I. INTRODUCTION

Beginning in 2007, the Center Harbor Planning Board, working in conjunction with the Conservation Commission (CHCC), established priorities for the creation of a natural resources inventory (NRI). As noted on the Town's web site,

> "A Natural Resource Inventory is the first step in CONSERVATION PLANNING (the development of a vision for the future ecological health of an area). An NRI, while a substantial project, is not an end in itself, but an important tool for use in efforts to protect a community's natural resources.
>
> It is used as a reference to prioritize areas for conservation, to review development proposals, to evaluate effects of land use and may become a very important part of a town's Master Plan. An Inventory can be used as a guide in setting priorities for future land and easement acquisitions. An NRI is a valuable tool for public education and outreach."

In 2009, the Center Harbor Conservation Commission initiated such a comprehensive study of the natural resources of its town with Ecosystem Management Consultants (EMC) of Sandwich, NH. The principal tasks were to update pre-existing maps and data resources with current information, conduct GIS base mapping of all natural resources, develop a conservation strategy for its wetlands and water resources, and support the update of the Center Harbor Master Plan. A corollary study was also initiated on the previously approved prime wetlands in town. The latter included the identification of additional potential prime wetlands and the finalization of five prime wetland maps that were to be registered with the New Hampshire Department of Environmental Services.

By mid-2010, most of the natural resources information about Center Harbor had been compiled by EMC. A set of large format natural resource maps summarized the location and extent of water resources, forest cover, soil types, and conservation lands. Task 2 of this project provided a rationale for and the development of several *Co-Occurrence Base Maps*, where selected natural resources were highlighted and given point values according to preferences assigned by the Commission. These co-occurrence maps included the following:[1]

1. Wetlands, vernal pools & other surface waters – with buffers as specified below
2. Unfragmented lands – with 50, 75, and 100-foot buffers from roads
3. Best agricultural lands – areas with prime and statewide/locally important soils
4. Best forest lands – unfragmented forest lands > 50 ac. on good growing soils
5. Wildlife habitat – both upland and wetland, based on the state's Wildlife Action Plan, which also included point data on rare & endangered plant and animal species

[1] The natural resource base maps and selected composite maps were prepared with assistance of the Lakes Region Planning Commission (LRPC). Large format print versions can be located both at the Center Harbor Town Hall and at LRPC in Meredith. See also http://www.lakesrpc.org/maps/Center_Harbor_Natural_Resources.pdf

Finally, a composite map was prepared that summarized the above five overlays and included a color-shaded depiction of where multiple, high-value natural resources *co-occurred*. A scaled version of this map is shown below:

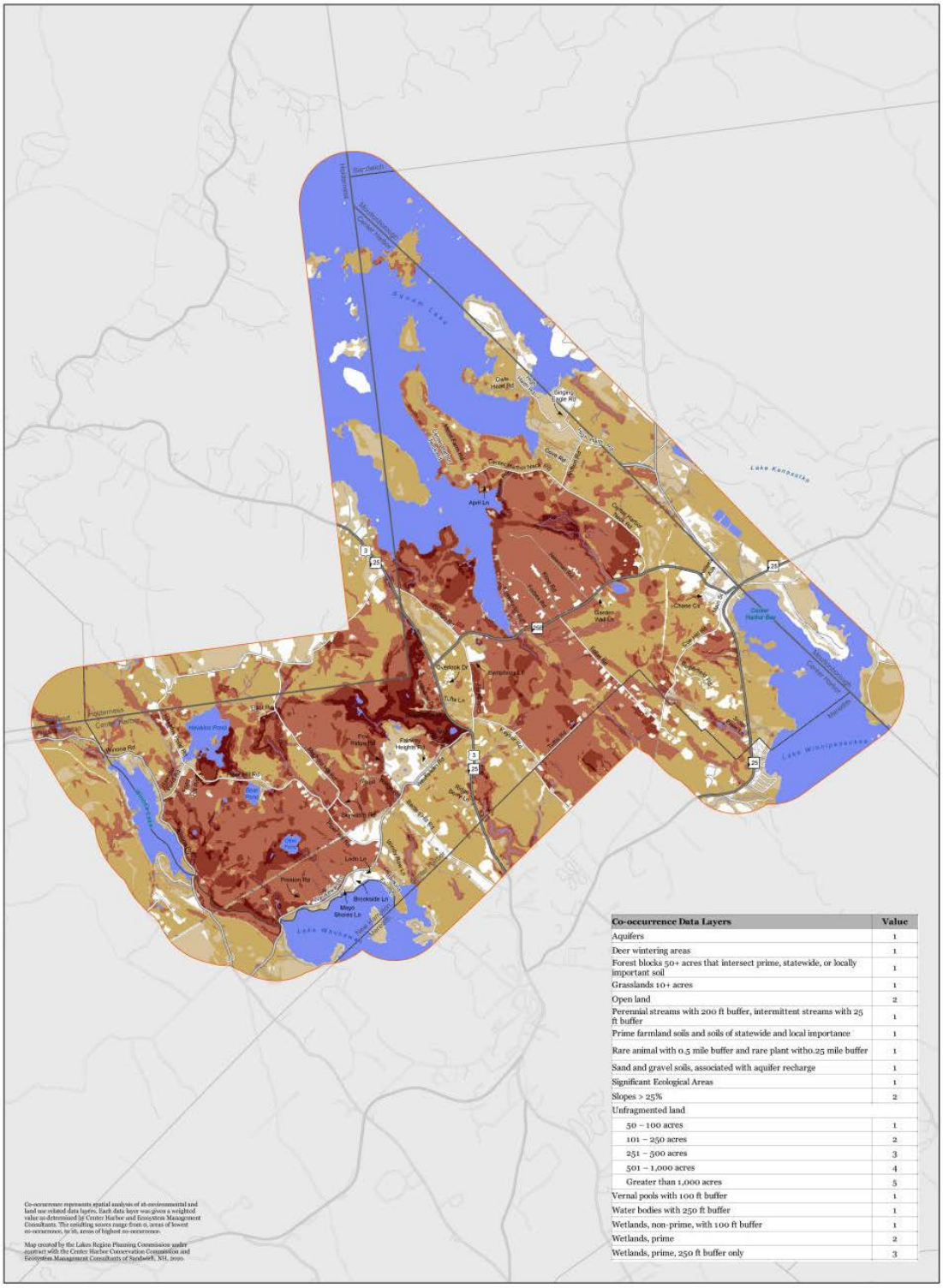

Figure 1. Co-occurrence Map of Center Harbor. The darker the brown shades, the higher the number of natural resource elements that overlay one another. Contributing layers and point values are listed at right.

In December of 2013, Cartographic Associates, Inc. of Littleton, N.H. completed an update of parcel mapping in Center Harbor. The update corrected a long-standing mapping error regarding the political boundary of the town. This resulted in an increase from 10,394 acres to 10,566 acres for the total size of the town, as well as a shift in the alignment of nearly all of the town's mapped boundaries. The Center Harbor Planning Board and the Conservation Commission, realizing that both the Master Plan and NRI maps were now inconsistent with the parcel map of town, hired EMC to update the natural resources maps. This update included additional data on natural resources, conservation lands, new prime wetlands, and the proposed designation of certain wetlands and streams.

The following report updates the 2011 NRI report and contains an explanation of the office and field methods used in deriving the natural resource data and maps. It also includes a brief synopsis of the findings for each natural resource element of concern and several descriptive recommendations for further NRI work and conservation planning by the CHCC. These recommendations reflect the updated Natural Resources Chapter of Center Harbor's Master Plan, which was also revised during this NRI update process. As in the 2011 NRI, the report includes seven, large format maps of Center Harbor's natural resources, with boundaries corrected to the most recent parcel map of the town.

II. METHODS

A. Office-based Procedures

The initial tasks of this project included a careful review of existing literature resources on Center Harbor, notably, an identification of existing map resources. The Lakes Region Planning Commission (LRPC) had already developed several geographic information system (GIS) maps of the region and these were helpful in recognizing what information had already been compiled in the past. [2] Most of the latter included GIS layers on hydrography (surface waters), groundwater, soils, land cover, and transportation networks. These data layers were being regularly updated by UNH Complex Systems Research Center (CSRC) and updates were searched for on the CSRC's statewide GIS database known as GRANIT. These included the following:

Resource Layer	Date	Description
Bedrock Geology	1997	UNH CSRC (Lyons et al.)
Conservation Lands	2010	Latest release April (updated locally)
Deer Yards	1995	NH Fish & Game Dept. (pdf's)
Digital Elevation Models	1987	From USGS topographic sources
Digital Orthophoto Quads (DOQ)	1998	Best available data
Digital Raster Graphics (DRG)	1987	USGS topographic maps
Landsat land use coverage	2001	Latest satellite imagery
NAIP aerial photography	2009	Latest statewide coverage
National Wetlands Inventory (NWI)	1986	USFWS Wetlands Inventory Data

[2] All GIS maps prepared for the town included information on areas within ½ mile of the town boundary.

NHDOT Aerial Photography	2006, 2010	1-foot pixel orthophotography for Lakes Region[3]
NHFG Wildlife Action Plan (WAP)	2010	Wildlife habitat & condition ranking
Political boundaries	1996	UNH CSRC
Public Roads	2009	NH DOT
Railroads	1993	UNH CSRC
Rare & Endangered Species	2013	Generalized location obtained from NHNHB
Soil Map Units	2005	NRCS (available through Web Soil Survey)
Tagged Vector Contours (TVC)	1998	20-foot contour intervals (USGS)
USGS Hydrography	2011	Streams & rivers, and other surface waters
Watershed boundaries	2002	UNH CSRC

Utilizing the above base layers, several derivatives were obtained through careful GIS analysis using ArcMap 9.2 and 10.0 technology. The following coverages were developed for the subsequent NRI analysis and co-occurrence of natural resources:

Data layer	Creator
1) prime wetlands - now updated with new soil / NWI types	EMC
2) designated and other non-designated wetlands	EMC
3) designated and non-designated streams	EMC
4) an updated shoreline layer based on 2010 API (aerial photo interpretation)	EMC
5) wetland buffers (100 feet)	EMC/LRPC
6) shoreline buffers for lakes and ponds – Squam, Winnipesaukee, Winona, & Waukewan lakes; Hawkins, Otter and Bear Ponds (250 feet)	EMC/LRPC
7) perennial stream buffer (200 feet) (wildlife & WQ)	EMC/LRPC
8) intermittent stream buffer (25 feet)	EMC/LRPC
9) unfragmented lands (50 - 250, 250-500, 500-1000, >1000)	LRPC
10) prime agricultural soils	NRCS/LRPC
11) soils of statewide or local importance	NRCS/LRPC
12) forest blocks > 50 acres that intersect good forestland soils (basically the prime, statewide and locally important soils)	LRPC
13) aquifers (shaded by transmissivity)	GRANIT
14) sand & gravel soils - #'s 12, 22, 24, 26, 27, 36	NRCS/LRPC
15) steep slopes (> 25%)	GRANIT
16) active agricultural (open) areas (based on API)	LRPC
17) grasslands > 10 acres (from active ag clip)	LRPC
18) deer yards (NHFG)	EMC
19) vernal pools	EMC
20) Rare & endangered species	EMC
21) Significant Ecological Areas (SEA's)	EMC

Table 1. Derived GIS data layers for Center Harbor

[3] All changes to water resources, wildlife habitats, and road alignments were made on the basis of the 2010 color infrared orthophotography flown by the NH Department of Transportation and made available through NH GRANIT in May 2011.

All prime wetlands, designated wetlands, other non-designated wetlands, designated streams, non-designated streams, shorelines, and other surface water features were initially derived from the 2006 1-foot color aerial photographs obtained from NH GRANIT. These were then updated using the 2010 color infrared aerial photographs from NH DOT. Maximum visible scale size for the aerial photo interpretation (API) was 1:1000, although most mapping took place at scales of 1:1250. All visible surface water features were mapped as polygons according to cover types established by the National Wetlands Inventory (NWI) in 1979.[4] Streams were mapped as polylines in order to establish appropriate buffer areas. Buffers for both polylines and polygon were established according to standardized recommended setback distances using the Buffer Tool in ArcGIS.

Unfragmented lands were defined as all lands that were not bisected by roads identified in the 2009 NH Department of Transportation (NHDOT) road coverage. Setback distances to roads that delimited the unfragmented blocks of land were based on roadway *class* according to recommended road fragmentation guidelines (see Section V. B. below). Prime agricultural soils as well as soils of statewide or local importance were taken from the published list on the USDA Natural Resource Conservation Service (NRCS) web site <http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm>. These soils were used to identify good crop growing areas as well as land areas with above average growing conditions for forests. Forest blocks of greater than 50 acres were initially identified from the 2001 Landsat land use coverage and then cross-checked with the 2010 aerial photographs.

Other soil and land use map derivatives included the aquifer coverage provided by NHDES, steep slopes, active agricultural areas and grasslands. Areas of stratified drift substrates (aquifers) were mapped according to their ability to convey groundwater for drinking water purposes (i.e. transmissivity). Steep slopes were derived from digital elevation models (DEM's) according to standardized slope classes (i.e. ≤ 25%, and > 25%). Active agricultural areas

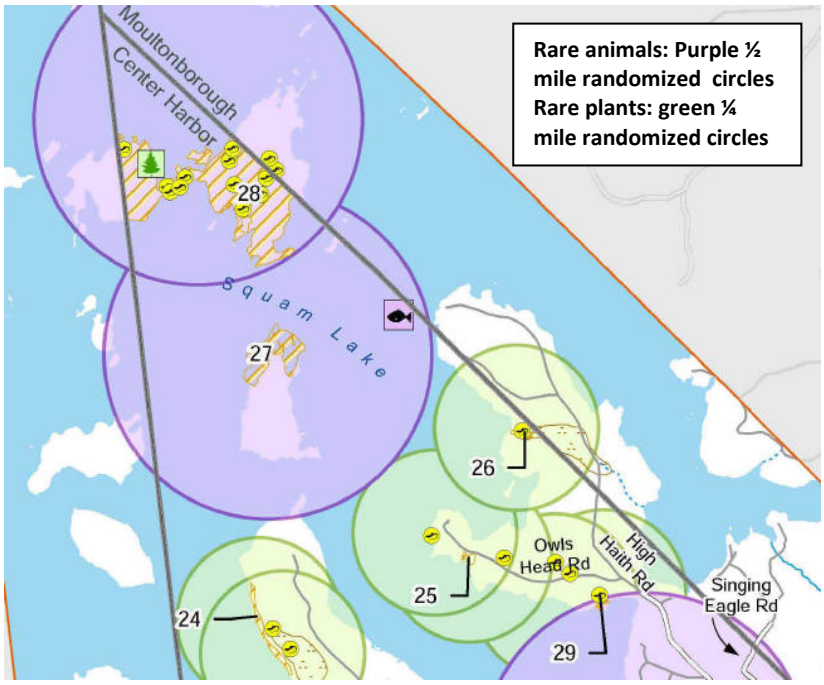

Figure 2. Clip of Significant Ecological Areas map showing R & E species polygons

[4] Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Fish and Wildlife Service. FWS/OBS – 79/31. Washington, D.C.: Government Printing Office.

were defined as unforested open land that was actively being kept open for pasture, hay, cropland, or Christmas trees. These were identified using the 2006 color aerial orthophotographs wherein polygons were created around all areas greater than a tenth of an acre. These open areas were then updated using the 2010 aerial photographs. Grasslands were created as a separate subset of active agricultural areas in order to isolate this specialized habitat for wildlife. These included pasture lands and hayfields that were identified from the 2006 and 2010 aerial photographs.

The last four GIS map derivatives addressed specialized biological resources that hold special significance for plants and wildlife. Deer yards, or areas where wintering whitetail deer likely congregate under conifers to survive winter, were digitized from NH Fish & Game Department hand-drawn 1995 map sheets. These were checked against land use cover types using both the Landsat data and the latest aerial photography and adjusted accordingly. Vernal pools were point-mapped according to visible open water pools on the 2010 aerial photographs. They were also derived from the extensive field experience of the author as well as members of the Center Harbor Conservation Commission. Rare & endangered species records were obtained from the New Hampshire Natural Heritage Bureau (NHNHB) and were cross-checked with NH Fish & Game and Loon Preservation Committee personnel. In keeping with confidentiality standards established by state law, these point data were randomized within quarter mile diameter (plants) or half-mile diameter (animals) circular polygons (see map above).

The final GIS derivative that was created from existing natural resource coverages was the Significant Ecological Areas (SEA) map. These areas were initially extracted from map data on rare or endangered species and then expanded to include areas of uncommon to rare natural communities, lands that are sensitive to human impacts, extensive wetland areas, and areas that contained a high concentration of natural resources. The latter was identified during the *co-occurrence* mapping process, which, as described and illustrated on Page 2, entailed a composite summary of all of the derived natural resource layers as defined above. A more detailed description of the SEA's is contained in Section VIII below.

Figure 3. Winona Lake pickerelweed

B. Field-based Procedures

Although most of the NRI tasks were completed in the office, there were a few opportunities to explore the roadsides and off-road areas of Center Harbor during the time period of the

NRI study.[5] Five field days were expended during the aforementioned prime wetlands study that was commissioned by the CHCC in 2008. These field days took place in the winter of 2008-2009 and focused on the five approved prime wetlands, namely, Hale Swamp, Leroux Wetland Complex, Paquette ("The Mug") Wetland, Johnson-Perkins Wetland, and Hawkins Pond. Two days in the summer of 2009 were spent checking rare plants and natural communities associated with these prime wetlands, especially Hale Swamp and the Leroux Wetland Complex. An additional fall day in 2009 was spent conducting a roadside and off-road survey of Center Harbor, especially in the vicinity of Squam Lake. Another field day was spent in March of 2010 exploring the largest roadless area in Center Harbor around Otter Pond, Bear Pond, and Fogg Hill. Six field days were conducted in the fall of 2012 while completing the third and final phase of the prime wetlands mapping process.[6] All field site visits were conducted with written landowner permission as coordinated by members of the CHCC. A hand-held Garmin 12XL GPS unit and Canon S3IS or SX20 digital camera were used to record salient features during these field site visits.

Highlights from the Natural Resources Inventory

Center Harbor has:

- Over 16 square miles of land & water area (10,566 acres)
- Over 25 miles of shoreline on three major lakes
- Over 28% of its land area covered by surface water and wetlands
- More than 70 active agricultural areas totaling over 400 acres
- Over 90 acres of prime farmland soils and 6700 acres of farmland soils of statewide or local importance
- An elevation drop of 617 feet from the high point on Sunset Hill (1121 feet) to the low point at Lake Winnipesaukee (504 feet).
- More than 500 acres of wintering deer yards at 33 locales
- Over 900 acres of prime wildlife habitat that supports rare species or natural communities
- Over 225 recognized vernal pools

Other Natural Resources in Center Harbor include:

- Two types of bedrock –Kinsman granite (Dk2x) & Winnipesaukee tonalite (Dw3A)
- Soils that are 76% glacial till, 1% glacial outwash, <1% alluvium, 2.5% organic material, and 2% filled land, with the remainder in open water

[5] It should be noted that extensive use of previous field notes and records of the author was used in deriving field-based data for Center Harbor's natural resources. Prior studies included the Squam Lakes Watershed Inventory Project (2001-2002) commissioned by the Squam Lakes Association, the 2006-2007 Waukewan Watershed Study conducted for Plymouth State University and the Town of Meredith, and various conservation lands inventories completed for the Squam Lakes Association (e.g. High Haith) and the Lakes Region Conservation Trust (e.g. Center Harbor Woods and Fogg Hill Bog).

[6] These six field days focused on Belknap Woods Beaver Ponds, Chamberlain-Reynolds/Heron Cove, Fogg Hill Bog Complex, Newman Trust Wetland, Otter Pond, and Sturtevant Bay, each of which was approved by town vote as prime wetlands in 2013 and 2014.

- Nine separate aquifers in five areas: 1) around the village and Center Harbor Bay (two), 2) along US Route 3/ NH Route 25 (Hawkins Brook) (one), 3) at the Holderness town line along Swainey Brook (one), 4) along the Snake River (three), and 5) around the south edge of Hawkins Pond (two)
- Over 31 miles of rivers and streams, 9.1 miles of which are perennial
- Part of two major watersheds—Squam (Pemigewasset) River, Winnipesaukee River
- Four major surface water bodies
  - Squam Lake – 1512.4 acres in Center Harbor with 18.0 miles of shoreline
  - Winnipesaukee Lake – 318.9 acres in Center Harbor with 3.7 miles of shoreline
  - Lake Waukewan – 4.5 acres in Center Harbor with 1.8 miles of shoreline
  - Winona Lake – 70.3 acres in Center Harbor with 2.0 miles of shoreline
- 1090 acres of hydric soils and 376 acres of Prime Wetlands (316 acres in Center Harbor)
- Over 8,224 acres of forest/shrub land or roughly 78% of Center Harbor's total land area.
- 2,623.8 acres (24.8%) in Tier 1 wildlife habitat (highest rank by ecological condition in NH), and 329 acres (3.1%) of Tier 2 wildlife habitat (highest in biological region)
- 1052.8 acres of protected lands of (Nov 2014), with three parcels managed by the Center Harbor Conservation Commission and remainder stewarded by private land trusts

Figure 4. Hawkins Pond in summer

III. PHYSICAL LANDSCAPE

Center Harbor lies in the heart of the Lakes Region of New Hampshire near the northwest edge of the Northeastern Highlands (Level III) Ecoregion.[7] It falls within the Level IV Sub-region identified as the Ossipee-Sebago Hills and Plains. This region is known for an abundance of lakes and ponds amidst sandy glacial outwash and till. It is largely forested, with hemlock-hardwood-pine and northern hardwood-conifer forests predominant in the uplands. The region is also transitional from the more rugged, higher elevation White Mountains to the north and low-lying plains to the southeast. As a result, some of the isolated peaks and mountain ranges contain boreal elements, such as can be found in the Ossipee Mountains. In Center Harbor, the only montane spruce-fir forest of this type can be found on the highest elevation point (1121 feet) on Sunset Hill. Additional higher elevation points can be found at "Observatory Hill" (910 ft.), McCrillis Hill (1085 ft.), and Fogg Hill (985 ft.), where northern hardwood-conifer forests can be found in their upper part. [See **General Topography Map, Map #1**].

An average of four inches of precipitation falls each month, which supplies both surface water bodies and sub-surface aquifers with needed water. As noted above, nearly 20% of the town is permanently inundated, and at least nine named islands can be found within the

[7] For more information on Ecoregions, see www.epa.gov/region1/neaeb2010/pdfs/PosterHellyerGreg.pdf

four lakes of note. Wetlands make up the balance of the surface water areas (10.3% of the town). These can be found adjacent to lakes, ponds, rivers and streams, as well as on flat terraces from low to high elevations. Groundwater infiltration is greatest in these flat or low slope areas, and five areas in town stand out as containing significant aquifers: 1) around the village and Center Harbor Bay, 2) along Route 3 & 25 (Hawkins Brook), 3) at the Holderness town line along Swainey Brook, 4) along the Snake River, and 5) around the south edge of Hawkins Pond. [See **Water Resources Map, Map #2**].

A. Bedrock Geology—Most of Center Harbor is Granite

The foundation of Center Harbor is comprised of Late Devonian magma domes associated with the Acadian Period of mountain-building.[8] Upwelling crustal material formed large crystalline granites of the Kinsman and Winnipesaukee formations during active periods of continental crust collision. The Kinsman Formation material can be easily identified by its large (i.e. 2 – 3 inch) crystals of potassium feldspar that are embedded in a fine granite or granodiorite matrix. It makes up less than 25% of the town and can be found in the Winnipesaukee trough. The slightly older Winnipesaukee Formation is comprised of even, medium-sized crystals of mica, quartz, and feldspar and has a more "classic granite" look to it. It can found throughout the remainder of the town, including the Squam Lake trough, the western highlands section, and along the Winona Lake-Snake River drainage. Some of the higher hills in Center Harbor are comprised of erosion-resistant pegmatite formed during this period of uplift. Good examples can be seen on Sunset Hill, McCrillis Hill and Fogg Hill.

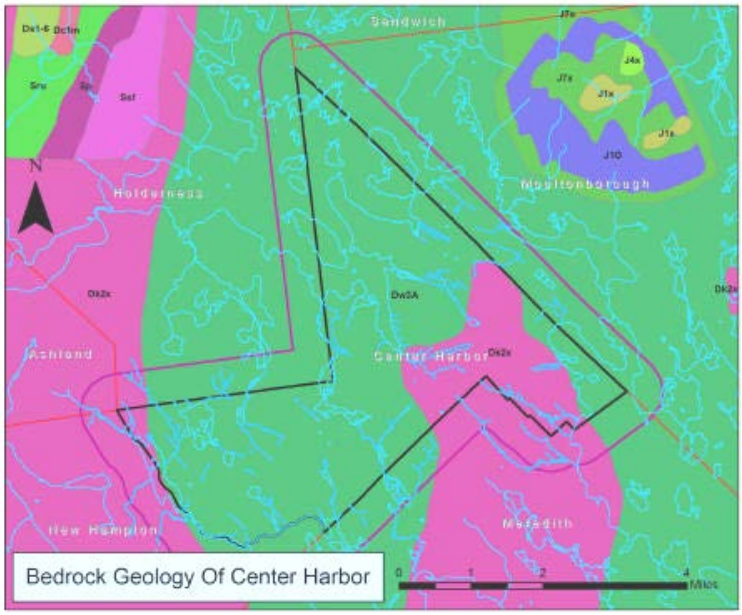

Figure 5. Bedrock geology map of Center Harbor[7]. Note that just two bedrock types are mapped for the town: Dk2x, the Kinsman granite, and Dw3A, the Winnipesaukee granite.

Figure 6. Many of the rock walls in Center Harbor are made up of granite stones with the classic 'salt-and-pepper' look, characteristic of the Winnipesaukee tonalite (Dw3A) as can be seen at Center Harbor Woods.

[8] See *Bedrock Geology of New Hampshire* (1997) Lyons et al.

B. Surficial Geology - Most of Center Harbor is covered with Stony Glacial Till with Sand & Gravel Outwash Materials in Low Lying Areas

Three-quarters of Center Harbor is overlain with glacial till, a loose assortment of boulders, stones, cobbles, sand, silt and clay that was laid down by the Wisconsin ice sheet over 13,000 years ago. Most of this till has more than 15% stones or boulders in the mix, and >50% of the till comes with a hardpan (densipan) less than three feet from the surface. The erosional byproducts of granite tend to be coarse, and so many of the areas where glacial debris was carried by water contain evenly sorted beds of sand between .05 and 2.0 mm in diameter. These "stratified drift" materials provide a good source of sand and gravel and in some cases, excellent recharge areas for groundwater. *Stratified drift* aquifers are shown on the **Water Resources Map, Map #2** along with other areas where sand and gravel have been deposited. The largest concentration of these deposits is at the five sites noted on Page 9.

Figure 7. Mourning doves also utilize sandy deposits, in this case, for swallowing grit to aid in digestion near Winona Lk.

IV. AGRICULTURE & SOILS

A. Soils – Most of Center Harbor Soils are Available for Agriculture or Silviculture

The glacial tills noted above has been acted upon for more than 13 millennia by climate, vegetation, and topography. Chemical and physical alteration of the parent soil material has resulted in very good growing conditions for plants over most of the landscape. Only in areas where surface water, steep slopes, or abundant stones and boulders adorn the hillsides has agriculture – or silviculture in extreme cases – been interrupted. Till soils range from low, flat terraces to higher elevation, steep slopes. Many are in stony or bouldery phases, although several have been modified somewhat by the removal of surface stones to nearby walls. Soil depths exceed five feet in certain places, although most depths are less than three feet to ledge, boulders, or water saturation.

Figure 8. Most soils in Center Harbor are fairly good for growing crops but only after having been cleared of stones and drained because of high water tables.

Sand and gravel deposits noted above comprise less than one percent of Center Harbor's landscape, including those areas where water is at or near the surface. Where surface water

stands for more than one month during the growing season, organic soils have developed.[9] During the wetland soils mapping project of the recently updated natural resources inventory or NRI, a total of 238 acres of organic soils were identified in Center Harbor. While these soils are poorly rated for growing crops or trees, some of them have been drained or filled for past land uses. In all, a total of 1.9% of the land in Center Harbor has been identified as containing fill materials.

B. Agriculture - Most of Center Harbor Soils are Fairly Productive

Nearly 65% of the soils in Center Harbor are either *prime farmland soils*, soils of *statewide importance*, or soils of *local importance* according to the U.S. Department of Agriculture's Natural Resource Conservation Service.[10] These three soils types are comprised of deep sandy loams or loamy sands, are not excessively droughty, and contain sufficient amounts of organic matter to provide excellent nutrients for plant roots. Prime farmland soils can be found in at least six different areas (56 acres), and all are associated with active agricultural land. Over 90% of the prime farmland soil is under production for hay, Christmas trees or other crops. Greater than 97% of the remaining active agricultural areas lie within soil map units that are rated good to excellent for agriculture. These areas are mostly open fields that are kept mowed for open space, although some, such as along Center Harbor Neck Road, are under crop and hay production. [**See Important Soils Map, Map #3**].

V. FOREST RESOURCES - Center Harbor has Large Tracts of Unfragmented Forest and Open Lands

One of the most important natural resources in Center Harbor is its forests. Center Harbor has over 8,223 acres of forest land or approximately 78% of Center Harbor's total land area as shown on **Map #4**, **Forest Cover Map**. Taking out the open water areas, Center Harbor is over 94% forested. This is above the average of 83% forest cover for the rest of state.

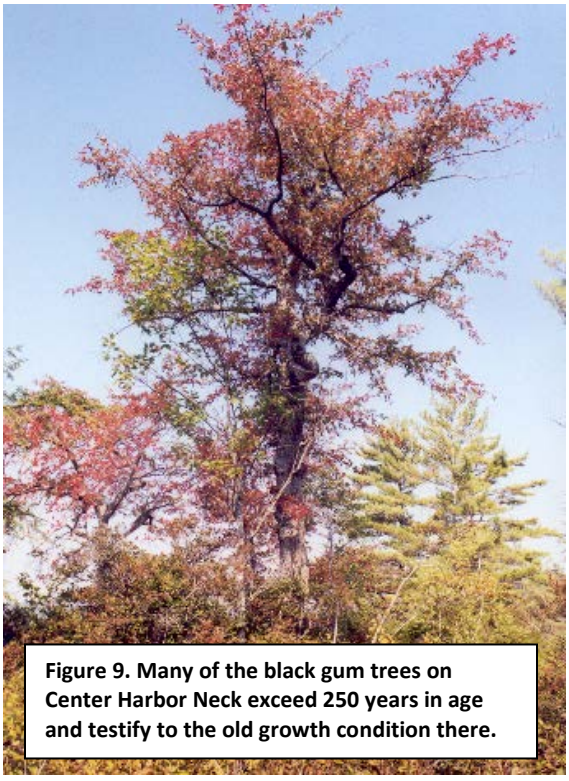

Figure 9. Many of the black gum trees on Center Harbor Neck exceed 250 years in age and testify to the old growth condition there.

Center Harbor's forests are nearly all second growth forests that were cut over or burned at the time of settlement in the late 18th century. Over the course of just a few decades the initial primeval forests of hemlock, spruce, oak, pine, and chestnut were converted to farm fields, pastures, and fuelwood lots. Tens of miles of stonewalls attest the fact that one time, more

[9] By definition, organic soils have > 12.5% carbon by volume for a minimum depth of 16 inches.

[10] The latest soils information can be viewed or downloaded at http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

than 75% of the town was farmland. Many of the islands in Squam Lake, extensive marshlands, and steep, bouldery slopes were the only places where trees remained. As a result, a small fraction of the original forests can be witnessed today. An old growth patch of hemlocks can be seen at Chamberlain-Reynolds Forest on Squam Lake, an ancient black gum swamp resides on Center Harbor Neck, and an old growth woodland that was pastured for a while can be seen atop Fogg Hill.

A. Forest Cover Types

The **Forest Cover Map** shows a predominance of mixed forest types in Center Harbor. The most common is what is called the Hemlock-Hardwood-Pine Type by the NH Fish & Game Department.[11] Dominated by canopy species such as eastern hemlock, beech, red oak, and white pine, this type is estimated to cover over 7000 acres of the town. This mixed forest can be found on all of the lower slopes and hillsides up to about 1100 feet in elevation. It occurs on well-drained soils, with hemlock and beech occupying the wetter sites and red oak and white pine the drier sites. Near the tops of the major hills in Center Harbor where south-facing slopes occur on thin, rocky soils, the entire forest can be made up of red oak and white pine. Occasionally, white oak and red pine can be found on these south-facing slopes as well.[12]

Only on the highest hills, especially those with a northerly aspect, can one find the Northern Hardwoods-Conifer Forest Type. It is uncommon in Center Harbor, although this type can be easily seen on the north side of McCrillis Hill along the roadside. There is also a small amount of it on Sunset Hill. The dominant canopy species are sugar maple, beech, yellow birch, and hemlock, although in most areas of the town where it occurs, hemlock and yellow birch tend to be the most frequent. Occasionally, this forest type can be found along cool drainageways that benefit from the cold air descending from nearby hills. A walk up into the far reaches of Belknap Woods will provide a view of such a forest.

Figure 10. Eastern hemlock is one of the most common and widespread trees in Center Harbor, and occurs form the lowland forest to near the top of Sunset Hill.

The NH Fish and Game Wildlife Action Plan habitat maps as cited below illustrate a small patch of the Lowland Spruce-Fir Forest Type in Center Harbor. Located on Sunset Hill, this roughly 19 acre patch occupies the uppermost, north-facing slopes of the hill. Although not verified on the ground, this type typically contains a high percentage

[11] The statewide coverage of forest and other habitat types can be viewed at www.wildlife.state.nh.us/

[12] Predominantly oak-pine forests on dry, thin soils correspond to the Appalachian Oak-Pine Type according to the NH Fish & Game Department (see Section VII.B).

of red spruce and balsam fir, along with an occasional paper birch and yellow birch. This habitat is considered a "lowland" type because it does not occur above 2500 feet in elevation, whereas the Montane Spruce-Fir Forest of the White Mountains occurs above this elevation on the average. Some of the best local examples of this forest type can be seen atop Red Hill, at the Castle-in-the-Clouds (Mt. Shaw), and on Leavitt-Ladd Mountain in Meredith.

The remaining forest types in Center Harbor largely belong to forested wetlands, and are more fully described under the next section entitled Water Resources.

Unfragmented Lands Provide:

- Highest quality wildlife habitat
- Uninterrupted biodiversity processes
- Reserves of biogenetic diversity
- Sources of commercial wood products
- Intact watersheds for drinking water supplies
- Hunting, fishing, and other recreational opportunities
- Aesthetic backdrop to the built landscape

B. Unfragmented Lands

Unfragmented lands are land blocks—typically forested uplands—that are not bisected or fragmented by roads or railroad corridors. They are also located away from residential and commercial development. Unfragmented lands are important as sources of forest products, as wildlife habitat, and as intact watersheds that supply clean drinking water. In Center Harbor there are approximately7,187 acres of unfragmented lands. Excluded from this area is 1906 acres of lakes, 712 acres of roads, roadside buffers and agricultural lands, 242 acres of non-forest wetlands, 117 acres of certain forested wetlands,[13] and 402 acres of active agricultural lands. Roadside buffers varied according to the type of the roadway, and were based on the rationale that a less travelled or narrower roadway presents less of a barrier to accessing forest resources and provides an easier crossing for wildlife. The following buffer widths from roads in Center Harbor were used for this analysis:

- State roads, Class I & II 110 feet
- Class V, paved 75 feet
- Class V, gravel 50 feet
- Class VI 0 feet
- Private roads, paved or unpaved 50 feet

Forest blocks of 500 or more acres tend to have high value for ensuring healthy wildlife habitat as well as providing a significant opportunity for sustained forest management. **See Map #5, Unfragmented Lands.** Center Harbor has four significant forest blocks, each of which contains > 500 acres within the town's borders. The largest block of over 900 acres exists north of Lake Waukewan on the slopes of Fogg Hill. The second largest forest block in Center Harbor includes an area north and west of Waukewan Golf Course (> 700 acres in

[13] Excluded forested wetlands include those where trees make up less than 30% of the canopy or are standing dead.

town). The third largest block surrounding Belknap Woods has over 600 acres in town, and another 800 acres in Meredith. The fourth largest forest block surrounds Sunset Hill and has just over 500 acres in Center Harbor. Curiously, one of the smallest forest blocks in Center Harbor (180 acres) is connected to the largest unfragmented land area that is adjacent to the town - an area of over 3,000 acres in northwest Center Harbor and southeast Ashland.

VI. WATER RESOURCES - Center Harbor has an Abundance of Surface and Groundwater Resources

A. Watersheds

Center Harbor contains a portion of two large watershed divisions in the state of New Hampshire,[14] – the Squam Lake watershed of the Pemigewasset River Basin and the Winnipesaukee Lake watershed of the Winnipesaukee River Basin. The Squam Lake watershed includes just one sub-watershed with 5874 acres in Center Harbor (55.6%) and the Winnipesaukee River watershed includes three sub-watersheds – Lake Waukewan, Meredith Bay, and Center Harbor Bay – that contains 4692 acres or 44.4% of the town. There are 11 hydrologic units known as "catchments" that comprise these four sub-watersheds, each of which is associated with a perennial stream. Five of these serve five of the prime wetlands in Center Harbor; two more feed into Squam Lake; one flows into the lower portion of Center Harbor Bay; two drain into Lake Waukewan, and the remaining catchment lies above Winona Lake.

B. Large Water Bodies

Surface water covers over 28% of Center Harbor. Of this, four principal water bodies are recognized:

Table 2. Major Lakes in Center Harbor

Water Body Name	Total Acreage	Acreage in Center Harbor	% of Total Acreage	Length of Shoreline (mi.)
Squam Lake	6,765	1512.4	22.4	18.12
Lake Winnipesaukee	44,586	318.9	0.72	3.64
Winona Lake	148	70.3	47.4	2.00
Lake Waukewan	912	4.5	0.5	.86

Center Harbor includes most of the southeastern portion of Squam Lake, including Dog Cove and Sturtevant Bay. Center Harbor Neck divides the latter two coves, and High Haith forms the eastern boundary of Sturtevant Bay. Aside from Long Island in Squam Lake, High Haith is the northernmost piece of land in the town. Center Harbor includes most of Great Island, all of Mouse Island and Kimball Island and most of Long Island in Squam Lake. In Lake Winnipesauke there are three islands in Center Harbor Bay – two known as Half Mile Island

[14] Known as "HUC 8" watersheds, the "Hydrologic Unit Codes" at this level contain eight digits in their identifying code. Pemigewasset River is known as 0107001 and Winnipesaukee is known as 0107002.

and one known as Mile Island, both of which were named for the distance from the principal boat dock of the *Mount Washington*. There are no islands contained in the Center Harbor portion of either Lake Waukewan or Winona Lake.

C. Streams and Rivers

The attached **Map #2**, **Water Resources** in Center Harbor indicates that there are 14 perennial streams and 30 additional intermittent stream systems. Perennial streams total 9.06 miles and include the 1.3 mile long Snake River, the 1.3 mile Hawkins Pond tributary, the 1.3 mile unnamed brook feeding into Center Harbor Bay, and the .63 mile section of Hawkins Brook above the Meredith town line. All of the latter do not include the flatwater (wetland) portions of the tributaries nor the ponds associated with these wetlands. All perennial streams have been proposed as "*designated streams*" in the approved Water Resources Map (see Center Harbor Master Plan). There are 22.1 miles of intermittent streams, many of which feed into the perennial streams. Several short sections can also be found leading directly into the four major lakes noted above. Although these contain very small catchments without perennial characteristics, they form critical basins that directly affect the water quality of the surface waters downstream.

There are no large (i.e. 4th order) streams or rivers in Center Harbor. This is significant because of the strict regulations associated with such streams and rivers in the state. The N.H. Surface Water Quality Protection Act (RSA 483-B) outlines restrictions to development and other activities within the 250-foot buffer zone of all great ponds (i.e. natural lakes and ponds > 10 acres in size) all fourth order (and some named third order) streams and rivers.[15] In Center Harbor, the largest riverine system is the Snake River, which is considered a third order stream.[16] All four lakes described above, along with Hawkins Pond, Bear Pond, and Otter Pond are considered great ponds, however, and are protected in part under the SWQPA.

Figure 12. Water-based recreation, biological integrity, and property values all depend on good water quality. The 2080 acres of lakes and ponds and 31.2 miles of streams in Center Harbor are all connected to upstream and downstream surface waters in the Lakes Region. The health of these open water bodies are, in turn, dependent on the quality of water that lies underground.

[15] The Surface Water Quality Protection Act (SWQPA) can be found at http://www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-L-483-B.htm.

[16] A full explanation of the Strahler stream order classification system can be found in C.A. Frissell, W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. *Environmental Management* Vol. 10(2) 199-214.

D. Groundwater

The **Water Resources Map** shows the presence of nine stratified drift aquifers in Center Harbor (352 acres). Mapped by the N.H. Department of Environmental Services Water Resources Division in 1987, these areas include porous, sands and gravels associated with glacial outwash where precipitation and infiltration rates are high. In four cases, the plurality of the mapped aquifer lies within Center Harbor, however in the fifth case (along Swainey Brook), most of the aquifer lies outside of the town. The entire Winnipesaukee watershed aquifers are low yield – i.e. < 1000 square feet per day transmissivity.[17] The single aquifer in the Pemigewasset watershed along Swainey Brook is rated as a medium yield aquifer at > 2000 square feet per day. Since these groundwater resources supply many registered wells – at least 8 in Center Harbor – as well as virtually all of the large surface waters of the town, they are extremely important to protect.

The **Important Soils Map #3** also shows where at least one fairly large deposit of sand and gravel exists outside of a known aquifer area. The flat terrace along Beaverside Drive off of Route 3/25 contains a 33-acre area with Colton loamy fine sand where groundwater infiltration and drinking water supply potential is also very high. Since this is not the only area where sand and gravel deposits support rapid infiltration by precipitation, snowmelt, and run-off, it would be of benefit to consider mapping all known past and present gravel pit areas to better understand where potential groundwater resources lie within the town.

E. Water Quality

Squam Lake Watershed

Squam Lake has been regularly monitored by the Lay Lakes Program at UNH for the past 36 years. Among the 20 monitoring locations one is located in Center Harbor Bay near the bridge that leads onto High Haith. Both open water and tributary data has been tested for transparency, chlorophyll α, total nitrogen, total phosphorus, dissolved oxygen, biologic oxygen demand (BOD), and conductivity (specific conductance). In general, the overall water quality of the Center Harbor Bay is excellent, although there are seasonal variations that have affected this condition, especially during periods of high precipitation leading to sediment and nutrient run-off and greater loss of transparency.

Winnipesaukee Watershed

On the Winnipesaukee side of Center Harbor's major watershed divide, the N.H. Department of the Environmental Services Volunteer Lake Assessment Program (VLAP) has been sampling Lake Waukewan and for almost 20 years. This sampling effort has included one deepwater site near Center Harbor, Mayo Station off Mayo Shores, and several shallow water sites in Center Harbor, such as the inlet to Lake Waukewan, along the Snake River, at Winona Lake, and at Hawkins Pond. The same abiotic and biotic parameters have been tested, with an additional emphasis on chlorides from road salt. In general, the findings of

[17] Transmissivity is a measure of the aquifer's ability to transmit precipitation into the subsurface outwash materials.

the VLAP effort have been positive, with relatively stable and predictable levels of physical and chemical parameters among sampling stations. Some concern has been expressed about summer levels of dissolved oxygen at the lake bottom, although nutrient inputs such as nitrogen and phosphorus have been within or well below statewide averages.

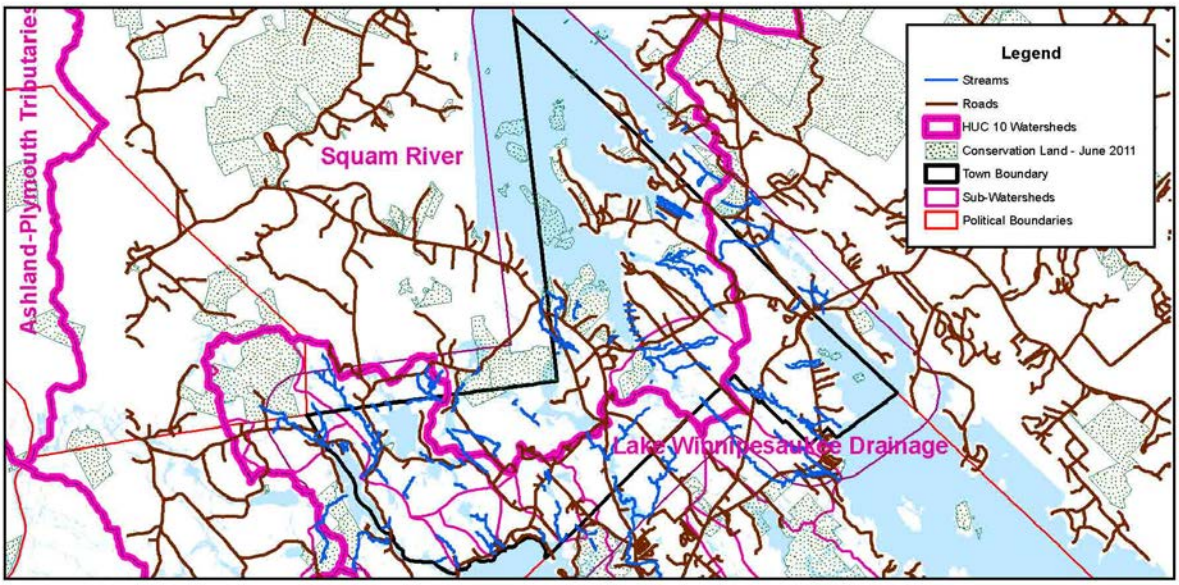

Figure 13. Major watersheds of Center Harbor

Considering the high value that Waukewan Lake has for its Center Harbor, New Hampton, and Meredith residents, a multi-town advisory committee was formed in 2004 to develop and implement a watershed wide management plan. The Waukewan Watershed Advisory Committee (WWAC) completed the plan in late 2005 and has been since charged with the task of its implementation. As a result, the entire watershed above Lake Waukewan has received greater scrutiny than any other watershed, sub-watershed or catchment in the town. This was demonstrated by a fairly recent suite of abiotic and biotic sampling performed by Plymouth State University in 2006-2007. During this sampling effort, chlorides were collected monthly at 14 sampling points around Waukewan, many of which were in Center Harbor. Three of these sampling sites were also the subject of long-term biomonitoring samples. The biomonitoring sites are summarized by the following table:

Table 3. Biomonitoring Stations above Lake Waukewan 2006-2007

SITE #	GEN. LOC	Trib. Name	LAT	LONG	Site Type	Sampling Approach
5	Just above West Lake Road	**5 - Winona Inflow**	43.68690178	-71.57804324	low riffle 2nd order stream near dirt rd	rock basket; series of 3 tied together
6	Below Hawkins Pond outflow dam	**6 - Hawkins Pond Inflow**	43.68525876	-71.56446783	2nd order stream, fast-running	rock basket; series of 3 tied together

7	150 m above inflow into lake; 1250 m below GC	**7 - Golf Course Drainage**	43.67175769	-71.52132550	2nd order stream below rock shelf	rock basket; series of 3 tied together

The findings from the chlorides study showed a general trend of increased levels during late winter and early spring samples followed by a rapid decline by early summer. Both the maximum spring levels and the mean summer levels have been well below the statewide average and well below the critical threshold set by the state and federal government. The biotic (macro-invertebrate) samples also showed a fairly positive trend in pollution levels, as evidenced by a preponderance of pollution-intolerant organisms. Although some indicators of water pollution are present at isolated locales in the town, Center Harbor appears to have very good water quality on the whole among all of its surface water areas.

Figure 14. Water chemistry & biomonitoring samples collected by Plymouth State University students in 2006-7 confirmed a fairly high degree of water quality in the Lake Waukewan watershed.

F. Wetlands

Map #6, Wetlands, illustrates the location of all areas in Center Harbor where water is at or near the surface of the land. Deepwater areas have been described above, yet those that involve shallow water as well as those areas that are at the edge of deepwater are described below. Wetlands are defined as follows:

> "Wetlands include those areas that are inundated or saturated by surface or groundwater at a frequency and duration to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted to life in saturated soil conditions." RSA 482-A:2 X.

In general, wetlands exist where surface and/or groundwater can be found at the soil surface for a long enough period of time for both hydric soil conditions to develop and wetland plants to grow. The latter, known as "hydrophytes," include such plants as cat-tails, sedges, and rushes in wet meadows and marshes, alder, blueberry and leatherleaf in scrub-shrub wetlands, and red maple, yellow birch, and black ash in forested wetlands. Although streams and rivers are "surface waters" in the eyes of the state, they often develop wetland conditions by having bordering vegetated areas with hydric soils and a prevalence of hydrophytes. Intermittent streams are also considered part of the jurisdictional wetland system by the state of New Hampshire, and therefore the wetlands mapping regime included these valuable surface water areas.

Wetlands provide valuable functions to society. The ability to store floodwaters continues to reduce downstream flood damage. The recharge of groundwater into underlying aquifers continues to provide clean drinking water supplies. Occurring in low lying areas, wetlands also receive, trap, and process sediments and nutrients that arrive from adjacent roadways and development. Thus they improve water quality by filtering out unwanted chemicals and suspended solids in our flowing streams and ponds. Perhaps most importantly, they serve as a refuge for wildlife, and offer countless numbers of habitats, shelter areas, and food sources for mammals, birds, fish, amphibians, and reptiles.

Figure 15. Wetlands, such as this one along Dane Road, provide innumerable values to society, including flood storage, water quality enhancement, wildlife habitat, scenic views, and recreational opportunities. Biologically, they represent the most important lands in a given region.

A total of 1,090 acres of wetland were identified during the Center Harbor NRI. This represents 10.3% of the town. With the exception of the prime wetlands, most of these were identified using leaf-off color aerial photography from 2006 and 2010. Eight principal wetland cover types were recognized among 112 wetland complexes in town.[18] The smallest wetland was .013 acres and the largest was 123 acres, with a mean size of 2.5 acres. Twelve of these have been named as "prime wetlands," 30 more as "designated wetlands," and the remainder as "undesignated wetlands." The attached **Map #6** also indicates where an additional 698 acres of non-lake wetlands were mapped in the half-mile "ring" that surrounds Center Harbor. In all, there are 1,788 acres of wetland and 4,682 acres of deepwater habitat in Center Harbor and the half-mile area that surrounds it.

G. Prime Wetlands

In Center Harbor, five wetlands were approved by town vote in 2006 as "prime." In 2009, revised mapping of these wetlands allowed for the official designation of these five areas as prime wetlands by the state of New Hampshire.[19] In March 2012, the Center Harbor portion of the Snake River was approved by town vote and subsequently by the state to be a prime wetland. Based on recommendations in the December 2011 version of this NRI, six other large, high value wetland complexes were nominated as prime wetlands in 2012. These were

[18] For a list of wetland types found in Center Harbor, see Appendix B.

[19] A summary of the prime wetlands report submitted to the state of New Hampshire is on file at the Town Hall.

approved by town vote in March 2013 and March 2014, all six of which were subsequently approved by the NH DES Wetlands Bureau.

According to RSA 482: A-15, prime wetlands are those that by virtue of their "unspoiled and fragile nature" can be voted on by the town to be specially registered with the state, and thereby receive extra protection under state law. At present, the latter includes a 100-foot development buffer or setback and a mandatory public hearing for any non-exempt activity within that buffer. Center Harbor's twelve prime wetlands are detailed in Table 4 below:

Table 4. Prime Wetland Summary – Center Harbor

Wetland Complex #	NAME	SIZE (est.)	SIZE (act.)	SIZE in Town	TAX MAP #'s	NEAREST ROAD(S)	ZONING
#6	Sturtevant Bay	4.53	11.23	11.23	208	Center Harbor Neck Road	RR
#15	Newman Trust Wetland	18.79	18.35	18.35	208	Newman Road, Mouse Road	RR
#41	Chamberlain Reynolds / Heron Cove	20.17	24.60	24.60	213	College Road	RR
#43	Otter Pond	15.94	15.52	15.52	104,229	Piper Hill Road, Waukewan Road	RR
#52	Paquette Wetland Complex	19.24	18.50	18.50	227	Daniel Webster Highway	RR,C
#54-55	Hale Swamp	128.55	123.17	96.68	221,224,226	Daniel Webster Highway, Waukewan Road	RR
#58	Leroux Wetland Complex	22.54	17.52	17.52	222,226	McCrillis Hill Road	RR
#68-69	Belknap Woods Beaver Ponds	10.53	19.30	19.30	215,220	Dane Road, Keyser Road	RR
#70	Snake River	58.2	58.20	25.11	105,229,230	Winona Road, Waukewan Road	RR
#71-72	Fogg Hill Bog Complex	11.32	11.66	11.66	224	Winona Road, Fogg Hill Road	RR
#79-80	Hawkins Pond	18.03	31.40	31.40	222,224,225	Piper Hill Road	RR
#87-88	Johnson-Perkins Wetland Complex	23.51	26.30	26.30	222	McCrillis Hill Road	RR
	SUM	351.35	375.75	**316.17**			

Sturtevant Bay encompasses a mostly undeveloped bay off High Haith Road at Squam Lake. It includes a high quality shallow to deep emergent marsh with exceptional migratory wildlife habitat. The Newman Trust Wetland includes an extensive beaver marsh at the outflow of two pristine perennial streams. The marsh outlets to a pristine shallow water bay on Squam Lake that contains rare plant and animal species. Chamberlain-Reynolds / Heron Cove includes the highest ranking wetland in Center Harbor for wildlife habitat and water quality maintenance. Used extensively for berry picking, camping, and swimming, this prime wetland can be directly viewed from a quarter-mile boardwalk. Otter Pond offers a remote and undisturbed beaver pond with regionally important value for migratory waterfowl. Hale Swamp is the largest and most diverse wetland complex in Center Harbor and contains excellent wildlife habitat across a low, wet divide at the headwaters of both major watersheds in the town. It also contains one of the two quaking bogs in Center Harbor. The Leroux Wetland Complex is west of Hale Swamp and includes a series of pristine beaver marshes below Pine Hill in Holderness. Belknap Woods Beaver Ponds also spans two watersheds but is connected by a wildlife-rich riparian corridor. It lies south of Dog Cove and Squam Lake. Snake River includes a protected riparian corridor between Lake Winona and Waukewan Lake. Although more of a marsh than a river, it has exceptional wildlife habitat and supports rare bird species. Just uphill to the east is the Fogg Hill Bog Complex,

which includes the most remote and undisturbed bog in Center Harbor. The Hawkins Pond Prime Wetland is located northeast of Fogg Hill, and is comprised of extensive leatherleaf fern mats surrounded by open water. Finally, the Johnson-Perkins Wetlands Complex lies to the east of Hawkins Pond, and includes the headwaters of the largest wetland complex in Holderness above White Oak Pond. All 12 prime wetlands provide invaluable flood water storage and water quality enhancement function, as well as exceptional wildlife habitat.

Figure 16. Hale Swamp (left) contains one of two floating bog mats in Center Harbor. It also supports one of the more rare orchids in the state, white-fringed orchid (*Platanthera = Habenaria blephariglottos*) at right.

VII. WILDLIFE – Center Harbor has an Abundance of Terrestrial and Aquatic Wildlife

One of the most highly valued features of Center Harbor's natural resources is its wildlife. For the purposes of this chapter, the term "wildlife" includes all vertebrate and invertebrate animals, both native and non-native, that regularly occupy one or more habitats within the town. Wildlife species are an integral part of the natural aquatic and terrestrial habitats of Center Harbor, they provide opportunities for hunting and fishing, are excellent subjects for study, and add to the general economic health of town for visitors who come here to see and enjoy the natural beauty of the town.

A. Wildlife Diversity

In general, wildlife species fall into five vertebrate classes and one large invertebrate group. The vertebrate classes include mammals, birds, fish, reptiles, and amphibians. The invertebrate group is typically split up into convenient sub-groups for the purposes of determining ecosystem health and for tallying and tracking rare species. These sub-groups include aquatic invertebrates (used for indicating water quality as demonstrated above), dragonflies and damselflies (*Odonata*), butterflies and moths (*Lepidoptera*), and "Other" (including spiders, terrestrial insects, worms, land snails, snow fleas, and hundreds of other orders and families). Based on two "bio-blitzes" and several field inventories in the Center Harbor area, the following table provides an estimate of the number of wildlife species that can be expected to occur within the municipality:

Table 5. Approximate Number of Wildlife Species in Center Harbor

MAMMALS	45
BIRDS	191
FISH	27
REPTILES	14
AMPHIBIANS	15
AQUATIC INVERTEBRATES	415
ODONATA	85
LEPIDOPTERA	775
OTHER^	950
GRAND TOTAL	**2,517**

^ Note that this estimate is only based on what has been found to date in the region

As the above chart indicates, there are over 290 vertebrate species of wildlife known for the Lakes Region that could occur in Center Harbor. This does not include accidental or casually introduced species such as the orange-crowned warbler that was found during a recent Christmas Bird Count, or the black crappie that was caught in Lake Winnipesaukee from an accidental introduction. Among vertebrates it includes all of the regularly occurring species that breed, temporarily reside or migrate through the area. Among invertebrates it includes the estimated number of year-round residents in the air, water and soil of Center Harbor. Invertebrate numbers are the most poorly known, and within the "Other" group, it is likely a very low estimate.

Figure 17. The tiny northern spreadwing damselfly below is far less noticeable than a broad-winged hawk (left), yet invertebrates outnumber vertebrates by more than 7:1 among species known to occur in town.

The diversity of forested habitats of Center Harbor include ample populations deer, moose, bear, raccoon, otter, fisher, mink, ermine, bobcat, coyote, fox, beaver, and porcupine. Higher concentrations of these species have been generally observed in isolated areas away from development and roadways. The unfragmented land areas described under the Forest Resources section above define those areas where terrestrial wildlife populations can be expected to be the highest. The aquatic habitats of Center Harbor are far less subject to pervasive disturbance and typically retain wildlife species that indicate good quality habitat.

This has been reflected by the N.H. Fish and Game Department's mapping of high quality habitat within the state, as described below.

B. Wildlife Action Plan

In 2005, the New Hampshire Fish and Game Department completed its first state-wide Wildlife Action Plan (WAP). The intent of the WAP was to identify and map the commonly recognized wildlife habitats in the state, and to identify where the most critical wildlife habitat locations remain. The WAP conveys habitat information through an explicit narrative, a comprehensive species database, and a series of GIS maps. In 2010, the habitat condition maps were updated in order to help the public focus on future conservation, restoration and management of critical habitat areas. The information contained in the WAP will continue to be revised in years to come.

The WAP identifies seventeen (17) habitat types throughout the state, six (6) of which were identified in the Town of Center Harbor. These areas are illustrated in **Map #4, Forest Cover**, and are described in part above. Based on the findings of the 2010 Natural Resources Inventory, several other WAP-recognized habitat types were found to occur in Center Harbor. The following table compares the findings of the WAP versus those identified from field and aerial photo interpretation:

Table 6. Summary of Wildlife Habitat Types in Center Harbor

Habitat Type	WAP acreage	% of Town	Field & Photo Interp.	% of Town
Appalachian oak-pine	0	0	73.4	.70
Hemlock-hardwood-pine	7,857.2	74.7	7920.6	74.96
Northern hardwood-conifer	0	0	210.3	2.0
Lowland spruce-fir	19	.18	15.1	.14
Rocky Ridge & Talus Slope	0	0	4.0	.04
Grassland > 10 ac.	590.9	5.59	401.9	3.80
Peatland	29.0	.27	255.5	2.42
Marshes	307.8	2.91	261.0	2.47
Open Water	1767.6	16.7	2081.0	19.7

The 2010 Center Harbor NRI revealed that at least three other WAP habitat types were present in Center Harbor. The south-facing oak dominated woodlands and forests described under Section V.A. Forest Resources represents a fourth forested wildlife habitat known as the Appalachian Oak-Pine Forest. Characterized by red and white oak and white or red pine, forests of this type can be found on Fogg Hill and along Winona Lake Road. Northern Hardwood-Conifer Forests were also not mapped for Center Harbor but occur in at least five locales in town. The north-facing summits of McCrillis and Sunset Hills support forests of this type, as well as the cool-air lowlands at Belknap Woods. Lastly, several areas of Rocky Ridge & Talus habitat were found at higher elevation and/or steep slope areas. Fogg Hill contains four of these sites and McCrillis Hill one site. Because each of these sites are small (i.e. < 1.5 acres) and easy to overlook, it is likely that other rocky ridge and talus sites occur in Center Harbor.

WAP Information about the *condition* of the above habitats was further analyzed to develop a statewide and regional ranking and identify the highest condition habitat relative to all areas of a given habitat type in the state. The plan established a ranking system in four (4) tiers as follows:

- Tier 1: Habitats of Highest Relative Rank by Ecological Condition in NH
- Tier 2: Habitats of Highest Relative Rank by Ecological Condition in Biological Region
- Tier 3: Supporting Landscapes
- Tier 4: Other Landscapes[20]

Table 7. 2010 Wildlife Action Plan Ranked Habitats in Center Harbor

Rank	# of Units^	Acreage	% of Town	Principal Areas
Tier 1	9	2623.8	24.83%	Squam Lake, Lake Winnipesaukee, Hawkins Pond
Tier 2	10	328.7	3.11%	Proctor Sanctuary, Hale Swamp, Johnson-Perkins
Tier 3	25	5,055.75	47.85%	North & central highlands; Winona Lake highlands
Tier 4	12	2,557.75	24.21	Remaining lowlands
SUM	**56**	**10,566.0**	**100.00%**	
^ Note: This does not include the Tier "add-ins" based on rare species or significant watersheds				

Nearly 25% of Center Harbor contains Tier 1 habitat. These lands include Squam Lake and its 500-foot buffer, Lake Winnipesaukee and its 500-foot buffer, and Hawkins Pond. These areas have statewide significance for promoting biodiversity, maintaining landscape-level ecological integrity, and having limited amounts of human impacts. Just 3.1% of Center Harbor's landscape contains Tier 2 habitat. The principal areas of Tier 2 habitat are the drainageway leading into Squam Lake through Proctor Sanctuary, portions of Center Harbor Woods, Hale Swamp, Johnson-Perkins Wetland, and Otter and Bear Ponds. While not as pristine or valuable in supporting biodiversity and exceptional species as Tier 1 habitat, these areas nonetheless have regional significance according to the Wildlife Action Plan and are deserving of conservation priority. Nearly 50% of the remaining habitat in Center Harbor is ranked as Tier 3 habitat known as "Supporting Landscape." Tier 3 lands have moderate importance for promoting wildlife diversity yet are somewhat compromised by human impact factors such as roads, agriculture, low-density development, and surface water impairment.

The Wildlife Action Plan is a valuable tool for setting regional priorities, yet because of its scope it cannot identify local areas that have ecological value. The following section fills this gap and provides site-specific information about those areas that rank very high *within Center Harbor* and therefore provide a clearer "road map" for conservation.

[20] Note: In 2014, Tier 4 ("Locally Significant") habitats were not mapped or updated.

Figure 18. The two streams that descend through the NH Audubon Society's Proctor Sanctuary add value to this SEA above Squam Lake

VIII. SIGNIFICANT ECOLOGICAL AREAS – 43 Areas, 985 acres

Significant ecological areas (SEA's) are lands that by virtue of their unspoiled condition, unique physical or biological features, rarity, and/or exemplary nature have special value in a particular locale. SEA's are often qualitatively defined by ecologists or wildlife biologists through fieldwork and/or high resolution aerial photograph interpretation. A total of 984.9 acres denoted as *significant* were identified among 43 sites. In Center Harbor, 37 of the 43 SEA's that were identified during the field portion of the NRI (see **Significant Ecological Areas Map, Map #7)**. The remainder was identified using aerial photographs and local knowledge. A complete list of the SEA's can be found in Appendix E and on Map #7.

Each significant ecological area was generally identified on the basis of the above definition and further described according to their outstanding physical and/or biological attributes. The SEA list in Appendix E notes the top three attributes associated with each SEA. Common examples include "pristine wetland," or "wildlife habitat," or "vernal pool." In each case the attributes involved outstanding examples for the town. In particular, these included pristine forest or wetland areas, late successional forests that have been undisturbed for over 150 years, and areas of exceptional wildlife habitat.

A. Exemplary Natural Communities

The New Hampshire Natural Heritage Bureau (NHB), a bureau of the Division of Forest and Lands, identifies, tracks, and promotes the protection of state-listed rare plants, animals, and exemplary natural communities.[21] The list of rare plants is published periodically according to state law (RSA 217-A), the rare animal list is published in cooperation with the Nongame and Endangered

[21] According to *Natural Communities of New Hampshire* by Sperduto and Nichols (2004), "exemplary natural communities represent the best remaining examples of New Hampshire's flora, fauna, and underlying ecological processes." They "include nearly all examples of rare types (such as alpine communities) and high-quality examples of common types." More information can be found on-line at http://www.nhdfl.org/bureaus/naturalheritage/index.htm

Wildlife Program of the NH Fish and Game Department and the NH Audubon Society. Exemplary natural communities are tracked by the NH Natural Heritage Bureau in conjunction with The Nature Conservancy and a number of consulting biologists, and are published in the "Town Lists" report that can be found at http://nhdfl.org.aurora.silvertech.net/library/pdf/Natural%20Heritage/TownList.pdf.

In Center Harbor there is just one listing for an exemplary natural community, the Black Gum-Red Maple Basin Swamp. Although this is defined as "historical" in the January 2013 town list, the site for the initial listing on Center Harbor Neck has not changed and still contains a high quality example of this natural community. In fact, according to the findings of the 2010 NRI there are five (5) Black Gum-Red Maple Basin Swamps in Center Harbor. All five examples can be found on Squam Lake on Center Harbor Neck or High Haith and can easily be viewed by boat as they occur along the shoreline.

Figure 19. The exemplary Black Gum-Red Maple Basin Swamp on Center Harbor Neck still contains a relatively undisturbed lakeshore 'ice-push' ridge, large black gum trees, and a characteristically old growth of wetland shrubs such as buttonbush and winterberry holly as can be seen at left.

The absence of other exemplary natural communities on the NH Natural Bureau's town lists is a function of limited staff resources or a lack of NHB field surveys and not actual absence of other exemplary natural communities. The SEA list in Appendix D refers to as many as nine (9) high quality natural communities that will likely prove to be of regional significance once they are properly documented. These include the dry rich and dry oak-pine communities on the southwest sides of Fogg Hill, the Snake River marsh, many of the above-cited black gum-red maple swamps, and four of the 12 designated prime wetland systems.

B. Rare & Endangered Species

A search of the NH Natural Heritage Bureau's records of state-listed plants and animals yielded a result of seven (7) historical records (five plants, and two animals), and three (3) extant records (one plant and two animals). Although the Center Harbor NRI did not include a field-based survey of the town, recent observations by the principal investigator recovered two of the historical plant records, and yielded records of an additional six (6) extant species, including several state "watch" species.

Animals

Bald eagles have become regular visitants to Center Harbor. Squam Lake, where a resident pair has been nesting since 2003, and Lake Winnipesaukee have supported winter-time eagle records during the mid-winter Eagle Count sponsored by the NH Audubon Society. Given the amount of available habitat, it is possible that a pair will breed in Center Harbor again in the future.[22] Meanwhile, common loon continues to breed in Center Harbor waters, particularly at Squam Lake where 3 nesting pairs have been found in Center Harbor during the past several years. Unfortunately, none in Center Harbor have produced successful fledglings due to nest failure, boating accidents, and/or predation. Squam Lake has been home to another rare species, the lake whitefish, which is listed by the NH Fish & Game Department as a "species of special concern."[23] Sometimes observed during the annual fishing derby, this medium-sized sport fish can be found in both Squam Lake and Lake Winnipesaukee. Lastly, although listed as a historic species, the pied-billed grebe can still be seen migrating through Center Harbor waters in the spring and (rarely) fall, especially along the Snake River where it was last recorded as a nesting species in the 1980's.

Plants

The only extant plant record in the NHB database is for water marigold (*Bidens beckii*), which was found by a Center Harbor resident in 2002 on Center Harbor Neck. Three of the listed historical species have been looked for by the NRI principal investigator with the result that two were relocated. Three-birds orchid (*Triphora trianthophora*) has been found on one of the islands in Squam Lake not very far from where it was originally described. American ginseng (*Panax quinquefolia*) was relocated across Winona Lake from where it was originally described. The third search species, Loesel's twayblade (*Liparis loeselii*), has not been relocated in the Winona Lake area after several attempts by several field botanists. Habitat conditions for the remaining two historical plants, erect knotweed (*Polygonum erectum*) and wild senna (*Cassia hebecarpa*), no longer exist at the sites where they recorded nearly 100 years ago.

Figure 20. Three bird's orchid (*Triphora trianthophora*) was relocated on an island in Squam Lake

Five (5) "new" species of rare plants were found by the principal investigator during the Center Harbor Prime Wetlands Completion Project in 2009, and one rare plant species was located during a reconnaissance of the

Fig. 21 Fern-leaved false-foxglove, Aureolaria pedicularia var. intercedens along Winona Lake Road

[22] In 2014, the nesting eagle pair on Squam Lake moved their nest to within 300 feet of the town's border.
[23] The list of rare wildlife in the state that is considered to be of "special concern" can be found at http://www.wildnh.com/Wildlife/Nongame/Nongame_PDFs/Species_of_special_concern_0309.pdf

recently conserved Fogg Hill property. The first, the state-endangered lake quillwort (*Isoetes lacustris*), was found in a shallow sandy bay of Squam Lake. The second and third species, both members of the figwort family, were found along Winona Road in one of the SEA's. Both *Aureolaria pedicularia var. intercedens* and *Aureolaria flava* occur in dry, semi-rich soils with ample sunlight in the oak-pine woodland near the lake. The fourth species, squawroot (*Conopholis americana*), was also found in a dry, semi-rich oak woodland on Fogg Hill above Winona Lake. The fifth, white-fringed orchid (*Platanthera blephariglottos*), was found in Hale Swamp in its favored bog mat habitat (see photo above). All of the last four species are currently listed as "State Watch" species and although they are rare, they have ample populations to keep them off the threatened and endangered list. The final species, Back's sedge (*Carex backii*), was recently found in a dry rich woodland on Fogg Hill. Of the 15 extant populations of this state endangered species, half of them occur in the Lakes Region.

IX. OPEN SPACE AND CONSERVATION LANDS

As of the end of 2014, Center Harbor had 34 parcels totaling 1052.9 acres in conservation (see Appendix F). This represents 9.96% of the town, or 12.0% of the land area. Other than the state boat ramp on Hawkins Pond, all of the conservation lands are held by private organizations. Ten (10) of these lands are held in fee, one (1) contains a reverter interest to a non-profit agency, and the remainder (23) are conservation easements that are held by non-profit land conservation organizations. Conservation lands are held by the following organizations, along with the acreage that they have a direct interest in:

- Center Harbor Conservation Commission – (440.7 acres)
- NH Fish & Game Department – (4.6 acres)
- Lakes Region Conservation Trust – (431.8 acres)
- New Hampshire Audubon Society - (48.5 acres)
- New England Forestry Foundation - (169.7 acres)
- Society for the Protection of New Hampshire Forests - (13.4 acres)
- Squam Lakes Association – (89.2 acres)
- Squam Lake Conservation Society – (345.6 acres)

The Town of Center Harbor through its Conservation Commission (CHCC) holds a direct interest in the 25.5-acre Kimball Island on Squam Lake and the 198-acre Fogg Hill Conservation Land off Piper Hill Road. The CHCC also hold a joint conservation interest on the 217.6-acre Center Harbor Woods with the Squam Lakes Conservation Trust. Owned by the Lakes Region Conservation Trust who received this property in 2010 from the Dane Family after a successful fund-raising effort, this recent conservation property is the largest in town. The CHCC also holds an executory interest in two properties, the Twombly easement and the Sturtevant Bay easements on Squam Lake.

Over 84% of the conservation land in Center Harbor falls within Tier 1, Tier 2, or Tier 3 wildlife habitat types according to the NH Fish & Game Department's Wildlife Action Plan or WAP (see above). About 16% of this land is within Tier 1 habitat, and most of the rest is in

Tier 3 habitat. Only 14.3% of the conservation land includes one or more Significant Ecological Areas (SEA's), however. Chamberlain-Reynolds Forest (owned by the New England Forestry Foundation) includes four SEA's entirely, and the Center Harbor Neck easements, the Center Harbor Woods property, and the Fogg Hill Conservation Area include over 95% of another five SEA's. Prime wetlands form the core of another four SEA's, yet the remaining 30 SEA's are completely unprotected. As described below, these areas should be considered top conservation priorities for the town.

In terms of future conservation, the Town of Center Harbor has a dedicated Conservation Fund that is used to support its protection of natural resources as defined by RSA 36-A.[24] Much of the money for this fund comes from the Land Use Change Tax (LUCT) that is imposed on land owners who develop property that is in Current Use. At present, 50% of this tax goes toward the Conservation Fund with 50% going to the General Fund. At present, there is no limit to the amount of LUCT monies that goes into the Conservation Fund.

X. SCENIC RESOURCES

Scenic vistas are a part of the fabric and quality of life in Center Harbor. In fact, it is the view of Center Harbor Bay as one drive into Center Harbor that gives the village so much of its charm. Although the Natural Resources Inventory was not charged with a detailed assessment of scenic resources in the town, several sites were noted during the roadside surveys that were conducted. The following list is not exhaustive, but does provide a preliminary list of exceptional scenic vistas that one can view from the roadsides of Center Harbor:[25]

- View from anywhere in the village of Center Harbor Bay
- View of Half-Mile Islands & Center Harbor Bay from Rte 25 south of the village
- View of village & Center Harbor Bay from Dane Road (Rte 25B)
- View west towards Pine Hill in Holderness from Hillcrest Farm on Dane Road
- View of Dog Cove from Dane Road
- View of Hale Swamp bog from Rte 3
- View of lower Hale Swamp & Swainey Brook from Rte 3
- Views from the top of "Observatory Hill" along College Road
- View NW from top of hill on Center Harbor Neck Road
- View of Squam Lake from the end of Mouse Lane
- View of the old airstrip fields along Mead Farm Road
- View of Sturtevant Bay & Moultonborough Bay from High Haith Road
- View of open fields along Coe Hill Road

[24] RSA 36-A enables towns in the state to create conservation commissions through an appointment process overseen by the Board of Selectmen, City Council or other local governing body. The principal charge of a conservation commission under RSA 36-A is to "protect the Town's natural resources, to develop and maintain an inventory of those natural resources, to preserve open space and scenic views, to monitor conservation easements held by the Town, to protect water quality and to develop and distribute information to the public on conservation issues."

[25] Note that many of these vistas are equally spectacular in winter or summer, but that some offer fuller views in winter

- View of hayfield along Dane Road from Follett Road
- View W across field from Keyser & Tuttle Roads
- View from top of hill at Waukewan Golf Course
- View south across the cat-tail marsh off of Waukewan Road
- View WSW from Perkins Farm on Waukewan Road
- View of Snake River and Lake Waukewan from Waukewan Road bridge
- View of Snake River & Winona Lake from Winona Road bridge
- View of Hawkins Pond from dam on Hawkins Pond Road
- View of Hawkins Pond Prime Wetlands from Hawkins Pond Road
- View S across fields on Hawkins Pond Road near the town line
- View of Bear Pond & Hawkins Pond inflow from Piper Hill Road
- View N from near the top of Piper Hill Road
- View from the high point on McCrillis Hill Road (at bend)
- View of the Johnson-Perkins Prime Wetland from McCrillis Hill Road

The above list does not include all of the scenic views that can be had in Center Harbor, and notably omits those that can be seen away from town roads. Arguably, the views from anywhere on Squam Lake or Lake Winnipesaukee rival the best roadside views in town. Similarly, the views from the front or back porch of many residences in Center Harbor offered unexcelled vistas of neighboring towns, lakes, and distant mountain ranges. Aside from the tax burden and property value benefits of such views, the scenic quality of Center Harbor has been a long-standing tradition that has brought about carefully designed commercial architecture, subdivision plans, and roadway lay-outs in town. Enhancing and protecting the scenic views of Center Harbor should factor into and all ordinances that guide development and protect property. This should also include views towards Center Harbor lands from adjoining municipalities.

Figure 22. Views across rural lands towards unbroken forests and open water offer the highest value views in the Lakes Region.

XI. RECOMMENDATIONS

Center Harbor has an abundance of natural resources that offer agricultural products, wood products, clean drinking water, flood protection, wildlife habitat, water-based recreation, and hunting opportunities for residents and visitors. Whereas existing zoning ordinances and overlay districts protect some of these valuable services, there are other action steps that could be taken to ensure that Center Harbor residents prosper by virtue of their natural resources in the future. The following offers a few of the bulleted highlights from the report

sections above, with recommendations for additional protection measures that can be taken.

A. Bedrock & Surficial Geology

In spite of the simplicity of the bedrock map – i.e. Center Harbor is almost entirely granite, bedrock aquifers account for more than 85% of the public and private drinking water supplies. Very little is known about these bedrock water sources and virtually no local protection is afforded these critical elements of Center Harbor's natural resources. The following action steps should be considered for long-term protection of invaluable drinking water supplies:

- Conduct a bedrock aquifer study of the town
- Identify probable deep well catchment areas for each section of town
- Consider an overlay district for "headwater protection areas"

The surficial geology picture of Center Harbor is slightly more complex yet no less important in terms of providing safe drinking water supplies to town residents. As noted in Section VI.D. above, there are just six surface aquifer areas in Center Harbor that are as yet unprotected by local ordinances. Passage of the proposed Water Resources Ordinance will ensure adequate protection for these critical resources. In addition, as noted on the Important Soils Map (#3), there is at least one sand & gravel resource that recharges groundwater that lies outside of the mapped aquifer areas. Regulating water use, extraction, and hazardous substances above these groundwater supply areas would help protect drinking water supplies over the long-term.

- Encourage passage of the proposed Water Resources Ordinance that provides protection for significant groundwater supplies through the creation of a Groundwater Protection District. Inventory known and historic gravel extraction sites and consider conserving these lands as potential future wellhead areas

B. Agricultural Resources

Section IV above and the Important Soils Map (#3) describes the general soil types in Center Harbor and identifies just six (6) areas (56 acres) as prime farmland, and just four (4) areas (52 acres) that contain soils of statewide importance. Together this represents only one percent of Center Harbor. Moreover, less than half of this area is in active agricultural production. Most of the 401.9 acres of active agricultural areas occur on soils of local importance. Less than 10% of these lands are currently protected from development.

- Conduct an assessment of active agricultural areas and determine those with the most productive soils
- Prioritize the protection of the most productive soils areas for conservation / agricultural uses

- Consider local tax relief for productive agricultural areas parcels that are less than 10 acres in size.

C. Forest Resources

Center Harbor's forest resources are of especial value for the following reasons:

- They provide a renewable resource with economic importance and value to the region for lumber, fuelwood, and other wood products
- They provide critical habitat for the town's flora and fauna
- They form the backdrop for a scenic and aesthetically pleasing environment for residents and visitors alike
- They provide ample opportunities for recreation

Although the forests of Center Harbor mostly belong to private individuals and non-profit conservation organizations, they nonetheless hold great value in the public interest. While individual owners of small forested tracts can join together to perform timber management activities, most subdivisions into tracts of less than 10 acres in size tend to put forestland out of production. Either large-lot (i.e. forest) zoning or direct conservation of large, unfragmented tracts of forest land will help protect this renewable resource.

- Continue to seek conservation of large, unfragmented blocks of forest land
- Target forest blocks with more productive soils for timber production

D. Surface and Groundwater Resources

Center Harbor contains more than 1900 acres of open water across four lakes with over 25 miles of shoreline, plus an additional 175 acres of ponds and open water marshes. There are over nine miles of perennial streams, plus an additional 22.1 miles of intermittent streams that drain two major watersheds in town. Wetlands add another 1090 acres to lands with water at or near the surface of the soil. Sub-surface water (groundwater) is identified from nine sites (352 acres), with an additional 33 acres of water-yielding sand and gravel soils near Hale Swamp. All of these water resources provide both environmental and economic value to the community and contribute significantly to the quality of life in town.

Center Harbor has a number of water resource protection measures in place, such as the Wetlands Conservation Overlay District and 12 designated Prime Wetlands. State regulations, especially the Shoreland Water Quality Protection Act, also help in the protection of surface water resources; however, they do not offer as strict an oversight as could be effected by local regulation. The following recommendations are offered for the purposes of enhancing existing land use restrictions related to water quality and quantity:

- Seek passage of the proposed Water Resource Protection Ordinance in order to provide additional, local protections for surface and groundwater. Conduct periodic

water quality assessments of water bodies such as Bear Pond that do not currently receive any statewide review

- Encourage best management practices for timber and erosion control, agricultural practices, and stormwater management by ensuring adequate outreach and education for all municipal officials, private residents and landowners

Figure 23. The conservation of prime wetlands protects both recreational (left) and wildlife opportunities (right). Hale Swamp offers a snowmobile link between Lake Winnipesaukee and Squam Lake as well as habitat for snowshoe hare.

E. Wildlife and Wildlife Habitat

The information presented in Section VII.A and VII.B provides a synopsis of the best wildlife habitat areas in Center Harbor. Both the Co-Occurrence Analysis contained in the updated 2010 NRI and the identification of significant ecological areas (SEA's) provides a road map for conservation protection of these important wildlife habitat areas. Over three-quarters of the town contains habitat of significance according to the NH Fish & Game Department's Wildlife Action Plan or WAP. The 2010 WAP update identified over 2,500 acres of high quality habitat around Squam Lake and Lake Winnipesaukee that has statewide or regional significance. The SEA assessment identified 43 areas totaling 985 acres, much of which includes uplands away from the WAP-identified high quality habitat areas. The aggregation of these two land assessment efforts provides the rationale to move ahead with a priority conservation plan for the town.

- Target the SEA lands that also fall within the WAP-identified high quality wildlife habitat areas as priority protection sites.
- Work with local non-profit land conservation organizations such as the Lakes Region Conservation Trust and the Squam Lakes Conservation Society to invite private landowners to help fulfill this goal of *apriori* protection.
- Offer conservation education programs that highlights the attributes of the SEA's
- Consider publishing a guide to recreational trail opportunities in Center Harbor that utilize existing conservation properties; include canoe and kayak trails in the guide

F. Scenic Resources

As noted in Section X above, scenic resources are an integral part of the quality of life in Center Harbor. The list of 27 vistas above is a beginning step in the identification and protection of scenic value in Center Harbor. The principal recommendation repeats that found in the Center Harbor Master Plan:

- Conduct a town-wide evaluation of scenic vistas, viewsheds, and other points of interest with town volunteers familiar with the scenic resources in Center Harbor
- Work with adjoining towns to play a role in this scenic assessment project, and coordinate activities that protect the viewsheds at the major roadway entrances to the town

Figure 24. Top: Snake River prime wetland; Bottom: Hale Swamp in winter

G. Open Space and Conservation Lands

Center Harbor has protected less than 10% of its land and water resources. While most of this land falls within the state-designated highest value habitat in the region, only 14% of the conservation land falls within one or more of the 43 significant ecological areas. In order to protect the highest and best quality wildlife habitat, rare and endangered species, and other important natural resources such as drinking water supply areas, the town should continue to seek permanent protection of its land and water resources.

6.10.20 As suggested by the 2001 *New Hampshire Everlasting* initiative, the town should seek long-term protection of at least 25% of its land resources

6.10.21 Continue to encourage the Conservation Commission to utilize the Land Use Change Tax Fund to protect the remaining unprotected significant ecological areas

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