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Natural Resource Stewardship and Science

Natural Resource Condition Assessment for the Roosevelt-Vanderbilt National Historic Sites (ROVA)

Natural Resource Report NPS/NER/NRR—2012/557

ON THE COVER
View from Vanderbilt overlook, Northwest across the Hudson River to the Catskill Mountains.
Photograph by: National Park Service staff

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Executive Summary

Background and Context

The Roosevelt-Vanderbilt National Historic Sites (ROVA) includes over 1,100 acres along the east bank of the Hudson River. The parks are located in Dutchess County, NY, north of Poughkeepsie, along the east bank of the Hudson River. The Home of Franklin D. Roosevelt (HOFR) NHS was developed “To preserve and interpret the birthplace, lifelong home, and memorial gravesite of President Franklin D. Roosevelt, so that current and future generations can appreciate the life and legacy of the longest-serving U.S. president — a man who led the nation through the two great crises of the 20th Century, the Great Depression and World War II” (USDI 2010). The Eleanor Roosevelt (ELRO) NHS has as its purpose “To commemorate and perpetuate the lifework of Eleanor Roosevelt, and to preserve and interpret the place most central to her emergence as a public figure, so that current and future generations can appreciate her life and legacy as a champion of democracy and human rights” (USDI 2010). The Vanderbilt Mansion (VAMA) NHS was set aside, “To preserve and interpret the country estate of Frederick W. and Louise Vanderbilt as a premier example of an “American country place,” illustrating important economic, social, and cultural developments resulting from America’s industrialization following the Civil War” (USDI 2010).

The Hudson River Valley, at the time of first European contact, was inhabited by a native people who were members of the Algonquin nation. The Wappinger tribe occupied what is now most of Dutchess County, New York. The village was presumably located on what is now called Wappinger Falls. The first known European to sail on the Hudson River was John de Verazzano in 1524, followed considerably later by Henry Hudson, in 1609. The county itself was formed in 1683 and became the second largest county (after Albany) by the end of the 18th century. Its rolling topography allowed ready access to the Hudson River, thus ensuring lucrative trade routes for agricultural products. Immigration into the county was primarily from Dutch setters until the middle of the 18th century, whereupon German settlers and New England immigrants predominated.

Once the railroads opened up from New York City in the mid-1800s, wealthy industrialists began to populate the Hudson valley with summer homes. Included among those with estates were J. P. Morgan, Franklin and Eleanor Roosevelt and Frederick W. and Louise Vanderbilt.

Each of the three culturally-based parks encompasses a wide variety of natural resources within their boundaries. The cultural aspects of the parks are well known and documented, but the natural resources are less well known. It is the purpose of this report to gather in one document the known data on ROVA natural resources and provide an assessment of the conditions of those resources.

Approach

All three units were assessed using available data from each unit, rather than by specific habitats. We used parameters (Vital Signs) set forth by the Northeast Temperate Network (NETN) as our baseline and developed the local data sets to compare with those values, trying to set a reference value whenever possible. The reference conditions and threshold values were based on federal or state agency regulations and criteria, peer-reviewed research, estimates of biotic integrity, or established NPS NETN Vital Signs condition categories for natural resources or NPS ARD categories. In cases where the data was qualitative in nature, best professional judgment was used to assign a condition category. When applicable, each metric was assessed for the percentage of reference or threshold attained. Further analysis of data resulted in each metric being given a condition category rating and assessment of trend of the natural resource condition. Condition category language generally included three categories: good, caution (moderate), and significant concern. A few metrics did not follow the three category assessment due to data limitations or regulatory language, as was the case for two metrics in the Biological Integrity category and one metric in the Water category. Trend analysis was assigned a condition of "increasing", "decreasing" or "no trend" after statistical analysis of quantitative historical and current data. Data gaps and confidence in assessment was discussed after each metric was assessed. Confidence in the assessment and trend was identified as high, fair, or limited.

Features of ROVA

The Home of Franklin D. Roosevelt (HOFR) NHS

The site is dedicated to both Springwood, FDR's lifelong home, as well as to the FDR library and museum, which are managed by the National Archives. Also under management is Top Cottage, a retreat built by FDR in the late 1930's. The HOFR site totals almost 771.93 acres (312.38 ha), almost half of the original estate.

The Eleanor Roosevelt (ELRO) NHS

The only NHS dedicated to a First Lady, ELRO features her cottage, Val-Kill, where she spent much time working on issues of social change. It served as a furniture factory training young men for work and it also contained a forge and a loom. ELRO encompasses another 181 acres (73 ha) of the original Roosevelt estate.

The Vanderbilt Mansion (VAMA) NHS

VAMA is dedicated to the exhibition of a time and place in America, as well as an example of the "Gilded Age" country place. The site includes the Vanderbilt Mansion and formal gardens. The NPS manages 212 acres (86 ha) of the original 684 acre (277 ha) estate.

Threats to ROVA

ROVA is surrounded on all sides by development issues that impact the park in some fashion. To the west, ROVA is bordered by the Hudson River, long known for its water quality problems, especially with PCB's (polychlorinated biphenyls). To the north, east, and south, ROVA is bordered by developing towns, all part of the New York-Northern New Jersey-Long Island, Metropolitan Area, a generally continuous population stretching from Albany south to New York City. External impacts, such as population growth, housing expansion, construction of roads and other infrastructure, disruption of hydrology, and habitat conversion can significantly affect natural resources through pressure on terrestrial and aquatic environments. ROVA is not exempt from these pressures since it is located in a matrix of forest, agriculture, and increased urbanization. Although ROVA is a small cultural park, it operates as a biological refuge in an urban environment for many resident and migratory species.

The Hudson River and a railroad abut ROVA to the east. Photograph by C. A Cole (December 16, 2009).

Current Condition of Natural Resources in ROVA

Air Quality

Air quality is an important concern in ROVA, and parameters of interest included *total wet deposition of sulfur(S), total wet deposition of nitrogen (N), mercury (Hg), ozone and visibility*. Based upon NPS standards, ROVA's air quality for wet S and N deposition is considered a *significant concern*. NPS has no current standards for mercury, though values were higher than one accepted standard, leading to 0% attainment. ROVA's air quality for ozone is considered a *significant concern,* as it is well above the NPS standard for both HOFR and VAMA (0% attainment). Visibility is also an area of *significant concern* as measurements are well above the NPS standard.

Water Quantity

ROVA has considerable aquatic resources and availability of water is critical to the health of these areas. However, due to a lack of data from within the park, we were unable to assess surface water quantity condition, leaving it as *unknown*. Continued growth in the region will likely stress water availability and ROVA should monitor this closely. Ground water quantity is better understood within ROVA and was rated as *good*. Again, with continued growth in the region, ROVA should continue to monitor groundwater availability.

Water Quality

The location of ROVA within an urban and developing setting has substantial implications for water quality within the park. Not all waters have been assessed but at least some of Fall Kill is rated as *impaired*. Several parameters were assessed and dissolved oxygen, pH, and acid neutralizing capacity all met compliance levels. Specific conductance did not meet compliance levels in some streams and total nitrogen and total phosphorus exceeded regulatory criteria for all streams.

Biological Integrity

There are concerns over the presence of non-native aquatic species within the region. Within proximity to ROVA, one plant species, four fish species, one crustacean species, and two mollusk species were identified and mapped as non-native species. Each of ROVA's three watersheds (Fallsburg Creek-Hudson River, Crum Elbow Creek, Fall Kill) were given a condition category of *invaded, with potential deleterious impact to the aquatic system,* thus receiving 0% attainment of reference condition requirements.

Non-native vegetation has been established in all three park subunits as a result of past and present disturbances and is threatening the ecological integrity of ROVA's open areas and forest communities. Based on NETN invasive vegetation monitoring, ELRO/HOFR received a *caution* rating and VAMA scored *significant concern*, indicating substantial numbers of invasive plants per sample plot.

Vegetation and Forest Health

Forest health showed mixed results. Structural stage distribution was *good*, but snag abundance was *caution* for ELRO/HOFR, though VAMA rated *good* for snags. Tree regeneration was rated *significant concern* for ELRO/HOFR, with VAMA showing *good*. Tree pests were noted at all parks (hemlock woolly adelgid), thus leading to a *caution* rating. Patch size was *good* at HOFR but generally *caution* and *significant concern* at VAMA and ELRO.

Fish Community

There is no recognized Index of Biotic Integrity (IBI) for fish in New York, necessitating the use of one developed for Northern Mid-Atlantic Slope. Crum Elbow Creek scored 'good' on five metrics, 'intermediate' on three and 'poor' on one. An unnamed stream showed similar results. However, an overall lack of data leads to definite uncertainty for these results.

Aquatic Macroinvertebrates

The NYDEC has been sampling aquatic macroinvertebrates around ROVA on a limited basis. Using their protocol and impact levels, all of the ROVA streams were seen as 'slightly impacted'. Impacts are likely due to the impoundments on site as well as non-point nutrient additions.

Birds

There is an available IBI for birds developed by the NETN based on guilds. Several categories at each unit were marked either as "caution" or "significant concern", largely based on a lack of migrant birds relative to resident species. This likely is a reflection of the parks' location within a fragmented landscape. The Index of Biotic Integrity is based on birds in forested habitat with the best conditions associated with large blocks of forest habitat that are structurally diverse. Parks that have relatively small areas of forest habitat or forest that is fragmented by roads, managed landscapes, and open habitat will tend to have lower IBI scores just by virtue of the fact that the forest patches are small with relatively large amounts of edge habitat. The goal should be to maintain or improve the IBI score instead of a goal of obtaining a score of "good" in all categories. This goal may be unattainable given the configuration of the park and the other management mandates. Currently, bird surveys are only occurring within mature forest habitat. This means that the ecological condition of birds in other habitats such as successional forest, managed lands like lawns and gardens, open habitats (except grasslands at the NETN park of Saratoga), and wetlands are not included. Separate indices of biotic integrity should be developed for these habitat types also.

Amphibians and Reptiles

Monitoring for amphibians and reptiles in ROVA has been inconsistent over the years, often occurring only when funding and personnel were available. There are records of Blanding's turtles (*Emydoidea blandingii*) in the park, which is a New York threatened species. Others have noted 16 amphibian and 16 reptilian species within ROVA, including the spotted turtle (*Clemmys guttata*), which is listed as a species of special concern, as are the wood turtle, the eastern box turtle, the Jefferson salamander, and the marbled salamander, all confirmed in 1992 at ROVA. ROVA is home to one *threatened* and three *special concern* turtle species under New York State 182.2(g) of 6NYCRR Part 182. Given the lack of detailed data over the years, we were unable to develop condition categories or an overall assessment for amphibians and reptiles in ROVA. However, it is important that species of concern continue to be inventoried and monitored and managers protect the habitat of threatened or endangered species in ROVA.

Soils

Park soils are relatively young, having formed since the retreat of the last glacier some 10,000 years ago. Soil monitoring is used to understand the effects of acidic deposition on forest health. Acid deposition alters soil chemistry by leaching calcium, magnesium and potassium from soils, thereby increasing the availability of aluminum, which carries toxic properties. Additionally, forested ecosystems may be experiencing increased inputs of nitrogen to forested systems, causing concern that excess nitrification and nitrogen leaching can exacerbate acidification effects, reducing plant growth, and increasing susceptibility of trees to other stresses (Aber et al. 1998, 2003). Using condition ratings developed by the NETN, ELRO/HOFR Ca:Al ratio rated *caution*, while VAMA rated *good*. ELRO/HOFR C:N rated *significant concern*, and VAMA rated *caution*. The results from samples collected in ROVA indicate that the park may be experiencing excess N saturation.

Landscape Dynamics

An understanding of the pattern and dynamics of land cover and land use context is crucial to assessing ROVA's natural resource condition. Some measure of natural landscape fragmentation—and hence ecosystem integrity—can be inferred from the decrease in forest cover and expansion of urban cover within the 5km buffer between 1973 and 2002. For ROVA, urban cover increased 132%, while forest cover of all types decreased from a range of 3 to 61%, depending on the area of analysis. Based on our assessment of the available spatial data regarding evolving land use patterns adjacent to ROVA, long-term development trends will continue to put pressure on the parks' natural resources. Given the change in land-use over time, our evaluation of this issue is that ROVA is under moderate threat at this time.

ROVA natural resource condition assessment categories, results and recommendations	
Resource	**Recommendation**
Air quality - *of significant concern with no trend*	Continue to monitor within and adjacent to park and work with local, state, and federal agencies to try and reduce sources.
Water quantity – *unknown trend*	Increase the assessment of groundwater within the park.
Water quality – *impaired, no improvement*	Increase monitoring within the park and work with local, state, and federal agencies to try and reduce sources.
Biological integrity – *caution to concern with declining condition*	Continue to monitor pests and invasive species. Use control measures as available and appropriate.
Vegetation – *caution to concern with declining trend*	Continue to employ forestry best management practices. Avoid fragmentation where possible.
Fish community – *good, with unknown trend*	Implement regular fish sampling every five years to develop a trend.
Aquatic macroinvertebrates – *slightly impacted with unknown trend*	Implement regular macroinvertebrate sampling every five years to develop a trend.
Birds – *caution or concern with unknown trend*	Continue regular bird monitoring to establish a trend.
Amphibians and reptiles – *concern with unknown trend*	Implement systematic sampling to establish a trend.
Soils – *good to concern with declining trend*	Monitor soils in relation to acid deposition. Reduce nitrogen inputs as possible.

Acknowledgements

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Chapter 1 NRCA Background Information

Natural Resource Condition Assessments (NRCAs) evaluate current conditions for a subset of natural resources and resource indicators in national park units, hereafter "parks". For these condition analyses they also report on trends (as possible), critical data gaps, and general level of confidence for study findings. The resources and indicators emphasized in the project work depend on a park's resource setting, status of resource stewardship planning and science in identifying high-priority indicators for that park, and availability of data and expertise to assess current conditions for the things identified on a list of potential study resources and indicators.

NRCAs represent a relatively new approach to assessing and reporting on park resource conditions. They are meant to complement, not replace, traditional issue and threat-based resource assessments. As distinguishing characteristics, all NRCAs:

- Are multi-disciplinary in scope. However, the breadth of natural resources and number/type of indicators evaluated will vary by park
- Employ hierarchical indicator frameworks. Frameworks help guide a multi-disciplinary selection of indicators and subsequent "roll up" and reporting of data for measures ⇨ conditions for indicators ⇨ condition summaries by broader topics and park areas
- identify or develop logical reference conditions/values to compare current condition data against. NRCAs must consider ecologically-based reference conditions, must also consider applicable legal and regulatory standards, and can consider other management-specified condition objectives or targets; each study indicator can be evaluated against one or more types of logical reference conditions. Reference values can be expressed in qualitative to quantitative terms, as a single value or range of values; they represent desirable resource conditions or, alternatively, condition states that we wish to avoid or that require a follow-on response (e.g., ecological thresholds or management "triggers")
- emphasize spatial evaluation of conditions and GIS (map) products. As possible and appropriate, NRCAs describe condition gradients or differences across the park for important natural resources and study indicators through a set of GIS coverages and map products
- summarize key findings by park areas . In addition to reporting on indicator-level conditions, investigators are asked to take a bigger picture (more holistic) view and summarize overall findings and provide suggestions to managers on a area-by-area basis: 1) by park ecosystem/habitat types or watersheds, and 2) for other park areas as requested
- follow national NRCA guidelines and standards for study design and reporting products

NRCAs Strive to Provide…

Credible condition reporting for a subset of important park natural resources and indicators

Useful condition summaries by broader resource categories or topics, and by park areas

Although current condition reporting relative to logical forms of reference conditions and values is the primary objective, NRCAs also report on trends for any study indicators where the underlying data and methods support it. Resource condition influences are also addressed. This can include past activities or conditions that provide a helpful context for understanding current park resource conditions. It also includes present-day condition influences (threats and stressors) that are best interpreted at park, watershed, or landscape scales, though NRCAs do not judge or report on condition status per se for land areas and natural resources beyond the park's boundaries. Intensive cause and effect analyses of threats and stressors or development of detailed treatment options is outside the project scope.

Credibility for study findings derives from the data, methods, and reference values used in the project work—are they appropriate for the stated purpose and adequately documented? For each study indicator where current condition or trend is reported it is important to identify critical data gaps and describe level of confidence in at least qualitative terms. Involvement of park staff and National Park Service (NPS) subject matter experts at critical points during the project timeline is also important: 1) to assist selection of study indicators; 2) to recommend study data sets, methods, and reference conditions and values to use; and 3) to help provide a multi-disciplinary review of draft study findings and products.

NRCAs provide a useful complement to more rigorous NPS science support programs such as the NPS Inventory and Monitoring Program. For example, NRCAs can provide current condition estimates and help establish reference conditions or baseline values for some of a park's "vital signs" monitoring indicators. They can also bring in relevant non-NPS data to help evaluate current conditions for those same vital signs. In some cases, NPS inventory data sets are also incorporated into NRCA analyses and reporting products.

In-depth analysis of climate change effects on park natural resources is outside the project scope. However, existing condition analyses and data sets developed by a NRCA will be useful for subsequent park-level climate change studies and planning efforts.

NRCAs do not establish management targets for study indicators. Decisions about management targets must be made through sanctioned park planning and management processes. NRCAs do provide science-based information that will help park managers with an ongoing, longer term effort to describe and quantify their park's desired resource conditions and management targets. In the near term, NRCA findings assist strategic park resource planning. NRCAs are an especially useful lead-in to working on a park Resource Stewardship Strategy(RSS) but study scope can be tailored to also work well as a post-RSS project. They also help parks report to government accountability measures. While accountability reporting measures are subject to change, the spatial and reference-based condition data provided by NRCAs will be useful for most forms of "resource condition status" reporting as may be required by the NPS, the Department of the Interior, or the Office of Management and Budget.

Important NRCA Success Factors …

Obtaining good input from park and other NPS subjective matter experts at critical points in the project timeline

Using study frameworks that accommodate meaningful condition reporting at multiple levels (measures ➪ indicators ➪ broader resource topics and park areas)

Building credibility by clearly documenting the data and methods used, critical data gaps, and level of confidence for indicator-level condition findings

Due to their modest funding, relatively quick timeframe for completion and reliance on existing data and information, NRCAs are not intended to be exhaustive. Study methods typically involve an informal synthesis of scientific data and information from multiple and diverse sources. Level of rigor and statistical repeatability will vary by resource or indicator, reflecting differences in our present data and knowledge bases across these varied study components.

NRCAs can yield new insights about current park resource conditions but in many cases their greatest value may be the development of useful documentation regarding known or suspected resource conditions within parks. Reporting products can help park managers as they think about near-term workload priorities, frame data and study needs for important park resources, and communicate messages about current park resource conditions to various audiences. A successful NRCA delivers science-based information that is credible and has practical uses for a variety of park decision making, planning, and partnership activities.

Over the next several years, the NPS plans to fund a NRCA project for each of the ~270 parks served by the NPS Inventory and Monitoring Program. Additional NRCA Program information is posted at: http://www.nature.nps.gov/water/NRCondition_Assessment_Program/Index.cfm

NRCA Reporting Products…

Provide a credible snapshot-in-time evaluation for a subset of important park natural resources and indicators, to help park managers:

Direct limited staff and funding resources to park areas and natural resources that represent high need and/or high opportunity situations

(near-term operational planning and management)

Improve understanding and quantification for desired conditions for the park's "fundamental" and "other important" natural resources and values

(longer-term strategic planning)

Communicate succinct messages regarding current resource conditions to government program managers, to Congress, and to the general public

("resource condition status" reporting)

Chapter 2 Introduction and Resource Setting

2.1. Introduction

The National Park Service (NPS) has as its' mission "… to conserve the scenery and the natural and historic objects and the wild life therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations" (http://www.nps.gov/legacy/mission.html). The NPS began a comprehensive inventory and monitoring program in 1999 in order to achieve its mission (http://www.nature.nps.gov/challenge) and to provide parks with the necessary data for informed decision making.

The Northeast Temperate Network (NETN) was established by the NPS to monitor ecological conditions in parks throughout the northeastern United States (Figure 1). Knowing the ecological condition within the parks is fundamental to the mission of the NPS and to its ability to manage park resources (http://science.nature.nps.gov/im/units/netn/). The parks within the NETN were selected by NPS for a natural resource condition assessment: the Home of Franklin Roosevelt, the Eleanor Roosevelt National Historic Site, and the Vanderbilt Mansion National Historic site, collectively known as the Roosevelt-Vanderbilt Historic Sites, or ROVA (Figure 2).

2.1.1 History & Enabling Legislation

Combined, ROVA includes over 1,100 acres of federally owned land along the east bank of the Hudson River (USDI 2010). The parks are located in Dutchess County, NY, north of Poughkeepsie and along the east bank of the Hudson River. The Home of Franklin D. Roosevelt (HOFR) NHS was developed "To preserve and interpret the birthplace, lifelong home, and memorial gravesite of President Franklin D. Roosevelt, so that current and future generations can appreciate the life and legacy of the longest-serving U.S. president — a man who led the nation through the two great crises of the 20th Century, the Great Depression and World War II" (USDI 2010). The Eleanor Roosevelt (ELRO) NHS has as its purpose "To commemorate and perpetuate the lifework of Eleanor Roosevelt, and to preserve and interpret the place most central to her emergence as a public figure, so that current and future generations can appreciate her life and legacy as a champion of democracy and human rights" (USDI 2010). The Vanderbilt Mansion (VAMA) NHS was set aside, "To preserve and interpret the country estate of Frederick W. and Louise Vanderbilt as a premier example of an "American country place," illustrating important economic, social, and cultural developments resulting from America's industrialization following the Civil War" (USDI 2010). ROVA's overall mission is as follows:

"The park's specific mandate is the preservation of all resources, cultural and natural, within its boundaries. In the broadest sense, the park's resource management objectives include preservation of the open space character of neighboring properties, the Town of Hyde Park, and important viewsheds such as the vista from FDR's home of the Hudson River and the agricultural lands and mountains of Ulster County."
(http://www.nps.gov/archive/vama/nr_intro.html)

Figure 1. The Northeast Temperate Network parks (from Mitchell et al. 2006).

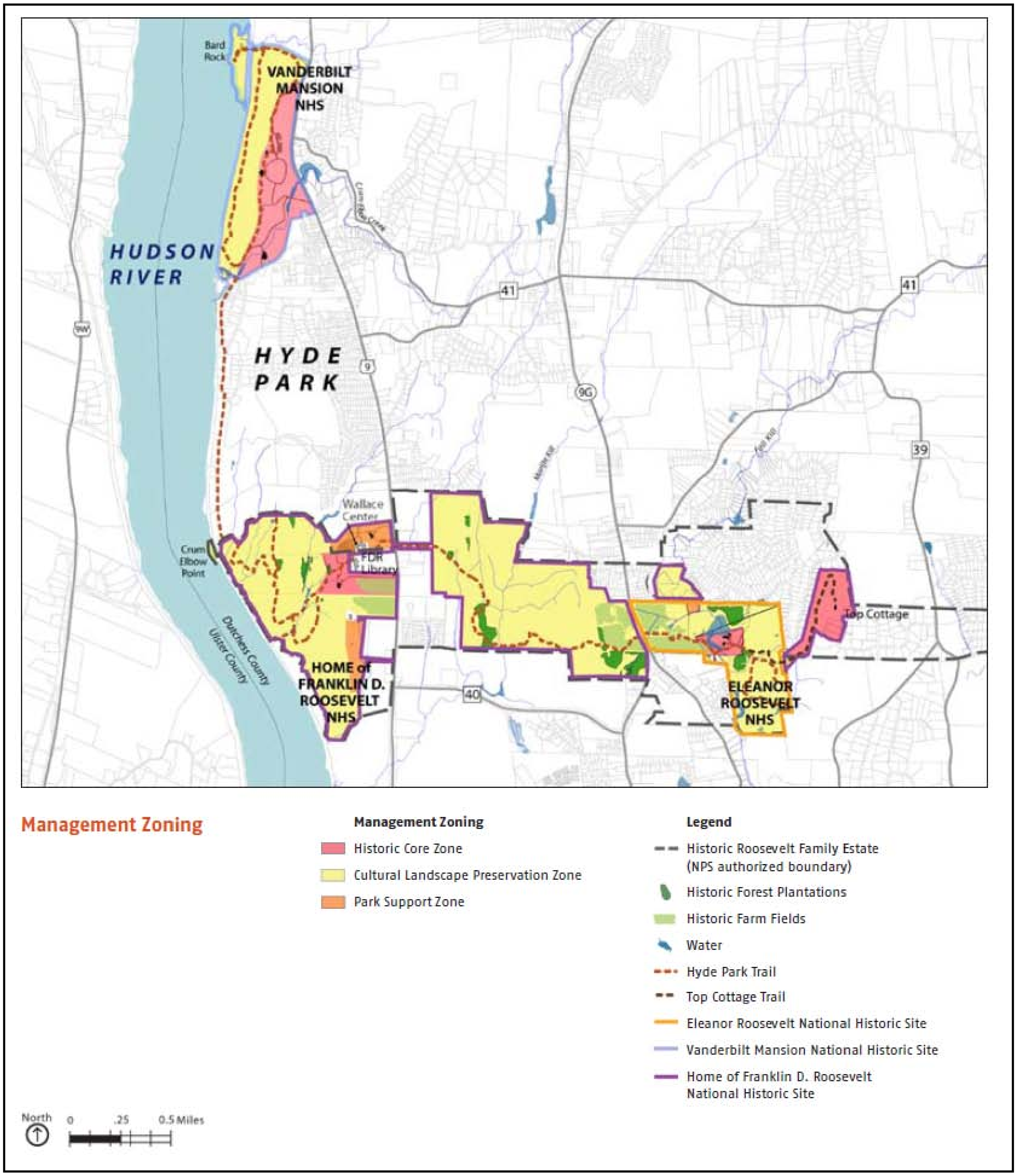

Figure 2. Location, boundaries and management zones of ROVA's three historic parks (Figure from USDI 2010). (Note: ROVA official (D. Hayes) has noted that the Top Cottage historic core zone is too large and should only be around the house).

Regional History

The Hudson River Valley, at the time of first European contact, was inhabited by a native people who were members of the Algonquin nation. The Wappinger tribe occupied what is now most of Dutchess County, New York. The village was presumably located on what is now called Wappinger Falls (Hasbrouck 1909).

The first known European to sail on the river was John de Verazzano in 1524, followed considerably later by Henry Hudson, in 1609 (Hasbrouck 1909). The county itself was formed in 1683 (and was named after the Duchess of York, taking the French form of spelling) and became the second largest county (after Albany) by the end of the 18th century (Frisbie 1995). Its rolling topography allowed for ready access to the Hudson River, thus ensuring lucrative trade routes for agricultural products (Frisbie 1995). Immigration into the county was primarily from Dutch settlers until the middle of the 18th century, whereupon German settlers and New England immigrants predominated (Pucher and Reynolds 1924).

Once the railroads opened up from New York City in the mid-1800's, wealthy industrialists began to populate the Hudson River valley with summer homes (R. Haynes no date). Included among those with estates were J. P. Morgan, Franklin and Eleanor Roosevelt and Frederick W. and Louise Vanderbilt.

Each of the three culturally-based parks encompasses a wide variety of natural resources within their boundaries. The cultural aspects of the parks are well known and documented, but the natural resources are less well known. It is the purpose of this report to gather in one document the known data on ROVA natural resources and provide an assessment of the conditions of those resources.

Cultural Resources

Although this report will assess the natural resources of ROVA, we must also consider the context in which those natural resources are found. ROVA's three parks are cultural resource parks, and their management is directed first to maintaining the cultural landscape.

The Eleanor Roosevelt (ELRO) NHS

The only NHS dedicated to a First Lady, ELRO features her cottage, Val-Kill, where she spent much time working on issues of social change. It served as a furniture factory training young men for work and it also contained a forge and a loom (http://www.nps.gov/elro/val-kill-industries.htm). ELRO encompasses another 181 acres (73 ha) of the original Roosevelt estate (USDI 2010).

The Vanderbilt Mansion (VAMA) NHS

VAMA is dedicated to the exhibition of a time and place in America, as well as an example of the "Gilded Age" country place. The site includes the Vanderbilt Mansion and formal gardens (http://www.nps.gov/vama/index.htm). The NPS manages 212 acres (86 ha) of the original 684 acre (277 ha) estate (USDI 2010).

The general management plan for ROVA also suggests considerable concern for the natural resources within the park. The general management plan (USDI 2010) goes into considerable detail on the potential impacts that management alternatives might have upon the park's natural resources (e.g., active management of historic forest plantations). It is that concern that has led to the development of this natural resource condition assessment, hereby referred to as the 'assessment' in the following text.

2.1.2 Geographic Setting

The Roosevelt-Vanderbilt National Historic Sites (ROVA) is located in Dutchess County, New York, along the Hudson River (Figure 2). Dutchess County is placed in the mid-Hudson Valley in New York. The county is 514,600 acres in size (Soil Survey of Dutchess County undated) and has a population of 297,488 (2010 census), a 6.2% increase since 2000. Hyde Park itself has a population of 21,571 (http://factfinder.census.gov).

2.1.3 Visitation

ROVA offers visitors the opportunity of seeing historic features in American history as well as exploring the natural resources of the region in three separate national historic sites. Like many historic national parks, visitation has been declining in the country and has been declining at ROVA's three park units over the past several years (USDI 2010). Visitation to VAMA has remained relatively steady at nearly 400,000 visitors per year for several decades but HOFR has declined to somewhat near 100,000 per year, down almost 75% since the 1960's. However, grant marketing efforts may have been effective in increasing visitation to HOFR in 2007 (USDI 2010). ELRO visitation in 2009 was about 54,000, down from about 90,000 in the early 1990's (http://www.nature.nps.gov/stats/state.cfm?st=ny). Restoration efforts to maintain the cultural integrity of ROVA has temporarily closed areas in buildings, which has reduced visitation to areas containing historical features of the park.

2.2 Natural Resources

2.2.1 Physical Setting of ROVA

Climate

ROVA is situated in the northern section of the temperate climate zone, within the Hudson Valley climate division. The average high temperature during summer is 71.6 ºF (22 ºC) during July and the low occurs in January at 24.7 ºF (-4 ºC) (http://www.ncdc.noaa.gov/oa/ncdc.html). The growing season extends from early May through the end of September. Precipitation averages about 38 inches per year (Chazen Companies 2006) in amounts evenly distributed across the months (Figure 3). Snowfall can occur from November through May and ranges between 30-50 inches (76-127 cm). Wind direction is seasonal, with south winds predominating during summer and stronger northerly and westerly winds during the winter (Bernhardt et al. 2008).

Geology

ROVA is situated in the ecoregion subsection of the Hudson Limestone Valley in the Lower New England/Northern Piedmont Ecoregion. This limestone valley is defined by low mountains and lakes throughout the landscape. Roosevelt-Vanderbilt NHS sits along the east bank of the Hudson River, which itself cuts through marine sedimentary rocks of Devonian age (NPS 2007). Shale, slate, and sandstone are common geologic units in the area. The sandstones form the high bluffs at Hyde Park, overlooking the river. The entire area was glaciated and under an ancient glacial lake, which drained some 10,000 years ago, leaving behind substantial deposits of clay and sand (NPS 2007). The bluffs at the edge of HOFR and VAMA have exhibited some mass wasting but appear to be relatively stable at this time (NPS 2007).

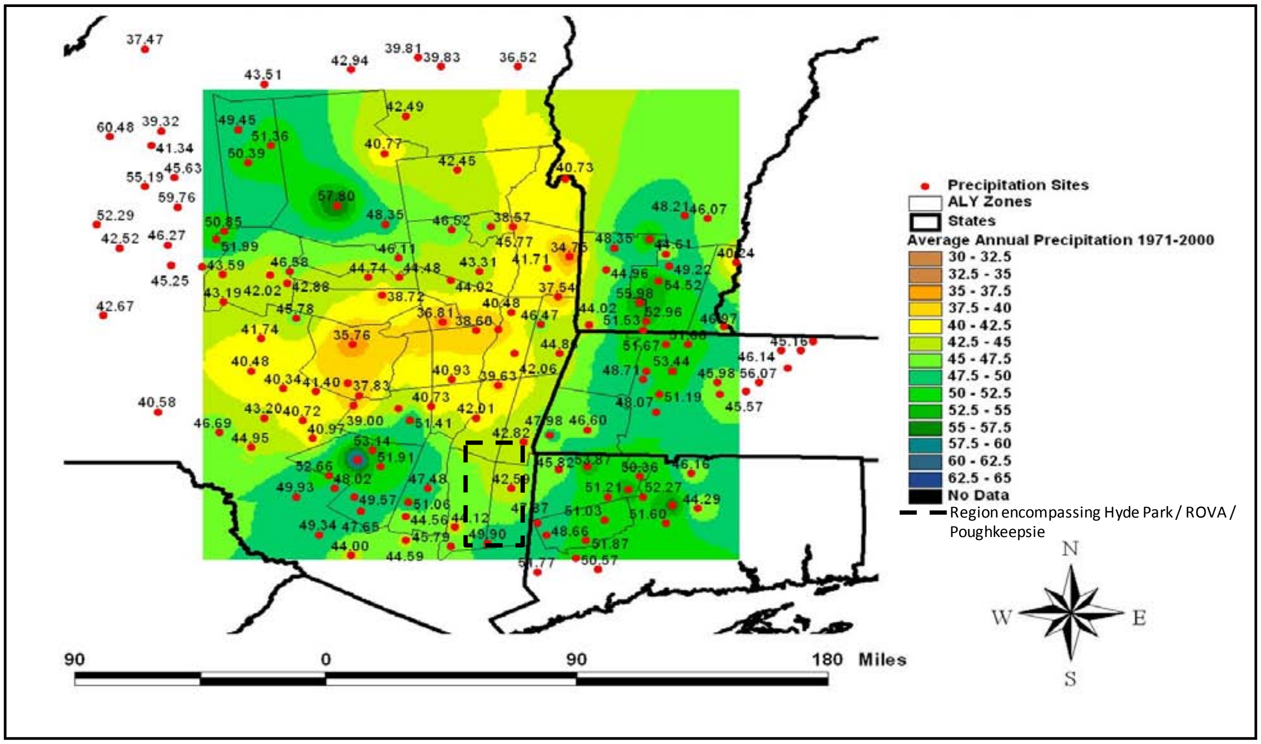

Figure 3. Average annual precipitation (inches) for ROVA and the surrounding area from 1971-2000. Map includes Albany, New York (ALY) precipitation zones which are delineated by the National Weather Service. Source NCDC. **http://www.weather.gov/climate/local_data.php?wfo=aly**. Accessed 2/9/2010.

2.2.2 Resource Descriptions and Ecological Units

Water Resources

ROVA is situated within the HUC 8 Hudson-Wappinger hydrological unit (02020008) and borders the Hudson River. Updated estimates of water resources within ROVA include 17.4 km (10.8 mi) of streams, 4.32 ha (10.68 acres) of ponds and 23.83 ha (58.9 acres) of wetlands (NWI) (per communication, D. Hayes [NPS] February 3, 2012) (Figure 4). However, vernal pools and wet meadows have yet to be delineated and mapped for ROVA which underestimates ROVA's aquatic resources and species richness. The NETN has established a monitoring protocol for assessing wetland integrity in NPS parks, but monitoring efforts have not been initiated within ROVA boundaries to date (Faber-Langendoen 2009). Streams within HOFR include perennial and non-perennials streams and the Roosevelt Ice Pond (0.3 ha, 0.7 acres). A freshwater tidal marsh under NPS stewardship is located on the southwest boundary of HOFR and is noted to have important natural vegetation communities and habitat for birds (2010).

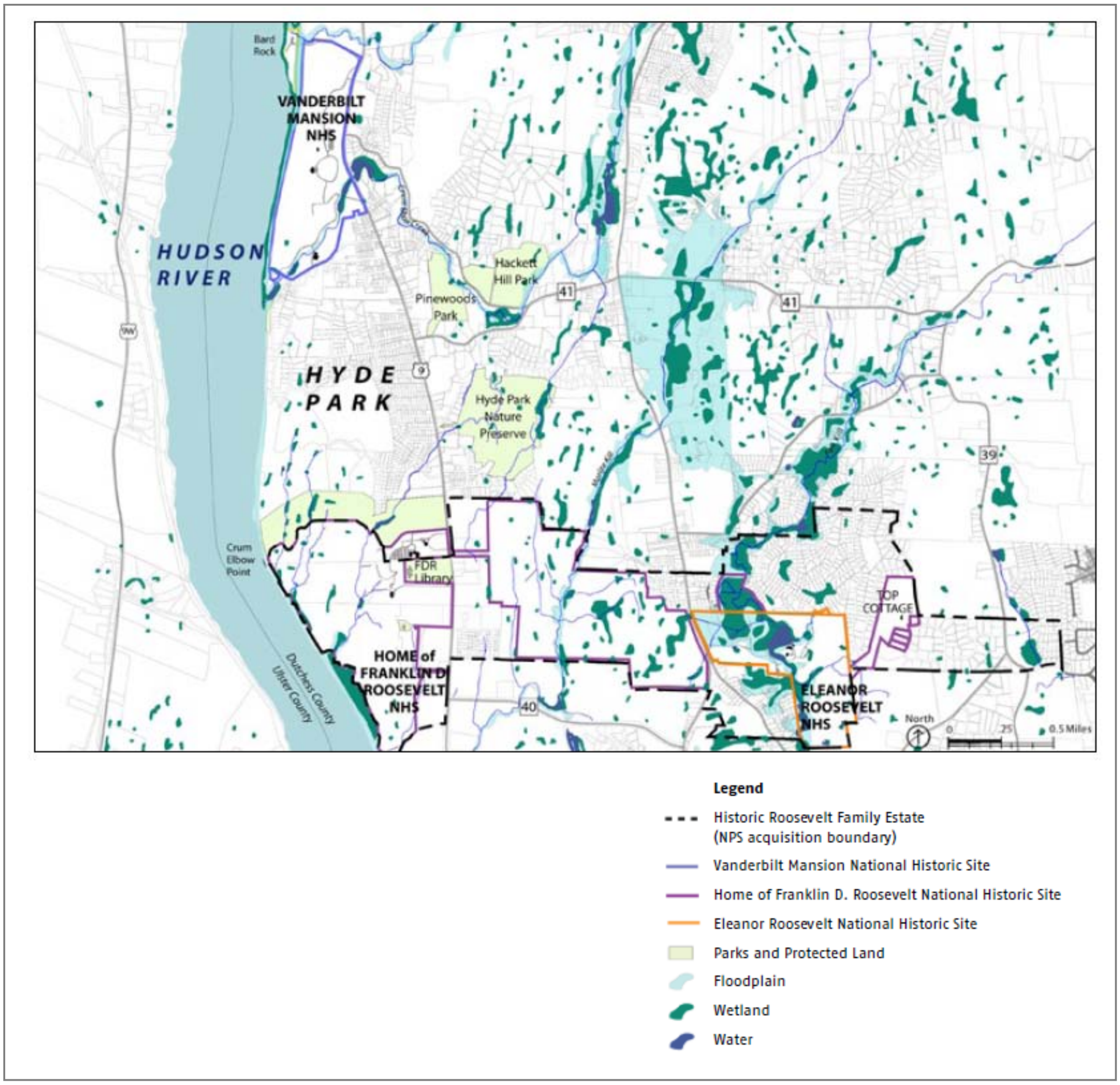

Figure 4. Water Resources in ROVA (from USDI 2010).

Within ELRO, the Fall Kill is the main fluvial system that flows though the park. Several permanent and ephemeral ponds are located in ELRO, including Middle Woodland, Boundary, Hayfield, Curnan House, and Loosestrife Pond, North Woodland Pond and Buttonbush Pond. Historical impounded ponds include the Upper Val-Kill, the largest impoundment measuring 2.8 ha (7 acres) and Lower Val-Kill and South Woodland Pond. Fall Kill creek was dammed by the Roosevelt family in 1925, creating extensive wetlands which are part of the Dutchess County Wetlands Complex (Complex #27) (library.fws.gov/pubs5/web_link/text/dcw_form.htm). This complex provides habitat for the Blandings's turtles and several other plant and animal species but is also ideal habitat for invasive purple loosestrife plants (Klemens et al. 1992, NPS 1997).

VAMA contains two perennial streams, Crum Elbow Creek, which enters at the eastern edge of the park (21.4 km, 13.3 mi) and Bard Rock Creek (2.4 km, 1.5 mi) situated at the northern boundary. An intermittent stream drains below the Visitor's Center and three impounded ponds- Upper Ponds, Middle Ponds and Lower Pond are situated on Crum Elbow Creek. Non-tidal wetlands total about 0.4 ha (1 acre) and a non-tidal freshwater wetlands is located along VAMA's western boundary (NPS 1997, USDI 2010). Additional information regarding the condition of ROVA's aquatic resources is located in the water quality and quantity section of this NRCA report.

Biological Resources of ROVA

A variety of wildlife and fish species have been identified within the park boundaries. To date, 49 mammal species have been observed, as well as 134 bird species, 30 fish species, 30 reptile species, and 27 amphibian species (https://science1.nature.nps.gov/npspecies/) (Appendix A). A breeding bird survey was conducted at ROVA in 2004 (Pooth 2004) with the purpose of documenting field or grassland birds. This sampling effort reported 72 bird species observed and NETN monitoring efforts have supplemented this species list to 81 bird species in the park (Faccio and Mitchell, 2009). In 2008, the NETN applied an index of biotic integrity (IBI) for birds at ROVA (Faccio and Mitchell 2009). They labeled several response guilds with caution or with significant concern. Mather et al. (2003) reported on the fish within ROVA, as part of a broader assessment of fish in the NETN. They found a large number of native species with only two non-natives (bluegill and rock bass). We are not aware of any work within ROVA leading to a fish index of biotic integrity (IBI). Blanding's turtle (NY State threatened species) has been found at Val-Kill (http://nrinfo.nps.gov/Species.mvc/Search), though not in the most recent survey (2010). The parks together have about 67% of the known herpetofauna of the mid-Hudson Valley (Klemens et al. 1992). A review of the New York Department of Environmental Conservation (NYDEC) Environmental Resource Mapper (http://www.nynhp.org/) indicates state significant rare plants, animals and natural communities within a short distance of ROVA (and possibly within ROVA given the deliberate vagueness of the mapping for security reasons).

Soils and Prime Agricultural Lands

Soils within Dutchess County are primarily glacial till and outwash, organic content, and lacustrine and alluvial sediments (Dutchess County Department of Planning, 1985). Soils for HOFR are primarily Hoosic gravelly loam, Colonie fine sandy loam, Steep ledgy land and Staatsburg gravelly loam. Major soils types in VAMA are Colonie fine sandy loam and Hoosic gravelly loam. ELRO's major soils types Hoosic gravelly loam and Saco silty clay loam (NPS 2005). Prime farmland soil and farmland of statewide importance, as defined by the USDA, are within ROVA boundaries (Figure 5). HOFR contains 1/10 acre prime farmland soil and six acres of state-wide significance soil; ELRO has one acre prime farmland soil and six acres of state-wide significance soil; VAMA contains two acres prime farmland soil and three acres statewide significance (USDI 2010). Secondary soil types and soil condition is discussed in the soil assessment section of this NRCA report.

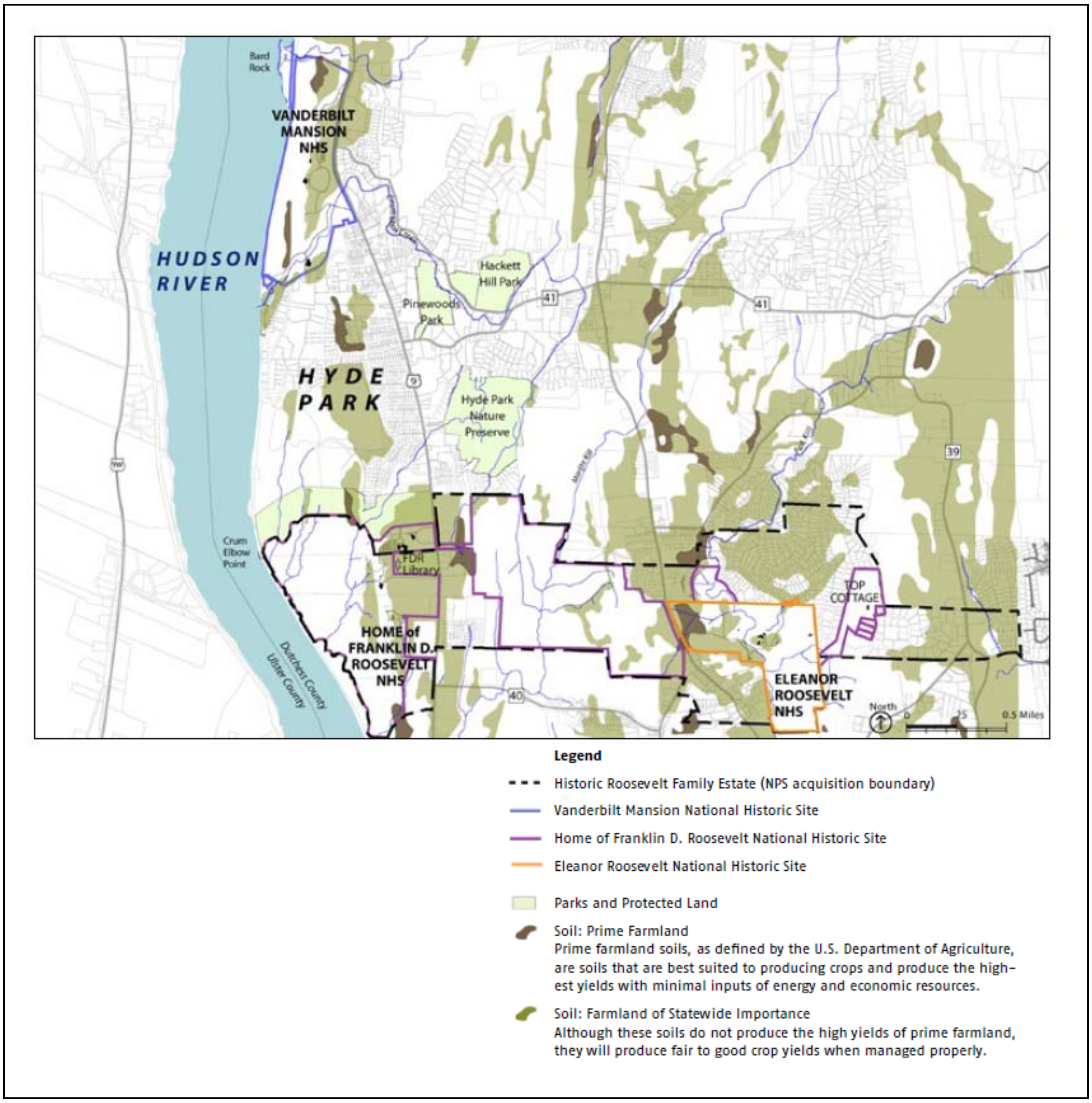

Figure 5. Prime Farmland Soil and Farmland Soils of Statewide Importance for ROVA. (from USDI 2010).

<u>Vegetation</u>

National historic parks are unique in the respect that the vegetation communities in the park are of both cultural and natural importance. ROVA contains many mowed lawn fields, gardens and ornamental plantings that were part of the Roosevelt-Vanderbilt estate, such as Eleanor Roosevelt's Cutting Garden and the Vanderbilt formal gardens. Information of ROVA's plant community composition and plant rarity was initially surveyed by the Brooklyn Botanic Garden (Dutton 1998, Glenn 1998). Dutton (1998) identified five ecological vegetation communities within ROVA: *Cultivated, Hemlock Northern Hardwood Forest, Old Field, Marsh* and *Rocky Outcrop* communities, finding over 380 plants species present, including several rare vascular plant species occurring at the historic sites.

The first vegetation mapping of these historic sites has recently been completed by the NY Natural Heritage Program using the National Vegetation Classification System (Sechler et al. 2009) (Appendix B). The NY Natural Heritage Program vegetation mapping efforts identified the following rare and/or significant communities within ROVA: *Red Cedar Rocky Summit, Fresh Water Tidal Marsh, Mature Oak/Tulip Tree Forest, Hemlock-Northern Hardwood Forest, Vernal Pools* and *Seeps*. Additional communities of interest include rich beech-maple mesic areas, red maple-black gum swamps, hemlock-hardwood swamps and red maple hardwood swamps. Invasive vegetation which has established populations within the park does threaten the native plant communities and the integrity of the cultural landscape. Inventories have been conducted which have aided the implementation of management and control efforts of invasive plant species in ROVA (Bravo et al. 2002, Keefer et al. 2010, Miller et al. 2009, 2010, 2011). Additionally, forest monitoring by NETN has identified pathogens and insect pests that may affect forest habitats within the historic sites (Miller et al. 2009, 2010, 2011). Further information on the condition of the vegetation communities in ROVA is located in the *Vegetation and Forest Health* section and *Invasive Exotic Terrestrial Plant* section in this report.

2.2.3 Current and Potential Stressors

ROVA is surrounded on all sides by development issues that impact the park in some fashion. To the west, ROVA is bordered by the Hudson River, long known for its water quality problems, especially with PCB's (polychlorinated biphenyls). To the north, east, and south, ROVA is bordered by developing towns, all part of the New York-Northern New Jersey-Long Island, Metropolitan Area, and a generally continuous population stretching from Albany south to New York City. External impacts, such as population growth, housing expansion, construction of roads and other infrastructure, disruption of hydrology, and habitat conversion can significantly affect natural resources through pressure on terrestrial and aquatic environments. ROVA is not exempt from these pressures since it is located in a matrix of forest, agriculture, and increased urbanization. Although ROVA is a small cultural park, it operates as a biological refuge in an urban environment for many resident and migratory species.

Population Density

According to the 2010 Census, 21,571 people lived in Hyde Park (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml). More than 297,000 live in Dutchess County, with a density slightly more than 370/mi2. Dutchess County was the 6th fastest growing county in New York between 2000 and 2003 (http://www.epodunk.com/top10/countyPop/coPop33.html). Dutchess County sits halfway between Albany and New York City, making it a reasonable commute to either. Counties near parks not only tend to have higher population densities, but also experience greater population changes than distant counties (Svancara et al. 2009), thereby creating an increased potential for adverse impacts to park resources (Luck 2007).

The geographic arrangement of population has evolved considerably since 1970. Mapped at the level of census tracts, we find evidence for denser populations south of the ROVA sites sprawling north from Poughkeepsie towards more sparse concentrations northward (Figure 6). Growth to the north and east yielded moderate densities (1,000-10,000 persons/mi2) throughout the site area by 2000. This change resulted from fairly rapid population growth to the north and east of the ROVA sites between 1970 and 1980, and much more moderate growth over the ensuing two decades in the same area (with population declining slightly near the sites between

1980 and 1990 and immediately south of the sites between 1990 and 2000) (Figure 7, Figure 8). Mapping population density in smaller geographic units, called block groups, provides a more precise picture of human settlement near the sites (Figure 6). With the exception of the block group intersecting Val-Kill to the northeast, reflecting fairly dense suburban settlement in that area, population density in the immediate areas of the ROVA sites ranges between 100 and 1,000 persons per square mi.

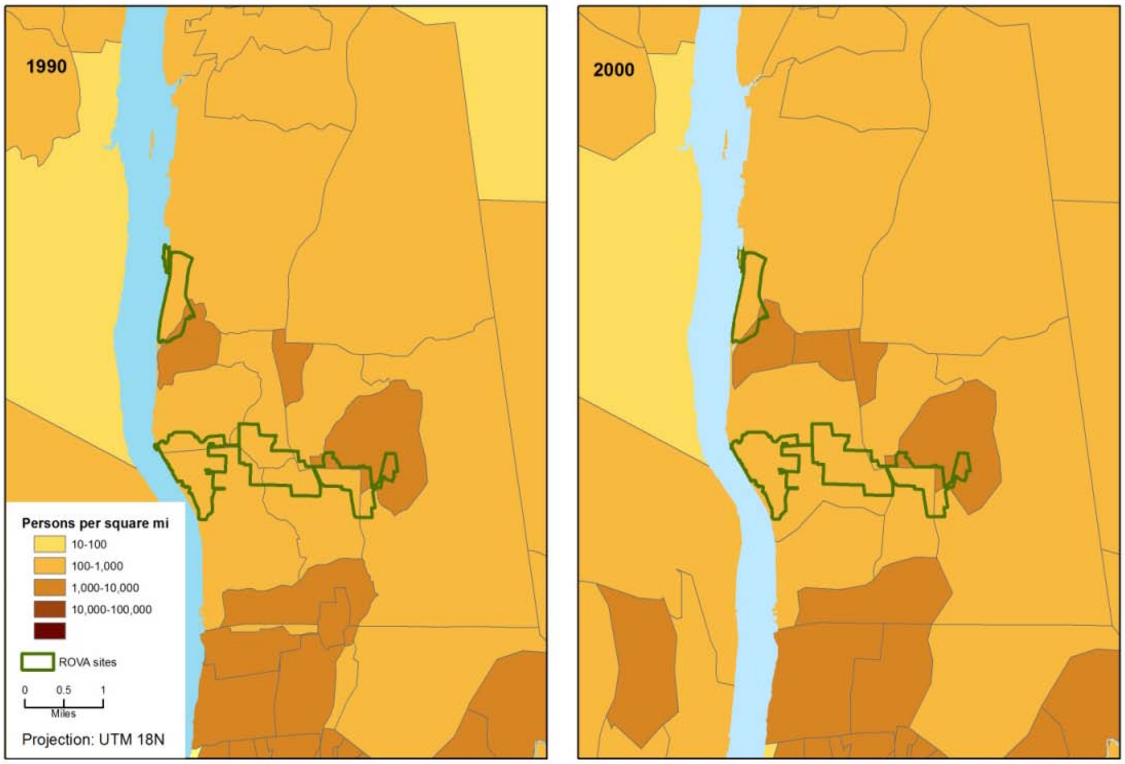

Figure 6. Population density by census block group in the vicinity of ROVA, 1990 and 2000.

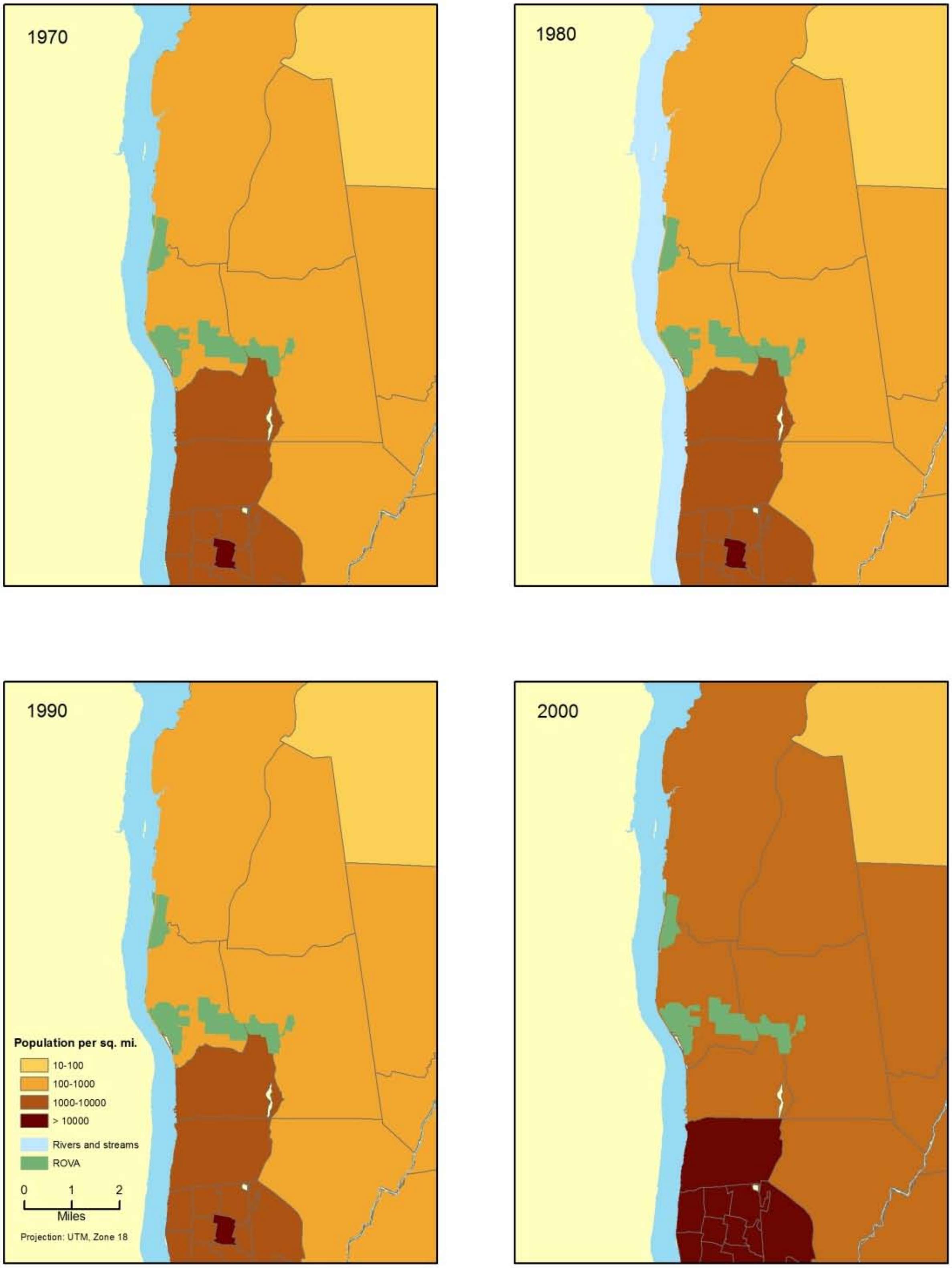

Figure 7. Population density by census tract in the vicinity of ROVA, 1970, 1980, 1990, and 2000.

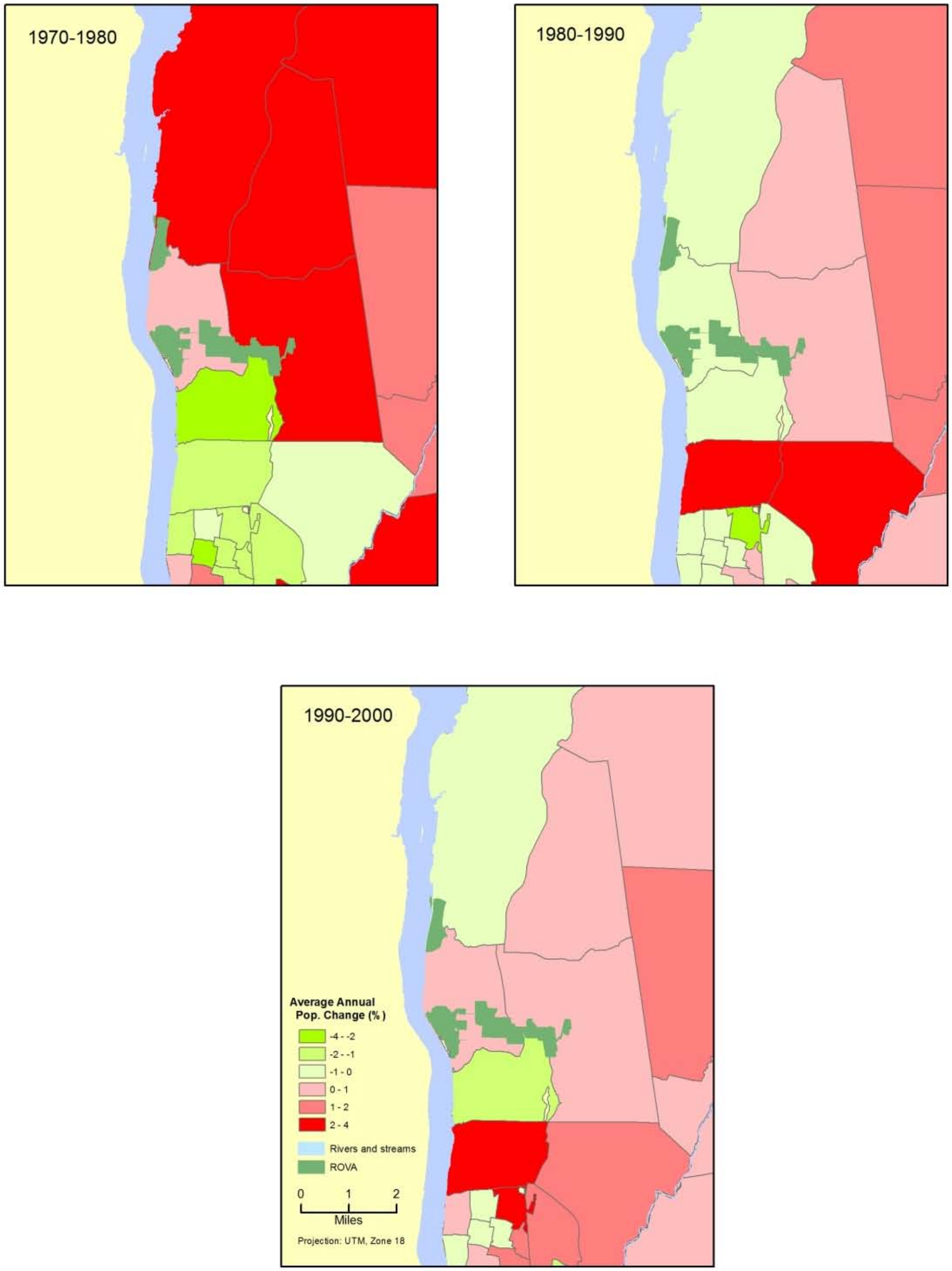

Figure 8. Average annual population change for census tracts in the vicinity of ROVA, 1970-1980, 1980-1990, and 1990-2000.

Transportation

NY Route 9 is the primary road through Hyde Park. Interstate 87 is close and to the west, heading to Albany to the north and the New York City metropolitan area to the south. Rail traffic passes along the bank of the Hudson, carrying New York Metro and Amtrak traffic. Barge traffic is common on the Hudson River. The construction of major and secondary roads has decreased patch area and has increased impervious area within and surrounding ROVA. Patch area due to the development of secondary roads within distances of >500m decreases to 0 to10 km2 (0 to 6.2 mi) (Figure 9). Additionally, disruptive impacts of roads can extend hundreds to thousands of meters beyond the roadside (Forman 2000, 2002). Impacts from roads include examples such as habitat fragmentation, edge effects, hydrological alterations and wildlife mortality.

Development

Development along the Hudson River has led to the loss of many of the historic lands that were associated with the Roosevelt farm and the Vanderbilt estate. As the county continues to grow, continued development is likely to increase pressure upon park boundaries and interior resources. Although many areas have been converted from natural habitat to some other form—primarily for human settlement or agriculture—as of 2001 developed lands did not completely dominate the area surrounding ROVA (Figure 10).What one finds are concentrations of converted areas, notably for residential and commercial development in Hyde Park and Poughkeepsie and related suburbs, and for agriculture and pasture. Some of this occurred between 1992 and 2001, though the pace of conversion from natural habitat over that decade was not rapid (and restoration of habitat was quite infrequent) (Figure 11). Part of the area surrounding ROVA has been progressively developed for housing and commercial use since the 1950's and such development affects ROVA's environment in the form of encroachment as well as in altering key types of natural environment. For example, specific sections between VAMA and HOFR were estimated to contain housing densities of 3-5 units/mi2 in 1950. The estimate for that section increased in 1990 to 56-191 units/mi2 and has been projected to increase to between 191-476 unit/mi2 by 2030, with an increase in impervious surfaces anticipated to accompany housing growth (Figure 12, Figure 13). Were these projected changes to occur, the natural setting surrounding ROVA would be considerably changed, almost certainly accompanied by adverse impacts on plants and animals within the parks themselves.

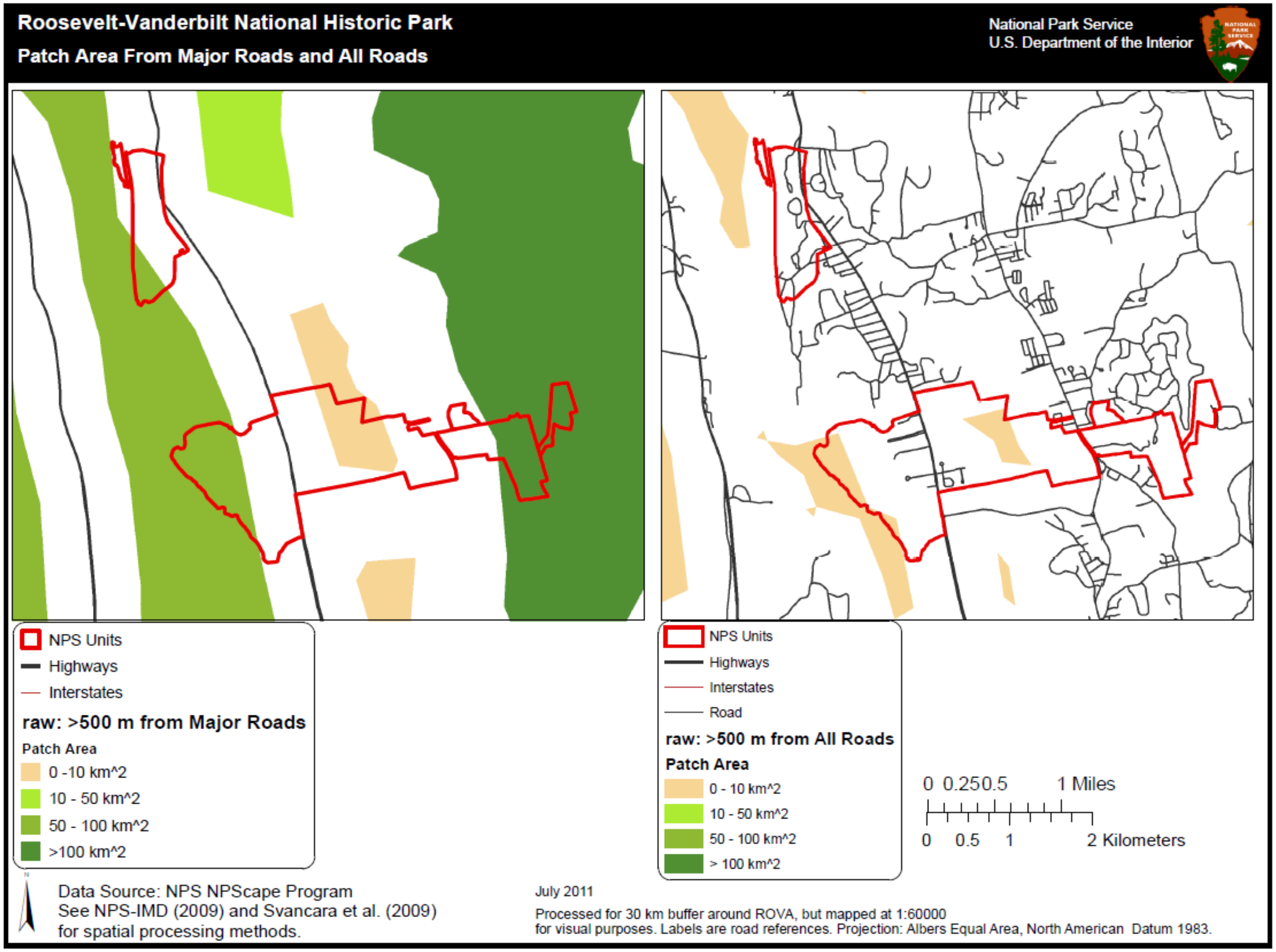

Figure 9. Patch area (km2) >500 m from major roads within and surrounding ROVA (left) and >500 m from all road types within and surrounding ROVA (right). Major roads surrounding ROVA include Albany Post Road, NY 9G, Crum Elbow Road, County Rd 40A, and Salt Point Turnpike/115.

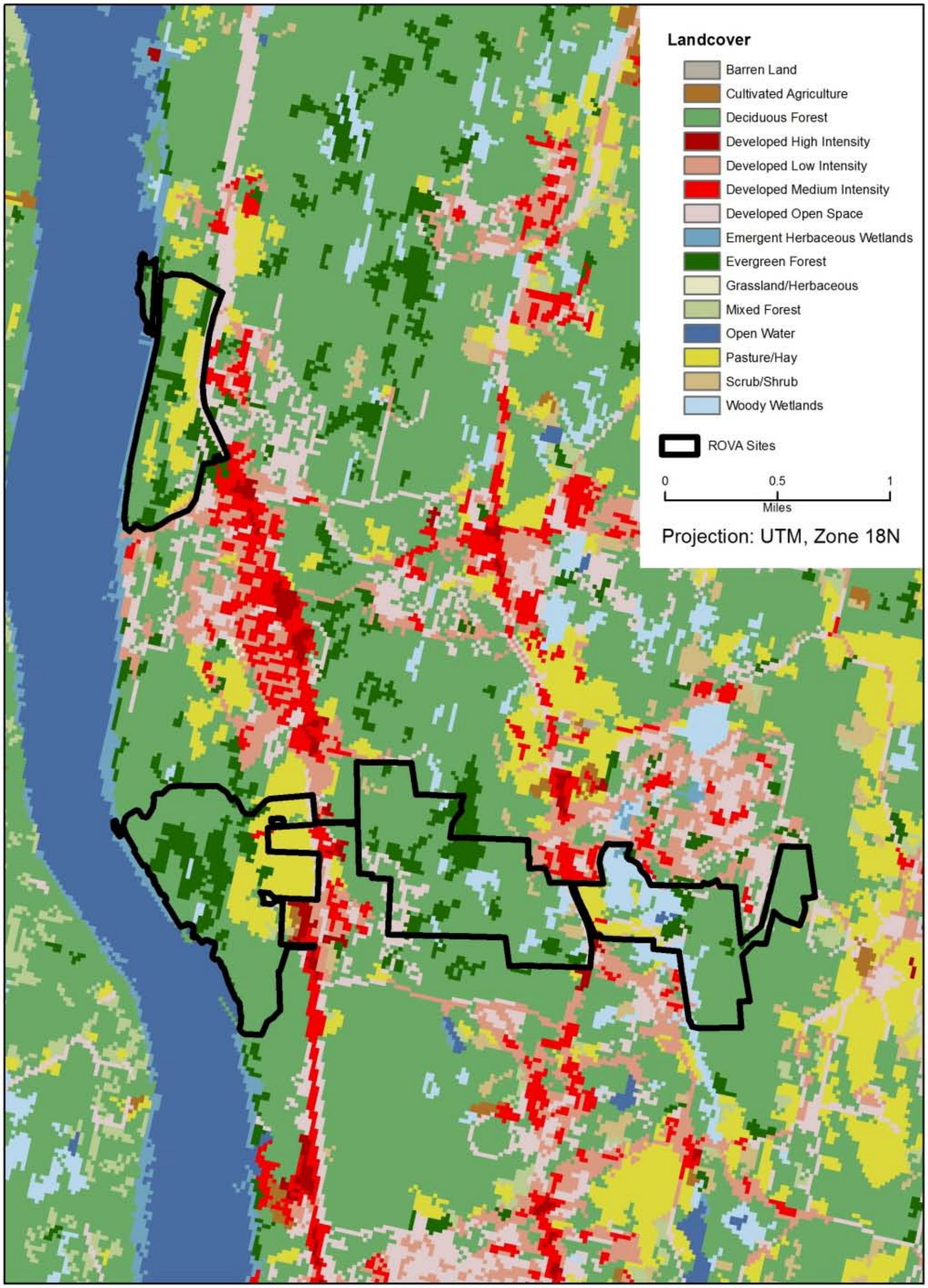

Figure 10. Land cover and land use in the vicinity of ROVA (2007 boundary).

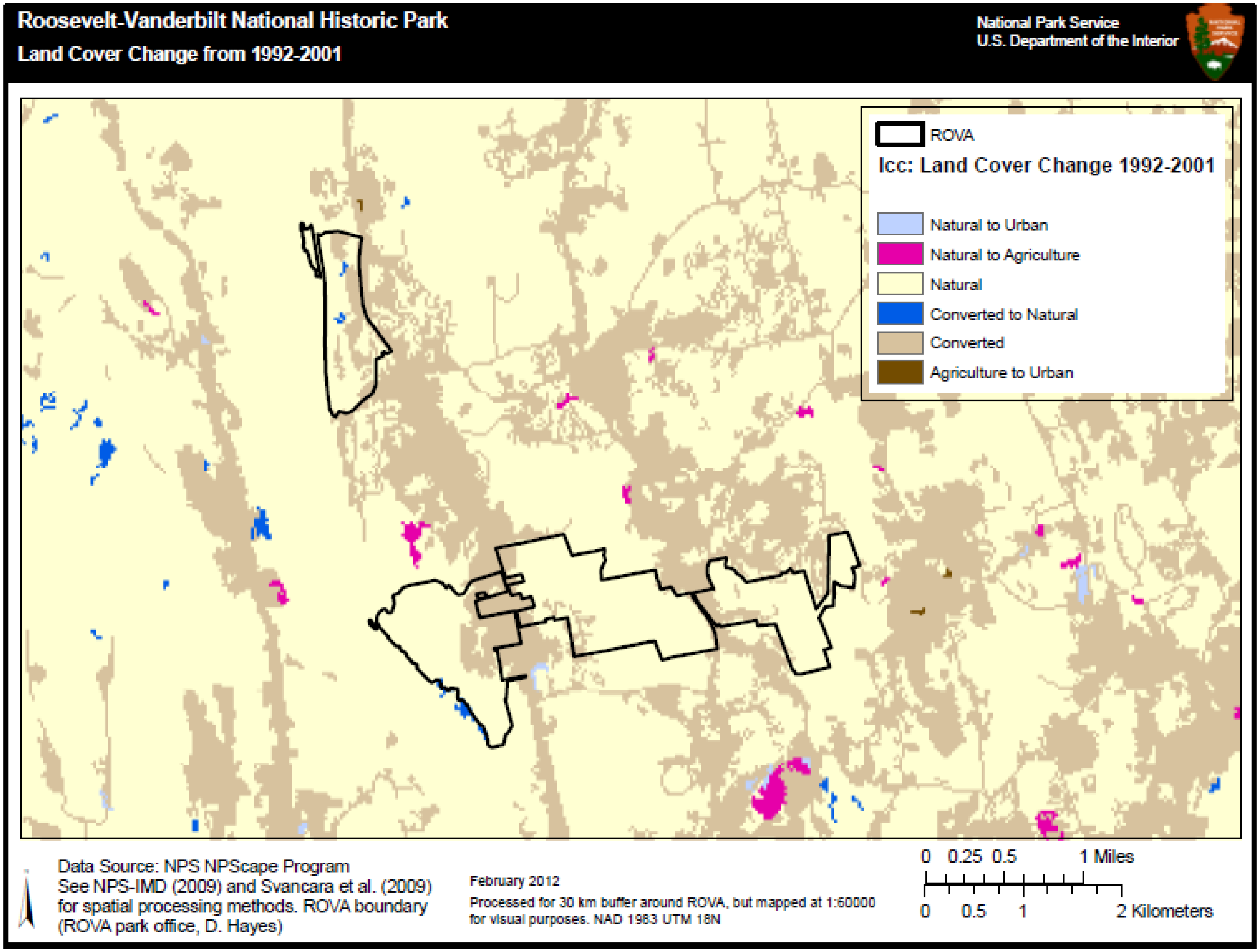

Figure 11. Change in natural and converted land cover from 1992-2001 within and surrounding ROVA. Refer to Svancara et al. (2009) for land cover conversion methods and definitions.

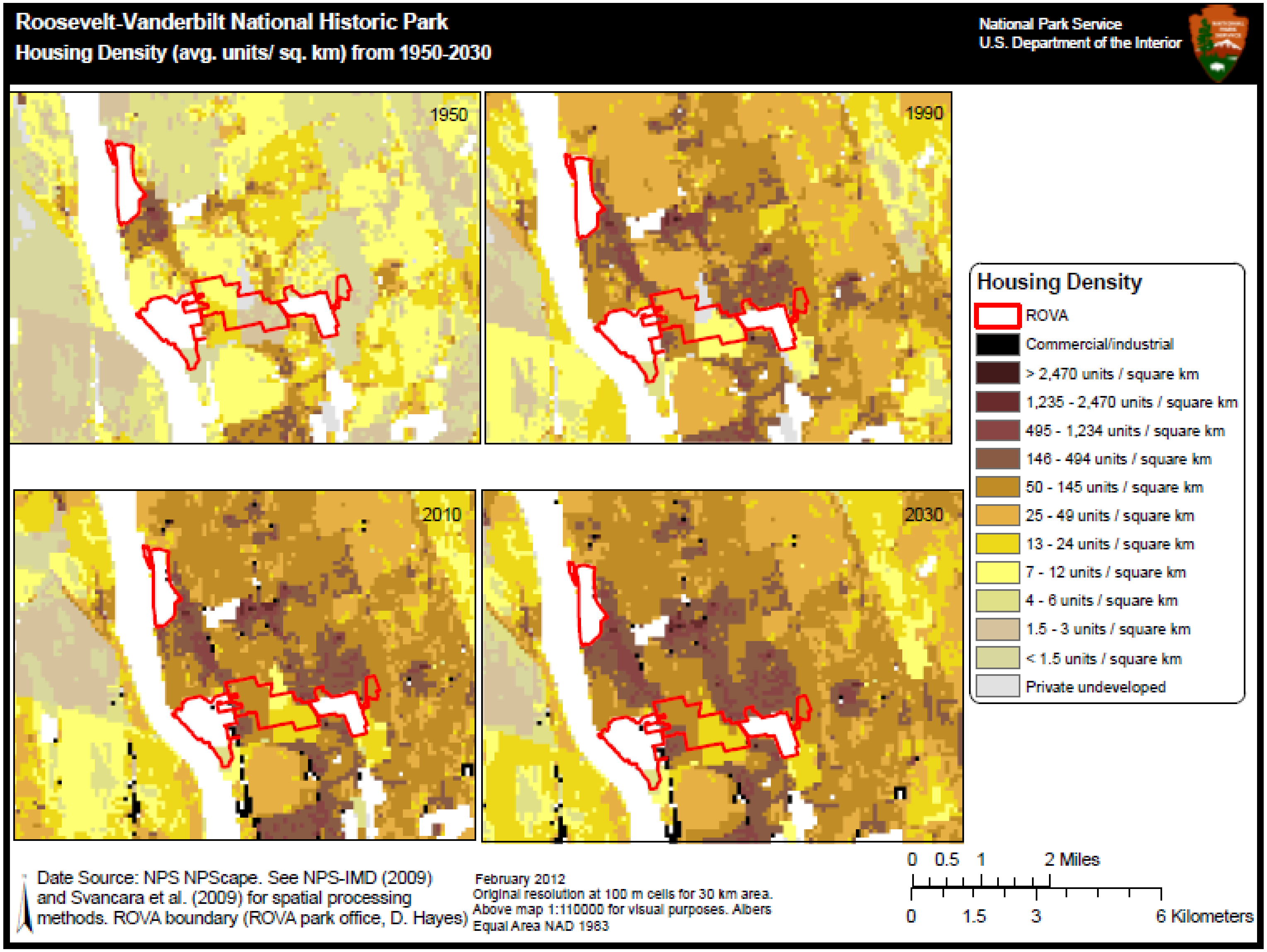

Figure 12. Housing density (average number of housing units per sq km) for historic, current and projected measures surrounding ROVA from 1950-2030.

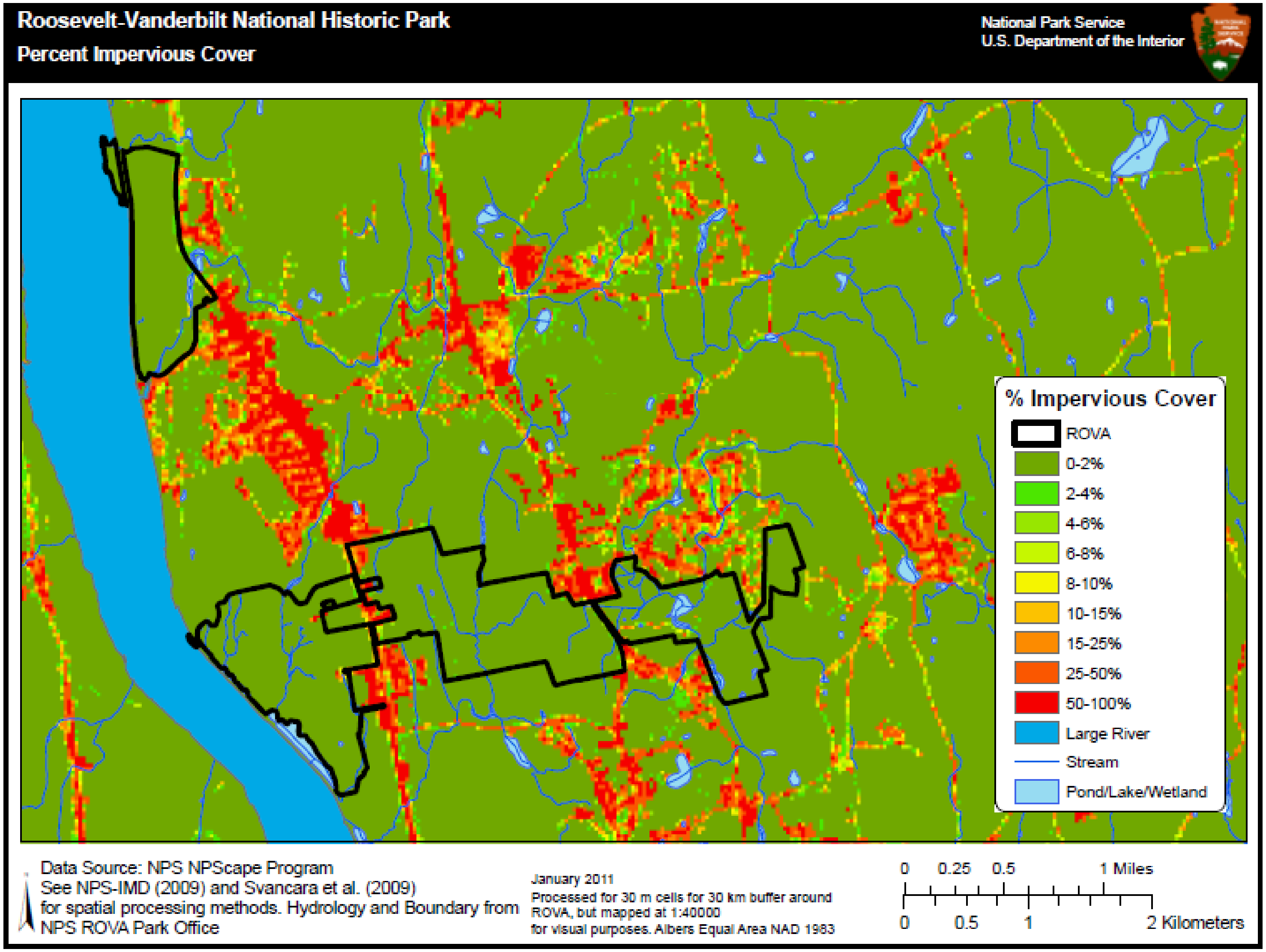

Figure 13. Percent impervious cover within and surrounding ROVA. Data Source: NPS NPScape. Original data resolution at 30 m cells processed for a 30 km area surrounding ROVA in 2001. Above mapping scale 1:60000 for visual purposes. See NPS-IMD (2009a,b) and Svancara et al. (2009a,b) for spatial processing methods.

Superfund Sites

Superfund sites are defined as uncontrolled or abandoned sites where hazardous waste is located, thereby affecting the surrounding ecosystem and human health. Three Superfund sites, Jones Sanitation, the Haviland Complex, and the Hudson River, are located near ROVA (Figure 14) and have been, or currently are listed on the National Priority List (NPL) (U.S. EPA 2009a). To date, the Haviland Complex and the Hudson River remains on the NPL as the Jones Sanitation site was removed due to achieving remediation goals established by the U.S. EPA.

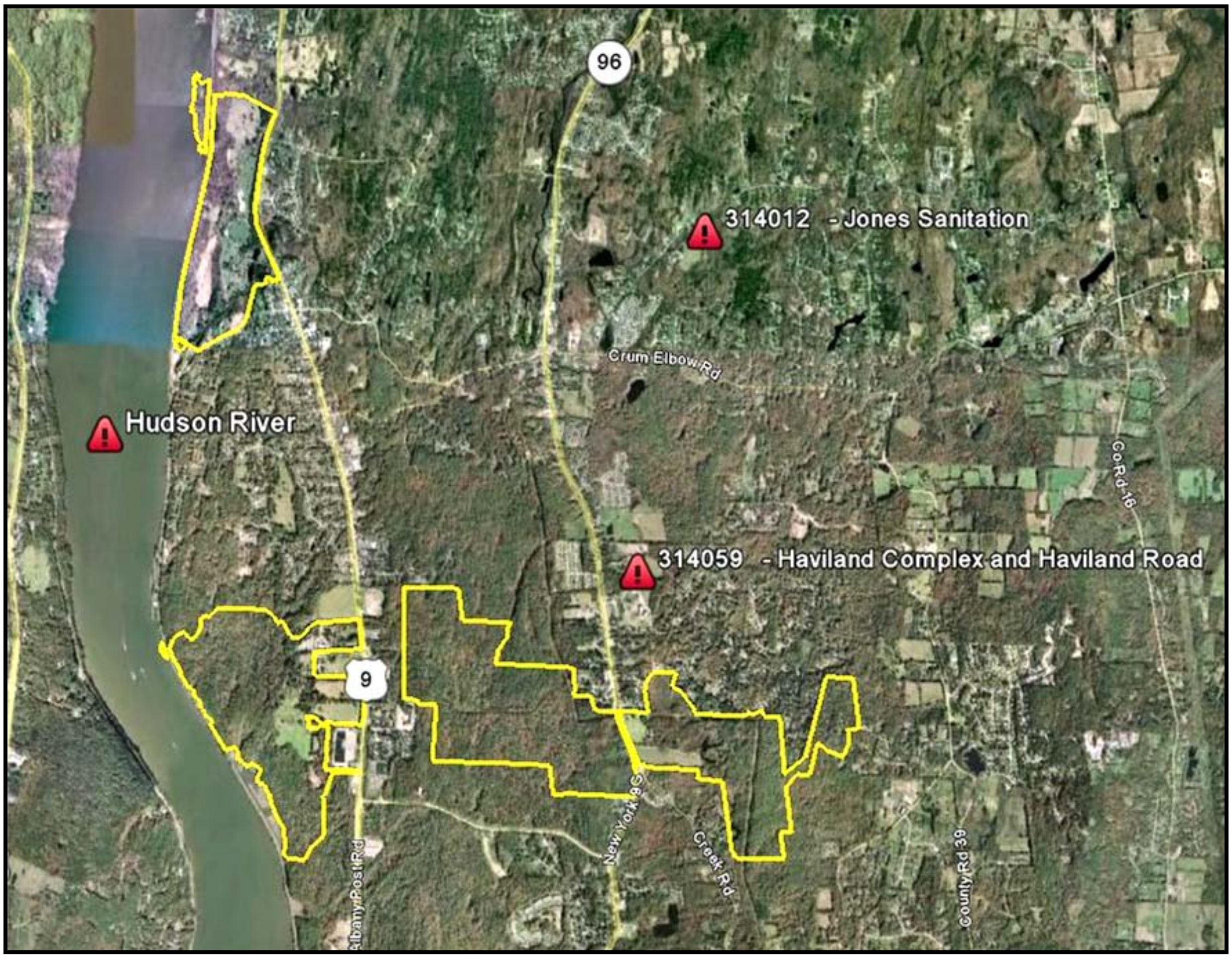

Figure 14. Locations of sites near ROVA (2007 boundary) that have been listed as a Superfund site within the last 10 years. (US EPA, www.epa.gov).

The Haviland Complex (EPA ID# NYD980785661), located near Route 9G and Haviland Road (directly north of ELRO), was proposed to the NPL in 1984 and has been listed as a final NPL site since 1986. The 275-acre site experienced failed septic and sewage systems from a local car wash and Laundromat, polluting the groundwater with five contaminants of concern including: perchloroethylene (PCE), trichloroethylene (TCE), 1, 2-dichloroethene, vinyl chloride, and chlorobenzene (U.S. EPA 2007). The groundwater in the Haviland Complex flows southeasterly and discharges into Fall Kill Creek. Although most of the 21,571 residents of Hyde Park are served by a public water supply, a percentage of the population obtains their water supply from residential wells. Sampling of these wells has shown contaminants exceeding safety standards of the groundwater (U.S. EPA 2007). The Haviland Complex has had immediate and long-term remedial clean-up phases in order to address the contamination. The groundwater continues to be monitored by the U.S. EPA and during sampling occasions, has been observed to be near maximum contaminant levels (MCLs). Although monitoring has not been performed within ROVA's boundaries, sampling in 2006 showed two monitoring wells (MW-99-01 and MW-99-02) which are located directly north of Haviland Road and situated close to ELRO boundaries containing the contaminant PCE at levels above drinking water standards. Additionally, chlorobenzene was detected at concentrations exceeding New York State water standards but below federal standards (U.S. EPA 2007). The last round of groundwater sampling conducted in November 2007 continued to show that the contamination in two monitoring wells remained above drinking water standards (U.S. EPA 2010).

The Hudson River has been designated as an American Heritage River due to its impact in U.S. history and its influence in American culture. From around 1947 to 1977, the General Electric Company (GE) discharged polychlorinated biphenyls (PCBs) into the river from manufacturing plants located in Hudson Falls and Fort Edwards, resulting in 200 miles of the Hudson River between Hudson Falls and the Battery in New York City being listed on the NPL in 1984 (EPA ID #NYD980763841) (Figure 15). The PCB discharge had heavily contaminated sediments in the river, affecting aquatic animals and plant life. Aquatic organisms, such as fish, have been found to exceed acceptable risk levels of PCBs for human consumption and pose a threat to other wildlife which consumes aquatic organisms as part of their diet. Possible PCB contamination not only within the river but also within the floodplains is of increasing concern to the adjacent communities. Home of Franklin D. Roosevelt NHS (HOFR), and Vanderbilt Mansion NHS (VAMA) border the Hudson River and consequently, the parks' natural resources and wildlife communities have potentially been exposed to PCB contamination from the Hudson River over the past several decades.

In 2002 the U.S. Environmental Protection Agency (EPA) issued a Record of Decision (ROD) requiring General Electric to remediate PCB-contaminated sediment "hot spots" along a 40-mile stretch of the Upper Hudson (U.S. EPA 2002). Clean up efforts included an initial "Phase I" dredging near Fort Edward, NY in May 2009. Clean up activities, including continued dredging and habitat restoration, are expected to be performed over a proposed six year period (U.S. EPA www.epa.go/hudson/).

The inactive Superfund site, Jones Sanitation (EPA ID#NYD980534336), was a 57-acre parcel north of ELRO and one-half mile northeast of Crum Elbow Road and Cardinal Road in Hyde Park, NY. The site received and treated septic and hazardous industrial wastes, which contaminated surrounding groundwater and sediments. Jones Sanitation was added to the NPL in 1987 and was deleted from the list in 2005, indicating that the clean up goals had been achieved as set forth by the U.S. EPA. Over 110 compounds were tested for possible contamination to the environment over the 18 years on the NPL (U.S. EPA 2006). In 2008, independent sampling was conducted of surface and groundwater in order to determine whether contaminated groundwater discharged to surrounding surface waters, including Maritje Kill, which flows through HOFR. Four water samples were collected and did not exceed any surface water standards (U.S. EPA 2009b).

Figure 15. Hudson River PCB Superfund Site. Source: http://www.epa.gov/hudson/Fig1-1.pdf. (U.S. EPA). Accessed April 13, 2010.

2.3 Resource Stewardship

2.3.1 Management Directives and Planning Guidance

The three units that comprise ROVA are fundamentally cultural parks, though each has significant natural resources that deserve attention. The General Management Plan (USDI 2010, p 12) states "Roosevelt-Vanderbilt National Historic Sites include natural resources that, while not fundamental to the legislated purposes of the parks, are important and are protected by federal laws, executive orders, and policy." The presence of key types of habitat, such as wetlands, and location in an area of rapid development, argue for the potentially important role that ROVA can play in maintaining natural resources along the Hudson River.

2.3.2 Status of the supporting science

Our approach to a natural resources assessment for ROVA was based on indicators developed by the Northeast Temperate Network (NETN) of the NPS Vital Signs program. This program provides long-term monitoring protocols for more than 270 park units of their most important natural resources (Fancy et al. 2009). These Vital Signs are generally intended to be information-rich indicators of the overall health of park ecosystems. Table 1 lists the high priority vital signs defined by the NETN signs which are applicable to ROVA (Mitchell et al. 2006). Data for theses analyses was requested or queried from NPS, State and Federal agencies, and peer-reviewed articles, with the final list of metrics and the period of date used for this NRCA listed in Table 2.

Table 1. NETN Vital Signs applicable to ROVA (Mitchell et al. 2006).

Level 1	Level 2	Level 3	Vital Sign	Potential measure
Air and climate	Air quality	Ozone	Ozone	Atmospheric ozone concentration (synthesize existing data), foliar injury to indicator species
		Wet and dry deposition	Atmospheric deposition and stress	Wet and dry deposition rates (synthesize existing data), streamwater ANC, streamwater nitrate concentration
			Contaminants	Heavy metal deposition (synthesize existing data)
	Weather and climate	Weather and climate	Climate	Air temperature, precipitation by type, relative humidity, solar radiation, wind speed and direction, snow water equivalent, snow depth (synthesize existing data)
Geology and soils	Soil quality	Soil function and dynamics	Forest soil condition	Ratios of carbon to nitrogen and calcium to aluminum
Water	Hydrology	Surface water dynamics	Water quantity	Water depth, water duration, lake levels, streamflow, groundwater levels/inputs, spring/ seep volume, sea level rise
	Water quality	Water chemistry	Water chemistry	Stream water nitrate, stream alkalinity/ANC, water temperature, % dissolved oxygen, specific conductance, pH, color, salinity, chlorophyll a, photosynthetically active radiation (PAR)
		Aquatic macroinvertebrates	Streams-macroinvertebrates	Diversity of selected communities and subcommunities
Biological integrity	Invasive species	Invasive/exotic plants	Invasive / exotic plants-early detection	Presence / absence
		Invasive/exotic animals	Invasive / exotic animals-early detection	Presence / absence
	Focal species or communities	Wetland communities	Wetland vegetation	Diversity of community and subcommunities, exotic species extent, beaver activity

Level 1	Level 2	Level 3	Vital Sign	Potential measure
		Forest vegetation	Forest vegetation	Community diversity (all layers), tree species, rates of mortality and regeneration, stand structural dynamics, tree basal area by species, canopy condition, snag density, coarse woodydebris volume, percent exotic species
			White-tailed deer herbivory	Browse intensity in forests
		Fishes	Fishes	Diversity of community and subcommunities, percent exotic species
		Birds	Breeding birds	Diversity of forest, high elevation, grassland/scrub, old-field, and subcommunities.
		Amphibians and reptiles	Amphibians and reptiles	Diversity of wetland/vernal pool communities and subcommunities, red-backed salamander abundance in forests
Human use	Visitor and recreation use	Visitor usage	Visitor usage	Number of visitors by location and activity, trampling impacts, soil erosion
Landscapes	Landscape dynamics	Landscape dynamics	Land cover / ecosystem cover	Change in area and distribution of ecological systems (including intertidal communities) within park and adjacent landscape, patch size distribution, patch connectivity, patch fragmentation, extent of major disturbance, ecological integrity index by ecological system
			Land use	Road network extent, nearby housing development permits, proportion of nearby lands in various categories of human uses, % impervious surface in watershed, nearby human population density, landscape buffers

Table 2. Monitoring data collected for the NRCA of Roosevelt-Vanderbilt National Historic Sites, New York.

Level 1	Level 2	Level 3	Vital Sign	Period of data for condition assessment and/or trend analysis	Reference/source
Air and climate	Air quality	Ozone	Ozone	1995-2009	NPS Air Resources Division
		Wet and dry deposition	Atmospheric deposition and stress	1984-2008	NPS Air Resources Division; NADP database
			Contaminants	2001-2009 (visibility); 2004-2009 (Hg)	NPS Air Resources Division; MDN database
Geology and soils	Soil quality	Soil function and dynamics	Forest soil condition	2007, 2009	NETN forest monitoring reports
Water	Hydrology	Surface water dynamics	Water quantity	1948-2001 (ground) 2006-2009 (surface)	USGS data collection; NETN monitoring; environmental assessment reports for sedimentation (i.e., PDA 1979)
	Water quality	Water chemistry	Water chemistry	1994-1997, 2006-2009	NPS data reports; US EPA STORET database; NETN monitoring data
		Aquatic macroinvertebrates	Streams-macroinvertebrates	1995-2004	NYSDEC data reports; Fall Kill Watershed Committee report
Biological integrity	Invasive species	Invasive / exotic plants	Invasive / exotic plants-early detection	Historical presence/absence data; 2007 and 2009 NETN monitoring data	USGS; NETN monitoring reports; NPS surveillance reports

Level 1	Level 2	Level 3	Vital Sign	Period of data for condition assessment and/or trend analysis	Reference/source
		Invasive / exotic animals	Invasive / exotic animals-early detection	Historical presence/absence data; 2007 and 2009 NETN monitoring data	USGS NAS database; NETN monitoring reports; NY State Dept. of Conservation surveillance; USDA risk assessments; peer-reviewed research articles
	Focal species or communities	Forest vegetation	Forest vegetation	2007, 2009; 2002-2006	NETN monitoring reports; ROVA vegetation mapping (Sechler et al. 2009)
		Fishes	White-tailed deer herbivory	2007, 2009; 2002-2006	NETN monitoring reports; ROVA vegetation mapping (Sechler et al. 2009)
			Fishes	2000	NPS report (Mather et al., 2003)
		Birds	Breeding birds	2002-2009	NPS data reports (Trocki & Paton 2003, Pooth 2004, Faccio & Mitchell 2009); NY breeding bird atlas (2005)
		Amphibians and reptiles	Amphibians and reptiles	1988-1990; 1996-2006	Historical inventory data for the region; NPS survey data (Hayes)
Landscapes	Landscape dynamics	Landscape dynamics	Land cover / ecosystem cover	Historical data collection and projected models for landscape variables from 1950-2050	NETN forest monitoring reports; Wang et al. 2006, 2009; NPScape historical and projected data; NPS transportation reports (2004); NLCD data; US census data (2010)
			Land use		

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Chapter 3 Study Scoping and Design

3.1 Preliminary Scoping

Preliminary scoping efforts for the ROVA condition assessment began in 2009 with a meeting of ROVA park staff and NPS coordinators for discussions and a tour of the park's grounds. Historical reports, photographs, geospatial data (GIS), and data from current sampling efforts were collected through several meetings and communication exchanges with ROVA staff, NPS Northeast Temperate Network staff (NETN) and NPS Air Resources Division (ARD). Pennsylvania State University (PSU) continued to collect data from federal (e.g., USGS) and state (e.g., NYSDEC) agency databases and local watershed committees in New York. Conference calls, meetings at PSU, and e-mail exchanges with NPS staff continued to assist the authors of this condition assessment by providing information which consisted of environmental issues/concerns in ROVA and the surrounding area, current data collection efforts and protocols for ROVA, and Vital Signs metric development. These communication efforts were essential to understanding the natural resources in ROVA, as NPS staff invests significant time inventorying, monitoring, and interpreting data for the park.

3.2 Study Design

3.2.1 Indicator Framework, Focal Study Resources and Indicators

Although ROVA is a historic cultural park, information regarding the natural resources in ROVA and the surrounding vicinity was abundant. The framework used for ROVA's assessment is organized by broad ecosystem resources as designed for the Northeast Temperate Network (NETN) Vital Signs approach (Mitchell et al., 2006, Fancy et al., 2009). The use of the Vital Signs metrics in this report allows NPS to utilize the NRCA results in future studies, since the Vital Signs program is a framework for long-term monitoring of park resources. However, the compiled data for ROVA's natural resources was limited in terms of quantitative measures or spatial and temporal sample sizes. Thus, the confidence of the historical and present data collected for ROVA determined which Vital Sign metrics were included in ROVA's NRCA assessment (Table 2), as well as determining the framework for the condition categories used for assessing ROVA's natural resources.

3.2.2 Reporting Areas

A total of six broad categories were used as the reporting area framework for the NRCA assessment. These categories included: *Air & Climate, Geology & Soils, Water, Biological Integrity,* and *Landscapes*. Vital Sign metrics in each of the above categories were used in the ROVA NRCA and evaluated as whether the metric was relevant to ROVA based on environmental occurrence, management objectives or data availability. A list of Vital Signs to be evaluated for the NRCA was finalized by the PSU team (Table 2). ROVA is a unique park in that three separate park units (HOFR, ELRO, and VAMA) compose the park. The metrics were assessed for each park unit unless data availability limited the assessment to a broader scale. In some cases, such as water chemistry, data collection efforts enabled a condition assessment of individual streams, allowing for a finer resolution of the natural resource condition assessment.

3.2.3 General Approach and Methods

Discussion of metric background, approach and justification are provided for each metric assessment in Chapter 4. Each evaluated natural resource metric in this NRCA begins with a brief description of the relevance and context of the resource to the general environment and

ROVA. A review of the data and methods used to assess the resource was established, followed by justification of condition categories by discussing reference conditions or threshold values utilized. The reference conditions and threshold values were based on federal or state agency regulations and criteria, peer-reviewed research, estimates of biotic integrity, or established NPS NETN Vital Signs condition categories for natural resources or NPS ARD categories. In cases where the data was qualitative in nature, best professional judgment was used to assign a condition category. When applicable, each metric was assessed for the percentage of reference or threshold attained. Further analysis of data resulted in each metric being given a condition category rating and assessment of trend of the natural resource condition. Condition category language generally included three categories: *good, caution (moderate),* and *significant concern*. A few metrics did not follow the three category assessment due to data limitations or regulatory language, as was the case for two metrics in the Biological Integrity category and one metric in the Water category. Trend analysis was assigned a condition of “increasing”, “decreasing” or “no trend” after statistical analysis of quantitative historical and current data. Data gaps and confidence in assessment was discussed after each metric was assessed. Confidence in the assessment and trend was identified as *high, fair,* or *limited*. High confidence included extensive spatial and temporal quantitative data in the assessment; *fair* indicated data were from some studies that were quantitative and/or qualitative in nature; *limited* indicated data were from limited studies that collected qualitative spatial and temporal data.

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Chapter 4 Natural Resource Conditions

4.1 Air Quality

ROVA has been designated as a Class II air quality area under the Clean Air Act (1970, amendments added in 1990). These areas are provided less stringent pollution protection versus Class I areas and are allowed increases in certain air pollutants. Class II parks must comply with federal standards as stated under the National Ambient Air Quality Standards (NAAQS) established by the U.S. Environmental Protection Agency (EPA), which sets two levels of standards. To derive a meaningful assessment of the park's air resources, the NPS Air Resources Division (ARD) air quality kriged results and classification systems were used (NPS 2010). The NPS Air Resources Division developed this approach to assess overall air quality conditions within all NPS parks. Parameters of assessment include *total wet deposition of sulfur (S) and nitrogen (N), mercury (Hg), ozone* and *visibility*. The ARD uses air quality monitoring data from national, state, and local stations averaged over five-year periods to generate interpolations to derive estimates of air quality parameter at all NPS units. Interpolation condition categories of 1) *good condition* 2) *moderate condition* and 3) *significant concern* are then assigned to assess each air quality parameter. The creation of these categories are based on regulatory standards/criteria and peer-reviewed literature which investigated the effects of air quality parameters on ecological systems. However, gaps in the impacts of air pollution on the environment exist and may underestimate the effects of air pollutants on the environment. Lovett et al. (2009) recommended that air quality impacts that are known to occur in the Northeast region be considered in any long-term environmental conservation strategy.

Although most pollution sources are outside NPS park boundaries, the park's ecological resources continue to be affected by air pollutants. Air quality monitoring stations in New York are monitored by the New York Department of Conservation (SLAMS, State and Local Air Monitoring Stations), National Atmospheric Deposition Program/National Trends Network (NADP/NTN), EPA Clean Air Status and Trends Network (CASTNet) and Interagency Monitoring of Protected Visual Environments (IMPROVE) (Figure 16). There are no monitoring stations for air quality located within ROVA's park boundaries.

4.1.1 Wet Sulfur & Nitrogen Deposition

<u>Relevance and Context</u>

Sulfate and nitrate ions in precipitation are used as indicators in atmospheric deposition due to their direct link to ecological effects such as acidification of waterbodies and nutrient enrichment. NPS Air Resources Division has set a criteria of >3 kg/ha/yr of total wet S or N atmospheric deposition as being a significant concern for air quality conditions. Atmospheric deposition in the forms of sulfur and nitrogen are released from fossil fuel emissions containing sulfur dioxide, nitrogen oxide and ammonia, which in turn can be transformed in the atmosphere to become acidic precipitation or particles. These forms can be directly deposited as dry deposition or combine into rain, snow, or cloud droplets allowing for an increase in the acidity of precipitation or wet deposition. Natural background deposition levels in the eastern U.S. are approximately 0.50 kg/ha/yr for N or S, with wet deposition accounting for 0.25 kg/ha/yr (NPS 2010). The Northeast region, including New York, has experienced elevated wet sulfate and nitrate deposition inputs to its ecosystems compared to the rest of the U.S. (Figure 17), specifically in the Adirondack and Catskill regions which have experienced acidification and N saturation to its ecosystems (Aber et al. 1989, Driscoll et al. 2003).

Average decreases in wet deposition between the periods 1989-1991 and 2006-2008 were approximately 35 percent for sulfate (kg-S/ha) and 21 percent for inorganic nitrogen (kg-N/ha) in the Northeast, although a high degree of variability was present in the measurements used to calculate wet nitrate (U.S. EPA 2008). Deposition trends have been shown to mirror emission trends in the Midwest and the northeastern U.S. (Butler et al. 2001, Driscoll et al. 2001). Therefore, changes in sulfur and nitrogen deposition have been found to correlate better with these regional emission trends than local emissions (Kelly et al. 2002). Dutchess County, NY (county location of Roosevelt-Vanderbilt National Historic Park) is downwind of the midsection of the U.S. where numerous coal burning power plants are located. Most air masses and precipitation that affect Dutchess County originate in these areas with high emissions of pollutants that can cause acid deposition (Bernhardt et al. 2008). Long-term trend analyses of sulfate in New York showed a decline in deposition while wet deposition trends of nitrate, ammonium and inorganic N are variable (Kelly et al. 2002, Driscoll et al. 2003).

Dry and wet sulfur and nitrogen deposition can directly enter the ecosystem and have direct implications to aquatic or terrestrial systems through acidification or nutrient enrichment (Driscoll et al. 2001). Examples of effects to the ecosystem include altering soil composition (Driscoll et al. 2001), affecting soil invertebrates (Rusek and Marshall 2000), stressing trees and vegetation (Horsley et al. 2002, Aber et al 2003, Thormann 2006, Wallace et al. 2007), altering aquatic structure and function and decreasing the diversity of aquatic organisms (Schindler et al. 1988, 1989, Dupont et al. 2005). Seasonal trends of aerosol deposition could potentially damage forests during the growing season. Wet NO3- concentrations have been recorded to be higher in summer than in winter in Dutchess County, potentially damaging leaf surfaces (Kelly et al. 2002).

Acidification creates indirect environmental impacts, such as increasing susceptibility of the environment to insects and disease (Throop and Lerdau 2004). Studies have shown that increased N deposition may predispose trees to attack and mortality by insects such as the hemlock woolly adelgid (*Adelges tsugae*) (McClure 1991). A study by Hames et al. (2002) negatively correlated the productivity of wood thrush populations with acid deposition levels across the Northeastern U.S., possibility due to acid-sensitive invertebrates declining in response to acidification, which are a primary calcium source for wood thrush. Acid deposition also increases the mobilization of aluminum in soils and a concurrent decrease in available calcium and magnesium, two elements necessary for the regeneration of many woody forest species and terrestrial and aquatic organisms (Driscoll et al. 2001).

Currently no EPA standards exist for S or N deposition levels. However, studies have been conducted to identify and establish thresholds or critical loads of N and S deposition on terrestrial and aquatic ecosystems. For example, Aber et al. (2003) showed that stream NO3-N exports increased as N deposition increased above 8 kg/ha/yr. Levels of deposition of both SO4 and NO3 of under 10 kg/ha/yr was identified as a level to ensure that aquatic acidification would bhe less likely to occur (Schindler 1988, Dupont et al. 2005). Acid neutralizing capacity (ANC) and soil carbon-to-nitrogen (C:N) ratio have been used as indicators to demonstrate whether deposition has induced changes to chemical, physical, or biological components of an ecosystem (Aber 1989, Bugler et al. 2000). ANC can be a key parameter in the recovery of aquatic systems to acidic inputs because it measures the capacity of waterbodies to buffer acid inputs (Aber et al. 2003, U.S. EPA 2004). This measurement is particularly important as approximately fifty percent of total nitrogen entering rivers and streams in New England was estimated to come from atmospheric deposition (Moore et al. 2004).

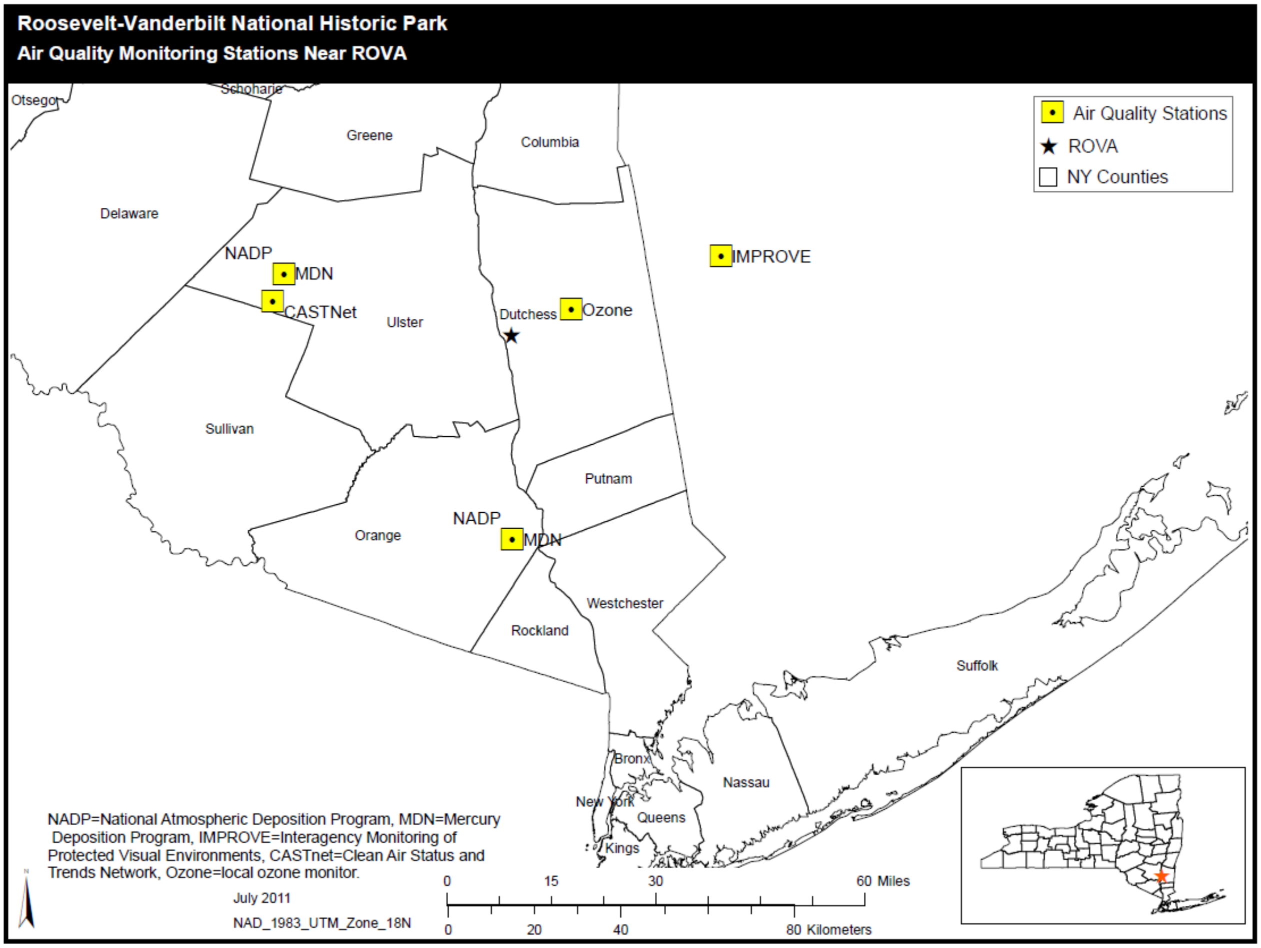


Figure 16. Air quality monitoring stations near ROVA. Data from these stations were used in the assessment of ROVA's air quality condition.

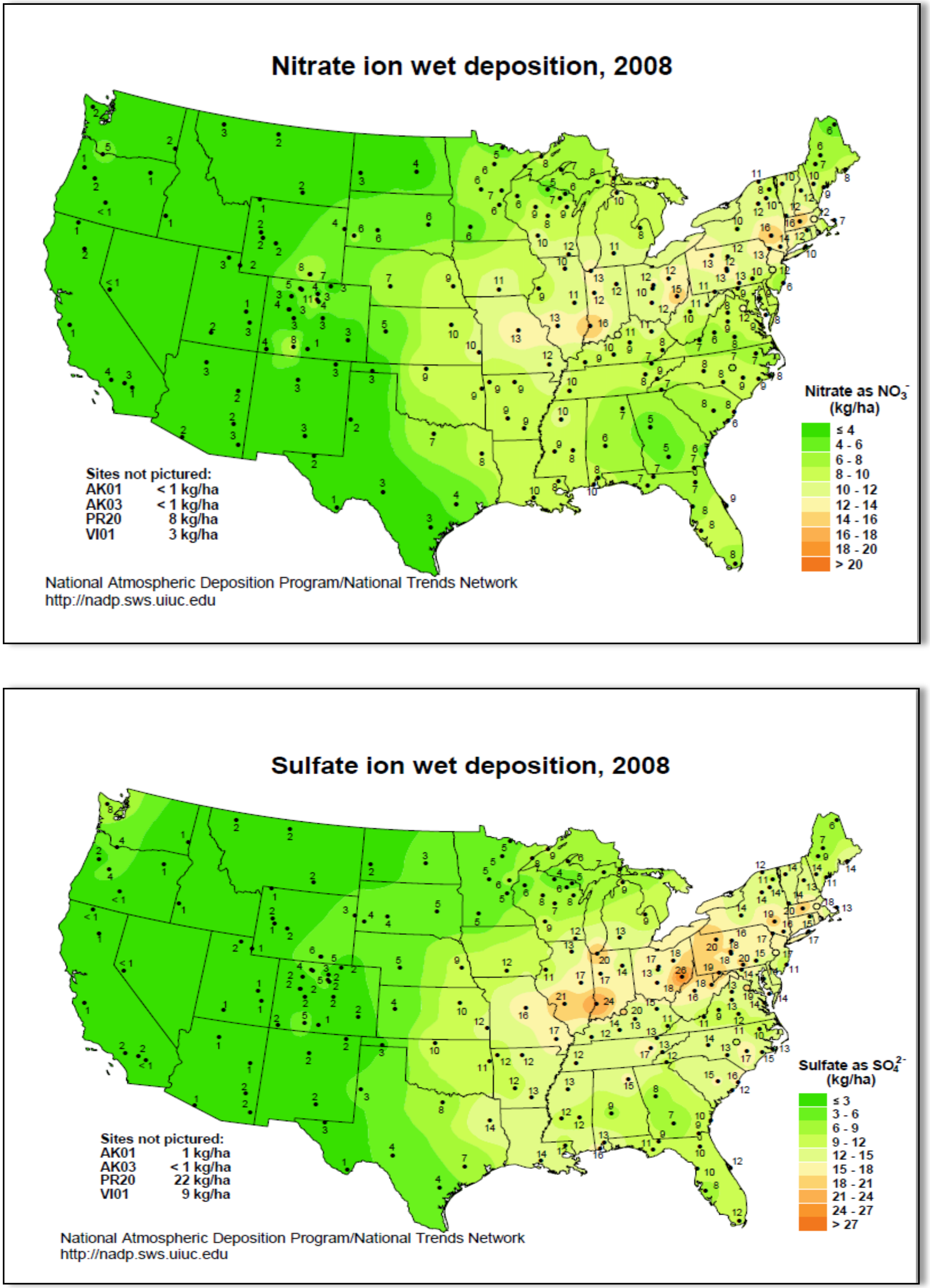


Figure 17. Nitrate and sulfate wet ion deposition, 2008. Source: NADP

Data and Methods

In order to evaluate the temporal and spatial trends of deposition, data were collected from various monitoring stations nearest to ROVA, in conjunction with using NPS ARD data and their established condition categories for assessing wet S and N deposition (Figure 18). Wet deposition monitoring stations closest to ROVA included two NADP/NTN stations. The West Point, NY, station (NY99) was established in 1983 and is located 30 miles (48 km) south of ROVA. The Claryville, NY, station (NY68 [Biscuit Brook]) was established in 1983 and is located 35 miles (56 km) west of ROVA. Dry deposition is currently monitored by U.S. EPA CASTNet. CAT175 station in Claryville, NY, is located 35 miles west (56 km) of ROVA and has been in operation since 1994. The Cary Institute for Ecosystem Studies located in Millbrook, NY (Dutchess County), contains the closest air monitoring station near ROVA (15 miles or 24 km east). CASTNet calculates dry deposition based on deposition velocities and ambient concentrations. Due to these methods, there is greater uncertainty in reported CASTNet data (Maniero 2004) and therefore, only wet deposition data is used for ROVA's S and N deposition analysis.

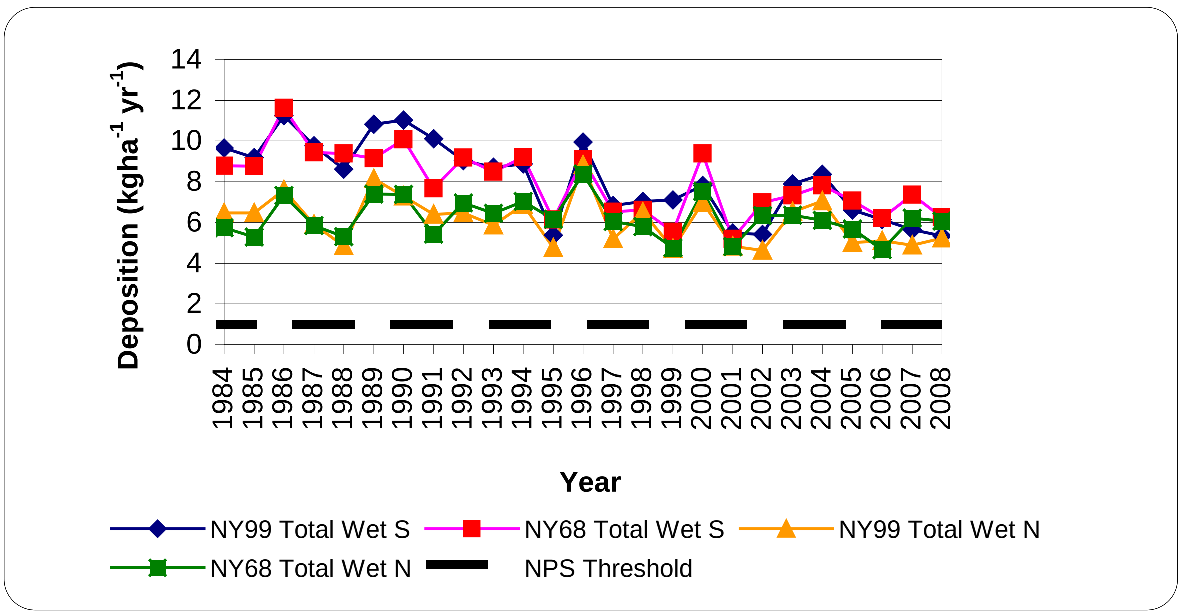


Figure 18. NADP/NTN wet deposition trends of total S and total N from 1984-2008 for monitoring stations NY68 and NY99. NPS threshold line indicates the reference condition of NPS ARD 1 kg/ha/yr.

Park resources sensitive to acidification were measured at a national scale based on a risk assessment by Sullivan et al. (2011a) and included acidification related risk ratings for 271 I & M parks, including HOFR and VAMA. This risk assessment considered three factors that influence acidification risk to parks resources from sulfur and nitrogen deposition: 1) pollutant exposure 2) ecosystem sensitivity and 3) park protection. The three factors each contained several measured variables which were calculated to represent aspects of the factor (see Appendix C, D for variables). National parks were ranked according to each of these three factors. A summary risk rating was then calculated for each park based on averages of the three above factors. Based on these averages, each factor was classified into one of five overall risk categories to acidification: very low, low, moderate, high, very high (see Sullivan et al. 2011a for further details on the variables included for each of the three factors and ranking assessment).

A second risk assessment was conducted by Sullivan et al. (2011b) to assess the relative sensitivity of NPS parks to potential nutrient enrichment effects caused by atmospheric nitrogen deposition. This risk assessment considered three factors that influence nutrient enrichment risk to park resources from atmospheric nitrogen deposition: 1) nitrogen pollutant exposure 2) ecosystem sensitivity and 3) park protection mandates. National parks were ranked according to each of these factors and an overall risk ranking was calculated based on averages of the three rankings. Results of quintile rankings of national parks throughout the U.S. were used to distinguish the risk levels of nutrient enrichment to a park (i.e., the lowest quintile are the 20% of parks that received the lowest N pollutant exposure ranking and the highest quintile are the highest 20% of park rankings) (see Sullivan et al. 2011b for further details on the variables included for each of the three factors and ranking assessment).

<u>Reference Condition/Threshold Values Utilized</u>
Critical loads have not been established in the Clean Air Act for S and N deposition. NPS is creating a critical load approach for wet deposition of S and N to protect and manage its parks' ecosystems (Porter et al. 2005, NPS ARD 2010). NPS ARD has created conditional assessment categories based on ecological responses documented in scientific literature (see 'Relevance and Context' section above, NPS ARD 2010). ROVA's NPS ARD values for wet S & N deposition were based on interpolated values over a five year average from NADP/NTN data collected from stations operating close to ROVA. Wet deposition was calculated by multiplying N or S concentrations in precipitation by a normalized precipitation amount for sites within the continental U.S. This normalized precipitation is calculated in order to minimize variation in data caused by interannual variation in precipitation.

The condition categories established by NPS ARD for wet deposition of S and N have been stated as the following: "*Monitoring evidence indicating that wet deposition amounts less than 1 kg/ha/yr cause ecosystem harm is not currently available. Therefore, parks with wet deposition less than 1 kg/ha/yr were considered to be in good condition for deposition; parks with 1-3 kg/ha/yr were considered to be in moderate condition; and parks with greater than 3 kg/ha/yr were considered to have a significant concern for deposition.*" (NPS 2010).

Risk assessments produced for national parks were used as supplemental information to assess ROVA's air quality and natural resources. As a coarse introduction to the risk assessment of acidification due to S and N deposition on ROVA's natural resources, we incorporated the summary risk categories produced by Sullivan et al. (2011a). These summary risk ratings included: *very low* (1.0-1.99), *low* (2.0-2.49), *moderate* (2.5-3.49), *high* (3.5-4.24), *very high* (4.25-5). Additionally, the summary risk rankings produced by Sullivan et al. (2011b) for nutrient enrichment effects from atmospheric N deposition were used to understand the risk ROVA may encounter with nutrient enrichment. Nutrient enrichment summary risk ratings included: *very low, low, moderate, high, very high*.

Condition and Trend

Interpolated wet S and N values for ROVA for the years 2005-2009 were 4.57 and 4.06 kg/ha/yr, respectively. These values do not meet an ecological threshold of 1 kg/ha/yr. Based on NPS ARD condition categories of *good, moderate* and *significant concern*, ROVA's air quality for wet S and N deposition is considered a *significant concern*, as it is >3 kg/ha/yr (0% attainment) (Table 3, NPS ARD 2010).

Table 3. NPS Air Resource Division 5-Year Interpolated Sulfur and Nitrogen Wet Deposition Values for ROVA. Park subunit values were reported when available (www.nature.nps.gov/air).

Parameter	NPR ARD Threshold		ROVA 5-Year ARD Values					
	Condition	Value	1995-1999	1999-2003	2001-2005	2003-2007	2004-2008	2005-2009
Wet Deposition of Total S (kg/ha/yr)	Good	<1			5.83 (HOFR)	5.81 (HOFR)	6.23 (HOFR)	4.57 (HOFR)
	Moderate	1-3	4.22 (ROVA)	5.83 (ROVA)	5.83 (ELRO)	5.80 (VAMA)	6.24 (VAMA)	4.57 (VAMA)
	Significant Concern	>3			5.83 (VAMA)			
Wet Deposition of Total N (kg/ha/yr)	Good	<1			4.98 (HOFR)	4.49 (HOFR)	5.27 (HOFR)	4.06 (HOFR)
	Moderate	1-3	3.76 (ROVA)	4.65 (ROVA)	4.98 (ELRO)	4.49 (VAMA)	5.24 (VAMA)	4.06 (VAMA)
	Significant Concern	>3			4.98 (VAMA)			

Sulfur wet deposition levels near ROVA had significantly decreased from 1984-2008 based on linear regression results (n=2 stations, $p<0.05$, Figure 19). Nitrogen wet deposition data collected from station NY99 had a significantly decreasing trend ($p<0.05$, Figure 20) while station NY68 had no statistically significant trend from 1984-2008 ($p>0.05$, Figure 20). Trends for sulfur wet deposition levels seem to be decreasing for ROVA while nitrogen wet deposition levels are slower to decrease within the region and are more variable. These trends are supported by peer-reviewed literature discussing deposition trends in the northeast region of the U.S. (Driscoll et al. 2001, Driscoll et al. 2003, Kelly et al. 2002). Although the trend for wet deposition levels is decreasing, the values of sulfur and nitrogen wet deposition for ROVA are still well above the NPS ARD *good condition* threshold of 1 kg/ha/yr and therefore, natural resources may still experience negative impacts from higher wet deposition levels.

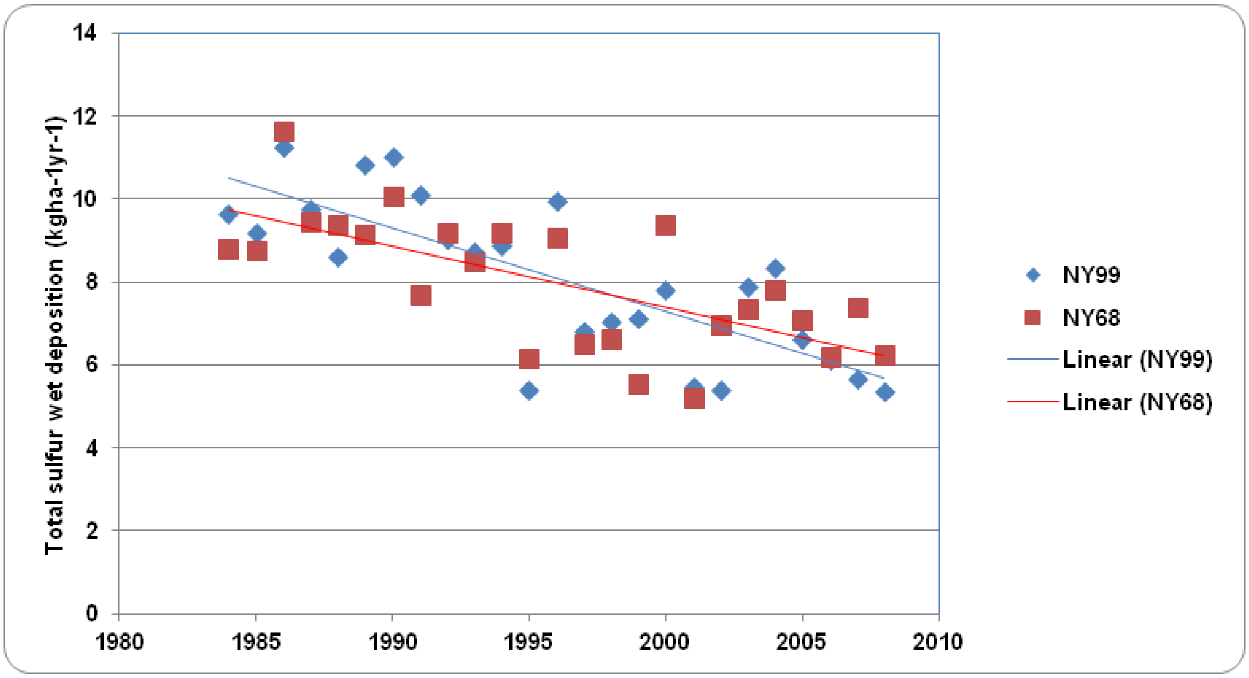


Figure 19. Trend of total sulfur wet deposition levels (kg/ha/yr) measured at stations NY99 and NY68 near ROVA from 1984-2008 (1983 data excluded due to only partial data collected for that year). Linear regression trend lines for each station included: NY99: y=-0.1467x+300.78, R2=0.6046, p<0.05; NY68: y=-0.2009x+409.16, R2=0.460076, p>0.05.

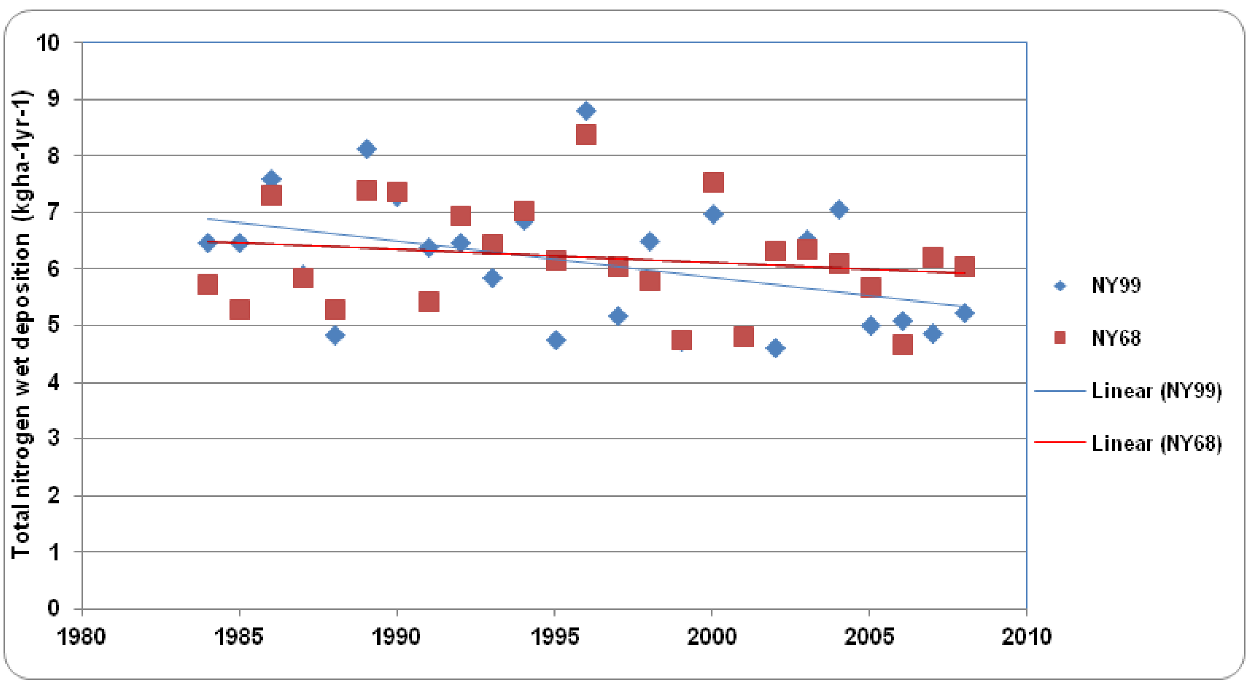


Figure 20. Trend of total nitrogen wet deposition levels (kg/ha/yr) measured at stations NY99 and NY68 near ROVA from 1984-2008 (1983 data excluded due to only partial data collected for that year). Linear regression trend lines for each station included NY99: y=-0.0651x+135.98, R2=0.1678, p<0.05; NY68: y=-0.0227x+51.599, R2=0.313, p>0.05.

The NPS risk assessment which evaluated the sensitivity of national parks to acidification effects from S and N deposition rated HOFR and VAMA (Sullivan et al. 2011a). Based on pollutant exposure, ecosystem sensitivity and park protection measures, HOFR and VAMA had scored a summary risk rating of *high* (score=3.67) (Table 4). HOFR and VAMA were also assessed in the NPS risk assessment of nutrient enrichment effects from atmospheric nitrogen deposition (Sullivan et al. 2011b). Based on nitrogen pollutant exposure, ecosystem sensitivity and park protection measures, HOFR scored a *high* summary risk rating (ranking 138.83) and VAMA's summary risk rating was *moderate* (ranking 129.75) (Table 5).

Table 4. Relative rankings of HOFR and VAMA for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Summary Risk from acidification due to acidic deposition (Sullivan et al. 2011a).

Relative Ranking of Parks to Acidification Sensitivity				
Park	**Avg. of Pollutant Exposure (numerical rank)**	**Avg. of Ecosystem Sensitivity (numerical rank)**	**Avg. of Park Protection (numerical rank)**	**Summary Risk (average categorical rank)**
HOFR	Very High (225.25)	Moderate (114.42)	Moderate (97)	High: 3.67
VAMA	Very High (217)	Moderate (122.58)	Moderate (97)	High: 3.67

Table 5. Relative rankings of HOFR and VAMA for Nitrogen Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Summary Risk from nutrient enrichment effect from nitrogen deposition (Sullivan et al. 2011b).

Relative Ranking of Parks to Nutrient Enrichment				
Park	**Avg. of Nitrogen Pollutant Exposure (numerical rank)**	**Avg. of Ecosystem Sensitivity (numerical rank)**	**Avg. of Park Protection (numerical rank)**	**Summary Risk (numerical rank)**
HOFR	Very High (211)	Low (108.5)	Moderate (97)	High (138.83)
VAMA	Very High (203.75)	Very Low (88.5)	Moderate (97)	Moderate (129.75)

Data Gaps and Confidence in Assessment

The NPS ARD has not included ROVA in a NPS-wide trend analysis of wet deposition (NPS 2010) but has interpolated wet deposition values for ROVA based on five year intervals and continues to report these values for ROVA. Confidence in the condition assessment of sulfur and nitrogen wet deposition is high and trend assessment was fair. Natural resource risk assessments for S and N acidification and nutrient enrichment effects from atmospheric nitrogen deposition are an initial step to providing information and identifying park resources that are thought to be sensitive from acidification and enrichment. These assessments should be considered coarse approximations of true risk (Sullivan et al 2011a,b). Confidence in the risk assessments ranking is fair and should increase as scientific knowledge of the factors increases and spatial and temporal data collection efforts improve.

4.1.2 Mercury Deposition

Relevance and Context

Mercury (Hg) occurs naturally in the environment but its distribution is through natural and anthropogenic processes. Incineration of solid waste and fossil fuel combustion facilities contribute 87% of the emission of mercury in the U.S. (U.S. EPA 2001). It has been estimated that New York receives 25% to 49% Hg deposition originating from other U.S. states, verses only 11% to 21% from emissions derived within New York (Seigneur et al. 2003). Mercury is a common constituent in both terrestrial and aquatic ecosystems coming by both wet and dry deposition (Lai et al. 2007). A 1998-2005 trend analysis showed significant declines of mercury wet deposition in the northeastern U.S. (Butler et al. 2007), while dry deposition of mercury was the highest in the Northeast (Driscoll et al. 2007). Total wet deposition of mercury is much higher in the southeastern United States than in the northeastern states (Figure 21). The indirect source of mercury to aquatic and terrestrial systems is through deposition from precipitation. Wet deposition may account for 50-90% of Hg loadings to surface waters (MDN 2008). A seasonal pattern for Hg in precipitation occurs with increased Hg concentration and deposition observed in spring and summer months (Lai et al. 2007). After deposition, ionic Hg may be reemitted to the atmosphere or converted to methylmercury (MeHg) which is a bioavailable form to biota. Additionally, acidic and sulfate deposition influence Hg methylation. Because mercury is a known neurotoxin, its effects have been studied to assess levels of exposure to humans and ecosystems. MeHg has the ability to bioaccumulate in individuals and biomagnify in food chains, thus potentially compromising reproduction, behavior, growth and development in organisms. The EPA is in the process of developing mercury emission standards for power plants and expects a final rule by late 2011.

Mercury can affect mammals, fish, salamanders, birds, plants, invertebrates and microflora in soils, especially in the northeastern U.S. where contamination has been well-documented (Bringmark and Bringmark 2001, Hammerschmidt and Fitzgerald 2005, Ericksen et al. 2003, Bank et al. 2005, Evers et al. 2005, Yates et al. 2005, Hammerschmidt and Fitzgerald 2006, Driscoll et al. 2007, Evers et al. 2007). Environments known to favor the production of methylmercury include forested areas with shallow surfical materials, high elevation forests, and wetlands and waters with low-productivity (Grigal 2003, Miller et al. 2005). Evers (2005) identified several attributes of waters sensitive to mercury, including: high acidity, low acid neutralizing capacity, high sulfate, abundant wetlands, low zooplankton and nutrient levels, and numerous trophic levels in the food chain.

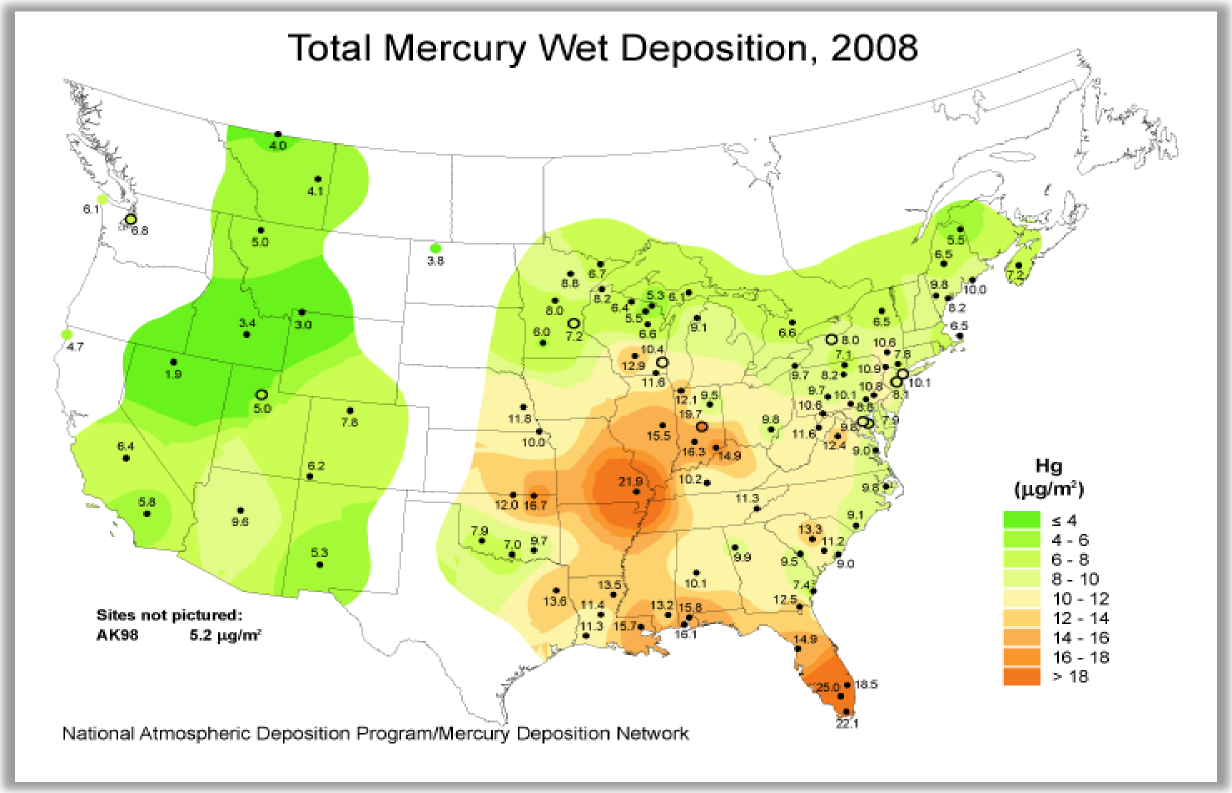


Figure 21. Total wet deposition of mercury in 2008. Source: NADP.

Aquatic systems can accumulate methylmercury more than a million-fold in the aquatic food chain, affecting fish and wetland feeding species (MDN 2008). Wetlands are net sinks for Hg and serve as sources of methylmercury as these waterbodies support bacteria which are responsible for methylation of mercury (Grigal 2003). ROVA contains approximately 23.8 ha (58.9 acres) of freshwater wetlands and numerous wetland habitats that have yet to be delineated. Thus, methylmercury bioaccumulation in these habitats may be a concern for the park's ecosystem health. Although mercury contamination has been extensively studied in aquatic systems, little research has been conducted in terrestrial systems. Grigal (2002) estimated total atmospheric mercury transferred to terrestrial environments in temperate zones is averaged to be four times open precipitation because of Hg additions via throughfall, litterfall, and dropping of leaves that have accumulated atmospheric Hg. Forests may provide conditions where Hg methylation can occur as documented by the relationships between litterfall Hg values and blood Hg values of the Bicknell's thrush (Rimmer et al. 2005).

Sections of New York have been identified as "biological hotspots" for mercury contamination based on mercury blood levels of common loon data (Evers et al. 2007). Studies have shown that songbirds near the Upper Hudson in New York have some of the highest blood Hg levels in the nation (Duron et al. 2009). A study implemented close to ROVA in Millbrook, NY in 2005 found Hg prevalent in terrestrial songbird blood but below Hg levels of negative reproduction (Evers and Duron 2006). Simonin et al. (2009) have found decreases in mercury concentrations in yellow perch studied in Adirondack lakes but still at levels of concern, particularly in large predatory fish. Mercury bioavailability in lakes is dependent on the methylation process and a large variation in this process exists due to the presence of diverse lake types. Due to this variation, determining thresholds for Hg deposition that will affect biota is difficult, but thresholds for fish are being investigated. Although mercury concentrations may be decreasing in certain fish species in New York, the New York Department of Health still establishes advisories for consuming sportfish deemed unsafe for human consumption due to mercury contamination (New York Department of Health 2010). No tributaries within Dutchess County have been listed for mercury consumption advisories (excluding the Hudson River), although several neighboring counties list mercury advisories for their water sources. U.S. EPA, under the Clean Water Act 304(a), has established a fish tissue criterion for human consumption that should not exceed 0.3 MeHg mg/kg (U.S. EPA 2001). Hammerschmidt and Fitzgerald (2006) linked atmospheric mercury deposition with mercury concentrations in fish. Meili et al. (2003) noted 2 ng/L of mercury in precipitation was modeled to 0.5 MeHg mg/kg wet weight in freshwater fish, but this is dependent on watershed dynamics (i.e., humic vs. non-humic waters). Additionally, chemical thresholds to predict Hg in fish have been identified for lakes and include: total phosphorus concentrations < 30 µg/L; pH <6.0; ANC <100 µeq/L; and DOC > 4 mg carbon/L (Driscoll et al. 2007).

Data and Methods

Data was queried from the Mercury Deposition Network (MDN) which included two mercury deposition monitoring stations within close proximity to ROVA. Station NY99 in West Point, NY is located 30 miles (48 km) south of ROVA and began mercury deposition monitoring in 2006. Station NY68 (Biscuit Brook) is located 35 miles (56 km) west of ROVA in Claryville, NY and began collecting mercury deposition data in 2004. Annual mean Hg concentrations (ng/L) were calculated for each station.

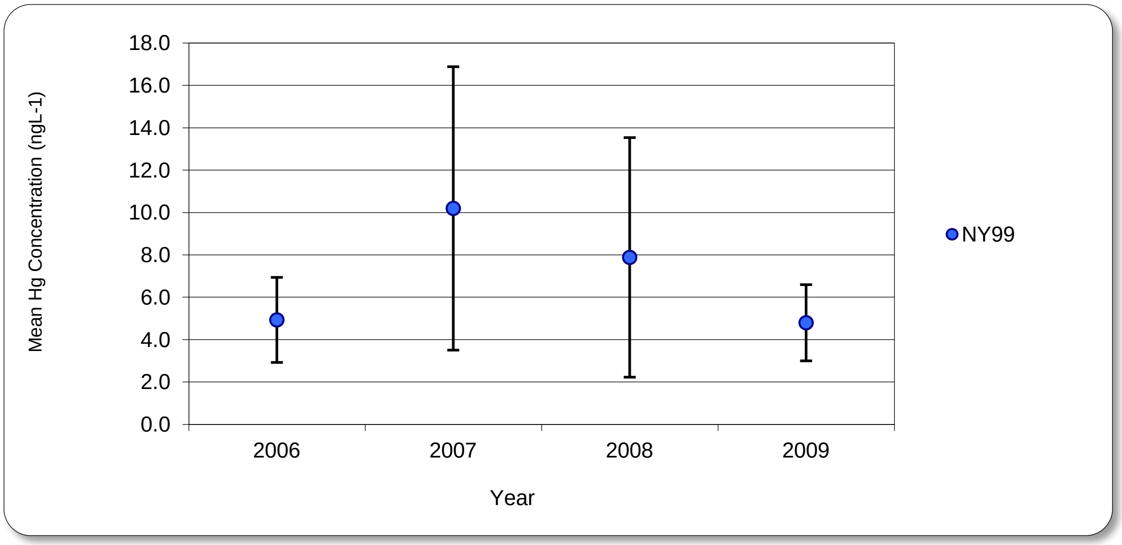
Reference Condition/Threshold Values Utilized

NPS ARD has yet to establish a mercury deposition condition category. Ecological data representing modeled Hg levels by Meili et al (2003) suggested that 2 ng/L of mercury in precipitation was modeled to 0.5 MeHg mg/kg wet weight in freshwater fish and the U.S. EPA, , has established a fish tissue criterion for human consumption that should not exceed 0.3 MeHg mg/kg (U.S. EPA 2001).

Condition and Trend

At this time, the NPS is currently working on guidance for mercury that would include condition categories (per communication, Holly Salazer, NPS air resources coordinator for NE region). Annual mean Hg concentrations from data collected at monitoring stations near ROVA are above a 2 ng/L threshold established by Meili et la. (2003) and had 0% attainment (Figure 22).

Trend analyses for mercury deposition for ROVA were not reported due to the lack of long term data for the two MDN stations closest to ROVA (year of establishment were 2004 and 2006). Butler et al. (2007) found a significant decline in mercury wet deposition from 1985-2005 based on a regional analysis in the northeastern U.S.



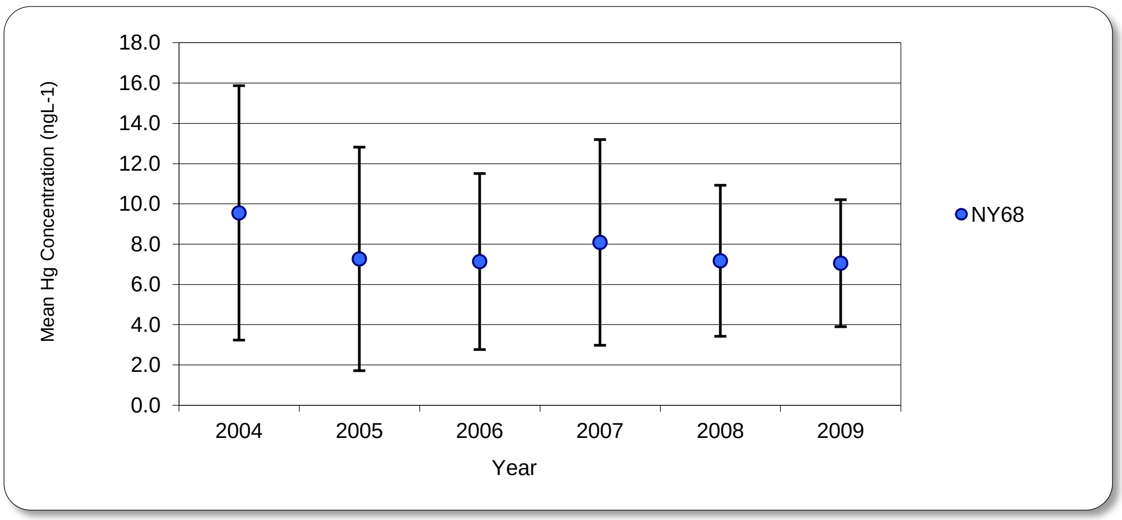


Figure 22. Mean atmospheric concentration of mercury recorded from 2004-2009 at stations NY99 and NY 68. Bars represent standard deviation. NPS ARD has not established a condition category for Hg deposition although mean Hg concentrations (ng/L) are greater than the 2 ng/L level modeled by Meili et al (2003) for fish Hg concentrations.

Data Gaps and Confidence in Assessment

A condition category was not established for ROVA due to lack of scientific threshold data for mercury deposition for several types of ecological systems. Although a 2 ng/L of mercury in rainfall has been identified by Meili et al. (2003), this threshold does not necessarily apply to all watershed types. Trend analysis was not conducted due to temporal limitations of data from MDN stations near ROVA. Confidence in the condition assessment of mercury deposition was limited and trend assessment was limited.

4.1.3 Ozone

Relevance and Context

Ozone is an important air quality indicator and one that is monitored extensively throughout the northeastern U.S. (Figure 23). National Ambient Air Quality Standards (NAAQS) indicate that for ozone "…the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitoring station within an area over each year must not exceed 0.075 ppm." New research has shown that the effects of lower ozone concentrations than the federal standards still lead to negative human health as well as ecosystem damages (U.S. EPA 2009). The U.S. EPA has recently proposed a change in the air quality standards for ozone. To date, the standards rely upon an 8-hour average of ozone concentration at 0.075 ppm. The recommended change is to between 0.060-0.070 ppm to protect children and other "at risk" populations. Furthermore, the EPA has recommended changing the secondary standard (also currently 0.075 ppm) to "…W126, a measure that preferentially weights the higher ozone concentrations most likely to affect plants and sums all weighted concentrations during daylight hours over three months during the growing season. This is a cumulative metric expressed in ppm-hours. EPA proposes setting a value for the secondary standard within the range of 7–15 ppm-hours" (NPS Air Resources Division letter to EPA).

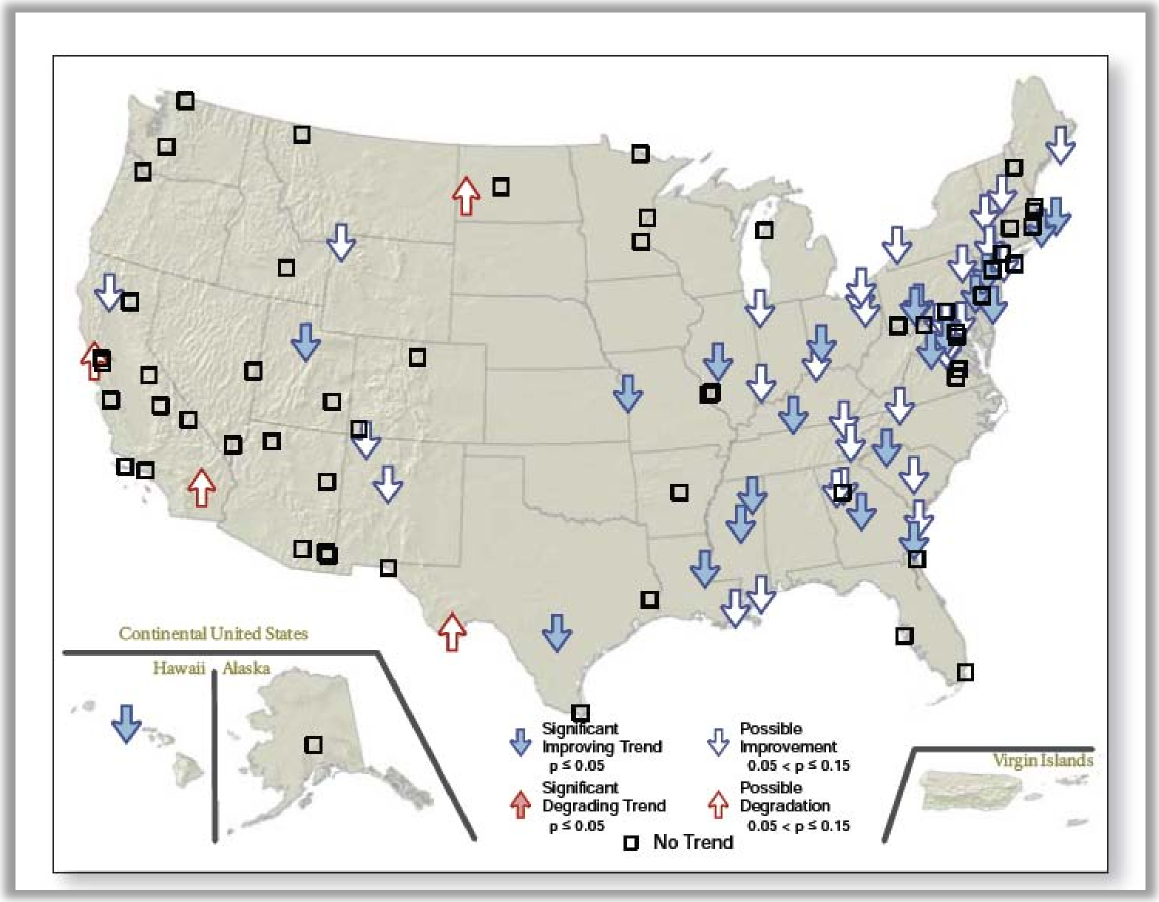


Figure 23. Trends for ozone concentrations from 1999-2008 based on annual 4th highest 8-hour concentrations (From NPS ARD 2010).

Ground level ozone is created by the presence of sunlight and chemical reactions between volatile organic compounds (VOCs) and oxides from nitrogen. These chemicals are primarily emitted from motor vehicle exhaust, industrial emissions, and chemical solvents (U.S. EPA 2006). ROVA is located in an ozone nonattainment area (Dutchess County), indicating that ozone levels exceed the EPA NAAQS for human health. High concentrations of ozone lead to inflammation and irritation of the respiratory tract, such as throat irritation, breathing difficulties, and coughing. State or local environmental agencies are responsible for implementing measures to reduce ozone levels in nonattainment areas.

The ecological effects of ozone levels include its contribution to foliar injury in specific plant species (Skelly 2000, Kohut 2007, Kline 2008). Plants can serve as bioindicators for high ozone levels and ROVA contains approximately 18 of 40 plants which are sensitive to ozone and also serve as bioindicators for foliar injury (see Appendix E). Foliar injury to vegetation located on federal lands has been assessed and as a result, a handbook on identifying and assessing foliar injury to plants on federal lands has been created (Kohut 2005).

A qualitative risk assessment of ROVA which used the presence of sensitive plant species to ozone in conjunction with ozone exposure data resulted in ROVA receiving a high risk rating due to ROVA's exposure to high ozone levels and soil moisture levels conducive to ozone uptake (Kohut 2007). Ozone levels were assessed for ROVA by the NPS Air Resources Division (ARD) using monitored and kriged data for SUM06, W126, and N-values exposure indices (NPS 2004a). Soil moisture status was assessed using the Palmer Z Index since low soil moisture levels can reduce the uptake of ozone through the stomates, thereby reducing the injury to plants in higher ozone exposure periods (Grulke et al. 2003, Matyssek et al. 2006).

Data and Methods

The evaluation of condition and trends for ozone levels was based on data collected from monitoring stations nearest to ROVA, in conjunction with using NPS ARD data and their established condition categories for assessing ozone. The most recent interpolated ozone data was collected from 2005-2009. Ozone data were collected and interpolated by NPS ARD from stations within the U.S., with the closest ozone station located in Millbrook, NY, 15 miles (24 km) east of the park (EPA AQS site ID 360270007). Using annual fourth-highest daily maximum eight hour ozone concentration, five year average values were calculated using interpolated values derived from all available monitoring data from NPS ARD (NPS 2010). Trend assessments is based on NPS ARD regional data from 1999-2008 (NPS 2010).

Reference Condition/Threshold Values Utilized

NPS ARD has established the following condition categories for ozone based on regulatory and ecological data and are used in condition assessment for ROVA:

"To derive an estimate of the current ozone condition at parks, the five-year average of the annual 4th-highest 8-hour ozone concentration is determined for each park from the interpolated values... If the resulting five-year average is greater than or equal to 76 ppb then the condition Significant Concern is assigned to that park. Moderate condition for ozone is assigned to parks with average five-year 4th-highest 8-hour ozone concentrations from 61 to 75 ppb (concentrations greater than 80 percent of the standard). Good condition for ozone is assigned to parks with average five-year ozone concentrations less than 61 ppb (concentrations less than 80 percent of the standard)." (NPS 2010).

Condition and Trend

Interpolated ozone values for ROVA for2005-2009 were 78.4 ppb (HOFR) and 78.1 ppb (VAMA). These values do not meet a regulatory threshold of 75 ppb. Based on NPS ARD condition categories of *good, moderate* and *significant concern*, ROVA's air quality for ozone is considered a *significant concern*, as it is ≥76 ppb for both HOFR and VAMA, well above the *good* condition level of ≤60 ppb (0% attainment). Five year interpolation values calculated since 1995 by NPS ARD for ozone have consistently been assessed as being *significant concern* (Table 6, NPS ARD 2010).

Trend assessment of ozone levels for national parks throughout the U.S. from 1999-2008 resulted in no significant trend (p=0.11). Several other eastern parks showed no significant trend in ozone levels during this time period (Figure 23. NPS 2010).

Table 6. NPS Air Resources Division 5-Year Interpolated Ozone Values for ROVA. Park subunit values were reported when available (www.nature.nps.gov/air).

Parameter	NPR ARD Threshold		ROVA 5-Year ARD Values					
	Condition	Value	1995-1999	1999-2003	2001-2005	2003-2007	2004-2008	2005-2009
Ozone (ppb)	Good	≤60			87.50 (HOFR)	81.53 (HOFR)	82.9 (HOFR)	78.4 (HOFR)
	Moderate	61-75	90.3 (ROVA)	88.1 (ROVA)	87.50 (ELRO)	81.23 (VAMA)	82.6 (VAMA)	78.1 (VAMA)
	Significant Concern	≥76			87.22 (VAMA)			

Data Gaps and Confidence in Assessment

Confidence in the current assessment was high and the assessment of trend was high. ROVA is lacking in field assessment documentation of foliar injury due to high ozone, although a plant bioindicator list for foliar ozone damage is available for ROVA (Appendix E, Kohut 2005).

4.1.4 Visibility

Relevance and Context

Haze degrades scenic visibility in many national parks due to the interaction of sunlight and tiny pollution particles (i.e., sulfates, nitrates, soot) in the air, causing discoloration and loss of visual range. Recognizing the importance of visibility, the U.S. federal government approved the Clean Air Act (1977) to include visibility as an indicator of emissions and air quality. This type of atmospheric impairment which is commonly caused by human-induced activities (e.g., industrial emissions) vs. natural occurrences (e.g., fire), has resulted in the monitoring of visibility at a number of national parks and wilderness areas, specifically Class I areas (Figure 24). The monitoring of visibility at these parks was implemented with the aid of the IMPROVE (Interagency Monitoring of Protected Visual Environments) program which tracks changes in visibility and determines causal mechanisms to impairment. Based on monitoring data, ROVA's region averaged a visibility distance of 80 km (49 miles) versus western U.S. based national parks that average up to 175 km (108 miles) based on 2005-2007 visibility data (NPS ARD 2010).

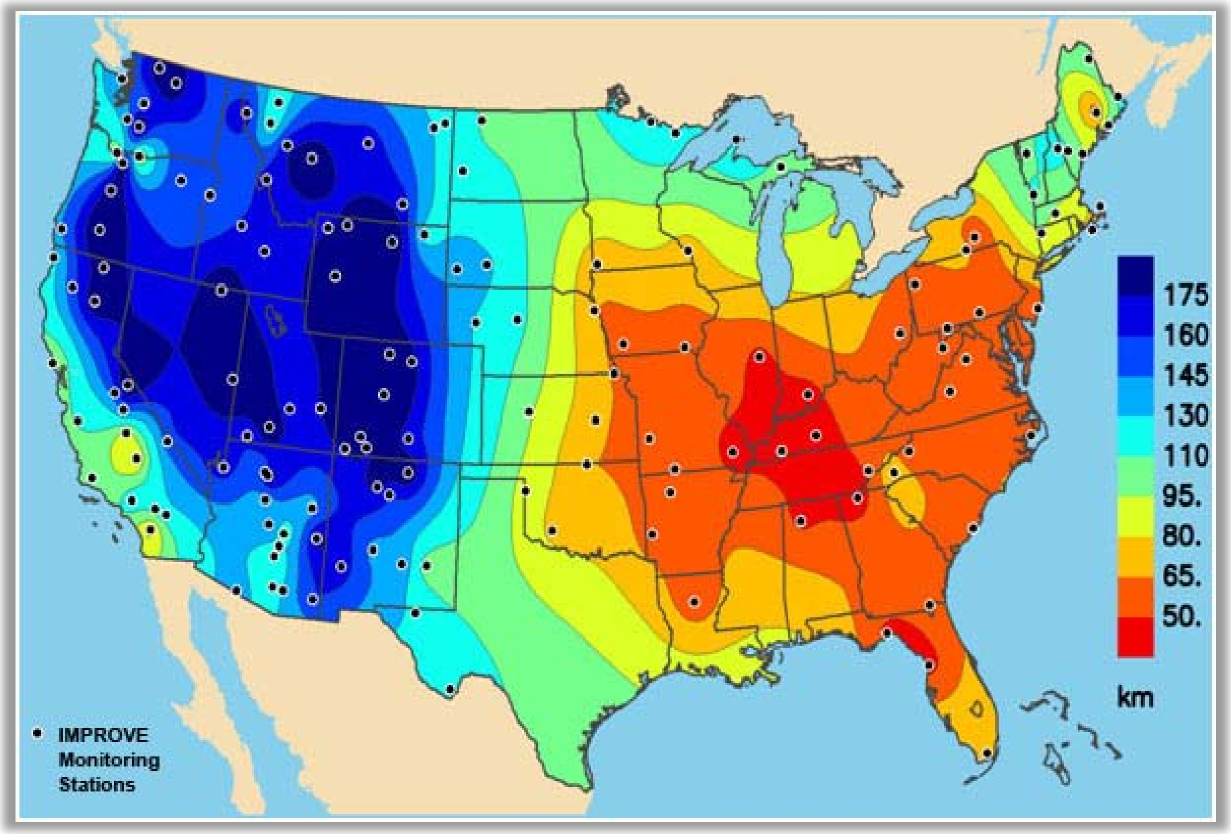


Figure 24. Location of IMPROVE monitoring stations within the U.S. and the annual average visual range (in kilometers) based on data collected from 2005-2007. ROVA is estimated to have a visual range of 80 km. From NPS Air Resources Division. www.nature.nps.gov/air/monitoring/vismonresults.cfm.

Data and Methods

The evaluation of condition and trends for visibility was based on data collected from monitoring stations closest to ROVA, in conjunction with using NPS ARD data and their established condition categories for assessing visibility (Table 7). The closest IMPROVE site to ROVA was identified as Mohawk Mountain (MOMO1, EPA station ID 090050005), located 30 miles (48 km) east of the park in Connecticut. The most recent NPS ARD interpolated visibility measures for ROVA using 5-year average values were from 2005-2009. NPS ARD visibility measures were presented as a haze index in deciviews (dv), which indicated that the difference between current group 50 (mean of the 40th-60th percentile data) visibility and the natural group 50 visibility (estimated visibility in the absence of human caused visibility impairment) (NPS 2010).

Trend assessment was created on a regional scale based on ten-year trends calculated by NPS ARD from 1999-2008 (NPS 2010).

Table 7. NPS Air Resources Division 5-Year Interpolated Visibility Values for ROVA. Park subunit values were reported when available (www.nature.nps.gov/air).

Parameter	NPR ARD Threshold		ROVA 5-Year ARD Values				
	Condition	Value	1995-1999	1999-2003	2001-2005	2003-2007	2005-2009
Visibility (dv) [Current group 50-Est. Group 50 natural]	Good	<2			7.56 (HOFR)	10.25 (HOFR)	9.0 (HOFR)
	Moderate	2-8			7.56 (ELRO)	9.93 (VAMA)	8.8 (VAMA)
	Significant Concern	>8			7.50 (VAMA)		

Reference Condition/Threshold Values Utilized

Reference visibility levels are regulatory estimates based on natural background conditions for Class I parks and wilderness areas. A reference visibility condition category of *good* has been established by NPS ARD of ≤2 (dv). NPS ARD has established the following categories for assessing visibility condition and was used in the condition assessment for ROVA:

The visibility condition is expressed as:
Visibility Condition = current Group 50 visibility – estimated Group 50 visibility under natural conditions*. Good condition is assigned to parks with a visibility condition estimate of less than two dv above estimated natural conditions. Parks with visibility condition estimates ranging two to eight dv above natural conditions are considered to be in Moderate condition and parks with visibility condition estimates greater than eight dv above natural conditions are considered to have a Significant Concern. The dv ranges of these categories, while somewhat subjective, were chosen to reflect as nearly as possible the variation in visibility conditions across the monitoring network* (NPS 2010).

Condition and Trend

Interpolated visibility values for ROVA for 2005-2009 were 9.0 dv (HOFR) and 8.8 dv (VAMA). Based on NPS ARD condition categories of *good*, *moderate* and *significant concern*, ROVA's air quality for visibility is considered a *significant concern*, as it is ≥8 dv for both HOFR and VAMA, well above the *good* condition level of <2 dv (0% attainment) (Table 7, NPS ARD 2010).

Trend assessment of visibility data based on the haziest days for national parks within the U.S. from 1999-2008 resulted in many eastern U.S. parks showing 'no significant trend' or 'possible improvement'. A few areas south of New York did have a statistically significant improving trend for visibility measures ($p<0.05$) (NPS ARD 2010).

Data Gaps and Confidence in Assessment

Visibility trend analyses for ROVA are not yet available from the NPS ARD's nation-wide trend calculations. Confidence in the current assessment of condition was high and the current assessment of trend was fair.

4.2 Water Quantity

Updated estimates of water resources within ROVA include 17.4 km (10.8 mi) of streams, 4.32 ha (10.68 acres) of ponds and 23.83 ha (58.9 acres) of wetlands (NWI) (per communication, D. Hayes [NPS] February 3, 2012). In HOFR, a perennial stream enters from Morgan Ice Pond and empties into a freshwater tidal cove along the Hudson River and Maritje Kill flows through a forested region (Figure 25). Two intermittent streams located in the northern section of ROVA total about 1.6 km (1 mi) (USDI 2010). In the southwest boundary is a 10.1 ha freshwater tidal marsh owned by the State of NY and under NPS stewardship. Within ELRO, Fall Kill is the largest perennial stream. It originates 11 km (7 mi) north of the park, travels less than a mile within ELRO, and then enters the Hudson at Poughkeepsie, more than 9.6 km (6 mi) to the south (NPS 1997). There are numerous ponds within ELRO, both permanent and temporary. The most famous are the Upper and Lower Val-Kill ponds, both formed by dams. At VAMA, two perennial streams move through the park: Crum Elbow and Bard Rock creeks. Crum Elbow Creek originates more than 21.4 km (13 mi) outside of the park, while Bard Rock Creek (2.4 km, 1.5 mi total length) originates in the Town of Hyde Park, just beyond VAMA's boundaries (NPS 1997, USDI 2010). Three ponds can be found in VAMA, each formed by a dam on Crum Elbow Creek and small, non-tidal marshes and a non-tidal freshwater swamp are located along the western boundary of VAMA.

All three park subunits have impounded areas in the aquatic habitats, built as concrete structures, earthen dams or beaver dams (Figure 26). Many of the impoundments serve as historical cultural landscape features to the park and have formed associated pond and wetlands areas which serve as habitat for various plant and animal species. However, the damming of the streams has contributed to the alteration of water quantity, quality and habitat structure from siltation, sedimentation and plant growth. HOFR contains a 4 m (13.1 ft) impoundment on the Roosevelt Ice Pond, which historically served as ice production and swimming for the estate. ELRO includes the Upper and Lower Val-Kill impoundments, which contains concrete dams built in 1925 and 1960 across the Fall Kill which historically was used for recreation by the Roosevelt family. ELRO also contains beaver dams in the southern section of the park on Fall Kill. VAMA retains four impoundments on Crum Elbow Creek on three ponds-Upper (White Bridge) Pond, Middle (Powerhouse) Pond and Lower (Lower Dam) Pond, with sedimentation noted in all three ponds (NPS 1997).

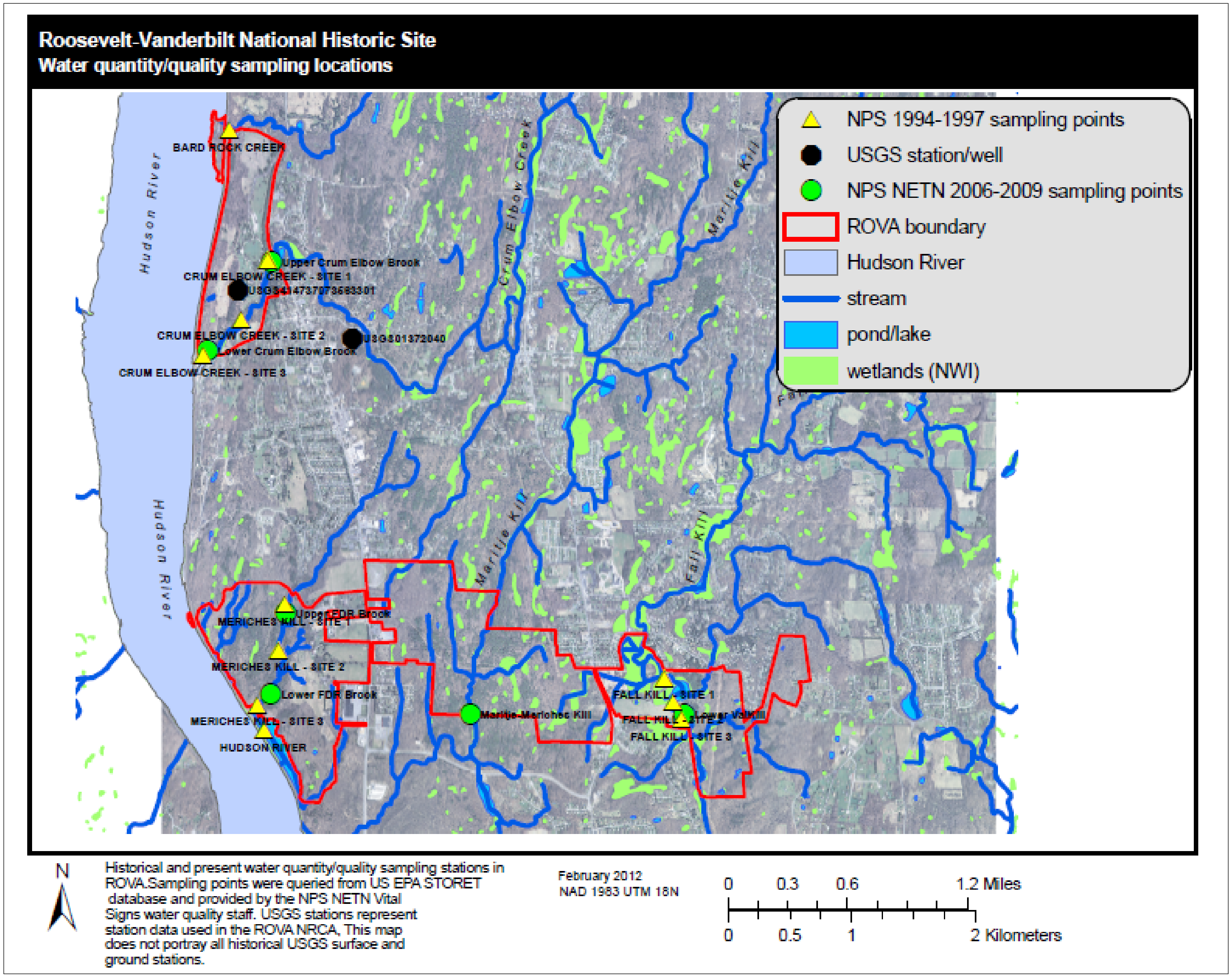


Figure 25. Water resources and surface water sampling locations used in ROVA's NRCA.

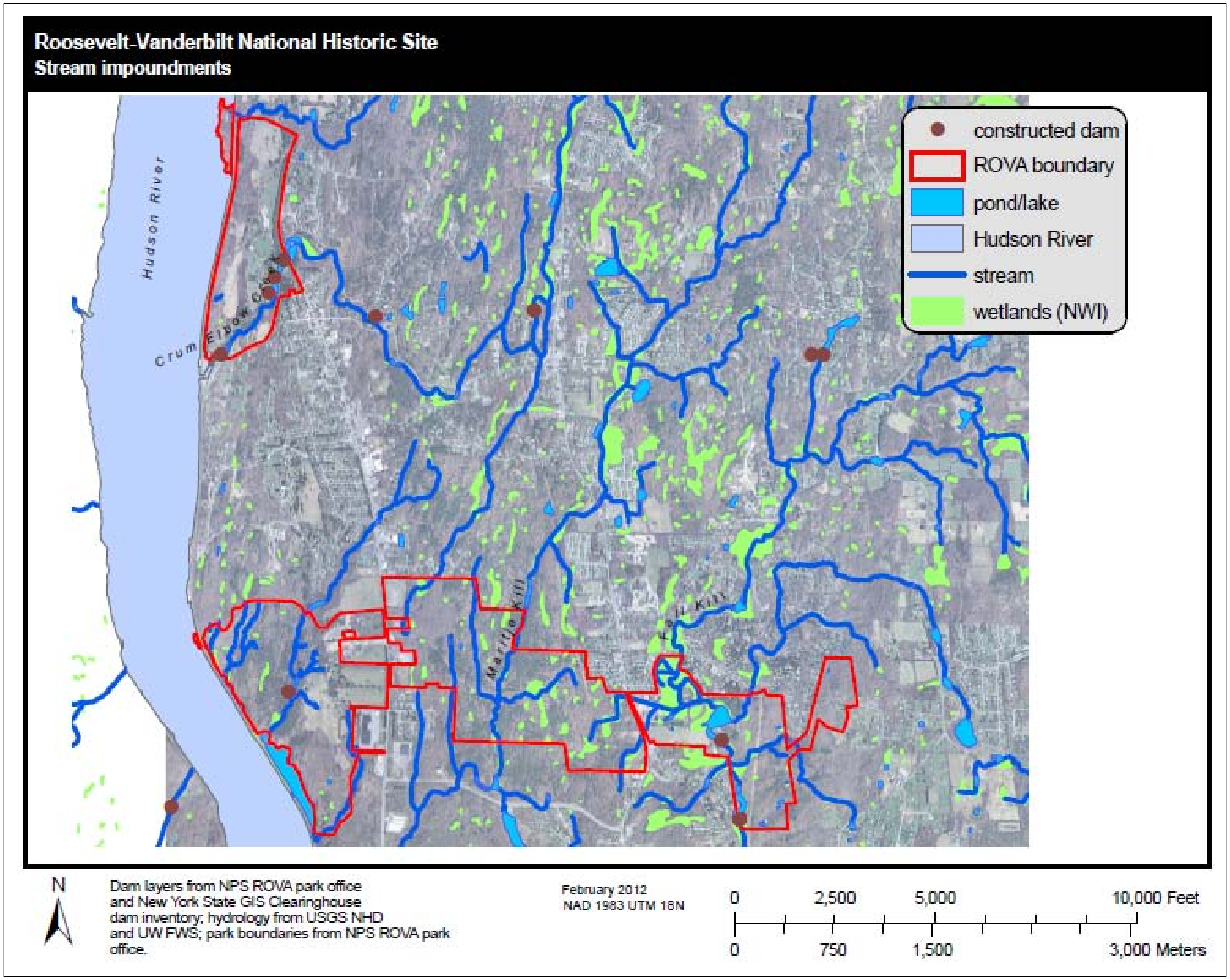
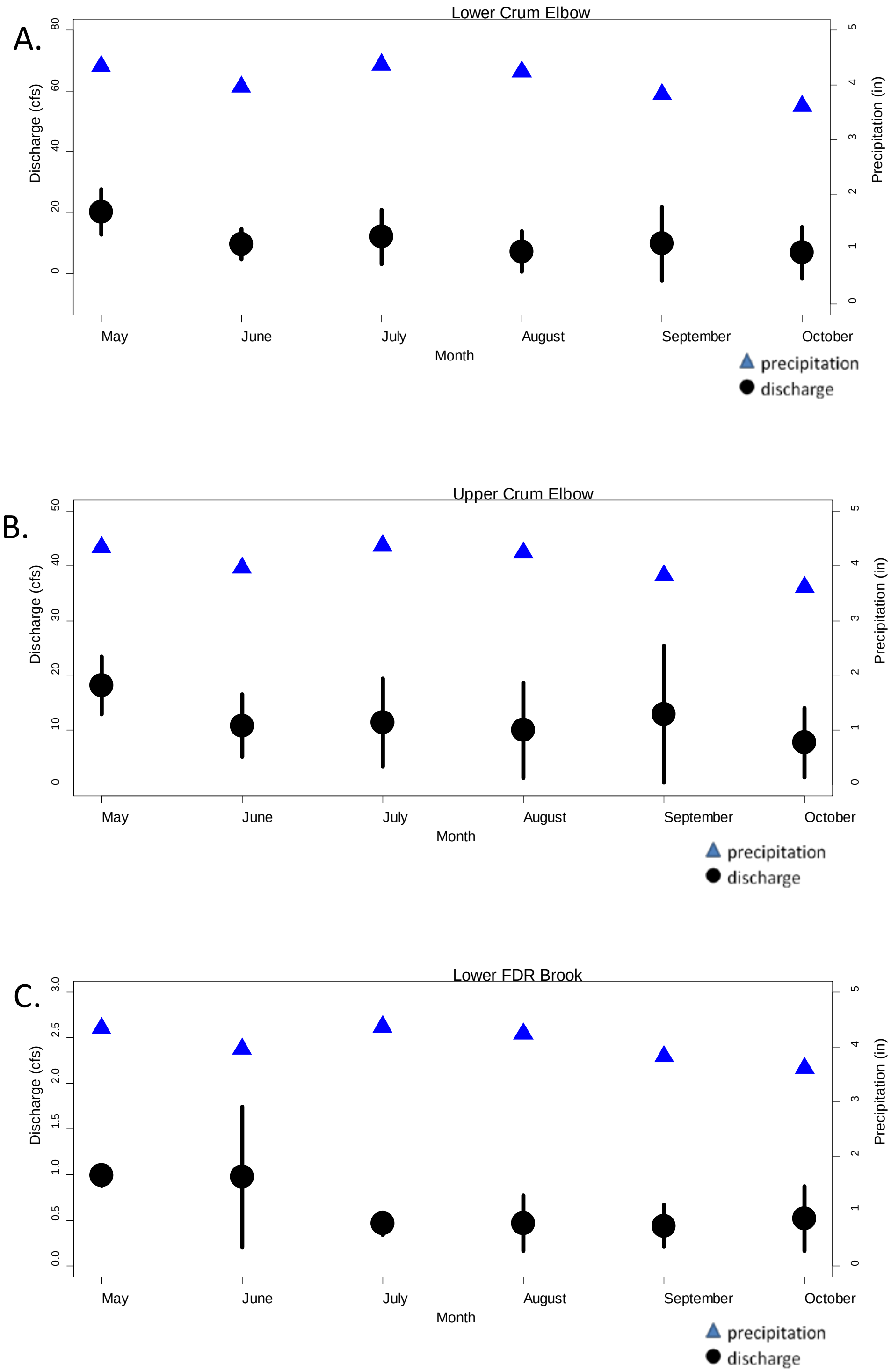


Figure 26. Impoundments located within and surrounding ROVA.

Factors that may impact water quantity in ROVA include increases in water demand from densely populated areas surrounding ROVA, changes in watershed characteristics that might influence storm runoff patterns, dam and diversion construction, and annual climate changes which influence the hydrologic cycle (i.e., drought, flooding cycles). Climate is a primary driver of hydrology, as precipitation affects the quantity of water moving through the system and temperature affects the timing and rate of snowmelt, which is a strong factor in ROVA's hydrology in the early spring months (Figure 27). Anthropogenic activities can influence the variability of water quantity in response to weather and climate conditions. Research regarding water quantity responses to projected future changes in climate has found that earlier snowmelt and diminishing snow pack is advancing the timing and reducing the magnitude of peak stream discharge associated with snowmelt (Campbell et al 2011). Past increases in precipitation have caused annual water yield to increase significantly and this trend it is expected to continue under continued climate change, but it is also predicted that evapotranspiration predictions will offset the increase in precipitation (Campbell et al. 2011).

Dutchess County's ground and surface water withdrawals (Mgal/d) have been estimated from 1985-2005 by USGS, in cooperation with State and local agencies (USGS, http://water.usgs.gov/watuse/). Total surface water withdrawals from 1985-2005 were greater than total ground water withdrawals (excluding 2000 data), with 2005 total freshwater withdrawal rates approximated at 39 Mgal/d (55% surface water vs. 45% ground water withdrawal) (Figure 28). Water withdrawal amounts are based on water consumption activity, with public supply and domestic use withdrawals the greatest fresh water consumption uses in the county. Aquaculture and irrigation withdrawal rates increased from1985-2005 in Dutchess County (Figure 28).


A.
Lower Crum Elbow
Discharge (cfs)
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precipitation
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B.
Upper Crum Elbow
Discharge (cfs)
Precipitation (in)
May
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August
September
October
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precipitation
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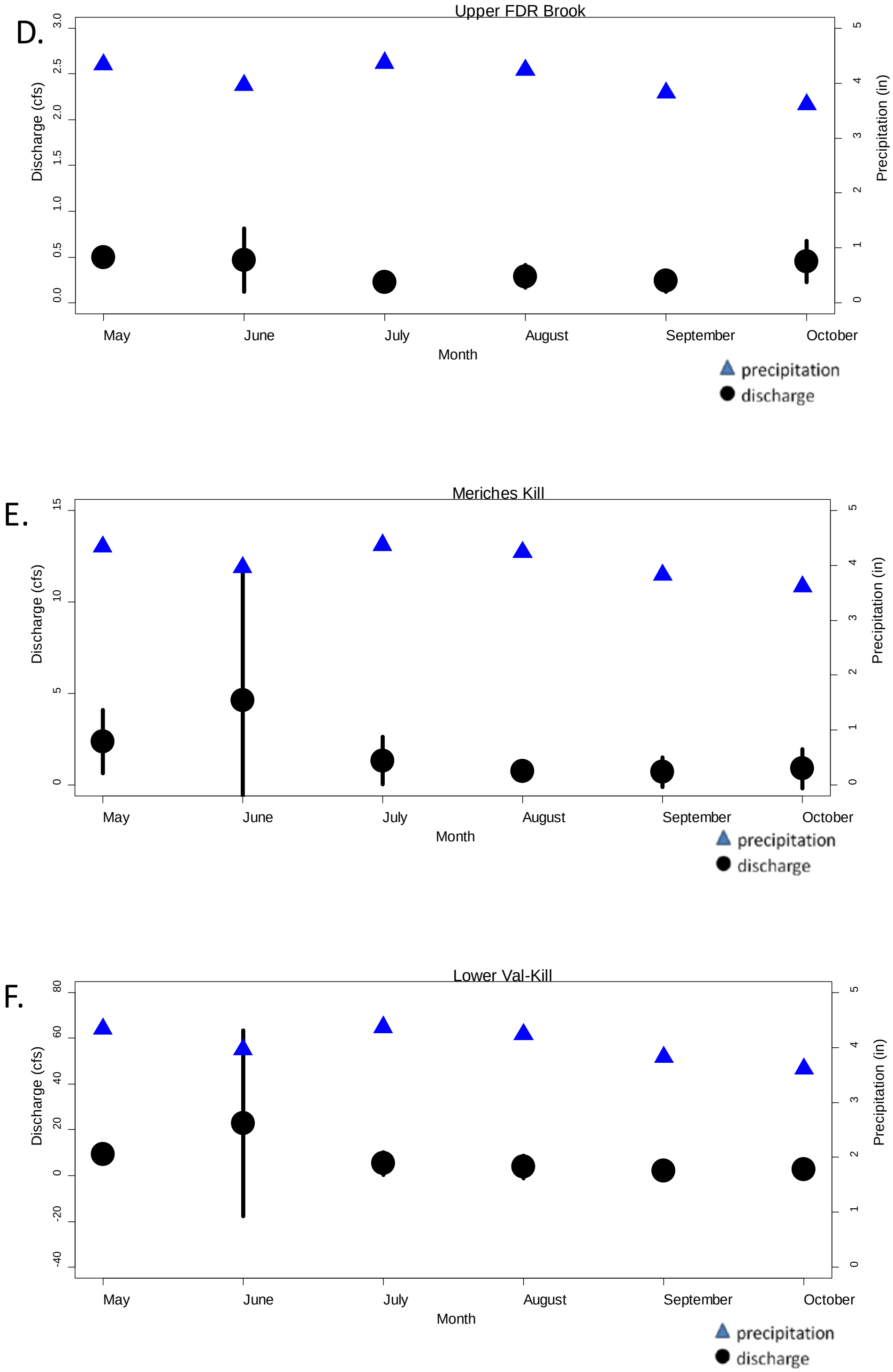
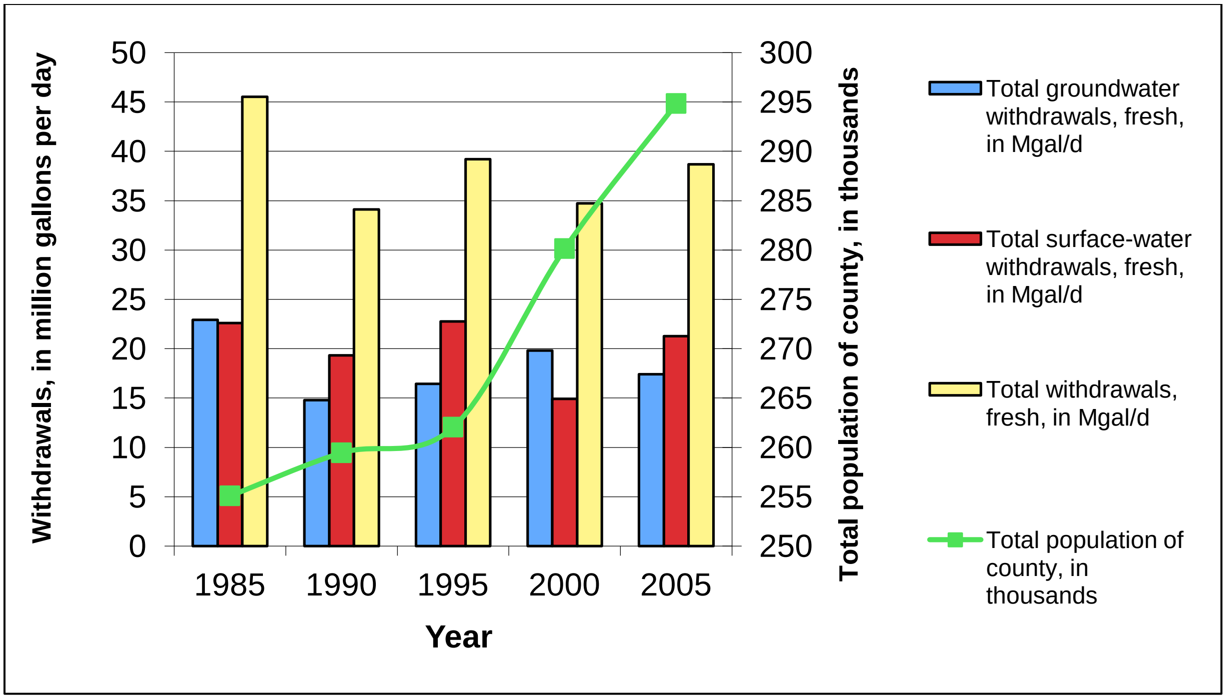


Figure 27 (A-F). Mean discharge measurements (cfs) (closed circles) recorded from six stream sites in ROVA from May through October, 2006-2009. Error bars represent ±1standard deviation. Mean monthly precipitation values (inches) (triangle) represent long term precipitation data records collected at three COOP weather stations near ROVA (NOAA NCDC 1970-2000).



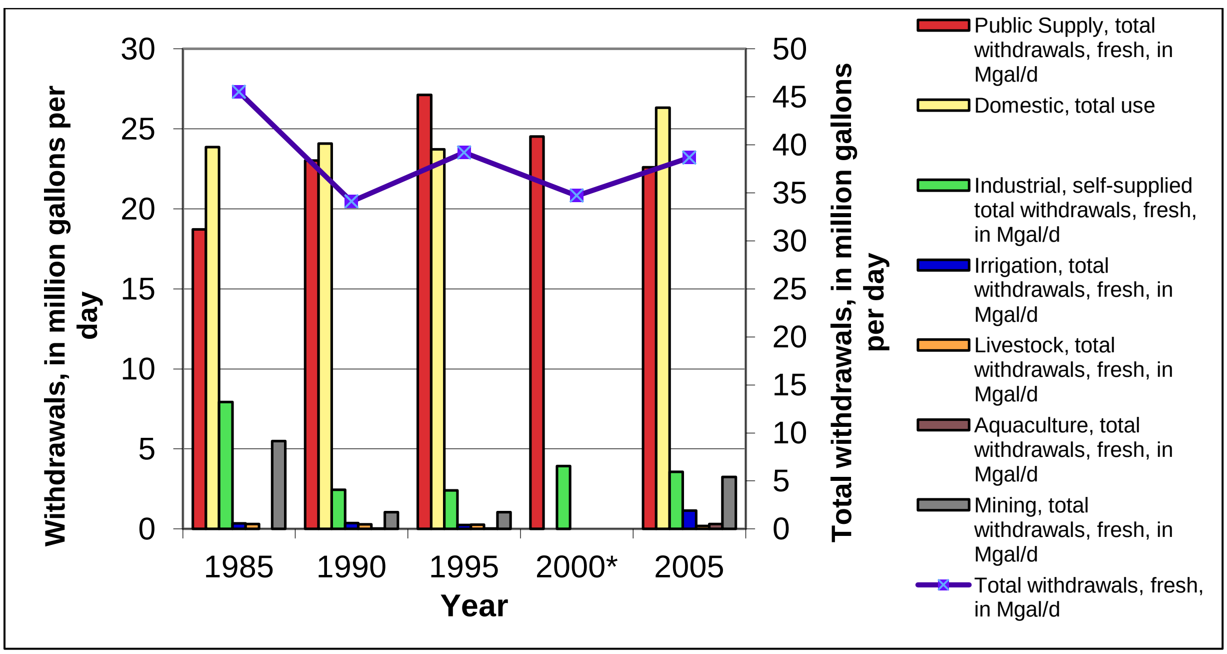


Figure 28. Total surface and ground water withdrawal quantities (Mgal/day) (top) and water withdrawal allocation by use (bottom) for Dutchess County, NY from 1985-2005. *Withdrawal allocation values not fully reported in 2000 (data source: USGS).

4.2.1 Stream Surface Water Quantity

Relevance and Context

Low flows can lead to high water temperatures, inadequate dissolved oxygen levels, and restrictions on movements of fish and other aquatic organisms. Water quantity can limit ROVA fish production due to reduced fish passage, spawning habitat, and rearing habitat. For instance, the American eel (*Anguilla rostrata*) has been inventoried in HOFR, VAMA, and ELRO streams by Schmidt (1995) and NPS (per communication, D. Hayes) and documented in Crum Elbow Creek by NYSDEC (2010b). Documentation of these species does occur unintentionally, as was the case in 1989 when an eel was captured in a turtle trap placed in Fall Kill within ELRO (per communication, D. Hayes [NPS] February 3, 2012). Populations of American eels have been declining for several reasons, including loss of habitat and upstream restriction due to small dams (Haro et al. 2000). Wiley et al. (2004) found that higher densities of eels occurred at sites with a greater velocity/depth diversity habitat at which the following four habitats were present: slow-deep (<0.3 m/s, >0.5 m), slow-shallow (<0.3 m/s, <0.5 m), fast-deep (>0.3 m/s, >0.5 m), fast-shallow (>0.3 m/s, <0.5 m). Water quantity variables most useful for identifying changes in aquatic communities have been modeled and suggested as tools for water quantity assessments. A study by Carlisle et al. (2011) identified that diminished flow magnitude models can be used as a general predictor of biological integrity for fish and macroinvertebrate communities, as streams with diminished flow magnitudes tend to increase common fish and macroinvertebrate taxa that possess trait characteristic of lentic habitats. However, the authors noted that streamflow alteration and complete understanding of its ecological consequences remain unresolved to due to a lack of basic accounting and a quantitative understanding of relationships between ecological integrity and stream flow alterations. Efforts to establish minimal environmental flows have resulted in procedures to determine how much water must be left in a specific channel to ensure good habitat value and ecological functioning. New York has not established minimal environmental flows to date, although research is being pursued to establish scientific information that will inform flow recommendations for the State (NY Coop News 2010).

Data and Methods

Data from stream discharge measurements (n=6 stream locations, 2006-2009) in ROVA from NETN Vital Signs monitoring were used for assessing ROVA's surface water quantity. Average stream discharge and variability for ROVA streams was analyzed by month (May through October) to account for seasonality and compared to historical discharge data if available for individual streams along with precipitation data collected by NOAA. Information on human population dynamics surrounding ROVA, data from Dutchess County water consumption use from 1985-2005, and peer-reviewed research on biotic water quantity requirements were also used to supplement the condition assessment of ROVA's water quantity.

Reference Condition/Threshold Values Utilized

A threshold value could not be established for surface water quantity in ROVA. Although the New York State Section 703.2 flow regulations cites, "no alteration that will impair the waters for their best usages" the scarcity of long-term gauging records for hydrologic parameters within ROVA is a limiting factor for assessing stream water quantity condition for the park as well as the lack of routine biological monitoring data for ROVA streams. No USGS Survey Hydro-Climatic Data Network stations are located within ROVA boundaries to monitor surface waters. The closest station, and the one most representative of streamflow conditions to ROVA streams, is located at Wappinger Creek in Wappingers Falls, NY, approximately 15 miles south of ROVA (NPS 1997). Limited historical data were available for the Crum Elbow Creek stream gauge (USGS 01372040) where daily discharge values were measured from October 1960-April 1962 at this station. Although this does not represent the full range of natural variability for Crum Elbow Creek, this data, which was collected within park boundaries, was the only available reference to provide comparisons to recent measurements for this stream. However, hydrographs of short gauging records are undermined by uncertainty and generally yield little value for analyses.

Condition and Trend

ROVA's surface water quantity condition was rated *unknown*. The hydrological record for ROVA streams was insufficient to assess the condition or document any statistical trends for water quantity variables. Stream discharge declined after May in most of ROVA streams due to decreased snow melt and rainfall (Figure 27). This corresponded to both Wappinger Creek's discharge pattern of declining discharge in early spring (NPS 1997) and Crum Elbow Creek data from the early 1960's (Figure 29). However, these temporal snow melt patterns may change based on projected climate changes (Campbell et al. 2011). Increasing summer temperatures related to periods of low stream quantity is when competition for water is greatest for public supply, agricultural and domestic needs and may not be sufficient for supporting the future needs of ROVA. The ROVA General Management Plan (2010) stated that there were no known flow reductions by upstream land owners. Currently, housing density surrounding ROVA averages 495-1234 units/sqkm and by 2030, areas surrounding ROVA are projected to contain expansive housing densities between 1235-2470 units/sqkm (Svancara et al. 2009), thus increasing pressure on ground and surface water quantity for consumption uses and threatening biological integrity.

The biotic communities of ROVA's streams may also experience stress from water quantity fluctuations or the impediment from historical dams/barriers in ROVA (O'Reilly et al. 2009). ROVA contains habitat for declining American eel populations (Haro et al. 2000, Schmidt 1995, NYSDEC 2010) and the presence of the four preferred velocity/depth profiles that support high American eel densities is unknown for ROVA streams. This lack of data is due to the absence of multiple spatial and temporal water quantity measurements that are needed for velocity/depth profiles.

Based on high consumption demands for water during low water quantity periods (e.g., summer months) (Figure 28), increasing human populations near ROVA, the annual and seasonal variability of stream measurements (Figure 27) and aquatic biota water quantity requirements, the continuation of monitoring efforts in ROVA will be critical in explaining the flow regimes of ROVA's streams and determining future water management strategies for the park.

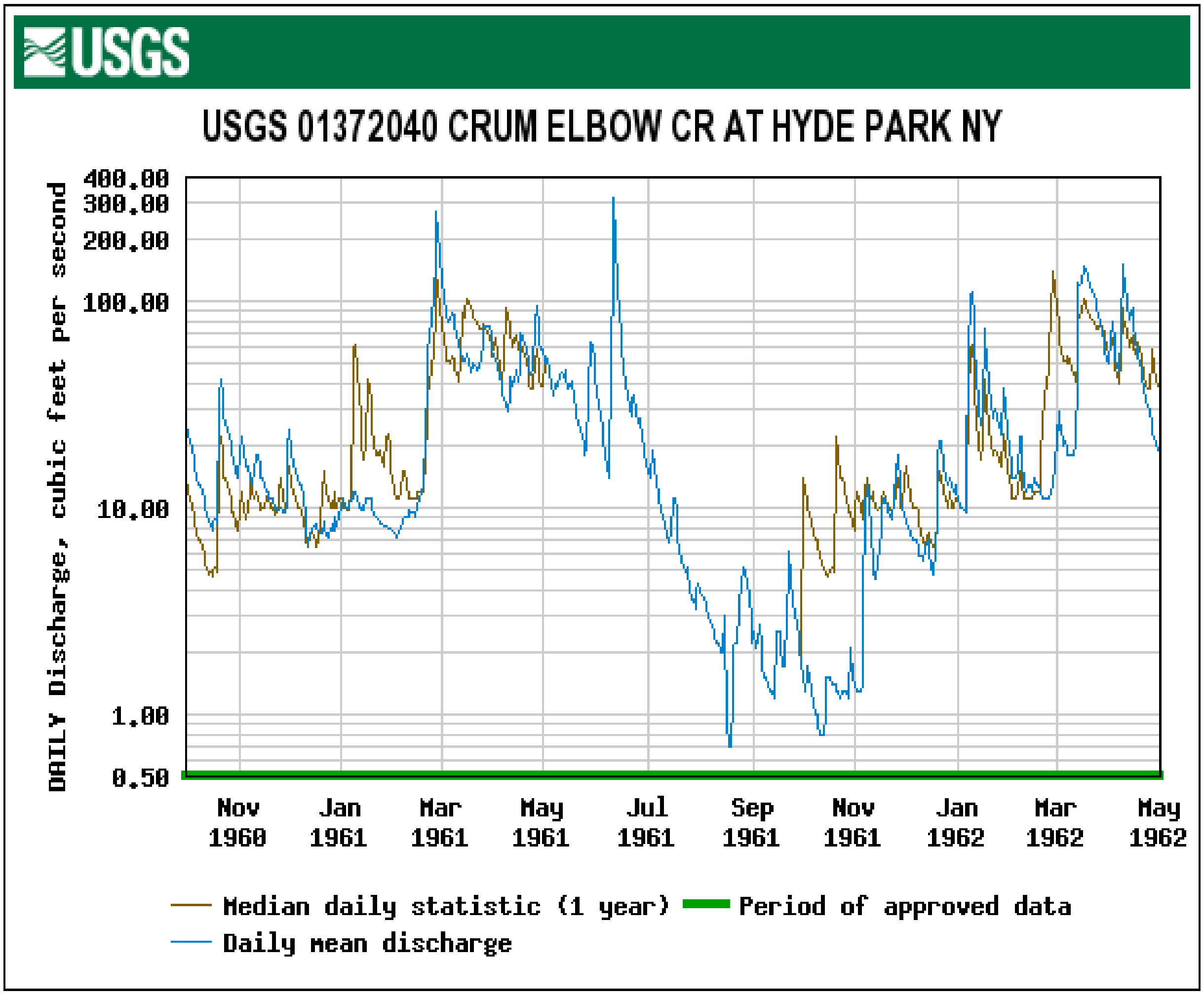


Figure 29. Daily discharge measurements (cfs) recorded at USGS surface water station 01372040 Crum Elbow Creek at Hyde Park NY from Oct. 1960 through station termination date of April 1962 (N=577).

Data Gaps and Confidence in Assessment

Confidence in the condition assessment of stream surface water quantity was limited and trend assessment was limited. The current lack of water quantity measurements and sufficient data quality hinders analyzing hydrologic data for ROVA's surface water. Part of this deficiency of data is due to the infancy of the NETN Vital Signs Program and a lack of historical baseflow data. It is important to note that studies investigating changes in streamflow usually use multiple decades of data to determine reference levels and trends (Stewart et al. 2005). The long-term collection of baseline stream flow and storm flow data are important variables in identifying critical minimum baseflow needs for stream flow preservation and assessing how anthropogenic activities are influencing surface and ground water quantities which in turn, may affect biological community composition. The determination of stream quantity needs or identifying a stream quantity threshold for ROVA should consider the management objectives for ROVA' s surface waters (i.e., to maintain fish and macroinvertebrate communities, conserve a threatened species, recreational value, cultural restoration), and identify what ROVA streams' "best usages" are in accordance with NY State flow regulations. Water quality is often tied to water quantity and the synchronization of monitoring quality and quantity variables will provide managers with an improved understanding of water quantity/quality relationships in ROVA.

Water quantity is a concern for impounded pond areas in ROVA with regards to sediment accumulation and invasive aquatic vegetation in the basins. Siltation is an issue due to the impoundment in HOFR, as a 1985 sedimentation study of the pond estimated that water retention capacity would be reduced to 20% within 100 years (USDI 2010). The open water surface of the Upper Val-Kill impounded pond (2.8 ha /7 acres) reduced due to silt accumulation and invading emergent plants, particularly purple loosestrife (USDI 2010). The Upper Val-Kill impoundment was dredged in the 1950s and was assessed by Pandullo Quirk Associates (1979) and Allen and Bobinchock (1986), who estimated 4.2 m (13.7 feet) of silt had accumulated since the initial dredging. A recent survey (2004) of the sediment and hydrography show that the surface area of the water has been reduced to approximately 1.6 ha (4 acres), and sediment thickness on average is between 1.8 and 2.4 m (6 and 8 ft) (GZA 2004). Given that the Upper Val-Kill pond serves as a foundation to the cultural landscape of ROVA, the implementation of restoration techniques is a desired goal for ROVA (USDI 2010). Factors which are recommended to monitor or inventory include: 1) sedimentation accumulation rates due to impoundment features in ROVA, particularly after restoration dredging of VAMA or ELRO ponds in order to obtain baseline data, 2) the monitoring of aquatic invasive plant species (e.g., purple loosestrife) density and the relationship to water surface area, and 3) completing an inventory of vernal pools and wet meadows within ROVA in order to obtain a comprehensive surface water quantity assessment for ROVA.

4.2.2 Ground Water Quantity

<u>Relevance and Context</u>

ROVA overlies the Austin Glen Graywacke and shale bedrock, with wells in this formation producing an estimated 16 gpm (Simmons et al. 1961, Dutchess County Department of Planning 1985). Glacial till with a high clay content overlays much of the bedrock, with the western half of HOFR, and a small portion of ELRO consisting of glacial till. Wells within the glacial till region are subjected to dry periods during low precipitation. Recorded yields in these deposits average 22 gpm in Dutchess County (Dutchess County Department of Planning 1985). ELRO and VAMA are contained in an unconfined aquifer region. Here, the bedrock is overlain by glacially-derived sand and gravel and aquifers produce 10 to 100 gallons per minute. Yields in areas adjacent to streams may exceed 100 gallons per minute through pumping-induced infiltration (Bugliosi et al. 1988).

The Dutchess County Natural Resource Inventory states that based on Dutchess County's aquifer monitoring program and water budget calculations, no broad depletions in aquifer water capacity or water table levels is occurring (Dutchess County Department of Planning 2011). However, areas do exist where stream flow quantity and groundwater recharge rates are reduced or at low levels when compared to relative water quantity levels of Dutchess County (Chazen Companies 2006). Aquifer recharge rates differ across Dutchess County due to different precipitation patterns. Precipitation in the town of Hyde Park near ROVA is approximately 38 inches versus 44 inches in portions of southeast Dutchess County, predicting proportionally lower net aquifer recharge rates near Hyde Park compared to the rest of Dutchess County. Recharge rates for aquifers in Dutchess County estimated based on Hydrogeologic Soil Groups (HSG) by the Natural Resources Conservation Service (NRCS) were highest in the watersheds where precipitation rates were the highest while the lowest aquifer recharge was projected for the town of Hyde Park due to proportionally lower available precipitation rates (Chazen Companies 2006). The relatively low aquifer recharge rates identified in Hyde Park are consistent with findings in a 2002 Dutchess County study documenting lowest County drought-stage stream flows in the Crum Elbow Creek in Hyde Park (Chazen Companies 2003).

Data and Methods

Ground water data was analyzed using weekly median measurements of depth to water level (ft) for USGS well 414737073563301 (local well Du-321) located in VAMA. Data from this well has been collected from 1948-2011 and the water stage is recorded hourly and reported to USGS in cooperation with the New York Department of Environmental Conservation. The depth of the well is 126 ft below land surface and the depth of the hole is 128 ft below land surface. Water levels respond to semidiurnal earth tides (approximately 0.05 ft) (USGS 2010).The 10th through the 90th percentile values were calculated in order to compare 2010-2011 ground water measurements to historic measurements for the well. To address long-term trends, historical water-level data from USGS 414737073563301 was analyzed using Seasonal Kendall trend test (p-value <0.05) based on the 50 year hydrograph (Figure 30).

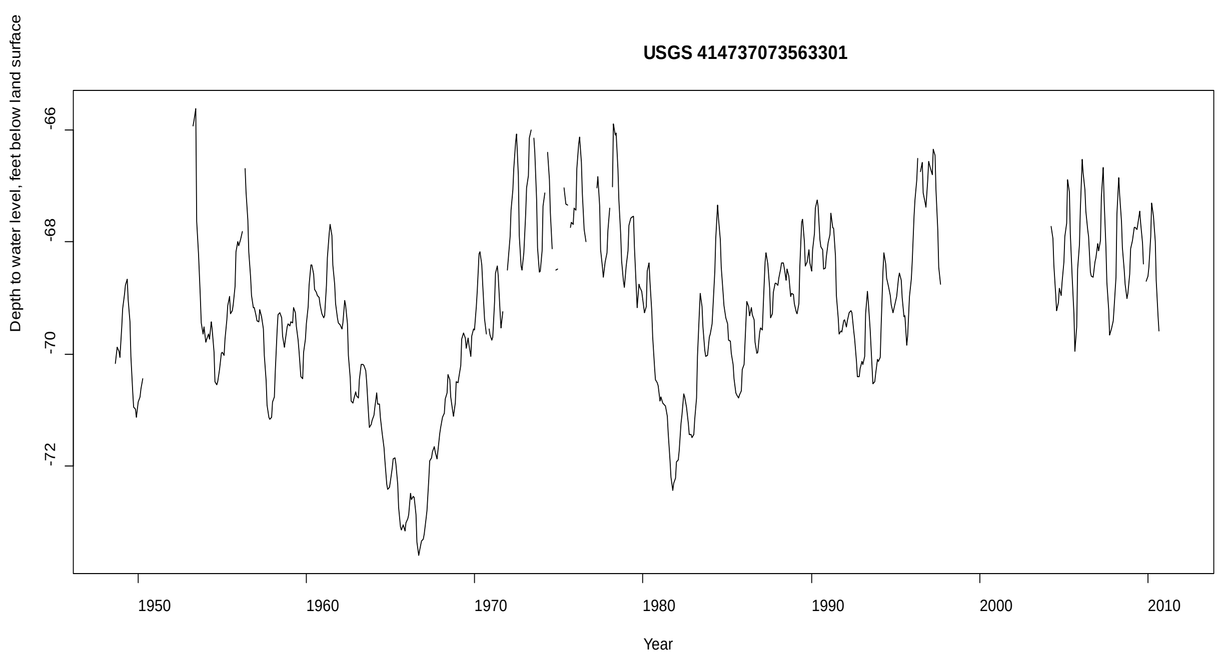


Figure 30. Period of record for depth to water level, feet below land surface in USGS well 414737073563301 (local well Du-321) from September 1948 through June 2011.

Reference Condition/Threshold Values Utilized

Ground water quantity for ROVA was based on categorizing monthly median ground water levels (feet below land surface) at the VAMA well to determine the percent of readings falling within the 10th through the 90th percentile for each month. Percentile categories are commonly used by USGS for monitoring the status of current ground water quantity conditions and for this assessment we interpreted the percentile categories into condition categories based on approximately 50 years of data collection for well 414737073563301. Monthly median water levels below the 10th percentile were considered to be a *significant concern*, levels within the 10-24th percentiles were categorized as *caution*, and monthly median levels above the 25th percentile were categorized as *good*.

Condition and Trend

ROVA's ground water quantity condition assessment was rated good. From 2010-2011, the monthly median ground water levels at VAMA well 414737073563301 were at or above historical monthly medians, with daily readings reaching the 90th percentile (Figure 31). Monthly median water levels from 2010-2011 had 100% attainment within the 25th or greater percentile. This well has historically experienced readings at or below the 10th percentile due to drought. During a period of regional drought during 2001 and 2002, the groundwater level in a well at the Vanderbilt Mansion had fallen to levels seen previously only during droughts in the mid-1960s (e.g., 73.85 feet below surface in 1966) and early 1980s (The Chazen Companies 2003). Long-term trend analysis resulted in a significantly positive slope, indicating increasing water quantity in well 414737073563301 (n=3573 observations, Seasonal Kendall=0.028, $p<0.05$). Future consumption levels for groundwater may increase due to population growth around ROVA. Total use of ground water in Dutchess County in 1950 was estimated to have averaged approximately 7 million gallons a day (Mgal/d) (Simmons et al 1961). By 2005, ground water withdrawal in Dutchess County increased by 2.5 fold to 17 Mgal/d. Trends in ground water withdrawal is estimated to increase in the area based on projected population growth estimates for the areas surrounding ROVA (Svancara et al. 2009).

Data Gaps and Confidence in Assessment

Confidence in the condition assessment of ground water quantity was fair and trend assessment was fair. Although a 50 year hydrograph was used to analyze the condition and trend of ground water quantity for ROVA, the assessment included only one well in ROVA and 50 years of data may not be adequate for detecting trends due to climate related changes. It should be recognized that the data collection and recording process is of quantitative value. Water quality is often tied to water quantity and the synchronizing of monitoring quality and quantity variables will provide managers with an improved understanding of water quantity/quality relationships in ROVA. For example, analysis between e-coli detection rates in ground water samples and the ground water level at the VAMA monitoring well found that e-coli exceedences only occurred when ground water levels fell below 71 feet in this well (The Chazen Companies 2003). The wide range of e-coli failures at the lower ground water level may be related to the duration of time that the groundwater level was below 71 feet or other factors.

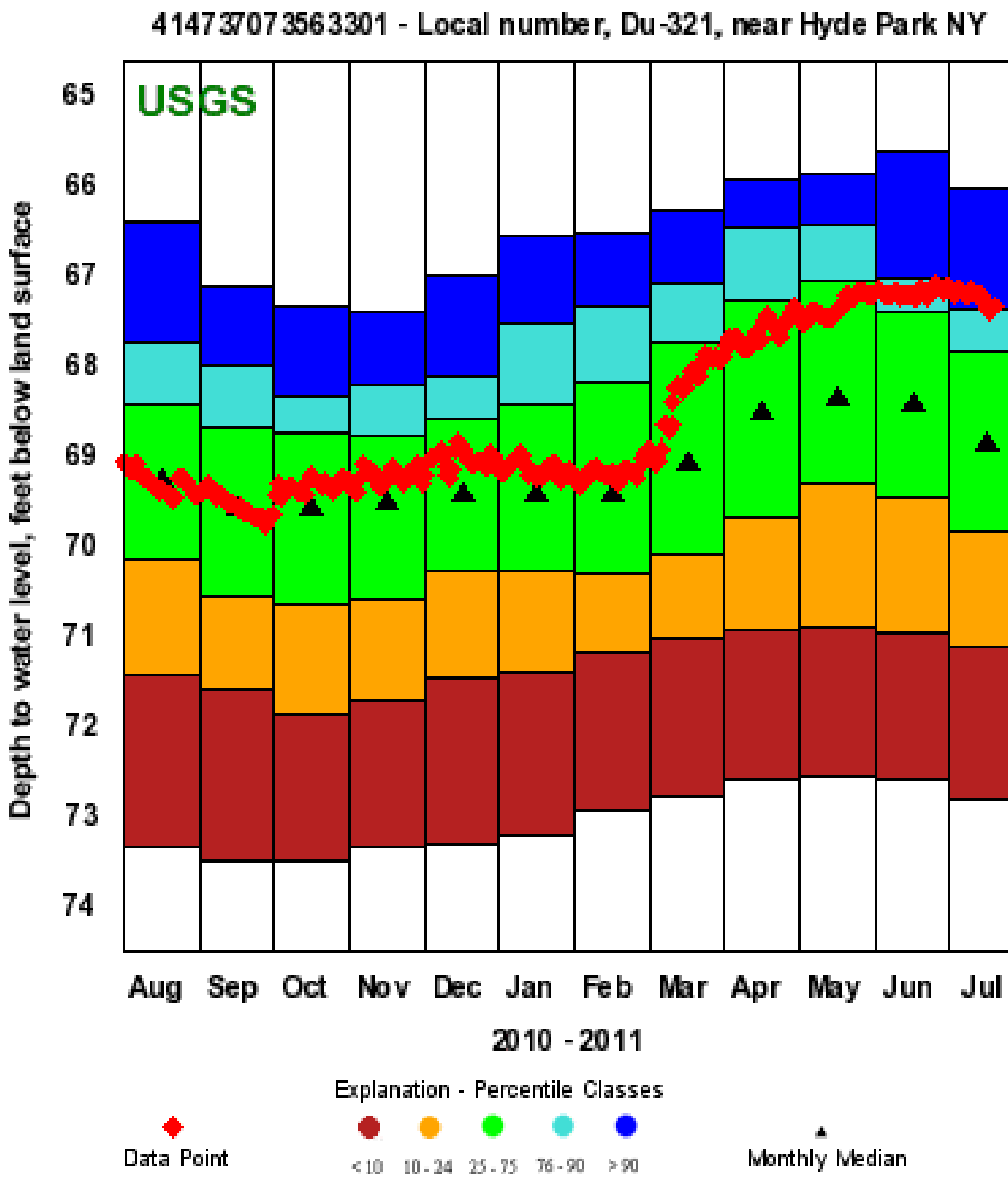


Figure 31. Percentile classes and water levels (ft) recorded at USGS groundwater well 414737073563301 (local well Du-321) from August 2010-July 2011 (From USGS Groundwater Watch, http://waterdata.usgs.gov).

4.3 Water Quality

Relevance and Context

The three parks reside in the Lower Hudson River Basin, a drainage area of 5276 mi2 that includes a population of almost 1.7 million people (NYDEC 2008a). Significant water quality issues within the basin include effects from urban/suburban development and runoff from agriculture. New York State has classified waters from AA through D based on existing or expected best usage of each waterway. The classifications include: AA or A waters used as a source of drinking water; B indicates usage for swimming and other contact recreation; C is for supporting fisheries and suitable for non-contact activities and D is the lowest classification and standard. Waters with classifications A, B, and C may also have a standard of (T), indicating that it may support a trout population or (TS), indicating that it may support trout spawning. Waters that are designated as C(T) or higher are collectively referred to as protected streams and are subject to the stream protection provision of the Protection of Waters regulations. The Waterbody Inventory/Priority Waterbodies List (WI/PWL) is a statewide inventory of New York State waterbodies which provides the foundation for both the compilation of the biennial Section 305(b) Water Quality Report for all NY waters and for the development of the State's Section 303(d) List which includes waters that do not meet water quality standards and may require Total Maximum Daily Load (TMDL) development. The current Lower Hudson River Basin Waterbody Inventory/Priority Waterbodies List Report was issued as a Final Draft Report in August 2008 (www.dec.ny.gov/chemical/23846.html). The 2010 *Section 303(d) List of Impaired/TMDL Waters* is currently available (http://www.dec.ny.gov/docs/water_pdf/303dlistfinal10.pdf). Below is a summary of the WI/PWL status for major streams flowing through ROVA's boundaries

Crum Elbow Creek and tributaries (segment ID: 1301-0200)

- WI/WPL: *No Known Impact*. Segment includes Class A, A(T) and small portion located in VAMA is classified as Class C. The classification AA or A is assigned to waters used as a source of drinking water and (T) indicates it can support trout populations. Class C is for waters supporting fisheries and suitable for non - contact activities. Historically, Crum Elbow Creek was rated as Class D due to contamination with alum by a municipal treatment plant prior to 1978.

- 305(b) (2008): 3 *segments Need Verification*. These segments are thought to have water quality problems or impact but there is not sufficient documentation.

Fall Kill and tributaries (segment ID: 1301-0087)

- WI/WPL: *Impaired Segment*. The stream and its reaches are all Class C. Aquatic life support and recreational uses are impaired by nutrient enrichment, pathogens and various other pollutants from municipal inputs and urban nonpoint sources. Aesthetics are known to be stressed.

- 305(b) (2008): 5 segments are assessed as *Impaired.*

- 303(d) (2010, 2008): TMDL development may be deferred. Impairment due to phosphorus from urban/storm runoff.

Minor Tribs to East of Hudson (segment ID: 1301-0192)

- WI/WPL: *Unassessed*. This includes Maritje Kill (Class B/C) and the FDR Brook (Class C) within HOFR.

Additional concerns to ROVA's streams include surrounding stormwater runoff. Stormwater runoff is a concern as pollutants are transported through Municipal Separate Storm Sewer Systems (MS4s) and discharged into local surface waters from residential, commercial, industrial, and construction sites. As development has expanded in the ROVA area, both sources of contamination and impermeable surface increased as well, contributing greatly to current levels of contamination. Transportation of nutrients such as phosphorus and nitrogen promote overgrowth of algae, oil and grease complicates oxygen transfers for aquatic organisms and sediments from construction alters habitats of organisms. Under federal regulation, permits for stormwater discharge from MS4s in urbanized areas are required.

We did not assess the condition and trend of drinking water quality in this report since drinking water is monitored for the park under yearly testing reports provided by the Dutchess County Water and Wastewater Authority (DCWWA). The DCWWA-Hyde Park System tap water quality (public water supply ID# 1302796) is tested annually for microbiological, inorganic, radioactive, and disinfection contaminates and byproducts. The water source for this area is the Hudson River. DCWWA reports for testing years in 2006, 2007, and 2008 showed that the water supply was in compliance with Federal and State regulations except in 2008 when odor was in violation of water quality standards. Municipal or industrial waste discharges and natural sites are sources of odor. Several contaminants will exert odor when they are present at levels near their Maximum Contaminant Levels.

<u>Data and Methods</u>

Baseline surface water quality data were available for ROVA for the late 1990's, but data had not regularly been collected until NETN established a monitoring program of ROVA's streams in 2006 as part of the Vital Signs program (NPS 1997, Mitchell et al. 2006). From 1994-1997, 11 water quality monitoring stations were established within ROVA to measure surface water parameters for chemistry, physical parameters and nutrients. Conductivity, pH and dissolved oxygen exceeded surface water quality standards several times during this time period (NPS 1997). As part of the NETN Vital Signs monitoring program, six water quality and quantity monitoring stations were established in 2006 as part of a once per month sampling schedule from May through October and a biannual nutrient sampling event in May and August (Figure 25) (Lombard et al. 2006). These sites are located near or at the original 11 sites that were monitored from 1994-1997 (Figure 25). Sampling stations have been established on Crum Elbow Creek (in VAMA, N=2 stations), Fall Kill (in ELRO N=1), unnamed historic site/FDR Brook (HOFR, N=2), and Maritje/Meriches Kill located on the recently acquired property between HOFR and ELRO (N=1). The NETN measures specific conductance, pH, water temperature, dissolved oxygen (DO), acid-neutralizing capacity (ANC), nutrients, color, and water clarity for their vital signs program. For this condition assessment report, we did not include color and clarity due to a low sample size for these parameters.

Water quality data was queried and/or requested from the U.S. EPA STORET database and the NPS Northeast Temperate Network (NETN). Calculated three year averages (2006-2009) of eight water quality parameters were used to assess the condition of ROVA's surface water (Table

8). In addition, the percentage of individual samples within the established water quality standards/criteria was calculated for each stream (Table 8). Trend analysis was included in the assessment of water quality parameters for ROVA (Table 8). Data included for the trend analysis was collected from 1994-1997 and 2006-2009 for all streams, as these are the longest consecutive temporal data sets available for streams within park boundaries. Linear regression of water quality variables was used to assess trends in water quality data collected from waterbodies in ROVA. Trends were *increasing*, *decreasing*, or *no trend*, based on the slope parameter of the *date* effect ($\alpha=0.05$).

Table 8. ROVA surface water quality condition assessment.

Resources	Metric	Threshold	Samples	Period of Data	Results (Mean±St.Dev)	Condition (% samples compliant)	Trend	Comment
Threshold: [1]New York State standards for AA streams (NYCRR Part 703) [2]U.S. EPA (1997): Range for good fisheries mix [3]Stoddard *et al*. (2003) [4]U.S. EPA ecoregional nutrient criteria for region VII (U.S. EPA 2000, 822-B-00-018) **Data:** NPS Northeast Temperate Network Vital Signs Monitoring Program U.S. EPA STORET Database	**Temperature** (ºC)	No threshold	HOFR: 50	2006-2009	HOFR: 16.3±4.4		No Trend	Compared 1994-1997 data to 2006-2009 data for trend analysis.
			VAMA: 56		VAMA: 18.1±4.8		No Trend	
			ELRO: 26		ELRO: 19.5±5.9		No Trend	
			Meriches Kill: 25		Meriches Kill: 16.7±4.8			
	Dissolved Oxygen (mg/L)	5.0 mg/L-non-trout waters [1] 6.0 mg/L-lakes and ponds [1] 6.0 mg/L-trout waters [1] 7.0 mg/L- cold water trout spawning[1]	HOFR: 50	2006-2009	HOFR: 9.5±1.0	COMPLIANT (100)	No Trend	Compared 1994-1997 data to 2006-2009 data for trend analysis.
			VAMA: 56		VAMA: 9.6±1.2	COMPLIANT (100)	No Trend	
			ELRO: 26		ELRO: 8.9±3.0	COMPLIANT (73)	No Trend	
			Meriches Kill: 25		Meriches Kill: 8.8±1.2	COMPLIANT (100)		
	pH	6.5≤pH≤8.5 [1]	HOFR: 50	2006-2009	HOFR: 8.1 ±0.1	COMPLIANT (100)	Increasing	Compared 1994-1997 data to 2006-2009 data for trend analysis
			VAMA: 56		VAMA: 8.3± 0.2	COMPLIANT (100)	Increasing	
			ELRO: 26		ELRO: 7.8±0.4	COMPLIANT (96)	Increasing	
			Meriches Kill: 25		Meriches Kill: 8.0±0.2	COMPLIANT (100)		
	Specific Conductivity (µS/cm)	150<conductivity<500 (µS/cm) [2]	HOFR: 50	2006-2009	HOFR: 629±91	EXCEED (12)	Increasing	Compared 1994-1997 data to 2006-2009 data for trend analysis
			VAMA: 56		VAMA: 379±112	COMPLIANT (91)	Increasing	
			ELRO: 26		ELRO: 477±125	COMPLIANT (50)	Increasing	
			Meriches Kill: 25		Meriches Kill: 540±127	EXCEED (32)		
	Acid Neutralizing Capacity (mg/L)	ANC> 5 (mg/L) (100 µeq/L) [3]	HOFR:16	2006-2009	HOFR:3028±339	COMPLIANT (100)		
			VAMA: 17		VAMA:2270±303	COMPLIANT (100)		
			ELRO: 7		ELRO:2265±410	COMPLIANT (100)		
			Meriches Kill:7		Meriches Kill:3294±398	COMPLIANT (100)		
	Total Nitrogen (mg/L)	0.54 mg/L (streams) [4] Cannot be at levels that will result in growths of algae or impair water for best usage.[1]	HOFR:17	2006-2009	HOFR: 2.35±0.53	EXCEED (0)		NETN field notes indicate filamentous algae present in all subunits
			VAMA: 17		VAMA: 0.77±0.24	EXCEED (12)		
			ELRO: 7		ELRO: 0.62±0.12	EXCEED (29)		
			Meriches Kill:7		Meriches Kill: 1.10±23	EXCEED (0)		
	Total Phosphorus (µg/L)	33 µg/L (streams)[4] Cannot be at levels that will result in growths of algae or impair water for best usage.[1]	HOFR:17	2006-2009	HOFR:40±17	EXCEED (41)		NETN field notes indicate filamentous algae present in all subunits
			VAMA: 17		VAMA:34±10	EXCEED (59)		
			ELRO: 7		ELRO:65±25	EXCEED (0)		
			Meriches Kill:7		Meriches Kill: 47±13	EXCEED (14)		
	NO_2+NO_3 (mg/L)	0.30 mg/L (streams)[4]	HOFR:16	2006-2009	HOFR: 2.13±0.50	EXCEED (0)		NETN field notes indicate filamentous algae present in all subunits
			VAMA: 16		VAMA: 0.51±0.20	EXCEED (13)		
			ELRO: 7		ELRO:0.23±0.10	COMPLIANT (57)		
			Meriches Kill:7		Meriches Kill: 0.86±0.20	EXCEED (0)		

Reference Condition/Threshold Values Utilized

The condition categories for water quality variables were *compliant* or *exceeded* in relation to agency standards/criteria (Table 8). Surface water quality was assessed using standards and criteria set forth by the New York Department of Environmental Conservation (NYCRR Part 703, NYDEC 2008b), U.S. EPA ecoregional nutrient criteria for region VII (U.S. EPA 2000, 822-B-00-018) and technical reports (U.S. EPA 1997, Stoddard et al. 2003).

New York State's surface water quality standards (NYCRR Part 703) identify Class AA as the most restrictive classification for stream water quality, and the park's streams are held to New York's highest classification standards (for standards see: (http://www.dec.ny.gov/regulations/regulations.html). Certain water quality parameters, such as acid neutralizing capacity, do not have numerical criteria under State or Federal standards. In such cases, water quality thresholds were identified through peer review journal articles, technical reports or no threshold assigned. The following identifies the threshold values utilized for each water quality variable:

- **Temperature**: New York State has not established a standard for stream temperature. Changes in temperature can affect availability of oxygen to aquatic organisms.

- **Dissolved Oxygen (DO)**: Aquatic life generally requires 5 mg/L of dissolved oxygen to thrive. Minimum average DO concentrations for New York standards vary according to trout vs. non-trout streams. Non-trout waters shall not be less than 5.0 mg/L (as a minimum average daily concentration and never below 4.0 mg/L), while trout waters shall not be less than 6.0 mg/L and trout spawning waters shall not be less than 7.0 mg/L.

- **pH**: A range of 6.5 to 8.5 is the current New York State standard. Changes in pH can result from metal contamination or increases in aquatic plant growth.

- **Specific Conductivity**: Conductivity in water is affected by the presence of anions and cations of inorganic dissolved solids such as chloride, nitrate, and phosphate, sodium, calcium, iron, and aluminum. Organic compounds like oil, phenol, alcohol, and sugar lower conductivity when in water. Conductivity in streams is affected primarily by the geology of the area through which the water flows. Discharges to streams can change the conductivity such as when failing sewage systems or agricultural runoff raise the conductivity because of the presence of chloride, phosphate, and nitrate. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µS/cm (U.S. EPA 1997).

- **Acid Neutralizing Capacity (ANC)**: ANC measures the ability of water to neutralize strong acid. New York does not have numerical criteria for their water quality standards. Values greater than 100 µeq/L (equivalent to 5 mg/L, Lombard et al. 2006) are considered well buffered and values less than zero are typical of acidic waters (Stoddard et al. 2003).

- **Nutrients**: New York State has not established numerical values for nutrient standards. New York has set standards which indicate, "…*there shall be no nitrogen or phosphorus that will result in growth of algae or impair the water for their best usage* (NYCRR Part

703.2).” The U.S. EPA has established an ecoregional nutrient criteria to represent conditions of surface waters that may be affected by anthropogenic activities. The U.S. EPA lists ROVA is located in Ecoregion 7 (U.S. EPA 2000).

Total Nitrogen: 0.54 mg/L (streams), 0.66 mg/L (lakes and reservoirs)
Total Phosphorus: 33 µg/L (streams), 14.75 µg/L (lakes and reservoirs)
NO2+NO3: 0.3 mg/L (streams)

Condition and Trend

Table 8 provides a summary of the condition assessment for water quality parameters of ROVA’s surface waters. Based on the three-year mean, dissolved oxygen (mg/L), pH, and acid neutralizing capacity (mg/L) were compliant when based on regulatory standards or criteria. Attainment of standards for each individual water sample ranged from 50%-100% for these parameters. Specific conductivity (µS/cm) measures were compliant for streams in VAMA and ELRO, but exceeded the criteria for the unnamed stream in HOFR and Meriches Kill when based on a three year mean. The percentage of samples which attained specific conductivity criteria ranged from 12-91%. Total nitrogen (mg/L) and total phosphorus (µg/L) exceeded U.S. EPA ecoregional VII criteria for all streams in HOFR, VAMA, ELRO and Meriches Kill when based on a three year mean. The percentage of samples which attained total nitrogen and total phosphorus criteria ranged from 12-91%. NO2+NO3 (mg/L) exceeded criteria for all streams except for Fall Kill in ELRO. The percentage of samples which attained NO2+NO3 criteria ranged from 0-57%.

Regression trend analysis for data collected from 1994 through 2009 was conducted for temperature, dissolved oxygen, pH, and specific conductivity measurements. No statistically significant trend was detected for temperature and dissolved oxygen ($p>0.05$). Specific conductivity and pH levels have been significantly increasing in all streams in park boundaries since 1994 (Table 8). Although ROVA has limestone bedrock which can form karst topography, thereby influencing parameters such as ANC, pH and specific conductivity, the increasing trend of these water variables may suggest the possibility of atmospheric or anthropogenic influences.

Data Gaps and Confidence in Assessment

Confidence in the condition assessment of stream surface water quality was high for chemical/physical parameters and fair for nutrient parameters. Trend assessment was considered fair due to the lack of long term temporal data and low sample sizes collected for ROVA streams from 1997-2009. The nutrient criteria used for this assessment are used by NETN as a starting point for their stream assessment program. However, the U.S. EPA nutrient criteria used in this assessment may be biased to larger streams, unlike the small streams present in ROVA. A lack of multiple sampling events and seasonal nutrient sampling restricts the analysis of linking water nutrient levels to trends in human activity in and around ROVA.

4.4 Biological Integrity

4.4.1 Non-indigenous Aquatic Species

<u>Relevance and Context</u>

A nonindigenous aquatic species is an aquatic organism that does not occur naturally in New York State aquatic environments. Many aquatic species have become naturalized over time, as they were introduced a relatively long time ago either as non-intentional introduction or intentional stocking, and have become fully integrated into New York aquatic ecosystems. The issue is that during the introduction period, newly introduced aquatic species disrupt the natural balances and relationships existing between other species already present, and can cause significant changes to the ecosystem. New York has over 240 introduced species to its aquatic environment, with more than 40 non-indigenous aquatic species identified in the lower Hudson-Wappinger river basin, the HUC 8 basin in which ROVA is located (Figure 32, Appendix F) (USGS 2004).

Although many species are a threat to ROVA's aquatic environment, non-indigenous species warnings emerge yearly in New York which alert managers and citizens to be proactive in the identification and reporting of species. For example, the New York DEC verified the presence of the Northern Snakehead (*Channa argus*) in neighboring Orange County, NY waters 2008 (http://www.dec.ny.gov/). The Department determined that swift action to eradicate this invasive species and prevent any possible expansion beyond the headwaters of Catlin Creek was essential to protect native fish populations, natural communities and multiple clean water bodies including the Wallkill, Hudson River, and potentially ROVA's streams. Two non-indigenous aquatic species whose populations are known to be within proximity to ROVA have been recently identified as a concern to park managers and researchers in New York. The crustacean commonly referred to as the Chinese mitten crab (*Eriocheir sinensis*) (CMC) and the diatom *Didymosphenia geminate* have been discovered within the past few years in waters connected to the Hudson River.

Chinese Mitten Crab (Eriocheir sinensis) specimen. Photo captured by: Smithsonian Environmental Research Center (SERC). www.serc.si.edu.

The Chinese mitten crab is one of the more recent species to invade the Hudson watershed. A non-native species from Asia, it becomes aggressive and may compete with the native blue crab in the Hudson River. These crabs are found in fresh and salt water, with the young moving upstream and spending 2-5 years in freshwater. The burrowing habits of the crab may promote stream bank erosion and habitat loss. CMC was first caught near the mouth of the Hudson River in June 2007 and one year later, was found at three upstream sites, suggesting consistent reproduction and movement. CMC has been found in tributaries near ROVA, including the Fall Kill in Poughkeepsie and at Norrie Point, Staatsburg (USGS 2004). A study of CMC exuviae abundance was conducted in Saw Kill, a tributary of the fresh-tidal Hudson River during the summer and fall of 2008. More than half of the specimens were collected in July when water temperatures ranged from 21 to 24.5° C (Schmidt et al. 2009). Exuviae numbers decreased with declining water temperature. Although the crabs were concentrated below the barrier structures within Saw Kill (waterfall and dam), crabs did circumnavigate both barriers. ROVA's average stream temperatures during the summer months fall within this range and nearby water bodies are already experiencing established populations (Figure 32), suggesting that ROVA's habitats are conducive to invasion of CMC. In 2008, CMC was detected at the HOFR (USDI 2009).

Didymosphenia geminate, often referred to as "rock snot" or "didymo", is an aggressively growing diatom that inhabits lentic and lotic waters. The development of these thick algal mats affects benthic organisms, alters fish communities, outcompetes native vegetation, and modifies the water chemistry (e.g., large quantities of didymo reduces dissolved oxygen levels).This microscopic alga is transmitted via attachment to wader, boats, fishing gear, and other objects and has the ability to survive outside water for a day or more, increasing its probability of transportation to other water bodies. *Didymosphenia geminata* is expanding its range, from occurring in northern latitude and low nutrient waters to lower latitude and nutrient rich water (Spaulding and Elwell 2007). The existence of didymo was confirmed in New York's Esopus Creek (Ulster County) in 2009 and had spread along 12 miles of the stream (NYDEC 2009). Additionally didymo has been confirmed to be present in Batten Kill in Washington County near the Vermont border and in the East and West branches of the Delaware River (NYDEC 2007). There are currently no known methods for controlling or eradicating didymo once it has been established in waters. The existence of didymo in New York State and its tendency to aggressively adapt to a variety of aquatic environments makes this organism a threat to ROVA's aquatic habitats.

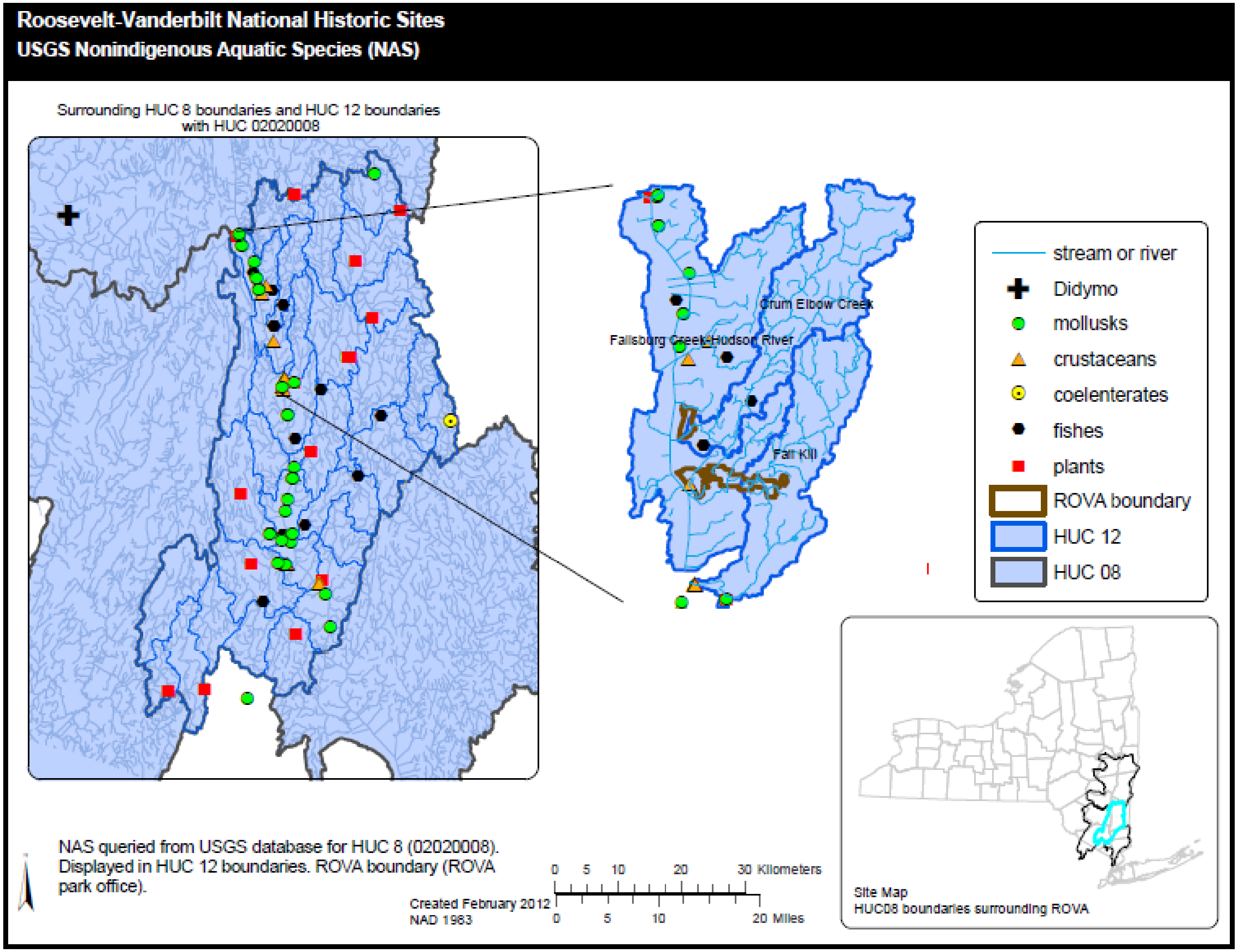


Figure 32. Locations of nonindigenous aquatic species groups based on USGS database query for HUC 02020008.

Data and Methods

Presence/absence observations of nonindigenous species by park staff and environmental agencies (e.g. USGS, NYDEC) within and near ROVA's waterbodies were collected and used to assess the condition of ROVA's aquatic systems. The locations of the observations were spatially mapped by HUC8 and HUC12 boundaries and a condition assessment category was applied to each HUC 12 boundary which encompasses ROVA.

Reference Condition/Threshold Values Utilized

The ideal reference condition for ROVA's waters was recognized as the absence of non-indigenous species from aquatic environments. Due to the lack of quantitative data for several non-indigenous aquatic species, the condition categories used to assess ROVA's waters included two qualitative condition categories: 1) *not invaded, with potential risk of invasion in ROVA's waters due to nonindigenous species establishment in adjacent tributaries*, and 2) *invaded, with potential deleterious impact to the aquatic system*. It was also noted whether CMC and didymo were present within the HUC 12 boundary, as we considered these high priority nonindigenous species for managers. Trend could not be statistically evaluated but was assessed using best professional judgment based on peer reviewed literature.

Condition and Trend

Within ROVA's HUC12 boundaries, one plant species, four fish species, one crustacean species, and two mollusk species were identified and mapped as nonindigenous species (Appendix F, Figure 32, USGS 2010). Each of ROVA's three HUC 12 watersheds (Fallsburg Creek-Hudson River, Crum Elbow Creek, Fall Kill) were given a condition category of *invaded, with potential deleterious impact to the aquatic system*, thus receiving 0% attainment of reference condition requirements. Fallsburg Creek-Hudson River contained the greatest number of nonindigenous species, with *Iris pseudoacorus* (plant), *Pomaxis annualris* (fish), *Scardinius erythrophthalmus* (fish), *Dreissena polymorpha* (mollusk), and *Eriocheir sinensis* (crustacean) being found in several areas. Crum Elbow Creek contained *Salmo trutta* (fish) and *Ambloplites rupestris* (fish), and Fall Kill was habitat to *Eriocheir sinensis* (crustacean) and *Cipangopaludina chinensis malleata* (mollusk) (Figure 32).

The detection of the Chinese mitten crab (CMC) in HOFR waters and in the Fall Kill watershed in addition to the extent of nonindigenous plants and animals located within ROVA's HUC 12 watershed, suggest that ROVA's aquatic ecosystem integrity is currently threatened. The trend of nonindigenous species establishing in aquatic systems will likely increase due to changes in climate patterns, increased recreational use and deficiency in the application of management tools due to time and cost (i.e., removal treatments, monitoring efforts).

Data Gaps and Confidence in Assessment

The confidence in the assessment was limited and the assessment of trend was limited. Data needs include continued surveys, population estimates and mapping to determine the extent and trend of non-indigenous aquatic species within ROVA's watersheds. The proactive surveying for species yet to colonize in ROVA's waters, such as *Didymosphenia geminata* ('didymo'), will reduce harmful economic and ecological impacts to aquatic communities and maintain the biological integrity of ROVA's waters (i.e., early detection promotes low impact, less costly remediation scenarios verses high impact, costly remediation scenarios).

4.4.2 Invasive Exotic Terrestrial Plants with Emphasis on Forest Invasives

Relevance and Context

Non-native vegetation has been established in all three park subunits as a result of past and present disturbances and is threatening the ecological integrity of ROVA's open areas and forest communities. Initial forest vegetation monitoring found non-native, exotic, and invasive species to be of concern to the ROVA parks (Miller et al. 2009). Presently, encroaching residential and commercial development delivers an influx of invasive plant species to the park. Non-native cultivated vegetation from the historically established landscapes and gardens in ROVA have been identified by Bravo (2002). The most common forest invasive species located in ELRO/HOFR include tree-of-heaven (*Ailanthus altissima*), garlic mustard (*Alliaria petiolata*), oriental bittersweet (*Celastrus orbiculata*) and Japanese barberry (*Berberis thunbergii*). The most frequent forest invasive species in VAMA include tree-of-heaven, garlic mustard, oriental bittersweet, Japanese barberry, and Norway maple (Miller et al. 2010). The presence of Norway maple in the understory of VAMA is an important concern since it has the potential to replace native understory maple species (Martin 1999). A list of non-native species detected in ROVA is located in Appendix G.

Invasive vegetation is currently being managed in ROVA (Figure 33). Management includes surveying of invasive forest vegetation populations and treatment of field and forest invasive vegetation via chemical (e.g., herbicides) or physical (e.g., picking, cutting) methods. Infestation of invasive vegetation ranges from light to heavy or sporadic. In order to prevent new infestations from establishing within park boundaries, early detection strategies have been created for NETN parks to ensure that high priority sites within the park are not invaded by new species (Keefer et al. 2010). An early detection list for ROVA has been developed to target "watch" species that are extremely rare, not currently present within the park, or have the potential to cause ecological and economical impairment. Early detection species, particularly giant hogweed (*Heracleum mantegazzianum*) and mile-a-minute week (*P. perfoliata*), are a concern for ROVA park managers, as the invasion of these species is rapid and ecologically distressing. A listing of early detection terrestrial and riparian invasive/exotic vegetation and pest species for ROVA is listed in Table 9.

Data and Methods

Key invasive exotic plant indicator species in the northeastern U.S. were identified and used for rating the condition of ROVA's invasive forest vegetation composition, as this was the most quantitative and recent data for the park (Table 10). The average number of key indicator invasive plant species per forest plot surveyed from 2006-2009 was calculated and compared to a rating system established for the NETN Vital Signs Program (Miller et al. 2010). Trend analysis was not conducted due to limited data collected because of the infancy of the NETN monitoring program.

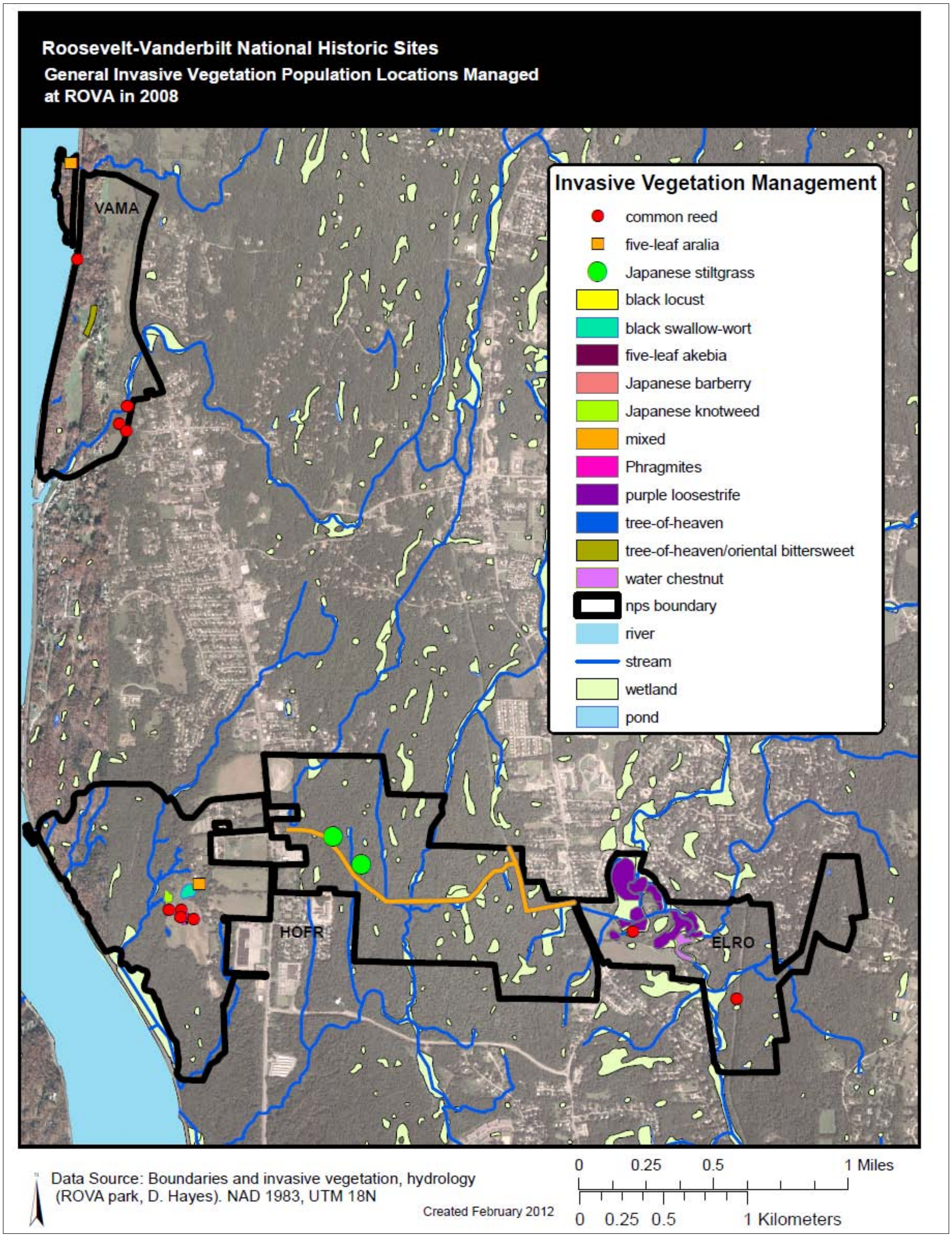


Figure 33. Example of general locations of invasive vegetation populations being managed at each park subunit in ROVA in 2008. Data source: NPS ROVA park office files.

Table 9. Early detection species for ROVA (Keefer et al. 2009, 2010).

PEST	
Agrilus planipennis	Emerald ash borer
Anoplophora glabripennis	Asian long-horned beetle
Pyrrhalta viburni	Viburnum leaf beetle
Sirex noctilio	Sirex woodwasp
HERB	
Heracleum mantegazium	giant hogweed
Oplismenus hirtellus ssp. Undulatifolius	wavyleaf basketgrass
Ranunculus ficaria	lesser celandine
Rubus phoenicolasius	wine raspberry
VINE	
Ampelopsis brevipedunculata	amur peppervine
Polygonum perfoliatum	mile-a-minute
Pueraria montana var. lobata	Kudzu
Frangula alnus	glossy buckthorn
Humulus japonicas	Japanese hop
Aralia elata	Japanese aralia
SHRUB	
Frangula alnus	glossy buckthorn
TREE	
Aralia elata	Japanese aralia

Table 10. Ratings for evaluating the composition of invasive exotic vegetation in ROVA (Miller et al. 2010).

	RATING		**NETN Monitoring Scores** (species/plot ± 1 st.er.) (Miller et al. 2010)	
			ELRO/HOFR	VAMA
Invasive exotic vegetation	GOOD	<0.5 key species / plot	CAUTION	SIGNIFICANT CONCERN
	CAUTION	0.5 to <3.5 key species / plot	2.96±0.43 (N=24 plots)	4.13±0.46 (N=16 plots)
	SIGNIFICANT CONCERN	3.5 or more key species / plot		

Reference Condition/Threshold Values Utilized
Condition categories established for the NETN Vital Signs Program were used to assess the condition of invasive species within forest habitat in ROVA (Miller et al. 2010). Less than 0.5 key indicator species/plot rated good, 0.5 to <3.5 species/plot rated *caution*, and 3.5 or more species/plot rated *significant concern*.

Condition and Trends
Based on NETN invasive vegetation monitoring, ELRO/HOFR received a *caution* rating and VAMA scored *significant concern* (2.96 and 4.13 key species/plot, respectively) (Table 10).

Data Gaps and Confidence in Assessment
The confidence in the condition assessment was fair and trend analysis was limited. The condition assessment of invasive exotic terrestrial species in ROVA was limited to only forest systems in which data collection efforts are in the early stages of the program. The infancy of the NETN sampling program limits trend analyses based on key indicator species density in ROVA's forests. A quantitative field monitoring effort of both forests and open areas in ROVA will enable managers to obtain a comprehensive assessment of invasive exotic terrestrial vegetation within park boundaries. Additionally, managers would benefit from information obtained from 'before and after' monitoring efforts of areas which are currently being subjected to removal of species in ROVA, such as Japanese stiltgrass (*Microstegium vimineum*) and Japanese knotweed (*Polygonum cuspidatum*).

4.4.3 Vegetation and Forest Health

Relevance and Context
The nearly 700 acres of land included in ROVA lie within a mixture of terrestrial, aquatic, natural, and human constructed vegetation communities. The condition of these communities has been quantified by a series of vegetation sampling programs conducted by NPS, as well as the Brooklyn Botanical Garden and the New York Natural Heritage Program. The limited area of the parks within ROVA necessitates the inclusion of lands adjacent to the parks to assess vegetation communities within NPS lands. The following sections describe the biotic plant diversity of ROVA, dominant land cover types, plant communities of interest, and special concerns about vegetation communities.

A total of 818 vascular plants have been identified as possible within the park (see Appendix H), although most (621) are listed as unconfirmed (https://science1.nature.nps.gov/npspecies/). Comprehensive vegetation classification and mapping has been completed for ROVA (Sechler et al. 2009) (Appendix B). Fifty vegetation associations have been identified within ROVA, including several human-dominated associations. Human dominated associations have been identified as a result of human activity in ROVA (Figure 34.). Vegetation includes invasive plants such as black locust (*Robinia pseudoacacia*) and purple loosestrife (*Lythrum salicaria*), successional landscapes and culturally significant plantations.

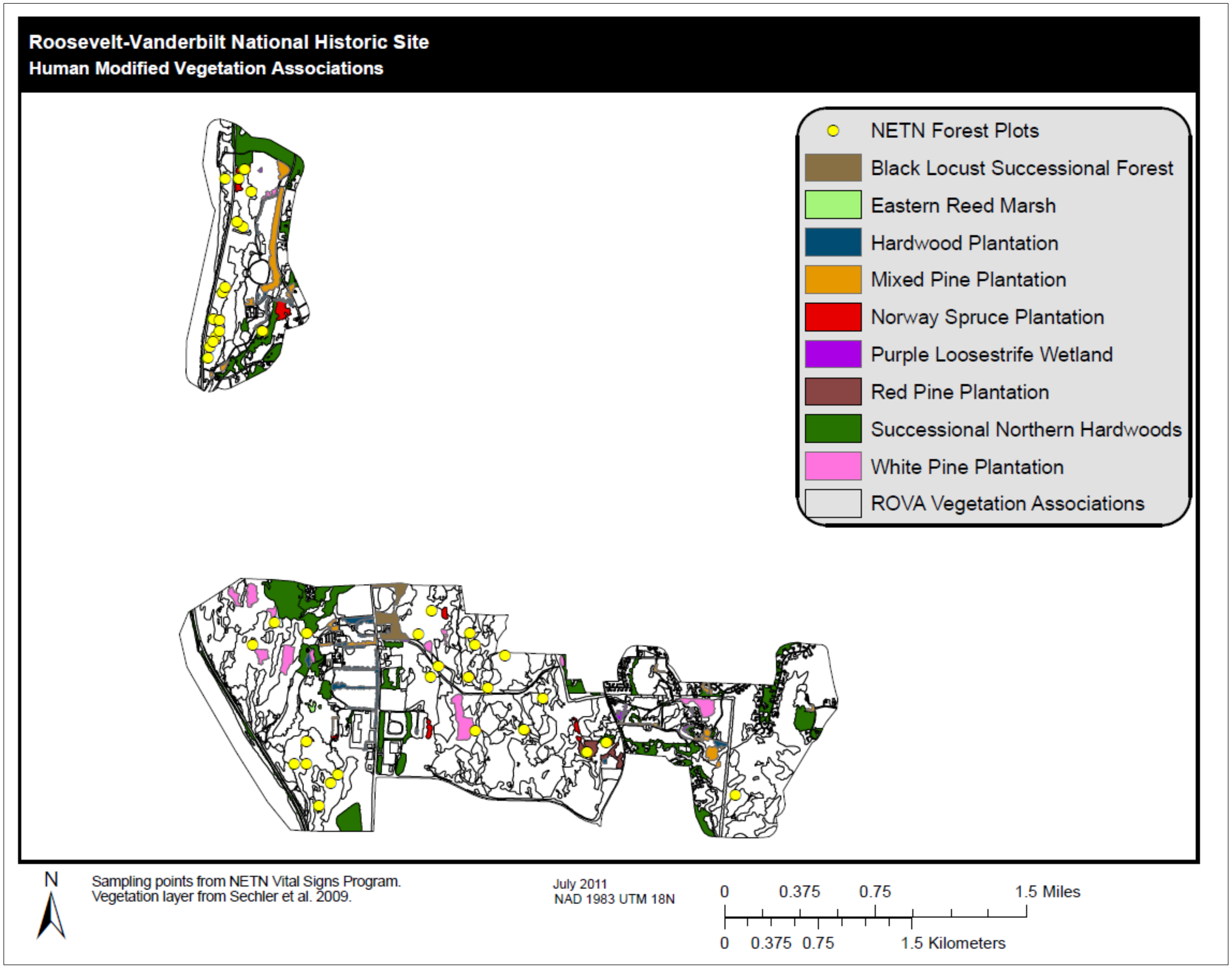


Figure 34. Human modified vegetation associations in ROVA (Sechler et al. 2009).

Most of the landscape within ROVA is northern hardwoods/mixed forest, old fields, plantations, or landscaped grounds (Mitchell et al. 2006). Over the past 30 years forest land cover in the region around ROVA has decreased by approximately 20%, while urban land cover has increased by nearly threefold (Wang et al. 2009a,b). This conversion from forest to urban landscapes has the potential to drastically affect biodiversity, watershed functioning, and habitat condition within ROVA.

Several small patches of vegetation found within and across the borders of ROVA are considered rare and significant by the New York Natural Heritage program: a 63-acre oak-tulip tree forest at VAMA NHS, the hemlock-northern hardwood forest at Roosevelt Farm and Forest, the red cedar rocky summit woodlands at HOFR NHS, vernal pools at both Val-Kill and Roosevelt Farm and Forest, and the freshwater tidal marsh at HOFR NHS (Sechler et al. 2009). In addition, endangered or threatened species found within the parks include Kentucky coffee tree (*Gymnocladus dioicus*), taperleaf bugleweed (*Lycopus rubellus*), Hill's pondweed (*Potamogeton hillii*), prickly hornwort (*Ceratophyllum echinatum*), Florida lettuce (*Lactuca floridana*), heartleaf avens (*Geum vermum*), swamp buttercup (*Rununculus hispidus var. nitidum*), burmarigold (*Bidens laevis*), and sharpwing monkeyflower (*Mimulus alatus*). ROVA contains areas of global and state vegetation biodiversity significance (Figures 35, 36). Small patches of vegetation associations considered globally rare and located within ROVA include Central Appalachian Hemlock-Chestnut Oak Forest, Eastern Woodland Vernal Pool and Red Cedar Rocky Summit (Sechler et al. 2009). Five natural communities considered as New York Natural Heritage significant occurrences include oak-tulip forest, hemlock-northern hardwood forest, red cedar rocky summit, vernal pool and freshwater tidal marsh (Sechler et al. 2009).

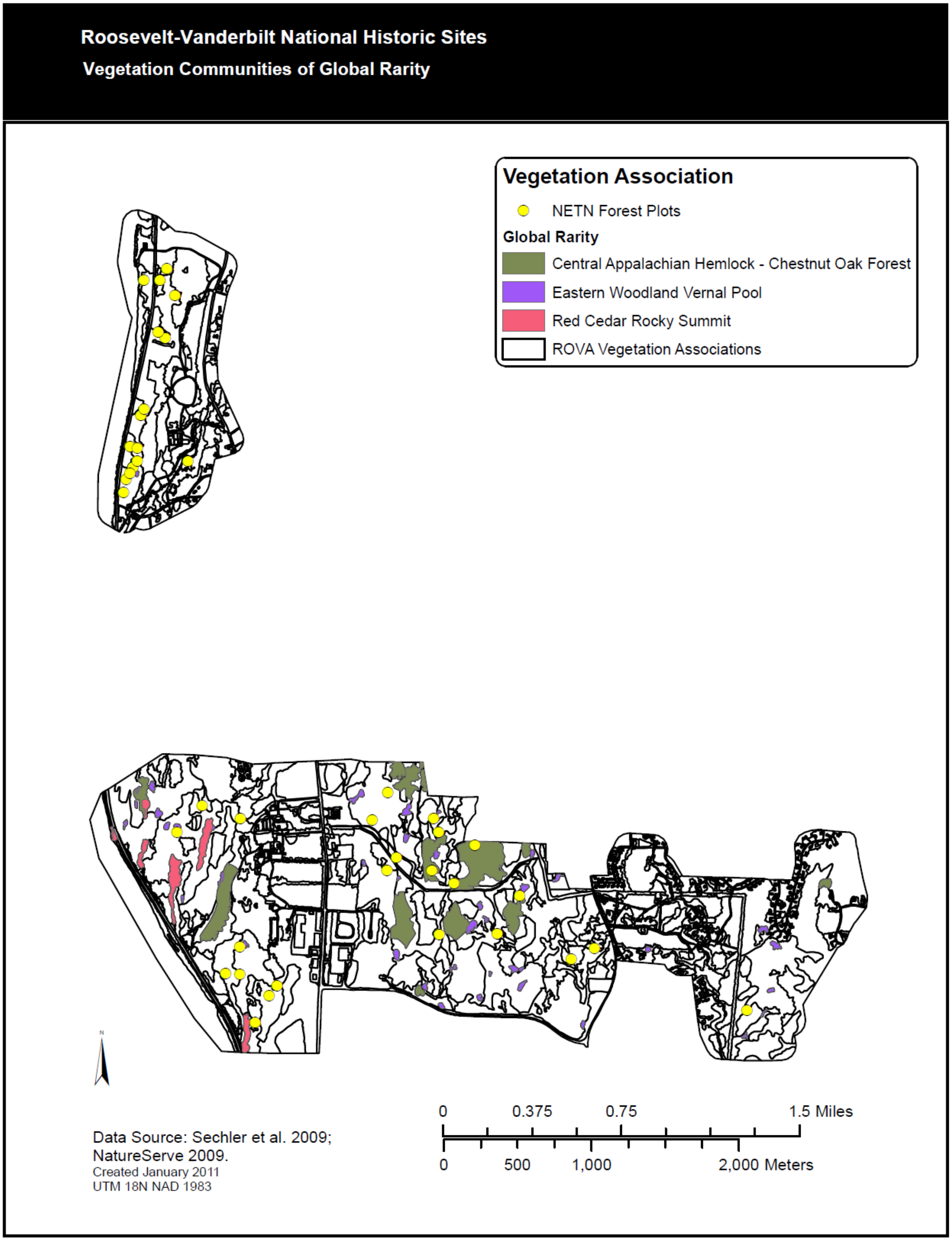


Figure 35. Globally rare vegetation associations in ROVA (Sechler et al. 2009).

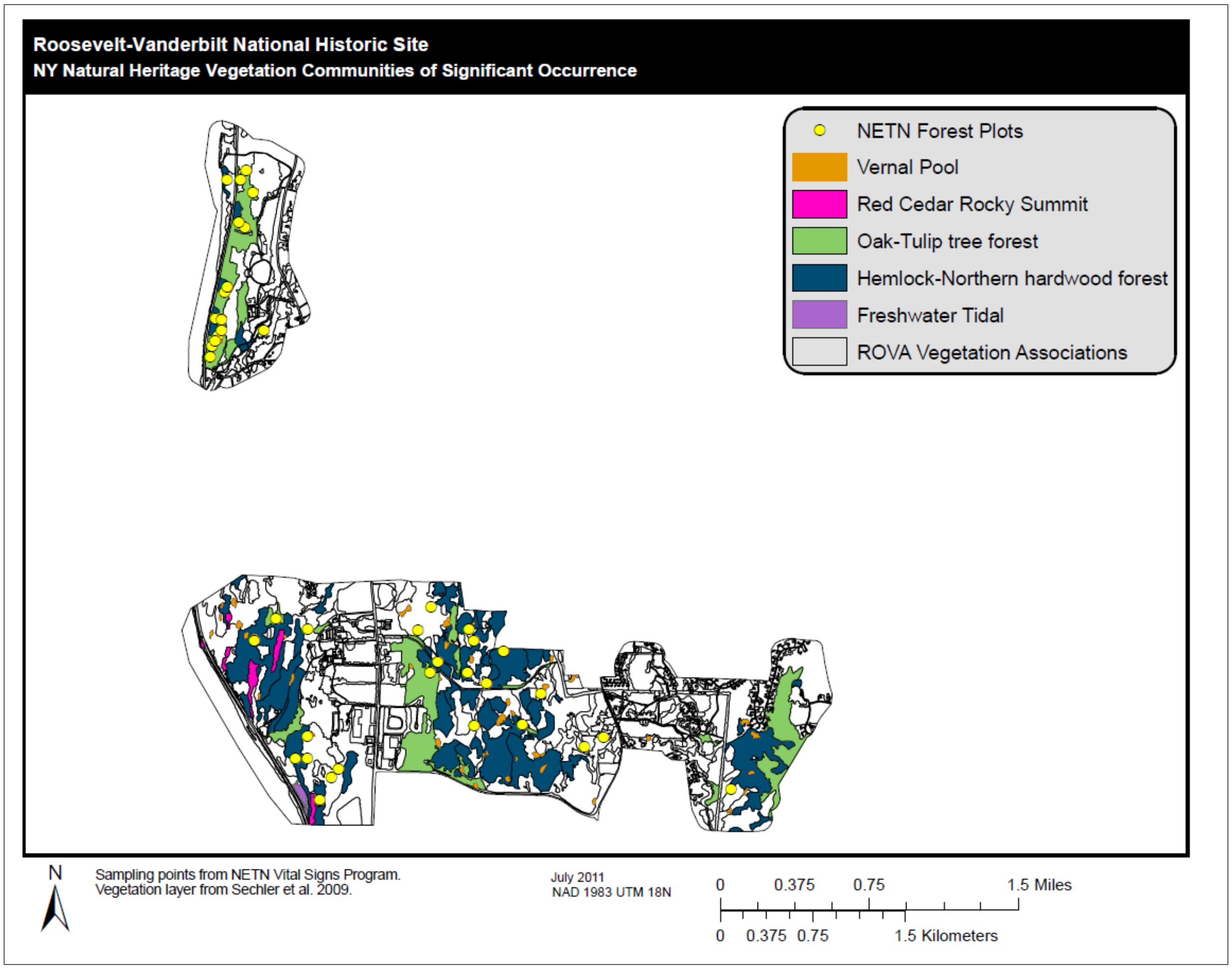


Figure 36. New York Natural Heritage vegetation associations of significant occurrence in ROVA (Sechler et al. 2009).

- **Attention to the Emerald Ash Borer**

Emerald ash borer (EAB) *Agrilus planipennis* (Coleoptera: Buprestidae) is an invasive wood boring beetle which predominantly attacks ash trees (*Fraxinus* spp.). Confirmed in North America in 2002, its introduction has spread to 13 states, with New York confirming EAB infestation in June 2009 in Cattaraugus County, and recently infesting trees west of Dutchess County in Ulster County (Figure 37), (NYDEC 2010a). ROVA has incorporated EAB traps within the park in 2011 and were negative for EAB when checked during the summer months. Additionally, EAB was not found in Dutchess County in 2011 (written communication David Hayes, NPS ROVA, February 3, 2012).

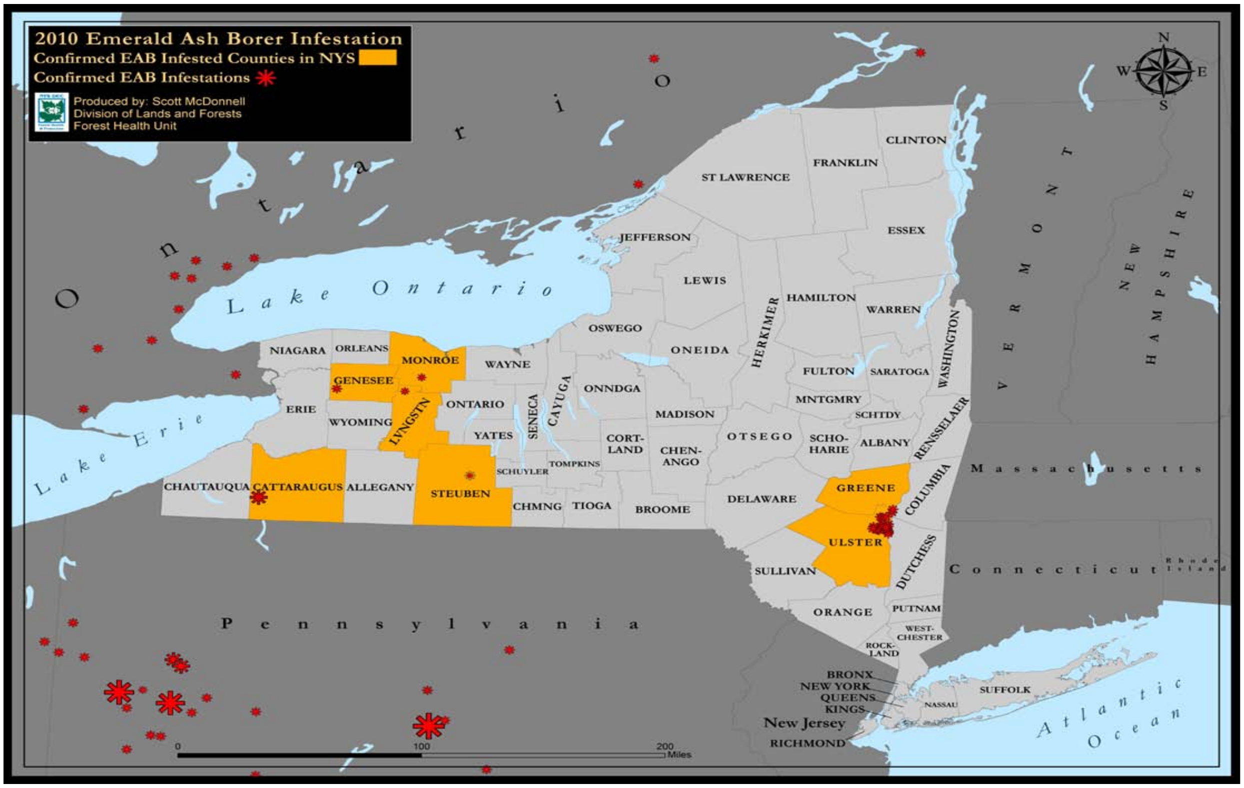


Figure 37. Emerald ash borer confirmed infestation distribution for New York State, 2010. Source: NYDEC 2010b (S. McDonnell). http://www.dec.ny.gov/animals/42674.html .

Although the natural spread of EAB is slow, (estimated at less than 5 miles per year), the rate increases 6 fold when human assisted (Smallidge et al. 2009). The infestation of EAB in seven New York counties has lead to the expansion of EAB quarantine areas within the U.S. to restrict the movement of ash products and firewood of all wood species. New York contains more than 900 million ash trees, with ROVA containing approximately 207 hectares of vegetation communities containing abundant species of mature ash ([e.g., green ash, black ash, and white ash], Sechler et al. 2009, NatureServe 2009) (Figure 38). Dutchess County has an estimated host tree volume from 289.14-2446.17 m^3/ha, with a calculated risk of EAB infestation equating as *extreme* (Table 11) (USDA Alien Forest Pest Explorer 2010). EAB infestation becomes fatal to healthy ash trees in 2 to 4 years, with signs of infestation including D-shaped exit holes in the outer bark, tree canopy dieback, yellowing, epicormic shoots and woodpecker damage from larvae extraction (New York Invasive Species Information, 2010). The loss of ash trees due to EAB infestation not only poses economic impacts but may induce direct and indirect ecological impacts on the forest canopy, leading to temperature changes (New York Invasive Species Information, 2010), habitat loss, food reduction for birds and mammals (Martin et al. 1951, Faanes 1984), loss of arthropods (Gandhi and Herms 2010), and increased air pollution (USDA APHIS 2010).

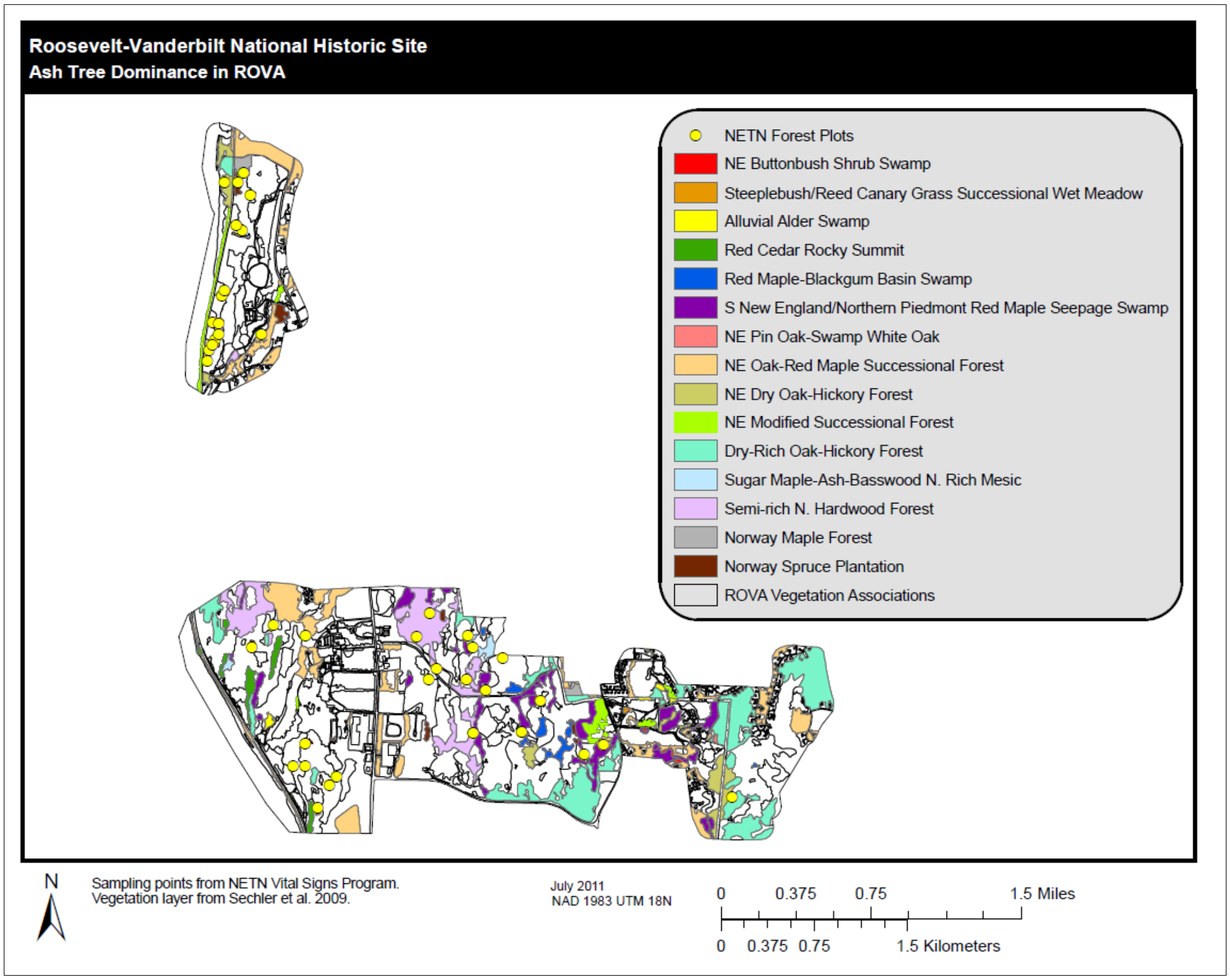


Figure 38. Ash tree dominated vegetation associations in ROVA (based on Sechler et al. 2009 survey).

Table 11. Pests identified as species of concern for NETN forests and their distribution and risk to ROVA and Dutchess County, NY forests.

Pest[1]	Scientific Name	Present in ROVA[2]	NETN Priority[2]	Present in Dutchess Co., NY[3]	Risk for Dutchess Co., NY[4]
Hemlock woolly adelgid	*Adelges tsugae*	yes	2	yes	high
Gypsy moth	*Lymantria dispar*			yes	high
Emerald ash borer	*Agrilus planipennis*		1	no	extreme
Balsam woolly aphid	*Adelges piceae*		2	no	low
Asian long-horned beetle	*Anoplophora glabripennis*		1	no	extreme
Sirex woodwasp	*Sirex noctilio*			no	low
Formosan subterranean termite	*Coptotermes formosanus*			unknown	unknown
European spruce bark beetle	*Ips typographus*			unknown	unknown
Butternut canker	*Sirococcus clavigignenti-juglandacearum*		2	yes	very low
Sudden oak death	*Phytophthora ramorum*		1	yes	extreme
Dogwood anthracnose	*Discula destructiva*			yes	very low
Beech bark disease	*Nectria coccinea*	yes	2	yes	medium
Elongate hemlock scale	*Fiorinia externa*	yes	2	yes	high

[1] Pest column does not indicate all potential species which may be detrimental to ROVA's forests. Species evaluated were identified as species of concern under the NETN Vital Signs Program as well as species listed as threats in ROVA's General Management Plan (USDI, NPS 2009).
[2] Miller et al. 2010.
[3] USDA Forest Service. 2010. Alien Forest Pest Explorer (AFPE). Data displayed in table represents mapping results generated on 7/20/2009.
[4] USDA Forest Service. 2010. Alien Forest Pest Explorer (AFPE). Data displayed in table represents mapping results generated on 7/20/2009. Risk category is associated with Host Tree Volume (m^3/ha) including: very low (0); low (0.45- 34.49); medium (34.49-116.05);high (116.05-298.3); extreme (298.3-2533.61).

Data and Methods

As part of the Northeast Temperate Network Vital Signs monitoring program, forest health has been monitored in ROVA in 2007 and 2009, with a total of 40 forest monitoring plots established in the park (N=24 plots ELRO/HOFR, N=16 plots VAMA) (Figures 34 - 36). Details of monitoring protocols for assessing forest health in NETN, specifically ROVA, can be found in Tierney et al. (2009, 2010). Trend analysis was not performed due to the temporal limitation of the NETN monitoring data. Metrics that have been used to assess ROVA's forest health based on initial data include the following:

- **Structural stage distribution***:* Forests recovering from disturbances may differ structurally from later successional stands. Disturbances such as human alteration have changed the structural stage distribution of forests, with distribution being further affected by factors such as climate change, pathogens and pests. The structural stage distribution of ROVA's forest is important for maintaining native vegetation species, which vary depending upon successional stages.

- **Snag abundance & Coarse Woody Debris***:* Standing dead trees (snags) and fallen coarse woody debris (CWD, defined as ≥ 10 cm diameter, ≥ 1 m long) are important dead wood structural features in forests that provide adequate habitat for species. Land management strategies can maintain and enhance snags and CWD, while other forest activities, such as hazard tree removal, can reduce the quantity and quality of these features.

- **Tree regeneration:** Tree regeneration assesses the future canopy structure and composition by addressing the current quantity and composition of advance tree regeneration in the forest understory. Significant impacts to tree regeneration can be affected by invasive species encroachment, climate change and heavy deer browsing pressure. Deer preferentially browse particular seedling species and size classes (30-75 cm tall; Cornett et al. 2000) and ROVA's forest community includes many tree species that are of palatability preference to deer (Table 12).

- **Tree condition/forest pest***:* Qualitative observations of specific tree health problems and canopy foliage condition can provide an early warning of problems or decline in canopy trees. As seasons progress, trees may develop minimal foliage problems. However, extensive damage to canopy foliage may be indicative of tree health problems. In particular, exotic pests and pathogens have the potential to severely impact forest tree composition, structure and function. Table 11 describes the distribution and risk of several forest pests within ROVA and Dutchess County, NY. Some pests have already invaded ROVA, such as the hemlock woolly adelgid. Others, such as the emerald ash borer, have not yet appeared at ROVA, but have been found in nearby counties and pose a significant threat to ROVA's vegetation communities (see subsection, "Attention to the Emerald Ash Borer").

- **Invasive exotic plants**-*See Invasive Exotic Terrestrial Plants Section*

- **Soil chemistry Ca:Al**-*See Soil Section*

- **Soil chemistry C:N**-*See Soil Section*

- **Landscape Context- Anthropogenic land use (ALU) and Forest Patch Size:** Historical alteration of forest habitat in the northeastern U.S. has resulted in highly fragmented forest patches which have been impacted by anthropogenic land use and disturbance. Impacts from fragmentation and anthropogenic alterations on forest condition includes reduction of interior forest habitat, increase in establishment of invasive species, biodiversity reduction and alteration of structural and compositional forest integrity (Austen et al. 2001, Boulinier et al. 2001, Fahrig 2003, Harper et al.

2005). Both forest patch size and ALU were used to investigate how the surrounding landscape may be influencing ROVA forest condition.

Reference Condition/Threshold Values Utilized
NETN Vital Signs ecological integrity scorecard (thresholds) and condition categories were used to assess ROVA's forest health These condition categories are based on ecological studies and management goals and included ratings of *good*, *caution* or *significant concern* for each forest metric. The combination of these metrics covers the forest's structural, compositional and functional integrity in relation to their natural and historical range of variation and theoretical modeling of metrics:

- **Structural Stage Distribution**

Existing structural stage distributions versus those expected under natural disturbance regimes was used as an indicator of altered disturbance regimes. Ratings based on expected percentage of late-successional forest stages across the landscape was compared to expected structural stage distributions based on the dominant matrix forest ecosystem (Miller et al. 2010). A category of *good* was indicated by ≥ 25% late-successional structure, *caution* was assigned for forests with < 25% late-successional structure and *significant concern* was categorized as < 25% combined mature *and* late-successional structure for ROVA (Miller et al. 2010, Table 13).

- **Snag Abundance & Coarse Woody Debris**

Assessing the percentage of standing trees that are snags and calculating the ratio of CWD volume to live tree volume are metrics that can be used to rate the condition of the forest community in ROVA. Forests that had ≥10% standing snags and ≥10% medium-large trees (medium-large trees are >30 DBH) as snags were rated *good*. Less than 10% standing tree snags or <10% medium-large trees as snags was categorized as *caution*. Less than 5 medium-large snags per hectare categorized the area as *significant concern* (Table 14). For CWD, forests >15% live tree volume was categorized as *good*, 5-15% live tree volume was *caution*, and <5% live tree volume was categorized as *significant concern* (Table 15).

- **Tree Regeneration**

Miller et al. (2010) assessed tree regeneration using a ratio of seedling species richness in browsed vs. unbrowsed size classes of preferred species (Sweetapple and Nugent 2004). This metric distinguished between a *good* and *caution* rating for this metric (Table 16). Additionally, an approach by McWilliams et al. (2005) which quantifies whether current seedling quantities are sufficient to restock a mid-Atlantic hardwood forest stand was used to assess minimum canopy tree stocking for ROVA, which was set at a stocking index of 25.

- **Tree Condition/Forest Pests**

A number of pest species pose serious threats to ROVA's forests if they advance into the northeast region, including *NETN Priority 1 pests*: Asian long-horned beetle, emerald ash borer and sudden oak death and *NETN Priority 2 pests*: balsam woolly adelgid, beech bark disease (severity > 2; heavily cracked bark with *Nectria* cankers or worse condition), butternut canker, elongate hemlock scale, and hemlock woolly adelgid. Priority 2 pests are forest pests which cause problems that are not as severe as Priority 1 pests. To incorporate the impact forest pests have on tree condition, plots with no Priority 1 or 2 pests received a *good* rating; plots with

Priority 2 pests or beech bark disease (BBD) >2 received a *caution* rating; plots with Priority 1 pests received a *significant concern* rating (Table 17).

- **Landscape Context-Forest Patch Size and Anthropogenic land use (ALU):**

Landscape context was analyzed using delineated forest patch size data at park level and adjacent land-use analyses at the level of the forest plot. Spatial analyses were performed on leaf-on orthophotography and incorporated into vegetation map delineations (Tierney et al. 2010). Forest patch size was defined as an area of continuous medium to high-canopy (≥8m height) forest vegetation with at least 60% overall canopy closure at least 0.5 ha (Tierney et al. 2010). Condition categories for forest patch size included: ≥50 ha rated *good*; patch 10 to less than 50 ha rated *caution*; patch 0.5 to less than 10 ha rated *significant concern* (Table 18). ALU condition categories were derived from theoretical models that examined the combined impacts of habitat loss and fragmentation (Tierney et al. 2010). These condition categories included: <10% anthropogenic land use rated *good*; 10-40% anthropogenic land use rated *caution*; >40% anthropogenic land use rated as a *significant concern* (Table 18).

Table 12. Listing of major tree species observed in ROVA during vegetation plot and thematic accuracy assessment sampling (NatureServe 2009) and rated by their potential to deer browsing.

Scientific name	Common name	Potential Deer Impact	Citation*
Acer rubrum	red maple	High	2
Acer saccharum	sugar maple	High	2
Cornus florida	flowering dogwood	High	1
Liriodendron tulipifera	tulip popular	High	2
Prunus pensylvanica	pin cherry	High	2
Sassafras albidum	sassafras	High	1
Thuja occidentalis	northern white cedar	High	1
Tilia americana	basswood	High	1
Tsuga canadensis	eastern hemlock	High	2
Betula alleghaniensis	yellow birch	Medium	2
Carya spp.	hickories	Medium	2
Fraxinus spp.	ashes	Medium	2
Hamamelis virginiana	witch hazel	Medium	1
Juglans nigra	black	Medium	1
Nyssa sylvatica	blackgum	Medium	3
Quercus spp.	oaks	Medium	2
Ulmus spp.	elm	Medium	1
Acer pensylvanicum	striped maple	Medium/Low	2
Fagus grandifolia	American beech	Medium/Low	2
Pinus resinosa	red pine	Medium/Low	1
Pinus rigida	pitch pine	Medium/Low	1
Pinus strobes	white pine	Medium/Low	1
Pinus sylvestris	scotch pine	Medium/Low	1
Alnus spp.	alder	Low	1
Betula papyrifera	paper birch	Low	1
Betula populifolia	graybirch	Low	1
Carpinus caroliniana	musclewood	Low	1
Crataegus spp.	hawthorn	Low	1
Juniperus virginiana	red cedar	Low	1
Larix laricina	tamarack	Low	1
Ostrya virginiana	hop hornbeam	Low	1
Picea spp.	spruces	Low	1
Populus spp.	aspens	Low	1
Prunus serotina	black cherry	Low	2
Rhamnus cathartica	buckthorn	Low	1
Robina pseudoacacia	black locust	Low	1

*1—New York State Department of Environmental Conservation (NYS DEC). A Preference List of Winter Deer Foods (www.dec.state.ny.us/website/dfwmr/wildlife/deer/foodlist.html); 2—USFS 2003. Forest Inventory and Analysis. Northeast Field Guide, Version 1.7, App. 12; 3—USFS Fire Effects Information System tree description. (www.fs.fed.us/database/feis/plants/index.html).

Table 13. Condition categories and assessment for evaluating structural stage distribution in ROVA (Miller et al. 2010).

	CONDITION CATEGORIES		**NETN Monitoring Scores** (Miller et al. 2010)	
			ELRO/HOFR	**VAMA**
Structural Stage Distribution	GOOD	≥ 25% late-successional structure	% late successional: 33% % mature and late successional: 83%	% late successional: 69% % mature and late successional: 94%
	CAUTION	< 25% late-successional structure		
	SIGNIFICANT CONCERN	< 25% combined mature *and* late-successional structure		

Table 14. Condition categories and assessment for evaluating snag abundance in ROVA (Miller et al. 2010).

	CONDITION CATEGORIES		**NETN Monitoring Scores** (Miller et al. 2010)	
			ELRO/HOFR	**VAMA**
Snag Abundance	GOOD	≥ 10% standing trees are snags and ≥10% med-lg trees are snags	% trees as snags (all sizes): 9.5% % trees as snags (M-L snags): 8% # of med-lg snags/ha: 11.5±4.8	% trees as snags (all sizes): 11.5% % trees as snags (M-L snags): 10.3% # of med-lg snags/ha: 10.9±3.2
	CAUTION	< 10% standing trees are snags or < 10% med-lg trees are snags		
	SIGNIFICANT CONCERN	< 5 med-lg snags/ha		

Table 15. Condition categories and assessment for evaluating coarse woody debris in ROVA (Miller et al. 2010).

	CONDITION CATEGORIES		NETN Monitoring Scores (Miller et al. 2010)	
			ELRO/HOFR	VAMA
Coarse Woody Debris	GOOD	> 15% live tree volume	26.9%±13.7 %	25.9%±5.6 %
	CAUTION	5 - 15% live tree volume		
	SIGNIFICANT CONCERN	< 5% live tree volume		

Table 16. Condition categories and assessment for evaluating tree regeneration in ROVA (Miller et al. 2010).

	CONDITION CATEGORIES		NETN Monitoring Scores (Miller et al. 2010)	
			ELRO/HOFR	VAMA
Tree Regeneration	GOOD	Seedling ratio ≥ 0	Miller et al. rated ELRO/HOFR as *significant concern*. Over 50% of plots ranked in this category.	Miller et al. stated VAMA rated *good*. Approximately 50% of plots ranked in this category.
	CAUTION	Seedling ratio < 0		
	SIGNIFICANT CONCERN	Stocking index range. For ROVA, index<25 is significant concern.		

Table 17. Condition categories and assessment for evaluating tree condition/forest pests in ROVA (Miller et al. 2010).

	CONDITION CATEGORIES		NETN Monitoring Scores (Miller et al. 2010)	
			ELRO/HOFR	**VAMA**
Tree Condition/Forest Pest	GOOD	Foliage problem < 10% *and* no priority 1 or 2 pests *and* BBD ≤ 2		
	CAUTION	Foliage problem 10 - 50% *or* priority 2 pest present *or* BBD > 2	Priority 2 pests present	Priority 2 pests present
	SIGNIFICANT CONCERN	Foliage problem > 50% *or* priority 1 pest present		

Table 18. Condition categories and assessment for landscape context metrics of forest patch and anthropogenic land use (ALU) in ROVA (Miller et al. 2011).

<table>
<tr><th rowspan="2"></th><th rowspan="2" colspan="2">CONDITION CATEGORIES</th><th colspan="3">NETN Monitoring Scores
(Miller et al. 2011)</th></tr>
<tr><th>ELRO</th><th>VAMA</th><th>HOFR</th></tr>
<tr><td rowspan="3">Forest Patch</td><td>GOOD</td><td>Patch ≥ 50 ha</td><td rowspan="3">Majority (60%) of patch area rated good</td><td rowspan="3">60% patch area good

40% patch area rated caution</td><td rowspan="3">Over 98% patch area rated good</td></tr>
<tr><td>CAUTION</td><td>Patch is 10 to less than 50 ha</td></tr>
<tr><td>SIGNIFICANT CONCERN</td><td>Patch is 0.5 to less than 10 ha</td></tr>
<tr><td rowspan="4">Anthropogenic Land Use (ALU)</td><th colspan="2">CONDITION CATEGORIES</th><th>ELRO/HOFR
N=24 plots</th><th colspan="2">VAMA
N=16 plots</th></tr>
<tr><td>GOOD</td><td>Less than 10% ALU</td><td rowspan="3">Plot average 5.2%</td><td colspan="2" rowspan="3">Plot average 23.2%</td></tr>
<tr><td>CAUTION</td><td>10-40% ALU</td></tr>
<tr><td>SIGNIFICANT CONCERN</td><td>> 40% ALU</td></tr>
</table>

Condition and Trend

- **Structural Stage Distribution**

Structural stage distribution in ELRO/HOFR and VAMA was categorized as *good*, indicating that the distribution of forest successional stages in ROVA is within the range of natural variation (Table 13). ELRO/HOFR had 33% late successional structure and 83% mature and late successional structure. VAMA contained 69% late successional structure and 94% mature and late successional structure.

- **Snag Abundance & Coarse Woody Debris**

ELRO/HOFR was categorized as *caution* due to 9.5% of trees being snags, with only 8% of medium-large trees constituting as snags. VAMA rated *good* for snag abundance, with 11.5% and 10.3% of trees as snags for all size trees and medium-large size trees, respectively (Miller et al. 2010, Table 14). ELRO/HOFR and VAMA were both categorized as *good* for CWD (26.9% and 25.9% live tree volume, respectively) (Table 15).

- **Tree Regeneration**

ELRO/HOFR rated *significant concern* and VAMA was categorized as *good* for tree regeneration (Table 16). Low regeneration at ELRO/HOFR may also be a concern, as over half of the plots sampled in ELRO/HOFR were categorized as *significant concern.* Oak (*Quercus* spp.) regeneration is rare in VAMA and ELRO/HOFR, while hemlock (*Tsuga canadensis)* regeneration is low in ELRO/HOFR. Tulip popular (*Liriodendron tulipifera)* regeneration is absent in both ELRO/HOFR and VAMA. Beech (*Fagus* sp.), white ash (*Fraxinus americana*) and red maple (*Acer rubrum*) were greater as seedlings and saplings than as canopy species of all park subunits (Figure 39). Low tree regeneration has been linked to the loss of soil nutrients associated with atmospheric acid deposition, especially for tree species such as the sugar maple (*Acer saccharum*) (Driscoll et al. 2001, Long et al. 2009). Conversly, the maple species, red maple (*Acer rubrum*) tends to be more tolerant of acid deposition than other species. ROVA rated *significant concern* for atmospheric total sulfur and total nitrogen wet deposition levels (Table 3) and *caution* for acid stress in soils samples (See Soil Section 4.5). Based on these air and soil results for ROVA, the notion of low tree regeneration existing in ROVA due to acid deposition effects cannot be excluded, especially with the greater stems/ha of the acid tolerant red maple (*Acer rubrum*) being measured in ROVA forests (Figure 39).

- **Tree Condition/Forest Pests**

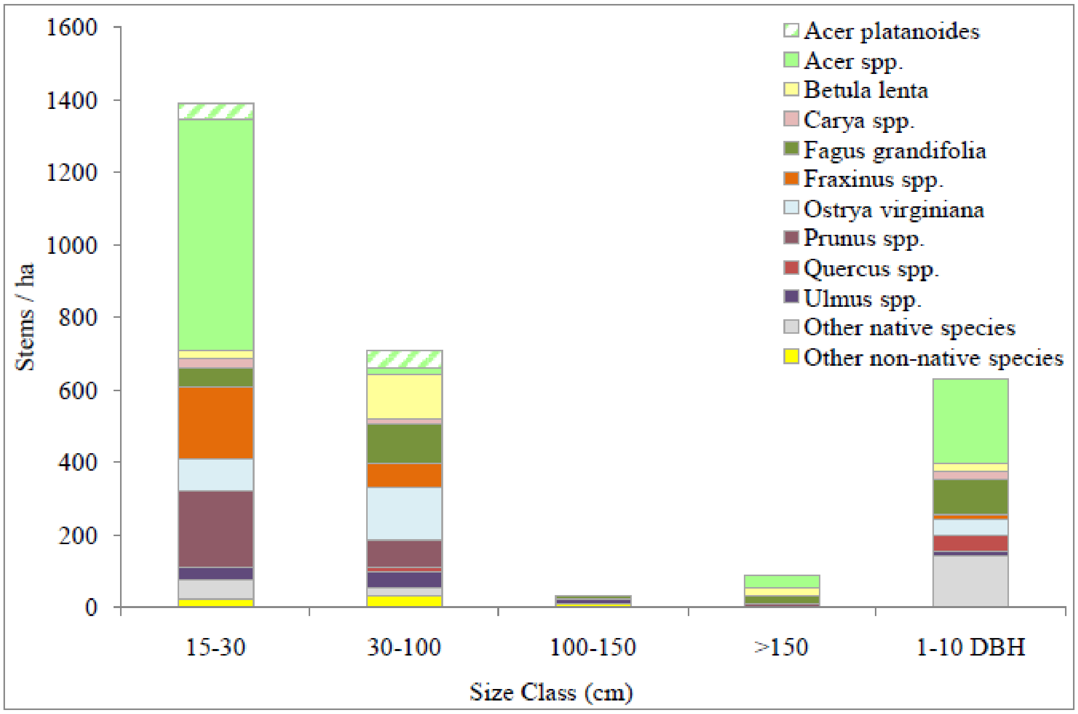
Hemlock woolly adelgid was detected in seven plots in ELRO/HOFR. Beech bark disease was also identified as occurring in ELRO/HOFR, thus receiving a *caution* condition rating (Table 17). One plot in VAMA contained hemlock woolly adelgid and elongated hemlock scale and received a *caution* rating for tree condition/forest pests (Miller et al. 2010). Over 150 hectares of hemlock occupy ROVA's environment and are at risk for attack by the hemlock woolly adelgid and elongated hemlock scale (Sechler et al. 2009, Figure 40). Although eastern hemlock is the second most common tree species (based on stem density) in the ELRO/HOFR sites and third most common at VAMA, no eastern hemlock seedlings and only a few saplings were observed in the 40 plots located throughout ROVA during a 2009 survey (Miller et al. 2010).

- **Landscape Context-Forest Patch Size and Anthropogenic land use (ALU):**

Over 98% of forest area in HOFR was categorized as *good* for patch size. 60% of the forest patch in VAMA rated *caution* and 40% rated *significant concern*. Patch size results for ELRO were mixed, as 60% of forest patch area was categorized as *good* for a 170 ha patch and the remaining 40% in ELRO was split between *caution* and *significant concern* (Table 18). Neighborhood ALU calculation for VAMA was categorized as *caution* while ELRO/HOFR rated *good*, with approximately 5% neighborhood ALU. The eastern section of HOFR had the least amount of neighborhood ALU (Table 18). Overall HOFR and ELRO have good forest buffer around portions of the park boundary and development or clearing of these areas may impact forest health by increasing risk of invasive species (Figures 41, 42).

<u>Data Gaps and Confidence in Assessment</u>

Confidence in the assessment was high, but any trend analysis was limited by a present lack of sufficient time series data. Continued monitoring of the forest plots in ROVA will enable managers to develop trend analyses for these metrics, with the number of years to monitor forest plots for trend based on study objectives and statistical power analyses. The continued monitoring of the forest understory in ROVA will allow ground truthing to be performed within the park and offer a 'soil to sky' view of forest health. For example, biotic homogenization within the park is beginning to be measured by NETN with the inclusion of exotic earthworm monitoring. The continued investigation of biotic homogenization in the understory will enable managers to detect if biodiversity is declining over time due to processes such as invasive plant and animal species, environmental modifications due to anthropogenic activity and climate change. Future forest monitoring plot locations in ROVA should be included within the globally rare vegetation or vegetation associations of significant occurrence.



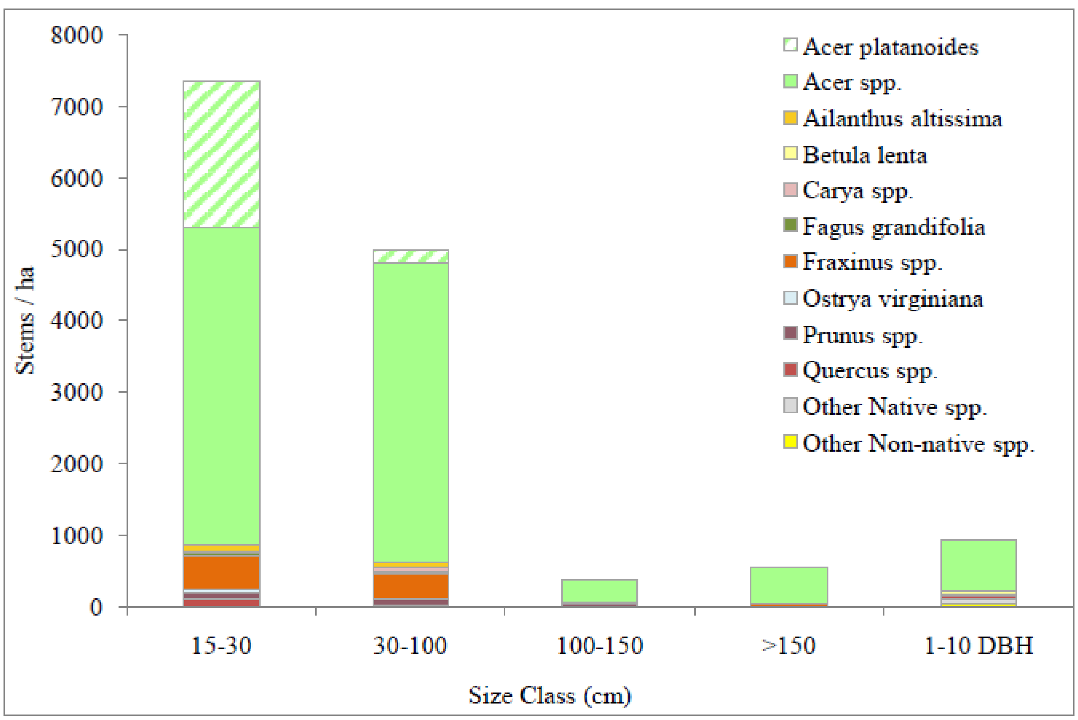


Figure 39. Density of seedlings and saplings in Roosevelt-Vanderbilt NHS in ELRO/ HOFR (top graph) and VAMA (bottom graph). Classes 15-30, 30-100, 100-150 and > 150cm (for individuals with diameter at breast height < 1) reflect seedling height, and 1-10 DBH reflects sapling diameter at breast height (from Miller et al. 2010).

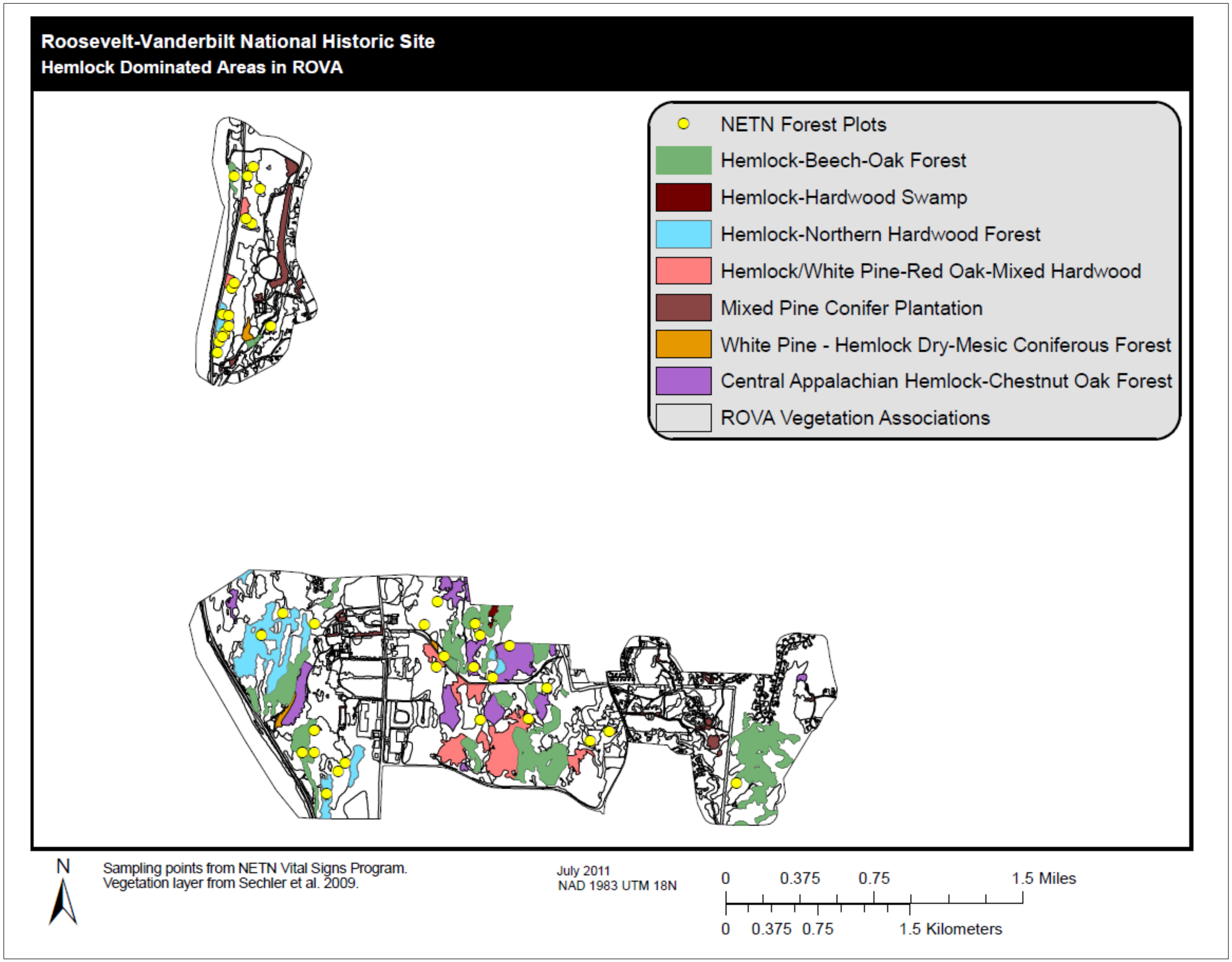


Figure 40. Hemlock dominated vegetation associations in ROVA.

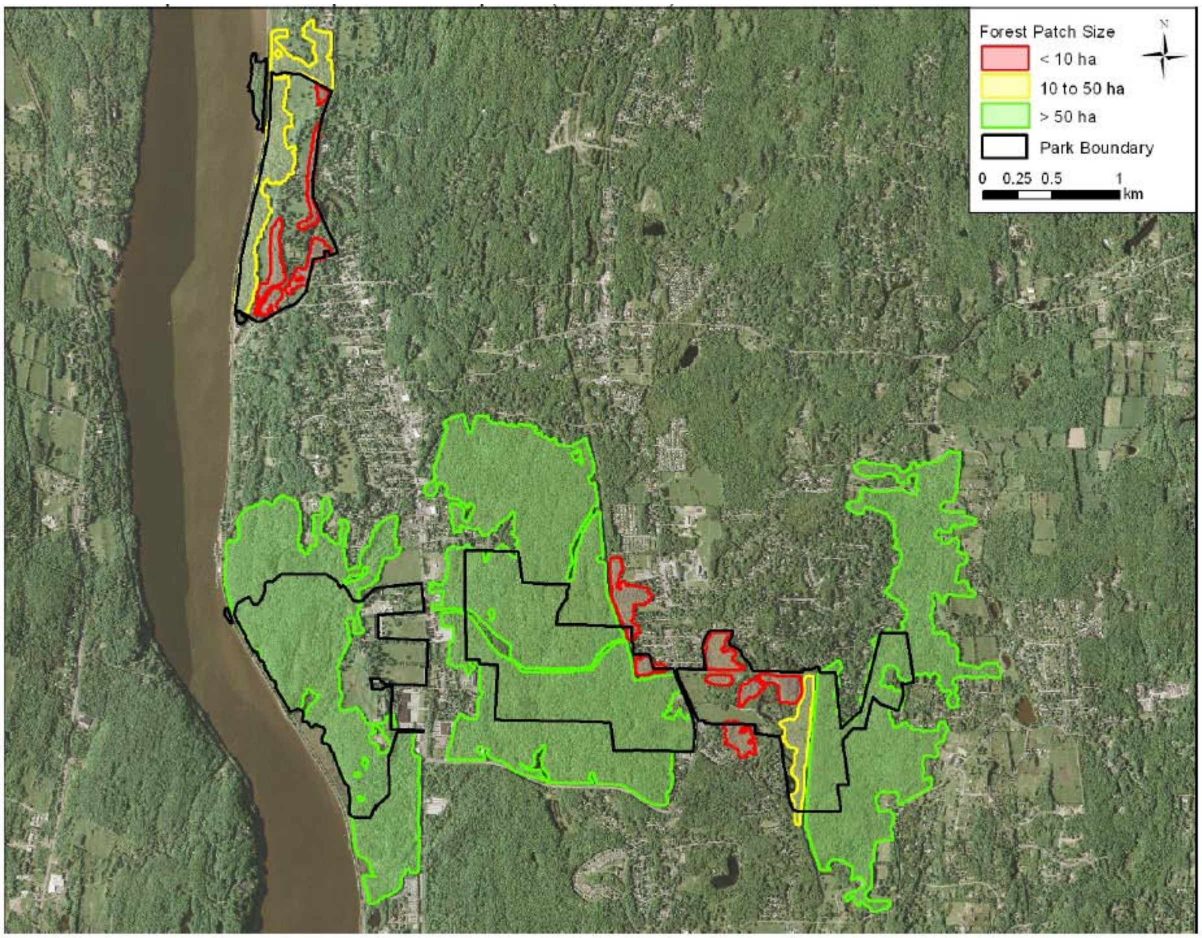


Figure 41. Forest patch delineations for ROVA (2007 boundary). Figure from Miller et al. (2011).

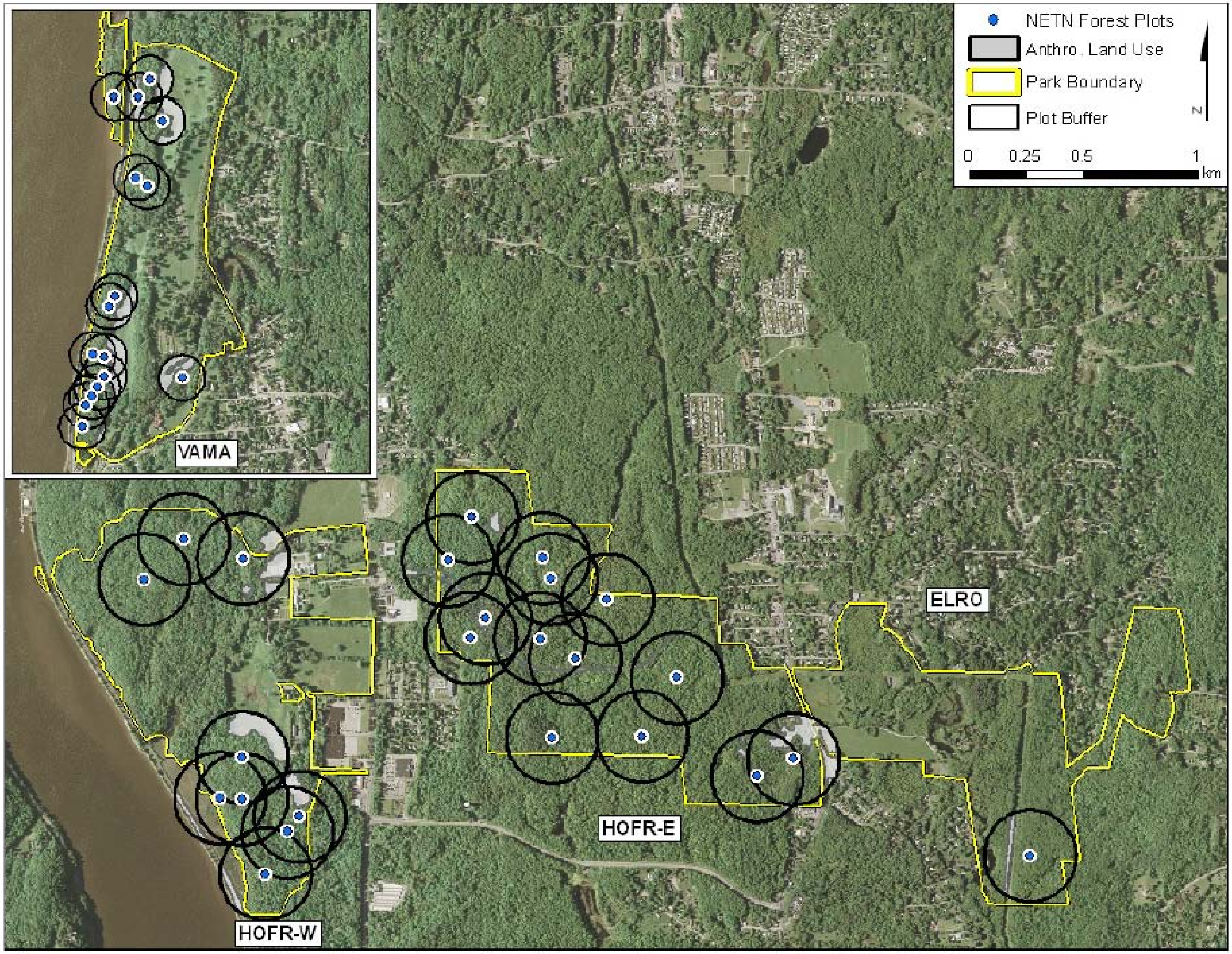


Figure 42. Anthropogenic Land Use (ALU) areas calculated for areas buffered around NETN forest plots. Figure from Miller et al. (2011).

4.4.4 Fish Community

Relevance and Context

ROVA contains streams, impoundments, and freshwater marshes which support a variety of fishes. These habitats have been surveyed by Fall Kill Watershed Committee (Bean 2006), Mather et al. (2003, Appendix I), Schmidt (1986, 1987, 1995), and Pandullo Quirk Associates (1979), with approximately 30 species being documented in these aquatic systems (Table 19). Endangered, threatened, or fishes of species of concern listed under New York State section 182.2 (g, h, i) of 6NYCRR Part 182 have not been found in ROVA's waterbodies based on the above surveys (excluding the Hudson River fish community which does contain endangered and candidate fish species). A unique species, American eel (*Anguilla rostrata*), is the only catadromous fish on the east coast and has been found in Crum Elbow Creek, Roosevelt Cove, and Fall Kill. Several nonindigenous species, such as bluegill, are in ROVA's habitats but have been present in these systems for over 100 years (Mather et al. 2003). Fish habitat in ROVA can be altered from sedimentation, invasive species colonization, or alteration of water chemistry due to surrounding development activities.

Data and Methods

New York State currently has not developed an Index of Biotic Integrity (IBI) of fish communities for the State's waterbodies. Daniels et al. (2002) developed the Northern Mid-Atlantic Slope Drainage IBI which encompasses waterbodies within the Hudson, Delaware and Susquehanna River basins based on fish assemblage data from the Mohawk River drainage of New York, with Fall Kill at Poughkeepsie, New York being sampled to assess the validity of this IBI. The Northern Mid-Atlantic Slope Drainage IBI was used in conjunction with the most recent fish survey (2000) in ROVA (Mather et al. 2003) to assess the condition of the park's fish community (Table 20). Crum Elbow Creek and the unnamed stream were assessed while Fall Kill was not included in this condition assessment due to data collected from Mather et al. (2003) being from a single sampling date, one site and one unit of effort. Ponds located in ROVA were not assessed using this IBI, which was developed for lotic systems. Although the catadromous American eel is present in ROVA's waterbodies, it was removed from the IBI analysis as suggested by Daniels et al. (2002). Trend analysis was not conducted due to a lack of quantitative, temporal data available for ROVA's fish community.

Reference Condition/Threshold Values Utilized

The Northern Mid-Atlantic Slope Drainage IBI uses 12 metrics (Table 20) which have been modified from the Midwestern IBI (Karr 1986), with each condition metric scoring either a 1 (poor), 3 (intermediate) or 5 (best condition) based on fish assemblage data. An overall IBI score is based on the sum of the condition metric scores (i.e., 1, 3, or 5) and is then applied to the final categorical scoring based on Karr et al. (1986) (e.g., no fish, 12-22=very poor, 28-34=poor, 40-44=fair, 48-52=good, 58-60=excellent). Due to the sampling design of the most recent fish data collected in ROVA (Mather et al. 2003) a final metric IBI score could not be calculated due to the absence of specific measurements needed for various metrics, specifically metrics 10-12 (Table 20). Due to this absence, nine out of the twelve metrics were assessed and given a condition metric score of either 1, 3 or 5 for Crum Elbow Creek and an unnamed stream. These condition metric scores are not indices and should not be used to deduce the overall integrity of the waterbody. However, Karr (1986) noted that it is often of value to examine individual metrics and these are reported in Table 20.

Condition and Trend

For Crum Elbow Creek, there was a single metric indicating *poor* condition, three metrics scoring *intermediate* conditions and five metrics scoring *best* conditions. Crum Elbow Creek is thus in intermediate to best condition based on the October 2000 sampling data. For the unnamed stream, three metrics scored *poor* condition, two in *intermediate* condition, and four in *best* condition. Both streams scored *poor* for the '% dominant species' metric, due to the high number of blacknose dace in the streams. The unnamed stream scored *poor* for the 'number of terete minnow species' and the '% of individuals that are top carnivores'. Trend could not be assessed for ROVA's fish community.

Data Gaps and Confidence in Assessment

The confidence in the assessment was fair and trend analysis was limited. This condition assessment was based on the best available data for ROVA, which was one survey conducted in ROVA in 2000. Additionally, an overall IBI score could not be calculated due to a lack of fish community data needed for three metrics but the analysis of individual metrics serve value in the assessment of structural composition and function of the fish community. An assessment of ROVA's fish community with the inclusion of the 'fish abundance and condition' metrics (Table 20) will provide managers with an overall condition assessment for the park.

Table 19. Fish species documented during surveys conducted in waterbodies within ROVA. One survey (a) was located directly outside of ROVA's boundaries.

		ELRO		VAMA				HOFR	
Scientific Name	**Common Name**	**Fall Kill Creek**	**Upper ValKill Pond**	**Crum Elbow Creek**	**unnamed pond**	**Middle Pond**	**Upper Pond**	**Unnmaed stream/ Meriches Kill**	**Roosevelt Cove**
Alosa pseudoharengus	alewife	X [c]							X [c]
Ambloplites rupestris	rock bass	X [c]	X [b]	X [bc]	X [c]		X [b]		
Ameiurus nebulosus	brown bullhead		X [b]						
Anguilla rostrata	American eel	X [ac]		X [bc]				X [bc]	X [c]
Apeltes quadracus	fourspine stickleback								X [c]
Carassius auratus	goldfish	X [f]							
Catostomus commersoni	white sucker	X [ac]	X [b]					X [b]	
Cyprinus carpio	carp								X [c]
Esox americanus	redfin pickerel	X [bc]	X [b]		X [c]		X [b]	X [b]	
Esox niger	chain pickerel			X [e]			X [b]		
Etheostoma nigrum	Johnny darter							X [b]	
Etheostoma olmstedi	tessellated darter	X [a]							
Exoglossum maxillingua	cutlips minnow			X [bc]					
Fundulus diaphanus	banded killifish							X [b]	X [c]
Fundulus heteroclitus	mummichog							X [b]	X [c]
Ictaluridae	catfish	X [f]							
Lepomis auritus	redbreast sunfish	X [abc]		X [bc]	X [c]	X [b]	X [b]	X [b]	X [c]
Lepomis gibbosus	pumpkinseed	X [ac]			X [c]	X [b]	X [b]	X [b]	
Lepomis macrochirus	bluegill	X [ac]	X [b]		X [c]				
Luxilus cornutu	common shiner			X [bc]					
Micropterus salmoides	largemouth bass	X [ac]			X [c]	X [b]	X [b]		
Morone americana	white perch								X [c]
Notemigonus crysoleucas	golden shiner	X [ac]			X [c]			X [b]	
Notropid sp.	minnow	X [f]							
Notropis hudsonius	spottail shiner								X [c]
Percaflavescens	yellow perch			X [e]					X [c]
Pomoxis nigromaculatus	black crappie				X [c]				
Rhinichthys atratulus	blacknose dace	X [a]		X [bc]				X [bc]	
Salmo trutta	brown trout			X [e]					
Semotilus atromaculatus	creek chub							X [b]	

[a] Fall Kill Watershed Committee (Bean 2006) -Dorsey Rd. below ELRO sampled in 2004; [b] Mather et al. (2003) sampled in 2000; [c] Schmidt (1995) sampled in 1995, [d] Schmidt (1986)-used report to identify species not found in other studies; [e] Schmidt et al. (1987)-used report to identify species not found in other studies; [f] Pandullo Quirk Associates (1979)-used report to identify species not found in other studies.

Table 20. IBI metrics for the Northern Mid-Atlantic Slope drainages (Daniels et al. 2002) with calculated metric values and condition metric scores (in parentheses) for Crum Elbow Creek and unnamed stream (in ROVA based on Mather et al. (2003) sampling data. Metrics 10-12 could not be assessed due to lack of specific data measurements. 1 (*poor*), 3 (*intermediate*), 5 (*best condition*).

	Index of Biotic Integrity metric	calculation (*condition metric score*) Crum Elbow Creek	Unnamed stream*
	species richness and composition		
1	total number of fish species[a]	5 (***3***)	10 (***5***)
2	# of benthic-insectivorous species [a]	2 (***5***)	2 (***3***)
3	# of water column species [a]	2 (***3***)	5 (***5***)
4	# of terete minnow species [a]	1 (***3***)	1(***1***)
5	% dominant species[b]	60.4% (***1***)	71% (***1***)
6	% of individuals that are white suckers[c]	0% (***5***)	1% (***5***)
	trophic composition		
7	% of individuals that are generalists[d]	15.1% (***5***)	25% (***3***)
8	% of individuals that are insectivores[e]	79% (***5***)	74% (***5***)
9	% of individuals that are top carnivores[f]	5.7% (***5***)	0% (***1***)
	fish abundance and condition		
10	fish per sample[g]		
11	% of species represented by two size classes[h]		
12	proportion of individuals with disease, tumors, fin damage, or other anomalies[i]		

[a] See Daniels et al. (2002) for calculation using maximum species richness line (MSRL)
[b] 5:<40%, 3:40-55%, 1:>55%
[c] 5:<3%, 3: 3-15%, 1:>15%
[d] 5:<20%, 3:20-45%, 1:>45%
[e] 5:>50%, 3:25-50%, 1:<25%
[f] 5:>5%%, 3:1-5%, 1:<1%
[g] See Daniels et al. (2002) for calculation using maximum density line (MDL)
[h] 5:>40%, 3:15-40%, 1:<15%
[i] 5:0%, 3:0-1%, 1:>1%
*Mather et al. (2003) referred to as Meriches Kill.

4.4.5 Aquatic Macroinvertebrate Community

Relevance and Context

To date, there is a limited routine collection and publication of aquatic macroinvertebrate data from waterbodies in ROVA boundaries. A 1988 survey was conducted sampling the aquatic invertebrate community in relation to the aquatic plant community in Roosevelt Cove (Kelly and Perotte 1989). The use of aquatic macroinvertebrates to address general water quality conditions using various indices has been conducted in and around ROVA boundaries on a limited basis by the New York State Department of Environmental Conservation (NYSDEC) and by a local watershed committee (Bean et al. 2006). The use of benthic macroinvertebrate species to determine water quality is due to their specific environmental requirements including habitat structure, food source, flow regime, temperature and water chemistry. Therefore, the structure of the macroinvertebrate community will become altered as these physical and chemical variables change. Macroinvertebrate community structure metrics such as species richness, Ephemeroptera-Plecoptera-Trichoptera (EPT) value, biotic index and percent model affinity are measured in order to assess the overall water quality of streams in New York State.

Data and Methods

Aquatic macroinvertbrate community integrity was based on reported assessments by the New York State Department of Environmental Conservation Stream Biomonitoring Unit for streams sampled within or buffered around 1 mile of ROVA boundaries and a local watershed group's sampling efforts. Based on NYSDEC protocol (www.dec.ny.gov/chemical/8459.html) four parameters- species richness, EPT value, Hilsenhoff Biotic Index and percent model affinity- were used to calculate a biological assessment profile of index values for riffle habitats based on data collection efforts. Values of the four indices were converted to a common 0-10 scale which represented the assessed impact for each site of *non-impacted*, *slightly impacted*, *moderately impacted*, or *severely impacted.* Trend analysis could not be performed on these limited biological temporal datasets.

Reference Condition/Threshold Values Utilized

The threshold was based on statewide assessments of benthic macroinvertebrate communities using the New York Biological Assessment Profile of Index Values for Riffle Habitats (www.dec.ny.gov/chemical/8459.html). Four levels of water quality impact based on the integrity of macroinvertebrate assemblages included: *non-impacted*, *slightly impacted*, *moderately impacted* and *severely impacted* (Table 21). A *non-impacted* site based on macroinvertebrate data reflected an environmental reference condition with excellent water quality. In this ecological state, the macroinvertebrate community was considered diverse, with at least 27 species in riffle habitats, EPT richness was greater than 10, the biotic index value was 4.50 or less and percent model affinity was greater than 64.

Table 21. New York State Water Quality Assessment Criteria Using Benthic Macroinvertebrates for Non-Navigable Flowing Waters (From Bode et al. 1995).

Impact Level	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity
Non-Impacted	>26	0.00-4.50	>10	>4
Slightly Impacted	19-26	4.51-6.50	6-10	3.01-4.00
Moderatly Impacted	11-18	6.51-8.50	2-5	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	0.00-2.00

Condition and Trend

Based on published reports, the surveyed streams inside ROVA boundaries were all considered *slightly impacted* based on New York State Biological Assessment Profile categories for benthic macroinvertebrates (Table 22, Figure 43). These macroinvertebrate communities in ROVA were slightly but significantly altered from the pristine non-impacted (reference) state. Species richness was between 19-26, EPT richness was between 6-10, the biotic index values were 4.51-6.50, and the percent model affinity was 50-64 for these slightly impacted streams. The impacts to ROVA's streams were most likely due to impoundment or nonpoint nutrient additions. Crum Elbow Creek was assessed at two sites within VAMA boundaries and three sites outside VAMA in 1995 (Bode et al. 1995). Macroinvertebrate scoring metrics indicated the sites inside VAMA were *slightly impacted* primarily due to effects of impoundment. Sites outside VAMA boundaries were assessed as *slightly impacted* and one site was *non-impacted*. In 1998, one of the VAMA sites was reassessed and results indicated *slightly impacted* water quality conditions due to impoundment upstream of Route 9 (Bode et al. 2004). Fall Kill was assessed in 1997 at one site above ELRO (Haviland Rd.) and macroinvertebrate metrics indicated it was *slightly impacted* (Bode et al. 1998). The sources of impact were determined to be primarily nonpoint from nutrient additions from the Hyde Park area. In 2004, macroinvertebrates were sampled on the Fall Kill below ELRO by the Fall Kill Watershed Committee (2006). This site was *slightly impacted* based on a biological assessment profile. Maritje Kill was assessed as *slightly impacted* by nonpoint source nutrient enrichment based on a 2002 sampling event near Hyde Park (Bode et al. 2004).

Data Gaps and Confidence in Assessment

The confidence in the assessment is fair and trend analysis was limited. The lack of recent inventories and assessments of ROVA's aquatic macroinvertebrate community decrease the confidence of this assessment. A recent study by Cuffney et al. (2010) found that the number of aquatic insects, especially those that are pollution sensitive, declines in urban and suburban streams at low levels of development, often at levels considered protective for stream communities. The importance of monitoring the aquatic macroinvertebrate community is vital as development of the landscape surrounding ROVA's waterways is projected to increase due to population growth (See Chapter 2). The incorporation of using macroinvertebrates to assess environmental changes and water quality has been featured as a NETN Vital Signs metric, but to date, a sampling program has not been established for the park.

Table 22. Summary of aquatic macroinvertebrate sampling locations and IBI results for locations in or near ROVA streams.

Stream	Sampling Location Nearest to ROVA	Year	Assessment
Crum Elbow	Hyde Park, below Route 9	1995	Slightly impacted
	Hyde Park, coach house service road	1995	Slightly impacted
	Hyde Park, coach house service road	1998	Slightly impacted
	Hyde Park, 20 m below Market St	1995	Slightly impacted
	Off Howard Blvd	1995	Non impacted
	East of Route 9	1995	Slightly impacted
Fall Kill	Hyde Park, at Haviland Road Bridge	1997	Slightly impacted
	E. Dorsey Rd. bridge	1997	Slightly impacted
	Dorsey Lane	2004	Slightly impacted
Maritje Kill	Hyde Park CR40A bridge	2002	Slightly impacted

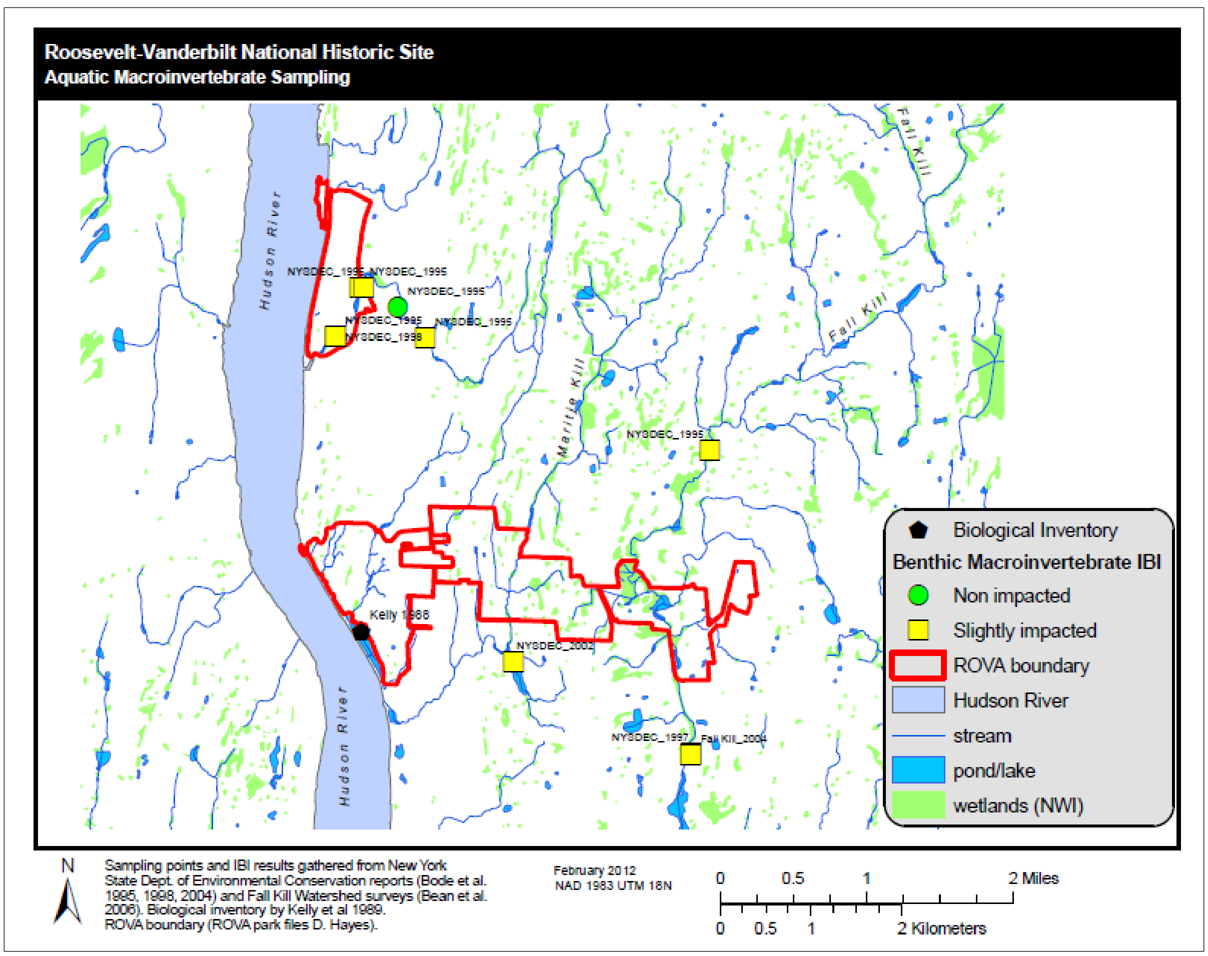


Figure 43. Historical macroinvertebrate sampling locations for species inventory and IBI. Benthic macroinvertebrate IBI results, investigators and year for each sampling location.

4.4.6 Birds

Relevance and Context

Breeding birds are excellent indicators of biotic integrity and ecosystem health because they are visible and vocal, easy to monitor, and individual species have specific habitat requirements and levels of sensitivity making them useful for tracking changes that may be impacting other species that are harder to measure. In addition, there is considerable public interest in birds, there are standardized methods for surveying birds, and there are many skilled amateurs who can assist with data collection at multiple levels from reporting the presence of a species at a park to conducting point count surveys. ROVA is located within Bird Conservation Region BCR13- Lower Great Lakes/St. Lawrence Plain and Partners in Flight Bird Conservation Region 17- Northern Ridge and Valley Physiographic Region (Rosenberg and Robertson 2003) http://www.partnersinflight.org/bcps/plan/pl_17_10.pdf. Priority species organized by habitat type are given in Table 23. The list includes species of both regional and continental importance. Land birds of conservation concern listed for BCR 13 include: Black-billed Cuckoo, Bobolink, Canada Warbler, Cerulean Warbler, Golden-winged Warbler, Henslow's Sparrow, Red-headed Woodpecker, Sedge Wren, Upland Sandpiper and Whip-poor-will.

Henslow's Sparrow (Ammodramus henslowii). Photo by NYS DEC Patricia L. Nelson.

Sedge Wren (Cistothorus platensis). Photo by U.S. National Park Service.

Table 23. Partners in Flight priority habitat-species suites for Area 17 (Northern Ridge and Valley). Species are sorted according to action level. Scale of Concern indicates whether a species is of continental (C) or regional(R) concern (Rosenberg and Robertson 2003).

Species	Scale of Concern	Action Level[a]
Shrub-Early Successional Habitat		
Golden-winged Warbler	C	IM, MO
American Woodcock	C	MA
Field Sparrow	R	MA
Eastern Towhee	R	MA
Willow Flycatcher	C	MA
Brown Thrasher	R	MA
Blue-winged Warbler	C	PR
Prairie Warbler	C	PR
Deciduous (oak-hickory) and riparian forest		
Worm-eating Warbler	C	MA
Cerulean Warbler	C	MA, MO
Red-headed Woodpecker	C	MA
Eastern Wood-Pewee	R	MA
Louisiana Waterthrush	R	PR
Wood Thrush	C	PR
Scarlet Tanager	R	PR
Kentucky Warbler	C	PR
Baltimore Oriole	R	PR
Agricultural / Grassland Habitat		
Henslow's Sparrow	C	IM, MO
Upland Sandpiper	C	MA, MO
Sedge Wren	R	MA, MO
Grasshopper Sparrow	R	MA
Northern hardwood-mixed forest		
Olive-sided Flycatcher	C	MA
Eastern Wood-Pewee	R	MA
Louisiana Waterthrush	R	PR
Wood Thrush	C	PR
Scarlet Tanager	R	PR
Canada Warbler	C	PR
Freshwater wetland		
American Black Duck	C	MA
King Rail	C	MA, MO
Wood Duck	R	PR
Bald Eagle	R	PR

a Action levels: IM = immediate management or policy needed to prevent regional extirpation; MA = management or other actions needed to reverse or stabilize declining populations or reduce Threats; MO = additional monitoring needed to better understand status or population trends

Data and Methods

The following is a list of the types of data sets that are available for ROVA with information on our assessment of how each data set might contribute to the evaluation of resource conditions.

Standardized Surveys

For the birds of ROVA, there are a number of data sets that provide information on the bird community. The most significant ones are described below.

- *Trocki and Paton (2003*) quantitatively assessed populations of birds at ROVA during 2002-2003. For data collection and analysis, they considered the three separate units which make up ROVA (HOFR, ELRO, and VAMA) as one unit. They established randomly generated survey points across the park with the abundance of points per habitat type based on the abundance of that particular habitat type within the park. This resulted in 41% of the stations in forest habitat (deciduous, mixed, and conifer combined), 32% in managed landscapes (lawns and landscape plantings), 15% in open grassland, 7% in forested wetlands and 5% in freshwater wetlands. They surveyed breeding birds at these points in 2002 and 2003. In addition, they conducted waterbird surveys along the adjacent Hudson River from February – May 2003. A total of 81 species were detected with 62 detected during point counts and 19 detected during the waterfowl surveys. From these data, they surmised that 42 species were breeding within the park. The most abundant species within the park were tufted titmouse (scientific names given in appendix), red-eyed vireo, and American crow. Five of the breeding species are listed as Partner's in Flight priority species (Wood Thrush, Worm-eating Warbler, Eastern Wood Pewee, Scarlet Tanager and Baltimore Oriole).This study provided a comprehensive survey of the abundance and distribution of birds in 2002-2003.

- *Pooth (2004)* – Researchers surveyed birds in open field habitat on the three ROVA parks. No obligate grassland species were observed nesting on these sites. Most of the species reported were woodland edge species. The most common species nesting on the fields were red-winged blackbirds.

- *Faccio and Mitchell (2009)* - Beginning in 2006, volunteers associated with NETN established point count stations and surveyed birds at the three parks that make up ROVA. Each park has 3-12 point counts separated by 250 m. Points are established in mature forest habitat and placed at least 50 m from an edge. Ten minute point counts are conducted by volunteers between mid-May – June. Points are surveyed once during a season (Faccio, Mitchell, Pooler 2011). See Faccio and Mitchell (2009) appendix A for a list of species, their relative abundances, and other summary statistics.
    - Eleanor Roosevelt NHS (ELRO) originally had six point counts, but five additional sampling points were added for the 2007 field season. In total, 39 species were

recorded in all four years (2006-2009). Red-eyed Vireo, Wood Thrush, Tufted Titmouse, and Northern Cardinal were the most commonly detected species across all years. Four species of conservation concern were detected: Eastern Wood-Pewee, Wood Thrush, Worm-Eating Warbler, and Baltimore Oriole.

- Twelve point count locations were established at the Home of Franklin D. Roosevelt National Historic Sites (HOFR) and surveyed 2006-2008. In total, 40 species were recorded (2006-2008). Tufted Titmouse, Red-Eyed Vireo, and Wood Thrush were the most commonly detected species. Three species of conservation concern were detected: Eastern Wood-Pewee, Wood Thrush, and Baltimore Oriole.
- Seven point counts were established at the Vanderbilt Mansion National Historic Site (VAMA). In total, 30 species were recorded (2006-2009). Red-Eyed Vireo, Wood Thrush, and Northern Cardinal were the most commonly detected species. Four species of conservation concern, Black-billed Cuckoo, Eastern Wood-Pewee, Wood Thrush, and Worm-Eating Warbler, were detected during the four survey years.

Breeding Bird Atlas
The New York Breeding Bird atlas was completed in 2005 http://www.dec.ny.gov/animals/7312.html. The atlas provides an overview of the breeding birds within a larger landscape around the parks. The three ROVA parks were included within blocks 5862A (VAMA), 5862C (HOFR), and 5862D (ELRO). Because each block is much larger than the park itself, it is usually not possible to use these as lists of birds breeding within the Park. However, because NPS participated in the Atlas survey as a block coordinator for the three ROVA blocks (D. Hayes, ROVA), ROVA has data of bird sightings specifically allocated to ROVA park boundaries.

Reference Values/Threshold Values Utilized
Breeding birds are one of the groups that NETN is monitoring. Faccio and Mitchell (2009) developed a guild-based Avian Index of Biotic Integrity (IBI) that can be used to track the condition of the bird community based on traits of the species reported on bird surveys in a particular park. Birds are grouped into guilds based on traits such as where the species feeds or nests, whether they are residents or migrants, and other characteristics. This guild based approach is much more useful than simply counting the total number of species because you may have the same number of species or even an increase in number of species as a park becomes more disturbed, but the types of species present will change. As habitat becomes more disturbed, shifts in the bird community occur with birds that are generalists and able to tolerate disturbance becoming more abundant while those that are specialists often decline. In other words, the total number of species present could stay the same, but the types of species present could change dramatically.

The guild-based biotic integrity scorecard consists of 13 guilds (Table 24) with each guild being broadly categorized as “specialist” or “generalist”. Specialist guilds may be thought of as those indicative of a high-integrity habitat condition, while generalist guilds are those indicative of a low-integrity condition. To calculate the IBI, species are first assigned to guilds (some species may be assigned to more than one guild, depending on their life history traits).The proportional species richness of each guild is then calculated by dividing the number of guild members detected by the total number of species detected. This value is then used to determine a rank of Good, Caution, or Significant Concern based on the proportional species richness thresholds and ranks listed in Table 24. The thresholds and ranks are largely based on those derived by O'Connell et al. (2000) for birds in forested habitats in the central Appalachians, and from those derived by Glennon and Porter (2005) for New York's Adirondack State Park.

Condition and Trend

The park-wide IBI for all years combined at ELRO resulted in 3 categories ranked as "Good," 7 ranked as "Caution," and 3 ranked as "Significant Concern" (Table 25). Among the categories ranked as "Significant Concern" were "single brooded," a guild that represents long-distance Neotropical migrants that only have time to raise one brood of chicks, and "low canopy foragers," which specialize in feeding in the forest sub-canopy. The park-wide IBI for all years combined at HOFR resulted in 3 categories ranked as "Good," 8 ranked as "Caution," and 2 ranked as "Significant Concern" (Table 25). Similar to ELRO the categories ranked as "Significant Concern" were "single brooded and "low canopy foragers". The park-wide forest IBI for all years combined at VAMA resulted in 3 categories ranked as "Good," 6 ranked as "Caution," and 4 ranked as "Significant Concern" (Table 25). A low proportion of migrants and single-brooded species may be indicative of a greater proportion of residents to migrants and reflect the park's location within a fragmented landscape.

Table 24. Avian Integrity Ranks for 13 response guilds and proportional species richness thresholds (based on O'Connell et al. 2000, and Glennon and Porter 2005).

Biotic Integrity Element	Response Guild Metric (Percent Species Richness)	Ratings		
		Good	Caution	Significant Concern
Compositional:	Exotic Species	0%	0.5 - 7%	> 7%
	Nest Predators/Brood Parasite	< 10%	10 - 15%	> 15%
	Residents	< 28%	28 - 41%	> 41%
	Single Brooded	> 68%	50 - 68%	< 50%
Functional:	Bark Prober	> 11%	4 - 11%	< 4%
	Ground Gleaner	> 9%	4 - 9%	< 4%
	High Canopy Forager	> 12%	7 - 12%	< 7%
	Low Canopy Forager	> 22%	14 - 22%	< 14%
	Omnivore	< 30%	30 - 50%	> 50%
Structural:	Canopy Nester	> 35%	29 - 35%	< 29%
	Forest-ground Nester	> 18%	5 - 18%	< 5%
	Interior Forest Obligate	> 35%	10 - 35%	< 10%
	Shrub Nester	< 18%	18 - 24%	> 24%

Table 25. Index of Avian Biotic Integrity based on survey data (2006-2009) for the 3 parks (ELRO, HOFR, VAMA) that make up ROVA (Faccio and Mitchell 2009).

Biotic Integrity Element	Response Guild Metric (Percent Species Richness)	Park		
		ELRO	HOFR	VAMA
Compositional:	Exotic Species	0% Good	2.5%[a] Caution	0% Good
	Nest Predators/Brood Parasite	5% Good	10% Caution	10% Caution
	Residents	31% Caution	35% Caution	37% Caution
	Single Brooded	41% Significant Concern	48% Significant Concern	37% Significant Concern
Functional:	Bark Prober	15% Good	15% Good	17% Good
	Ground Gleaner	8 % Caution	8% Caution	10% Good
	High Canopy Forager	8 % Caution	10% Caution	7% Significant Concern
	Low Canopy Forager	5 % Significant Concern	13% Significant Concern	17% Caution
	Omnivore	38 % Caution	30% Caution	30% Caution
Structural:	Canopy Nester	23 % Significant Concern	30% Caution	27% Significant Concern
	Forest-ground Nester	10 % Caution	8% Caution	7% Caution
	Interior Forest Obligate	23 % Caution	20% Caution	23% Caution
	Shrub Nester	21 % Caution	20% Caution	27% Significant Concern

[a] Value for HOFR was changed from value given in report because Mute Swan is an exotic species and was not counted as one in the data analysis.

Of the four most common species reported at ROVA, two are residents and two are Neotrpoical migrants. Tufted Titmouse and Northern Cardinal are resident species that are common in wooded suburban areas and fragmented landscapes. The Red-eyed Vireo is one of the most abundant and widespread migrants breeding in forests in New York and are found in forest habitat throughout the state (McGowan and Corwin 2008). Wood Thrush was also a common species at ROVA. This is a species of conservation concern and one that has been declining throughout the East. If additional surveys, monitoring or research are done at the parks, this would be a good species to focus on. Maintaining and enhancing habitat for Wood Thrush could be an important conservation goal.

Wood Thrush (Hylochichla mustelina). Photo by USFWS (Steve Maslowski).

The Index of Biotic Integrity is based on birds in forested habitat with the best conditions associated with large blocks of forest habitat that are structurally diverse. Parks that have relatively small areas of forest habitat or forest that is fragmented by roads, managed landscapes, and open habitat will tend to have lower IBI scores just by virtue of the fact that the forest patches are small with relatively large amounts of edge habitat. The index can still be useful in terms of monitoring direction of change. The goal should be to maintain or improve the IBI score instead of a goal of obtaining a score of “good” in all categories. This goal may be unattainable given the configuration of the park and the other management mandates. There is currently discussion about revising these indices to incorporate Park missions (Faccio and Mitchell 2009). If this is done, it may be useful to maintain the current index and then add a second park-specific one based on its own land configuration and mission. This would be an index where the top value would correspond to the best a park could be with different parks having different scales.

Currently, bird surveys are only occurring within mature forest habitat. This means that the ecological condition of birds in other habitats such as successional forest, managed lands like lawns and gardens, open habitats (except grasslands at Saratoga), and wetlands are not included. Separate indices of biotic integrity should be developed for these habitat types also. Even habitats like managed landscapes have a range of management options that influence their biotic integrity. In the long run, these are the habitats where managers may have the most options and make the most difference.

Data Gaps and Confidence in Assessment

Factors that influence the quality of the monitoring data collected by NETN depend on the skills of the volunteers who conduct the point counts, the consistency between years of the individuals who conduct the counts, and the probability that a bird that is present during the time the point count is occurring is detected. Researchers working on the monitoring program have continued to revise the monitoring protocol to address these issues (Faccio et al. 2011). They are establishing a training program for volunteers and are attempting to retain volunteers over multiple years. This will no doubt improve the quality and consistency of the data. Ten minute point counts improve the probability of detecting a species, but because points are surveyed only once per year, there is always the chance that rare or less vocal species go undetected. This can be a problem when calculating the biotic assessment index which is calculated based on the number of species within different guilds. To deal with this issue, the assessment data should be averaged over multiple years. This is what the NETN is currently doing, but it means that managers will only be able to look at trends in the Index of Biotic Integrity over spans of perhaps ten years instead of on an annual basis. The ability to detect changes in individual species is low, but the data can be used to detect or monitor changes in guilds such as forest interior species or shrub nesters.

Criteria that are probably not useful for assessing ecological condition

One of the criteria that is easy to measure and often tempting to use as a measure of ecological integrity is number of species either represented as total number of species ever reported in the park or total number of breeding species. Lists of the names of all species ever reported in the Park (such as the NPS species list) is interesting and useful as a comprehensive document about which species have ever been reported there, but it is not useful as a measure of ecological health or integrity. There is no information on abundance, frequency of occurrence or habitat use. There is no way to distinguish between the vagrant that might have shown up there for a day, and a species which nests there annually. An additional problem in terms of tracking changes is the time that surveys or reports occurred and the survey locations are not reported.

The number of breeding species and measures of species richness also are not in themselves good measures of ecological condition.The reason is that species numbers are often highest at intermediate levels of disturbance. Thus, a healthy high integrity forest would often have fewer species than an area that was more fragmented.

4.4.7 Amphibians and Reptiles

Relevance and Context

Monitoring for amphibians and reptiles in ROVA has been inconsistent over the years, often occurring only when funding and personnel were available. There are records of Blanding's turtles (*Emydoidea blandingii*) in the park (Klemens et al. 1992, internal ROVA documents), which is a New York threatened species (http://www.dec.ny.gov/animals/7166.html). Klemens et al. (1992) noted 16 amphibian and 16 reptilian species within ROVA, including the spotted turtle (*Clemmys guttata*), which is listed as a species of special concern, as are the wood turtle, the eastern box turtle, the Jefferson salamander, and the marbled salamander, all confirmed in 1992 at ROVA. ROVA is home to one *threatened* and three *special concern* turtle species under New York State 182.2(g) of 6NYCRR Part 182.

Data and Methods

The Terrestrial Salamander Monitoring Program (TSMP) at ROVA was established in 1999 and is part of the North American Amphibian Monitoring Program (Hayes 1999). Supplemental presence/absence surveys of amphibians have being conducted in prior years in 1988-1990 by Klemens et al. (1992) in areas surrounding ROVA (Table 26). TSMP count data from 1999-2006 was used in the assessment of terrestrial salamanders in ROVA. These data were collected in spring (and one fall event in 2006) within a 568 m sampling transect located at Eleanor Roosevelt National Historic Site (Val-Kill). This transect is in an upland wooded area on the east side of the park. The vegetation is second-growth mixed hardwood and the sites were selected based upon its low level of disturbance, easy access, and known salamander population (Hayes 1999) (Figures 44, 45). A second sampling transect was established in Home of Franklin Roosevelt NHS (HOFR) in 2007.

Monitoring efforts to assess turtle populations have existed at locations in concentrated wetland habitats in Eleanor Roosevelt National Historic Site (ELRO) from 1988-2006 and were used to assess the turtle population for the park (Table 27, Figure 46), along with the general reporting of turtle sightings by park staff. The goal of these monitoring efforts is to provide information of the population status of the threatened Blanding's turtle and special concern listed spotted turtle. The Blanding's turtle in Dutchess County has been noted to be a metapopulation by Klemens *et al.* 1992. Incidental aquatic and terrestrial species are also captured and documented during these monitoring periods.

Reference Condition/Threshold Values Utilized

Due to limited historical quantitative data and spatial data available for amphibian and reptile communities in ROVA, this condition assessment was based on small scale surveys conducted in the park and best professional judgment.

Table 26. Historical documentation of terrestrial salamanders occurring in ROVA from 1988-2006. Taxa listing of all salamanders identified as occurring in Dutchess County, NY from the ten year Herp Atlas Project is also included. Increased taxa occurrence in later years may be attributed to increased sampling effort in ELRO and/or weather patterns. State Conservation Ranking definitions and NY State Conservation Status may be found at: NatureServe, http://www.natureserve.org/explorer/nsranks.htm, and NYDEC, http://www.dec.ny.gov/animals/7494.html.

			Dutchess Co., NY	**ELRO**	**VAMA**	**HOFR**	**ELRO**				
Common Name	**Scientific Name**	**Conservation Rank/Status**	**NY Herp Atlas 1990-1999**[†]	**1988-1990**[a]			**1999**[b,d]	**2000**[c,d]	**2001**[d]	**2002**[d]	**2006**[d]
Jefferson salamander complex	*Ambystoma jeffersonianum x A. laterale*	SNA	X	X				X			X
Blue Spotted Salamander	*Ambystoma laterale*	S4/Special Concern	X								X
Jefferson salamander	*Ambystoma jeffersonianum*	S4/Special Concern	X					X			X
Marbled Salamander	*Ambystoma opacum*	S3/Special Concern	X			X					X
Spotted Salamander	*Ambystoma maculatum*	S5	X	X		X	X		X	X	X
Northern Dusky Salamander	*Desmognathus f. fuscus*	S5	X								
Northern Two-lined Salamander	*Eurycea bislineata*	S5	X	X		X					
Four-toed Salamander	*Hemidactylium scutatum*	S5	X	X							
Redback Salamander	*Plethodon cinereus*	S5	X	X	X	X	X	X	X	X	X
Northern Slimy Salamander	*Plethodon glutinosus*	S5	X	X		X					X
Red-Spotted Newt	*Notophthalmus v. viridescens*	S5	X	X		X	X				X

[†] New York State Department of Environmental Conservation Amphibian & Reptile Atlas Project (Herp Atlas). Data retrieved from the New York State Department of Environmental Conservation. http://www.dec.ny.gov/. [a] Klemens, M.W., Cook, R.P., Hayes, D.J. 1992. Herpetofauna of Roosevelt-Vanderbilt Sites Hyde Park, New York, with emphasis on Blanding's Turtles (*Emydiodea blandingii*). U.S. National Park Service, Technical Report NPS/NAROSS/NRTN-92/08. [b] Hayes, D. 1999. Roosevelt-Vanderbilt National Historic Sites Terrestrial Salamander Monitoring Program. Unpublished Report from the National Park Service. [c] Hayes, D. 2000a. Terrestrial Salamander Monitoring 2000 Summary. Unpublished Report from the National Park Service. [d] Hayes, D. Unpublished Counts for Terrestrial Salamander Monitoring Efforts in Roosevelt-Vanderbilt National Historic Park from 1999-2006. Retrieved Oct. 14, 2009.

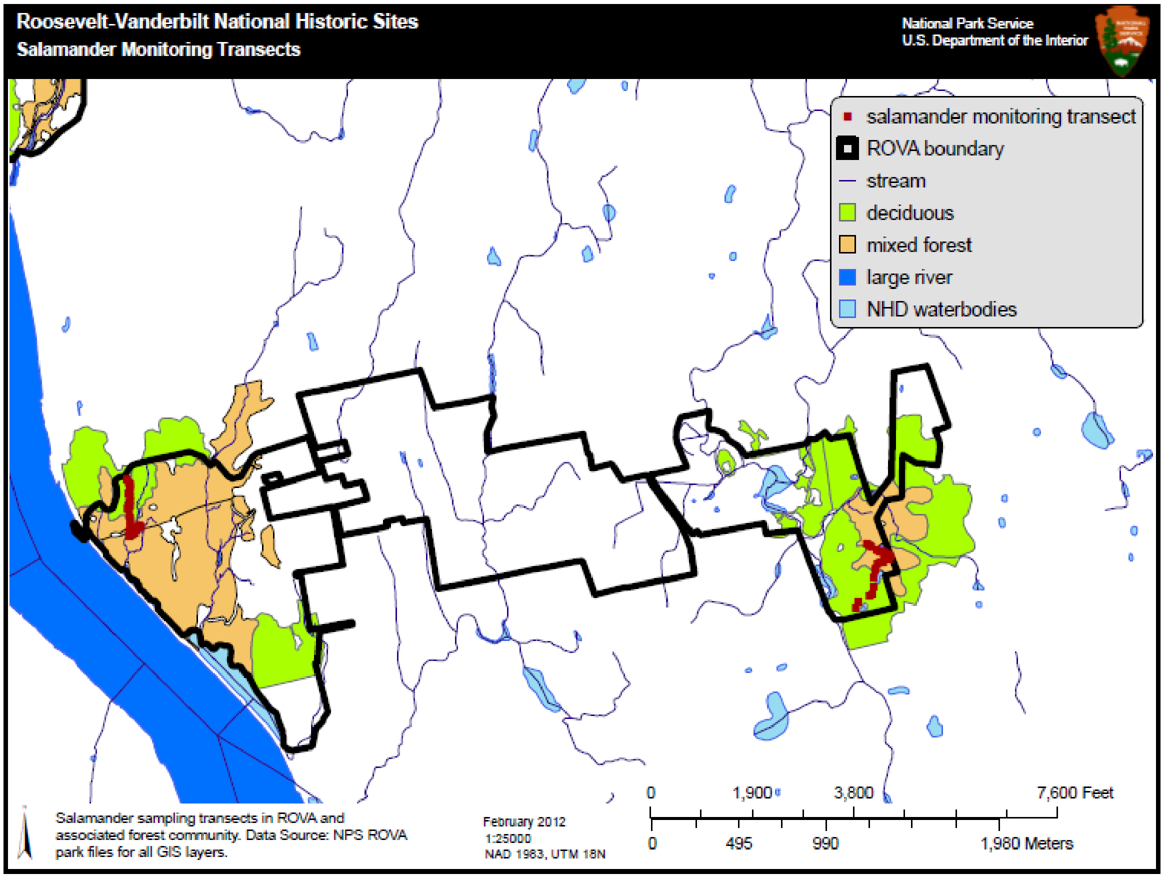


Figure 44. Salamander monitoring transect established in HOFR and ELRO and the associated forest vegetation community.

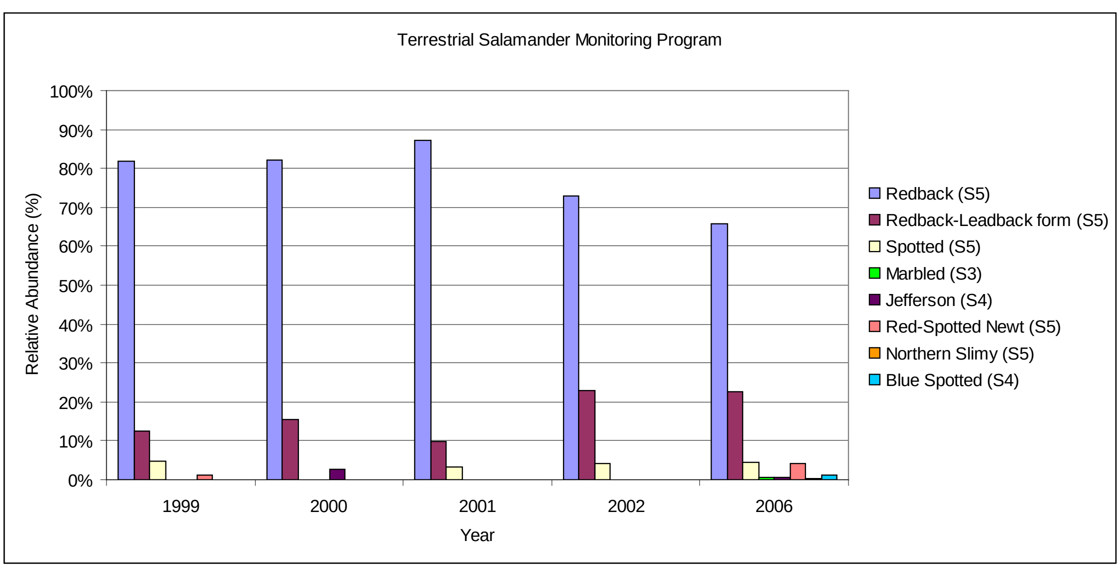


Figure 45. Percent relative abundance and conservation rankings for terrestrial salamanders surveyed in ELRO from 1999-2006. Sampling events included spring (1999-2006) and fall (2006).

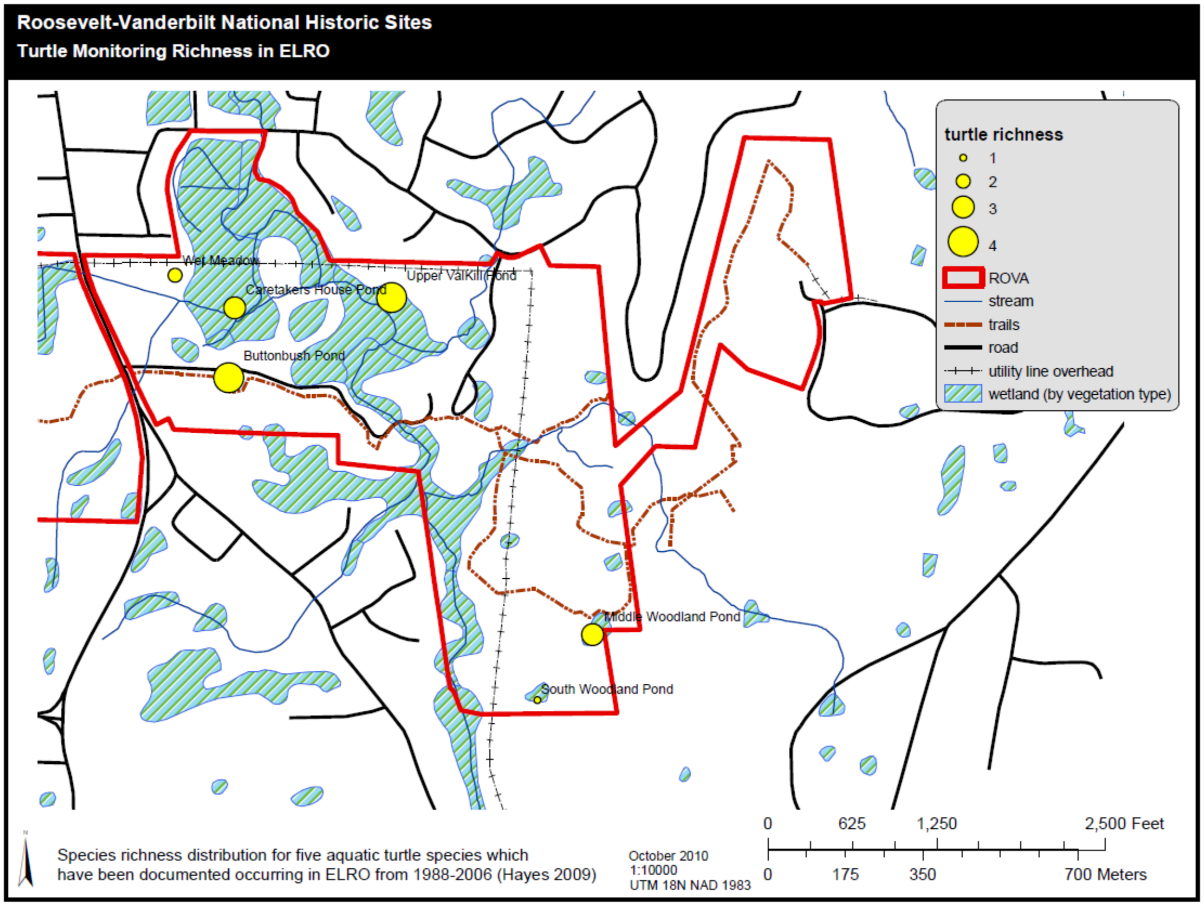


Figure 46. Turtle sampling locations within ROVA.

Condition and Trend

Given the lack of detailed data over the years, we were unable to develop condition categories or an overall assessment for amphibians and reptiles in ROVA. However, it is important that species of concern continue to be inventoried and monitored and managers protect the habitat of threatened or endangered species in ROVA. The monitoring data collected in ROVA are scattered, and although useful in some instances (i.e., documenting species of concern), make it difficult to ascertain any trends in populations of any amphibian or reptile.

Monitoring for salamanders from 1999 through 2006 found eight species or forms of species, including: redback, redback-leadback form, spotted, marbled, Jefferson, red spotted newts, northern slimy and blue-spotted salamanders (Figure 45). An increase in salamander taxa richness in 2006 may be attributed to an increase in the number of sampling events, which included spring and fall seasons versus solely spring sampling in prior years. State Conservation Rankings from S3 (vulnerable) to S5 (secure) have been documented for salamander species occurring in ROVA, including species listed as Special Concern under NY State listing. Special Concern species are defined in Section 182.2(i) of 6NYCRR Part 182 as those which warrant attention and consideration but current information, collected by the department, does not justify listing these species as either endangered or threatened.

Turtle monitoring took place in 2000 in ELRO and recorded one Blanding's turtle, 16 painted turtles, and two box turtles. A Blanding's turtle was photographically documented in Val-Kill in 2003. In 2006, monitoring efforts at ELRO yielded well over 100 painted turtles, three spotted turtles, 18 snapping turtles, and one musk turtle. In 2010, trapping of the Blandings's turtle was unsuccessful (Written communication, David Hayes, NPS ROVA 2011). The current lack of the Blanding's turtle presence (as well as other species during surveys), should not be interpreted that the species does not exist in ROVA. The capture of new individuals, as well as the recapture of marked individuals, provides some information in assessing turtle populations in ELRO, but the most reliable indicator of a population is gathered from consistent sampling effort (Figure 47). Sampling effort increases will provide managers with tools necessary for assessing the population dynamics of ROVA's amphibian and reptile species. If a lack of new individuals identified or the inability to recapture previously mark turtles is evident, then the turtle population may be in decline due to factors such as a reduction of landscape connectivity, road mortality, or adjacent land development (Marchand and Litvaitis 2004, Baldwin et al., 2004).

Data Gaps and Confidence in Assessment

Confidence in the assessment was limited and trend analysis was limited. The deficiency of historical survey data, in addition to reductions in monitoring efforts (e.g., yearly and seasonally), hinders the assessment in reptile and amphibian populations in ROVA and whether species are becoming rarer or remain common within the park. Several global and regional factors can negatively impact amphibians and reptiles and their habitat in ROVA, such as acid precipitation, UV-B radiation, pesticides, disease, and development (Clark and Hall 1985, Karraker et al. 2008, Glista 2008). Monitoring of malformation of amphibians can be used as an indicator of pollution presence and malformation of fused hind legs has been found on the Jefferson salamander complex in a survey conducted in ELRO during 2006 (Taylor et al. 2005, Hayes 2006a). Since redback salamanders are abundant in ROVA (Figure 45), this species would be a good indicator species to be incorporated for long-term monitoring of other Vital Signs such as forest health. Wetland and vernal pool buffers around areas where turtles are known to nest in ROVA may be a protective management plan for turtle populations. Additionally, road mortality of turtles and migrating amphibians should be a variable measured since species' migration and breeding routes may involve crossing high traffic roadways within and surrounding ROVA (Figure 46).

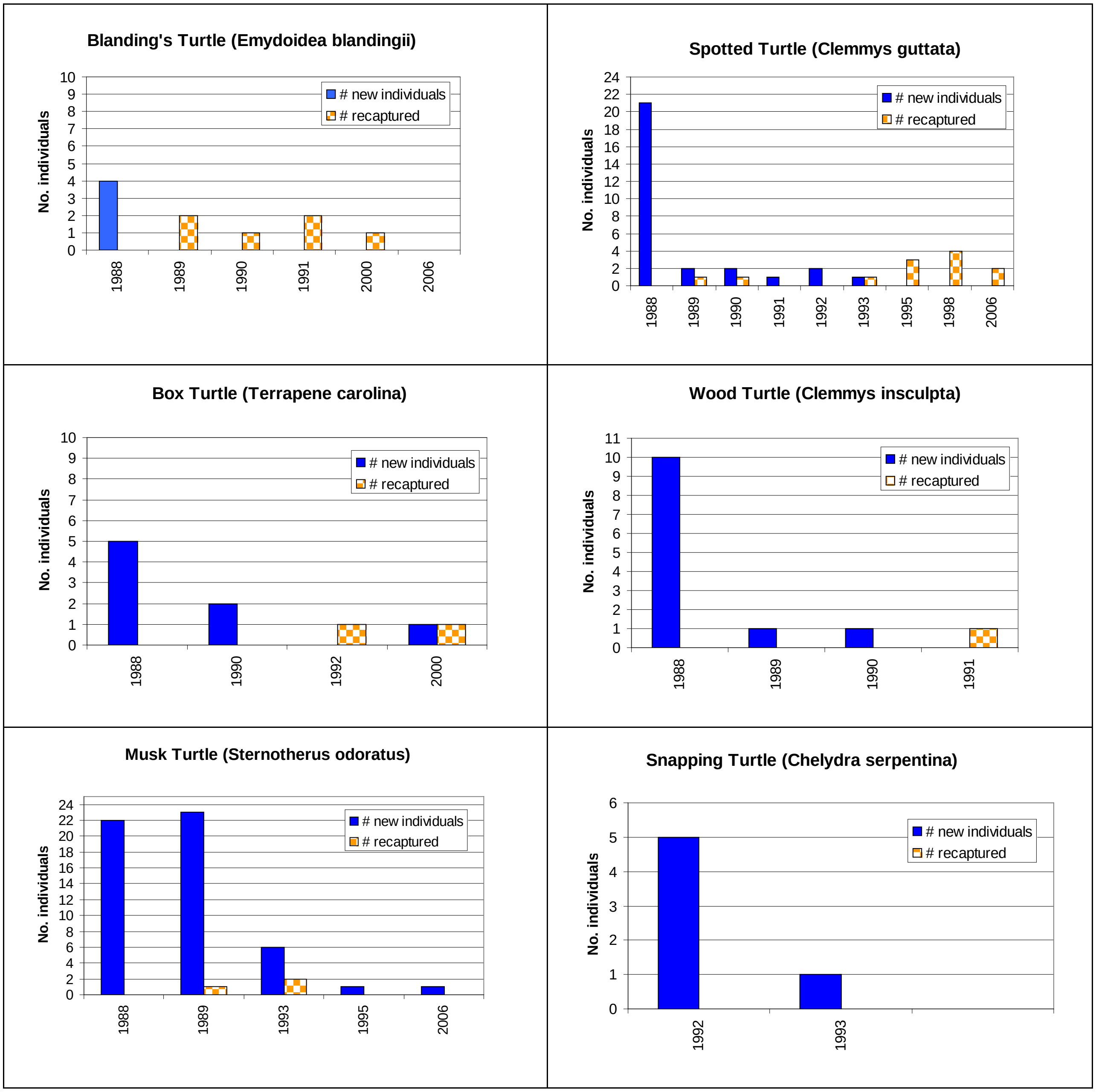


Figure 47. Turtle count data from mark/recapture survey in ROVA from 1988-2006 (Hayes 2009). Total # sampling events for each species' temporal dataset includes: Blanding's=11, spotted=34, box=14, wood=12, musk=25, snapping=4.

Table 27. Historical survey documentation (trapping or sighting) of turtles occurring in ROVA from 1988-2006. Taxa listing of all turtles identified as occurring in Dutchess County, NY from the 10 year Herp Atlas Project is also included along with State Conservation Ranking and NY State Conservation Status for each species.

			Dutchess Co., NY	**ELRO**	**VAMA**	**HOFR**	**ELRO**							
Common Name	**Scientific Name**	**Conservation Rank/Status***	**NY Herp Atlas 1990-1999**[†]	**1988-1990**[a]			**1991**[b]	**1992**[b]	**1993**[b]	**1995**[b]	**1998**[b]	**2000**[b,c]	**2003**[b]	**2006**[b,d]
Blanding's Turtle	*Emydoidea blandingii*	S2S3/ Threatened	X	X			X			X		X	X	
Bog Turtle	*Glyptemys muhlenbergii*	S2/ Endangered	X											
Map Turtle	*Graptemys geographica*	S3	X			X								
Musk Turtle	*Sternotherus odoratus*	S5	X	X	X				X	X				X
Eastern Box Turtle	*Terrapene carolina*	S3/Special Concern	X	X	X	X		X				X		
Painted Turtle	*Chrysemys picta*	S5	X	X	X	X						X		X
Slider	*Trachemys scripta*	SNA	X											
Snapping Turtle	*Chelydra serpentine*	S5	X	X	X	X		X	X					X
Spotted Turtle	*Clemmys guttata*	S3/Special Concern	X	X			X	X	X	X	X			X
Wood Turtle	*Glyptemys insculpta*	S3/Special Concern	X	X		X	X							

*State Conservation Ranking definitions and NY State Conservation Status may be found at: NatureServe, http://www.natureserve.org/explorer/nsranks.htm, and NYDEC, http://www.dec.ny.gov/animals/7494.html.
[†] New York State Department of Environmental Conservation Amphibian & Reptile Atlas Project (Herp Atlas). Data retrieved from the New York State Department of Environmental Conservation. http://www.dec.ny.gov/.
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[c] Hayes, D. 2000b. Turtle Monitoring 2000 Summary. Unpublished Report from the National Park Service.
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4.5 Soils

Relevance and Context

Park soils are relatively young, having formed since the retreat of the last glacier (the Laurentide ice sheet) some 10,000 years ago. The soils are largely derived from various stratified and non-stratified glacial deposits that were laid down over metamorphic and igneous bedrock and have broken down to form soils. The soils of Roosevelt-Vanderbilt NHS are therefore primarily stony and moderately well drained. Those along the Hudson River and other streams are alluvial deposits (Figure 48). The NPS has developed a list of soils by unit, and these are shown below (NPS Fire Management Plan (draft) 2005). Soil monitoring is used to understand the effects of acidic deposition on forest health. Acid deposition alters soil chemistry by leaching calcium, magnesium and potassium from soils, thereby increasing the availability of aluminum, which carries toxic properties. Additionally, forested ecosystems may be experiencing increased inputs of nitrogen to forested systems, causing concern that excess nitrification and nitrogen leaching can exacerbate acidification effects, reducing plant growth, and increasing susceptibility of trees to other stresses (Aber et al. 1998, 2003).

Home of Franklin D. Roosevelt NHS
Ck: Colonie fine sandy loam, hilly and steep phases 15-35 % slopes)
Hg: Hoosic gravelly loam, nearly level and undulating phases, (0-8 % slopes)
Hf: Hoosic gravelly loam, hilly phase (15-25 % slopes)
Rb: Rhinebeck silt loam (0-5 % slopes)
Sc: Staatsburg gravelly loam, very ledgy hilly phase (15-30 % slopes)
Sd: Staatsburg gravelly loam, very ledgy rolling phase (5-15 % slopes)
Sf: Steep ledgy land (Wassaic and Staatsburg soil materials) (30+ % slopes)
Ta: Tidal marsh, fresh water phase (0-1 % slopes)

Eleanor Roosevelt NHS
Ae: Atherton silt loam (0-5% slopes)
Bd: Boynton gravelly silt loam, (0-8 % slopes)
Cw: Cossayuna gravelly loam, hilly phase (15-30 % slopes)
Cx: Cossayuna gravelly loam, undulating and rolling phases (3-15 % slopes)
Cy: Cossayuna stony silt loam, hilly phase (15-30 % slopes)
Hg: Hoosic gravelly loam, nearly level and undulating phases, (0-8 % slopes)
Hh: Hoosic gravelly loam, rolling phase (5-15 % slopes)
Hl: Hoosic gravelly sandy loam, nearly level and undulating phases (0-8 % slopes)
Mg: Muck, acid, deep phase (0-2 % slopes)
Nc: Nassau-Cossayuna gravelly loams, undulating and rolling phases (3-15 % slopes)
Ra: Red Hook silt loam (0-3 % slopes)
Sa: Saco silty clay loam (0-2 % slopes)
Sc: Staatsburg gravelly loam, very ledgy hilly phase (15-30 % slopes

Vanderbilt Mansion NHS
Cl: Colonie fine sandy loam, nearly level phase (0-3 % slopes)
Ck: Colonie fine sandy loam, hilly and steep phases 15-35 % slopes)
Eb: Elmwood fine sandy loam (0-5 % slopes)
Hf: Hoosic gravelly loam, hilly phase (15-25 % slopes)

Hg: Hoosic gravelly loam, nearly level and undulating phases, (0-8 % slopes)
Hk: Hoosic gravelly loam, steep phase (25-45 % slopes)
Na: Nassau-Cossayuna gravelly loam, eroded hilly phases (15-30 % slopes)
Nc: Nassau-Cossayuna gravelly loams, undulating and rolling phases (3-15 % slopes)
Sd: Staatsburg gravelly loam, very ledgy rolling phase (5-15 % slopes)

Data and Methods

The monitoring of soil chemistry variables congruent with forest structure, composition, and function metrics will increase the understanding of the impacts of acid deposition on forest health. Two indicators, the calcium to aluminum ratio (Ca:Al, an acid stress metric) and the carbon to nitrogen ratio (C:N, a nitrogen saturation metric) were measured from the O and A (surface) horizon of soils in ROVA during NETN forest monitoring efforts (Tierney 2011, Miller et al. 2010). Composite soil samples from 24 forest plots in ELRO/HOFR and 16 forest plots in VAMA were collected in 2007 and 2009 for laboratory analyses. Trend analyses were not performed due to limited temporal sampling effort, thus reducing the power of trend detection.

Reference Condition/Threshold Values Utilized

The NETN Vital Signs program has established condition categories (ratings) for Ca:Al and C:N in order to assess the impacts of atmospheric deposition on forest soil. These condition categories are based on ecological studies which have assessed the use of these indicators for acid stress and nitrogen saturation on forest soils (e.g., Cronan and Grigal 1995, Aber et al. 2003). Ca:Al condition categories included the following: median Ca:Al ratio >4 was rated *good*, a ratio of Ca:Al from 1-4 rated *caution*, and a ratio <1 was considered *significant concern* (Table 28). Nitrogen saturation was assessed using a C:N soil ratio with the following condition categories: a *good* rating included C:N >25, a *caution* rating was between C:N 20-25, and a *significant concern* rating fell below C:N of 20 (Table 28).

Condition and Trend

ELRO/HOFR Ca:Al ratio rated *caution*, with a median Ca:Al ratio of 3.52 while VAMA rated *good*, with a score of 5.94.ELRO/HOFR C:N rated *significant concern* (C:N=16.67), and VAMA rated *caution* (C:N=20.49). The results from samples collected in ROVA indicate that the park may be experiencing excess N saturation, which may affect forest vegetation (see Section 4.4.3 for further discussion).

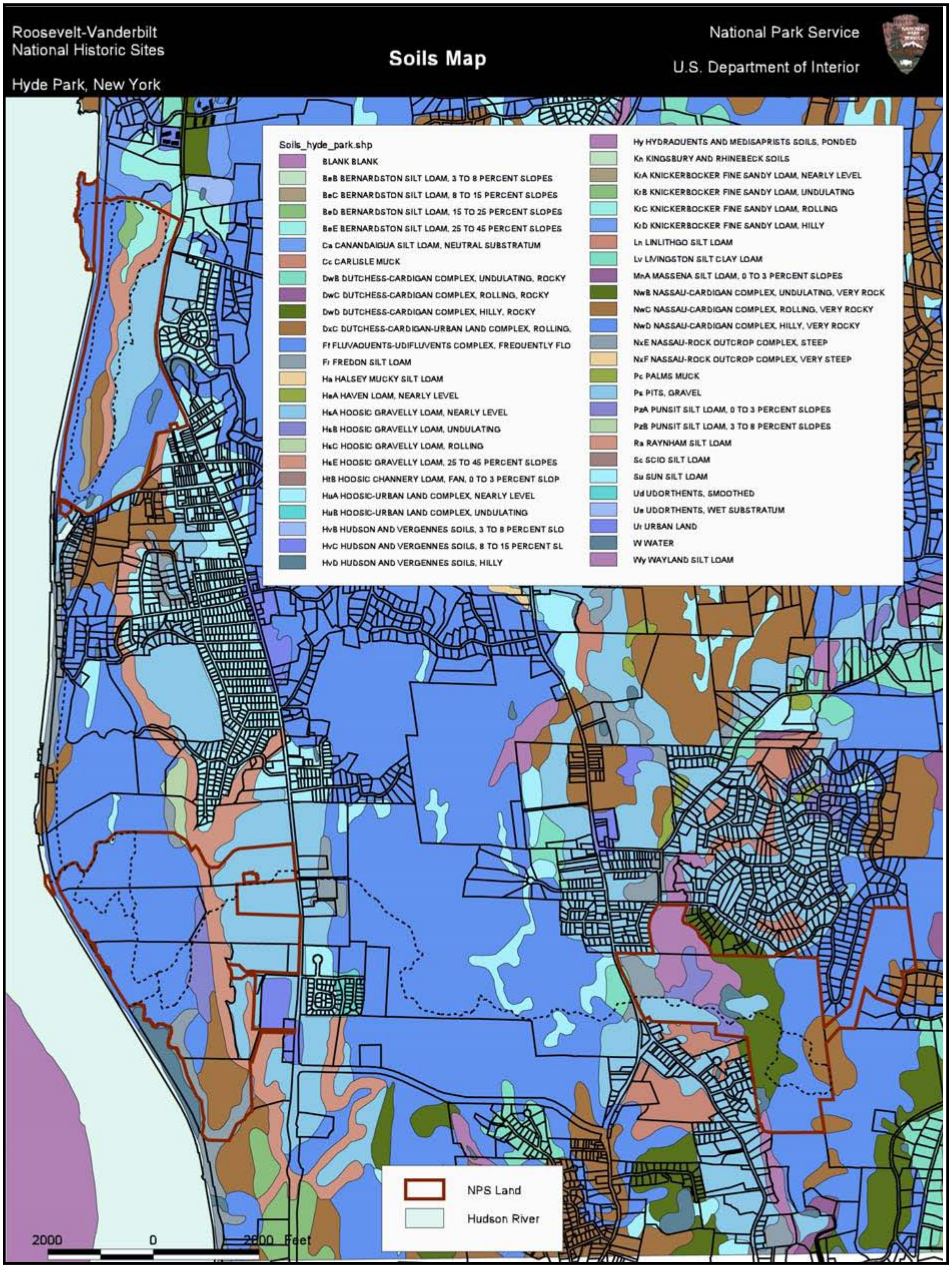

Figure 48. Soils map for ROVA (from NPS 2005).

Table 28. Condition of ROVA forest soils based on NETN collections and measurements for acid stress (Ca:Al) and nitrogen saturation (C:N).

Soil Chemistry Measurement	CONDITION CATEGORY		2006-2009 NETN Monitoring (Miller et al. 2010)	
			ELRO/HOFR	**VAMA**
acid stress Ca:Al	GOOD	Soil Ca:Al ratio > 4	3.52	5.94
	CAUTION	Soil Ca:Al ratio 1 - 4		
	SIGNIFICANT CONCERN	Soil Ca:Al ratio < 1		
nitrogen saturation C:N	GOOD	Soil C:N ratio > 25	16.67	20.49
	CAUTION	Soil C:N ratio 20 - 25		
	SIGNIFICANT CONCERN	Soil C:N ratio < 20		

Data Gaps and Confidence in Assessment

Confidence in the assessment was fair and trend analysis was limited. The use of solely Ca:Al and C:N metrics limits the assessment of acid deposition and stress in forest soils. With increased soil sampling effort, in conjunction with atmospheric deposition data, trend analyses will provide a comprehensive understanding of regional soil acidification and nutrient saturation. Inaccuracy in the measurements of Ca:Al ratios for ROVA are probable due to the type of extractant used for Ca:Al measurements and the methodology of separating the O and A soil layers in field collections (per communication, NPS, Peter Sharpe February 3, 2012). The ammonium chloride extractant currently used by NPS to derive the Ca:Al ratio has been considered by some forest and soil scientists as being too strong of an extractant and therefore yields inaccurate results. Strontium chloride extractant may be a more suitable alternative as it mimics the Ca:Al ratio that is bio-available in the soil. Furthermore, the Ca:Al ratios in ROVA tended to be higher in the organic layer (O horizon) and lower in the mineral soil layer (A horizon). Contamination of the mineral sample with the O horizon soil can lead to greater Ca:Al ratios which may be an explanation as to why VAMA Ca:Al ratios were rated *good*, even though atmospheric wet S deposition in ROVA is a *significant concern* and acid tolerate red maple species regeneration is high in ROVA's forest understory (see Section 4.4.3).

NETN has recognized that Ca:Al and C:N metrics alone are insufficient to understand atmospheric deposition and stress on forest soils (Miller et al. 2010). Spatial and temporal variability of these ratios in forest soils hinders a complete condition assessment of soils in ROVA. Spatial variability of individual cations is highly dependent upon local site conditions, and temporal variability in cation concentrations can be high, reflecting soil water table fluctuations, rainfall patterns, litter decomposition rates, etc. Yanai et al. (2005) suggested intensive sampling is needed to detect even small changes in soils. Additional soil indicators are available which can be used in conjunction with C:N and Ca:Al ratios. For example, there are a variety of soil pH thresholds and optimal ranges for different soil processes and plant species which could be used to assess risk to soil functions and conservation of habitats. pH plays a major role in the regulation of several soil processes such as cation availability to plants, phosphorus immobilization in acidic soils, and changes in biological communities due to pH levels. This information can be used at a site level to assess the risk to forest structure from acidification (Smart et al., 2005).

4.6 Landscape Context and Dynamics

Relevance and Context

An understanding of the pattern and dynamics of land cover and land use context is crucial to assessing ROVA's natural resource condition. In a recent resource brief, NETN states, "In order to guide land management, restoration, and conservation decisions in national parks in the northeast, park managers need to understand the regional landscape in which parks are situated. An understanding of landscape change also provides a context in which to understand and measure ecosystems and the stressors affecting them. Knowledge of how much, where, and when changes have occurred can help park managers understand current conditions and plan for the future" (NPS 2009a). The literature on landscape ecology in developing areas and biodiversity threats from human-induced land cover is extensive. Wang (2009a) notes that "land-use legacies can persist for a long time, influencing plant species composition, nutrient cycling, water flows, and climate." In addition, conservation biologists and landscape ecologists have long documented the impacts of landscape-scale land development on wildlife, both in terms of direct loss of habitat and through landscape fragmentation and resultant impediment to flows of genetic information (Noss 1994, Forman 1995, Soulé and Terborgh 1999). The people of the Town of Hyde Park, too, have recognized the "disintegrative patterns of land use"—sprawling settlement patterns, unprotected open space, endangered sensitive areas and wildlife habitats, and vanishing rural character are all cited as concerns for community well-being (DCDPD 2005 [Underlying Contradictions Chart]).

ROVA's GMP mentions biological diversity as a 'desired resource condition', and makes periodic reference to habitat fragmentation and ecological disturbance beyond park boundaries as an outgrowth of all management alternatives (NPS 2009b). However, it generally understates the importance of ecological context. For example, under Stewardship of Important Natural Communities, there is no explicit statement on the vital importance of ecological interdependencies extending beyond park borders (NPS 2009b). This needs to be reconciled with NETN's call for ecological contextuality (NPS 2009a) where it is seen as critical to promote internal ecological integrity and habitat functions within a park as well as with its surrounding landscape.

Wang et al. (2006, 2009a, b) used remote sensing data to report on landscape dynamics (i.e. land cover changes) from 1973-2002 for a series of NETN parks, including ROVA. Urban, forest, and wetland cover were documented for 0.5, 1 and 5-kilometer buffers (measured from the park boundary). Results for land cover change within the 5km buffer are shown in Table 29. Urban areas were likely largely underestimated in earlier data due to lower resolution of the data.

Some measure of natural landscape fragmentation—and hence ecosystems integrity—can be inferred from the decrease in forest cover and expansion of urban cover within the 5km buffer between 1973 and 2002. For ROVA, urban cover increased 132%, while forest cover of all types decreased 3 to 61%. In comparison, NETN parks overall showed an increase in urban area of 212% and a decrease in forested area of 17-18% (Wang et al. 2009a, b).

The NPScape data summarized in prior sections is a good starting point for assessing ROVA's landscape ecological and land use settings. However, further investigation is necessary to achieve a place-based, quantitative analysis of the morphology, dynamic distribution, and interconnectedness of ecological core reserves and corridors in the area. Since ecological integrity of ROVA is substantially dependent on the robustness of surrounding core areas, corridors, and specialized ecosystems, it would seem prudent to conduct a comprehensive, interdisciplinary study of ROVA's landscape ecological and fluvial contexts. A local example is the report prepared by Hudsonia Ltd. (Bell and Stevens 2009) for the northern portion of the Town of Hyde Park.

Table 29. Acreage of land cover type within ROVA and 5km buffer, 1973, 1988, 2002 (Wang et al. 2009a).

Land Cover Type	1973	1988	2002
Urban	2,801	5,732	6,492
Deciduous Forest	19,488	18,805	18,946
Coniferous Forest	4,290	2,817	1,674
Mixed Forest	6,048	6,297	3,482
Water	3,194	3,789	3,441
Wetland	1,799	1,475	3,063
Herbaceous Vegetation	5,008	3,617	5,434

<u>Data and Methods</u>

Available digital orthophoto quadrangles can be used in concert with NPScape data and other GIS data sets to document ecological core reserves, corridors and specialized ecosystems, as well as sustainability metrics (e.g. pervious cover, density of roads and built form, etc.) in the landscape matrix. Field truthing is a crucial step in establishing the reliability of digital data. Even a cursory 'snapshot' examination of Google Earth satellite imagery, along with awareness of initiatives by local and County organizations, can suggest the imperative of landscape ecology and eco-hydrology approaches to the ecological network surrounding ROVA. Collapsing land use into two converted categories and two natural habitat types provides a sense of the basic structure of the environment in the vicinity of the three sites, and the nature of the challenge to maintaining key ecosystem functions of connectivity (Figure 49). Despite the loss of much important natural environment, the encroachment of developed areas on key habitat within the boundaries of ROVA, and the increase in patchiness and (especially) edges between developed and undeveloped areas, there remain several opportunities to manage the park, and pursue strategic regional planning, that will help maintain key ecosystem function and some of the biodiversity present in the NPS facilities.

Condition and Trend

Based on our assessment of the available spatial data regarding evolving land use patterns adjacent to ROVA, long-term development trends will continue to put pressure on the parks' natural resources. Given the change in land-use over time, our evaluation of this issue is that ROVA is under moderate threat at this time.

The NPS must take advantage of several opportunities to help secure undeveloped (or less developed) lands adjacent to ROVA such that ecological integrity can be maintained or improved. The following are some of the conditions and opportunities that should be approached as a means of preserving the local landscape. The NPS should work with all local landowners to maintain these connections, or improve them.

- Strip development occurs along much of the Albany Post Road corridor (Route 9), and incessant infill threatens the integrity of lateral forested corridor connections linking HOFR and VAMA with riparian and terrestrial core ecosystems to the east. The NPS should make every effort to aid in the maintenance (and restoration) of all forested corridors through the region, even external to the park.
- More specifically, local development—buildings, parking lots, and related infrastructure—is displacing habitat contiguous to all three parks, but the HOFR / FDR Home site in particular. The Hyde Park Drive-in Theatre (proposed Hudson Valley Welcome Center), Golden Manor, Hyde Park Brewing Company, and Roosevelt Theatre properties along the east side of Rt. 9 impede the continuity of the wooded corridor between HOFR and ELRO, and nearly sever the FDR Home tract's already tenuous link to the large forested core reserves to the east. The NPS should work with local officials to develop a plan to help preserve as much habitat as possible contiguous to the parks. This should entail working with local conservation groups to preserve and protect adjacent properties.
- The 105-acre Winnakee Nature Preserve and the adjacent Hyde Park Nature Preserve combine to serve as a large, highly valuable wooded core reserve contiguous to the central portion of HOFR. Links to the Home of FDR site are more tenuous; some riparian ecological functions may be expected along the intermittent stream that connects Winnakee to the Home of FDR via the Morgan Property conservation easement. The NPS should continue to work in partnership with these areas to maintain and improve ecological functions.
- Relatively undeveloped land may provide a semblance of an east-west ecological corridor just south of the intersection Rt. 9 and Rt. 40A, adjacent to Coco's Pizza and surrounding the Guardian Self Storage facility. Every effort should be made to encourage landowners to keep these lands undeveloped.
- Low-density residential development is pressing in on ELRO from both the north and the south along Rt. 9G / Violet Avenue and Creek Road. However, a large tract of fairly contiguous forest surrounds Top Cottage, extending south and east of the Val-Kill cottage complex. This area should be a high priority for land conservation activities by the NPS.

- VAMA is only weakly linked with larger tracts of undeveloped terrestrial and riparian ecosystems to the east. The Crum Elbow Creek corridor and associated ponds link the east and south portion of the VAMA with fairly contiguous forest cover that lies between Hudson Drive and Howard Blvd. east of Rt. 9. The NPS should proceed with phase 2 of the Heritage Greenways trail to help enshrine the natural corridor linking VAMA with Pinewoods Park and Hackets Hill Park to the east (NPS 2004b, IQLA 2009). Further north, an east-west oriented wooded corridor associated with Bard Rock Creek skirts the upper boundary of VAMA. This area needs to be protected and increased in size, if possible.
- Traffic along transportation corridors can impede ecological and biological connectivity (Forman 2003). Besides physical discontinuities posed by road and Conrail infrastructures, the ROVA Regional Transportation Report (NPS 2004b) cites annual daily traffic flows (ADT) of 22,300 at the intersection of Rt. 9 and 40A (St. Andrew's Road) adjacent to ROVA's southeasterly corner; 11,200-19,400 ADT on Rt. 9 along the easterly boundary of VAMA, and 11,000-14,300 ADT on Rt. 9 along the eastern boundary of VAMA. Expansion of travel lanes is called for along the frontage of HOFR north of St. Andrew's Road (NPS 2004b). As a counterpoint to increasing traffic and calls for expanded infrastructure, ROVA's regional transportation report calls for strengthened pedestrian linkages between the parks and the surrounding community (NPS 2004b).
- While the Hudson River serves as a major aquatic ecosystem bounding the western edges of both HOFR and VAMA, terrestrial ecological linkage between the two historic properties is minimal. The Hyde Park Heritage Greenway Trail system offers recreational continuity, but the combination of the Conrail line and existing waterfront development suggest negligible capacity for ecological corridor functions. Planned residential development such as River's Edge will further impact connectivity. Still, new easements, such as that granted by the Anderson Foundation through its school property, help link VAMA to Norrie Point State Park, offering hope for ecological continuity despite continued development in this northerly sector of Hyde Park.

Data Gaps and Confidence in Assessment

These and other near-ROVA natural heritage resources should be the subject of further quantitative and spatially explicit study. Ultimately, these are complex land use and land management challenges that must be undertaken in partnership with surrounding public and private stakeholders at several scales of operation. Initiatives by Dutchess County, the Town of Hyde Park, and non-profits such as the Winnakee Land Trust suggest that there is institutional and civic willingness to press forward on local ecosystems conservation initiatives to the benefit of both ROVA sites and the surrounding community (DCDPD 2005, IQLA 2009, WLT 2010). A broader listing of existing and potential partnerships which could cooperate in conserving natural heritage corridors, core areas, and specialized habitats are described in the ROVA draft GMP (NPS 2009b).

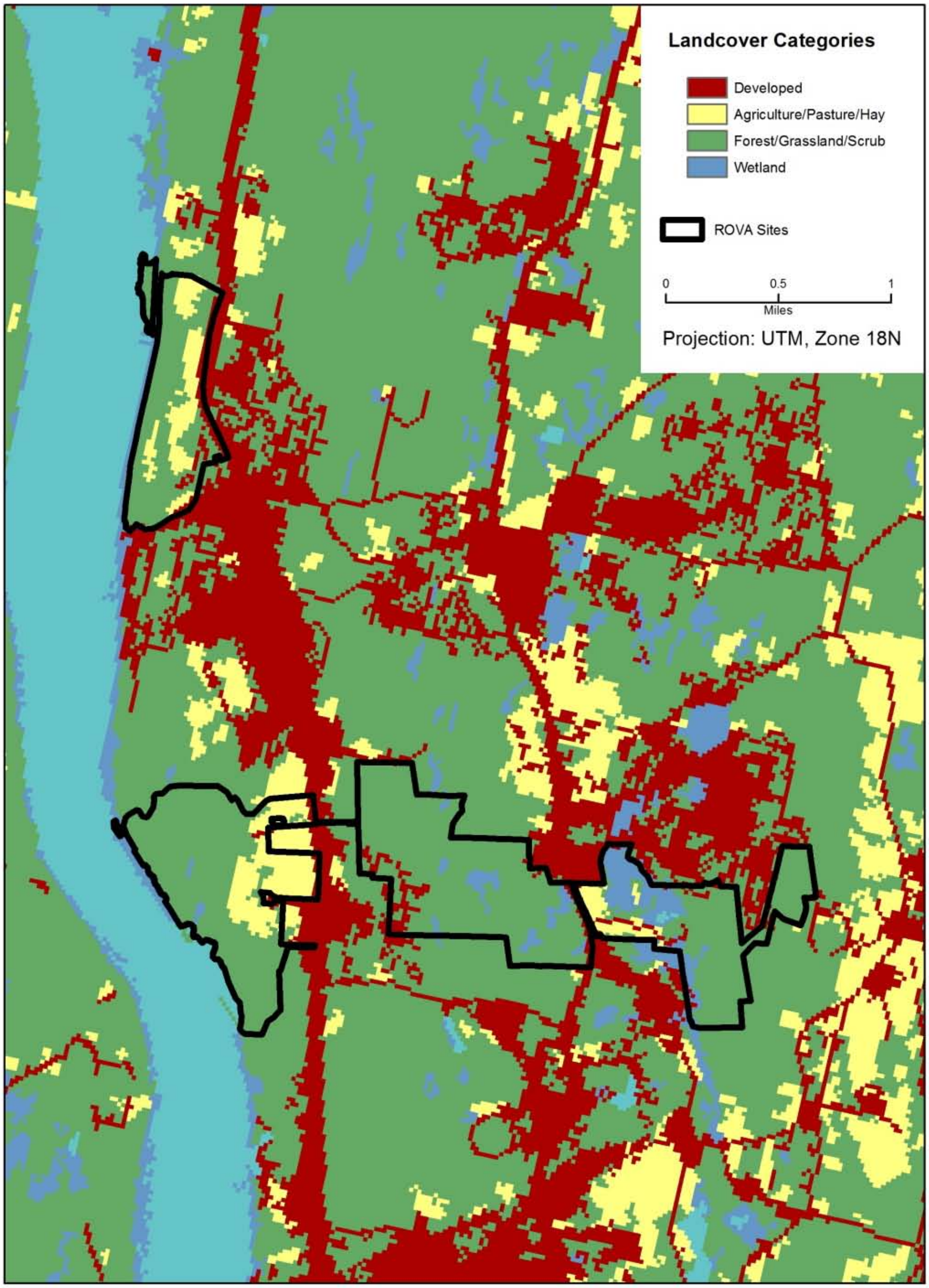

Figure 49. Land use in the vicinity of ROVA (2007 boundary), categorized in terms of two natural and two converted categories, 2001.

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Chapter 5 Discussion

ROVA is located within an urban context, situated as it is between New York City and Albany. As a result, it is surrounded by development and all the attendant pressures such activities bring. To the west, ROVA is bordered by the Hudson River, long known for its water quality problems, especially with PCB's (polychlorinated biphenyls). To the north, east, and south, ROVA is bordered by developing towns, all part of the New York-Northern New Jersey-Long Island, Metropolitan Area, a generally continuous population stretching from Albany south to New York City. External impacts, such as population growth, housing expansion, construction of roads and other infrastructure, disruption of hydrology, and habitat conversion can significantly affect natural resources through pressure on terrestrial and aquatic environments. ROVA is not exempt from these pressures since it is located in a matrix of forest, agriculture, and increased urbanization. Although ROVA is a small cultural park, it operates as a biological refuge in an urban environment for many resident and migratory species.

Given the parks' location and its relative small size, what can park personnel do to help maintain and manage the natural resources within the park itself? The answer lies largely external to the park boundaries and involves continuing interaction with local and regional entities. The park must continue to reach out to municipalities and other governments to make sure that the parks interests are known and included in local and regional planning efforts. ROVA is too small in and of itself to effect substantial change in the management of its resources.

One of the most difficult aspects for the park to manage is its air quality. Impacts to air quality occur largely outside of park boundaries. Park personnel can, however, continue to work towards increasing air quality monitoring activities within the park. Several air quality monitoring stations are located some distance from ROVA and it would be helpful to be able to have more stations located within the park itself. Specifically, the park should work towards developing ozone and visibility monitoring stations within its boundaries. Secondarily, a monitoring program for wet S and N, as well as Hg would also be beneficial. Such efforts should be coordinated with NPS regional air quality support and nationally with the air resources division. Local colleges and universities could also be approached to better leverage both funds and personnel.

Impacts to water resources are more of a local issue compared to air resources, and thus it is more likely that ROVA personnel can effect changes on the ground. ROVA has considerable surface water resources and every effort should be made to buffer streams, wetlands, and ponds from activities both within the park (e.g., grounds maintenance such as mowing) and external to the park (e.g., road runoff). Keeping effective vegetated buffers is often a balancing act between competing uses, but the larger the buffer of forest and scrub between activities and water bodies, the better the protection will be. Furthermore, as there is no stream gauge within the park, reference hydrology is unknown. ROVA should work with both the USGS, NETN and local conservation entities and universities to reinstate a gauge at Crum Elbow Creek.

In addition to a gaging station, ROVA should attempt to increase water quality sampling within park boundaries, as this is key to understanding impacts from disturbances, either internal or external to the park. Sampling seasonally and collecting multiple samples will be important to understanding park water quality. Depending on the water sampling objective, multi-parameter sondes can also be used for recording water measurements on a minute by minute to a monthly time scale versus performing traditional field grab sample collections.

Sampling for aquatic invasive species also needs to be increased to at least an annual cycle. There are a number of problem species within the region and the park, yet sampling frequency is too low to make an adequate assessment of the problem. Also, continued sampling for invasive species in ROVA's terrestrial ecosystems will provide valuable temporal data useful for management actions. At the present, only the forest systems within ROVA are systematically sampled leaving other areas (e.g., wetlands) unassessed.

Forest health is fairly good at ROVA, though there are issues with pests and regeneration of some tree species. ROVA personnel need to keep close track on the emerald ash borer and exotic earthworms. Continued forest plot assessment is planned and will help in the long-term.

Fish communities were in relatively poor condition but data was sparse and analysis was thereby limited. Fish communities need to be sampled on a 5-year basis in order to develop some idea of trends. Macroinvertebrates, however, were generally seen as slightly impacted and this bodes well for stream water quality within ROVA. Again, data were limited and regular sampling needs to occur if trends are desired. Bird species status varied with their need for intact interior forest. Edge species did better than interior species. Generally, the bird community was what might be expected in a fragmented urban setting. However, bird surveys need to take place outside of the forest, the only location where surveys currently happen. It is difficult to assess amphibian and reptiles within ROVA due to the lack of repeated data. It is likely that managing the wetlands and streams with proper buffers and corridors will do much to help this group.

Soils are slightly impacted within ROVA, likely from increased levels of acid precipitation. The impacts to ROVA come from off-site and park personnel are limited in their ability to respond. Monitoring, however, should continue as methods do exist for treating Ca, Mg and K deficient soils if ROVA staff determines that a soil treatment program is necessary to address this issue.

Finally, ROVA is in a setting where development will continue and it is of the utmost importance for park personnel to continue their interactions with the local community especially in areas where the possibility exists for increasing buffers around the park. Keeping impacts away from ROVA is difficult, but is the single most important management action the park can take, when it becomes available.

Appendix A. Vertebrate species identified as likely to be found at ROVA (NPSpecies database).

MAMMALS				
Category	Order	Family	Latin Name	Common Name
	Artiodactyla	Cervidae	Odocoileus virginianus	white-tailed deer
	Carnivora	Canidae	Canis latrans	coyote
			Urocyon cinereoargenteus	gray fox, common gray fox
			Vulpes fulvus	fox
			Vulpes vulpes	red fox
		Mephitidae	Mephitis mephitis	striped skunk
		Mustelidae	Lutra canadensis	river otter
			Mustela criminea	short-tailed weasel
			Mustela frenata	long-tailed weasel
			Mustela vison	American mink, mink
		Procyonidae	Procyon lotor	raccoon, common raccoon, Northern raccoon
		Ursidae	Ursus americanus	American black bear, black bear
	Chiroptera	Vespertilionidae	Eptesicus fuscus	big brown bat
			Lasionycteris noctivagans	silver-haired bat
			Lasiurus borealis	Eastern red bat, red bat
			Lasiurus cinereus	hoary bat
			Myotis keenii	Keen's myotis
			Myotis leibii	Eastern small-footed myotis, small-footed myotis
			Myotis lucifugus	little brown bat, little brown myotis
			Myotis sodalis	Indiana bat
			Pipistrellus subflavus	Eastern pipistrelle
	Didelphimorphia	Didelphidae	Didelphis marsupialis	common opossum
			Didelphis virginiana	Virginia Opossum
	Lagomorpha	Leporidae	Lepus americanus	snowshoe hare
			Sylvilagus floridanus	Eastern cottontail
			Sylvilagus transitionalis	New England cottontail
	Rodentia	Castoridae	Castor canadensis	American beaver, beaver
		Dipodidae	Zapus hudsonius	meadow jumping mouse
		Muridae	Clethrionomys gapperi	Southern red-backed vole
			Microtus pennsylvanicus	meadow vole
			Microtus pinetorum	pine vole, woodland vole
			Mus musculus	house mouse
			Neotoma floridana	Eastern woodrat
			Ondatra zibethicus	muskbeaver, muskrat
			Peromyscus leucopus	white-footed mouse
			Peromyscus maniculatus	deer mouse
			Rattus norvegicus	Norway rat
		Sciuridae	Glaucomys sabrinus	Northern flying squirrel
			Glaucomys volans	Southern flying squirrel
			Marmota monax	woodchuck
			Sciurus carolinensis	Eastern gray squirrel, gray squirrel
			Tamias striatus	Eastern chipmunk
			Tamiasciurus hudsonicus	red squirrel
	Soricomorpha	Soricidae	Blarina brevicauda	Northern short-tailed shrew, mole shrew, short-tailed shrew
			Cryptotis parva	north american least shrew, bee

				shrew, least shrew, little short-tailed shrew, small short-tailed shrew
			Sorex cinereus	cinereus shrew, common shrew, masked shrew
			Sorex fumeus	smoky shrew, smokey shrew
		Talpidae	Condylura cristata	star-nosed mole
			Scalopus aquaticus	Eastern mole, topos

BIRDS				
Category	Order	Family	Latin Name	Common Name
	Anseriformes	Anatidae	Aix sponsa	wood duck
			Anas acuta	Northern pintail
			Anas platyrhynchos	mallard
			Anas rubripes	American black duck
			Aythya valisineria	canvasback
			Branta bernicla	brant, brant goose, brent goose
			Branta canadensis	Canada goose
			Bucephala albeola	bufflehead
			Bucephala clangula	common goldeneye
			Cygnus olor	mute swan
			Mergus merganser	common merganser
	Apodiformes	Apodidae	Chaetura pelagica	chimney swift
		Trochilidae	Archilochus colubris	ruby-throated hummingbird
	Ciconiiformes	Accipitridae	Accipiter striatus	sharp-shinned hawk
			Buteo jamaicensis	red-tailed hawk
			Buteo lineatus	red-shouldered hawk
			Buteo platypterus	broad-winged hawk
			Haliaeetus leucocephalus	bald eagle
			Pandion haliaetus	osprey
		Ardeidae	Ardea herodias	great blue heron
			Botaurus lentiginosus	American bittern
			Butorides striatus	green-backed heron
			Butorides virescens	green heron
			Nycticorax nycticorax	black-crowned night heron, black-crowned night-heron
		Charadriidae	Charadrius semipalmatus	semipalmated plover
			Charadrius vociferus	killdeer
		Ciconiidae	Cathartes aura	turkey vulture
		Falconidae	Falco sparverius	American kestrel
		Gaviidae	Gavia immer	common loon, great northern loon
		Laridae	Larus argentatus	herring gull
			Larus delawarensis	ring-billed gull
			Larus marinus	great black-backed gull
		Phalacrocoracidae	Phalacrocorax auritus	double-crested cormorant
		Podicipedidae	Podilymbus podiceps	pied-billed grebe
		Scolopacidae	Calidris mauri	Western sandpiper
			Catoptrophorus semipalmatus	willet
			Gallinago gallinago	common snipe
			Tringa solitaria	solitary sandpiper
	Columbiformes	Columbidae	Columba livia	common pigeon, rock dove, rock pigeon
			Zenaida macroura	mourning dove
	Coraciiformes	Alcedinidae	Ceryle alcyon	belted kingfisher

Cuculiformes	Cuculidae	Coccyzus americanus	yellow-billed cuckoo
Galliformes	Phasianidae	Bonasa umbellus	ruffed grouse
		Meleagris gallopavo	wild turkey
		Phasianus colchicus	common pheasant, ring-necked pheasant
Gruiformes	Rallidae	Rallus limicola	Virginia rail
Passeriformes	Bombycillidae	Bombycilla cedrorum	cedar waxwing
	Cardinalidae	Cardinalis cardinalis	Northern cardinal
		Passerina cyanea	indigo bunting
		Pheucticus ludovicianus	rose-breasted grosbeak
	Certhiidae	Certhia americana	brown creeper
		Certhia familiaris	Eurasian treecreeper
		Polioptila caerulea	blue-gray gnatcatcher, blue-grey gnatcatcher
	Corvidae	Corvus brachyrhynchos	American crow
		Corvus ossifragus	fish crow
		Cyanocitta cristata	blue jay
	Emberizidae	Junco hyemalis	dark-eyed junco
		Melospiza georgiana	swamp sparrow
		Melospiza melodia	song sparrow
		Pipilo erythrophthalmus	Eastern towhee, rufous-sided towhee
		Spizella arborea	American tree sparrow
		Spizella passerina	chipping sparrow
		Spizella pusilla	field sparrow
		Zonotrichia albicollis	white-throated sparrow
	Fringillidae	Carduelis pinus	pine siskin
		Carduelis tristis	American goldfinch
		Carpodacus mexicanus	house finch
		Vermivora chrysoptera X pinus	Brewster's warbler
	Hirundinidae	Hirundo rustica	barn swallow
		Iridoprocne bicolor	tree swallow
		Stelgidopteryx serripennis	Northern rough-winged swallow
		Tachycineta bicolor	tree swallow
	Icteridae	Agelaius phoeniceus	red-winged blackbird
		Icterus galbula	Baltimore oriole, Northern oriole
		Molothrus ater	brown-headed cowbird
		Quiscalus quiscula	common grackle
		Sturnella magna	Eastern meadowlark
	Mimidae	Dumetella carolinensis	gray catbird, grey catbird
		Mimus polyglottos	Northern mockingbird
	Paridae	Parus atricapillus	black-capped chickadee
		Parus bicolor	tufted titmouse
	Parulidae	Dendroica caerulescens	black-throated blue warbler
		Dendroica castanea	bay-breasted warbler
		Dendroica coronata	yellow-rumped warbler
		Dendroica magnolia	magnolia warbler
		Dendroica pensylvanica	chestnut-sided warbler
		Dendroica petechia	American yellow warbler, yellow warbler
		Dendroica virens	black-throated green warbler
		Geothlypis trichas	common yellowthroat
		Helmitheros vermivorus	worm-eating warbler
		Mniotilta varia	black-and-white warbler

			Oporornis formosus	Kentucky warbler
			Parula americana	Northern parula
			Seiurus aurocapillus	ovenbird
			Seiurus motacilla	Louisiana waterthrush
			Seiurus noveboracensis	Northern waterthrush
			Setophaga ruticilla	American redstart
			Vermivora chrysoptera	golden-winged warbler
			Vermivora pinus	blue-winged warbler
			Wilsonia canadensis	Canada warbler
		Passeridae	Passer domesticus	house sparrow
		Regulidae	Regulus calendula	ruby-crowned kinglet
			Regulus satrapa	golden-crowned kinglet
		Sittidae	Sitta canadensis	red-breasted nuthatch
			Sitta carolinensis	white-breasted nuthatch
		Sturnidae	Sturnus vulgaris	common starling, European starling
		Thraupidae	Piranga olivacea	scarlet tanager
		Troglodytidae	Thryothorus ludovicianus	Carolina wren
			Troglodytes aedon	house wren
		Turdidae	Catharus fuscescens	veery
			Hylocichla mustelina	wood thrush
			Sialia sialis	Eastern bluebird
			Turdus migratorius	American robin
		Tyrannidae	Contopus virens	Eastern wood pewee, Eastern wood-pewee
			Empidonax alnorum	alder flycatcher
			Empidonax minimus	least flycatcher
			Empidonax traillii	willow flycatcher
			Myiarchus crinitus	great crested flycatcher
			Sayornis phoebe	Eastern phoebe
			Tyrannus tyrannus	Eastern kingbird
		Vireonidae	Vireo flavifrons	yellow-throated vireo
			Vireo gilvus	warbling vireo
			Vireo olivaceus	red-eyed vireo
			Vireo solitarius	blue-headed vireo, solitary vireo
	Piciformes	Picidae	Colaptes auratus	Northern flicker
			Dryocopus pileatus	pileated woodpecker
			Melanerpes carolinus	red-bellied woodpecker
			Picoides pubescens	downy woodpecker
			Picoides villosus	hairy woodpecker
			Sphyrapicus varius	yellow-bellied sapsucker
	Strigiformes	Caprimulgidae	Chordeiles minor	common nighthawk
		Strigidae	Bubo virginianus	great horned owl
			Nyctea scandiaca	snowy owl

FISH

Category	Order	Family	Latin Name	common name
	Anguilliformes	Anguillidae	Anguilla rostrata	American eel
	Clupeiformes	Clupeidae	Alosa pseudoharengus	alewife, bigeye herring, branch herring, freshwater herring, gray herring, grayback, kyak, sawbelly, white herring
	Cypriniformes	Catostomidae	Catostomus commersoni	white sucker
		Cyprinidae	Carassius auratus	goldfish
			Cyprinus carpio	European carp, common carp

		Exoglossum maxillingua	cutlip minnow, cutlips minnow
		Luxilus cornutus	common shiner
		Notemigonus crysoleucas	golden shiner
		Notropis cornutus	common shiner
		Notropis hudsonius	spottail shiner
		Phoxinus phoxinus	minnow
		Rhinichthys atratulus	blacknose dace, Eastern blacknose dace
		Rhinichthys cataractae	longnose dace
		Semotilus atromaculatus	creek chub
Cyprinodontiformes	Fundulidae	Fundulus diaphanus	banded killifish
		Fundulus heteroclitus	mummichog
Esociformes	Esocidae	Esox americanus	grass pickerel, redfin or grass pickerel, redfin pickerel
		Esox americanus americanus	redfin pickerel
		Esox niger	chain pickerel
Gasterosteiformes	Gasterosteidae	Apeltes quadracus	bloody stickleback, fourspine stickleback
Perciformes	Centrarchidae	Ambloplites rupestris	rock bass
	Centrarchidae	Lepomis auritus	redbreast sunfish
	Centrarchidae	Lepomis gibbosus	kiver, pumpkinseed
	Centrarchidae	Lepomis macrochirus	bluegill
	Centrarchidae	Micropterus salmoides	largemouth bass
	Centrarchidae	Pomoxis nigromaculatus	black crappie
	Moronidae	Morone americana	white perch
	Percidae	Etheostoma nigrum	johnny darter
	Percidae	Perca flavescens	yellow perch
Siluriformes	Ictaluridae	Ameiurus nebulosus	brown bullhead

REPTILES				
Category	Order	Family	Latin Name	common name
	Squamata	Colubridae	Carphophis amoenus	Eastern worm snake, Eastern wormsnake
		Colubridae	Coluber constrictor	racer
		Colubridae	Coluber constrictor constrictor	Northern black racer
		Colubridae	Diadophis punctatus	ring-necked snake, ringneck snake
		Colubridae	Diadophis punctatus edwardsii	Northern ringneck snake
		Colubridae	Elaphe obsoleta	rat snake, Texas ratsnake
		Colubridae	Heterodon platyrhinos	Eastern hognose snake
		Colubridae	Lampropeltis triangulum	milk snake, milksnake
		Colubridae	Lampropeltis triangulum triangulum	Eastern milk snake
		Colubridae	Natrix sipedon	Northern water snake
		Colubridae	Nerodia sipedon	Northern water snake
		Colubridae	Nerodia sipedon sipedon	Northern water snake
		Colubridae	Opheodrys vernalis	smooth greensnake
		Colubridae	Storeria dekayi	brown snake, Dekay's brownsnake, Dekay's brown snake
		Colubridae	Storeria occipitomaculata	red-bellied snake, redbelly snake
		Colubridae	Thamnophis sauritus	Eastern ribbon snake
		Colubridae	Thamnophis sirtalis	common garter snake
		Viperidae	Agkistrodon contortrix	copperhead
		Viperidae	Crotalus horridus	timber rattlesnake

	Testudines	Chelydridae	Chelydra serpentina	snapping turtle, common snapping turtle
		Chelydridae	Chelydra serpentina serpentina	common snapping turtle
		Emydidae	Chrysemys picta	painted turtle
		Emydidae	Clemmys guttata	spotted turtle
		Emydidae	Clemmys insculpta	ornate box turtle, wood turtle
		Emydidae	Clemmys muhlenbergii	bog turtle
		Emydidae	Emydoidea blandingii	Blanding's turtle
		Emydidae	Graptemys geographica	common map turtle
		Emydidae	Terrapene carolina	eastern box turtle, common box turtle
		Emydidae	Terrapene carolina carolina	eastern box turtle
		Kinosternidae	Sternotherus odoratus	common musk turtle

AMPHIBIANS

Category	Order	Family	Latin Name	common name
	Anura	Bufonidae	Bufo americanus	American toad
		Bufonidae	Bufo americanus americanus	Eastern american toad
		Hylidae	Hyla crucifer	Northern spring peeper
		Hylidae	Hyla versicolor	gray treefrog
		Hylidae	Pseudacris crucifer	spring peeper
		Hylidae	Pseudacris crucifer crucifer	northern spring peeper
		Ranidae	Rana catesbeiana	American bullfrog, bullfrog
		Ranidae	Rana clamitans	green frog
		Ranidae	Rana clamitans melanota	green frog, northern green frog
		Ranidae	Rana palustris	pickerel frog
		Ranidae	Rana sylvatica	wood frog
		Scaphiopodidae	Scaphiopus holbrookii holbrookii	Eastern spadefoot
	Caudata	Ambystomatidae	Ambystoma jeffersonianum	Jefferson salamander
		Ambystomatidae	Ambystoma jeffersonianum X laterale	Jefferson salamander/blue-spotted salamander complex
		Ambystomatidae	Ambystoma maculatum	spotted salamander
		Ambystomatidae	Ambystoma opacum	marbled salamander
		Plethodontidae	Desmognathus fuscus	dusky salamander, Northern dusky salamander
		Plethodontidae	Desmognathus fuscus fuscus	Northern dusky salamander
		Plethodontidae	Desmognathus ochrophaeus	Allegheny mountain dusky salamander, mountain dusky salamander
		Plethodontidae	Eurycea bislineata	Northern two-lined salamander, two-lined salamander
		Plethodontidae	Gyrinophilus porphyriticus porphyriticus	Northern spring salamander
		Plethodontidae	Hemidactylium scutatum	four-toed salamander
		Plethodontidae	Plethodon cinereus	Eastern red-backed salamander, red-backed salamander, redback salamander
		Plethodontidae	Plethodon glutinosus	Northern slimy salamander, slimy salamander
		Plethodontidae	Pseudotriton ruber	red salamander
		Salamandridae	Notophthalmus viridescens	Eastern newt
		Salamandridae	Notophthalmus viridescens viridescens	red-spotted newt

Appendix B. Distribution of vegetation associations and Anderson Level II categories in HOFR and ELRO and VAMA.

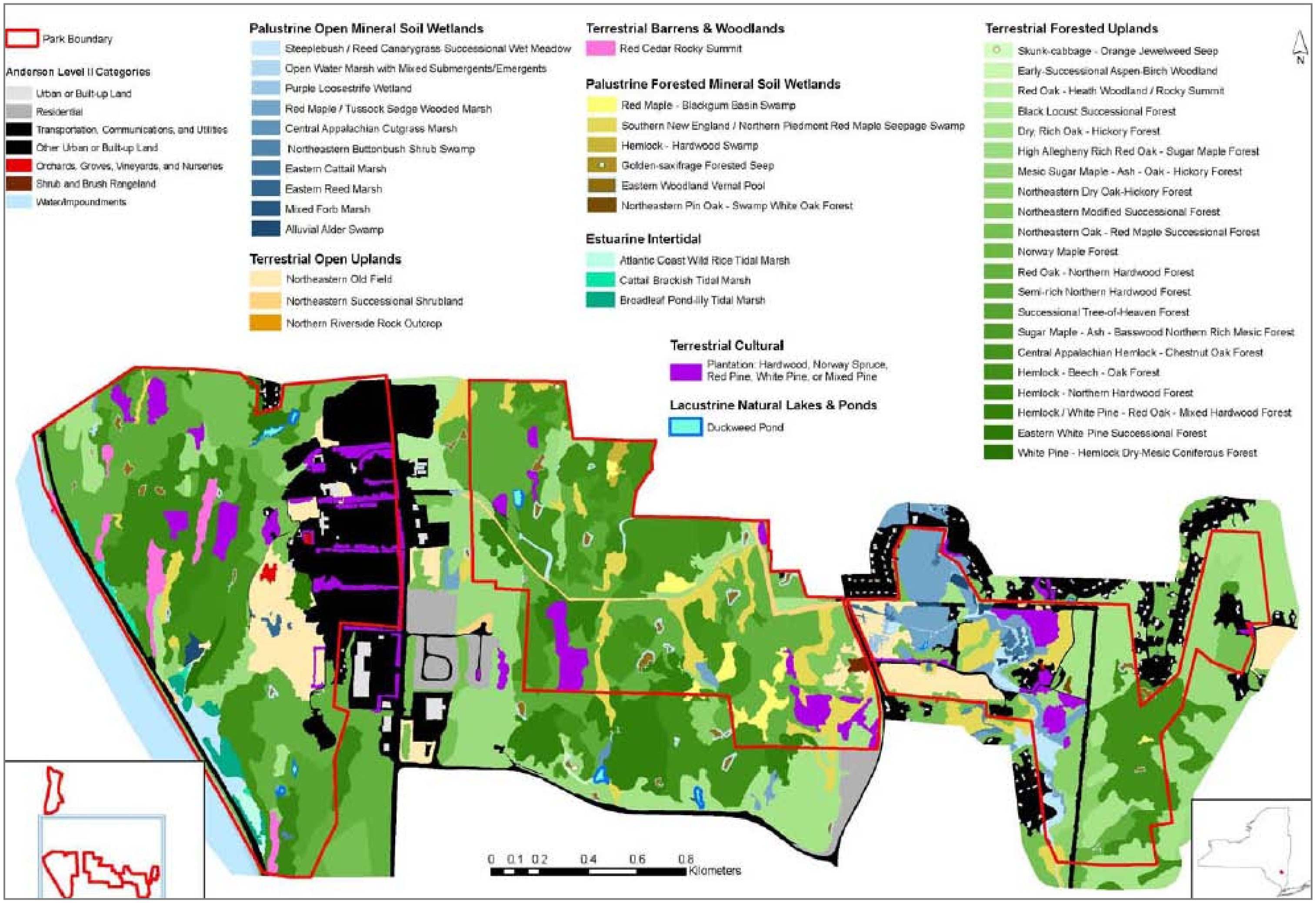

Figure B1. Distribution of vegetation associations and Anderson Level II categories in HOFR and ELRO. Figure from Sechler et al. 2009.

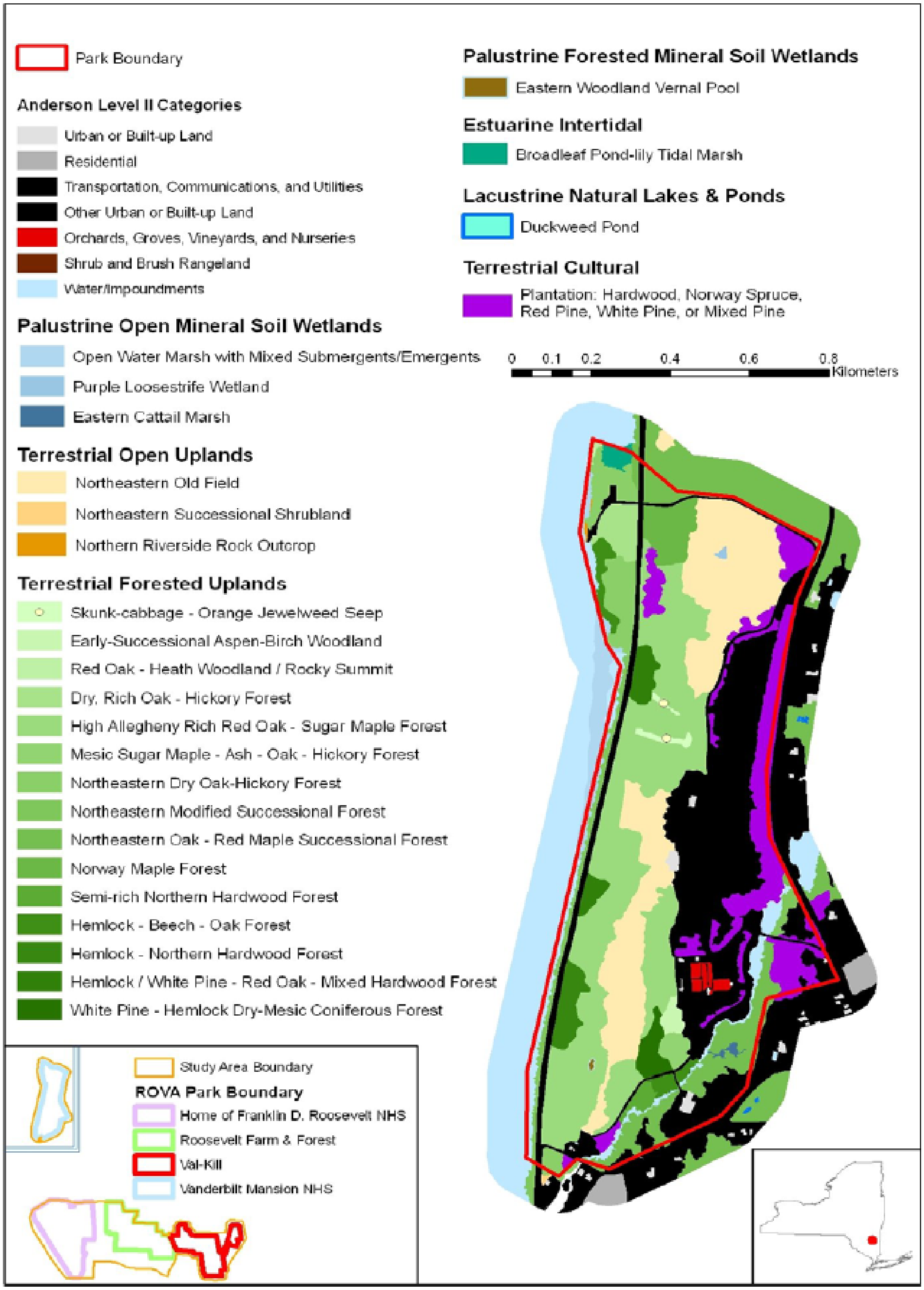

Figure B-2. Distribution of vegetation associations and Anderson Level II categories in VAMA. Figure from Sechler et al. 2009.

Appendix C. Variables, calculation methods and results used to determine park rankings and risk from acidification due to acidic deposition.

Variable	Method of Calculation	Subunit	
		HOFR	***VAMA***
Nitrogen Pollutant Exposure Variables			
Average N deposition	Average total annual N deposition for all lands within the park (kg/ha/yr)	11.30	10.50
Average S deposition	Average total annual S deposition for all lands within the park (kg/ha/yr)	14.20	12.20
N emissions by county	Total county-level annual N emissions, as areally weighted average of all counties bordering on the park and within 100 miles of the park boundary, per unit area	10.12	9.99
S emissions by county	Total county-level annual S emissions, as areally weighted average of all counties bordering on the park and within 100 miles of the park boundary, per unit area	5.90	5.79
Ecosystem Sensitivity Variables			
Percent sensitive vegetation types	Amount of land within parks that occur within the network occupied by vegetation types expected to contain red spruce and/or sugar maple	44.71	39.63
Number of high-elevation lakes	Number of high-elevation lakes within the park	0	0
Length of low-order streams	Total length of streams within park that are 1st, 2nd, 3rd order (km)	1.57	1.04
Length of high-elevation streams	Total length of streams within park that occur at high elevation (km)	0	0
Average slope	Average slope of lands within park (degrees)	6.01	13.39
Sensitive area	Occurrence of more than 5% of park land within one or more of three regional studies that mapped acid sensitive areas in the United States	1	1
Park Protection Variables			
Amount of lands in the park receiving special protection	Area of park designated as wilderness and/or Class I	0	0
Percent of lands in the park receiving special protection	Percent of park designated as wilderness and/or Class I	0	0

Source: Sullivan et al. 2011a. Refer to Sullivan et al. 2011a for ranking results.

Appendix D. Variables, calculation methods and results used to determine park rankings and risk from acidification due to acidic deposition.

Variable	Method of Calculation	Subunit	
		HOFR	***VAMA***
Nitrogen Pollutant Exposure Variables			
Average N deposition	Average total annual N deposition for all lands within the park (kg/ha/yr)	11.30	10.50
N emissions by county	Total county-level annual N emissions, as areally weighted average of all counties bordering on the park and within 100 miles of the park boundary, per unit area	10.12	9.99
Ecosystem Sensitivity Variables			
Percent sensitive vegetation types	Percent of land within the park occupied by arctic, alpine, meadow, wetland and arid and semi-arid vegetation	6.37	1.73
Number of high-elevation lakes	Number of high-elevation lakes within the park	0	0
Park Protection Variables			
Amount of lands in the park receiving special protection	Area of park designated as wilderness and/or Class I	0	0
Percent of lands in the park receiving special protection	Percent of park designated as wilderness and/or Class I	0	0

Source: Sullivan et al. 2011b. Refer to Sullivan et al. 2011b for ranking results.

Appendix E. Ozone plant bioindicators for foliar injury and their distribution among ROVA'subunits (NPS 2003 and NPS 2006).

Scientific Name	Common Name	ROVA	ELRO	HOFR	VAMA
*Ailanthus altissima**	Tree-of-heaven	x	x	x	x
Alnus rubra	Red alder				
Alnus rugosa	Speckled alder	x			x
Apios americana	Groundnut	x	x	x	x
Apocynum androsaemifolium	Spreading dogbane				
Artemisia douglasiana	Mugwort				
Artemisia ludoviciana	Silver wormwood				
Asclepias exaltata	Tall milkweed				
*Asclepias syriaca**	Common milkweed	x	x	x	x
Aster acuminatus	Whorled aster				
Aster macrophyllus	Big-leaf aster				
*Cercis canadensis**	Redbud	x			x
Corylus americana	American hazelnut	x	x	x	x
Eupatorium rugosum	White snakeroot	x	x	x	x
*Fraxinus americana**	White ash	x	x	x	x
Gaylussacia baccata	Black huckleberry	x	x		x
*Liriodendron tulipifera**	Yellow-poplar	x	x	x	x
Lyonia ligustrina	Maleberry				
Oenothera elata	Evening primrose				
Physocarpus capitatus	Ninebark				
Physocarpus malvaceum	Pacific ninebark				
Pinus jeffreyi	Jeffrey pine				
Pinus ponderosa	Ponderosa pine				
*Platanus occidentalis**	American sycamore	x	x	x	x
*Populus tremuloides**	Quaking aspen	x	x		
*Prunus serotina**	Black cherry	x	x	x	x
Rhus trilobata	Skunkbush				
*Rubus allegheniensis**	Allegheny blackberry	x	x	x	x
Rubus canadensis	Thornless blackberry				
Rudbeckia laciniata	Cutleaf coneflower	x		x	
Salix scouleriana	Scouler's willow				
*Sambucus canadensis**	American elder	x	x	x	x
Sambucus mexicana	Blue elderberry				
Sambucus racemosa	Red elderberry				
Sapium sebiferum	Chinese tallowtree				
*Symphoricarpos albus**	Common snowberry	x			x
Vaccinium membranaceum	Huckleberry				
Verbesina occidentalis	Crownbeard				
*Vitis labrusca**	Northern fox grape	x	x		x
Vitus vinifera	European wine grape				

*Plant species which serve both as a bioindicator and are considered sensitive to high ozone levels.

Appendix F. USGS Nonindigenous Aquatic Species Database (NAS) listing of nonindigenous aquatic species recorded in the Hudson-Wappinger watershed (HUC 02020008).

Group	Family	Scientific Name	Common Name
Coelenterates-Hydrozoans	Olindiidae	*Craspedacusta sowerbyi*	freshwater jellyfish
Crustaceans-Copepods	Temoridae	*Eurytemora affinis*	a calanoid copepod
Crustaceans-Crabs	Grapsidae	*Eriocheir sinensis*	Chinese mitten crab
Fishes	Centrarchidae	*Ambloplites rupestris*	rock bass
Fishes	Centrarchidae	*Lepomis gulosus*	warmouth
Fishes	Centrarchidae	*Lepomis macrochirus*	bluegill
Fishes	Centrarchidae	*Pomoxis annularis*	white crappie
Fishes	Centrarchidae	*Pomoxis nigromaculatus*	black crappie
Fishes	Cyprinidae	*Notropis amoenus*	comely shiner
Fishes	Cyprinidae	*Scardinius erythrophthalmus*	rudd
Fishes	Salmonidae	*Salmo trutta*	brown trout
Mollusks-Bivalves	Corbiculidae	*Corbicula fluminea*	Asian clam
Mollusks-Bivalves	Dreissenidae	*Dreissena polymorpha*	zebra mussel
Mollusks-Gastropods	Bithyniidae	*Bithynia tentaculata*	mud bithynia, faucet snail
Mollusks-Gastropods	Viviparidae	*Cipangopaludina chinensis malleata*	Chinese mysterysnail
Mollusks-Gastropods	Viviparidae	*Viviparus georgianus*	banded mysterysnail
Plants	Polygonaceae	*Polygonum caespitosum*	oriental lady's thumb
Plants	Asteraceae	*Solidago sempervirens*	seaside goldenrod
Plants	Asteraceae	*Sonchus arvensis*	field sow thistle
Plants	Boraginaceae	*Myosotis scorpioides*	true forget-me-not
Plants	Brassicaceae	*Nasturtium officinale*	water-cress
Plants	Chenopodiaceae	*Chenopodium glaucum*	oak-leaved goosefoot
Plants	Cyperaceae	*Carex flacca*	sedge
Plants	Haloragaceae	*Myriophyllum heterophyllum*	variable leaf water-milfoil
Plants	Haloragaceae	*Myriophyllum spicatum*	Eurasian water-milfoil
Plants	Hydrocharitaceae	*Hydrilla verticillata*	hydrilla

Plants	Iridaceae	*Iris pseudacorus*	yellow iris
Plants	Lamiaceae	*Mentha spicata*	spearmint
Plants	Lythraceae	*Lythrum salicaria*	purple loosestrife
Plants	Najadaceae	*Najas minor*	brittle naiad
Plants	Onagraceae	*Epilobium hirsutum*	great hairy willow herb
Plants	Poaceae	*Agrostis gigantea*	redtop, black bent
Plants	Poaceae	*Echinochloa crusgalli*	barnyard grass
Plants	Polygonaceae	*Polygonum persicaria*	lady's thumb, smartweed
Plants	Polygonaceae	*Rumex obtusifolius*	bitter dock
Plants	Potamogetonaceae	*Potamogeton crispus*	curly pondweed
Plants	Primulaceae	*Lysimachia nummularia*	moneywort
Plants	Salicaceae	*Salix alba*	white willow
Plants	Salicaceae	*Salix purpurea*	purple willow
Plants	Solanaceae	*Solanum dulcamara*	bittersweet nightshade
Plants	Typhaceae	*Typha angustifolia*	narrow-leaved cattail

List retrieved on March 3, 2010 from http://nas.er.usgs.gov.

Appendix G. Listing of invasive vegetation identified as key invasive exotic plant indicator species in the NETN Ecological Integrity Scorecard and surveyed in ROVA (2006-2008) (Miller et al. 2009).

Genus	Species	Common Name	Key Indicator Species	ELRO/ HOFR	VAMA
Acer	*platanoides*	Norway maple	x	x	x[a]
Ailanthus	*altissima*	tree-of-heaven	x	x	
Alliaria	*petiolata*	garlic mustard	x	x	x
[b] *Akebia*	*quinata*	chocolate vine			
[b] *Anthriscus*	*sylvestris*	wild chervil			
Berberis	*thunbergii*	Japanese barberry	x	x	x
Berberis	*vulgaris*	European barberry	x		
Cardamine	*impatiens*	narrowleaf bittercress	x		x
Celastrus	*orbiculata*	oriental bittersweet	x	x	x
[b] *Centaurea*	*stoebe ssp. micranthos*	spotted knapweed			
Chelidonium	*majus*	celandine		x	x
[b] *Cirsium*	*vulgare*	bull thistle			
[b] *Commelina*	*communis*	asiatic dayflower			
Conium	*maculatum*	hemlock		x	x
Cynanchum	*louiseae*	black swallow-wort	x		
Cynanchum	*rossicum*	European swallow-wort	x		
Duchesnea	*indica*	Indian mock-strawberry		x	
Epipactis	*helleborine*	broadleaf helleborine		x	
Euonymus	*alata*	winged burning bush	x	x	x
[b] *Forsythia*	*Spp.*	forsythia			
Frangula	*alnus*	glossy buckthorn	x		
Glechoma	*hederacea*	ground ivy		x	
Hemerocallis	*fulva*	tawny daylily			x
Hesperis	*matronalis*	dames rocket		x	
Humulus	*japonicas*	Japanese hop	x		
[b] *Iris*	*pseudacorus*	pale yellow iris			
Ligustrum	*obtusifolium, vulgare*	privet	x		
Lonicera	*japonica*	Japanese honeysuckle	x		
Lonicera	*morrowii, tatarica, x bella*	exotic honeysuckles	x	x	
Luzula	*luzuloides*	forest woodrush	x		
[b] *Lythrum*	*salciaria*	purple loosetrife			
Lysimachia	*nummularia*	creeping jenny		x	x
Microstegium	*vimineum*	Japanese stiltgrass	x	x	x
[b] *Morus*	*alba*	white mulberry			
Myosotis	*scorpioides*	true forget-me-not			x
Phragmites	*australis*	common reed			x
Picea	*abies*	Norway spruce		x	
Plantago	*major*	common plantain			x
Polygonum	*caespitosum*	oriental ladysthumb	x	x	
Polygonum	*cuspidatum*	Japanese knotweed	x		

Genus	Species	Common Name	Key Indicator Species	ELRO/ HOFR	VAMA
Ranunculus	*acris*	tall buttercup			x
Rhamnus	*cathartica*	common buckthorn	x		
Rhodotypos	*scandens*	jetbead	x		
Robinia	*pseudoacacia*	lack locust		x	
Rosa	*multiflora*	multiflora rose	x	x	x
Rubus	*phoenicolasius*	wineberry	x		
[b] *Sedum*	*sarmentosum*	stringy stonecrop			
Solanum	*dulcamara*	climbing nightshade		x	
Vinca	*minor*	common periwinkle			x
[b] *Wisteria*	*floribunda*	Japanese wisteria			

[a] Species not documented as occurring in Miller et al. 2009, but was noted in Miller et al. 2010
[b] Species documented as present within park by Keefer et al. (2010) but not documented in surveys in ROVA from 2006-2009.

Appendix H. Listing of Vascular Plants of Roosevelt-Vanderbilt National Historic Park (ROVA).

A total of 876 species have been documented, including 818 species and subspecific, and 58 above species plants. Source: NPSpecies - The National Park Service Biodiversity Database. Secure online version. https://science1.nature.nps.gov/npspecies/web/main/start (scientific names; accessed April 2, 2010).

Order	Family	Latin name	Common name
Alismatales	Alismataceae	Alisma plantago-aquatica	American water plantain
		Sagittaria	arrowhead
		Sagittaria latifolia	broadleaf arrowhead, common arrowhead, duck-potato, wapato
Apiales	Apiaceae	Angelica atropurpurea	purple stem angelica
		Anthriscus sylvestris	bur chervil, cow parsley, keck, wild chervil
		Cicuta bulbifera	bulb water hemlock, bulblet-bearing water hemlock, bulblet-bearing water-hemlock
		Cicuta maculata	common water hemlock, poison parsnip, spotted cowbane, spotted parsley, spotted water hemlock, spotted water-hemlock, spotted water hemlock, water hemlock
		Conioselinum chinense	Chinese hemlock parsley
		Conium maculatum	cigue maculee, cigue tachetee, deadly hemlock, poison hemlock, poison parsley, poison-hemlock
		Cryptotaenia canadensis	Canadian honewort, honewort
		Daucus carota	Queen Anne's lace, bird's nest, wild carrot
		Osmorhiza claytonii	Clayton's sweetroot, hairy sweet-cicely
		Osmorhiza longistylis	aniseroot, longstyle sweetroot
		Sanicula gregaria	
		Sanicula trifoliata	largefruit blacksnakeroot
		Zizia aptera	heart-leaf alexanders, heartleaf alexanders, meadow zizia, meadowparsnip, zizia
		Zizia aurea	golden alexanders, golden zizia

Order	Family	Latin name	Common name
	Araliaceae	Acanthopanax sieboldianus	
		Aralia nudicaulis	wild sarsaparilla
		Aralia racemosa	American spikenard
Arales	Araceae	Arisaema atrorubens	
		Arisaema triphyllum	Indian jack in the pulpit, Jack in the pulpit, Jack-in-the-pulpit
		Arisaema triphyllum ssp. triphyllum	Jack in the pulpit
		Peltandra virginica	Virginia peltandra, green arrow arum
		Symplocarpus foetidus	skunk cabbage
	Lemnaceae	Lemna	duckweed
		Lemna minor	common duckweed, least duckweed, lesser duckweed
		Spirodela polyrhiza	giant duckweed
		Spirodela polyrrhiza	common duckmeat, common duckweed, greater duckweed
		Wolffia	watermeal
Aristolochiales	Aristolochiaceae	Asarum canadense	Canadian wild ginger, Canadian wildginger
Asterales	Asteraceae	Achillea millefolium	bloodwort, carpenter's weed, common yarrow, hierba de las cortaduras, milfoil, plumajillo, western yarrow, yarrow (common)
		Ambrosia artemisiifolia	Roman wormwood, annual ragweed, common ragweed, low ragweed, ragweed, short ragweed, small ragweed
		Antennaria neglecta	field pussytoes
		Antennaria neglecta var. attenuata	
		Antennaria plantaginifolia	plantainleaf pussytoes, woman's tobacco
		Arctium minus	bardane, beggar's button, burdock, common burdock, lesser burdock, lesser burrdock, small burdock, smaller burdock, wild burdock, wild rhubarb
		Artemisia vulgaris	common wormwood, mugwort
		Aster	aster

Order	Family	Latin name	Common name
		Aster cordifolius	common blue wood aster
		Aster divaricatus	
		Aster divaricatus	serpentine aster, white wood aster
		Aster ericoides	heath aster, white aster, white heath aster
		Aster infirmus	
		Aster lanceolatus	white panicle aster
		Aster lateriflorus	calico aster
		Aster lowrieanus	
		Aster novae-angliae	New England aster
		Aster novi-belgii	New Belgium aster
		Aster puniceus	purplestem aster
		Aster vimineus	
		Bidens	Spanish needles, beggartick, beggarticks, devil'ssticktight
		Bidens cernua	bur marigold, nodding beggartick, nodding beggarticks, nodding bur marigold, nodding burmarigold, nodding burr-marigold, sticktight
		Bidens discoidea	discord beggarticks, small beggarticks, swamp beggar-ticks
		Bidens frondosa	bur marigold, devil's beggartick, devil's beggarticks, devil's bootjack, devil's-pitchfork, devils beggartick, pitchfork weed, sticktight, sticktights, tickseed sunflower
		Bidens laevis	burmarigold, smooth beggartick, smooth beggarticks
		Bidens tripartita	three-lobe beggarticks, threelobe beggarticks
		Centaurea calcitrapa	purple starthistle, red star thistle, red star-thistle
		Centaurea maculosa	spotted knapweed
		Centaurea scabiosa	greater knapweed
		Cichorium intybus	Common chicory, blue sailors, chicory, coffeeweed, succory

Order	Family	Latin name	Common name
		Cirsium arvense	Californian thistle, Canada thistle, Canadian thistle, creeping thistle, field thistle
		Cirsium muticum	swamp thistle
		Cirsium vulgare	bull thistle, common thistle, spear thistle
		Conyza canadensis	Canada horseweed, Canadian horseweed, horseweed, horseweed fleabane, mares tail, marestail
		Coreopsis lanceolata	lance coreopsis, lanceleaf tickseed
		Erechtites hieraciifolia var. hieraciifolia	American burnweed
		Erigeron annuus	annual fleabane, eastern daisy fleabane
		Erigeron philadelphicus	Philadelphia daisy, Philadelphia fleabane
		Erigeron strigosus	Daisy Fleabane, prairie fleabane, rough fleabane
		Eupatorium altissimum	tall joepyeweed, tall thoroughwort
		Eupatorium fistulosum	Joe Pye weed, trumpetweed
		Eupatorium leucolepis	justiceweed
		Eupatorium maculatum	spotted joe-pye-weed, spotted joepyeweed
		Eupatorium perfoliatum	bonset, common boneset
		Eupatorium rugosum	richweed, snakeroot, white snakeroot
		Euthamia graminifolia	flat-top goldentop, flattop goldentop
		Galinsoga ciliata	shaggy soldier
		Galinsoga quadriradiata	fringed quickweed, hairy galinsoga, shaggy soldier, shaggy-soldier
		Gnaphalium obtusifolium	
		Helenium autumnale	bitterweed, common sneezeweed, fall sneezeweed, false sunflower
		Helianthus annuus	annual sunflower, common sunflower, sunflower, wild sunflower
		Helianthus divaricatus	woodland sunflower

Order	Family	Latin name	Common name
		Helianthus strumosus	paleleaf woodland sunflower
		Heliopsis helianthoides	heliopsis sunflower, oxeye, smooth oxeye, sunflower heliopsis
		Hieracium caespitosum	meadow hawkweed, yellow hawkweed
		Hieracium canadense	Canadian hawkweed, yellow hawkweed
		Hieracium kalmii	Kalm's hawkweed
		Hieracium murorum	wall hawkweed
		Hieracium paniculatum	Allegheny hawkweed
		Hieracium perforatum	
		Hieracium piloselloides	tall hawkweed
		Hieracium venosum	rattlesnakeweed
		Inula helenium	elecampane inula
		Krigia virginica	Virginia dwarfdandelion
		Lactuca biennis	tall blue lettuce, wild blue lettuce
		Lactuca floridana	Florida lettuce, woodland lettuce
		Lapsana communis	common nipplewort, nipplewort
		Leucanthemum vulgare	ox-eye daisy, oxeye daisy, oxeye-daisy, oxeyedaisy
		Matricaria matricarioides	disc mayweed, pineappleweed
		Mikania scandens	climbing hempvine, climbing hempweed
		Prenanthes alba	white rattlesnake-root, white rattlesnakeroot
		Prenanthes altissima	rattlesnakeroot, tall rattlesnakeroot
		Prenanthes trifoliolata	gall of the earth
		Rudbeckia fulgida	orange coneflower
		Rudbeckia hirta	blackeyed Susan, blackeyedsusan
		Rudbeckia hirta var. pulcherrima	blackeyed Susan
		Rudbeckia laciniata	cutleaf coneflower, green-head coneflower
		Rudbeckia serotina	

Order	Family	Latin name	Common name
		Rudbeckia triloba	browneyed Susan
		Senecio aureus	golden ragwort
		Solidago	goldenrod, goldenrod species
		Solidago arguta	Atlantic goldenrod
		Solidago bicolor	white goldenrod
		Solidago caesia	wreath goldenrod
		Solidago canadensis	Canada goldenrod, Canadian goldenrod, common goldenrod
		Solidago flexicaulis	zigzag goldenrod
		Solidago gigantea	giant goldenrod
		Solidago hispida	hairy goldenrod
		Solidago juncea	early goldenrod
		Solidago nemoralis	dyersweed goldenrod, gray goldenrod
		Solidago odora	anisescented goldenrod, fragrant goldenrod
		Solidago rugosa ssp. aspera	wrinkled goldenrod, wrinkleleaf goldenrod
		Solidago rugosa ssp. rugosa var. rugosa	wrinkleleaf goldenrod
		Solidago tenuifolia	
		Tanacetum vulgare	common tansy, garden tansy, tansy
		Taraxacum officinale	blowball, common dandelion, dandelion, faceclock
		Tragopogon pratensis	Jack-go-to-bed-at-noon, meadow salsify
		Tussilago farfara	colts foot, coltsfoot
		Vernonia noveboracensis	New York ironweed
		Xanthium strumarium	cocklebur, cockleburr, common cocklebur, rough cocklebur, rough cockleburr
		Xanthium strumarium var. glabratum	cocklebur, common cocklebur, rough cocklebur, rough cockleburr
Campanulales	Campanulaceae	Campanula rotundifolia	bluebell, bluebell bellflower, bluebell-of-Scotland, roundleaf harebell

Order	Family	Latin name	Common name
		Lobelia cardinalis	Cardinal flower, cardinalflower
		Lobelia inflata	Indian tobacco, Indian-tobacco
		Lobelia siphilitica	great blue lobelia
		Specularia perfoliata	
		Triodanis perfoliata	Venus looking-glass, clasping Venus' looking-glass, clasping Venus' lookingglass, clasping bellwort, clasping venuslookingglass, clasping-leaf venus'-looking-glass, common Venus' lookingglass, roundleaved triodanis
		Triodanis perfoliata var. perfoliata	clasping Venus' looking-glass, clasping Venus' lookingglass, clasping-leaf venus'-looking-glass
Capparales	Brassicaceae	Alliaria officinalis	
		Alliaria petiolata	garlic mustard, garlic-mustard
		Arabidopsis thaliana	mouse-ear cress, mouseear cress
		Arabis divaricarpa	
		Arabis glabra	tower rockcress, tower-mustard
		Arabis laevigata	smooth rock-cress, smooth rockcress
		Arabis lyrata	lyrate rockcress
		Arabis X divaricarpa	spreading rockcress, spreadingpod rockcress
		Barbarea vulgaris	garden yellow rocket, garden yellow-rocket, garden yellowrocket, winter cress, yellow rocket
		Capsella bursa-pastoris	shepardspurse, shepherd's purse, shepherd's-purse, shepherdspurse
		Cardamine bulbosa	bulb bittercress, bulbous bitter-cress, bulbous bittercress
		Cardamine diphylla	crinkleroot
		Cardamine hirsuta	hairy bittercress
		Cardamine impatiens	narrowleaf bittercress
		Cardamine pensylvanica	Pennsylvania bittercress, Quaker bittercress

Order	Family	Latin name	Common name
		Cardamine rotundifolia	American bittercress
		Dentaria diphylla	
		Draba verna	spring Whitlowgrass, spring draba
		Hesperis matronalis	dame rocket, dame's rocket, dames rocket, dames violet, mother-of-the-evening
		Lepidium campestre	cream-anther field pepperwort, field pepperweed
		Lepidium virginicum	Virginia pepperweed, Virginian peppercress, peppergrass, poorman pepperweed, poorman's pepper, poorman's-pepperwort
	Cruciferae	Cruciferae	
Caryophyllales	Cactaceae	Opuntia humifusa	devil's-tongue, pricklypear
	Caryophyllaceae	Arenaria serpyllifolia	thymeleaf sandwort
		Cerastium arvense	field chickweed, field mouse-ear chickweed, starry chickweed
		Cerastium fontanum	common chickweed, common mouse-ear chickweed, mouse-ear chickweed
		Cerastium fontanum ssp. triviale	
		Cerastium semidecandrum	fivestamen chickweed
		Cerastium vulgatum	big chickweed, mouseear chickweed
		Dianthus armeria	Deptford pink, Deptford's pink
		Lychnis alba	white cockle
		Sagina japonica	Japanese pearlwort
		Saponaria officinalis	bouncing bet, bouncing-bett, bouncingbet, bouncingbet soapweed, soapwort, sweet Betty
		Silene cucubalus	
		Silene latifolia	bladder campion
		Silene vulgaris	bladder campion, bladder silene, cowbell, maiden's tears, maiden's-tears, maidenstears, rattleweed
		Stellaria graminea	grass-leaf starwort, grassleaved stichwort, grasslike starwort,

Order	Family	Latin name	Common name
			grassy starwort, lesser starwort, little starwort
		Stellaria media	chickweed, common chickweed, nodding chickweed
	Chenopodiaceae	Chenopodium album	common lambsquarters, lambsquarters, lambsquarters goosefoot, white goosefoot
	Phytolaccaceae	Phytolacca americana	American pokeweed, common pokeweed, inkberry, pigeonberry, poke, pokeberry, pokeweed
	Portulacaceae	Portulaca oleracea	akulikuli-kula, common purslane, duckweed, garden purslane, little hogweed, little-hogweed, purslane, pursley, pusley, wild portulaca
Celastrales	Aquifoliaceae	Ilex laevigata	smooth winterberry
		Ilex verticillata	common winterberry
	Celastraceae	Celastrus orbiculata	Asian bittersweet
		Celastrus orbiculatus	Asian bittersweet, Asiatic bittersweet, oriental bittersweet
		Celastrus scandens	American bittersweet, staffvine, waxwork
		Euonymus	burningbush, spindletree
		Euonymus alata	burning bush, winged burning bush, winged euonymus
		Euonymus alatus	
		Euonymus americana	strawberry bush, strawberrybush
		Euonymus fortunei	climbing euonymus, winter creeper
Commelinales	Commelinaceae	Commelina communis	Asiatic dayflower, common dayflower
		Tradescantia virginiana	Virginia spiderwort
Cornales	Cornaceae	Cornus alternifolia	alternate-leaf dogwood, alternateleaf dogwood
		Cornus amomum	silky dogwood
		Cornus florida	flowering dogwood
		Cornus foemina ssp. racemosa	
		Cornus racemosa	gray dogwood
		Cornus rugosa	round-leaf dogwood, roundleaf dogwood

Order	Family	Latin name	Common name
Cornales	Nyssaceae	Nyssa sylvatica	black gum, black tupelo, blackgum
Cyperales	Cyperaceae	Carex	carex, sedge, sedge species, sedges
		Carex amphibola var. turgida	eastern narrowleaf sedge
		Carex blanda	bland sedge, eastern woodland sedge, woodland sedge
		Carex bromoides	bromelike sedge
		Carex cephalophora	oval-leaf sedge, oval-leaved sedge, ovalleaf sedge
		Carex conoidea	open-field sedge, openfield sedge
		Carex cristatella	crested sedge
		Carex festucacea	fescue sedge
		Carex flava	yellow sedge
		Carex granularis	limestone meadow sedge, limestone-meadow sedge
		Carex grayi	Gray's sedge
		Carex lacustris	hairy sedge, lakebank sedge
		Carex lupulina	hop sedge
		Carex muehlenbergii	Muhlenberg's sedge, muhlenberg's sedge
		Carex pallescens	pale sedge
		Carex pensylvanica	Penn sedge, Pennsylvania sedge
		Carex platyphylla	broad-leaved sedge, broadleaf sedge
		Carex radiata	eastern star sedge
		Carex rosea	rosy sedge
		Carex stipata	owlfruit sedge, sawbeak sedge, stalk-grain sedge
		Carex stricta	upright sedge, uptight sedge
		Carex tetanica	rigid sedge
		Carex vulpinoidea	common fox sedge, fox sedge
		Cyperus bipartitus	brook flatsedge, shining flat sedge, slender flatsedge
		Cyperus brevifolioides	

Order	Family	Latin name	Common name
		Cyperus esculentus	chufa, chufa flatsedge, yellow nutgrass, yellow nutsedge
		Cyperus odoratus	fragrant flatsedge, rusty flat sedge
		Cyperus strigosus	stawcolored flatsedge, strawcolor flatsedge, strawcolor nutgrass, strawcolored flatsedge, strawcolored nutgrass
		Eleocharis	spikerush, spikesedge
		Eleocharis intermedia	matted spikerush
		Scirpus	bulrush, bulrush spp.
		Scirpus atrovirens	dark-green bulrush, green bulrush
	Gramineae	Gramineae	
	Poaceae	Agropyron	other wheatgrasses, wheatgrass
		Agrostis	bentgrass
		Agrostis hyemalis	winter bentgrass
		Agrostis perennans	autumm bentgrass, upland bent, upland bentgrass
		Anthoxanthum odoratum	sweet vernalgrass
		Arrhenatherum elatius	tall oatgrass
		Brachyelytrum erectum	bearded shorthusk
		Bromus inermis	awnless brome, smooth brome
		Cinna arundinacea	stout wood reed-grass, stout woodreed, sweet wood-reed, sweet woodreed
		Dactylis glomerata	cocksfoot, orchard grass, orchardgrass
		Deschampsia	hairgrass
		Deschampsia caespitosa	tufted hairgrass
		Deschampsia cespitosa	tufted hairgrass
		Digitaria ischaemum	small crabgrass, smooth crab grass, smooth crabgrass
		Echinochloa crus-galli	Japanese millet, barnyard grass, barnyardgrass, cockspur, large barnyard grass, watergrass
		Echinochloa crus-galli var. crus-galli	large barnyardgrass

Order	Family	Latin name	Common name
		Echinochloa muricata	rough barnyard grass, rough barnyardgrass
		Echinochloa muricata var. microstachya	rough barnyard grass, rough barnyardgrass
		Echinochloa walteri	coast cockspur, coast cockspur grass, walter's barnyard grass
		Elymus hystrix	eastern bottle-brush grass, eastern bottlebrush grass
		Elymus virginicus	Virginia wild rye, Virginia wildrye
		Eragrostis spectabilis	petticoat-climber, purple lovegrass
		Festuca elatior	
		Leersia virginica	white grass, whitegrass
		Muhlenbergia schreberi	nimblewill, nimblewill muhly
		Muhlenbergia tenuiflora	slender muhly
		Oryzopsis asperifolia	roughleaf ricegrass, white-grain mountain-rice grass
		Panicum	low panicum sp, panicgrass, panicum
		Panicum clandestinum	deer-tongue witchgrass
		Paspalum setaceum var. muehlenbergii	
		Phleum pratense	common timothy, timothy
		Phragmites australis	common reed
		Phragmites communis	common reed
		Poa	bluegrass, bluegrass spp.
		Poa alsodes	grove bluegrass
		Poa annua	annual blue grass, annual bluegrass, walkgrass
		Poa compressa	Canada bluegrass, flat-stem blue grass
		Poa palustris	fowl blue grass, fowl bluegrass
		Poa pratensis	Kentucky bluegrass
		Schizachyrium scoparium var. scoparium	little bluestem
		Secale cereale	Cultivated annual rye, cereal rye, common rye, cultivated rye, rye

Order	Family	Latin name	Common name
		Setaria faberi	Chinese foxtail, Chinese millet, Japanese bristlegrass, giant bristlegrass, giant foxtail, nodding foxtail, tall green bristlegrass
		Setaria geniculata	marsh bristlegrass
		Setaria glauca	
		Tridens flavus	Purpletop, purpletop tridens
		Tridens flavus var. flavus	purpletop tridens
		Zizania aquatica	annual wildrice
Dilleniales	Paeoniaceae	Paeonia	peony
Dipsacales	Caprifoliaceae	Kolkwitzia amabilis	beautybush
		Lonicera	honeysuckle
		Lonicera japonica	Chinese honeysuckle, Japanese honeysuckle
		Lonicera maackii	Amur honeysuckle, Amur honeysuckle bush
		Lonicera morrowii	Morrow's honeysuckle
		Lonicera tatarica	Tartarian honeysuckle, Tatarian honeysuckle, bush honeysuckle
		Lonicera xylosteum	dwarf honeysuckle
		Sambucus canadensis	american elder
		Sambucus racemosa ssp. pubens	
		Symphoricarpos albus	common snowberry, snowberry (common)
		Triosteum aurantiacum	orangefruit horse-gentian
		Viburnum acerifolium	mapleleaf viburnum
		Viburnum alnifolium	
		Viburnum dentatum	arrow-wood viburnum, arrowwood, southern arrowwood
		Viburnum lentago	nanny-berry, nannyberry
		Viburnum plicatum	Japanese snowball
		Viburnum prunifolium	blackhaw
		Viburnum rafinesquianum	downy arrow-wood, downy arrowwood

Order	Family	Latin name	Common name
		Viburnum recognitum	northern arrow-wood
		Viburnum trilobum	american cranberrybush
		Weigela japonica	
	Dipsacaceae	Dipsacus fullonum	Fuller's teasel, common teasel, teasel, venuscup teasle
	Valerianaceae	Valeriana officinalis	garden heliotrope, garden valerian
Ebenales	Styracaceae	Halesia tetraptera	mountain silverbell
		Styrax americana	american snowbell
		Styrax americanus	American snowbell, snowbell
Equisetales	Equisetaceae	Equisetum	horsetail, scouring rush
		Equisetum arvense	field horsetail, scouring rush, western horsetail
		Equisetum hyemale	horsetail, scouring horsetail, scouringrush, scouringrush horsetail, tall scouring-rush, western scouringrush
Ericales	Ericaceae	Enkianthus campanulatus	
		Gaultheria procumbens	eastern teaberry
		Gaylussacia baccata	black huckleberry
		Kalmia latifolia	mountain laurel
		Rhododendron	azaleas, rhododendron
		Rhododendron catawbiense	Catawba rosebay, catawba rhododendron
		Rhododendron obtusum var. kaempferi	torch azalea
		Rhododendron periclymenoides	pink azalea
		Vaccinium	blueberries, blueberry, huckleberry, vaccinium
		Vaccinium angustifolium	lowbush blueberry
		Vaccinium corymbosum	highbush blueberry
		Vaccinium pallidum	Blue Ridge blueberry, Blueridge blueberry
		Vaccinium stamineum	deerberry
		Vaccinium vacillans	
	Monotropaceae	Monotropa uniflora	Indianpipe, one-flower Indian-

Order	Family	Latin name	Common name
			pipe
	Pyrolaceae	Chimaphila maculata	striped prince's pine, striped prince's-pine
		Chimaphila umbellata	common pipsissewa, pipsissewa
Euphorbiales	Euphorbiaceae	Acalypha gracilens	slender copperleaf, slender threeseed mercury
		Acalypha virginica var. rhomboidea	Virginia threeseed mercury
		Chamaesyce maculata	spotted sandmat
		Chamaesyce nutans	eyebane, nodding spurge, spotted sandmat, spotted spurge
		Euphorbia cyparissias	cypress spurge
		Euphorbia esula	leafy spurge, spurge, wolf's milk, wolf's-milk
		Euphorbia pseudoesula	
		Euphorbia X pseudoesula	spurge
		Poinsettia dentata	
Fabales	Fabaceae	Amorpha fruticosa	desert false indigo, desert indigobush, dullleaf indigo, false indigo, false indigo-bush, indigobush, leadplant
		Amphicarpaea bracteata	American hogpeanut, hog-peanut
		Apios americana	apios americana, groundnut, potatobean
		Cassia hebecarpa	
		Cercis canadensis	Redbud, eastern redbud
		Cladrastis kentukea	Kentucky yellowwood, yellowood
		Desmodium canadense	Canada tickclover, showy tick-trefoil, showy ticktrefoil
		Desmodium glutinosum	Largeflower tickclover, pointedleaf ticktrefoil, trefoil tickclover
		Desmodium paniculatum	narrow-leaf tick-trefoil, panicled tickclover, panicledleaf ticktrefoil
		Gleditsia triacanthos	Honey locust, common honeylocust, honey-locust, honeylocust, honeylocusts
		Gleditsia triacanthos var. inermis	

Order	Family	Latin name	Common name
		Gymnocladus dioicus	Kentucky coffeetree, Kentucy coffeetree
		Lespedeza intermedia	intermediate lespedeza
		Lespedeza procumbens	trailing lespedeza
		Lespedeza violacea	violet lespedeza
		Lotus corniculatus	Birdsfoot trefoil, birdfoot deervetch, bloomfell, cat's clover, crowtoes, garden bird's-foot-trefoil, garden birdsfoot trefoil, ground honeysuckle
		Medicago lupulina	black medic, black medic clover, black medick, hop clover, hop medic, nonesuch, yellow trefoil
		Medicago sativa	alfalfa
		Medicago sativa ssp. sativa	alfalfa
		Melilotus alba	white sweetclover
		Melilotus officinalis	yellow sweet-clover, yellow sweetclover
		Robinia pseudo-acacia	black locust
		Robinia pseudoacacia	black locust, false acacia, yellow locust
		Sophora japonica	Japanese pagoda tree
		Trifolium agrarium	
		Trifolium arvense	hairy clover, hare's foot clover, oldfield clover, rabbit-foot clover, rabbitfoot clover, stone clover
		Trifolium aureum	golden clover
		Trifolium dubium	hop clover, smallhop clover, suckling clover
		Trifolium hybridum	alsike clover
		Trifolium incarnatum	crimson clover
		Trifolium medium	zigzag clover
		Trifolium pratense	red clover
		Trifolium repens	Dutch clover, ladino clover, white clover
		Vicia cracca	bird vetch, cow vetch
		Vicia tetrasperma	lentil vetch, sparrow vetch

Order	Family	Latin name	Common name
		Wisteria sinensis	Chinese wisteria
Fagales	Betulaceae	Alnus incana ssp. rugosa	speckled alder
		Alnus rugosa	
		Alnus serrulata	alder, brook-side alder, hazel alder
		Betula alleghaniensis	yellow birch
		Betula lenta	sweet birch
		Betula papyrifera	paper birch
		Betula populifolia	gray birch
		Carpinus caroliniana	American hornbeam, american hornbean
		Corylus americana	American hazelnut, american hazelnut, hazel, hazelnut
		Ostrya virginiana	eastern hophornbeam, hophornbeam
	Fagaceae	Castanea dentata	American chestnut
		Fagus grandifolia	American beech
		Fagus sylvatica	European beech
		Quercus	oak, oak spp., oaks
		Quercus acutissima	sawtooth oak
		Quercus alba	white oak
		Quercus bicolor	swamp white oak
		Quercus coccinea	scarlet oak
		Quercus macrocarpa	bur oak
		Quercus montana	
		Quercus palustris	pin oak
		Quercus prinus	chestnut oak
		Quercus rubra	northern red oak
		Quercus velutina	black oak
		Quercus X saulii	Saul's oak
Gentianales	Apocynaceae	Apocynum cannabinum	Indian hemp, Indian-hemp, Indianhemp, common dogbane, dogbane, hemp dogbane, prairie

Order	Family	Latin name	Common name
			dogbane
		Apocynum cannabinum var. hypericifolium	
		Vinca minor	common periwinkle, lesser periwinkle, myrtle
	Asclepiadaceae	Asclepias incarnata	rose milkweed, swamp milkweed
		Asclepias syriaca	broadleaf milkweed, common milkweed
		Asclepias verticillata	eastern whorled milkweed, whorled milkweed
		Cynanchum nigrum	Louis' swallow-wort, black swallowwort, climbing milkweed
Geraniales	Balsaminaceae	Impatiens capensis	jewelweed, spotted touch-me-not
	Geraniaceae	Geranium	geranium, geranium spp.
		Geranium bicknellii	Bicknell's cranesbill, northern crane's-bill
		Geranium maculatum	spotted crane's-bill, spotted geranium, wild crane's-bill
		Geranium robertianum	Robert geranium
	Oxalidaceae	Oxalis acetosella	
		Oxalis dillenii	Dillen's oxalis
		Oxalis europaea	
		Oxalis montana	mountain woodsorrel
		Oxalis stricta	common yellow oxalis, erect woodsorrel, sheep sorrel, sourgrass, toad sorrel, upright yellow wood-sorrel, upright yellow woodsorrel, yellow woodsorrel
Ginkgoales	Ginkgoaceae	Ginkgo biloba	common ginkgo, maidenhair tree
Hamamelidales	Hamamelidaceae	Hamamelis virginiana	American witchhazel, witch-hazel, witchhazel
		Liquidambar styraciflua	sweetgum
	Platanaceae	Platanus occidentalis	American sycamore, sycamore
Juglandales	Juglandaceae	Carya cordiformis	bitternut hickory
		Carya glabra	pignut hickory
		Carya ovata	carya ovata australis, shag-bark

Order	Family	Latin name	Common name
			hickory, shagbark hickory
		Carya tomentosa	mockernut hickory
		Juglans cinerea	butternut
		Juglans nigra	black walnut
Juncales	Juncaceae	Juncus effusus var. solutus	lamp rush
		Juncus marginatus	grassleaf rush
		Juncus pelocarpus	brownfruit rush
		Juncus tenuis	field rush, path rush, poverty rush, slender rush, slender yard rush, wiregrass
		Luzula multiflora	common wood-rush, common woodrush
Lamiales	Boraginaceae	Echium vulgare	blueweed, common echium, common vipersbugloss
		Hackelia virginiana	beggar's-lice, beggarslice, sticktight, virginia stickseed
		Myosotis laxa	bay forget-me-not
		Myosotis scorpioides	forget-me-not, true forget me not, true forget-me-not, yelloweye forget-me-not
	Lamiaceae	Agastache scrophulariifolia	purple giant hyssop
		Ajuga genevensis	blue bugle
		Ajuga reptans	common bugle
		Clinopodium vulgare	wild basil
		Collinsonia canadensis	richweed
		Glechoma hederacea	creeping charlie, gill-over-the-ground, ground ivy, groundivy, haymaids
		Glecoma hederacea	
		Lamium amplexicaule	common henbit, giraffehead, henbit, henbit deadnettle
		Lamium purpureum	purple deadnettle, red deadnettle
		Leonurus cardiaca	common motherwort, motherwort
		Lycopus americanus	American bugleweed, American water horehound, American waterhorehound, cut-leaf water-horehound, water horehound,

Order	Family	Latin name	Common name
			waterhorehound
		Lycopus rubellus	taperleaf bugleweed, taperleaf water horehound
		Lycopus uniflorus	bugleweed, northern bugleweed, northern water-horehound, oneflower bugleweed
		Mentha	mint
		Mentha arvensis	wild mint
		Mentha spicata	bush mint (spearmint), spearmint
		Mentha X piperita	peppermint
		Monarda fistulosa	wildbergamot beebalm
		Origanum vulgare	oregano
		Prunella vulgaris	common selfheal, heal all, healall, selfheal
		Pycnanthemum tenuifolium	narrowleaf mountainmint, narrowleaf mountianmint
		Pycnanthemum virginianum	Virginia mountain-mint, Virginia mountainmint, Virginia mountianmint
		Satureja vulgaris	
		Scutellaria galericulata	hooded skullcap, marsh scullcap, marsh skullcap
		Scutellaria lateriflora	blue skullcap, mad dog skullcap
		Stachys palustris	marsh hedgenettle
		Teucrium canadense	American germander, Canada germander, Candad germander, germander, hairy germander, wood sage
		Trichostema dichotomum	blue curls, forked bluecurls
	Verbenaceae	Phryma leptostachya	American lopseed, lopseed
		Verbena hastata	Simpler's-joy, blue verbena, blue vervain, swamp verbena
		Verbena urticifolia	white verbena, white vervain
Laurales	Calycanthaceae	Calycanthus floridus	eastern sweetshrub
	Lauraceae	Lindera benzoin	northern spicebush, spicebush
		Sassafras albidum	sassafras

Order	Family	Latin name	Common name
Liliales	Dioscoreaceae	Dioscorea villosa	wild yam
	Iridaceae	Crocus	crocus
		Hypoxis hirsuta	common goldstar, eastern yellow star-grass
		Iris pseudacorus	paleyellow iris, yellow flag
		Iris versicolor	harlequin blueflag
		Sisyrinchium atlanticum	eastern blue-eyed grass, eastern blueeyed grass
		Sisyrinchium montanum	mountain blue eyedgrass, mountain blueeyed grass, strict blue-eyed grass, strict blue-eyed-grass
	Liliaceae	Allium	Wild onion, onion
		Allium canadense	Canada garlic, meadow garlic, meadow onion, wild onion
		Allium tricoccum	ramp, small white leek, wild leek
		Allium vineale	wild garlic
		Asparagus officinalis	asparagus, garden asparagus, garden-asparagus
		Convallaria majalis	European lily of the valley, lily-of-the-valley
		Erythronium americanum	dogtooth violet
		Galanthus nivalis	snowdrop
		Hemerocallis fulva	orange day lily, orange daylily, tawny daylily
		Hosta plantaginea	fragrant plantain lily
		Hosta ventricosa	blue plantain lily
		Lilium canadense	Canada lily
		Lilium superbum	turk's-cap lily
		Maianthemum canadense	Canada mayflower, false lily-of-the-valley, twoleaved Solomonseal
		Medeola virginiana	Indian cucumber
		Narcissus	daffodil, narcissus
		Ornithogalum umbellatum	Pyrenees Star of Bethlehem, Star-of-Bethlehem, sleepydick
		Polygonatum biflorum	King Solomon's-seal, Solomon's seal, king Solomon's seal,

Order	Family	Latin name	Common name
			smooth Solomon's seal
		Polygonatum pubescens	hairy Solomon's seal
		Smilacina racemosa	
		Trillium	trillium
		Trillium erectum	red trillium
		Trillium grandiflorum	snow trillium
		Trillium recurvatum	bloody butcher, prairie trillium
		Tulipa	tulip
		Uvularia perfoliata	perfoliate bellwort
		Uvularia sessilifolia	sessile-leaf bellwort, sessileleaf bellwort
		Veratrum viride	green false hellebore
	Pontederiaceae	Pontederia cordata	pickerelweed
	Smilacaceae	Smilax	Common greenbriar, greenbriar, greenbrier
		Smilax herbacea	herbaceous greenbriar, smooth carrionflower
		Smilax rotundifolia	bullbriar, common catbriar, common greenbrier, greenbrier, horsebriar, roundleaf greenbriar, roundleaf greenbrier
Lycopodiales	Lycopodiaceae	Lycopodium	club moss, clubmoss, clubmosses
		Lycopodium annotinum	clubmoss, stiff club moss, stiff clubmoss
		Lycopodium complanatum	christmas green, creeping jenny, groundcedar
		Lycopodium digitatum	fan clubmoss
		Lycopodium lucidulum	
		Lycopodium obscurum	ground pine, rare clubmoss, tree club moss
Magnoliales	Magnoliaceae	Liriodendron tulipifera	tulip poplar, tuliptree, yellow poplar, yellow-poplar
		Magnolia acuminata	cucumber-tree, cucumbertree
		Magnolia stellata	star magnolia
		Magnolia tripetala	umbrella magnolia, umbrella-tree

Order	Family	Latin name	Common name
		Magnolia X soulangiana	Chinese magnolia
Malvales	Malvaceae	Hibiscus syriacus	althea, rose of Sharon, rose-of-sharon, shrub althea, shrub-althea
		Malva moschata	musk mallow
	Tiliaceae	Tilia	basswood
		Tilia americana	American basswood
		Tilia neglecta	
		Tilia platyphyllos	largeleaf linden
		Tilia X euchlora	Crimean linden
Myrtales	Lythraceae	Decodon verticillatus	swamp loosestrife
		Lythrum salicaria	purple loosestrife, purple loosestrife or lythrum, purple lythrum, rainbow weed, salicaire, spiked loosestrife
	Onagraceae	Circaea canadensis	
		Circaea lutetiana	broad-leaf enchanter's-nightshade, broadleaf enchanter's nightshade
		Circaea lutetiana ssp. canadensis	broad-leaf enchanter's-nightshade, broadleaf enchanter's nightshade
		Circaea quadrisulcata	
		Circaea quadrisulcata ssp. canadensis	
		Epilobium ciliatum ssp. ciliatum	coast willowweed, fringed willowherb
		Epilobium coloratum	purple-leaf willowherb, purpleleaf willowherb, willowweed
		Ludwigia palustris	marsh primrose-willow, marsh seedbox
		Oenothera biennis	common evening primrose, common evening-primrose, common eveningprimrose, evening primrose (common), hoary eveningprimrose, king's-cureall
	Thymelaeaceae	Dirca palustris	eastern leatherwood, moosewood
	Trapaceae	Trapa natans	water chestnut, water chestnut, water nut

Order	Family	Latin name	Common name
Najadales	Potamogetonaceae	Potamogeton crispus	curly pondweed, curly-leaved pondweed
		Potamogeton hillii	Hill's pondweed
		Potamogeton nodosus	long-leaf pondweed, longleaf pondweed
Nymphaeales	Cabombaceae	Cabomba caroliniana	Carolina fanwort, fanwort
	Ceratophyllaceae	Ceratophyllum demersum	common hornwort, coon's tail, coon's-tail, coontail, hornwort
		Ceratophyllum echinatum	prickly hornwort, spineless hornwort
	Nymphaeaceae	Nuphar lutea ssp. variegata	varigated yellow pond-lily, yellow pond-lily
		Nuphar luteum variegatum	
		Nuphar variegata	
		Nymphaea odorata	American waterlily, American white waterlily, white waterlily
Ophioglossales	Ophioglossaceae	Botrychium dissectum	cut-leaf grape fern, cutleaf grapefern
		Botrychium lanceolatum	lance-leaf moonwort, lanceleaf grapefern
		Botrychium virginianum	rattlesnake fern
Orchidales	Orchidaceae	Cypripedium acaule	lady's-slipper orchid, moccasin flower, pink lady's slipper, pink lady's-slipper, pink lady's-slipper orchid, pink ladyslipper, pink moccasin flower
		Epipactis helleborine	broadleaf helleborine
		Goodyera pubescens	downy rattlesnake plantain, downy rattlesnake-plantain
		Spiranthes cernua	nodding ladies'-tresses, nodding ladiestresses, white nodding ladies'-tresses
Papaverales	Fumariaceae	Corydalis	corydalis, fumewort
		Corydalis flavula	pale corydalis, yellow fumewort
		Corydalis sempervirens	rock harlequin
		Dicentra canadensis	squirrel corn
		Dicentra cucullaria	Dutchman's-breeches, Dutchmans breeches, dutchman's breeches, dutchmans britches
	Papaveraceae	Chelidonium majus	celandine

Order	Family	Latin name	Common name
		Sanguinaria canadensis	bloodroot
		Stylophorum diphyllum	celandine poppy
Pinales	Cupressaceae	Chamaecyparis pisifera	sawara cypress
		Juniperus chinensis pfitzerana	Pfitzer’s juniper
		Juniperus communis	common juniper, dwarf juniper
		Juniperus virginiana	eastern red-cedar, eastern redcedar, red cedar juniper
		Thuja occidentalis	arborvitae, eastern white cedar, northern white cedar, northern white-cedar, swamp cedar
	Pinaceae	Abies cilicica	cilicica fir
		Abies nordmanniana	Caucasian fir, Nordmann fir
		Larix decidua	European larch
		Larix laricina	alaskan larch, american larch, eastern larch, hackmatack, tamarack
		Picea abies	Norway spruce
		Picea glauca	black hills spruce, canadian spruce, cat spruce, porsild spruce, skunk spruce, western white spruce, white spruce
		Picea pungens	blue spruce, colorado blue spruce, silver spruce
		Picea rubens	red spruce
		Pinus resinosa	norway pine, red pine
		Pinus rigida	pitch pine
		Pinus strobus	easter white pine, eastern white pine, northern white pine, soft pine, weymouth pine, white pine
		Pinus sylvestris	Scotch pine, Scots pine
		Pseudolarix amabilis	
		Pseudotsuga menziesii	Douglas fir, Douglas-fir, douglas spruce, oregon pine, red fir
		Pseudotsuga taxifolia	
		Pseudotsuga taxifolia var. glauca	
		Tsuga canadensis	canada hemlock, eastern hemlock, hemlock spruce

Order	Family	Latin name	Common name
Piperales	Saururaceae	Saururus cernuus	lizard's tail, lizards tail
Plantaginales	Plantaginaceae	Plantago lanceolata	English plantain, buckhorn plantain, lanceleaf Indianwheat, lanceleaf plantain, narrowleaf plantain, ribgrass, ribwort
		Plantago major	broadleaf plantain, buckhorn plantain, common plantain, great plantain, rippleseed plantain
		Plantago media	hoary plantain, lanceleaf plantain
		Plantago rugelii	Rugel's plantain, black-seed plantain, blackseed plantain
Polygalales	Polygalaceae	Polygala sanguinea	blood milkwort, purple milkwort
		Polygala verticillata	whorled milkwort
Polygonales	Polygonaceae	Polygonum arifolium	halberdleaf tearthumb
		Polygonum aviculare	prostrate knotweed, yard knotweed
		Polygonum caespitosum	bristled knotweed, bunchy knotweed, oriental ladysthumb
		Polygonum cespitosum	oriental ladysthumb
		Polygonum cespitosum var. longisetum	oriental ladysthumb
		Polygonum convolvulus	black bindweed, black-bindweed, climbing buckwheat, climbing knotweed, cornbind, dullseed cornbind, pink smartweed, wild buckwheat
		Polygonum cuspidatum	Japanese knotweed, Mexican bamboo, fleeceflower
		Polygonum hydropiperoides	swamp smartweed
		Polygonum opelousanum	
		Polygonum persicaria	lady's-thumb, ladysthumb, ladysthumb smartweed, smartweed, spotted knotweed, spotted ladysthumb, spotted smartweed
		Polygonum punctatum	dotted smartweed
		Polygonum robustius	stout smartweed
		Polygonum sagittatum	arrow-leaf tearthumb, arrowleaf knotweed, arrowleaf tearthumb, arrowvine
		Polygonum virginianum	Virginia smartweed, jumpseed

Order	Family	Latin name	Common name
		Rumex acetosa	garden sorrel
		Rumex acetosella	common sheep sorrel, field sorrel, red (or sheep) sorrel, red sorrel, sheep sorrel
		Rumex crispus	Curley dock, curly dock, narrowleaf dock, sour dock, yellow dock
		Rumex obtusifolius	bitter dock, bluntleaf dock
		Tovara virginiana	
Polypodiales	Aspleniaceae	Asplenium platyneuron	ebony spleenwort
		Asplenium trichomanes	maidenhair spleenwort
		Camptosorus rhizophyllus	walking-fern spleenwort
	Dennstaedtiaceae	Dennstaedtia punctilobula	eastern hayscented fern
		Pteridium aquilinum	bracken, bracken fern, brackenfern, northern bracken fern, western brackenfern
	Dryopteridaceae	Athyrium asplenioides	
		Athyrium filix-femina	common ladyfern, lady fern, ladyfern, subarctic lady fern
		Cystopteris fragilis	brittle bladder fern, brittle bladderfern, fragile fern
		Dryopteris carthusiana	spinulose wood fern, spinulose woodfern
		Dryopteris intermedia	intermediate woodfern
		Dryopteris marginalis	marginal woodfern, woodfern
		Dryopteris spinulosa	
		Onoclea sensibilis	sensitive fern
		Polystichum acrostichoides	Christmas fern
		Woodsia obtusa	blunt-lobe woodsia, bluntlobe cliff fern
	Osmundaceae	Osmunda cinnamomea	cinnamon fern
		Osmunda claytoniana	interrupted fern
		Osmunda regalis	royal fern
	Polypodiaceae	Polypodium virginianum	rock polypody
		Polypodium vulgare	

Order	Family	Latin name	Common name
	Pteridaceae	Adiantum pedatum	maidenfern, maidenhair, maidenhair fern, northern maidenhair
	Thelypteridaceae	Dryopteris noveboracensis	
		Thelypteris noveboracensis	New York fern
		Thelypteris palustris	eastern marsh fern, marsh fern, meadow fern
Primulales	Primulaceae	Lysimachia ciliata	fringed loosestrife, fringed yellow-loosestrife
		Lysimachia nummularia	creeping jenny, moneywort
		Lysimachia quadrifolia	whorled loosestrife, whorled yellow loosestrife
		Trientalis borealis	starflower
Ranunculales	Berberidaceae	Berberis thunbergii	Japanese barberry
		Berberis vulgaris	European barberry, beet, common barberry, epine-vinette, epine-vinette commune, vinetteier
		Caulophyllum thalictroides	blue cohosh
	Lardizabalaceae	Akebia quinata	chocolate vine
	Menispermaceae	Menispermum canadense	Canadian moonseed, common moonseed
	Ranunculaceae	Actaea	baneberry
		Actaea pachypoda	baneberry, white baneberry
		Anemone canadensis	Canada anemone, Canadian anemone
		Anemone cylindrica	candle anemone, cottonweed
		Anemone quinquefolia	nightcaps
		Anemone virginiana	Virginia anemone, tall thimbleweed
		Anemone virginiana var. virginiana	tall thimbleweed
		Anemonella thalictroides	
		Aquilegia canadensis	American columbine, Colorado columbine, red columbine
		Caltha palustris	yellow marsh marigold, yellow marsh-marigold, yellow marshmarigold
		Clematis virginiana	Virginia bower, devil's darning needles, devil's-darning-

Order	Family	Latin name	Common name
			needles, virgin's bower
		Hepatica acutiloba	
		Hepatica americana	
		Hepatica nobilis var. obtusa	roundlobe hepatica
		Ranunculus	buttercup, buttercup spp.
		Ranunculus abortivus	early woodbuttercup, kidney-leaf buttercup, littleleaf buttercup, smallflower buttercup, smallflower crowfoot
		Ranunculus acris	meadow buttercup, tall buttercup
		Ranunculus bulbosus	St. Anthony's turnip, blister flower, bulbous buttercup, bulbous crowfoot, gowan, yellow weed
		Ranunculus hispidus var. nitidus	bristly buttercup, swamp buttercup
		Ranunculus recurvatus	blisterwort, littleleaf buttercup
		Thalictrum	meadow-rue, meadowrue
		Thalictrum dioicum	early meadow-rue
		Thalictrum pubescens	king of the meadow
Rhamnales	Rhamnaceae	Rhamnus alnifolia	alder-leaf buckthorn, alderleaf buckthorn
		Rhamnus cathartica	European buckthorn, European waythorn, Hart's thorn, carolina buckthorn, common buckthorn, nerprun cathartique
	Vitaceae	Parthenocissus	creeper
		Parthenocissus quinquefolia	American ivy, Virginia creeper, fiveleaved ivy, woodbine
		Vitis	grape
		Vitis aestivalis	summer grape
		Vitis labrusca	fox grape
		Vitis riparia	river-bank grape, riverbank grape
Rosales	Crassulaceae	Sedum acre	goldmoss stonecrop
		Sedum sarmentosum	stringy stonecrop
		Sedum spectabile	showy stonecrop

Order	Family	Latin name	Common name
	Grossulariaceae	Ribes	currant
		Ribes cynosbati	eastern prickly gooseberry, pasture currant
		Ribes hirtellum	hairy-stem gooseberry, hairystem gooseberry
		Ribes rotundifolium	Appalachian gooseberry
		Ribes uva-crispa var. sativum	European gooseberry
	Hydrangeaceae	Deutzia gracilis	slender pride of Rochester
		Deutzia X carnea lactea	
		Deutzia X lemoinei	
		Hydrangea paniculata	panicled hydrangea
		Philadelphus	mock orange, mockorange
		Philadelphus coronarius	sweet mock orange
		Philadelphus floribundus	
		Philadelphus grandiflorus	
		Philadelphus laxus	
		Philadelphus lewisii	Lewis' mock orange
		Philadelphus X floribundus	
		Philadelphus X magnificus	
		Philadelphus X monstruosus	
		Philadelphus X virginalis	
		Philadelphus X zeyheri	
	Rosaceae	Agrimonia	agrimony
		Agrimonia gryposepala	agrimony, tall hairy agrimony, tall hairy grooveburr
		Agrimonia pubescens	groovebur, roadside agrimony, soft agrimony, soft groovebur
		Amelanchier	serviceberry
		Amelanchier canadensis	Canadian serviceberry
		Amelanchier sanguinea	huron serviceberry, roundlead juneberry, roundleaf serviceberry, shore shadbush
		Amelanchier stolonifera	running serviceberry

Order	Family	Latin name	Common name
		Aronia melanocarpa	black chokeberry
		Crataegus crus-galli	bush hawthorne, cockspur hawthorn
		Crataegus viridis	green hawthorn
		Fragaria	strawberry
		Fragaria virginiana	Virginia strawberry, thickleaved wild strawberry, wild strawberry
		Geum aleppicum	yellow avens
		Geum canadense	white avens
		Geum vernum	heartleaf avens, spring avens
		Geum virginianum	cream avens
		Malus	apple
		Malus prunifolia	plumleaf crabapple
		Malus pumila	paradise apple
		Malus X magdeburgensis	malus
		Physocarpus opulifolius	Atlantic ninebark, common ninebark
		Physocarpus opulifolius var. opulifolius	common ninebark
		Potentilla	cinquefoil
		Potentilla argentea	silver cinquefoil, silver-leaf cinquefoil
		Potentilla arguta	tall cinquefoil
		Potentilla canadensis	dwarf cinquefoil
		Potentilla recta	roughfruit cinquefoil, sulfur (or erect) cinquefoil, sulfur cinquefoil, sulphur cinquefoil
		Prunus	chokecherry, plum, prunus
		Prunus avium	sweet cherry
		Prunus serotina	black cherry, black chokecherry
		Prunus virginiana	Virginia chokecherry, chokecherry, chokecherry (common), common chokecherry
		Rhodotypos scandens	jetbead

Order	Family	Latin name	Common name
		Rosa	rose, wildrose spp.
		Rosa carolina	Carolina rose
		Rosa foetida	
		Rosa multiflora	multiflora rose
		Rosa palustris	swamp rose
		Rosa virginiana	Virginia rose
		Rubus	blackberry, brambles
		Rubus allegheniensis	Allegheny blackberry
		Rubus enslenii	
		Rubus flagellaris	northern dewberry, whiplash dewberry
		Rubus hispidus	bristly dewberry
		Rubus occidentalis	black raspberry
		Rubus odoratus	purpleflowering raspberry
		Rubus phoenicolasius	Japanese wineberry, wine raspberry, wineberry
		Rubus setosus	setose blackberry
		Spiraea alba var. latifolia	white meadowsweet
		Spiraea chamaedryfolia	Germander meadowsweet
		Spiraea latifolia	
		Spiraea prunifolia	bridalwreath spirea
		Spiraea tomentosa	steeplebush
		Spiraea X vanhouttei	Van Houtt's spirea
	Saxifragaceae	Astilbe japonica	florist's spiraea
		Chrysosplenium americanum	American golden saxifrage
		Mitella diphylla	twoleaf miterwort
		Saxifraga virginiensis	early saxifrage
Rubiales	Rubiaceae	Cephalanthus occidentalis	buttonbush, common buttonbush
		Galium	bedstraw
		Galium aparine	bedstraw, catchweed bedstraw,

Order	Family	Latin name	Common name
			cleavers, cleaverwort, goose grass, scarthgrass, sticky-willy, stickywilly, white hedge
		Galium asprellum	rough bedstraw
		Galium circaezans	licorice bedstraw, wild licorice, woods bedstraw
		Galium lanceolatum	lanceleaf wild licorice
		Galium mollugo	false baby's breath
		Galium triflorum	fragrant bedstraw, sweet bedstraw, sweetscented bedstraw
		Hedyotis caerulea	
		Mitchella repens	partridgeberry
Salicales	Salicaceae	Populus grandidentata	bigtooth aspen
		Populus tremuloides	quaking aspen
		Salix	salix, willow, willow species
		Salix discolor	pussy willow
		Salix fragilis	crack willow
		Salix nigra	black willow
Santalales	Santalaceae	Comandra umbellata	bastard toadflax
Sapindales	Aceraceae	Acer mono	
		Acer negundo	ashleaf maple, box elder, boxelder, boxelder maple, california boxelder, manitoba maple, western boxelder
		Acer nigrum	black maple, black sugar maple, hard maple, rock maple, sugar maple
		Acer palmatum ssp. atropurpureum	Japanese red maple
		Acer pensylvanicum	moosewood, striped maple
		Acer platanoides	Norway maple
		Acer pseudoplatanus	sycamore, sycamore maple
		Acer rubrum	red maple
		Acer saccharinum	silver maple
		Acer saccharum	sugar maple

Order	Family	Latin name	Common name
		Acer spicatum	moose maple, mountain maple
	Anacardiaceae	Cotinus coggygria	European smoketree
		Cotinus obovatus	American smoketree
		Rhus glabra	smooth sumac
		Rhus radicans	poison ivy
		Rhus typhina	staghorn sumac
		Toxicodendron radicans	eastern poison ivy, poison ivy, poisonivy
		Toxicodendron vernix	poison sumac
	Hippocastanaceae	Aesculus hippocastanum	horse chestnut
	Rutaceae	Zanthoxylum americanum	Common pricky-ash, common pricklyash, toothachetree
	Simaroubaceae	Ailanthus altissima	ailanthus, copal tree, tree of heaven, tree-of-heaven
	Staphyleaceae	Staphylea trifolia	American bladdernut, american bladdernut
Scrophulariales	Bignoniaceae	Campsis radicans	common trumpetcreeper, cow-itch, trumpet creeper
		Catalpa bignonioides	southern catalpa
		Catalpa speciosa	northern catalpa
	Oleaceae	Forsythia	forsythia
		Forsythia suspensa	weeping forsythia
		Forsythia viridissima	greenstem forsythia
		Forsythia X intermedia	showy forsythia
		Fraxinus	ash
		Fraxinus americana	white ash
		Fraxinus pennsylvanica	green ash
		Ligustrum	ligustrum, privet
		Ligustrum obtusifolium	border privet
		Ligustrum vulgare	European privet, wild privet
		Syringa	lilac
		Syringa reticulata	Japanese tree lilac

Order	Family	Latin name	Common name
		Syringa vulgaris	common lilac
		Syringa X chinensis	Chinese lilac
		Syringa X hyacinthiflora	
	Orobanchaceae	Conopholis americana	American squawroot, squaw-root
		Epifagus virginiana	beechdrops
		Orobanche uniflora	naked broom-rape, naked broomrape, oneflowered broomrape
	Scrophulariaceae	Aureolaria pedicularia	fernleaf yellow false foxglove
		Chelone glabra	white turtlehead
		Digitalis purpurea	purple foxglove
		Linaria vulgaris	Jacob's ladder, butter and eggs, butterandeggs, flaxweed, greater butter-and-eggs, ramsted, wild snapdragon, yellow toadflax
		Melampyrum lineare	narrowleaf cowwheat
		Mimulus alatus	sharpwing monkeyflower
		Mimulus ringens	Allegheny monkey-flower, Allegheny monkeyflower, ringen monkeyflower
		Pedicularis canadensis	Canadian lousewort, early lousewort
		Penstemon digitalis	talus slope penstemon
		Verbascum blattaria	moth mullein, white moth mullein
		Verbascum thapsus	big taper, common mullein, flannel mullein, flannel plant, great mullein, mullein, velvet dock, velvet plant, woolly mullein
		Veronica agrestis	field speedwell, green field speedwell
		Veronica americana	American speedwell, brooklime
		Veronica anagallis-aquatica	blue water speedwell, water speedwell
		Veronica arvensis	common speedwell, corn speedwell, rock speedwell, wall speedwell
		Veronica longifolia	long-leaf speedwell, longleaf speedwell

Order	Family	Latin name	Common name
		Veronica officinalis	common gypsyweed
		Veronica peregrina	neckweed, purslane speedwell
		Veronica persica	Persian speedwell, bird-eye speedwell, birdeye speedwell, birdseye speedwell, winter speedwell
		Veronica serpyllifolia	thyme-leaf speedwell, thymeleaf speedwell
Solanales	Convolvulaceae	Calystegia sepium	bearbind, devil's guts, hedge bindweed, hedge false bindweed, hedge falsebindweed, hedgebell, large bindweed, old man's night cap, wild morning glory
		Calystegia sepium ssp. sepium	hedge false bindweed
		Convolvulus	Field bindweed, bindweed
		Convolvulus sepium	hedge false bindweed
	Cuscutaceae	Cuscuta compacta	compact dodder
		Cuscuta gronovii	scaldweed
		Cuscuta pentagona	bush-clover dodder, field dodder, fiveangled dodder, lespedeza dodder
	Polemoniaceae	Phlox divaricata	wild blue phlox
	Solanaceae	Physalis heterophylla	clammy ground-cherry, clammy groundcherry
		Physalis subglabrata	husk tomato, longleaf groundcherry, smooth groundcherry
		Solanum carolinense	Carolina horsenettle, apple of Sodom, bull nettle, devil's tomato, horsenettle, sand briar
		Solanum dulcamara	European bittersweet, bitter nightshade, bittersweet nightshade, blue nightshade, climbing nightshade, fellenwort, woody nightshade
		Solanum nigrum	black nightshade
Taxales	Taxaceae	Taxus canadensis	Canada yew
		Taxus cuspidata	Japanese yew
Theales	Clusiaceae	Hypericum perforatum	Klamath weed, Klamathweed, St. John's wort, St. Johnswort, common St Johnswort, common St. John's wort, common St.

Order	Family	Latin name	Common name
			Johnswort
		Hypericum punctatum	spotted St. Johnswort
Typhales	Sparganiaceae	Sparganium americanum	American bur-reed, American burreed
	Typhaceae	Typha angustifolia	narrow-leaf cat-tail, narrowleaf cattail
		Typha latifolia	broadleaf cattail, cattail, cattail (common), common cattail
Urticales	Moraceae	Morus alba	mulberry, white mulberry
	Ulmaceae	Celtis occidentalis	common hackberry, hackberry, western hackberry
		Ulmus	elm
		Ulmus americana	American elm
		Ulmus glabra ssp. pendula	weeping elm
		Ulmus procera	English elm
		Ulmus pumila	Chinese elm, Siberian elm
		Ulmus rubra	slippery elm
	Urticaceae	Boehmeria cylindrica	small-spike false nettle, smallspike false nettle, smallspike falsenettle
		Laportea canadensis	Canada lettuce, Canada woodnettle, Canadian wood-nettle, Canadian woodnettle
		Pilea pumila	Canada clearweed, Canadian clearweed
		Urtica dioica	California nettle, slender nettle, stinging nettle, tall nettle
		Urtica dioica ssp. dioica	stinging nettle
Violales	Cucurbitaceae	Sicyos angulatus	bur cucumber, burcucumber, oneseed burr cucumber, wall bur cucumber
	Violaceae	Viola	violet
		Viola cucullata	marsh blue violet
		Viola incognita	
		Viola macloskeyi	Macloskey's violet, small white violet
		Viola macloskeyi ssp. pallens	smooth white violet
		Viola papilionacea	common blue violet, hooded

Order	Family	Latin name	Common name
			blue violet, meadow violet
		Viola pubescens	downy yellow violet
		Viola rostrata	longspur violet
		Viola sororia	common blue violet, hooded blue violet

Appendix I. Fish communities sampled in ROVA waterbodies in October 2000 by Mather et al. (2003).

Name	Flow	Scientific Name	Common Name	Total Individuals	Trophic
Crum Elbow Creek	high gradient stream	*Anguilla rostrata*	American eel	3	piscivore
		Exoglossum maxillingua	cutlips minnow	9	benthic insectivore
		Luxilus cornutu	common shiner	1	insectivore
		Rhinichthys atratulus	blacknose dace	32	benthic insectivore
Crum Elbow Creek	low gradient stream	*Ambloplites rupestris*	rock bass	3	piscivore
		Lepomis auritus	redbreast sunfish	8	generalist
Fall Kill	low gradient stream	*Esox americanus*	redfin pickerel	1	piscivore
		Lepomis auritus	redbreast sunfish	1	generalist
Unnamed stream/Meriches	high gradient stream	*Rhinichthys atratulus*	blacknose dace	12	benthic insectivore
Unnamed stream/Meriches	low gradient stream	*Anguilla rostrata*	American eel	3	piscivore
		Catostomus commersoni	white sucker	2	generalist
		Esox americanus	redfin pickerel	1	piscivore
		Etheostoma nigrum	Johnny darter	13	benthic insectivore
		Fundulus diaphanus	banded killifish	1	generalist
		Fundulus heteroclitus	mummichog	68	generalist
		Lepomis auritus	redbreast sunfish	25	generalist
		Lepomis gibbosus	pumpkinseed	15	generalist
		Lepomis gibbosus	pumpkinseed	3	generalist
		Rhinichthys atratulus	blacknose dace	15	benthic insectivore
Unnamed stream / Meriches	moderate gradient stream	*Catostomus commersoni*	white sucker	4	generalist
		Notemigonus crysoleucas	golden shiner	2	omnivore
		Rhinichthys atratulus	blacknose dace	304	benthic insectivore
		Semotilus atromaculatus	creek chub	1	Insectivore
Middle Pond	high flow impoundment	*Lepomis auritus*	redbreast sunfish	1	generalist
		Lepomis gibbosus	pumpkinseed	1	generalist
		Micropterus salmoides	largemouth bass	2	piscivore

Name	Flow	Scientific Name	Common Name	Total Individuals	Trophic
Upper ValKill	low flow impoundment	*Ambloplites rupestris*	rock bass	1	piscivore
		Ameiurus nebulosus	brown bullhead	1	generalist
		Catostomus commersoni	white sucker	7	generalist
		Esox americanus	redfin pickerel	2	piscivore
		Lepomis macrochirus	bluegill	17	generalist
Upper Pond	high flow impoundment	*Ambloplites rupestris*	rock bass	2	piscivore
		Esox americanus	redfin pickerel	2	piscivore
		Esox niger	chain pickerel	1	piscivore
		Lepomis auritus	redbreast sunfish	1	generalist
		Lepomis gibbosus	pumpkinseed	4	generalist
		Micropterus salmoides	largemouth bass	4	piscivore

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