found in wetland areas and are defined as being perennially saturated with water.
- *Important forest soils* includes those soils which are particularly well suited to timber production[9].

Important forest soils are widespread and extensive in the watershed, occurring in approximately 60.5% of the watershed. Of these, the class IC soils (outwash sands and gravels) occur over only 2.7% of the watershed. This soils class is highlighted on the map as it is considered to be ideal for growing high volumes of White Pine (*Pinus strobus*), a particularly valuable and marketable timber. IC soils are also typically well suited for development and thus are often threatened. IC soils tend to fall in valley bottoms, and thus along transportation corridors. This is the case in the Mascoma River watershed, perhaps increasing the threat to this valuable soil class.

This map is perhaps the best description of the extent of wetlands in the watershed through the display of Hydric soils. These soils tend to be concentrated in valley bottoms and along stream corridors. Wetlands tend to be areas where wildlife concentrate as they provide relatively open travel corridors, sources of water, and high plant diversity for forage.

[9] See Appendix 1 for full NRCS description of Important Forest Soils.

Water Resources

This map / analysis shows potential water resources and threats to water quality (see **Map 5, Water Resources**). Water resources include aquifers and potentially favorable gravel well areas, as well as lakes, ponds, mapped perennial streams, and wetlands. Aquifers displayed here are valuable as they have high recharge rates, and can thus potentially provide significant amounts of water for the public water supply. Potentially favorable gravel well areas are those portions of the aquifers which have the highest recharge rates and which are not yet subject to potential water contamination[10].

Public water supplies and the surrounding protection areas are also shown on this map. A sanitary radius describes the zone around a well site from which the well draws water; this zone is regulated by the New Hampshire Department of Environmental Services (NH DES) and is required to be kept in natural land cover. Well head protection areas describe a similar but larger zone around the surface water intake of public wells for municipally owned water supplies. Ideally these zones should be protected from development, and certainly from contamination.

Threats to water quality include contamination sites and point sources of pollution, junkyards, underground fuel storage tanks, and the Lebanon Snow Dump.

This map shows the spatial coincidence of threats to water quality and water resources. In New England valley bottoms, transportation corridors and development typically overlay high quality aquifers. One can see here that on and around many of the aquifers and public water supplies, threats to water quality can be found. There are, however, some potentially high quality gravel well areas which are as yet unimpacted and effort should be put into securing a degree of protection in these areas.. **Table 4, Conserved Water Resources** shows the extent of conserved land over water resource areas. (see **Conservation Opportunities** section for more information on water resource protection)

Table 4: Conserved Water Resources

	Total Acreage	Conserved Acreage	% Conserved
Sanitary Radii	110.3	14.4	13.0
Well Head Protection Areas	5010.4	231.9	4.6
Potentially Favorable Gravel Well Areas	258.8	70.8	27.4

[10] See Appendix 1 for detailed NH DES information on deriving Potentially Favorable Gravel Well Areas

Wildlife Habitat

The objective of this map is to show natural resources as they relate to wildlife habitat features and to give a sense for where such features are likely to be found in close proximity or interacting with each other (see **Map 6, Wildlife Habitat**). Several special data sets were used or developed for this map including:

- Undeveloped Shorelines
- Open / Agricultural Lands
- Quarries and Gravel Pits
- Deer Yards
- South Facing Slopes
- Steep Slopes
- NWI (highlighting emergent wetlands)

Undeveloped shorelines were developed by creating 150 and 300 foot buffer around lakes and ponds over 10 acres and perennial streams. The tighter buffers (150') are generally considered to be a critical boundary; that is, important wildlife generally will not make use of undeveloped shoreline narrower than 150'. The larger boundaries (300') are considered "ample", allowing adequate area for nesting, local migration, etc. Developed areas were delineated through the interpretation of digital aerial photographs and land cover data. Areas upon which there was construction or paved surfaces were considered developed, as were mowed grass or fields, power line right-of-ways, or agricultural lands. These developed areas were then removed from the buffers to create a model of undeveloped shorelines. These remaining areas provide unbroken wildlife corridors as well as quality riparian habitat.

Open and agricultural lands are simply a derivative of the land cover data layer. The agricultural fields and open lands classes were selected and then saved as a new data layer. Open lands in this watershed include agricultural lands as well as old fields and cleared forest. These areas provide a variety of habitat from grassland to early successional forests and depending on their size and site can provide ideal settings for a whole host of unique species, including the New England Cottontail.

Quarries and gravel pits derived from the DES data layer "point pollution sources". Inactive and abandoned quarries and gravel pits were displayed on this map as a point feature. For the final analysis (ie. the co-occurrence analysis) quarries and gravel pits were drawn as polygon features through the use of digital USGS topographic maps and aerial photo interpretation. Quarries and gravel pits offer important nesting habitat for reptiles and breeding habitat for amphibians due to the presence of open soils and sands, and pools of water.

UVLSRPC staff provided deer yard data, which they digitized for this study from paper maps produced by the NH Fish and Game Department. Deer yards are areas where deer herds over-winter and typically consist of coniferous forest cover type (especially hemlock groves) where they can find forage and be sheltered from snow.

Slope data were derived from a digital elevation model of northern New England produced and provided by the US Geological Service. South facing slopes were considered to be any south or southwest facing slopes with a gradient over 10%. These areas are generally sunny (and warm) and thus preferred by wildlife (such as Wild Turkey and White-tailed Deer), especially in the winter. Steep slopes were considered to be any slopes over 35%. Steep slopes are typically rocky and provide good habitat for bobcat and porcupine, especially where the land cover on south-facing slopes is hardwood forest.

The NWI (National Wetlands Inventory) data layer is produced by the US Fish and Wildlife Service. Wetlands are areas, often at the boundary of terrestrial and aquatic ecosystems, where the soil is seasonally or perennially saturated. Wetland ecosystems are typically diverse and many species of wildlife spend part of their life in or around wet areas. Emergent wetlands, open marshes and fens are highlighted on this map as they often show a higher degree of diversity and lack a forest canopy (and thus provide an open travel corridor).

Table 5, Wildlife Habitat Acreages shows the extent of each habitat type in the watershed. These figures make clear that there is much potential here for land protection, particularly focused on deer yards, wetlands, and open lands.

Table 5: Wildlife Habitat Acreage

	Total Acreage	% Watershed	Conserved Acreage	% Conserved
Deer Yards	9949.2	8.0	822.7	8.3
Wetlands (All)	8806.7	7.1	862.8	9.8
Emergent	997.5	0.8	82.8	8.3
Non-emergent	7809.2	6.3	780	10.0
Open Lands	12033.3	9.7	536.2	4.5
Steep Slopes	3770.1	3.0	827.3	21.9
South Slopes	13195.8	10.6	1,479.60	11.2
Undeveloped Shorelines	10136.3	8.1	1,575.30	15.5

3. Co-occurrence Model

The seventh and final map / analysis product is **Map 7, Natural Resource Co-Occurrence Model**. Creating this map was the final and integrative stage of the NRI. The map was developed by overlaying selected natural resource layers in the GIS to identify locations where multiple co-occurrences of resources existed. These co-occurrences were then displayed on the map with a range of colors to indicate increasing value/importance based on a numerical value assigned to each data factor equally, i.e. one point for each factor. Darker shades indicate more resources lie on a particular location. For this model all of the following factors were scored:

Habitat Components

- Prime Agricultural Soils
- Soils of Statewide Importance
- Composite Wetlands (Hydric Soils + NWI)
- Undeveloped Shorelines/Riparian Zones
- Unfragmented Natural Landcover Blocks > 1000 acres
- Open/Agricultural Lands (landcover classes: hay/pasture, orchards, and cleared/other open)
- Quarries & Gravel Pits
- South-facing slopes (>10% slope)
- Steep slopes (>35%)
- Deer Yards

Water Resource Components

- Stratified Drift Aquifer (maximum transmissivity >= 1000 sq ft/day)
- Potentially Favorable Gravel Well Areas
- Source Water Protection Areas (active sources only)
- Sanitary Radii (active wells only)

So the theoretical maximum score for any particular location would be fourteen (14) (i.e. all fourteen factors occur at that location). In the case of the Mascoma River watershed, the maximum score was actually nine (9), so in no location did all factors co-occur. To some extent this is due to the fact that certain classes are mutually exclusive. For instance, there is no overlap between Prime Agricultural Soils and Soils of Statewide Importance. Also, some layers are limited in geographic extent (e.g. gravel pits) and are thus less likely to overlay with other factors.

Figure 2, Co-occurrence Values by Acreage show the acreages of co-occurrence classes as they are shown on the map. Natural resource co-occurrence values of 3 or less fall on the majority of the land area of the watershed (~95%). High value areas might be considered in any number of ways. **Figure 3, High Co-occurrence Value Areas** displays concentrations of high resource values in two ways. **Figure 3A** shows the top 20% of co-occurrence values by acreage (values of 3 and higher). These concentrations of values are well distributed in the watershed with each town approximately equally represented. **Figure 3B** displays a more limited set of values, the top 5% (values of 4 or higher), and more clearly emphasizes those high value areas.

The concentrations of highest natural resource value fall largely along the Mascoma River corridor in Canaan, and seem to be largely driven by water resource values here. However, there are smaller areas of higher co-occurrence in southeast Hanover, northeast Plainfield, and in Enfield south of Mascoma Lake.

Figure 2: Co-occurrence Values by Acreage

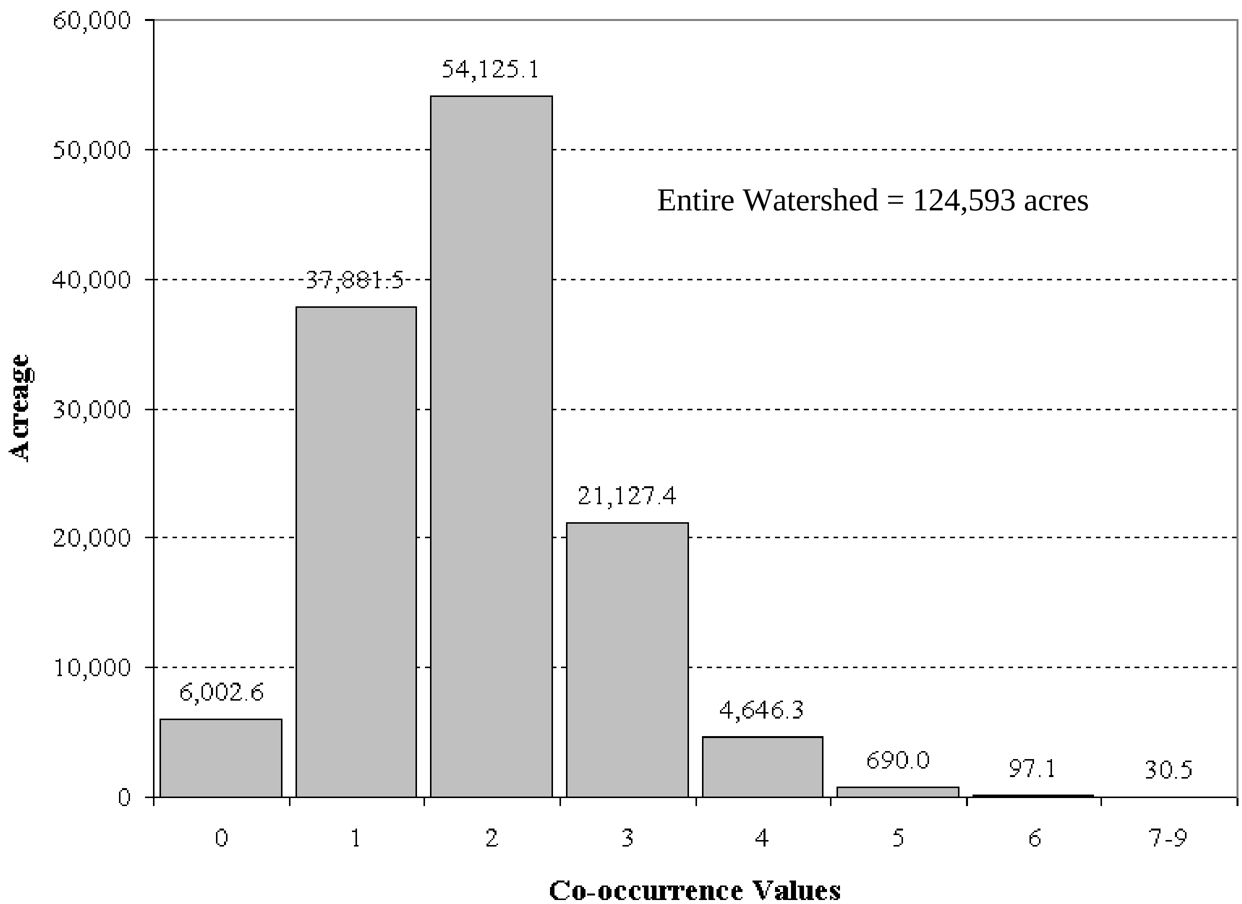
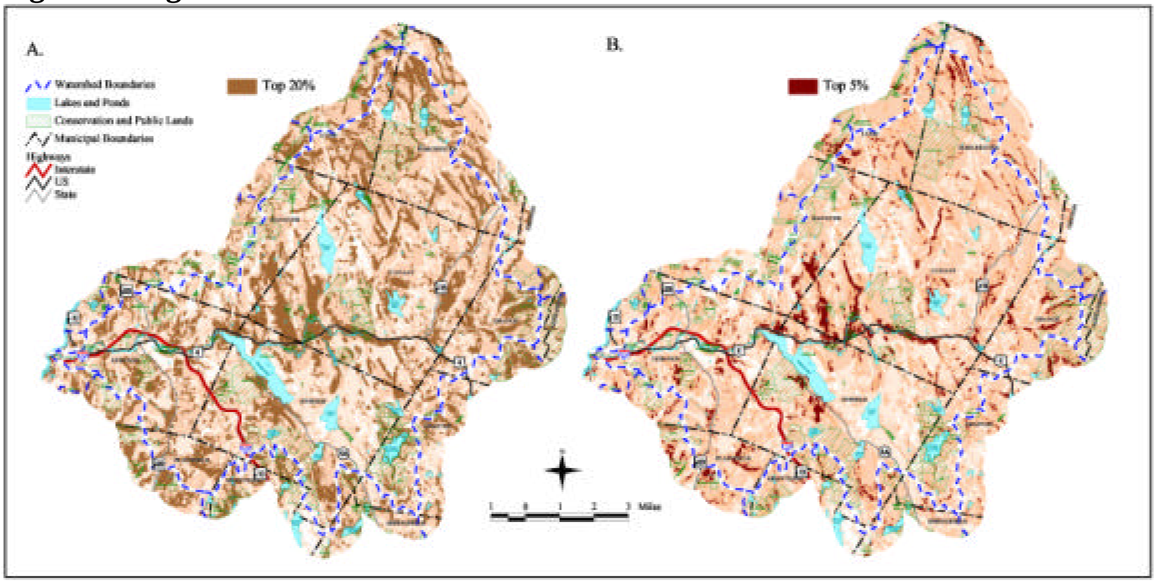


Figure 3: High Co-occurrence Value Areas



The **habitat co-occurrence map**, which shows only the habitat components listed on page 13, shows a slightly different picture (see Map 7 inset, "**Resource Co-occurrence Subtotals**"). High value areas tend to expand spatially from the comprehensive co-occurrence values; this seems to demonstrate that away from the Mascoma River corridor, habitat values are largely driving natural resource values. This makes sense as the water resources are clearly concentrated in this corridor.

The high co-occurrence values of the comprehensive model provide a good starting point for land protection efforts. Areas with values of four (4) or greater encompass approximately 5500 acres (or about 5%) within the watershed, with several distinct concentrations. These specific high-value areas provide a reasonable guide for visually recognizing and selecting focus areas for land protection.

Unfortunately, digital tax map data are not available for most of the Mascoma River watershed, so a parcel by parcel analysis of co-occurrence values is not possible at this time. Nor is it possible to factor parcel size into the strategic conservation planning process (larger parcels are generally viewed as preferable, except in cases where very high resource co-occurrence values can be protected on key, smaller ownerships). However, the co-occurrence maps could be compared side-by-side with paper tax maps, and specific parcels could be identified for further research.

4. Conservation Opportunities

Staff from SPNHF research and land protection departments reviewed the co-occurrence model and NRI analyses to evaluate conservation opportunities and priorities for the Mascoma River watershed. Our recommendations can be seen graphically in **Figure 4, Recommended Conservation Focus Areas** below, and center around working:

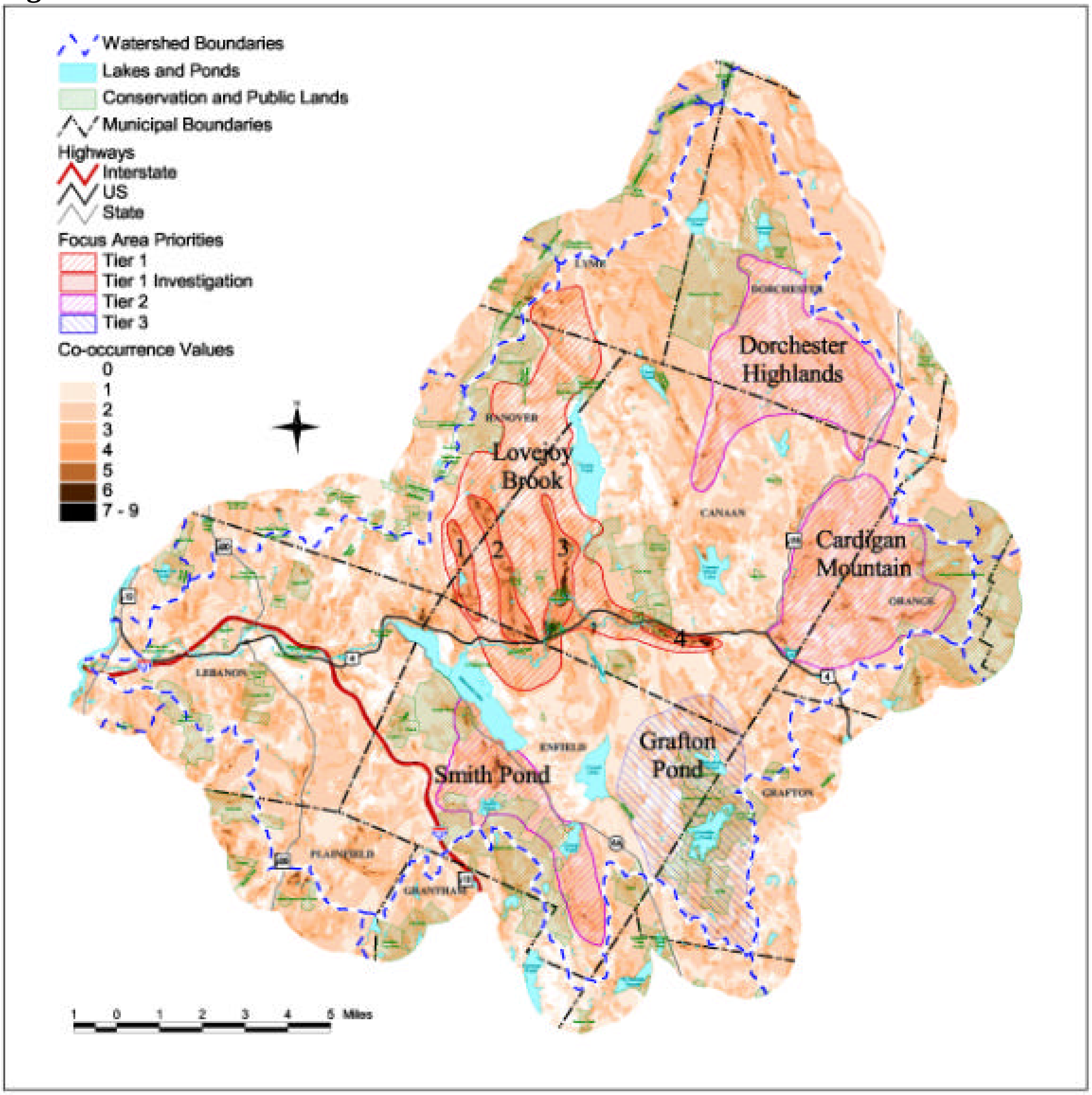
- in areas of high-concentration natural resource values;
- in proximity to existing conservation lands;
- with regional conservation partners and statewide land conservation programs;

We focused our recommendations on those communities which are served primarily by MWCC including Canaan, Dorchester, Enfield, Lebanon, and Orange. Towns such Hanover and Lyme may be less of a priority for MWCC as they are well represented by various town and regional conservation organizations, but nevertheless represent potential partners in collaborative land conservation initiatives.

It should be noted that this evaluation of conservation opportunities is somewhat subjective. However, the regions which were chosen as focus areas were selected based on the objective outcome of the NRI and co-occurrence modeling and on regional knowledge and experience of SPNHF research and land protection staff. The lines which were drawn are not absolute and should be adjusted based on better, local knowledge of landscape conditions, revisions to the MWCC mission, and/or new funding opportunities.

Figure 4 shows the outcome of this review of natural resource values and conservation opportunities in the Mascoma River watershed. We developed a focus area scheme with several tiers. The ranking of the various tiers was driven largely by concentration of natural resource values, but other factors such as adjacency to conserved lands, and the potential accompanying conservation partnerships were considered as well.

Figure 4: Recommended Conservation Focus Areas



Tier 1 Conservation Focus Area

Tier 1 is in our view, the highest priority for MWCC conservation activity. A single focus area was selected as **Tier 1** and is labeled Lovejoy Brook on the **Figure 4** map. It includes several concentrations of the highest natural resource co-occurrence values within the study area (shown in fine cross-hatching) and falls in parts of the towns of Enfield, Canaan, Hanover, and Lyme. Perhaps most compelling is the fact that this area is largely unprotected, despite having the highest concentration of natural resource values in the watershed.

Four "locales" within the Lovejoy Brook focus area recommended for further investigation are outlined on the map (numbered 1 through 4). These areas were selected based on their natural resource scores which were largely driven by wildlife habitat factors. The three investigation areas which lie to the west (numbers 1 through 3) fall along three valleys running roughly north to south. Each has significant wildlife values with several deer yards, extended undeveloped riparian zones, diversity of forest type and open lands, and large wetland complexes. Also, each of these areas falls within some of the largest unfragmented blocks of land which fall entirely within the watershed.

A review of the available geological data indicates that a portion of these investigation areas is underlain by calcareous bedrock. It is likely that the downslope wetlands are enriched as a result, and that diversity is increased on these sites. Wetlands in these and all of the high value resource areas might be evaluated for rare herpetiles such as Blandings or Wood turtles.

We recommend that more detailed biological inventories be undertaken in these locales. The three investigation areas as they are drawn here encompass a relatively large area (2000+ acres), are relatively undeveloped, and largely unprotected. Wetland complexes in particular (where highest biodiversity would most likely be found) would seem to be key areas for visits by local natural resource professionals, and should be evaluated by the Natural Heritage program. Given the potential high wildlife habitat value, this might be an area where NH Fish and Game would have interests.

The fourth locale recommended for further investigation (number 4; to the east along Route 4), while smaller and lying in a less remote setting, appears no less worthy of further investigation. The high concentration of values found here is driven largely by water resources (aquifers and potentially favorable gravel well areas) but has wildlife value as well in wetland complexes and undeveloped shorelines. This area is also adjacent to the Bear Pond conservation complex, and as a result might be considered a high priority focal area for MWCC due to the organizational role in this locale.

Table 4 (page 10) demonstrates the potential for water resource protection in the Mascoma River watershed. This table shows the total and conserved acreages of the three major water resources in the watershed (sanitary radii, well head protection areas, and potentially favorable gravel well areas). As can be seen from the "% conserved" column, these resources remain largely unprotected.

Water will be an increasing issue for towns in this watershed and statewide in years to come. If development pressure increases (which is widely expected to occur) water resources will be stretched thin. It will be critical for towns to protect these very limited resources while the opportunity remains.

In light of these considerations regarding water resources, the fourth area for investigation may have high potential for municipal protection for water. This area and the rest of the Lovejoy Brook focus area cover the majority of the town of Canaan's potentially favorable gravel well areas. Those facts combined with the coincident high wildlife habitat values makes this area a very attractive conservation option.

In addition to the potential for municipal funding for conservation here, there may be state level opportunities as well. The Department of Environmental Services offers grants for drinking water protection which could be used in this focus area[11].

Tier 2 Conservation Focus Areas

We selected three **Tier 2** focus areas. These areas were selected for their concentrations of moderate to high natural resource co-occurrence values (4 to 6) and adjacency to large existing conservation complexes. We had particular conservation partnerships in mind for each of these areas based on patterns of ownership and landscape setting.

The Smith Pond focus area falls between the two large NH Fish and Game ownerships of the Enfield Wildlife Management Area. This area is part of a large unfragmented block of land (~8000 acres) and has some areas of moderately high co-occurrence values. Most notable is the high value area falling in the corridor between Smith Pond and Mascoma Lake; this area is also underlain by calcareous bedrock and might produce rare species if investigated. These values are largely habitat-driven and consist of undeveloped shoreline, steep slopes, and large deer yards. The area was drawn to connect the two portions of the Enfield Wildlife Management Area and to include the relatively undeveloped Smith and George Ponds.

There is a clear opportunity to partner with the New Hampshire Fish and Game Department, given the location between their two parcels and the relatively high wildlife habitat values. The New Hampshire Natural Heritage Inventory Program has recently evaluated State-owned properties to assess the potential for harboring exemplary natural communities. The Enfield WMA has been rated as highest priority for further investigation, second only to Pawtuckaway State Park (in southeast New Hampshire). NH NHI has cited a predominance of nutrient rich, silt-loam soils, widespread calcium enrichment on uplands, and high ecological diversity. This favorable reprioritization of this WMA may create a strong opportunity for partnerships with state agencies. Also, the Upper Valley Land Trust holds several large conservation easements in this area, and may have an interest in expanding upon them.

The Cardigan Mountain focus area falls to the east, in the towns of Orange and Canaan. Like the Enfield tier 2 area, this one encompasses a few areas of moderately high co-occurrence values driven mostly by wildlife habitat factors. This area is relatively undeveloped and adjacent to Cardigan Mountain State Park. Opportunities for partnerships with state agencies such as the Department of Resources and Economic Development, (DRED) Division of Forests and Lands and the DRED Division of Parks and Recreation potentially could be found here, particularly on parcels adjacent to the park.

The Dorchester Highlands focus area can be found to the north in the towns of Dorchester and Canaan. The most significant natural resource factor of this focus area is

[11] Contact NH DES Land Acquisition Grants and Assistance program staff , Sherry Godlewski (603) 271-0688 or Sarah Pillsbury (603) 271-1168. More information at http://www.des.state.nh.us/dwspp/

the very large block of unfragmented land which extends into the watershed from the north (~60,000 acres). The area was defined to connect with the Mascoma and Cummins Pond Wildlife Management Areas, two large, NHF&G held conservation easements. There may be opportunities to expand on these properties as well.

Ownership information was not available for this report, however, past research by SPNHF indicates that the portion of Dorchester which falls into the Mascoma River watershed is dominated by large industrial timber land ownerships. Partnering with these companies on conservation easements is a definite possibility. The USDA Forest Service Forest Legacy Program is one key potential source of funding in this area[12]. The program focuses on protecting large, working forests, and this area would seem to be a good candidate.

Tier 3 Focus Area

The Grafton Pond focus area was ranked as **Tier 3** and surrounds the conservation lands complex on Grafton and Spectacle Ponds. This area does not have particularly high natural resource values in the larger regional context of the Mascoma River watershed co-occurrence model. However, this is a well known area of outstanding natural beauty and remote recreation opportunities. There are several non-profit conservation ownerships here, including those of the Grafton Pond Land Trust, the Upper Valley Land Trust, and SPNHF, all of which are good prospects for partnered land conservation.

[12] Contact US Forest Service Forest Legacy Program Coordinator Deirdre Raimo, (603) 868-7695. More information at http://www.na.fs.fed.us/legacy/

Recommendations for Further Study

This NRI presents a comprehensive analysis of the best available data for the Mascoma River watershed. However, it would be possible to create or derive several new data sets in order to carry out more "in-depth" investigations. In addition, field work in selected areas of the watershed would round out this study (as suggested in the section 4). In this section, we suggest several "next steps" which might be taken as a follow up to this study, primarily for the wildlife component.

Old Field and Early Successional Habitat

Old fields and early successional forests are typically diverse ecosystems with a varied combination of herbaceous, shrub, or young trees. These areas tend to be excellent habitat for a large variety of birds, insects, and mammals and include abandoned farm fields, recent clear cuts, or burned areas. Because of the high biodiversity of these areas, mapping them as part of a wildlife study would be an excellent addition to the information presented here.

This mapping was originally planned to be included in the Wildlife section of this NRI, however, it was not pursued due to timing and project priorities. The process for delineating these habitats involves using a variety of digital and analog sources including, digital orthographic photos, digital topographic maps, landcover data, and false-color infrared photos. Detailed information on this process is included in **Appendix 2**.

Wildlife Corridors

Another addition to the wildlife component of this study would be a wildlife corridor model. Such a model could be determined based on likely wildlife paths such as stream corridors, valley bottoms, wetlands, and ridges and passpoints. Information on the migration of watershed wildlife would be key to determining ideal linkages between conservation lands and potential new conservation projects.

This was another suggested addition to this NRI which was not included due to a lack of data at the outset of the project. However, with the data generated from this project, creating such a model is one step closer. Undeveloped stream corridors, deer yards, and slope data could be combined with topographic data and wetlands to generate the corridors.

Natural Heritage Inventory Data

The New Hampshire Natural Heritage Bureau focuses on inventorying field observations of rare species, managing data for land management, and interpreting that information for the public. However, the detailed digital wildlife information is often not accessible in a form which would be useful to this type of analysis. A cooperative project with the bureau would be a way to access their more detailed data for the purposes of verifying the wildlife model which was begun here, or adding to it based on actual field observations.

More information is available at: http://www.nhdfl.org/formgt/nhiweb/ or (603) 271-3623.

Cliffs and Rocky Outcrops

A final wildlife data layer which would augment the information here would be a cliffs and rocky outcrops data layer. This was proposed as part of this NRI, however, our method of digitizing these features was untested and proved to require additional field work. For this study, steep slopes (>35%) were used instead of cliffs and rocky outcrops, and serve as a reasonable proxy.

Cliffs and rocky outcrops could be determined through initial work with digital orthographic photos and topographic maps. Point features could be identified (such as named cliffs or other geologic features) and digitized, as well as steep slopes based on contour lines. These features must then be confirmed and delineated through field work, as the features do not resolve well on the digital ortho-photos.

Acknowledgements

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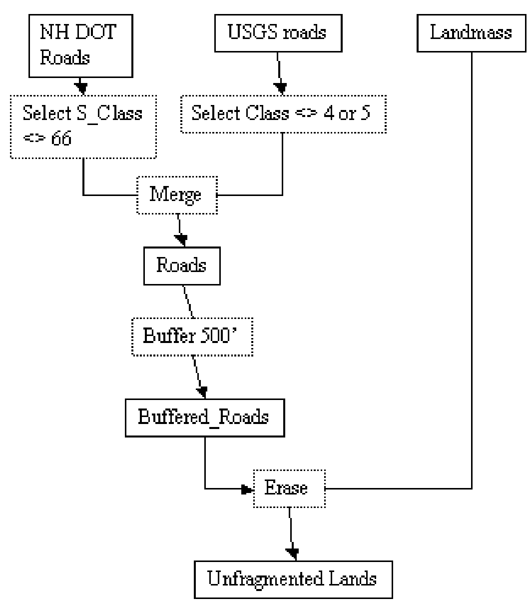
Appendix 1: Technical Report on GIS Data

Section 1: Study Specific Data

This section gives detailed information on the data which was generated specifically for this study. It is aimed at the GIS user, to help future planners or natural resource specialists interpret the data or repeat the analyses we have performed here.

Unfragmented Lands:

Unfragmented Lands were created according to the guidelines in the 2001 University of New Hampshire Cooperative Extension publication Natural Resource Inventories; A Guide for New Hampshire Communities and Conservation Groups. Our specific process is detailed here:



Potentially Favorable Gravel Well Areas:

Potentially favorable gravel well areas display digital water resource data derived from a range of state and federal agencies as of July 2001. The FGWA area is delineated through a computerized GIS analysis which determines areas of stratified drift aquifer potentially having water yield and quality sufficient to serve as large public water supplies. The process of delineating these areas is referred to as a potentially favorable gravel well analysis (FGWA). These data are to be used for planning or educational purposes only. Local land use information and further hydrogeologic analysis are essential to determine the suitability of any location as an actual well site.

The computerized FGWA analysis process involves the buffering of various features that represent potential or known sources of contamination to a source well. These include surface water features, urban features such as roads, and NH DES known and potential contamination sites. These buffered features are then "subtracted" from the extent of the stratified drift aquifer, leaving the “potentially favorable” areas.

The buffers used to identify the FGWA areas do not guarantee protection from well contamination. The status of sites and associated buffers are subject to change when contamination has been cleaned up. Similarly, the existing source water protection areas may be revised as more site-specific hydrogeologic information becomes available. The FGWA information provided in this map includes a subset of databases developed by the New Hampshire Department of Environmental Services. Development of these databases is ongoing and this map may not contain all existing and potential threats to groundwater. NHDES and SPNHF are not responsible for the use or interpretation of this information, nor any inaccuracies in site names, locations, projected yields, or groundwater flow direction. All information is subject to verification.

These data are to be used for planning or educational purposes only and the following cautions should be observed:

- Site-specific hydrogeologic investigations are necessary to determine whether a high-yielding well can be sited within a particular area.
- This method applies only to stratified-drift aquifers. High yielding public water supply wells may also exist in bedrock aquifers.
- Site-specific investigations must be made to determine the quality of groundwater available at any site.
- The methodology of the favorable gravel well analysis applies well siting constraints that are the minimum requirements that must be met according to the Department of Environmental Services’ new well siting process for community water supply wells.

For further information, please refer to the DES technical manual: ‘A Guide to Identifying Potentially Favorable Areas to Protect Future Municipal Wells in Stratified-Drift Aquifers’, NH Department of Environmental Services, Publication NHDES-WD-99-2.

Sanitary Radii:

Sanitary Radii are developed according to NH DES guidelines, and are based on the permitted daily production of the given well. Public water supplies (pws.shp) are buffered according to the "Sanitary Radius" field in the following table:

Permitted Daily Production	Sanitary Radius
<14,401 gal/day	150'
14,401 - 28,800	175'
28,801 - 57,600	200'
57,601 - 86,400	250'
86,401 - 115,200	300'
115,201 - 144,000	350'
> 144,000	400'

Lebanon Snow Dump:

This point was located by MWCC board members at a January 30, 2003 meeting, and subsequently digitized by SPNHF staff.

Gravel Pits:

This layer was derived from the NH DES layer "Point/Non-point Pollution Sources" (NP_PT). Selected all active (ACTIVE field = 2 or 3) sand and gravel mines (TYPE field = MQ or MS) for display. These points were digitized as polygon features for the co-occurrence model; digital orthophotos and digital USGS quad information were used.

Undeveloped Shorelines:

Undeveloped shorelines were developed through the following process:

1. buffer perennial streams and lakes and ponds >10 acres at 150 feet and 300 feet.
2. create a "developed" layer based on interpretation of digital aerial photographs; on-screen digitize at scales between 1:5,000 and 10,000. A strict definition of developed was used in this case, and was considered to be any non-natural surface including buildings, paved surfaces, railroad right-of-ways, mowed grass (including lawns, road sides and medians, and hayed fields), agricultural fields, orchards, active gravel pits or quarries, power line right-of-ways
3. remove the developed layer from the shoreline buffers.
4. edit the 0 – 150 foot buffer. If any section of the buffer was erased by the developed layer, the buffer was clipped entirely to the extent of the erase.

Open Lands:

Open Lands were derived from the 2001 NH Landcover Assessment, classes 211 (Row Crops), 212 (Hay/Pasture), 221 (Orchards), and 790 (Other Cleared).

Steep Slopes:

Slopes were developed from the USGS National Elevation Digital Elevation Model, provided by USGS. Steep slopes included all slopes 35% and over.

South Facing Slopes:

Slopes were developed from the USGS National Elevation Digital Elevation Model, provided by USGS. South Facing Slopes included all slopes with south and southwest aspects (all azimuths between 157.5 degrees (SSE) and 246.5 degrees (WSW)).

Co-occurrence Model:

The co-occurrence model included the following factors:

Prime Farmland Soils (..\Data\Co-occurrence\soil_prime_farm.shp)
Soils of Statewide Importance (..\Data\Co-occurrence\soil_state_farm.shp)
Composite Wetlands (NWI + Hydric Soils; ..\Data\Co-occurrence\nwi-hydric-composite.shp)
Undeveloped Shorelines (..\Data\Co-occurrence\undev_shore.shp)
Unfragmented Natural Landcover Blocks (> 1000 acres; ..\Data\Co-occurrence\unfrag1000+.shp)
Open/Agricultural Lands (..\Data\Co-occurrence\open_lands.shp)
Quarries and Gravel Pits (..\Data\Co-occurrence\gravelpits.shp)
South-facing slopes (> 10% slope; ..\Data\Co-occurrence\south_slopes.shp)
Steep Slopes (> 35%; ..\Data\Co-occurrence\steep_slopes.shp)
Deer Yards (..\Data\Co-occurrence\deer_yards.shp)
Stratified Drift Aquifer (max transmissivity >= 1000 sq ft/day; ..\Data\Co-occurrence\sda_1000+.shp)
Potentially Favorable Gravel Well Areas (..\Data\Co-occurrence\fgwa.shp)
Well Head Protection Areas (active sources only; ..\Data\Co-occurrence\whpa.shp))
Sanitary Radii (..\Data\Co-occurrence\san_rad.shp)

Each factor was assigned one point by creating a unique field in each shapefile attribute table and calculating 1.0 for each record. The shapefiles were then unioned (using the ArcView Geoprocessing Wizard). The resultant shapefile then included 14 fields for each factor (input shapefile) with a value of 1.0 where that factor existed, and a value of 0.0 where that factor did not exist. Additional “totals” fields were added, and calculated as the sum of the various factor fields (e.g. all 14 for the total co-occurrence, only habitat factors for the habitat co-occurrence).

Section 2: Stock GIS Metadata

This section describes GIS layers which are essentially unaltered from the versions provided by the issuing agency (GRANIT, NH DES, etc.). The majority of the GIS data used for the Mascoma NRI was provided by GRANIT. Detailed information on any GRANIT data set can be found at their web page: http://www.granit.sr.unh.edu/ . In some cases, appropriate metadata is available on the internet, and appropriate links are given. In some cases, text from agency metadata is inserted here and is shown in dark green.

Base Layers:

Watershed Boundaries:
Source: GRANIT, "NH_HUC12", October 2002
http://www.granit.sr.unh.edu/data/datacat/pages/wshed.pdf

Contour Lines:
Source: GRANIT, "Hypsography", March 2000
http://www.granit.sr.unh.edu/data/datacat/pages/hypso.pdf

Utility Lines (includes Lebanon Airport):
Source: GRANIT, "Pipenh", March 2000
http://www.granit.sr.unh.edu/data/datacat/pages/pipe.pdf

Rail Lines:
Source: GRANIT, "Rrnh", March 2000
http://www.granit.sr.unh.edu/data/datacat/pages/rr.pdf

Conservation Lands:
Source: GRANIT, "Cons", February 2003
http://www.granit.sr.unh.edu/data/datacat/pages/cons.pdf
This layer includes selected updates and additions from UVLSRPC and MWCC.

Streams:
Source: GRANIT, "Perstrms", March 2000
http://www.granit.sr.unh.edu/data/datacat/pages/hydro.pdf

Lakes and Ponds:
Source: GRANIT, "Hydropol", March 2000
http://www.granit.sr.unh.edu/data/datacat/pages/hydro.pdf

Roads:
Source: NH DOT, "Roads", May 2002
From NH DOT Metadata:

The New Hampshire Department of Transportation is responsible for maintaining an inventory of every publicly owned road, street, and highway in the state. The inventory contains numerous fields of physical characteristics such as number of lanes, lane width, pavement type, and street name, as well as administrative characteristics such as functional classification owner, access control, and maintenance responsibility. Most of the information is maintained to satisfy our federal reporting requirements, and some information is required for calculating block grant funding for the municipalities or for the state transportation system management. Each road in the state is uniquely identified with a three digit town code; a four digit inventory number, unique within a town; a direction code required to identify divided highways; and a segment number used when an inventoried road is not contiguous. Each road is then divided into sections based on differences in the information in the inventory fields.

The SmartMap data is an intelligent map that is generated from the NHDOT Road Inventory database. For display purposes and portability, the NHDOT SmartMap is maintained as an ArcView shapefile set. Each graphic entity has a matching record in the Road Inventory database, and the graphic entity carries a select subset of the inventory information described above as attributes. Each graphic entity also carries a unique key attribute which allows us to link to the entire inventory. Periodically, as the Road Inventory database is updated and corrected, a new 'snapshot' of the database is taken and a new SmartMap coverage generated to keep the maps and attributes current. In the future, the SmartMap coverage will be replaced by a stable 'Link-Node' map base with the capability of defining the attribute information based on milepoint and/or coordinate positioning. The stable link-node base will then allow users to attach their own attribute data to the roadway links.

Also, see metadata in electronic files

Wetlands:

Source: GRANIT, "NWI", September 2001
http://www.granit.sr.unh.edu/data/datacat/pages/nwi.pdf

Map Specific Layers:

Land Cover:

Source: GRANIT, "NHLC2001", January 2002
http://www.granit.sr.unh.edu/data/datacat/pages/nhlc01.pdf
From GRANIT Metadata:

Data_Quality_Information:
Attribute_Accuracy_Report:
The project achieved an overall accuracy of 82.2% at the full 23-class level. Below is a summary of User's and Producer's Accuracy for each of these classes.

CLASS – Code	PRODUCER'S ACC.	USER'S ACC.
Residential/Commercial		

/Industrial – 100	86.9%	88.3%
Transportation - 140	100.0%	85.0%
Row Crops – 211	94.6%	88.3%
Hay/Pasture – 212	84.6%	91.7%
Orchards – 221	97.4%	92.5%
Beech/Oak – 412	68.1%	53.3%
Paper Birch/ Aspen – 414	28.6%	28.6%
Other Hardwood – 419	53.2%	70.0%
White/Red Pine – 421	90.7%	81.7%
Spruce/Fir – 422	93.8%	80.4%
Hemlock – 423	95.1%	65.0%
Pitch Pine – 424	100.0%	97.5%
Mixed Forest – 430	39.7%	62.5%
Alpine (Krumholz) – 440	100.0%	80.0%
Water – 500	100.0%	100.0%
Forested Wetland – 610	74.3%	86.7%
Open Wetland – 620	88.2%	75.0%
Tidal Wetland – 630	100.0%	100.0%
Disturbed – 710	90.0%	90.0%
Bedrock/ Veg. – 720	100.0%	100.0%
Sand Dunes – 730	100.0%	100.0%
Other Cleared – 790	82.4%	93.3%
Tundra – 810	100.0%	100.0%

When the classification is collapsed to the 17-class level, the overall accuracy is 88.4%, and the User's and Producer's Accuracies are as follows:

CLASS – Code	PRODUCER'S ACC.	USER'S ACC.
Residential/Commercial /Industrial – 100	86.9%	88.3%
Transportation - 140	100.0%	85.0%
Crops/Pasture - 211-212	95.0%	95.8%
Orchards – 221	97.4%	92.5%
Deciduous Forest - 410-419	90.7%	94.8%
Coniferous Forest - 420-429	97.3%	81.9%
Mixed Forest – 430	39.7%	62.5%
Alpine (Krumholz) – 440	100.0%	80.0%
Water – 500	100.0%	100.0%
Forested Wetland – 610	74.3%	86.7%
Open Wetland – 620	88.2%	75.0%
Tidal Wetland – 630	100.0%	100.0%
Disturbed – 710	90.0%	90.0%
Bedrock/ Veg. – 720	100.0%	100.0%
Sand Dunes – 730	100.0%	100.0%
Other Cleared – 790	82.4%	93.3%
Tundra – 810	100.0%	100.0%

So that users can interpret the data most effectively, rules were created to develop broader ("fuzzier") categories of "right" and "wrong" and to assess the accuracy using these fuzzy sets. We applied the linguistic scale developed by Woodcock and Gopal (2000):

(1) Absolutely wrong: This answer is absolutely unacceptable. Very wrong.

(2) Understandable but wrong: Not a good answer. There is something about the site that makes the answer understandable, but there is clearly a better answer. This answer would pose a problem for users of the map. Not right.
(3) Reasonable or acceptable answer: May not be the best possible answer but it is acceptable; this answer does not pose a problem to the user if it is seen on the map. Right.
(4) Good answer: Would be happy to find this answer on the map.Very right.
(5) Absolutely right: No doubt about the match. Perfect.

Each accuracy assessment site was given a fuzzy rating (see fuzzyratings.pdf for definitions). The overall accuracy of the 23-class classification increases to 89.1% when the "good answers" are included as "right," and to 92.0% when "reasonable or acceptable answers" are included as well. Please see the project's final report for a full discussion of the accuracy assessment.

Soils:

Source: Natural Resource Conservation Service (via GRANIT), "Soi", November 2002
http://www.granit.sr.unh.edu/data/datacat/pages/soi.pdf
Detailed soils description (based on NRCS Definitions):

-Hydric Soils
"A hydric soil is a soil that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part." As a result of soil saturation and reducing conditions, hydric soils undergo chemical reactions and physical processes which differ from those found in upland soils. Hydric soils are one of the three diagnostic environmental characteristics used in the identification of wetlands, with the other two characteristics being a prevalence of wetland vegetation and the presence of wetland hydrology.

-Farmland of Statewide Importance
These are lands that are not prime or unique but are considered farmlands of statewide importance for the production of food, feed, fiber, forage and oilseed crops.

-Prime Farmland Soils
The Natural Resource Conservation Service (NRCS) defines prime farmland as land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these uses. It may be pasture, cultivated land, forest land or other lands except for those that represent urban, built-up, or water areas. Prime farmland soils produce the highest yields with the least expenditure of time and energy. Farming them results in the least environmental damage.

-Productive Forest Soils.
The NRCS productive forest soil groups indicate the relative productivity of lands for timber production. The top three categories are: IA, IB, and IC. IA consists of the deeper, loamy textured, moderately well, and well-drained soils. Generally, these soils are more fertile and have the most favorable soil moisture relationships and are best suited to hardwoods. The successional trends on these soils are toward stands of shade tolerant hardwoods such as beech and sugar maple. Hardwood competition is severe on these soils so softwood

regeneration is usually dependent upon persistent hardwood control efforts.

IB soils are generally sandy or loamy soils over sandy textures and slightly less fertile than those in group IA. These soils are moderately well and well drained and are primarily suited to hardwoods. Soil moisture is adequate for good tree growth, but may not be quite as abundant as in group IA soils. Soils in this group have successional trends toward a climax of tolerant hardwoods, predominantly beech. Hardwood competition is moderate to severe on these soils and successional softwood regeneration is dependent upon hardwood control. IC soils are outwash sands and gravels. Soil drainage is somewhat excessively to excessively drained and moderately well drained. Soil moisture is adequate for good softwood growth, but is limited for hardwoods. Successional trends on these coarse textured, somewhat droughty and less fertile soils are toward stands of shade tolerant softwoods, i.e., red spruce and hemlock. Balsam fir is a persistent component in many stands, but is shorter lived than red spruce and hemlock. White pine, red maple, aspen, and paper birch are common in early and mid-successional stands. Hardwood competition is moderate to slight on these soils. Due to less hardwood competition, these soils are ideally suited for softwood production, especially white pine.

Overlap between Soil Classes –
In this study area there is no overlap between hydric soils (HYDRIC = "yes") and important agricultural soils (FARMCLASS = "all areas are prime farmland" or FARMCLASS = "farmland of statewide importance"), nor is there overlap between the two agricultural soil classes. Since these soil classes are mutually exclusive, they are displayed in solid colors for clarity's sake. There is overlap between the larger important forest soils group (FORSOILGRP = "IA" or "IB" or "IC") and the other soil classes; this soil group serves as a "backdrop" to the others. For reference, there is no overlap between hydric soils and important forest soils, class 1C (FORSOILGRP = "IC"). Also, all prime farmland soils (FARMCLASS = "all areas are prime farmland") are also important forest soils, class 1A only (FORSOILGRP = "IA"). And, all farmland soils of statewide importance are either 1A or 1C important forest soils only.

Underground Storage Tanks:

Source: NH Department of Environmental Services (DES), "Ust_Site", October 2002

From DES Metadata:

Underground storage tank sites. Developed by the Oil Remediation and Compliance Bureau

Also, see metadata in electronic files

Junk Yards:

Source: DES, "Junkyd", November 1991

From DES Metadata:

Automobile Salvage Yards which are registered with NHDES. Developed by the Water Quality and Permits Compliance Bureau.

Also, see metadata in electronic files

Public Water Supplies:

Source: DES, “PWS”, November 2002

From DES Metadata:

Sources (wells and surface intakes) for public, community, and non-transient Public Water Supply Systems. Developed by the Water Supply Engineering Bureau.

Also, see metadata in electronic files

Wellhead Protection Areas:

Source: DES, “WHPA”, October, 2002

From DES Metadata:

Public Water Supply Drinking Water Protection Areas (DWPA) which are being delineated as part of the State’s wellhead protection program under RSA 485-C. The coverage is limited to the sources of community and noncommunity, nontransient water systems. Under the State’s program, wellhead protection areas are defined as the area from beneath which groundwater is likely to flow toward and reach a water supply well. Developed by the Water Supply Engineering Bureau. NOTE: The ARCINFO coverage, **DWPA**, has region topology with two subclasses: SWPA, WHPA. A third region subclass, WAIVER, is to be used only for the Phase II & V Sampling Waiver program. For DES ArcView Users, the region subclasses are represented as individual shapefiles.

Also, see metadata in electronic files

Contamination Sites:

Source: DES, “Csite”, November 2002

From DES Metadata:

Existing and potential threats to source water quality including, but not limited to: Above-ground storage tanks, CERCLA superfund sites, complaints, leaking bulk fuel storage facilities, groundwater release detection permits, isolated gw sample w/contaminant detection, non-petroleum hazardous waste, non-hazardous/non-sanitary holding tanks, initial spill response, lined landfills, proposed landfills, unlined landfills, leaking above-ground storage tanks, leaking underground storage tanks, lined wastewater lagoons, leaking motor oil storage tanks, old open dump sites, leaking heating oil tanks, rapid infiltration basins, septage lagoons, subsurface wastewater disposal >20,000gal/day, unsolicited site assessments, sludge lagoons, sludge applications, oil spill/releases, spray irrigation, municipal/commercial stump/demo dumps, solid waste transfer stations, underground injection control, unlined wastewater lagoons. Developed by the Oil Remediation and Compliance Bureau; and Water Supply Engineering Bureau.

Also, see metadata in electronic files

Threats to Source Water Quality:

Source: DES, “Carea”, November 2002

See metadata description for “Contamination Sites” above

Also, see metadata in electronic files

Potential Sources of Point Pollution:

Source: DES, “Np_pt”, March 1995

From DES Metadata:

Selected types of potential and existing point and non-point pollution sources, including: CSOs (combined sewer outfalls); quarries; sand and gravel operations; sand/salt storage piles; septage/sludge applications; septage/sludge lagoon/composting sites; snow dumps; and storm drains. Developed by NH Regional Planning Commissions and DES.

Also, see metadata in electronic files

Aquifers:

Source: DES, “Nh_tm”, October 2002

From DES Metadata:

Aquifer boundaries, material types, water table elevations, saturated thickness, transmissivity, seismic lines. Tiled by USGS bond study area. Provided by the US Geological Survey.

Also, see metadata in electronic files

Appendix 2; Open Lands and Early Successional Habitat Mapping

Land cover types that can be characterized as "open lands and early successional habitats" are declining in both distribution and extent in New Hampshire, and are thought to represent only about 4% of the land cover of the state overall. These habitat types include a range of both natural land cover, such as abandoned hay lots and pastures (old field habitat) grading into early successional shrub and tree species, and managed land cover such as actively cropped agricultural fields, orchards, hay meadows, and disturbed areas associated with gravel pits and powerline right-of-ways.

These habitat features are important to a number of wildlife species that depend on field and early successional habitats for breeding, foraging, and shelter, including the blue-winged and golden-winged warblers, New England cottontail rabbit, upland sandpiper, and several other species-of-concern which are included in this study. Unfortunately, very little detailed geographic information delineating these cover types is available from GRANIT or other sources.

Accordingly, an experimental, low-tech/rapid assessment procedure was developed using ArcView GIS software to identify and delineate early successional habitat features and other open land cover types features. A unique datalayer comprised of 679 polygons was produced for the entire lower Lamprey River watershed using a combination of conventional aerial photo interpretation and delineation, followed by digitizing of delineated features directly in the GIS, as follows:

Image Data Sources

Two digital imagery data sources were used in concert with one another in the development of this datalayer:

- geo-referenced digital orthophoto quads (DOQ's) available from GRANIT, and
- color infrared (CIR) aerial photography currently available statewide on request from the UNH Cooperative Extension county offices.

Detail resolution and color rendition is far superior in the CIR images as compared to the panchromatic DOQ's, so they were used as the initial basis for delineation and coding of various open land and early successional features. However, the CIR photos are not available as digitally-mosaicked images nor are they geo-referenced for use in the GIS, so the GRANIT DOQ imagery was used as the "spatial backdrop" against which features identified in the CIR imagery could be accurately located and digitized on-screen. Since both image datasets were acquired in 1998/1999, features are consistent from one image to the other, with few exceptions.

Note: if CIR photos are not available, DOQ's can be used alone for delineation, but features such as field edges and details such as the texture of ground surfaces (important in clarifying cover types and early successional canopy closure) tend to be somewhat unclear, especially at larger scales, thus making interpretation difficult at times.

<u>For the purposes of this project, the steps in generating the open lands/early successional habitat datalayer are as follows:</u>

1. Stock 9x9 CIR photos were first scanned at 300 dpi on a flatbed scanner and then converted to TIFF graphic files that can be inserted into an MSWord document or into ArcView layouts for reprinting. These files were output on a color laser printer at close to the original 9" x 9"format for use as stereo photo pairs, and also at larger scales measuring up to 18" x 18" on a large-format inkjet plotter for detail viewing and reference without magnification. The color laser prints yield the best resolution – at near photographic quality – and thus are used as the basis for delineation.

2. Agricultural fields, hay meadows, old fields in varying stages of natural succession, and other features such as gravel pits and cleared/disturbed areas are outlined and coded with felt-tip pen directly on each 9 x 9 CIR print, with allowances for the inherent overlap from image to image. Stereo viewing glasses and matching pairs of photos can be used to view three-dimensionally to confirm field patterns and/or verify early successional stands of trees embedded within a larger forest context.

3. An ArcView project view is then built with the DOQ's displayed as an image background on which other reference datalayers (roads, streams, NWI wetlands, etc) are overlaid in color to help in orientation and "pattern-seeking" as the CIR photo delineations are transferred into the GIS environment. A view scale of 1:12,000 is typically a good starting point for identifying field patterns and delineating edges, but larger scales are helpful in situations where shapes are complex and overlapping polygons are to be avoided.

4. Working systematically from the CIR images, various features and spatial patterns on the CIR's are located visually in the context of the DOQ image, and at least one graphic polygon is first drawn according to field edges and other defining features. The Draw Polygon tool is used for this purpose.

5. Then, using the Xtools convert-graphic-to-polygon function, a shapefile theme is created on which the remainder of open land/early successional habitat datalayer is built. Using the Theme Edit function in ArcView and the Draw Polygon tool, all remaining polygons can be rapidly added to the initial shapefile, digitizing "on-the-fly" and on-screen.

6. During digitizing, delineations on the CIR imagery are checked against reference datalayers, such as the NWI wetlands, and interpretive errors are corrected. In some cases, as with identification of old gravel pits, toggling between the DOQ and the corresponding USGS topographic quad digital raster graph (DRG) helps to verify the type and location of features. Similar toggling with the GRANIT land cover type grid can also be used to check feature and cover types.

7. Since the attribute table is also actively being built while the theme is being edited, habitat type codes and any other data associated with each polygon may be entered into the attribute table, as each polygon is digitized, or in small batches as all the polygons from one CIR are digitized and before moving on to the next image.

8. Area and perimeter data for each polygon must be updated periodically using the Xtools extension. This may also be done on-the-fly and while in the Theme Edit mode.

9. A redundant back-up system is recommended while the datalayer is being developed. Periodically converting the shapefile to another filename, e.g., version 1, version 2, etc., is an easy method of saving data frequently as work progresses. The ArcView .apr file should also be backed up frequently to guard against corruption of the project file, which is a possibility when working with large image datasets and several extensions.

Identifying and classifying open land and early successional habitats from aerial photography requires a certain amount of skill and experience in interpreting spatial details and patterns visible in the imagery. However, in the predominately forested landscape of New Hampshire, field patterns and other types of openings in the tree cover are clearly evident in most aerial photography. The tendency to "read" emergent wetlands as early successional habitat is probably the most likely error in interpretation, but features in the photography can easily be checked against NWI wetlands mapping in the GIS and discounted. Similarly, cemeteries were easily recognized and culled from delineation by comparing to USGS DRG mapping on-screen.

Figure 3 below depicts a typical CIR image on the left and a corresponding DOQQ image for comparison.

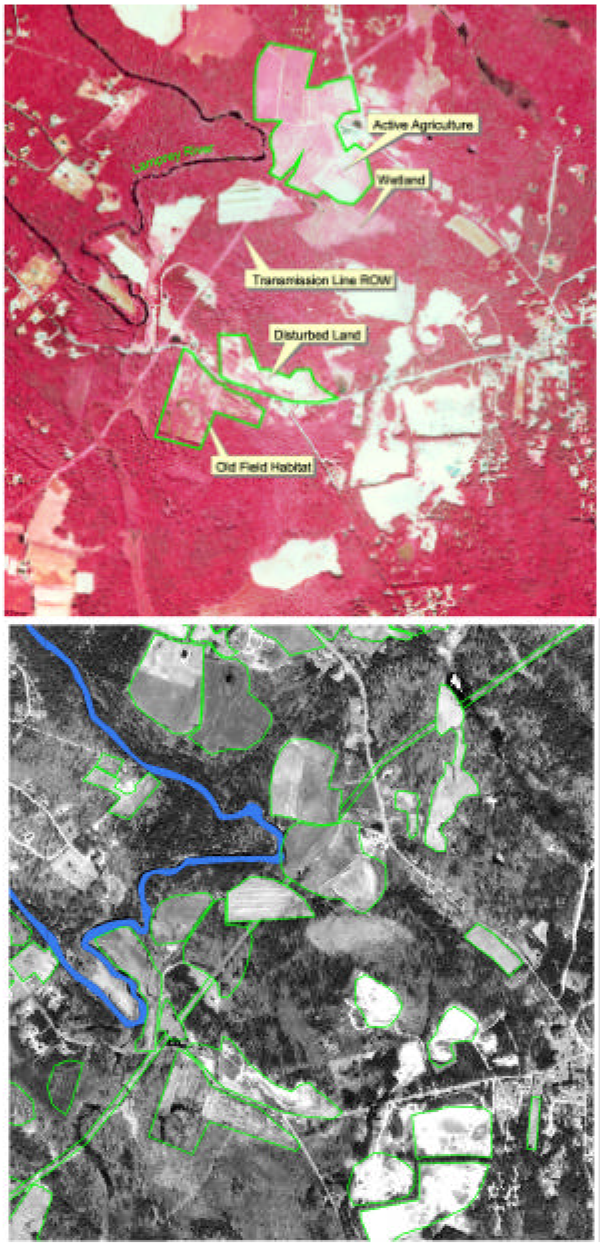


Figure 3*: Color infrared source photography with selected habitat features noted on the left, and typical GRANIT DOQQ geo-referenced imagery on the right with all features digitized.*

<u>Classification Scheme</u>

The initial tendency in experimenting with a method to generate this datalayer was to classify features in the simplest terms and according to broad groupings of habitat features, as follows:

- "open lands" in the form of fields and meadows,
- "early successional habitats" in the form of overgrown hay meadows and pastures, and fields becoming dominated by tree and shrub canopy,
- disturbed or cleared lands of various types, and

- gravel pits.

However, it quickly became evident in viewing the aerial photos that a continuum of open land and early successional cover types exists, ranging from actively-worked agricultural fields and croplands to advanced early successional stands of tree canopy moving into later seral stages of forest cover. The same was true of gravel pits, which also include sand and clay pits and associated disturbed or cleared land, and which can be actively worked, newly reclaimed, or abandoned and reverting to vegetation. Thus, the need to make distinctions along such a continuum generated seventeen (17) discrete classes of habitat features in the initial digitizing of the datalayer, which added qualitatively to usefulness the final dataset.

A total of 679 polygons were digitized and attributed in approximately 30 hours work, covering the entire 85 square mile watershed and extending beyond the study area boundary in cases where significant habitat features and patterns exist within the half-mile context buffer. Generally, a two-acre minimum size was used to avoid including residential yards and other small openings with little habitat value. Exceptions occur where clusters of small openings were evident in a predominately natural land cover context, e.g., a series of small meadows surrounded by woodland, with probable habitat value in the aggregate, or where smaller units were associated with larger units in a cluster.

An overview of the seventeen habitat features, a working definition, polygon count and total acreage in the study area is found in the table below.

Habitat Feature	Definition	Count	Acres
Old field	Abandoned fields with <50% tree/shrub canopy cover	86	656.1
Old field/Early successional	Old fields with >50% but <100% canopy cover	8	70.6
Early successional	Old fields or openings with 100% sapling tree cover	81	887.4
Advanced early successional	Homogenous patterns of distinctly younger tree canopy	5	150.2
Powerline ROW	ROW clearings through forested/other natural land cover	4	348.6
Fields	Active agricultural uses, including row crops and hay fields	398	3,797.8
Fruit	Small fruit farming, eg., blueberries	2	6.8
Orchard	Apple orchard	3	70.6
Gravel pit	Active gravel extraction and workings	15	145.1
Sand pit	Active sand extraction and workings	9	67.3
Clay pit	Active clay extraction, including ponded areas	1	45.6
Old gravel pit	Abandoned/revegetating or reclaimed gravel pits	5	71.0
Old sand pit	Abandoned/revegetating or reclaimed sand pits	10	45.6
Disturbed land	Land cleared of all or most vegetation; timber harvests	27	259.2
Disturbed/Gravel pit	Land cleared in associated with active gravel extraction	9	112.9
Wet Field	Fields with tile lines or ditching evident, adjacent wetlands	15	60.9
Man-made Wetland	Obvious constructed wetlands with regularized forms	1	37.7
	Totals	**679**	**6,732.3**

Discussion

Overall, this datalayer represents about 12% of the study area land base, but narrowing to features more closely allied with the concept of "early successional habitat" – old fields and young shrub/tree canopy cover – shows only about 3.2% of the study area is supporting the most critical habitat features for a range of wildlife species.

Also, as can be seen in the polygon counts and acreage distribution, "Fields" are the dominant feature mapped, accounting for more than 50% of both the polygon count and the total acreage. However, even within this habitat feature class, a wide range of cover types exist. It is clear in the aerial photos that many of these fields are being worked intensively for row crops or hay, and thus have limited habitat value for certain species such as ground-nesting birds. Still, some fields are likely utilized much less intensively, primarily for occasional hay crops or pasture. Older meadow openings that are likely mowed only once in a few years are also evident in the photos, but have been classed as "Fields" in this study. Thus, this cover class tends to be quite inclusive of a number of open field types, with differing habitat qualities, but the class as a whole cannot be more finely delineated without extensive fieldwork to rate the fields for type and intensity of use.

The "Old Field" cover type class is relatively easy to pick out in the aerial photos due to the spotty patterns of pasture juniper and invading shrub and tree canopy. These features are also mapped most often associated with other field patterns and farming activities; some of the polygons as old fields are clearly overgrown pastures still being used as part of a working farm.

"Early Successional" habitat features were delineated from three sources:

- true old field environments progressing to later seral stages,
- openings created by timber harvest, and
- powerline right-of-ways.

The break point for old field-versus-early successional habitat features was determined to be 50% combined tree and/or shrub canopy cover across the area seen as a field unit. Determining percentage of canopy closure on old field sites was done visually; no image processing and quantification was used, nor is it warranted because field patterns and edges are generally well-defined and the eye can easily judge distinctions of less-than and more-than 50% cover.

Timber harvests are readily decipherable as patterns of openings and skid road trails in the context of the prevailing forest canopy patterns. Lighter harvests, as with selective cuts, were not mapped as early successional habitat due to relatively minor openings created. However, several heavy cuts where more than 50% of the entire harvest zone is composed of openings, and a few clear-cut harvests, were evident in the photography. These were mapped as early successional habitats for the purposes of this study, but were not coded as timber harvest sites. In hindsight, it would be valuable to document timber harvest sites since the quality of the early successional habitat varies significantly from old field sites and because the early-successional composition and structure of the feature can be assumed to be ephemeral (i.e., area is being managed for timber and will likely be allowed to return to a forested condition).

Three major electric transmission right-of-ways traverse the study area from west to east, with cleared areas ranging from 85 feet to more than 200 feet in width. Although the ground cover under the powerlines is heavily managed to keep vegetation low, these right-of-ways were mapped as early successional habitat due to their similarity to old field environments. Powerline right-of-ways were mapped according to the prevailing cover type where the line crosses agricultural fields or other cover classes that have no woody growth.

Identifying active "gravel/sand/clay pit" sites is not difficult in the photography since the working face of the pit is often visible and haul roads are evident; they are also easily checked against USGS DRG images which label such extraction sites. Reclaimed pits are seen as smoothed, open areas, most often adjacent to active mine workings, as are a number of cleared/disturbed areas also associated with mining. Old or abandoned extraction sites are not readily seen, however, and these unique habitat sites were located by toggling from the DOQ's to the USGS DRG images that date from 1987. As a related cover class, "Disturbed" areas are sites that are clearly unvegetated or sparsely vegetated. In some cases, these areas might be temporary site clearings in advance of new construction, but others are more permanently "cleared", as with the seasonal parking lot at the Epping speedway.

"Wet field" identification was made possible by scanning the field patterns for regularly-spaced, darker strips of vegetation, signally the wetter soils in ditches or over drain tile lines. These fields are almost always immediately adjacent wetlands, as well. Although all wet fields appeared to be under active agricultural management, the cover class was distinguished because wetland plants such as sedges could be present on wetter sites, and wildlife utilization could be enhanced.

The "Made Wetland" class was created to account for a single instance of a clearly manmade wetland constructed as a mitigation project near Route 101.

Summary

While field checking of habitat delineation remains to be done in upcoming field seasons, this data has proved extremely useful in targeting geographic priorities for wildlife habitat conservation purposes. Land cover type mapping available from GRANIT is useful in determining broad-scale patterns of habitat type and structure, and to a limited degree in validating features digitized from aerial photography, but the relatively coarse resolution and definition in the land cover grid does not reveal the true extent and distribution of field and early successional habitat patterns on-the-ground.

Diversifying the classification system is also important since it allows the datalayer to be queried for specific habitat types, and thus helps to pinpoint the modeling to only the most suitable habitat feature co-occurrences. However, ground-truthing the initial delineation, and "training" the data and method is very critical to the accuracy of the modeling effort.

New, alternative imagery is now available that would likely enhance the delineation accuracy and perhaps the precision. For example, geo-referenced digital images from Emerge with a sub-meter resolution show plant and land cover types in much more detail than either the CIR or DOQ imagery used in this study, and would obviate the need for back and forth referencing while digitizing on-screen.

Taken to a higher level, the use of high resolution spectral imagery and more sophisticated GIS processing than is possible with ArcView would allow the development of an open lands and early successional habitat datalayer at regional scale, or even statewide, with periodic updates of this baseline data to detect change in location and maturity of the habitat features.