New York City Watershed Forest Management Plan

CAT-374

Ashokan Reservoir

Prepared by:

USDA Forest Service TEAMS Enterprise Unit

For:

New York City Department of Environmental Protection

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Acknowledgements

This Forest Management Plan is the result of several years of planning and efforts by numerous people, and represents a strong collaborative effort by the New York City Department of Environmental Protection with their stakeholders. A partnership between DEP and the United States Forest Service resulted in the successful completion of this document. Over one hundred individuals contributed to this effort, and their efforts are greatly appreciated. The following individuals were instrumental in completing this effort.

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Dear Friends:

The New York City (City), through its Department of Environmental Protection (DEP), is charged with supplying high-quality drinking water to over 9 million New Yorkers within the City and surrounding counties. The City has made significant investments in protecting upstate water supply lands and reservoirs - from working with local farmers and landowners, municipalities and other stakeholders to providing funds for land acquisition and sewer treatment plant upgrades. One key component of land protection is maintaining a healthy and diverse forest on City-owned water supply lands. Healthy forests provide important ecosystem services such as reducing soil erosion and attenuating nutrient inputs into the waterways and reservoirs.

Forests within the watershed, which includes those lands owned by the City, State and private landowners, face a multitude of potential threats from invasive species, such as the Emerald Ash Borer, forest fragmentation and lack of regeneration from deer impacts. For these reasons, the City is taking a proactive approach to managing its forests. Through sound silvicultural practices, primarily through forest improvement projects involving logging contractors, we can strengthen forests and promote local economies. Supporting a healthy forest-products industry is vital to helping us carry out our projects.

This Plan supports several goals as outlined in the DEP's *Strategy 2011-2014*. That is why I am pleased to present this forest management plan, the first of its kind for DEP's water supply lands, to help guide future forest activities. This project was an exciting partnership between the City and the United States Forest Service, one we hope will continue for years to come.

Paul V. Rush, P.E.
Deputy Commissioner
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Figure 1. Watersheds for New York City drinking water supply

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List of Acronyms

BMPs	Best management practices
CEA	Critical environmental area
CEC	Cation exchange capacity
CEQR	City Environmental Quality Review
CWCS	Comprehensive Wildlife Conservation Strategy
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
d.b.h.	Diameter at breast height
DMAP	Deer management assistance program
EHS	Environmental Health and Safety
ECL	New York State Environmental Conservation Law
EOH	East of Hudson
EPA	United States Environmental Protection Agency
ERA	Ecological Research and Assessment Group
EZ	Exclusion zone
FITT	Forestry interdisciplinary technical team
FLIR	Forward Looking Infra-Red
GIS	Geographic Information System
GP	Guiding principle
GPS	Global Positioning System
MBF	Thousand board feet
MMBF	Million board feet
Mcords	One thousand cords
NHP	New York National Heritage Program
NRCS	National Resource Conservation Service
NRM	Natural Resources Management Section
NYC	New York City
QMD	Quadratic mean diameter
SEQRA	State Environmental Quality Review Act
SGCN	Species of greatest conservation need
SHPO	State Historic Preservation Office
SMZ	Special management zone
SSURGO	Soil Survey Geographic Database
TES	Threatened or endangered species
USDA	United States Department of Agriculture
USFS	United States Forest Service

USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAC	Watershed Agriculture Councils
WaLIS	Watershed Lands Information System
WBBC	West Branch/Boyd Corners
WOH	West of Hudson
WQ	Directorate of Water Quality
WWQO	Division of Watershed Water Quality Operations

1. EXECUTIVE SUMMARY

The New York City Watershed covers almost 2,000 square miles and encompasses two distinct water supply regions, one west of the Hudson River in the Catskill Mountains and Delaware River Basin and one east of the Hudson River in the Lower Hudson Valley. The Watershed supplies 1.3 billion gallons of water per day to 9 million consumers in the City and in upstate watershed communities. Of the vast watershed area, New York City directly owns close to 140,000 acres, of which approximately 35,000 acres are the 19 reservoirs and 3 controlled lakes that make up the water supply system. Of the remaining land, about 95,000 acres are forested. This forest management plan will guide management activities on the forested lands.

Forest cover within public water supply watersheds offers greater water quality protection than other types of cover such as developed or open land. The benefits of forest cover are maximized when forests are managed to promote long-term continuity of forest cover. Management to enhance the likelihood of continuous forest cover involves promoting vigorous tree growth and diversity in all aspects of forest composition, e.g., species, forest structure, natural community type, and development stage, to maximize resilience to disturbance. The most effective way to establish and maintain diversity and vigorous tree growth in the Northeast is through active forest management.

Compared to more conventional options like filtration, maintaining forest cover improves water quality protection at reduced expenditure. As a result, many major public water supply managers, including the New York City Department of Environmental Protection (DEP), have committed to acquiring and managing forested land within their watersheds to aid in the production of high-quality drinking water. Responsible management of forests requires knowledge and careful planning. DEP contracted with the United States Department of Agriculture (USDA) Forest Service TEAMS Enterprise Unit (TEAMS) to conduct a complete forest inventory of City-owned forest land and develop a forest management plan. Recommendations were developed to guide management over the next 20 years, with an interim update to the plan required in 2017.

Recommendations in the plan are based on guiding principles and goals developed by DEP and refined by TEAMS that specifically acknowledge that protecting water quality is central to DEP's mission. Guiding principles are hierarchical so that other resources and uses of the forest, such as wildlife or recreation, are addressed, but also identified as secondary to water-quality protection efforts. The Guiding Principles are as follows:

1. Forest cover promotes high water quality. Associated goals include creating and maintaining diversity within forest stands and across the ownership to promote resilience to disturbance and capacity for natural regeneration.
2. Watershed forests provide multiple benefits. Associated goals include providing habitat, recreational opportunities, economic benefits, and carbon sequestration.
3. Management decisions are informed by gathering and sharing knowledge and information. Associated goals include gathering information through active monitoring of management activities and sharing information as opportunities arise through community outreach and education.

In order for forests to grow and thrive, individual trees need adequate light, water, and nutrients from the soil. The humid climate in the Northeast means that water is not typically a

limiting factor across the New York City watershed. Nutrient supply is adequate in most locations despite relatively young soils following recent glaciation. Therefore, the limiting factor to tree growth on City-owned forest land that forest management can address is light availability, which is determined by density of trees and other vegetation. Vegetation varies based on forest age, type, and condition.

City-owned forest land can be broken down into three broad types. More than 60 percent of the forest is broadleaf with maples and oaks as the dominant species. Six percent is conifer forest dominated by hemlock and white pine. The remaining forest area is a mix of broadleaf and conifer species. Specific forest types can be determined based on characteristic groupings of species. The most common forest types on City water supply land are oak northern hardwoods (27 percent), hemlock hardwoods (22 percent), and northern hardwoods (19 percent).

Forest management activities on City water supply land are typically developed to help to ensure long-term continuity of forest cover over the largest area possible by maintaining or enhancing forest vigor and resilience. A number of conditions currently exist on City water supply land that present a risk to continuity of cover, including:

- Areas of extremely high density where inter-tree competition is fierce, weakening the stand as a whole. Almost 50 percent of City water supply land has a density of 80 percent or higher as measured by the percent of total available growing space currently occupied by vegetation. Densities greater than 80 percent generally indicate that reducing competition between trees would improve vigor and resilience.
- Mature and overmature stands where growth has slowed or stagnated, making trees more susceptible to damage from stressors like drought or insects. Effective age on almost 65 percent of City water supply land is greater than 80 years, a point at which forest management activities to reduce effective age are likely to improve forest vigor.
- Unmanaged plantations where initial planting densities were never reduced by subsequent thinning, causing high rates of tree decline and mortality.
- Strongly skewed distributions of density and age resulting in large areas of land in the same condition that reduce diversity at the ownership level, increasing the likelihood of widespread disturbance.
- Significant impacts to tree seedlings, also known as regeneration, from browsing by white-tailed deer. Sampling data suggest that without some sort of deer control, regeneration has a low likelihood of success on almost 85 percent of City water supply land.
- Presence of numerous exotic invasive species. Exotic invasive species, also referred to as invasive species, are those pathogens, plants, animals, or insects native to other areas that colonize a new site to such an extent that they exclude native species, interrupting natural processes such as nutrient cycling. Many invasive plants are already well-established East of Hudson; a smaller number of species are established West of Hudson, though distribution is less widespread. Damaging invasive insects, like emerald ash borer and hemlock wooly adelgid that kill their namesake trees, are already established in the Watershed, and others are sufficiently nearby to pose a significant threat.

By increasing species, structural, and spatial diversity, forest management can reduce these risks to long-term continuity of forest cover.

A number of forest management treatments can be implemented to address forest cover risks. These include:

- Regeneration treatments that replace declining forest with new forest by removing some or all of the existing trees and replacing them with regeneration. Regeneration can be established naturally from seed of surrounding trees, or artificially through planting. Most regeneration on City water supply land will be obtained naturally and will include deer-impact mitigation. Regeneration treatments are useful to apply where, due to age or condition, forest growth has begun to stagnate.
- Intermediate treatments that reduce competitive stress between trees by removing some trees to increase resources available to remaining trees. Intermediate treatments are useful to apply where trees are competing, but growth has not yet significantly slowed. Intermediate treatments can strengthen remaining trees and increase growth.
- Control treatments that reduce the impact of white-tailed deer on regeneration. Control treatments can include hunting programs, deer exclusion fencing, and spatial grouping of regeneration and intermediate treatments that create so much regeneration in one place that existing deer populations cannot consume it all before it grows out of reach.
- Control treatments that reduce the presence of invasive plant species. Control treatments for invasive plants can include removing small, satellite populations by manual, mechanical, or chemical methods, and minimizing the likelihood of spreading plants during forest management activities.
- Control treatments that reduce the potential impact of invasive pathogen and insect species. Those with slower rates of spread can sometimes be controlled by removing host species within a certain radius of a known infestation. In general, though, the most practical forest management treatment to address invasive pathogens and insects is to favor unsusceptible species.
- Planting treatments on land that is currently not forested that is not being used for other purposes such as infrastructure or agricultural leasing.

Based on current conditions, approximately 38,000 acres of forested land and 4,700 acres of unforested land would benefit from treatment over the next 10 years. Though it is unlikely that treatment could be accomplished on such a large number of acres in this time period, areas of highest priority will be identified and addressed.

Forest management treatments will enhance water quality protection over the long term. However, forest management activities must be properly planned and implemented to avoid short-term negative impacts to other natural resources, cultural resources, and water quality. DEP implements a wide array of conservation practices designed to minimize the potential for negative impacts during forest management. These conservation practices include the use of special management zones in which forest treatment will be modified or avoided in and around sensitive features such as surface waters, wetlands, vernal pools, or steep slopes. They also include specific practices to maintain stability of the forest access system, to protect threatened, endangered, and special concern species and archeological resources, and to take into account potential aesthetic concerns and noise production.

In order to assess the effectiveness of forest management activities and conservation practices, treated sites will be monitored during and after treatment. After-treatment monitoring can help assess long-term effectiveness in meeting goals and objectives. Monitoring can yield valuable information whether it is quantitative or qualitative, formal or

informal. Results of monitoring will be used to update treatments, conservation practices, and this plan.

The forest management plan is the first comprehensive plan developed for all City-owned watershed forest land. It provides the framework for management actions to occur now and into the future. Revisions and refinements of the plan will occur at regular intervals. Revisions may be enhanced with expansion or refinement of available data, including wetland mapping, additional stand delineation, and stand-level forest inventory data collection. This plan establishes criteria and guidelines for current forest management activities, and provides a solid foundation upon which increasingly robust plans can be developed in the future.

2. INTRODUCTION

The New York City Watershed Forest Management Plan (Plan) has been developed to promote and protect water quality by using the best available science to develop and guide forest management strategies to achieve vigorous and sustained forest cover. The Plan provides comprehensive, overarching direction to achieve long-term goals related to water quality protection through good forest management stewardship on water supply lands, as well as other important benefits provided by lands owned by New York City (NYC) and managed by the New York City Department of Environmental Protection (DEP).

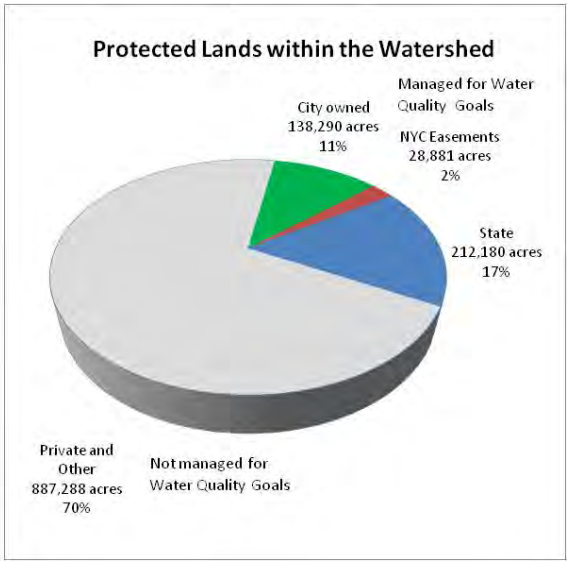


Figure 2. Protected lands within the

New York City's high-quality water supply system is one of the largest and most complex unfiltered water systems in the world; delivering 1.3 billion gallons of water to 9 million people each day (see Figure 1, p.i.). The Croton, Delaware, and Catskill water supply systems (referred to collectively as The Watershed) cover 1,971 square miles in parts of 8 counties with 3 reservoir systems for a total of 19 reservoirs and 3 controlled lakes that store 580 billion gallons of water at capacity. Within this vast Watershed, approximately 30 percent of the lands are managed with water quality protection objectives (Figure 2, Map Packet Section 2 Protected Lands). DEP manages City-owned lands (fee lands), and has review, monitoring, and enforcement rights over forest management and other activities on NYC easement lands[1] within the Watershed.

Scientific research has demonstrated that forest cover within watersheds offers greater water quality protection than other types of cover such as developed lands (Barnes et al. 2009, Brown and Binkley 1994, Germain and Kelly 2011, Neary et al. 2009). Since maintaining forest cover has significant, demonstrated benefits for water quality protection, typically at reduced expenditure when compared to more conventional options like filtration, DEP has committed to acquiring and managing undeveloped land within the watersheds to support the continued production of high-quality drinking water. In addition, DEP has regulatory authority over numerous aspects of development in the Watershed, and also manages and supports a variety of programs to assist private landowners in protecting their own natural resources within the watersheds through such entities as the Watershed Agricultural Council which provides forest management planning on private lands.

[1] NYC Easements ("CEs") are properties that are encumbered by conservation easements held by the City or the Watershed Agricultural Council (WAC); to protect water quality; these CEs restrict certain land uses and provide for review, approval, and monitoring of farm and forest management activities by the City and/or WAC.

2.1 Plan Scale

The Plan applies to all City-owned water supply lands within the Watershed and adjacent city-owned lands that extend just over the watershed boundaries. The Watershed is divided into individual basins, which are delineated based on the drainage area for each reservoir (Figure 3 and Figure 4). Ownership patterns of City water supply land within each basin is fragmented often into small blocks, with the exception of the lands immediately surrounding the reservoirs within each basin (Map Packet, Section 2 Protected Lands). The Plan provides an analysis of inventory data, identifies those areas in need of treatment, and provides prescriptions for the treatments of those areas. This plan does not cover DEP-held conservation easements or Watershed Agricultural Council Conservation Easements, which are managed by private owners.

General representations of data and analysis summaries within the Plan are based upon City water supply lands in each basin as of a certain date, displayed in Table 1 column "as of date." These dates correspond to the most recent land acquisitions included in the inventory. This is not meant to imply that the direction contained in the Plan only pertains to these lands; rather it is a basis for reference regarding the analysis data. Land acquisitions after this date are not included in the inventory data and analysis displays. All Conservation Easements included were acquired "as of" May 8, 2009. Continued acquisitions of land to support water supply protection under the City's Long-Term Watershed Protection Program will also fall within the management direction contained in this Plan.

City water supply lands are geographically separated by the Hudson River, and are commonly referred to as East of the Hudson River (EOH) and West of Hudson (WOH). Existing conditions and management opportunities are displayed by EOH and WOH. WOH is also displayed by individual basin, and EOH is subdivided for specific forest attribute discussions into three basin groups (West Branch/Boyd Corners, Croton System, and Kensico) to assist in future project planning. For some resource discussions, the WOH is subdivided into two basin systems, the Delaware System (Cannonsville, Pepacton, Neversink, and Rondout) and the Catskill System (Ashokan and Schoharie basins).

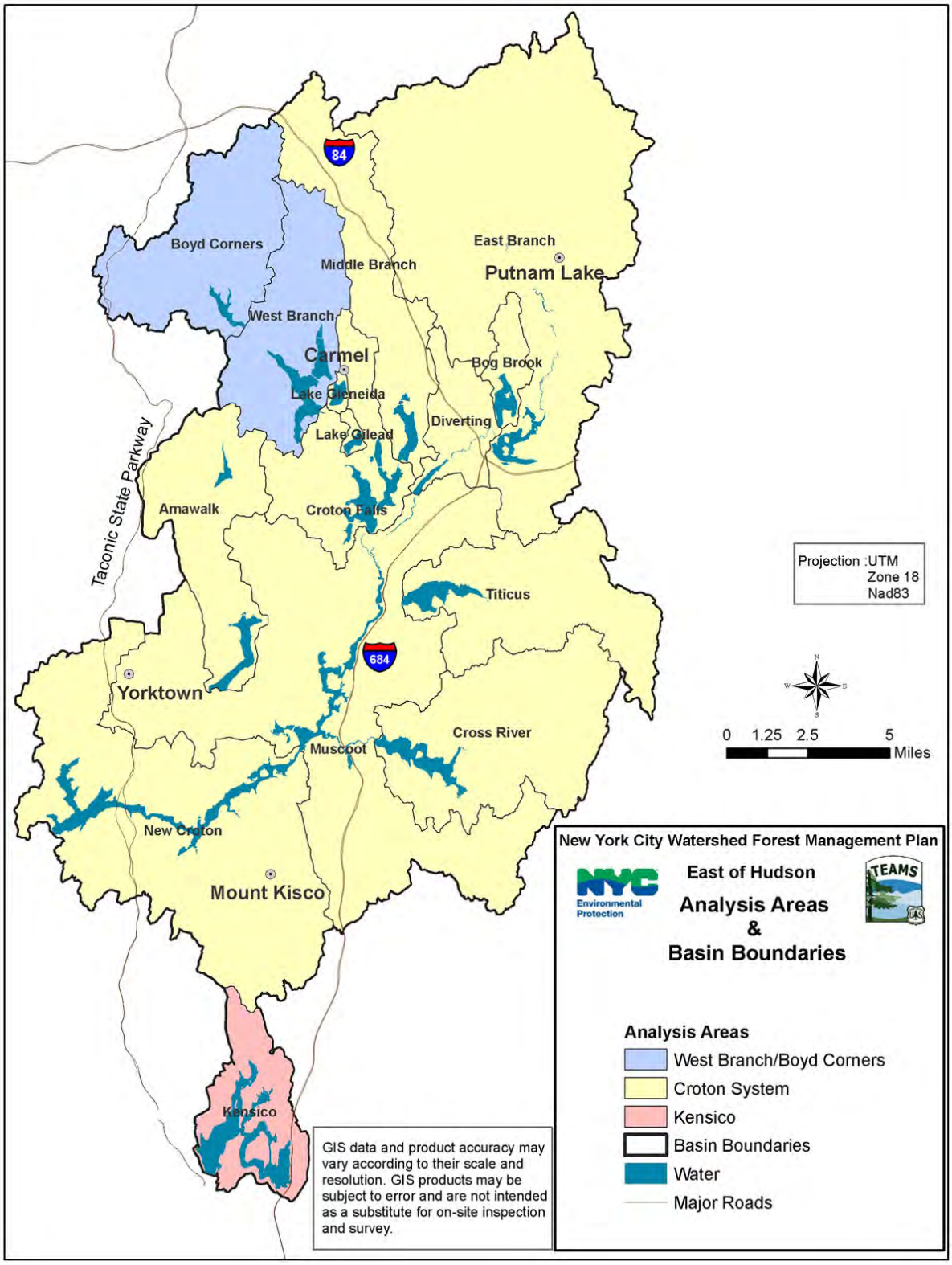


Figure 3. Basins in the East of Hudson Watershed

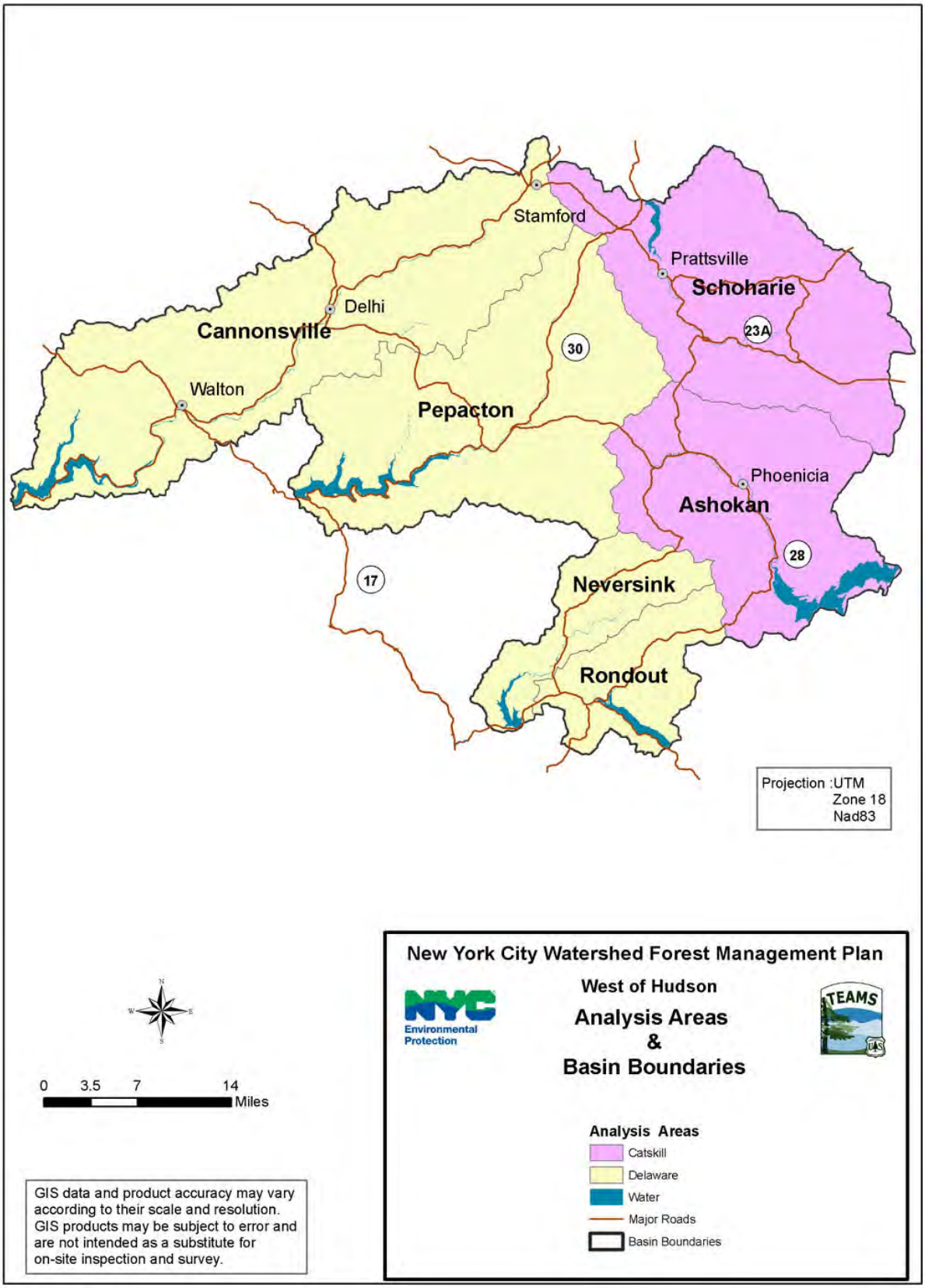


Figure 4. Basins in the West of Hudson Watershed

Table 1. Basin ownerships in acres

Basin	As of Date	City-Owned Fee Land	City-Owned Easements[1]	New York State	Private and Other
East of Hudson					
Amawalk (includes Kirk Lake)	9/14/2009	1,248	0	779	10,546
Bog Brook	9/14/2009	584	0	132	1,650
Boyd Corners	9/14/2009	4,779	351	1,422	7,885
Cross River	9/14/2009	1,439	90	41	17,622
Croton Falls	9/14/2009	2,521	0	1	7,706
Diverting	9/14/2009	448	0	0	4,356
East Branch	9/14/2009	1,172	0	1,562	45,332
Kensico	5/8/2009	4,577	83	0	4,137
Lake Gilead	9/14/2009	190	0	1	229
Lake Gleneida	9/14/2009	221	0	0	195
Middle Branch	9/14/2009	534	195	337	12,329
Muscoot	9/14/2009	3,823	89	1,035	43,472
New Croton	9/14/2009	5,125	248	520	31,323
Titicus	9/14/2009	954	0	3	14,617
West Branch	9/14/2009	4,801	275	1,176	6,484
West of Hudson					
Ashokan	5/8/2009	22,553	2,173	82,948	57,105
Cannonsville	9/14/2009	28,668	13,522	6,055	243,674
Neversink	8/19/2009	7,438	2,146	25,256	24,598
Pepacton	8/19/2009	23,534	5,921	33,474	174,974
Rondout	8/19/2009	9,531	527	20,051	31,660
Schoharie	9/14/2009	14,150	3,261	37,387	147,394
Grand Total		138,290[2]	28,881	212,180	887,288

Source: 2009-2010 GIS Data: (DEP City Land, State Land, Basin Boundary layers; Stand Layer)

[1] As of May 8, 2009. For reference purposes only. The Plan does not apply to conservation easements.

[2] Includes reservoir acres

2.2 Role of Forestry in Watershed Management

The principal goal of watershed management—which is the planned manipulation of one or more factors of the natural or disturbed drainage to effect a desired change in or maintain a desired condition of the water resource (Black 2005)—for the City is to prevent contaminants from reaching water resources. With careful planning and communication, water quality can be protected while still serving multiple priorities (NYC Department of Environmental Protection website 2011). New York City actively engages in watershed management at many levels by implementing a comprehensive Long-Term Watershed Protection Program. The Forest Management Plan is one component of this program, designed to promote vigorous, resistant, and resilient forest cover on City water supply lands in the Watershed using sustainable forest management practices.

2.3 Forest Effects on Water Quality and Yield

Surface waters generated from fully vegetated watersheds with minimal exposed soils generally carry very low turbidity. Forested areas intercept incoming precipitation and a portion of this evaporates before it reaches the ground. The remainder may run down branches and stems to reach the ground. Interception is the net loss of precipitation, by evaporation, between the top of the forest canopy and the forest floor; this water is returned to the atmosphere and does not enter the soil or increase runoff. As much as 10 to 35 percent of incoming precipitation can be intercepted by forest cover (Swank 1968). The amount of interception varies with the magnitude and intensity of rainfall, the structure and composition of the canopy, the season, and the form of precipitation (Anderson et al. 1976). In general, forest vegetation intercepts more precipitation than grassland, and conifers intercept more water than hardwoods.

Additionally, the interception of precipitation by forests reduces the kinetic energy of rain drops, reducing the ability of rain to dislodge soil particles and cause erosion. Forest floor materials such as duff and litter and smaller trees help reduce raindrop impacts (Stuart and Edwards 2006), as well as adsorbing water and increasing infiltration rates due to the large amount of surface area.

Once incoming precipitation reaches the forest floor, it may either infiltrate into the soil or become surface runoff. Vegetation creates more porous soils by both protecting the soil from pounding rainfall, which can close natural gaps between soil particles, and loosening soil through root action. This is why forested areas have the highest infiltration rates of any vegetative types. Most forests have an organic surface layer that protects the soil surface and facilitates infiltration. In most cases, this infiltrated water moves by subsurface pathways through soil and subsoil to streams (Hewlett 1961) and can contribute to stream baseflow (streamflow which results from precipitation that infiltrates into the soil and eventually moves through the soil to the stream channel). Because forest soils have high infiltration rates, water rarely flows over the ground surface. Hewlett and Hibbert (1967) proposed that during storms, ephemeral streams expand upstream by collecting overland flow and shallow subsurface runoff along their channels (the variable source area concept).

In forested watersheds, water yields are affected by evapotranspiration rate, which is the combined evaporative loss from the canopy and through transpiration (the process by which plant leaves release water as vapor to the atmosphere). Evapotranspiration is influenced by soil moisture, vegetation type, vapor pressure gradients across leaf surfaces, and the same factors that affect evaporation, including solar radiation, temperature, humidity, and wind.

Forest management activities that affect vegetation are likely to change evapotranspiration rates and in turn affect water yield. Activities that decrease evapotranspiration, such as removing large amounts of trees, are likely to increase water yield. Generally, larger scale intensive even-age management of forested watersheds provides consistently greater water yields than selection harvest, multi-age management, or the absence of forest vegetation management. Watershed studies (MacDonald and Stednick 2003, de la Crétaz and Barten 2007, Stednick 1996) from many areas across the country indicate that water yield increases usually do not occur until approximately 20 to 30 percent of a forested watershed is cut, and that water yield generally returns to pre-harvest levels within a decade or less. Researchers (Hornbeck et al. 1997, Troendle et al. 2010) suggest that more humid areas may experience water yield increases with less forest clearing.

Watershed forest cover conditions differ in their regulation of certain nutrients (e.g., nitrates, phosphates). For instance, a declining trend in nitrogen immobilization as a stand matures may explain why nitrate leaching losses are typically larger in mature versus vigorously growing forests. Longer periods without disturbance may allow high forest nitrogen accumulation, low carbon-to-nitrogen ratios, and increased nitrification potentials (Van Miegroet and Johnson 1993).

2.4 Forest Management for Water Quality

Well-managed forests provide the most beneficial land cover for water quality protection (National Academy of Sciences 2008). Within the variety of watershed land cover types, the best regulation of nutrients is provided by maintaining vigorously growing diverse forest across the vast majority of watershed sites. DEP's interest is to ensure continued forest cover on City water supply lands over time. Continuity is best ensured by minimizing risk of large-scale disturbance. Disturbance risk is minimized by maximizing resilience. Therefore, well-planned and properly implemented forest management activities can increase resistance and resilience of forest stands and decrease susceptibility to disturbance.

Maintaining a species and age/size class of diverse forest cover increases that cover's resistance to disturbance and ability to recover quickly when disturbance occurs. A variety of size classes (structural diversity) as well as species allows for faster recovery from disturbances (ice storms, wind events, hurricanes, etc.). In the loss of an individual tree species, such as chestnut or elms that were lost due to introduced disease organisms in the past, having a diversity of species allows for faster recovery by quickly replacing those lost species. Also, forest management actions can reduce overall stress among the individual trees that make up a forest by maximizing the growing space, and therefore, reducing competition for resources. This permits individual trees to maximize their photosynthetic (ability to transform nutrients into energy) potential, which leads to maximum vigor. Trees generally allocate photosynthate for maintenance respiration, production of fine roots and leaves, flower and seed production, primary growth (height, branches, and root extension), diameter growth, and insect and disease resistance mechanisms (Oliver and Larson 1996), in approximately that order. Forest thinning activities increase light, water, and nutrients to residual trees, resulting in increased photosynthate production (Smith et al. 1997). Therefore, forest thinning and other forest management activities will increase resistance to pathogens.

Resistance is a component of resilience (Walker et al. 2004). Therefore, increasing resistance will help to increase resilience. Ecological resilience, the ability of an ecosystem to recover from perturbations, is driven by diversity of functional groups of species (Peterson et al. 1998, Folke et al. 2004).

There is an inverse relationship between the age of a forest stand and the magnitude of disturbance required to disrupt it. Intentional replacement of older stands with younger (e.g., through forest management) reduces the risk of disturbance since disturbances of increasing magnitude happen with decreasing frequency (Oliver and Larson 1996). Forest management activities increase mechanical strength of residual trees, which reduces susceptibility to disturbance (Oliver and Larson 1996, Smith et al. 1997).

Riparian areas and wetlands have an extremely important role in water quality protection. The proper management and protection of forests in wetland and riparian zones is a critical component of watershed protection, in part because these frequently are concentrated water

supply source areas and because they represent the final opportunity to capture mobile sediments and nutrients before they enter surface waters.

2.5 Sustainable Forest Management

Sustainable forest management is the practice of meeting the forest resource needs and values of the present without compromising the similar capability of future generations (Helms 1998). The management treatments and recommendations contained in this Plan are supported by the best available science, knowledge, and experience. Harvesting practices, conservation practices, and operational principles, as well as environmental impact analysis processes are based on extensive research, scientific literature, and professional experience.

An internationally driven initiative to measure and promote sustainable management of the world's forests, known as the Montreal Process (http://www.rinya.maff.go.jp/mpci/), identifies seven criteria to measure sustainability:

1) Conservation of biological diversity
2) Maintenance of productive capacity of forest ecosystems
3) Maintenance of forest ecosystem health and vitality
4) Conservation and maintenance of soil and water resources
5) Maintenance of forest contribution to global carbon cycles
6) Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies
7) A legal, institutional and economic framework for forest conservation and sustainable management

The Guiding Principles, Goals and Objectives are closely aligned with these criteria, utilizing the best available information to guide management of the forest resources.

2.6 Land Use History and Background

The oldest portion of the City's water supply system is on the east of Hudson River in Westchester and Putnam Counties. This area also has the oldest effects of European colonization and settlement. The original forest of oaks mixed with pine and other hardwoods was being cut to establish farming as early as 1640 (Westchestergov.com 2010). Farming was in decline by 1840, the same time as the first water supply project began—the construction of the Croton Dam.

In the Catskills, the development of the tanning industry in the 1850s and '60s brought the first real dynamic change in the area with the harvesting of vast quantities of hemlock for tan bark, damming the rivers for tannery power, and the influx of labor. Many of the laborers became settlers and farmers during and after the hemlock resource was exploited and the tannery industry had moved on.

Forest compositions were changed first by the depletion of hemlock in the mid 19th century and then by aggressive harvesting of the remaining timber in the late 19th and early 20th century (Barten et al. 1998). Some of the more inaccessible lands were conserved when the

Catskill Forest Preserve was created in 1885. Farming gradually declined in much of the area, resulting in a large portion of the land reverting to tree cover, resulting in primarily even-aged forests established at approximately the same time. This is evidenced today by the large amount of forest cover that is 60 to 100 years old.

By the late 1800s much of the accessible Catskill forest had been cut for settlement or industry. By 1885, an estimated 80 to 90 percent of the original first growth Catskill forest was no longer in existence (Kudish 2000). Many of these areas were cleared for farms, pastures and other agricultural uses as evidenced today by the number of stone walls found within the forest. Forest removal for charcoal production, tannins and lumber was conducted with little to no consideration for reforestation.

For the forests that remained, changes in composition and structure were occurring as introduced diseases (chestnut blight, butternut canker, Dutch elm disease) virtually eliminated entire species from the forest (Schlarbaum et al. 1997) Human activities (fires, logging of only certain species such as hemlock and white pine) and natural disturbances (wind, hurricanes, tornadoes, ice storms) also affected forest composition and structure. Increasing development from the rapidly expanding population further reduced forest cover.

Beginning in the early 1900s, a tremendous reforestation effort statewide was initiated, planting trees to reclaim abandoned cleared lands to stabilize soils, improve watershed protection and restore nutrients depleted from unsustainable agricultural practices. These plantings were conducted through the Great Depression on State lands and private estates, as well as City water supply lands.

Early DEP reforestation records indicate that between the years 1910 and 1920, over 2.8 million conifer trees and close to 10,000 hardwood trees were planted around the Ashokan, Kensico, and Hillview Reservoirs. Active forest management was recognized even then as important to establish forest cover to reduce erosion and provide for water quality protection. Although early planting methods included thinning native stands and subsequent planting amidst the residual trees (increasing age class diversity and structure), the majority of the plantings were in newly established plantations. These plantations were established primarily with conifers, due to the belief at the time that conifers would screen out hardwood leaf litter that clogged intake areas, and would not discolor the water as much as hardwood tree litter. Trees were acquired by transplanting native tree stock from surrounding areas, and from nurseries in other locations. Some of the nursery stock was held in on-site nursery beds for a few years while dam or other infrastructure construction took place, but it is not clear that the intention was to create semi-permanent nurseries in most places. The majority of the planted trees obtained from nurseries were nonnative species, primarily European species (Norway spruce, Scots pine, Austrian pine, European larch, and others).

Figure 5. 1913 Ashokan basin forest planting

During the first few years of the reforestation effort, trees were planted approximately 6 feet apart yielding approximately 1,200 trees per acre; later the spacing became more varied, increasing to up to 20 feet apart (unpublished summary, DEP). Other reforestation efforts continued over time, resulting in over 2,000

acres of plantations on City water supply lands. Many of these plantations are overcrowded and unhealthy due to the high levels of competition for sunlight and nutrients, resulting in increased susceptibility to windthrow, snow, and ice damage. These stands typically lack species diversity, as usually only one or two species were planted.

When lands were first cleared for conversion to agriculture, a layer of organic material provided a short-term nutrient supply for crops (Bellemare et al. 2002). When this organic matter was not replaced by annual leaf deposits and the land was continually tilled, it lost much of its original fertility (Compton and Boone 2000). Many farms created from the forest were returning to forest cover after only one or two generations of farming. These were mostly upper and mid-slope areas. Initially, pioneers avoided the coarse alluvial soils of the valley bottoms. Gradually, these became farmed more long term because the soils were deeper, more easily tilled, and could be limed and fertilized.

The resulting reduced fertility of the uplands often resulted in a new forest populated with species with lower demands for nutrients like beech or red maple, and fewer higher demand species like sugar maple and ash. Often, when farms were declining, the owners found other sources of income, and pastured animals as the last use of their open lands. The browsing animals typically consumed the natural hardwood regeneration along with the grasses, while avoiding the conifer regeneration (Leak et al. 1995). These locations usually became stocked with white pine or hemlock. Some of the earliest crops of white pine on old pastures have already been harvested and the land regenerated back to hardwoods (Desmarais and Leak 2005). These stands often have higher representations of oak.

Recognition of the need for forest management on the watershed lands was identified as early as 1917, when C. Stuart Gager published the article “Forest Problems of the Ashokan Watershed” in the *Brooklyn Botanic Garden Leaflet* in October 1917. In this article, Gager notes “…it is also known that the run-off from a forested area is more gradual and more evenly distributed through a given period of time than from an area devoid of trees. For these and other reasons it is highly essential to maintain proper forest conditions on the watershed of any municipal water supply system.” He also recognized the importance of having trained foresters implement “scientific forest management.” In 1951, Charles Hursh published in the *Journal of Forestry*, “Watershed Aspects of the New York Water Supply Problems,” identifying the need for a variety of measures, including stand and forest management techniques to promote watershed protection and sustain forest growth and vigor. Both of these articles identify the need for active, scientific forest management to maintain and promote forest cover to protect the water supply.

DEP has a long history of managing the forests surrounding the reservoirs, including tree and shrub planting for watershed protection, harvesting trees and milling the lumber (DEP sawmills were located in both Shokan and Downsville) for use in dam and aqueduct construction, thinning and stand tending activities to improve forest cover, and removal of invasives and exotic species. Some management occurred prior to 1980, under the guidance of New York State foresters, and under the direction of the DEP District Engineer. In 1980, DEP hired a professional forester to oversee the management of the forest resource on City water supply lands, and to begin developing a forest management strategy.

DEP conducted a Rapid Forest Inventory in 2003 to assess the overall forest condition, which identified numerous forest conditions of concern (lack of age class diversity, lack of forest regeneration, low vigor stands, high susceptibility to disturbances) that emphasized the need for a comprehensive inventory across the entire Watershed to determine the extent of these

conditions. Based on this information, DEP recommended that a comprehensive inventory be conducted, and a comprehensive Watershed Forest Management Plan be completed as one component of the Watershed Protection Program. A comprehensive inventory was conducted in 2009 and 2010 to provide sufficient information to support the development of the Plan.

3. PLAN PURPOSE

The Plan provides specific management direction related to the forest and vegetation resources based on the Guiding Principles, identifies and recommends forest management program priorities based on the Goals and Objectives, and provides implementation objectives and conservation practices to ensure the protection of the environment during forest management activities. The Plan provides the overarching direction for the identification, prioritization, and implementation of forest management projects. Further, the Plan provides the support for compliance with the New York City Environmental Quality Review (CEQR) and the New York State Environmental Quality Review Act (SEQRA) on forest projects implemented that follow the direction of the Plan.

3.1 Guiding Principles, Goals, and Objectives

Maintaining the existing quality of water that New York City enjoys is the foundation for developing the Forest Management Plan. The Guiding Principles developed by DEP (2010b) are a hierarchical approach defining the desired forest conditions that forest management strives to attain, providing the overarching direction for development of Forest Management Plan that ultimately guide management activities. The Goals and Objectives take this overarching direction and provide focus to developing management actions and activities that will promote the achievement of the guiding principles. All management activities will be designed to fully satisfy the Guiding Principles in the order listed. Management activities designed to meet lower-ranked Guiding Principles must fully satisfy higher ranked Guiding Principles and must not degrade the ability of forest cover to achieve water quality protection.

Guiding Principles (GP) describes an integrated vision of a properly functioning forest that supports a broad range of biodiversity maintaining ecological functions and services.

Goals are concise statements that describe ways to achieve the guiding principles. These statements are normally expressed in broad general terms without a distinct timeframe for achievement. Goal statements form the basis from which objectives are developed, with more specific timeframes.

Objectives form the basis for project level actions or proposals to achieve the goals within the existing planning timeframe, generally considered to be the next 10 to 15 years.

Guiding Principles will be achieved through project-level actions that occur on the ground (forest management projects). Planning these actions uses an interdisciplinary process incorporating all relevant resource staff in identifying and designing site-specific projects to ensure that goals and objectives are achieved.

3.1.1 Guiding Principle I – Forest Cover Promotes High Water Quality

New York City is committed to protecting water quality by providing ecologically diverse, vigorous and sustainable forests that are resilient to disturbance, capable of natural

regeneration of desired species, and producing high-quality water. These values are promoted through forest management utilizing the best available science in an ecologically sensitive manner.

3.1.1.1 Goals

Goal 1 − Desired Forest Conditions

Apply a complete range of varied and adaptive forest management practices to retain and promote forest resiliency, optimizing site productivity. Minimize nonpoint source pollution from all forest management related sources. Manage wetland and riparian zones while protecting the function of these zones.

Goal 2 − Ecological Forest Diversity

Create and maintain diverse forest composition (age, tree size, species, and forest structure) within stands and a mosaic of conditions across the landscape. Maintain the ability of the forest to establish natural regeneration to sustain forest cover, and encourage species that are well suited to the local sites. Discourage the spread of existing and introduction of new invasive species.

3.1.1.2 Objectives

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), and former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species dominated areas.

GPI-3 Maintain forest stands through periodic treatment to maintain vigorous growing conditions and reduce forest competition.

GPI-4 Apply conservation practices to prevent adverse water quality impacts and reduce or eliminate soil erosion. Restore and reclaim detrimentally impacted areas for the control of point and nonpoint source pollution concurrent with forest projects where appropriate.

GPI-5 Designate special management zones around riparian, wetland and hydrologically sensitive areas (steep slopes, unstable geology, etc.) and establish specific management practices with objective standards to maintain and enhance ecological function to prevent sediment delivery.

GPI-6 Maintain and promote forest structural diversity while reducing competition to enhance resiliency.

GPI-7 Manage deer populations and other regeneration limiting factors to restore the forest's ability to naturally regenerate.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

3.1.2 Guiding Principle II – Watershed Forests Provide Multiple Benefits

New York City supports a variety of uses, values, goods, and services that benefit both New York City and watershed communities compatible with maintaining excellent water quality.

3.1.2.1 Goals

Goal 1 − Habitat

Provide habitat conditions to maintain and enhance the diversity of native forest species, promoting and enhancing habitat for threatened, endangered and special concern species where they exist.

Goal 2 − Forest Aesthetic Values and Recreation Uses

Forest management practices will be compatible with established and desired aesthetic and recreation uses.

Goal 3 − Economic Benefits to Local Communities

Forest management activities may provide forest products and employment opportunities to support local economies.

Goal 4 − Carbon Sequestration

Forest management activities will contribute toward long-term carbon sequestration and mitigate greenhouse gas emissions through maintenance of ecologically diverse and healthy forest cover.

3.1.2.2 Objectives

GPII-1 Management activities will incorporate basin-specific opportunities to protect or promote desired habitat conditions.

GPII-2 Identify conservation recommendations to protect or enhance habitat components for Threatened, Endangered and Special Concern species.

GPII-3 Design forest treatments to be visually sensitive around public access sites, highly visible areas, and adjacent landowners, dependent upon adjacent landowner use.

GPII-4 When appropriate, forest management may be used to develop, maintain, and enhance recreation sites.

GPII-5 Provide opportunities to utilize forest products and employment opportunities where compatible with other forest uses.

GPII-6 Maintain and enhance forest cover to promote carbon sequestration.

3.1.3 Guiding Principle III – Knowledge and Information Sharing

New York City will promote improved knowledge and understanding of City watershed forests and their management.

3.1.3.1 Goals

Goal 1 − Community Outreach and Education

Provide opportunities to inform and involve watershed partners, local government, and other interested parties (stakeholders).

Goal 2 − Monitoring

Implement a monitoring strategy to measure progress toward achievement of Guiding Principles and Goals, and project-level implementation effectiveness of conservation practices.

3.1.3.2 Objectives

GPIII-1 Promote coordination and outreach activities with the Watershed Agriculture Council (WAC), local governments, and adjacent landowners and other interested parties and stakeholders.

GPIII-2 Conduct annual and five-year incremental monitoring to identify needs for adaptive management (change in specific management practices) and Forest Management Plan amendment needs to address changes to ensure Guiding Principles are achieved.

4. FOREST MANAGEMENT PLAN PLANNING PROCESS

The planning process to develop the Plan began by identifying the need for a comprehensive forest inventory to assess existing forest conditions, quantify a variety of forest characteristics, and provide data to support the analysis involved with forest planning on City water supply lands. DEP held meetings with local stakeholders to discuss the need for a management plan, and get a sense for their concerns. DEP staff then began developing the framework for the Plan and enlisted the assistance of the United States Department of Agriculture Forest Service (Forest Service) to conduct the inventory and develop the Plan. DEP and the Forest Service utilized an interdisciplinary approach to integrate a wide breadth of resource experts throughout the process. Using the inventory data, forest conditions were characterized to provide an understanding of the existing conditions. These existing conditions provided the basis for comparison to a future desired condition that will fully protect the water supply and that exemplifies the guiding principles. Through this comparison between the existing and desired conditions, forest management treatment opportunities were identified that incorporated principles of watershed management and the

interaction of forest vegetation, water quality and water supply protection to develop the forest management strategy.

In July 2011, DEP and Forest Service staff invited representatives of 40 stakeholder organizations to attend two public information meetings, one held WOH and one EOH. This provided an opportunity for interested parties to learn about the Forest Management Plan and provide input.

4.1 Interdisciplinary Approach

The interdisciplinary approach consists of an integrated planning team composed of resource specialists with a variety of related backgrounds that are relevant to forest resources working collaboratively. Forest Service resource specialists with backgrounds in land planning, silviculture, hydrology, geology, forest ecology, botany, soils, wildlife, economics, and public affairs worked collaboratively with DEP staff from a variety of program areas to develop a management plan that not only addresses the forested vegetation component of the landscape, but ensures continued communications, support, and involvement of all affected program areas in implementing the Plan. Discussions about issues, environmental impacts, operational practices, and resource needs occurred throughout the planning process using onsite meetings, field trips, and management plan review opportunities.

Forest Service planning team members and internal "focus groups" composed of individual DEP resource staff groups held several meetings. These meetings were designed to discuss methods and opportunities to incorporate each focus group's program emphasis areas to ensure consistent management approaches in the Plan. Focus groups were provided opportunities to review drafts of the Plan, with each focus group commenting individually and after group discussions to provide a thorough and comprehensive review of the Plan throughout the planning process.

DEP Focus Groups

Water Quality
Monitoring/Modeling
Stream Management
Stormwater Management
Operations
Wetlands
Invasive Species
Economics
Forest Management
Land Acquisition
Wildlife

Quarterly briefing meetings were conducted with DEP senior management to provide updates on progress, discuss and resolve issues raised during the focus group reviews, and ensure information flow during the planning process.

Forest Service resource specialists prepared comprehensive reports documenting the existing conditions for their resource area, analyzing the effects of implementing the management strategy to assure that implementing the treatments proposed would meet the Guiding Principles, Goals, and Objectives of the Plan, incorporating the best scientific information available. These reports provide the scientific underpinnings of the Plan.

4.2 Forest Inventory

DEP began establishing a baseline Continuous Forest Inventory plot system in 2003 (will be completed in all basins by the end of 2011) to provide long-term forest dynamics measurements for forest growth, seedling recruitment, and mortality. These plots will be re-measured periodically to assess trends and create forest growth models. These plots take

detailed information, but are not at a sufficient intensity to provide the level of information necessary to develop the Plan, therefore additional information was necessary to support plan development.

In preparation for the Forest Management Plan, DEP initiated an inventory process to collect existing condition information to support the analysis and planning efforts. DEP worked with the Forest Service to design an inventory to provide specific information regarding forest vegetation type, size, density, health, and condition. Additional data collected during the inventory process included disturbance history, deer browse impacts, abundance and distribution of invasive and interfering plant species, as well as general land cover type assessments on non-forested areas, providing a representative sample of information representative of each basin to develop the Plan.

Forest Service crews conducted the forest inventory over two summers (2009 and 2010) gathering information across all City water supply lands within each basin based on a grid pattern of one plot for every 10 acres (a total of approximately 9,500 plots) to develop baseline information across the entire water supply lands. Forest Service Research Station employees worked with DEP forest staff to develop the inventory protocols and inventory collection and analysis methodologies tailored to meet DEP inventory needs. The inventory protocols are documented in the Forest Inventory Manual that is associated with the Plan (DEP Forest Inventory Manual 2010a).

In addition to the forest inventory, individual Forest Service resource specialists conducted site visits to determine overall site characteristics related to their specific resource, examined transects to collect deer data, and reviewed the most current available science, literature, and studies pertinent to the development of the Plan.

The inventory was conducted at a broad scale, that is, it was useful to generate landscape-level information that can be used for planning and prioritization. The inventory scale was not such that it could be used for individual project-level planning, that will still require additional inventory work by DEP Foresters.

4.3 Desired Conditions – Planning for the Future Forest

The desired conditions as set forth by DEP describe an integrated vision of a properly functioning forest that supports a broad range of biodiversity-maintaining ecological functions and services. The Guiding Principles incorporate vegetation characteristics and conditions that achieve the greatest level of water quality protection first, and maintain other important ecological services secondly. These desired conditions are timeless, in that they are a goal to achieve and strive for over the long and short term. As forests continue to grow, management activities to achieve these future conditions also take time to implement, and are frequently necessary at various intervals throughout time in individual stands to fully realize the benefits from these actions.

Vegetation characteristics that represent the desired condition include a diversity of age classes both at the stand and landscape level to increase resiliency. Having a variety of age classes provides for replacement of overstory trees in the event of blowdown, insect infestation, or other factors that could remove the majority of the overstory, increasing the stand resistance to disturbance and ability to recover quickly. Species diversity provides the variety to ensure that should species-specific damaging agents impact a forest, not all forest cover would be affected. Additional vegetation characteristics that represent the desired

condition relate to the health and vigor of the forest, primarily the ability of the forest vegetation to have sufficient nutrients, light and moisture to achieve the highest productivity to respond to disturbances and minimize stress that predisposes trees to insect and disease impacts.

4.4 Forest Management Actions

Forest management actions were developed to address the differences between the existing conditions and the desired conditions. These actions are summarized in the Management Strategy section (Section 7.7) and prioritized based upon the risks associated with the difference between the two conditions and the relative ecological services that are desirable. Other actions are recommended to address potential disturbance threats such as invasive insects (emerald ash borer, Asian longhorned beetle, defoliation events, etc.) or catastrophic events (wind storms, ice storms, fire, etc.) whose specific location and scale of impact cannot be reliably predicted in advance.

Forest management actions may include, but are not limited to: no action (a conscious decision not to intercede due to environmental, political, or economic considerations), silvicultural treatments using a variety of logging systems and methods (described in detail in Section 7.4), stand maintenance treatments, reforestation activities, and invasive species control.

4.5 Relation to Laws and Regulations

The DEP Forest Management Projects and the Conservation Practices document (Appendix 1) summarize the applicable regulations. Many of these are specific to certain aspects of individual site-specific projects (permitting or regulatory requirements). Actions implementing the Plan will comply with all regulations as applicable Specific Conservation Practices are defined within which specific management actions can be implemented to ensure both compliance with Plan requirements and protection of important resources and ecological functions. When these practices are followed, individual forest management activities will fall within the New York City Environmental Quality Review (CEQR) Negative Declaration issued for the Plan and will not require additional environmental review.

The Conservation Practices identify two specific zones where management activities require additional protection considerations. Exclusion Zones (EZ) are identified where no forest management action would occur. The second zone is the Special Management Zone (SMZ), where forest management actions are allowed, but with specific treatment action modifications designed to protect these areas (Map Packet, Section 4.5 Conservation Practices). Should there be a need for a management action within the Exclusion Zone or within the Special Management Zone beyond those approved in the Conservation Practices; the non-conforming portion of the action within the zone will be subject to CEQR for environmental assessment prior to implementation.

Many local municipalities within the Watershed have regulations regarding vegetation manipulation, road management, and harvest actions. DEP will continue to comply with local regulations. DEP Foresters will check with local government agencies to determine if DEP needs any permits and inform them of DEP activities and plans.

5. EXISTING CONDITIONS – ASSOCIATED RESOURCES

Many associated resources affect the growth, resiliency, and ecological functions a forest provides. These non-forest resource conditions are described to provide an understanding of the interactions between these non-forest resource conditions and the forest vegetation, and the influences these conditions have on forest management.

5.1 Physical Settings

During the Pleistocene Epoch, continental ice sheets moved from Canada in a southwesterly direction, often moving down the similar-trending stream valleys. The continental ice extended southward through the Schoharie basin (WOH) and along the East of Hudson (EOH) Watershed. In the southeastern Catskills, the high Central escarpment dividing the Schoharie basin from that of Esopus and Rondout Creeks (Ashokan Basin) was perpendicular to the direction of ice flow. This escarpment ridgeline today is nearly scoured to bedrock, leaving behind glacial till (Soil Survey Geographic (SSURGO) Database soils mapping, NRCS 2010), and it may have served to isolate the Esopus, Rondout, and Neversink subbasins, at least during major retreats of the Wisconsinan glaciations, because it effectively resisted the occasional re-advancements of the ice sheet (Caldwell 1986). The relative isolation of the southeastern subbasins may have permitted mountain glacial development in the upper stream drainages, such as the Stony Clove Creek local glaciers. The mountain glaciers eventually carved very steep-sided distinct U-shapes to the already deep narrow valleys.

5.1.1 West of Hudson

The West of Hudson basins are located in the Catskill Mountains, with topography of a maturely dissected plateau with a steep 2,000- to 3,000-foot scarp on its eastern margin (the Catskill Mural Front). It slopes gently westward, where it merges into the hilly landscape that typifies the rest of the Allegheny Plateau. The Catskill Mountains have some of the highest elevations on the plateau. They are characterized by steeply rolling uplands and ridges interlaced with deep ravines. Glaciation is expressed mostly by rounded hilltops and by cirques and other scour features. Mass wasting, fluvial erosion, transport, and deposition are the primary geomorphic processes operating in this area. Elevation ranges from 900 to 4,200 feet, and peak elevations range from 3,000 to 4,200 feet. Local relief is from 1,000 to 3,000 feet. Farther west, the Cannonsville and Pepacton basins typically have a gently rolling landscape with more mature river valleys. Glacial till dominates their geology, making large portions of the Cannonsville and Pepacton basins suitable for agriculture (Miller 1970).

The Catskill Mountains are formed from a dissected plateau of sedimentary bedrock composed largely of repeating sequences of Devonian age sandstone, siltstone, and shale. The repeated glaciation of these mountains during the last 1.6 million years abraded the bedrock, particularly the shale and siltstone, into clay and silt-sized particles. These fine particles along with coarser sized sediment were entrained into the base of the ice or along the ice margin to form glacial till, a mixed assemblage of sediment. When the glacial till was compressed by ice flow between the ice and terrain it is referred to as lodgment till. In the Catskills, the glacial till tends to be enriched with clay and silt from the eroded bedrock. As the ice melted, the fine sediment would get entrained in glacial meltwater that discharged into lakes impounded by the ice, recessional moraines, and mountain topography. The sediment

deposited in these proglacial lakes is referred to as lacustrine sediment. The silt and clay in these ice age deposits are the principal geologic sources that get entrained in the Catskill Mountain streams.

5.1.2 East of Hudson

This area straddles two distinct geologic regions: the Hudson Highlands in the north, characterized by rugged, rolling mountains formed in the Pre-Cambrian; and the Manhattan Prong in the south, consisting of rolling lowlands dating to the early Paleozoic. The Hudson Highlands are aptly named, with elevations reaching 1,329 feet above sea level on North Mount Beacon. The greatest elevation of the Manhattan Prong directly south, by contrast, reaches only about 328 feet above sea level.

The rocks of the Hudson Highlands formed from the deposits of a shallow sea 1.3 billion years ago. These sedimentary rocks later metamorphosed into gneiss containing large amounts of iron ore. The bedrock is composed of stratified (layered) and non-stratified metamorphic rocks that are highly resistant to erosion (Isachsen and Gates 1991, Fisher et al. 1995). Very shallow soils with substantial areas of exposed bedrock are characteristic surficial features of much of the Hudson Highlands, with local pockets of deeper soil.

The surface of the Manhattan Prong in the southern portion of the watershed is closely controlled by the shape of the underlying bedrock. Erosion-resistant gneiss, schist, and quartzite underlie the hills, and less-resistant marble underlies the valleys. The Manhattan Prong has deep soils in the valleys with shallow soils on the upper slopes of hills. The soils of both geologic regions are generally well drained and developed on glacial till (a heterogeneous mixture of stones, gravel, sand, silt, and clay). Granitic material, schist, and gneiss dominate the parent material of the acid brown earth soils, which are very strongly leached, deeply weathered, acid, and low in fertility (Cline 1963).

5.2 Water Resources

5.2.1 Climate

Annual precipitation for the West of Hudson basins averages between 40 to 70 inches (Figure 6). Higher elevation areas in the Neversink, Rondout, and Ashokan basins receive more total precipitation, with a higher percentage of snowfall. Increased precipitation from orographic effects in the Catskills occur as maritime air masses move north along the Hudson River or as continental air moves east up the Ohio River. These storms tend to increase precipitation, especially at higher elevations in the Neversink, Rondout, and Ashokan basins. For West of Hudson, January is typically the coldest month, and July the warmest. January, February, September, and October are the driest months, and May and June are the wettest.

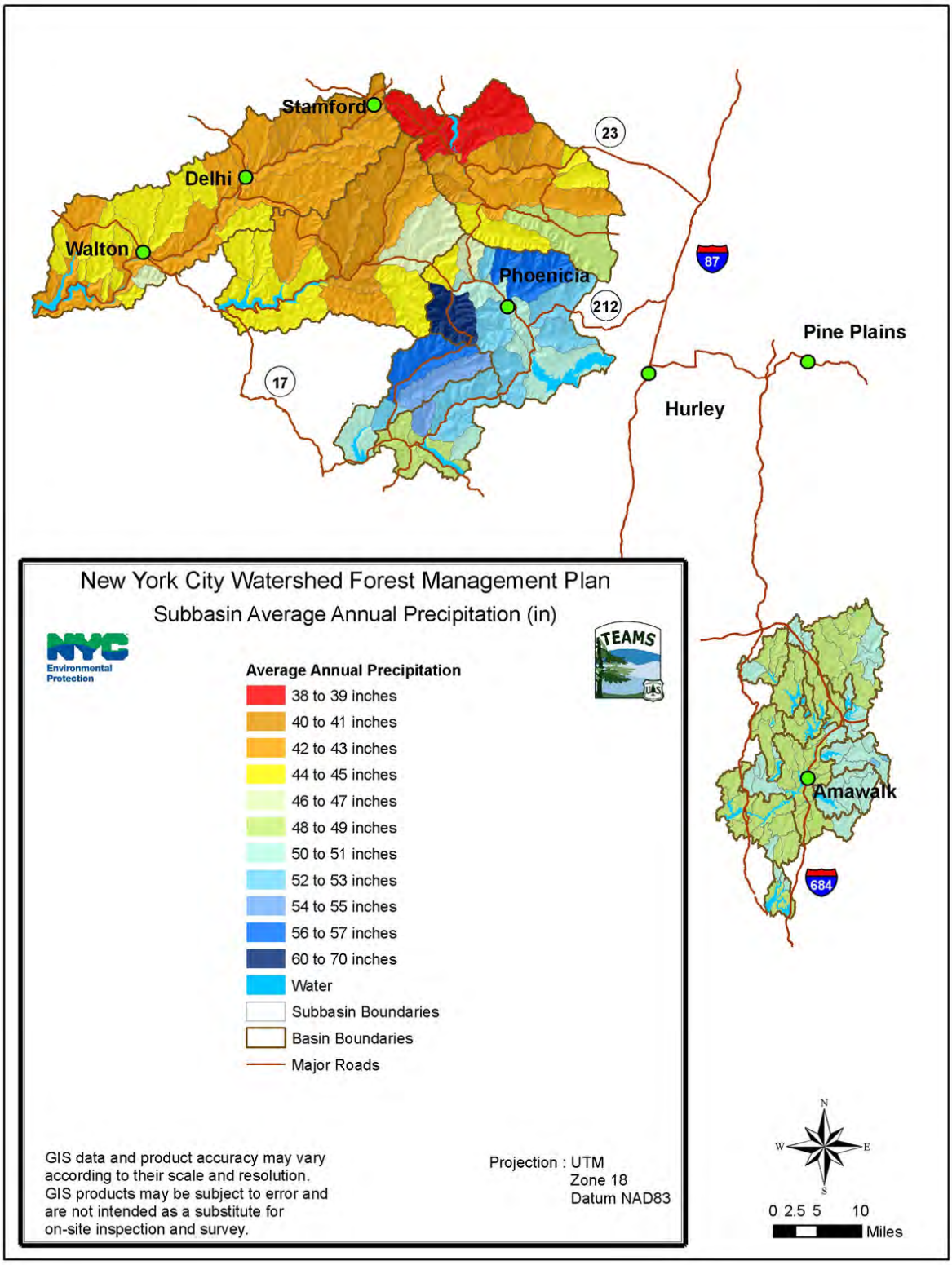


Figure 6. Average precipitation by subbasin, West of Hudson and East of Hudson areas

Annual precipitation for the East of Hudson basins ranges from about 48 to 53 inches (Figure 6), and precipitation is fairly evenly distributed throughout the year. In winter months,

precipitation may fall as snow. Based on climate records at Valhalla, New York, average monthly precipitation ranges from about 3 to 5 inches. Typically, March through May is the wettest period, and February, June, and July are the driest months. The coldest month is January and July is the warmest.

On average, January is the coldest winter month in the mountains and on the higher plateaus West of Hudson at elevations over 1,000 feet. Above-freezing temperatures are far less common than in lowland areas in the East of Hudson, with little or no daytime melting. Average January temperatures are a good 3 to 4 degrees colder at elevations from 1,000 to 2,000 feet and over 7 degrees colder over 2,000 feet than the Hudson Valley (Thaler 1996), and East of Hudson.

The high variability of monthly mean temperatures in the northeastern United States holds true in the Catskills. At Mohonk Lake, a 21-degree difference separates the warmest January (34.8 °F) in 1932 from the coldest (13.6 °F) in 1918. Such winter variability can affect the success and planning for winter logging operations.

Normally, the coldest week of the year is the 7-day period of January 12 to 18 at Deposit (17.0 °F), Walton (18.7 °F), Downsville Dam (17.7 °F), Delhi (18.3 °F), Cobleskill (17.4°F), and Slide Mountain (14.8 °F). Often a “January thaw” comes in late January. This atypical period of a few days of relative warmth comes about a week after the coldest time of the year. In the warmer areas along the Hudson River, the thaw is a period when minimum temperatures are above freezing. In the colder, higher regions, it can mean a few days of maximum temperatures well above freezing. The timing of this event is variable, but it clearly appears in the long-term daily average temperature records.

After the last three days of January, average daily temperatures at seven Catskill weather stations drop to the lowest for February from the fourth to the sixth. This cold period is close to, but not quite as cold, as the third week of January. From that time to mid-July, average daily temperatures show a steady increase. By mid-February, often average daily temperatures have risen so rapidly, that they are higher than any day in January. Average monthly temperature for thirteen Catskill weather stations show February to be 1.8 °F warmer than January. February snowfall on average is slightly less than January. Large snowstorms can occur into March, with occasional winter rains sometimes occurring in March. Precipitation in March ranges from 5 inches in the high peak region to 2.5 inches in the western Catskills.

5.2.2 Hydrology

The hydrology of the Watershed is strongly influenced by forest cover, other land uses, topography, and precipitation patterns. Net water yield in forested areas is the result of forest interactions with precipitation, evapotranspiration, interception, soil moisture, and groundwater storage. Overall runoff patterns are highly influenced by impermeable surfaces associated with development or changes in runoff patterns due to other land uses such as agriculture, and reflect other physical variables such as channel length and density, stream gradient, total basin relief, and soil depth.

In forested areas, watershed studies show that evapotranspiration losses from forests are significant, but highly variable, with water yield increases occurring when over 20 to 30 percent (Troendle et al. 2010) of forest cover within a subbasin is removed or replaced by herbaceous vegetation. The most significant yield differences among forest cover types are

between conifers and deciduous trees. In general, forest canopy interception and evapotranspiration losses are greater for conifers than for deciduous species; although this varies with stocking and with storm characteristics (deciduous forests average 13 percent overall interception losses, while coniferous forests average 28 percent, Dunne and Leopold 1978). The creation and maintenance of open land generally reduces interception and evapotranspiration losses, and can result in an increase in water yield.

From an analysis of gauging station data from Catskill streams, it was found that average annual runoff in the West of Hudson basins ranges from about 25 to 40 inches. Maximum monthly flows occur in March and April in response to snowmelt. Extreme peak flows can occur any time of year and can be associated with rainfall from hurricanes, other rainstorms, or rain-on-snow events. Minimum monthly flows occur in August, September, and sometimes October. Similar data are not available for East of Hudson.

Geology helps shape the runoff patterns in the Catskills. The Catskills contain more than 30 peaks above 3,500 feet and parts of six important rivers. The highest mountain, Slide Mountain in Ulster County, has an altitude of 4,180 feet. Partly as a result of the higher elevations, the eastern part of the Catskills in Neversink, Rondout, Ashokan, and to some degree, the Schoharie basins receive generally more precipitation than the western portion in the Cannonsville and Pepacton basins.

The western Catskills generally have broader and shallower valleys, and much of the eastern Catskills consists of highly dissected landscapes with deeper and steeper-sided valleys. Partly as a result of this geography, the western and eastern portions of the range generally have distinct and very different flow regimes. Higher streamflow yields per unit watersheds were found in the eastern Catskills than in the west. Important variables that correlated with flow were percent steep slopes within subbasins, the percent area with moderately low permeability, and the percent agricultural and urban land.

For West of Hudson basins, soil infiltration rates are controlled by soil characteristics, vegetation, and land use practices that affect the infiltration characteristics of the soil surface. For forest soils, infiltration capacities are generally higher than rainfall intensity. For instance, Walter et al. (2000) found that rainfall intensities in the Catskill Mountains, New York, rarely exceeded infiltration rates on undisturbed sites. Saturation-excess runoff occurs when rain (or snowmelt) encounters soils that are nearly or fully saturated due to a perched water table that forms when the infiltration front reaches a zone of low transmission (USDA-SCS 1972). The locations of areas generating saturation-excess runoff, typically called variable source areas, depend on topographic position in the landscape and soil transmissivity. Variable source areas expand and contract in size as water tables rise and fall, respectively. For humid, well-vegetated watersheds in the Catskill Mountains, saturation-excess on variable source areas is the predominant runoff mechanism, and runoff generation is more indicative of landscape position than land use (Schneiderman et al. 2007).Often these water source areas are located near streams.

5.2.3 Water Quality

Water quality variables of primary concern and that could be affected by past and current land management activities in the Watershed are nutrients such as nitrogen and phosphorous, suspended sediment, and bacteria. Surface-water runoff supplies a large portion of the water collected in the reservoirs. The biophysical setting within the basins influences the quantity and quality of surface water entering the streams and reservoirs (Herlihy et al. 1998). The

rate of water runoff depends on properties such as the amount of forest cover, slope, and water-holding capacity (Nash et al. 1992 and 1999) of soils and sub-soils. The amounts of surface water total nitrogen, phosphorus, suspended sediment, and fecal coliform bacteria are likely strongly affected by topography, soil, and forest cover (Slaymaker 2000).

Percent of the basins in urban development and in agriculture have a strong positive relationship with concentrations of total nitrogen, total phosphorus, or fecal coliform (EPA 2001). These two land use measurements also show up as being important in an assessment of trends with time. The smaller contribution of percent agriculture to surface water nutrient concentrations in the late 1990s is a result of the percent forest cover net gains and agriculture losses through time, partially as a result of Watershed Protection Programs such as the Whole Farm Program and Watershed Agricultural Council programs. Urbanization typically increases runoff quantities due to increases in impervious surfaces, and also increases the amount of pollutants that are delivered to the water supply. In addition, increased development reduces groundwater recharge and baseflow stream contributions as this water leaves the site as runoff instead of infiltrating into the soil. For the water supply, DEP has established a strong relationship between fecal coliform bacteria levels and water birds (gulls and geese). DEP's Waterfowl Management Program has been responsible for reducing seasonal fecal coliform elevations and maintaining compliance with the federal Surface Water Treatment Rule for Filtration Avoidance continuance.

Suspended sediment concentrations and turbidity in the Watershed are likely strongly tied to stream discharge, topography and slope, land uses, and soils (Nagle et al. 2007). Simon (2008) separates sources of fine-grained sediment that impair water clarity into three categories:

- Upland Landscape (slopes, fields, roads, etc.)
- Urban Areas (developed land with impervious surfaces)
- Stream Channels (stream bed and banks)

A study of turbidity in the Ashokan and Schoharie basins found that turbidity is largely episodic due to storm events that erode glacially derived silt and clay from deposits exposed in the landscape or stream channel (DEP 2008). These deposits are the source of suspended sediment that periodically turns the streams and reservoirs a characteristic reddish-brown. The sources of turbidity are mainly from in-stream processes including erosion of layered glacial lake silt/clay and glacial till deposits in streambanks and beds, stream-adjacent hill slope failures of these glacial deposits following high-flow conditions, and re-suspension of fine-grained sediment in the streambed material.

Upland sources are generally derived from overland flow eroding and/or entraining fine-grained particles from exposures in the landscape. In urban settings (more common in East of Hudson), stormwater runoff across impervious surfaces may increase the potential of the runoff to erode material from the landscape before getting into the stream channel. Roadside ditches intended to convey storm water runoff are assumed to be part of the stream channel network. Further, the delineation between channel network sources and upland sources can be arbitrary, in that steep hill slopes adjacent to streams can be eroded by a combination of stream channel process and mass failure of hill slope material. Upland landscape erosion sources are thought to represent a significantly smaller source for suspended sediment (DEP 2008). For example, for the Ashokan and Schoharie basins, the range of sediment delivery ratios estimates that roughly 69 to 89 percent of potential suspended sediment inputs to the

Ashokan Reservoir are derived from instream sources and only 13 to 31 percent are generated from terrestrial sources.

Best management practices (BMP) and conservation practices are routinely used in the Watershed to reduce suspended sediment and turbidity source areas in upland areas (DEP 2008). In the Ashokan Basin, more than 40 landowners have completed forest management plans covering approximately 7,100 acres and approximately two dozen forestry BMP projects have been completed, primarily road remediation projects. It is important to recognize that because forests contribute the least amount of pollution per acre of any land cover, the impacts of the Watershed Agricultural Council (WAC) Forestry Program on suspended sediment loading will generally be sporadic and minimal compared to stream channel sources (DEP 2008). Improvement in logging road construction and maintenance is likely to be the most relevant component of this program for reducing suspended sediment from the landscape.

5.2.4 Wetland Communities

Wetlands are known by many names, such as marshes, swamps, bogs, and wet meadows. Wetlands are often transition areas between uplands and lake, reservoir, or stream habitats. Standing water is only one clue that a wetland may be present. Many wetlands only have visible water during certain seasons of the year, and some never have visible water as they are saturated below the surface. For many years, people did not recognize the many diverse benefits and values of wetlands. Consequently, New York has lost almost half of its historic wetlands to such activities as filling and draining.

Vernal pools are temporary pools of water. They are usually devoid of fish, and thus allow the safe development of amphibian and insect species. Most pools are dry for at least part of the year and fill with winter rains or snowmelt. Some pools may remain at least partially filled with water over the course of a year or more. They are called vernal pools because they are often, but not necessarily, at their peak depth in the spring ("vernal" meaning of, relating to, or occurring in the spring). Despite being dry at times, once filled, they teem with life. The most obvious inhabitants are various species of amphibians, including the wood frog, the spadefoot toad, and some species of salamanders.

Springs and seeps may be considered wetlands because of the presence of wetland soils, water, and wetland vegetation. Many springs and seeps on City water supply lands do not appear on topographic maps or wetland inventories, and these unique ecosystems can be quite extensive. Seeps primarily occur on strongly sloping to steep side slopes and low-slope landforms at the base of hills.

Wetlands perform important functions in ecosystems. Some of the functions and benefits that wetlands and vernal pools provide include:

Flood and Storm Water Control − Wetlands provide critical flood and stormwater control functions, absorbing, storing and slowing the movement of rain and melt water, minimizing flooding and stabilizing water flow. Streamside wetlands also store overbank flooding.

Surface and Ground Water Flow Protection − Wetlands serve as groundwater discharge sites; maintaining baseflow in streams and rivers; and supporting ponds and lakes. In some places, wetlands are very important in recharging groundwater supplies.

Erosion Control − Wetlands slow water velocity and filter sediments, protecting streams, lakes, reservoirs, and channels. As wetlands are typically formed in level terrain, this low-energy environment allows sediment to "settle out" before the water moves into the stream system, preventing much of the sediments derived from upland sources from reaching streams, lakes, and reservoirs. Wetlands improve water quality by absorbing pollutants and reducing turbidity.

Pollution Treatment and Nutrient Cycling − Wetlands cleanse water by filtering out pollutants, which are then broken down or immobilized. Organic materials are also slowly broken down and recycled back into the environment, where they support aquatic and terrestrial food webs. Some wetland types are carbon sinks due to the slow degradation of organic matter under anoxic conditions.

Fish and Wildlife Habitat − Wetlands and vernal pools are one of the most productive habitats for feeding, nesting, spawning, resting, and cover for fish and wildlife, including many rare, endangered, and threatened species.

National Wetlands Inventory mapping has been conducted throughout the City Watershed. In the West of Hudson, wetland cover is relatively low, with the highest concentrations in the Cannonsville and Schoharie basins. In the East of Hudson system, wetlands are concentrated in the East Branch, Titicus, Boyd Corners, and Cross River subbasins. DEP continues to conduct additional wetland identification and inventory to identify and delineate these resources.

5.2.5 Riparian Areas

Riparian areas are transition zones between terrestrial and aquatic ecosystems (e.g., streams, lakes, and wetlands). Riparian areas extend down into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the watercourse at a variable width (Ilhardt et al. 2000). Properly functioning riparian areas are physically and biologically diverse and highly productive environments. These land-water interfaces are generally very dynamic and support complex associations of plant and animal communities. Riparian areas also maintain or improve water quality, moderate impacts of flooding, and provide groundwater recharge areas. Riparian areas act as a buffer to trap sediment and nutrients moving from upland areas, moderate stream temperatures, provide streamside cover and food for wildlife, provide large wood reserves and organic matter to riparian areas and aquatic systems, maintain overall channel stability, and moderate cumulative effects of actions within the watershed. Forest cover is important to maintain in riparian areas to provide many of these benefits.

Intact wetlands, streams, and associated riparian areas provide water quality protection benefits (Naiman et al. 1992). Riparian areas protect water quality by capturing, storing, and treating water that flows through their soils. A thick growth of diverse vegetation, plant residues covering the soil surface, and porous, non-compacted soil facilitates water capture in riparian areas. Intact streambanks can provide water storage capacity. Vigorously growing plants in riparian areas take up nutrients. Understanding these components of healthy riparian areas can help guide land management practices that protect riparian areas and water quality.

Figure 7. Riparian area

Healthy riparian vegetation slows and captures runoff and sediment and facilitates water infiltration into the soil. Riparian areas slow the flow of water and store it for future use. Riparian species are not arranged in a random manner. Rather, they are adapted to survive in the specific moisture regime of that area and perform specific ecological functions. Vegetation found at the edge of the water, often consists of sedges and rushes, and may have water-adapted tree and shrub species. Vegetation found in the wet ground near the edge of the bank also consists of shrubs, trees, moisture-loving grasses, and water-tolerant broad-leaved plants. Vegetation found where the riparian zone merges into the uplands often includes a mixture of riparian and upland plant species (Huel 1998).

Plants nearest the stream or other water feature are water-loving and have extensive, strong roots that stabilize streambanks against bank erosion and subsequent water quality degradation (Clark 1998). Plants throughout the riparian zone catch water and facilitate its absorption. They also take up nutrients transported into the area by runoff and groundwater and provide habitat for terrestrial and semi-aquatic animals. If land management practices reduce the riparian zones, some or all of the environmental and habitat benefits of these areas are lost.

Today, riparian areas are generally in a mid- to late-structural stage of forest development, and riparian vegetation in places provides canopy over streams. Most of the current disturbances in these areas are the result of roads near streams, suburban development, trails,

and developed recreational areas, as well as natural events such as floods, wind, insect infestations, and deer browse.

5.3 Soil Resources

The primary soil concerns for forest management are the degree of wetness on a site that can affect forest growth potential and restrict equipment travel. Integrating soils and the site context of where projects occur in a watershed into the management strategy can optimize the filtering ability of forested lands to capture and retain nutrients onsite for growth while limiting offsite pollutants into surface waters. City Watershed lands also have varying productive potential based on soils, with a large part of site productivity controlled by parent material, and secondarily, from past effects of agricultural use, timber harvest, and land development.

Soil potential integrates these past impacts, along with the current imprint of vegetation and the parent material which is the mineral material for soil formation. Much of the Catskill region parent material is dominated by till and valley bottom influenced glacial outwash and deposition over a backdrop of largely acidic sedimentary rocks. The East of Hudson plain contrasts with subtle topography and largely meltwater deposition with till derived from crystalline rocks. These parent materials have varying inherent nutrient properties depending on the decomposition state of the bedrock, whether the material was transported, and the position on the slope. Generally speaking, bottomland soils are more productive for agricultural purposes than adjacent forest soils. However, the deciduous forest vegetation and humid climate leads to productive forest soils on even poor rocky sites.

5.3.1 Soil Types

Soil mapping is useful for assessing site potential for forest management because mapping provides productivity constraints, engineering properties for road building, and wetness indicators for suitability of species and machine operability. For the purposes of the forest management planning, the Natural Resources Conservation Service (NRCS) SSURGO County soil surveys (2010) were assembled into a master database for all counties within the Watershed. The scale of soil surveys varies with SSURGO levels from 12,000 to 63,500. Soil properties and interpretations were output using the Soil Data Viewer 5.2. Soil surveys were corroborated with USGS geology mapping (Rich 1935). Analysis found strong controls by soil parent material and underlying geology for soil properties. Significant properties that affect forest growth include adequate drainage, pH, cation exchange capacity as an indication for acid rain effects, and adequate forest nutrition and organic matter.

The majority of soil types are newly formed soils within the last 10,000 years, with moderate development of strata, though very little below-ground clay development. This is notable since less developed soils generally would have a lower level of mineral nutrients available for forest growth. The soils of the region are newly developed in the wake of the Pleistocene glacial retreat with till derived from sandstones, siltstone, and shales.

In the Catskills, soils developed in glacial till plastered on mountainsides and layered sediments left in the wake of the retreating ice and glacial lakes. High elevations have soils developed in the sandstones, siltstone, and shales that make up the underlying bedrock

Soils in the Catskills are acidic, predominantly inceptic with moderate development, and approximately 12 percent clay content on average. Inceptic soils lack substantial subsurface accumulation of organic matter and clay fines that occur over a long period of time. These

soils optimally support forest growth when adequate moisture, a humic litter layer, and well-drained conditions are present. Soil pH in the West of Hudson basin is very acidic with an average pH of 5.0. In lower Neversink and Rondout, City lands have limestone bedrock that buffers soils to a pH of 6.0. Blueberries are an understory species that is indicative of acid conditions. Sugar maple could be limited on very acid soils because these conditions can strip minerals from the matrix, leading to nutrient deficiencies for high-demand species.

The glacial ice that extended south to the Catskills essentially layered fresh till on the eroded peneplain of the Schoharie, Pepacton and Cannonsville basins. In the West of Hudson basin the weight of these glaciers led to dense layers in the subsoil that restrict drainage and plant rooting. These dense soil layers are considered fragipans, impeding downward drainage and resulting in lateral surface drainage. Mountain glaciers further dissected the Ashokan, Neversink, and Rondout basins compared to the continental ice that influenced the broad valley Cannonsville, Pepacton, and Schoharie basins. Valley bottoms have medium to coarse deposits from subsequent alluvial deposition. However, the steep sideslopes and upper drainages are steep and strongly dissected leading to quick creek rises in response to storm events.

Clay-rich deposits, soils having from 26 to 40 percent clay in subsurface, are found from glacial lake outwash in the Schoharie and Ashokan basins (Table 2). The strong clay subsurface is termed as an argillic subsurface horizon. These soils are most commonly found on stream terraces adjacent to the higher order stream drainages. Examples include the red-banded clays highlighted in the Upper Esopus Stream Management Plan (2007). Soils with these clay-rich deposits and advanced development have argillic subsurface horizons. These higher-developed soils have greater buffering capacity against leaching acidic conditions with average soil pH of 6.5. These clay-rich deposits support higher orders of productivity with high levels of cation exchange capacity for nutrient needs.

Muck soils are most commonly found in the Cannonsville, Pepacton, and Schoharie basins where drainage lacks the larger topographic relief of the more dissected mountain glacial terrain in the Ashokan, Neversink, and Rondout basins (Table 2). In particular, Cannonsville and Pepacton basins have broad valley geometry with subtle topography mirroring the peneplain development. This predisposition leads to higher potential for aquic conditions.

Aquic soil conditions are those where soils are saturated either periodically or continuously. Using a coarse filter approach, aquic nomenclature was queried from Soil Order up to Soil Great Group. This would capture soils that had high saturation potential that alludes to a high water table or presence of an impermeable layer that could perch water. Cannonsville, Pepacton, and Schoharie basins have the largest amount of aquic soils. These soils have the potential for ponding and have high potential for wetland classification depending on the duration of wet conditions. Comparisons of data between the mapped wetlands layer and the soils data for aquic soils indicate a higher potential for wetland existence than the mapped wetlands layer portrays (wetland density of 7 acres per watershed area for aquic soils versus 1.8 acres per watershed area of mapped wetland classification). Some error is expected because soils data are designed for field verification, given the variable nature of soils. Forest species growth can be limited by the degree of saturated conditions during the growing season. The saturation prevents roots from acquiring oxygen needed to respire, and thus, restricts metabolic processes. Clay-rich soils particular to the lakebed sediments would have a high propensity to hold water once trees were removed with no transpiration pressure.

The East of Hudson plain was dominated by meltwater from the retreating continental ice that stopped at the Catskills. This meltwater left alluvial deposits, glacial lake deposits, and till with highly variable soil textures. Strong winds during glacial retreat left wind deposits. The underlying bedrock is primarily schist, gneiss, and granite, in addition to some isolated carbonaceous rocks. Elevation range in these watersheds is significantly less than in the Catskills. Growing conditions are moderated by the mesic thermic regime that supports a longer growing season than the high-elevation Catskills.

The meltwater created soils with a high level of bases in the mineral profile in some cases, in contrast to the residual soils that are predominantly found in the mountainous Catskills. However, these areas lack the clay-rich lakebed sediments that persist along drainages in Schoharie and Ashokan basins. Clay content in these East of Hudson soils averages 8 percent. High clay soils are not mapped, though they could occur locally from wind deposits.

The recent glacial influence leads to young, inceptic soils throughout the area; however, the nature of the parent material can support productive forests compared to bedrock-controlled areas of the Catskills. The deposit-rich soils that cover most of the East of Hudson area would have high potential cation exchange capacity for adequate nutrients. Further, limestone is commonly found that helps to buffer soils. City lands with limestone are found in Boyd Corners, West Branch, Kensico, Croton Falls, and Amawalk basins. The strong rainfall leads to an overall average soil pH of 4.9 for East of Hudson.

The most limiting substrates for tree growth would be excessively drained soils on sand deposits and poorly drained soils that proximate wetland conditions. Excessively drained conditions are common on City lands within Boyd Corners, Muscoot, Kensico, New Croton and Croton Falls basins. The variable deposition from alluvium and lake deposits creates a higher density of wetlands throughout the East of Hudson area that leads to a high density of saturated soils with aquic conditions, though with no obvious basin trends. These aquic conditions produce muck soils in cases where ponding is frequent and drainage is somewhat poorly to very poorly drained.

Table 2. Soil characteristics by watershed[1]

Basin	Basin (acres)	Muck Soils (acres)	*Aquic Soils (acres)	**Ksat (um/s)	***Temp. regime	Clay rich soils (acres)	****Soils with Fragipan (acres)
Amawalk	12,573	569	2,633	18	Mesic		
Ashokan	163,408	94	6,071	14	Mesic/Frigid	2,251	26,152
Bog Brook	2,366	123	272	18	Mesic		
Boyd Corners	14,318	761	1,044	22	Mesic		
Cannonsville	291,082	92	28,145	12	Frigid/Mesic		149,957
Cross River	19,192	948	3,233	25	Mesic		
Croton Falls	10,228	247	1,494	21	Mesic		
Diverting	4,804	282	864	21	Mesic		
East Branch	48,066	1,978	10,070	23	Mesic		
Kensico	8,476	109	723	22	Mesic		
Lake Gilead	420		47	21	Mesic		
Lake Gleneida	416		31	11	Mesic		
Middle Branch	13,395	485	2,174	20	Mesic		
Muscoot	48,418	1,422	9,046	22	Mesic		
Neversink	58,903	52	3,672	16	Frigid/Mesic		19,280
New Croton	37,128	790	6,778	20	Mesic		
Pepacton	237,477	16	15,327	11	Frigid/Mesic	116	100,134
Rondout	61,040	110	3,799	17	Mesic/Frigid		19,945
Schoharie	202,043	341	24,858	13	Frigid/Mesic	1,649	91,759
Titicus	15,574	550	4,138	25	Mesic		
West Branch	12,736	360	1,037	21	Mesic		

[1]Blank entries in the table indicate that this condition does not exist for the basin

*Mapped acres with aquic soils have aquic nomenclature from Soil Order to Soil Great Group.

**Saturated conductivity (Ksat) from SSURGO output for engineering properties.

***Frigid thermic regimes are mean annual soil temperatures of 32 to 46.5 degrees Fahrenheit. Mesic thermic regimes are 46 to 59 degrees Fahrenheit.

**** Fragipans are dense subsurface layers in soil that restrict downward movement of water.

5.3.2 Site Productivity

From a site-productivity standpoint, soils provide water, aeration, and nutrients for sustained forest growth, both below- and above-ground growth. A primary limitation on forest growth is the degree of saturation during the growing season. Most of the forest types outside forested wetlands depend on adequate aeration during the growing season to respire. Vegetation transpires water from soil that in turn moderates soil moisture and can alleviate saturated conditions. Soils with poorly drained, somewhat poorly drained, and very poorly drained conditions are prone to saturation. These soils comprise 9,012 acres of City water supply lands within the Watershed. To the other extreme, excessively drained soils that do not retain moisture can limit forest growth despite the humid conditions. Excessively well drained and somewhat excessively well drained soils comprise 16,602 acres of the Watershed.

Minerals key to forest growth depend on the inherent "fertility" of the parent material and degree of leaching from the climate. Soil's inherent ability to produce minerals is restricted by the extent parent rock is decomposed—in this case broken down into smaller pieces whereby microbes and plants can extract minerals. The humid climate setting leads to acid soils even without the added effects from acid pollution. This acidity strips base minerals from the soil matrix that can result in mineral deficiencies in plants with high demands. Sugar maple decline is attributed in part to poor mineral availability (Horsely et al. 2002, Bailey et al. 2005). Retaining nutrient-rich foliage is one way to retain base nutrients where soils are deficient. Mineral availability is typically greater at the lower elevations due to movement downslope from higher elevations.

Similarly, the placement of a site in a watershed can lead to higher nutrient availability in addition to the inherent properties of parent material. Alluvial and colluvial fans at the base of hillslopes in addition to glacial deposits along valley bottoms and hillslopes have higher proportions of minerals for adequate forest nutrition. Limestone bedrock has favorable conditions for growth from abundant supplies of calcium (Ca^{2+}) and magnesium (Mg^{2+}). Bedrock ridges are prone to mineral nutrient depletion compared to lower hillslope locations. Limestone is common on water supply lands around the Neversink reservoir, southern Rondout basin, Boyd Corners, Middle Branch, West Branch, Lake Gilead, and Amawalk basins.

Soils with high cation exchange capacity (CEC) have less potential for mineral deficiencies for plant growth. Cation exchange capacity is a measure of the ability of a soil to retain cations, some of which are plant nutrients (NRCS 2010, Soil Properties and Qualities). From this aspect, the highest CEC soils are found where derived from lakebed sediments in Schoharie and Ashokan basins. Table 3 shows the difference in cation exchange capacity in molar equivalents per 100 grams of soil (Meq/100 gram) for contrasting parent materials, essentially a measure of the positive charge available in a fixed amount of soil.

Table 3. Contrast of soil parent material and available cation exchange capacity for plant nutrition

Soil parent material	CEC Meq/100 gram (range)	Locations where commonly found
Sedimentary rock	2 (0-7)	Ridge outcrop in Catskills
Limestone derived	6 (0-14)	Neversink, Rondout, west side East of Hudson
Clayey lake sediment	15 (12-19)	Schoharie, Ashokan
Organic matter	141 (64-155)	Wetlands, throughout

Data derived from the SSURGO soil survey (NRCS 2011)

5.3.3 Nutrient Processes

Nutrient availability for plants, soil fauna, and soil microbes hinges on a combination of biologic and abiotic resources. As mentioned above, abiotic fraction of soil provides a reservoir for essential nutrients such as calcium (Ca), magnesium (Mg), and potassium (K), in addition to a physical medium for holding water, aeration for roots, and stability for plant growth. These are inherent properties that depend on the parent material as the result of soil processes in the 1,000- to 10,000-year timeframe. In contrast, soil biologic processes are a primary mechanism for nutrient production and allocation, and may be described as dynamic properties and more sensitive to time frames in terms of years and months. Dynamic properties are also the most susceptible to land management activities and impacts.

Plants uptake nutrients, such as nitrate (N), but the production of nutrients is a function of soil microbes. Microbes and plants compete for similar forms of nutrients as there are fungi and bacteria "consumers" as well as producers. Excess N leaching occurs when either the amount of base material—detritus—exceeds the capacity of available producers, or production exceeds capacity of plant and microbe consumer uptake.

Degree of nitrogen leaching can also be related to dominant tree species in a forest and the quality of litter for decomposition. Recent studies have shown forests dominated by sugar maple have less nitrate-N retention and are prone to leaching (Lovett et al. 2002, Templer and Dawson 2004, and Christenson et al. 2009). Christenson et al. (2009) showed that red oak, beech, and sugar maple, along with forest soils, preferentially consumed ammonium N, but very little nitrate was consumed. Once more, the maple litter is readily decomposed with a low C:N ratio leading to high rates of nitrate-N production. Thus, the system is easily saturated, creating higher nitrate-N export potential. The implication is a sugar maple forest stand on well-drained soils near surface waterways could be more prone to delivering nitrate through subsurface flow, assuming all other factors are equal.

5.3.4 Organic Matter and Resiliency

The role of organic matter is recognized in resource management (Covington and Sackett 1984, Jurgensen et al. 1997) to maintain nutrient base for site productivity and ameliorate temperature flux for soil processes. Applying forest residues from harvest is one of the tools for managing stormwater included in the Conservation Practices. Organic matter includes all biological residues, both above and below ground, and is commonly characterized in terms of the form and character of forest floor, fine twig litter, and downed tree boles. In these eastern hardwood stands, leaf fall is a substantial annual input for organic matter.

Organic matter accounts for the largest proportion of carbon on a site with the majority in the mineral soil for eastern forests. For eastern forests, Heath et al. (2003) reported soils account for 54 to 76 percent of total carbon. Detritus, including the forest floor and down logs is 7 to 18 percent of total site carbon.

5.4 Wildlife Resources

A wide variety of wildlife habitat conditions occur within the Watershed, and numerous species use these lands. Wildlife distribution and use of an area is determined largely by the availability of suitable habitat and can be influenced by site-specific needs such as the vegetative structure or physical features on a site, as well as by landscape considerations such as the proximity to other habitat or the need for isolation or seclusion.

The City's ongoing land acquisition helps to shift development within the Watershed from more sensitive to less sensitive lands and to lower the overall amount of land available for development, reducing the single most common threat to species of greatest conservation need (SGCN) (DEC 2009b-d), being habitat loss. This includes loss of habitat directly due to development and associated fragmentation, as well as increased human-wildlife interactions. Water quality impacts such as siltation, toxic contamination, and loss of riparian vegetation threaten all watersheds, as do invasive species (including forest pests and pathogens) and the associated reduction in habitat quality and diversity. Deer browsing that reduces understory structure and forest regeneration is cited as a threat because of effects to habitat quality and wildlife.

The analysis of wildlife resources is grouped into the following five analysis groups: Delaware (Cannonsville, Neversink, Rondout, and Pepacton basins); Ashokan/Schoharie, Kensico, West Branch, Boyd Corners, and the Croton System (Amawalk, Bog Brook, Cross River, Croton Falls, Diverting, East Branch, Lake Gilead, Lake Gleneida, Middle Branch, Muscoot, New Croton, and Titicus basins) to be consistent with existing wildlife data sources. Delaware and Ashokan/Schoharie comprise the West of Hudson basins, and Kensico, West Branch Boyd Corners and the Croton System comprise the East of Hudson basins.

5.4.1 Deer

White-tail deer are considered a keystone herbivore, a species that has a disproportionate effect on its environment relative to its abundance (Paine 1995). A deer impact assessment was completed as part of the Forest planning process that summarizes recent information related to deer and provides management recommendations related to reducing deer impacts.

Marquis et al. (1992), Redding (1995), and deCalesta and Stout (1997) define deer impact as a joint function of deer density and foraging availability, and suggest that as forage availability increases, the impact on forest resources decreases. Deer density or the number of deer on a given area (e.g., deer per square mile) is affected primarily by mortality associated with winter severity in northern New York, whereas hunting harvest, including the allocation of deer management permits is the primary deer control factor in southern New York (DEC 2010a). Forage availability is affected by both natural (e.g., windstorms) and human-induced (e.g., timber harvest, agriculture) disturbances that create patterns and amounts of forest openings that produce deer forage. Also, both forage availability and deer density are affected by landscape patterns of vegetation and deer harvest, which vary spatially and temporally (McShea et al. 1997). While landscape condition affects deer density in southern New York, ultimately deer numbers are affected by hunting, particularly the use of deer management permits, which allow hunters to take antlerless deer (DEC 2010a).

White-tailed deer are highly selective feeders that choose foods that are highest in quality and require the least amount of energy to find (Pennsylvania Game Commission 2010). Consequently, when deer populations are overabundant, one of the first observable impacts is a reduction in species diversity, as deer selectively remove preferred forage species. As a result, much of the analysis provided evaluates deer impacts in terms of their effects on highly preferred (e.g., oak and ash), moderately preferred (e.g., white pine and black cherry), and least preferred (e.g., beech and birch) species.

5.4.1.1 Deer Density and Impacts

In order to obtain site-specific deer density information, as well as to collect comprehensive deer impact, data transects were conducted in the spring of 2010 using a method developed by deCalesta (2009), as it provides a reliable estimate of deer density on small and large landscapes. It is also used by DEC and by using this method, data collected on City water supply lands can be compared to monitoring information collected on other lands across the State. These transects provide information regarding both deer density and browsing impacts (Table 4). The Ashokan transect was located within a managed forest with deer hunting allowed, and may not be representative of the entire basin.

Kensico basin was not inventoried using transects, as deer density information had been collected previously using Forward Looking Infra-Red (FLIR) surveys during the winter of 2006. This technique involves using fixed-wing aircraft equipped with FLIR that fly a

prescribed course. The FLIR detects the heat sources of deer and other animals and records images on videotape. Trained observers review the tape and count the number of deer recorded, from which population estimates are made.

Table 4. Deer transect summary

Transect	West Branch Headwaters	Horse Pound	Camp Alamar	Ashokan Reservoir	Rondout North	West Settlement	Johnny Brook	Murphy Hill	Hollow Brook	Ward Pound[1]	Kensico FLIR[2]
Basin	Boyd Corners	West Branch	Boyd Corners	Ashokan	Rondout	Schoharie	Cannonsville	Pepacton	Neversink	Cross River	Kensico
Watershed	WBBC[3]	WBBC	WBBC	WOH Catskill	WOH Catskill	WOH Catskill	WOH Delaware	WOH Delaware	WOH Delaware	Croton System	Kensico
Deer Density Range (Deer/mi^2)	10.3-23.2	2.9-15.6	2.6-15.7	15.0-20.1	0-52.3	7.2-39.7	9.1-28.8	8.5-35.1	6.7-9.7	31.8-104.2	12.5-66.7
% of Vegetation plots with no Regeneration	65%	68%	68%	58%	93%	32%	29%	58%	86%	92%	N/A
% of Vegetation plots with Regeneration and No Impact	1	0	2	10	2	7	14	4	3	2	N/A
No. of Plots with Low Preference Species (% moderately to severely browsed)[4]	34 (80%)	42 (69%)	47 (45%)	33 (39%)	5 (40%)	30 (67%)	45 (24%)	49 (43%)	18 (39%)	7 (100%)	N/A
No. of Plots with Moderate Preference Species (% moderately to severely browsed) [4]	22 (46%)	3 (33%)	6 (0%)	13 (67%)	0	25 (60%)	22 (6%)	14 (100%)	1 (100%)	2 (100%)	N/A
No. of Plots with Highly Preferred Species (% moderately severely browsed) [4]	0	0	1 (100%)	13 (100%)	3 (100%)	3 (67%)	18 (22%)	27 (93%)	1 (100%)	0	N/A
Overall Forage Availability	Low to Moderate	Low	Low	Moderate to High	Low	Moderate	Moderate to High	Low to Moderate	Low	Moderate	Moderate
Overall Deer Impact[5]	High	High	Moderate to High	Moderate	Very High	Moderate to High	Low to Moderate	Moderate	High to Very High	Very High	High
Hunter Access/use	High	High	High	Moderate to None	Moderate	Moderate	Moderate to High	High	Moderate with Illegal Use	None	Low

Source: Deer Impact Assessment, Reitz 2010

1- Conducted at deer density workshop in 2008 (deCalesta and Pierson 2008).

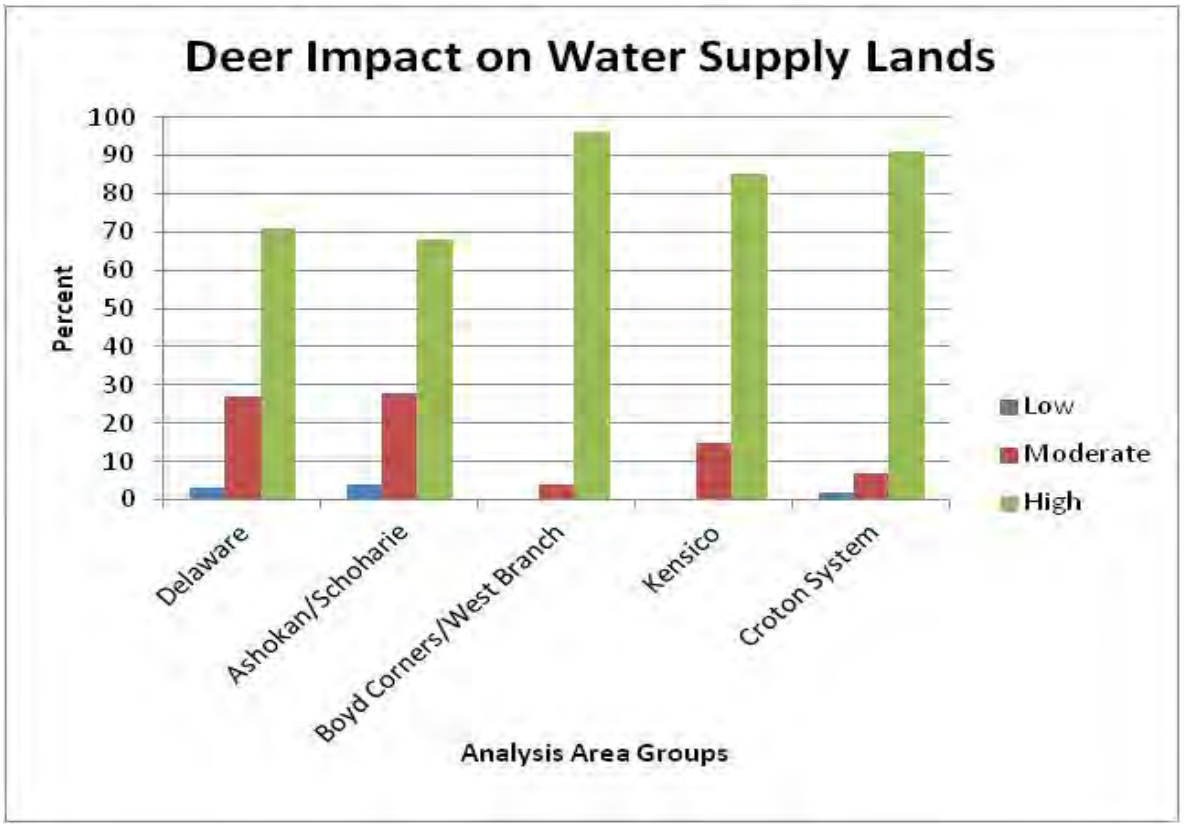
2-Kensico FLIR data used, no transects completed.

3- WBBC = West Branch/Boyd Corners.

4- In order to compare these transects with others across the State, preferences were based on those used by New York Department of Environmental Conservation, and differ somewhat from those used in the stand-level analysis, which are based on those developed by DEP (DEP 2010a).

5- Overall deer impact is based on categories described in DEP 2010a.

In addition to transect and FLIR data, deer impact data were collected during the Forest Inventory to provide additional data over a larger area (Figure 8).



Source: Reitz, Deer Impact Assessment 2011b

Figure 8. Deer impacts by percent of basin analysis area (water supply lands)

5.4.1.2 Regeneration Risk from Deer Impacts

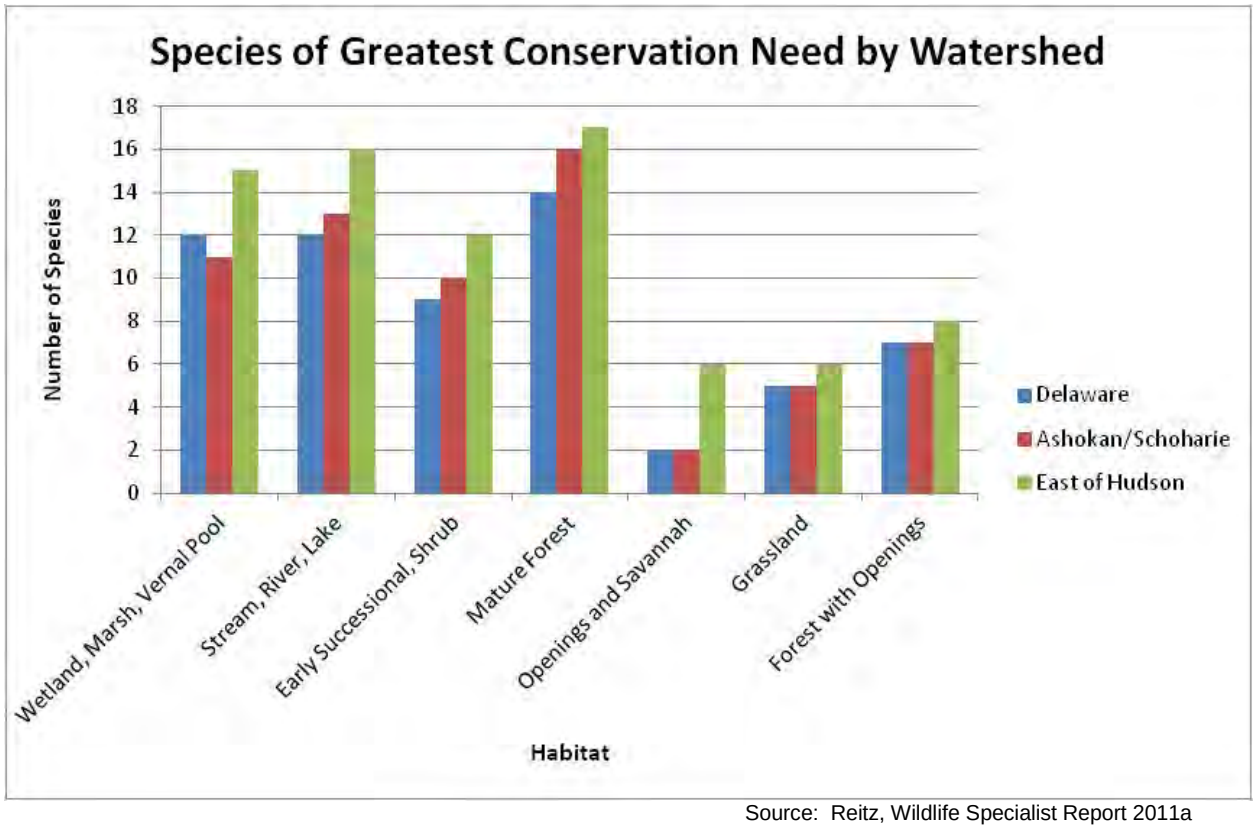
One of the primary objectives of obtaining deer impact data is to identify a strategy that will help promote adequate forest regeneration to become established on City water supply land. Based on the deer density and impact data, stands that presently contain a larger component of preferred species and also receive moderate to high levels of hunting provide the best opportunity to achieve successful regeneration. Also, more isolated stands that currently have lower deer impacts may be at greater risk than stands in landscapes that contain a larger component of lands with reduced deer impact (i.e., moderate to low). Consequently, to identify risks associated with regeneration of forested lands under City water supply lands; the stand-level deer impact data, the understory plot data (used to identify stands with a larger preferred species component), hunter access, and spatial considerations such as impacts on adjacent lands were collectively used to develop a Deer Regeneration Risk Rating, displayed in Table 25, Section 6.10.3.

5.4.2 Species of Greatest Conservation Need

Over 50 percent of New York's species of greatest conservation need (SGCN) live in specific forest communities. When vernal pools, streams, rivers, ponds, lakes, wetlands, and other habitat types that rely on fresh water for temperature control, food, and other benefits provided by forests are taken into consideration, nearly half of the State's SGCN rely on

forests (DEC 2010a). A variety of sources were used to identify SGCN that have been documented on City water supply lands including; New York Natural Heritage Program Documentation (NHP 2009a, NHP 2009b, and NHP 2010), New York breeding bird atlas data (DEC 2008a), New York amphibian and reptile (Herp Atlas) data (DEC 2008c), breeding bird survey route data (DEC 2008b), State Comprehensive Wildlife Conservation Strategy (CWCS) watershed documentation (DEC 2009c-k), and documentation identified in the New York Nature Explorer (DEC 2009l). These species are recorded using different watershed delineations.

A list of species that have been documented on water supply lands and their current status is included in Appendix 3. Approximately 48 bird species, 28 reptiles and amphibians, 4 mammals and 11 invertebrate species have been documented to occur on City water supply lands, with 123 species occurrences documented WOH, and 80 species occurrences documented EOH. (Figure 9 identifies the number of species by habitat type.)



Source: Reitz, Wildlife Specialist Report 2011a

Figure 9. Species of greatest conservation need occurrences by habitat type

The potential effects to threatened, endangered, and other species of greatest conservation need species and their habitat are largely protected through implementation of conservation recommendations and operational guidelines included in this Plan. The project review process, which includes involvement with the DEP Wildlife Studies Section throughout the planning and implementation phase and when necessary, involvement of DEC and United States Fish and Wildlife Service (USFWS) biologists, greatly reduces the likelihood that these species or their habitat would be adversely affected.

5.4.2.1 Bald Eagles and Forest Raptors

The Bald eagle (*Haliaeetus leucocephalus*) is a State-listed Threatened species, with nesting, roosting and foraging activity documented across many City reservoir basins including Ashokan (multiple sites), Bog Brook, Cannonsville (multiple sites), Neversink (multiple sites), New Croton, Titicus, Pepacton (multiple sites), Rondout (multiple sites), and Schoharie (multiple sites). Also, activity occurs along both reservoirs and rivers under City water supply lands. Management to date has included nest protection and monitoring. Potentially suitable bald eagle habitat has been identified on approximately 39,000 acres of City water supply property and includes all of the reservoirs within the Delaware and Catskill Watersheds, as well as land adjacent to the New Croton Reservoir (NHP 2009a-b, NHP 2010).

Specific threats to this species include habitat loss or alteration; human activity or disturbance; alteration of prey base; contaminants; vehicle collisions; and collisions with wind towers, electrical lines, etc. (DEC 2009e). Conservation Practices include protection of occupied nesting territories and wintering areas, and adequately reviewing actions proposed within suitable habitat to minimize adverse effects of occupied and suitable habitat.

Forest raptors include the coopers hawk (*Accipiter cooperii*), northern goshawk (*Accipiter gentilis*), red-shouldered hawk (*Buteo lineatus*), and sharp-shined hawk (*Accipiter striatus*). Potential threats to all species include habitat fragmentation or a loss or reduction in larger blocks of interior habitat, disturbance to nest sites during breeding, reduction in prey diversity, and collection of eggs and young by falconers. All forest raptors have increased in most areas as agricultural land has reverted to forest edge (DEC 2009e, Steele et al. 2010).

While there is potential for nest site disturbance during treatment, recommendations to avoid active nest sites will reduce disturbance during the nesting and post-fledgling period. While there may be some short-term disturbance to nesting birds, following recommendations for nest buffers and limited operating periods would effectively reduce the likelihood of direct mortality to nesting birds, eggs, or fledglings (USDA Forest Service 2007c). As a result, it is unlikely that nest reproduction or success would be affected.

5.4.2.2 Fisheries

There were no fish SGCN documented within City basins (DEC 2009f, NHP 2009b, NHP 2010a), although invertebrate SGCN were documented within or immediately below City Watersheds (DEC 2009h, DEC 2009j, NHP 2009b, NHP 2010a), and are identified in Appendix 3.

New York State provides stream classifications and standards based on existing or expected usage of each waterway and streams designated as Class A, B or C are capable of supporting fisheries (DEC 2011c). Streams containing trout and trout spawning are also classified based on water quality conditions and documented use. Table 5 displays streams within each watershed that are capable of supporting fish, as well as those that currently support trout and trout spawning.

Table 5. Watershed or basin streams supporting fish

State Classification	Analysis Areas									
	West of Hudson						East of Hudson			
	Delaware[1]		Ashokan/ Schoharie		W. Branch Boyd Corners		Kensico[1]		Croton System	
	Mi.	%[2]	Mi.	%[2]	Mi.	%[2]	Mi.	%[2]	Mi.	%[2]
Streams supporting trout	1,283	87	477	58	29	36	0	0	192	29
Stream supporting trout spawning	486	32	260	32	13	16	0	0	88	13
Streams supporting fish (total)	1,478		825		79		20		652	

Source: NYS DEC Stream Classification GIS layer – this layer does not include smaller intermittent streams

[1]- Trout spawning has been documented from streams in the Kensico and Neversink basins, although because stream classification is still pending by NYS DEC, these miles are not reflected.

[2]- Percent of total stream miles that support fish

While all watersheds/management areas support fish, they vary in terms of their capability to support trout, which require colder water and higher levels of oxygen. As a result, most of the trout waters exist in the headwater streams that are generally smaller and often have greater levels of forested cover that provide shade, although this varies depending on the species present (e.g., some trout species tolerate warmer temperatures). Conversely, many of the non-trout waters within all watersheds occur as smaller headwater streams, which contain very little flowing water. The reduced miles of trout and trout spawning waters in the WBBC, Kensico and Croton System basins is also partially due to the fact that these areas are at lower elevations and would generally experience warmer temperatures and lower oxygen levels, as well as increased urbanization.

Habitat for fish and aquatic species is provided by maintaining water quality, protecting the hydrology of waterways and protection of stream and riparian habitat. This is achieved largely through implementation of conservation practices (Appendix 1) and establishment of exclusion and special management zones around reservoirs and lakes, streams and rivers, wetlands, vernal pools, and springs and seeps. Additionally, the project review process in place, which includes coordination with the DEP Fisheries Biologist also help to ensure that potential impacts to native fisheries will be reduced or eliminated.

5.4.3 Habitat Components Related to Forest Structure

The distribution or mixing of vegetative types, size classes, and other features to a large extent determines the wildlife communities that occur within forest vegetation (DeGraaf et al. 1992). Horizontal and vertical diversity are two components of habitat structure and the number of species that occupy a given habitat is, in part, a function of vegetation composition and distribution that occur at both the site and landscape scale. Structural conditions that occur at the site or local scale are referred to as vertical diversity, whereas horizontal diversity is the amount of diversity across the landscape. The following is a discussion of how horizontal and vertical diversity can affect wildlife distribution and use within City Watersheds.

5.4.3.1 Vertical Diversity and Wildlife

Vertical diversity refers to the extent to which plants are layered within a site and is evaluated at the stand scale. Stands with a high degree of vertical diversity typically develop multiple vegetative layers and are generally characterized by a diverse overstory, woody mid-story

layers, and a well-developed herbaceous and shrub understory. Structural diversity has important implications for wildlife, because many species of songbirds, reptiles, and amphibians have specific requirements for differing amounts of vertical diversity in their habitats. While some species require both types of diversity, vertical diversity is probably of greatest importance to birds (DeGraaf et al. 1992).

5.4.3.2 Horizontal Diversity and Wildlife

Wildlife species composition and abundance are greatly affected by the spatial relationships of available habitat, and horizontal diversity refers to the complexity or arrangement of plant communities and other habitats across the landscape (DeGraaf et al. 1992). For example, 72 percent of all wildlife in a northern hardwood stand will utilize more than one size class (combination of seedling, sapling, and sawtimber). Also the bird community in a mature stand that is adjacent to a regenerating stand or opening may be different than the bird community in a stand that is surrounded by mature forest. For these reasons, there is often a greater likelihood of meeting more species' requirements when a variety of habitat conditions are present. Maintaining a variety of age classes and cover types is important for maintaining wildlife diversity in forested landscapes (McShea and Healy 2002), particularly landscape-level birds and mammals (DeGraaf et al. 1992). As a result, providing a balance of age classes and adequate amounts of early-, mid-, and late-successional forest is a recommendation across the State and in City Watersheds (DEC 2010a, DEC 2009e, and PIF 2003).

Over 150 species in the Northeast, including over 25 SGCN found within City Watersheds, utilize landscapes that contain a diversity of forested size classes and the structural conditions they provide. As a result and when consistent with water quality objectives, forest management can be used to enhance both site- and landscape-level diversity.

5.5 Flora Resources

Biodiversity of forests encompasses all plants, animals, fungi, and microbes within forested areas and the ecological roles they perform. Levels of biodiversity can be considered on ecosystem, landscape, species, population, or genetic levels, and complex interactions occur within and amongst these levels. It is this complexity that allows organisms to adapt to continually changing environmental conditions and to maintain ecosystem functions. Furthermore, forest biodiversity is linked to a web of socioeconomic factors and human well-being. This connection is exemplified in the City landholdings managed by the DEP where forest ecosystems serve as natural filtration for the drinking water supply for the City metropolitan area.

5.5.1 Invasive Species

Invasive flora are those nonnative plants, introduced intentionally or unintentionally into the landscape, that populate their new ranges to such an extent that they exclude native vegetation, disrupt ecosystem function, reduce biodiversity, degrade the natural areas they inhabit, and pose a threat to water-quality protection. Invasive species can damage native habitats by altering hydrology, increasing fire frequency, changing soil chemistry and fertility, hastening soil erosion, interrupting natural succession, decreasing forest regeneration, disrupting the food chain, degrading habitat, and increasing risk of predation of nestlings (Holton and Plumb 2010). In addition to compromising species density and diversity of forest floor herbs and woody plant seedlings, the climbing vine species (oriental bittersweet and mile-a-minute vine) shade out mature native shrubs and trees. Oriental

bittersweet, with its perennial, woody vine, has the unique reputation for weakening and completely killing mature trees by girdling, and/or increasing the tree's vulnerability to limb breakage and uprooting in wind and storm events (Table 6).

Some invasive species pose serious health risks both directly as in the case of giant hogweed, which contains phototoxic sap, and indirectly as in the case of Japanese barberry thickets that provide favorable habitat for mice and consequently are associated with increased cases of Lyme disease in adjacent human populations (Williams et al. 2009).

Approximately one-third (36 percent) of all plant species known in New York State are nonnative (DEC 2010a). Of these, some species demonstrate the ability to be invasive (i.e., crowd out native vegetation and/or alter ecology). In preparation for development of the Forest Management Plan, field survey crews collected data on forest condition in the project area. The surveys included data on 11 common invasive exotic plants that are known to impact forest resources in a variety of ways.

Table 6. Summary of invasive species impacts on forest regeneration, growth, and health

Species	Impact on Forest
Common buckthorn	Shades out native understory; Inhibits regeneration of native species
Garlic mustard	Shades out native understory; Inhibits regeneration of native species, affects soil mycorrhizae; Depletes soil moisture
Japanese barberry	Shades out native understory; Inhibits regeneration of native species; Changes soil chemistry
Japanese knotweed	Shades out native understory; Inhibits regeneration of native species
Japanese stiltgrass	Shades out native understory; Inhibits regeneration of native species
Multiflora rose	Shades out native understory; Inhibits regeneration of native species
Norway maple	Shades out native understory; Inhibits regeneration of native species
Oriental bittersweet	Shades out native herbs, shrubs and trees; Girdles host tree; Increases likelihood of limb breakage and uprooting host tree
Shrub honeysuckle	Shades out native understory; Inhibits regeneration of native species; Depletes soil moisture; Competes for pollinators
Tree of heaven	Shades out native understory; Allelopathic (produces toxins that prevent establishment of other plants); Inhibits regeneration of native species
Winged euonymus	Shades out native understory; Inhibits regeneration of native species

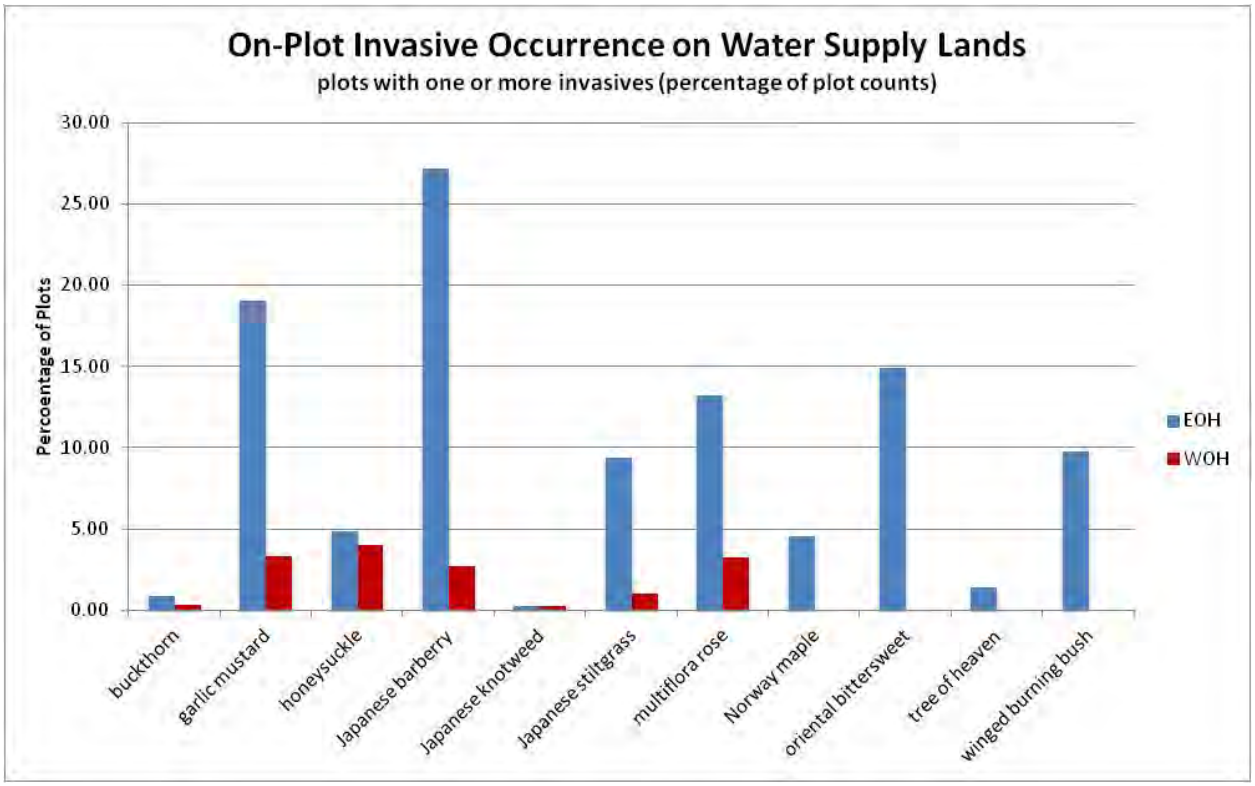
5.5.1.1 Invasive Species Presence

Invasive plants occur more frequently in the EOH Watershed, likely because of the higher level of fragmentation and disturbance. While the forests of the WOH Watershed are less fragmented and more protected, invasive species do exist. However, the presence typically is associated with roadsides, utility corridors and other disturbances and less frequent farther away. A side-by-side comparison of invasive plant occurrence plot count percentages highlights the difference between the two watersheds (Table 7, Figure 10).

Table 7. On-plot invasive species occurrences, percent of total plots

	buckthorn	garlic mustard	honey suckle	Japanese barberry	Japanese knotweed	Japanese stiltgrass	multiflora rose	Norway maple	oriental bittersweet	tree of heaven	winged burning bush
EOH	<1	19	5	27	<1	9	13	5	15	1	10
WOH	<1	3	4	3	<1	1	3	<1	<1	<1	0

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

Figure 10. Invasive species occurrences, percent of total plots

In the EOH Watershed the top four most commonly occurring invasive plant species based on plot data are: Japanese barberry, garlic mustard, oriental bittersweet, and multiflora rose, in that order.

In the WOH Watershed the top four most common occurring invasive plant species based on plot data are: honeysuckle, garlic mustard, multiflora rose, and Japanese barberry, in that order. In looking at invasive plant occurrences plot data for WOH it is evident that there are differences in species infestation levels between basins (Table 8).

Table 8. Most common occurrence species by basin, West of Hudson

Basin	Most common	Second most common	Next most common
Ashokan	Japanese barberry	garlic mustard	multiflora rose
Cannonsville	multiflora rose	honeysuckle	garlic mustard/Japanese barberry
Neversink	Japanese barberry	Japanese stiltgrass	garlic mustard/buckthorn
Pepacton	honeysuckle	garlic mustard	Japanese barberry
Rondout	multiflora rose	Japanese barberry	garlic mustard
Schoharie	garlic mustard	honeysuckle	Japanese barberry

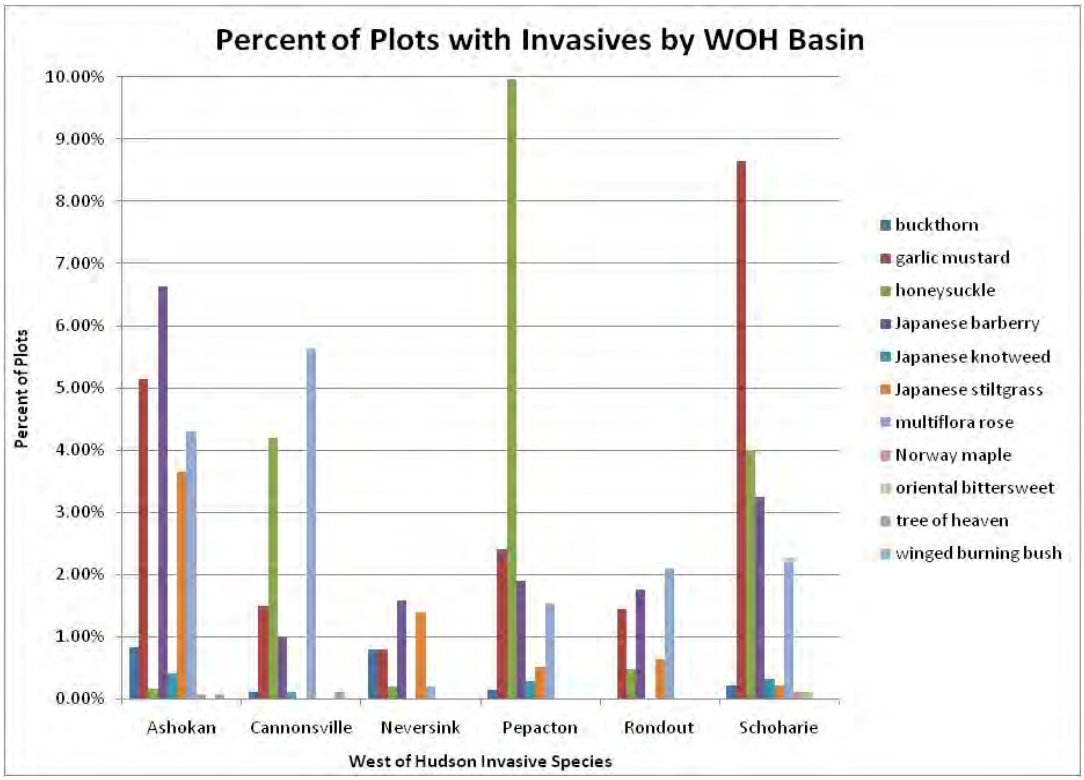
Source: Forest Inventory 2009-2010

Table 9, Figure 11, and Figure 12 display the number of on-plot invasive species that occur for individual basins. Japanese barberry, garlic mustard, and multiflora rose occurred in every basin inventoried.

Table 9. Occurrence of invasive plant species on-plot by basin (percentage of total plots by basin)

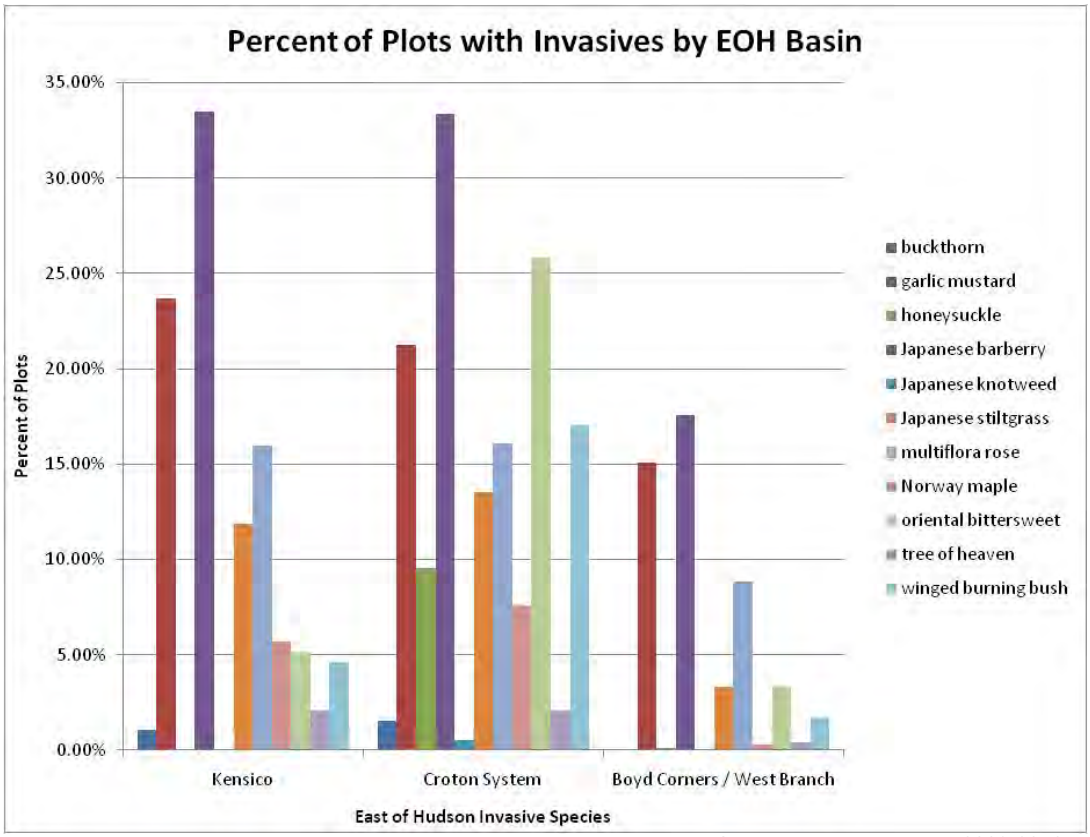
Species	Ashokan	Boyd Corners/ West Branch	Cannonsville	Croton System	Kensico	Neversink	Pepacton	Rondout	Schoharie
Buckthorn	1%	0%	<1%	2%	1%	1%	<1%	0%	<1%
Garlic mustard	5%	15%	1%	21%	24%	1%	2%	1%	9%
Honeysuckle	<1%	<1%	4%	10%	0%	0%	10%	<1%	4%
Japanese barberry	7%	18%	1%	33%	34%	2%	2%	2%	3%
Japanese knotweed	<1%	0%	<1%	1%	0%	0%	<1%	0%	<1%
Japanese stiltgrass	4%	3%	0%	14%	12%	1%	1%	1%	<1%
Multiflora rose	4%	9%	6%	16%	16%	<1%	2%	2%	2%
Norway maple	<1%	<1%	0%	8%	6%	0%	0%	0%	<1%
Oriental bittersweet	0%	3%	0%	26%	5%	0%	0%	0%	<1%
Tree of heaven	<1%	<1%	<1%	2%	2%	0%	0%	0%	0%
Winged burning bush	0%	2%	0%	17%	5%	0%	0%	0%	0%

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

Figure 11. Invasive occurrence by West of Hudson Basin



Source: Forest Inventory 2009-2010

Figure 12. Invasive occurrence by East of Hudson Basin

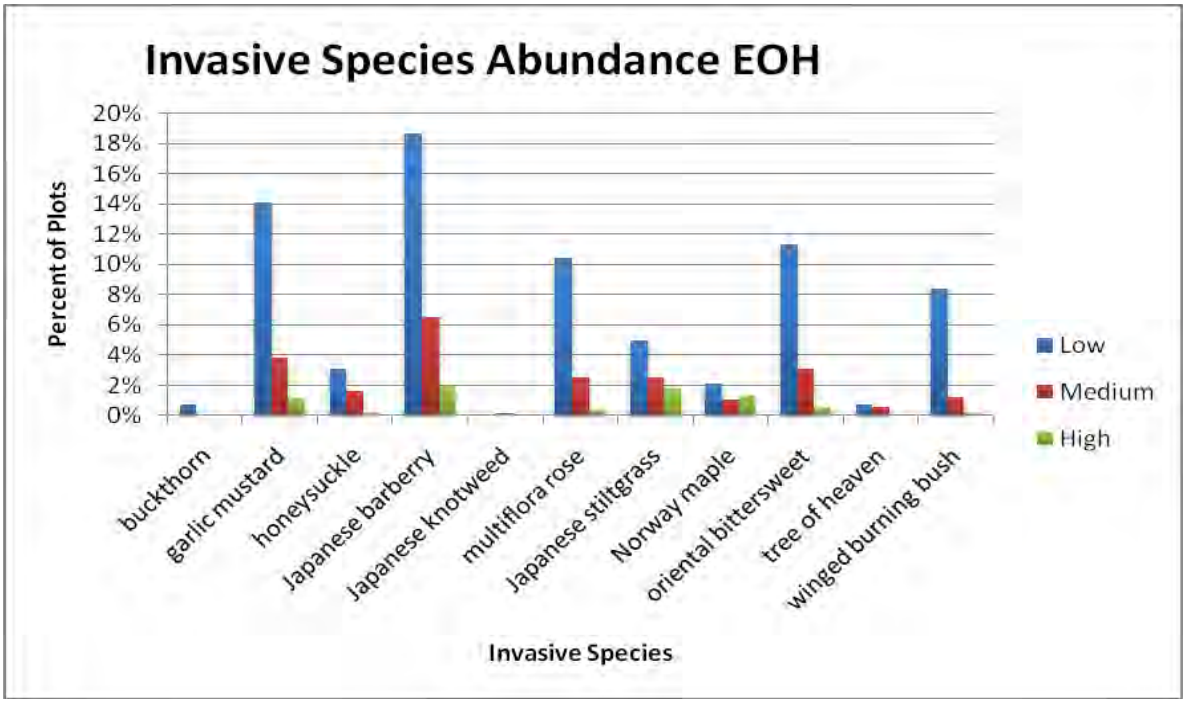
5.5.1.2 Invasive Species Abundance

In most of the plots EOH abundance levels of invasive species were low; however, there were a few plots with medium abundance and a few with high abundance (Table 10, Figure 13). Garlic mustard, Japanese barberry, Japanese stiltgrass, Norway maple, and oriental bittersweet had 10 or more plots with high abundance. The low numbers of plots encountered that had greater than low abundance indicates that this is a relatively site-specific, project or site level scale issue to be addressed where these occur. It should be noted that plots with Japanese stiltgrass had a higher chance of having a medium or high abundance level than other invasive species. This suggests that once this species becomes established, it has a tendency to dominate the understory to a greater extent than other invasive plants. Though it may not be as widespread as some of the other invasive species, nearly half of the areas infested by the grass were significantly impacted (medium or high abundance within plots). As a result, establishment of this species into new areas may be of particular concern.

Table 10. East of Hudson abundance of invasive plant species (percent of total plots)

Abundance	buckthorn	garlic mustard	honey-suckle	Japanese barberry	Japanese knotweed	multiflora rose	Japanese stiltgrass	Norway maple	oriental bitter-sweet	tree of heaven	winged burning bush
Low	1%	14%	3%	19%	<1%	10%	5%	2%	11%	1%	8%
Medium	<1%	4%	2%	7%	<1%	2%	3%	1%	3%	1%	1%
High	<1%	1%	<1%	2%	0%	<1%	2%	1%	1%	<1%	<1%

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

Figure 13. East of Hudson invasive plant species abundance

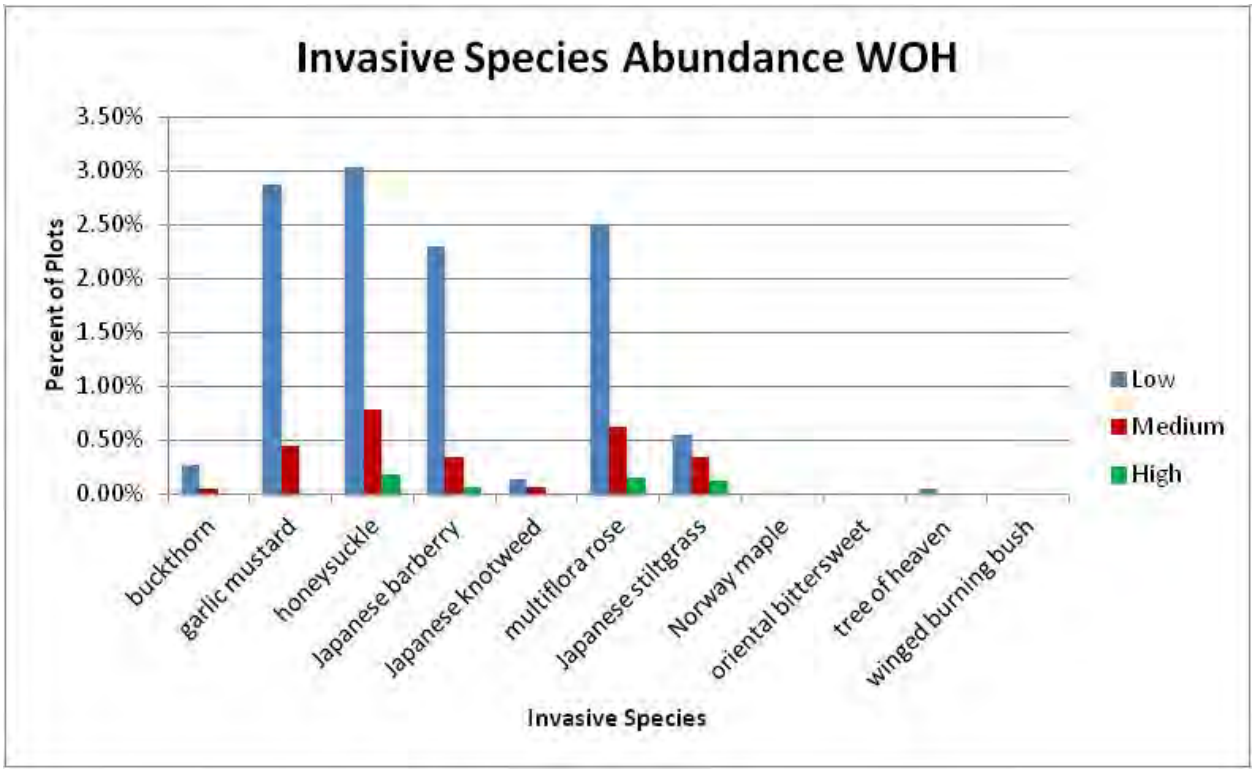
In most of the plots WOH abundance levels of invasive species were low; however, there were a few plots with medium abundance and a few with high abundance (Table 11, Figure 14). The low numbers of plots encountered that had greater than low abundance indicates that

this is a relatively site-specific, project or site level scale issue to be addressed where these occur. It should be noted that plots with Japanese stiltgrass had a higher chance of having a medium or high abundance level than other invasive species due to its growth characteristics and rapid occupancy of a site.

Table 11. West of Hudson abundance of invasive plant species (percent of total plots)

Abundance	buckthorn	garlic mustard	honey-suckle	Japanese barberry	Japanese knotweed	multiflora rose	Japanese stiltgrass	Norway maple	oriental bitter-sweet	tree of heaven	winged burning bush
Low	<1%	3%	3%	2%	<1%	2%	1%	<1%	<1%	<1%	0%
Medium	<1%	<1%	1%	<1%	<1%	1%	<1%	<1%	0%	0%	0%
High	0%	<1%	<1%	<1%	<1%	<1%	<1%	0%	0%	0%	0%

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

Figure 14. West of Hudson invasive plant species abundance

Invasive species exist throughout the Watershed, and depending on site-specific location, may be present in sufficient quantities to warrant consideration during project planning. It is apparent that locations of many species are associated with past disturbance, and therefore activities adjacent to these locations should include appropriate operational recommendations.

5.5.2 Federally Threatened and Endangered, and State Protected Plant Species

The City Watersheds have not been comprehensively inventoried for sensitive flora. The New York State Natural Heritage Program (NHP) provides a valuable resource for determining what sensitive plants may be present.

Two federally listed plant species have potential habitat within the Watershed, small-whorled pogonia (*Isotria medeoloides*) and Northern monkhood (*Aconitum noveboracense*). Small-whorled pogonia is listed by New York State as historical (SH), which is defined as having no existing sites known in the State in the last 20 to 30 years. There are approximately 25 endangered, 16 threatened, and one rare plant species listed by New York State DEC. The majority of these plants occur in geographically restricted locations, and limited extent.

Project planning protocols incorporated in the DEP Forest Management Projects And Conservation Practices (Appendix 4) address protected species during the planning and implementation stages of a forest management activity. This includes thorough investigation to determine what plants could potentially inhabit the site, interagency communication between the DEP and the DEC and/or the NHP, and development of species-specific protection measures to ensure plants are not adversely impacted by the project. Priority will be placed on avoidance whenever possible. When impacts are unavoidable they will be minimized or mitigated, and plants may be transplanted when no better option is available.

5.6 Socio-Economics

Managing forest lands provides numerous benefits, including social and economic. While employment and income effects of the Forest Management Strategy are important to consider, other benefits and costs associated with forest management must also be considered. For example, management can improve the capacity of the forest to provide ecosystem services, such as water quality maintenance, in addition to other services such as recreation opportunities and improved quality of life for adjacent communities. In contrast, without forest management, the opportunity cost of benefits forgone would accrue.

To accurately portray the relationship of current forest management and the community, the geographic scope of economic analysis must be defined. The social and economic effects from the Plan feasibly extend beyond the immediate vicinity of City lands, as wood-processing facilities and industry workers live in adjoining counties. In addition, the role of City lands must be addressed while not masking change within the sub-basins. A multidimensional approach is thus appropriate, examining the role of forest management for both East and West of Hudson Watershed counties. Consequently, characteristics and effects are presented for two groups of counties and their towns that encompass the East and West of Hudson Watersheds. The West of Hudson Watershed counties include Chenango, Delaware, Greene, Otsego, Schoharie, Sullivan, Ulster Counties, and a small part of Fairfield County, Connecticut, and those towns depicted in Figure 15. East of Hudson Watershed counties include Dutchess, Putman and Westchester Counties, and those towns depicted in Figure 15. East and West of Hudson Watershed county groups include areas outside the immediate vicinity of City water supply lands since communities and industry in adjacent counties are considered linked to the area.

Figure 15. East and West of Hudson Watershed counties and towns

5.6.1 Population Trends

From 1970 to 2010, population in East and West of Hudson Watershed counties, (including areas both inside and outside the watershed portion of the counties), grew by 14.5 and 25 percent, respectively (from 1.18 to 1.35 million and 401,472 to 502,726 people, respectively). Growth in both the East and West of Hudson counties outpaced the State (6 percent), but not the Nation (52 percent) during this period. State population decreased by 4 percent from 1970 to 1980, primarily due to decreases in New York City's population; however, population in East and West of Hudson counties increased during this period (by 1 and 12 percent, respectively) (U.S. Census Bureau 2009).

Between 1990 and 2000, the population in East of Hudson Watershed towns outpaced the counties in which they are located. East of Hudson Watershed towns grew by 10 percent, while East of Hudson counties grew by 7 percent. During this same period, West of Hudson Watershed towns and their respective counties both grew by 4 percent (U.S. Census Bureau 2000). These data indicate population growth in the East of Hudson counties was concentrated in towns, while population growth in West of Hudson counties was spread more evenly across the counties.

5.6.2 Employment/Income

Employment distributions amongst industry sectors differ between East and West of Hudson Watersheds. While the highest sectors are similar for both EOH and WOH (Government,

Health Care and Social Assistance and Retail trade), differences are greater between the two when it relates to the specialized industries related to forest management. The two industries demonstrating the highest degree of employment specialization in East of Hudson counties are the Construction and Utilities sectors, while the West of Hudson counties are most specialized with respect to employment in the Forestry and Logging, and the Agriculture sectors (IMPLAN 2009).

The two industries demonstrating the highest degree of income specialization in East of Hudson counties are the Utilities and Management of Companies sectors. The West of Hudson counties are most specialized with respect to income in the Forestry and Logging and the Wood Products Manufacturing sectors (IMPLAN 2009).

5.6.3 Timber Industry in the State and Watershed Counties

The timber industry (which includes industries involved in the growing and harvesting of timber, sawmills and paper mills, and wood products manufacturing) is an integral part of the regional economy (NENY Forest Initiative Concept Paper 2010). Of the 225 primary wood products processing facilities in New York active in 2009, four were located within East of Hudson counties and 35 were located within West of Hudson counties. Delaware County contained most of these facilities (nine facilities) and the facility with the largest capacity within East and West of Hudson counties. More than 50 percent of facilities in East and West of Hudson counties had processing capacities of less than 1 million board feet (New York State 2009).

Between 1998 and 2008, timber industry employment in East and West of Hudson counties has decreased by 28 and 8 percent, respectively; however, non timber employment has increased in both East and West of Hudson counties (by 10 and 6 percent, respectively). As a share of total employment, timber industry employment has also decreased in both East and West of Hudson counties (from 0.13 to 0.09 percent and from 1.20 to 1.05 percent, respectively) (U.S. Department of Commerce 2010). Average annual timber industry labor income in the East of Hudson counties was $44,010 in 2009, compared to $33,389 in West of Hudson counties, lower than that for the State and the Nation ($47,192 and $46,261, respectively) (U.S. Department of Labor 2010).

On an average annual basis, DEP has harvested 97 thousand board feet (MBF) of hardwood and 93 MBF of softwood between 1976 and 2010. While small relative to harvests statewide, timber removed from City water supply lands may provide an important resource when other sources are scarce. As mentioned previously, most wood products processing facilities in watershed counties have capacities less than 1 million board feet (MMBF). Since most log receipts of small-capacity facilities likely come from New York production (DEC 2010a), it is also likely that current and future DEP harvests will be an important component of supply for many of these smaller-capacity facilities. This would further DEP's interest to seek to improve the economic viability of forest land ownerships and the forest products industry in ways compatible with water-quality protection and sustainable forest management

Ninety-seven percent of historic DEP harvest has occurred in West of Hudson counties; consequently, comparing that harvest with East of Hudson counties would provide limited insight into area economic connections with current DEP harvest. In addition, East and West of Hudson county timber markets are likely integrated, thus, the current economic contributions are examined for all watershed counties combined. On an average annual basis,

timber removed from City water supply lands in these 10 counties provides 2.6 jobs and $117,000 in labor income (IMPLAN 2009).

5.7 Cultural Resources

Cultural resources include a variety of human-created resources that provide a link to local and state history, and are managed according to State law. Many of these resources include historic properties (buildings, structures, objects and archeological sites), as well as stone walls, aqueducts and other artifacts.

Few buildings and structures exist within the City water supply lands where forest management activities would have the potential to impact, however, numerous stone walls and other remnant artifacts of the past agricultural heritage remain.

The most comprehensive inventory of these resources is available through the New York State Historic Preservation Office. This inventory is reviewed early during project design to identify known historic sites, and archeological sensitivity areas to ensure protection measures are designed to protect these resources.

Specific Operational Principles (section 7.6.1) are required in the Plan to ensure that these resources are identified and protected.

5.8 Critical Environmental Areas and Agricultural Districts

Critical environmental areas (CEAs) are designated by State or local agencies to identify areas that have exceptional or unique character with respect to one or more of the following:

- a benefit or threat to human health;
- a natural setting (e.g., fish and wildlife habitat, forest and vegetation, open space and areas of important aesthetic or scenic quality);
- agricultural, social, cultural, historic, archaeological, recreational, or educational values; or
- an inherent ecological, geological or hydrological sensitivity to change that may be adversely affected by any change.

Activities that may impact these areas must be considered during evaluation of projects to minimize potential impacts (DEC 2011b).

Agricultural districts are created to protect and promote the availability of land for farming purposes, and can be created by local municipalities to counteract the impact which nonfarm development can have upon the continuation of farm businesses. Agricultural districts provide the framework to limit unreasonable local regulation on farm practices, to modify public agencies' ability to acquire farmland through eminent domain, and to modify the right to advance public funds to construct facilities that encourage development. The law also requires state agencies to modify their administrative regulations and procedures to encourage the continuation of farm businesses (New York State Department of Taxation and Finance Website).

Table 12 displays the acres of both CEAs and agricultural districts that occur on water supply lands.

Table 12. Critical environmental areas and agricultural district lands

Basin	Critical Environmental Areas (acres)	Agricultural District (acres)
WOH Basins		
Cannonsville	0	3,318
Neversink	0	96
Pepacton	728	4,612
Rondout	0	841
Schoharie	0	1,790
EOH West Branch/Boyd Corners Basin		
Boyd Corners	0	5
West Branch	0	1
EOH Croton System Basins		
Amawalk	849	13
Cross River	82	1
Croton Falls	0	0
Diverting	0	0
East Branch	187	0
Middle Branch	0	0
Muscoot	443	21
New Croton	102	20
Titicus	0	5
EOH Kensico Basin		
Kensico	1,953	0

Source: DEC Division of Environmental Permits; Cornell IRIS (NY State Department of Agriculture and Markets)

6. EXISTING AND DESIRED FOREST CONDITIONS – FOREST RESOURCES

The forest resources section provides numerous tables and charts displaying the existing conditions from the inventory data collected in 2009 and 2010. The inventory was conducted at a landscape scale, collecting data (forest and non-forest) on approximately 134,977 acres, 97.6 percent of the City water supply lands and reservoirs at the time of inventory. The inventory data was then input into the NED-2 analysis software for summary and analysis purposes. The remaining 3,313 acres, 2.4 percent, were not inventoried, and are not included in the analysis. Lands were classified as either forested or non-forested using remote sensing data, previous inventory information or aerial photo interpretation. The inventory was designed to collect information related to these classifications. During the inventory process, some non-forested classified stands (2,934 acres) were determined to meet the forested classification, and were classified under Land Cover Type as forested. However, due to the inventory design, specific forest vegetation data was not collected for these stands. Therefore, in Table 13, the Forest category includes these stands; however, the remaining tables and

charts in this section only include the actual forested stands where forest vegetation data was collected (89,078 acres).

Desired forest conditions are also discussed in these sections as well, providing the basis for development of the Management Strategy and treatments to move toward attainment of the Guiding Principles, Goals and Objectives.

6.1 Land Cover Types

Figure 16 and Table 13 show the current land cover types for all inventoried City water supply lands. (Map Packet Section 6.1 Land Cover Types.)

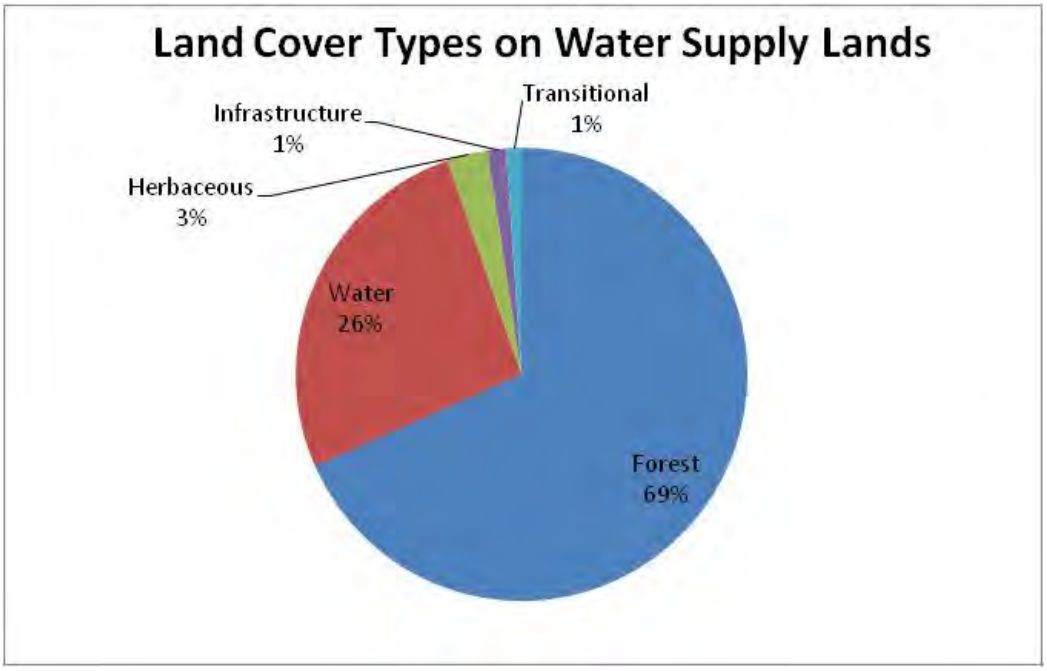
Forest includes lands that had existing forest cover, those classified non-forested lands that were found to meet the definition of forest having at least 10 percent of the area in forested crown cover, and forested wetlands.

Herbaceous areas are open, usually abandoned agricultural areas that have not been regenerated to trees.

Water includes reservoirs and other lakes, ponds, non-forested wetlands, rivers and canals.

Infrastructure includes areas with buildings, roads or highways, utilities, athletic fields, quarries, utility rights of way, hayfields and pasture lands leased for farming, and bare rock.

Transitional areas are in the process of developing forest cover, but are still dominated by herbaceous vegetation.



Source: Forest Inventory 2009-2010

Figure 16. Land cover types for City water supply lands

Table 13. Land cover types for all inventoried City water supply lands (acres and percent by basin)

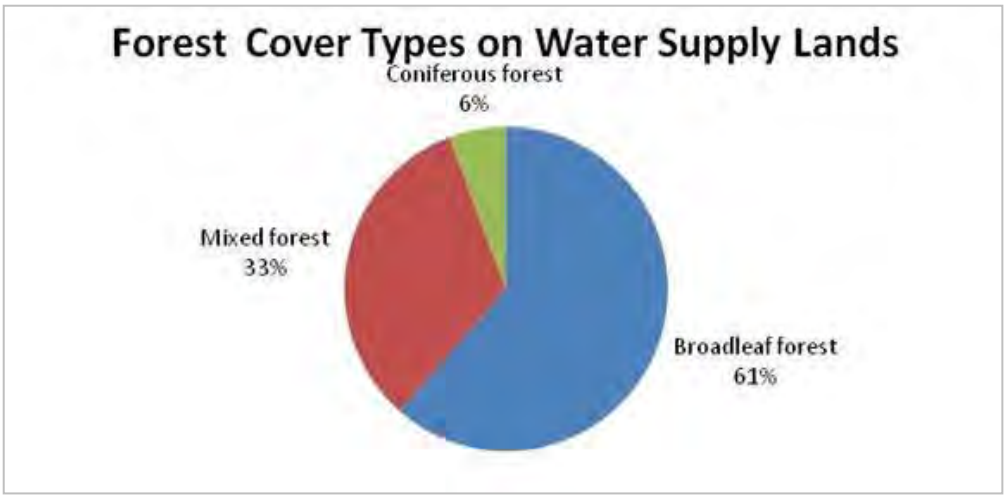
	Forest		Herbaceous		Infrastructure		Transitional		Water		Grand Total (acres)
	acres	%	acres	%	acres	%	acres	%	acres	%	
East of Hudson											
Boyd Corners/ West Branch	7,994	84	14	0	34	0	56	1	1,423	14	9,521
Croton System	8,818	51	115	1	126	1	48	0	8,183	47	17,290
Kensico	2,045	46	7	0	166	4	0	0	2,214	50	4,432
EOH Totals	**18,857**	**60**	**136**	**0**	**326**	**1**	**104**	**0**	**11,820**	**38**	**31,243**
West of Hudson											
Ashokan	13,197	59	6	0	461	2	136	1	8,486	38	22,285
Cannonsville	20,697	73	1,364	5	559	2	780	3	4,961	17	28,362
Neversink	5,504	76	85	1	60	1	10	0	1,558	21	7,217
Pepacton	15,878	68	1,273	5	69	0	354	2	5,720	24	23,294
Rondout	6,988	75	177	2	62	1	32	0	2,055	22	9,313
Schoharie	10,891	82	853	6	257	2	43	0	1,231	9	13,275
WOH Totals	**73,155**	**71**	**3,758**	**4**	**1,468**	**1**	**1,355**	**1**	24,011	**23**	**103,747**
Grand Total	92,012	68	3,894	3	1,794	1	1,459	1	35,831	26	134,990

Source: Forest Inventory 2009-2010

The primary land cover types identified for inclusion in the Management Strategy to meet the desired conditions are forest, herbaceous, and transitional. The forest land cover type will be further discussed by individual vegetation characteristics later in this section. Herbaceous lands that are not necessary to meet other management objectives are identified to be converted to forest cover, and would be identified through the project planning process, as the inventory did not include sufficient data parameters to quantify this need. Transitional lands are those that are converting to Forest, and forest management activities that can promote this transition are included in the Management Strategy.

6.2 Forest Cover Types

Forest cover types can be separated into three major types: broadleaf forest, which is predominantly deciduous or hardwood species; conifer forest, predominantly conifers or softwoods; and mixed forest containing at least 25 percent stocking of one as well as mixed (Figure 17 and Table 14). This may occur when a stand contains areas that are primarily one or the other, but these are not large enough to define as a stand. One additional type was identified separately due to its importance for watershed function—forested wetlands, the majority of which are hardwoods, or a hardwood/hemlock mix. This category is under-represented by the dataset due to the data collection methodology, and therefore is included within the Mixed forest type for analysis purposes.



Source: Forest Inventory 2009-2010

Figure 17. Forest composition of inventoried City water supply lands

East of the Hudson tree vegetation has much less conifer cover either as whole or mixed stands.

Table 14. Forest land cover types for all inventoried City water supply (acres and percent by basin)

	Broadleaf forest		Mixed forest		Coniferous forest		Grand Total (acres)
	acres	%	acres	%	acres	%	
East of Hudson							
Boyd Corners/West Branch	7,459	95	294	4	107	1	7,860
Croton System	7,277	84	938	11	412	5	8,628
Kensico	1,730	85	140	7	171	8	2,040
EOH Totals	**16,466**	**89**	**1,372**	**7**	**690**	**4**	**18,528**
West of Hudson							
Ashokan	8,051	61	4,283	33	827	6	13,161
Cannonsville	12,505	64	6,619	34	399	2	19,523
Neversink	2,157	39	2,981	55	327	6	5,465
Pepacton	7,864	52	6,071	40	1,234	8	15,168
Rondout	3,546	51	2,943	43	435	6	6,924
Schoharie	3,605	35	5,568	54	1,134	11	10,307
WOH Totals	**37,728**	**53**	**28,465**	**40**	**4,356**	**6**	**70,550**
Grand Total	54,194	61	29,837	33	5,046	6	89,078

Source: Forest Inventory 2009-2010

Coniferous forest types are generally less prevalent than the broadleaf and mixed forest types, and are likely a result of past planting activities. Desired conditions are to have forests that represent the natural forest that would occur, therefore, the desire is to convert these plantations in the future to either a mixed forest or broadleaf forest that would have naturally

occurred on these sites. Naturally occurring coniferous forests would be managed to maintain the health and vigor of those forests.

6.3 Tree Species and Forest Type Groups

Forest cover types can be further refined and expressed in terms of species and forest type groups. Both are developed from basal area, which is comparable to site occupancy (Marquis et al. 1997) (Map Packet Section 6.3 Forest Types).

Data displayed in Table 15 and Table 16, and Table 33 through Table 56 (Appendix 2) show by overall water supply lands, East of Hudson and West of Hudson, as well as individual basin, the amount of species by percent of total basal area within the area and the number of acres and percent of acres of forest types within each area. To make these tables more useful, 80 species that are not well represented (occur only occasionally) were combined into the "other" category. In addition, minor amounts of similar types were combined (for example, small quantities of other oak or hardwood types were added to oak northern hardwoods), and small acreages of various softwood and hardwood mixtures were combined into "other mixed woods." These combinations are explained in the Forest Resource Report (Wingate and Jaeschke 2011).

Table 15. Species by percent basal area for all inventoried City water supply lands

Species	Percent
Red maple	16
Sugar maple	13
Northern red oak	13
Eastern hemlock	12
Eastern white pine	10
Ash	7
Sweet birch	4
American beech	4
Black cherry	2
Chestnut oak	2
White oak	2
Other (80 species)	14

Source: Forest Inventory 2009-2010

Table 16. Forest types for all inventoried City water supply lands

Forest type	Acres	Percent
Oak northern hardwoods	24,084	27
Hemlock hardwoods	19,706	22
Northern hardwoods	16,965	19
Other mixed woods	6,559	7
Pine hardwoods	6,316	7
Allegheny hardwoods	5,874	7
Other hardwoods	4,039	5
Oak	2,042	2
Oak northern pine	1,913	2
Other softwoods	1,581	2
Total	89,078	

Source: Forest Inventory 2009-2010

A diversity of species, both at the stand and landscape level is desired, but cannot be easily quantified. Where a single species is present, or dominates a stand, the desire is to promote additional species diversity to increase the resiliency of the stand to disturbances. Having multiple species within a stand reduces the potential to lose the entire stand should a species-specific disturbance occur (such as a stand comprised of mostly ash becomes infested with emerald ash borer).

6.3.1 East of Hudson

In areas east of the Hudson River, oaks are one-third of the total stocking. Oaks mixed with red maple, sugar maple, and sweet birch make up the most common type—oak northern hardwoods. In this mix, generally the faster growing oaks often dominate the upper canopy,

with the more shade-tolerant maples and birches occurring in more secondary positions in the overstory. Less frequently and in various mixtures, ash, white pine, tulip poplar, and black cherry may be in the canopy structure.

Table 17. East of the Hudson species by percent basal area

Species	Percent
Northern red oak	16
Sugar maple	11
Red maple	11
Eastern white pine	8
Sweet birch	8
Ash	8
Tuliptree	6
White oak	4
Black oak	4
Chestnut oak	3
Norway spruce	3
Hickory	2
Other	17

Source: Forest Inventory 2009-2010

Table 18. East of Hudson forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	10,803	58
Northern hardwoods	1,774	10
Other hardwoods	1,753	9
Allegheny hardwoods	1,403	8
Oak	1,001	5
Pine hardwoods	759	4
Hemlock hardwoods	472	3
Other softwoods	226	1
Other mixed woods	183	1
Oak northern pine	153	1
Total	18,528	

Source: Forest Inventory 2009-2010

6.3.2 West of Hudson

Today, forested areas west of the Hudson tend to be northern hardwoods or northern hardwoods mixed with hemlock, oaks, or pine. Red or sugar maple comprise nearly one-third of the stocking generally mixed with oaks, hemlock, and pine.

Species composition and forest types in the Catskill region have changed dramatically since the first boundary surveys were taken in the 16th century. Early survey records (McIntosh 1962) indicated that the majority of the Catskill region was occupied by 49 percent beech, 20 percent hemlock, 13 percent sugar maple, and 7 percent birch.

Lands acquired in the Ashokan Basin exhibit an agricultural and forest harvesting history with oak northern hardwoods, pine hardwoods, oak pine, oak, and others representing 62 percent of the forest cover. Higher elevations include hemlock hardwoods, northern hardwoods, and others that are more representative of the original forest.

Cannonsville, as with the remainder of the western basin, has a less prominent agricultural heritage expressing more forest mixtures associated with maples and hemlocks.

Lands acquired in Schoharie Basin have a fairly even mix of agricultural heritage and northern hardwood, hemlock mix forest.

Table 19. West of the Hudson species by percent basal area

Species	Percent
Red maple	18
Eastern hemlock	16
Sugar maple	14
Northern red oak	12
Eastern white pine	11
Ash	6
American beech	4
Sweet birch	3
Black cherry	3
Yellow birch	2
Chestnut oak	2
Other	9

Source: Forest Inventory 2009-2010

Table 20. West of the Hudson forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	19,233	27
Northern hardwoods	15,191	22
Oak northern hardwoods	13,281	19
Other mixed woods	6,375	9
Pine hardwoods	5,557	8
Allegheny hardwoods	4,471	6
Other hardwoods	2,286	3
Oak northern pine	1,760	2
Other softwoods	1,354	2
Oak	1,041	1
Total	70,550	

Source: Forest Inventory 2009-2010

6.4 Stand Density

Relative density is an important measurable characteristic of forests, which is the amount of tree occupation relative to maximum site occupation. Theoretically, 100 percent relative density is the maximum tree population that could occupy a given forest area. Stocking is another term often used to describe stand density. Stocking is a subjective term used to describe an observed level of stand density with respect to a silvicultural goal (Gingrich 1967), and is typically expressed as relative terms such as “sparsely, minimally, fully.” These terms, for the Plan purposes, are defined below.

> Modeling systems like NED-2 attempt to account for variables like species and size composition and age in calculating relative density (Twery et. al. 2011). However, not all variability can be accurately addressed; therefore, results of analysis are approximate. Stands of trees with little variation in species are likely to be fully stocked when the measure of relative density is something less than 100 percent. Stands with diverse species are likely to have multiple canopies and uneven crown cover leading to measures of relative density above 100 percent.

A substantial amount of the City Watershed is less than fully stocked. The most common reason for lower stocking is past timber harvesting (Kelty and D’Amato 2006), most of which occurred before acquisition by the City. Other reasons for less than full stocking include: severe weather-related damage, a forest decline event (repeated defoliation, for example), thin rocky soils, dense understories of mountain laurel, and wet saturated soils. There are also younger stands where past agriculture use compacted and depleted the soil, and deer browse pressures combine to limit current stocking.

6.4.1 Stand Density Groups

Stands were grouped using relative density to identify possible management actions. Table 21 and Figure 18 display the amount of inventoried area associated with each group.

Sparsely stocked stands (0 to 40 percent relative density) are unlikely to develop a closed canopy as long as deer prevent regeneration from filling in the canopy. This level of stocking will not fully protect water quality as there is not full forest canopy cover. Where deer populations are not influencing forest regeneration, stands left untreated will usually develop regeneration and evolve into a fully stocked two-age stand that would protect water quality.

Minimum stocked stands (41 to 60 percent relative density) have adequate stocking for future management, with several management options to achieve full forest canopy cover. There may be enough uniform structure and tree quality to let the stand grow until it reaches a more desirable level of stocking. Otherwise, the stand could be managed as a shelterwood system to promote forest regeneration and full stocking.

Moderately stocked stands (61 to 80 percent relative density) will probably grow to full or nearly full stocking within 20 years. This stand structure may encourage the development of tree regeneration. The resulting composition can be managed as a shelterwood system in the future. If other factors, such as poor quality or thin, rocky soils; dense understories of mountain laurel; and wet saturated soils, are limiting stocking, then this may be the maximum level for conditions.

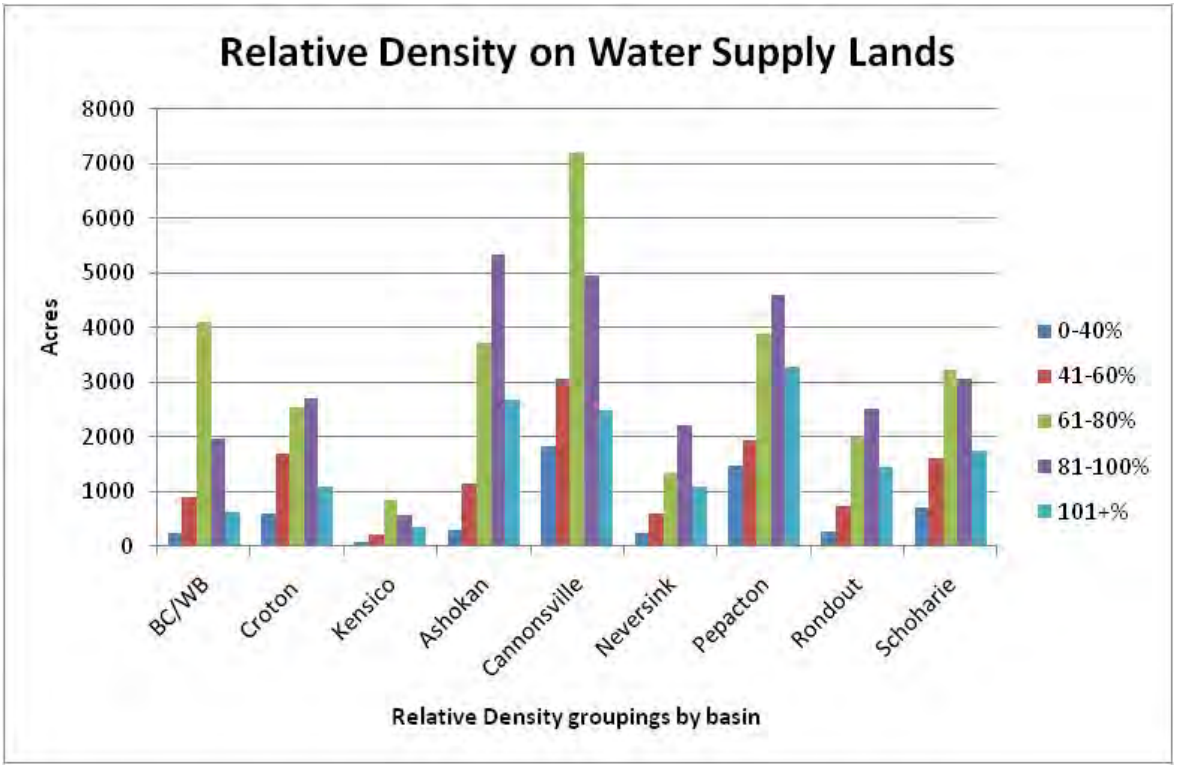
Fully stocked stands (81 to 100 percent relative density) and overstocked stands (101+ relative density) are close to or already at crowded conditions, with trees actively competing with each other for growing space. Without management, overall vigor will decline and mortality would be anticipated, reducing structural and species diversity. Regeneration strategies are desirable if they are mature or intermediate, and stocking reduction to extend the vigor if regeneration is not feasible. Stocking reduction will encourage tree growth, vigor, health, and the maintenance of water quality protection.

The desired conditions is to have stands in the moderately to fully stocked condition, as these stocking levels provide the highest levels of forest cover, and provide a greater range of management activity options to maintain these stands.

Table 21. Overstory relative density by acres and percentage of all City water supply lands inventoried

	0-40		41-60		61-80		81-100		101+		Grand Total
	acres	%	acres	%	acres	%	acres	%	acres	%	
East of Hudson											
Boyd Corners/ West Branch (BC/WB)	237	3	910	12	4,114	52	1,975	25	625	8	7,860
Croton	602	7	1,701	20	2,528	29	2,705	31	1,092	13	8,628
Kensico	80	4	208	10	835	41	573	28	344	17	2,040
EOH Totals	**919**	**5**	**2,818**	**15**	**7,477**	**40**	**5,253**	**28**	**2,061**	**11**	**18,528**
West of Hudson											
Ashokan	288	2	1,144	9	3,719	28	5,324	40	2,687	20	13,161
Cannonsville	1,825	9	3,070	16	7,189	37	4,940	25	2,499	13	19,523
Neversink	247	5	582	11	1,343	25	2,216	41	1,077	20	5,465
Pepacton	1,476	10	1,947	13	3,888	26	4,589	30	3,268	22	15,168
Rondout	265	4	720	10	1,979	29	2,504	36	1,456	21	6,924
Schoharie	697	7	1,602	16	3,216	31	3,059	30	1,734	17	10,307
WOH Totals	**4,798**	**7**	**9,065**	**13**	**21,334**	**30**	**22,633**	**32**	**12,720**	**18**	**70,550**
Grand Total	5,717	6	11,883	13	28,811	32	27,886	31	14,781	17	89,078

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

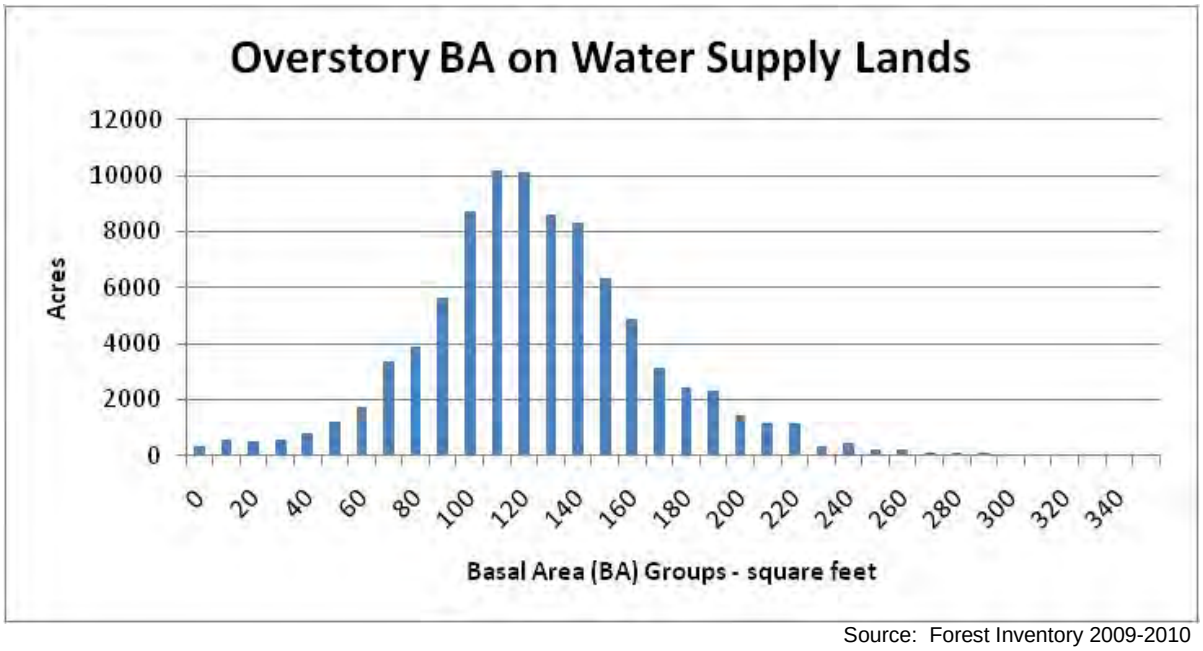
Figure 18. Basin stocking levels

Combining the sparsely stocked group with other low or unstocked land cover types (herbaceous and transitional), approximately 11,069 acres (11 percent) of City water supply lands have an opportunity to improve water quality protection through forest management. Some of these acres may be naturally limiting, dedicated to agriculture or other management objectives, which eliminate consideration for reforestation.

Of even higher importance to maintaining a healthy watershed forest condition is the amount of acreage in the fully or overstocked categories. Over 48 percent of the forested acreage falls into this group, indicating a compelling need to begin reducing stocking levels throughout the City water supply lands at a fairly large scale.

6.5 Basal Area

Another way to describe stocking is by basal area (Figure 19). Basal area is the cross-sectional area of tree trunks in an area in units of square feet per acre. Basal area is useful because it provides a measure of the density of tree trunks in an area which corresponds to occupation of growing space. In other words, it offers a tool to evaluate how much of the space on a site is already occupied by vegetation and how much is available for additional growth.



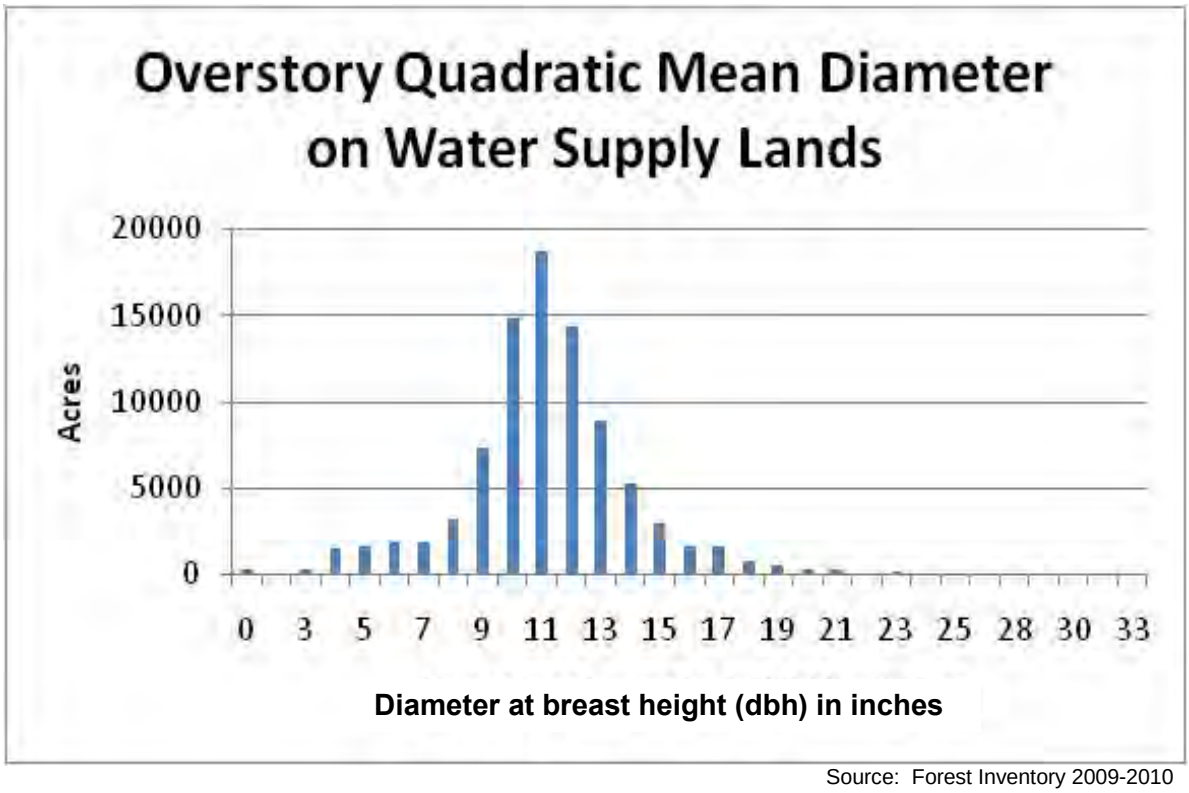
Source: Forest Inventory 2009-2010

Figure 19. Overstory basal area (BA) for City water supply

Desired conditions for basal area are similar to relative density, but cannot be easily quantified, primarily because a range of basal area that promotes forest vigor and resiliency is dependent on other factors such as species, shade-tolerance, and size class.

6.6 Quadratic Mean Diameter

Quadratic mean diameter (QMD) of a stand is the diameter of a tree of average basal area. QMD is often used in forestry applications in place of the arithmetic mean because it has a stronger correlation to stand volume. Also, QMD gives more weight to larger trees in the calculation, which can be helpful to the forester for determining merchantable potential of the stand. On City water supply lands, the distribution of QMD, displayed in Figure 20, shows that most stands have a QMD between 9 and 13 inches. Because that means there are as many trees larger than the mean as there are smaller, QMDs in this range indicate that much of the forest has potential for commercial management. Desired conditions related to diameter are associated with the diversity of age and size classes, which represent a range of classes across the continuum, as opposed to the current condition where much of the forest condition occurs within a narrow portion of the spectrum.



Source: Forest Inventory 2009-2010

Figure 20. Overstory quadratic mean diameter for City water supply lands

6.7 Effective Age

Determining the true biological age of a tree or stand of trees is difficult, costly, and prone to error. It is more practical to calculate the "effective age" using diameter as a variable. This fits well with the fact that trees mature according to their size rather than their biological age (Goodell and Faber-Langendoen 2007). Effective age is not an absolute number and it can be influenced by management actions. These same actions extend the growth and longevity of a stand, which makes using effective age valid when making decisions regarding regeneration or when analyzing age diversity. Thinning can influence effective age calculations by changing average stand diameter.

Groups presented below are associated with age-related decision points for potential management options. Table 22 and Figure 21 illustrate the existing amount of each age group in all inventoried stands.

The 0 to 40 age group include young stands where timber stand improvement projects to increase species diversity may be desirable. Many of the stands originated when deer populations were increasing, therefore species highly desired by deer may be in limited quantities or occupy a lower position in the canopy. If these species are released from direct competition, they will be more likely to remain in the overall stand composition. If this age class group is in the low-stocked group as well, partial reforestation measures like inter-planting or tree shelters or portable fences to encourage natural regeneration may be desirable.

The 41 to 60 age group may be considered for pre-commercial thinning when they reach full stocking levels. Stocking in the stand is reduced by removing the lower quality and the smaller of the most common species to encourage rapid growth of the highest quality or most desirable tree species.

The 61 to 80 age group are entering a period when a commercial thinning may become practical. This may be difficult when there is a limited low-grade or pulpwood market.

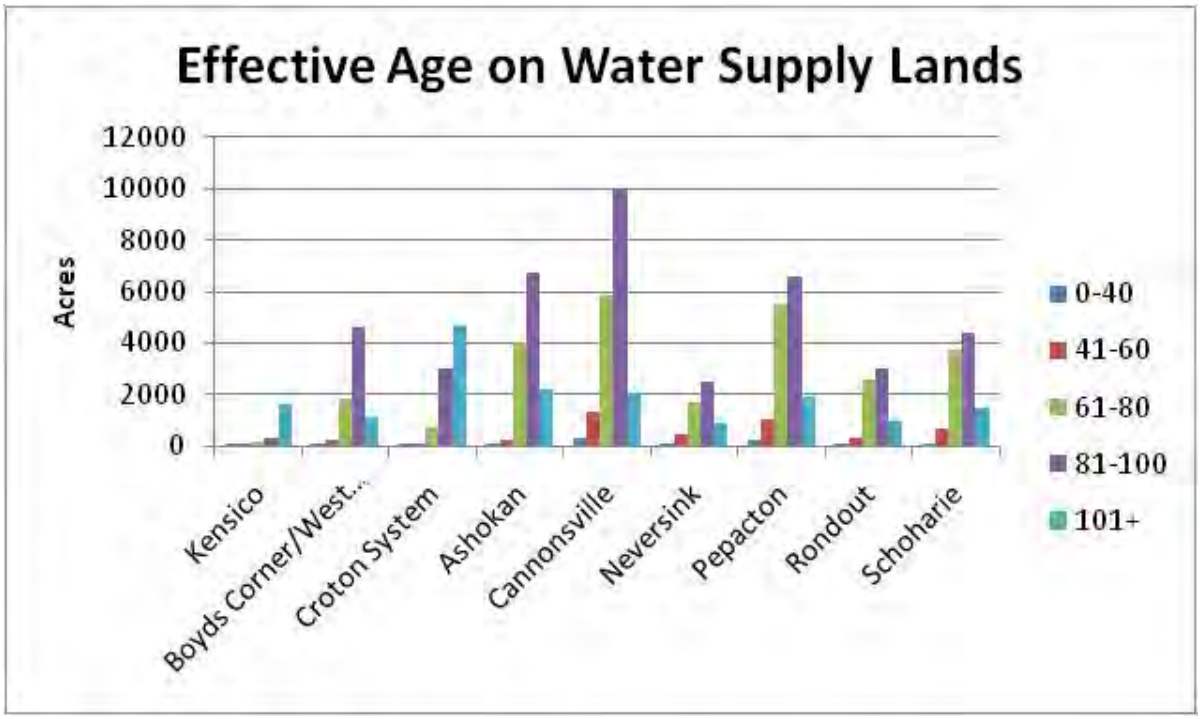
The 81 to 100 and 101+ age group may be mature or maturing and, depending on species composition, regeneration may be desirable. Other options include maintenance thinning to allow growth to continue on a positive trajectory.

The desired condition is to have a more balanced representation of age groups across the Watershed, providing age classes more evenly distributed to provide diversity.

Table 22. Effective age of all inventoried City water supply lands (grouped by age group and shown in acres and percent)

	0-40		41-60		61-80		81-100		101+		Grand Total
	acres	%	acres	%	acres	%	acres	%	acres	%	
East of Hudson											
Boyd Corners/ West Branch	1	0	247	3	1,827	23	4,646	59	1,139	14	7,860
Croton System	49	1	110	1	719	8	3,042	35	4,708	55	8,628
Kensico	13	1	23	1	134	7	281	14	1,590	78	2,040
EOH Totals	**63**	**0**	**380**	**2**	**2,680**	**14**	**7,968**	**43**	**7,438**	**40**	**18,528**
West of Hudson											
Ashokan	1	0	234	2	4,015	31	6,711	51	2,200	17	13,161
Cannonsville	290	1	1,317	7	5,880	30	9,987	51	2,049	10	19,523
Neversink	20	0	445	8	1,657	30	2,469	45	875	16	5,465
Pepacton	215	1	1,040	7	5,472	36	6,557	43	1,886	12	15,168
Rondout	11	0	297	4	2,587	37	3,030	44	999	14	6,924
Schoharie	72	1	653	6	3,731	36	4,389	43	1,463	14	10,307
WOH Totals	**608**	**1**	**3,987**	**6**	**23,341**	**33**	**33,143**	**47**	**9,471**	**13**	**70,550**
Grand Total	671	1	4,366	5	26,021	29	41,111	46	16,909	19	89,078

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

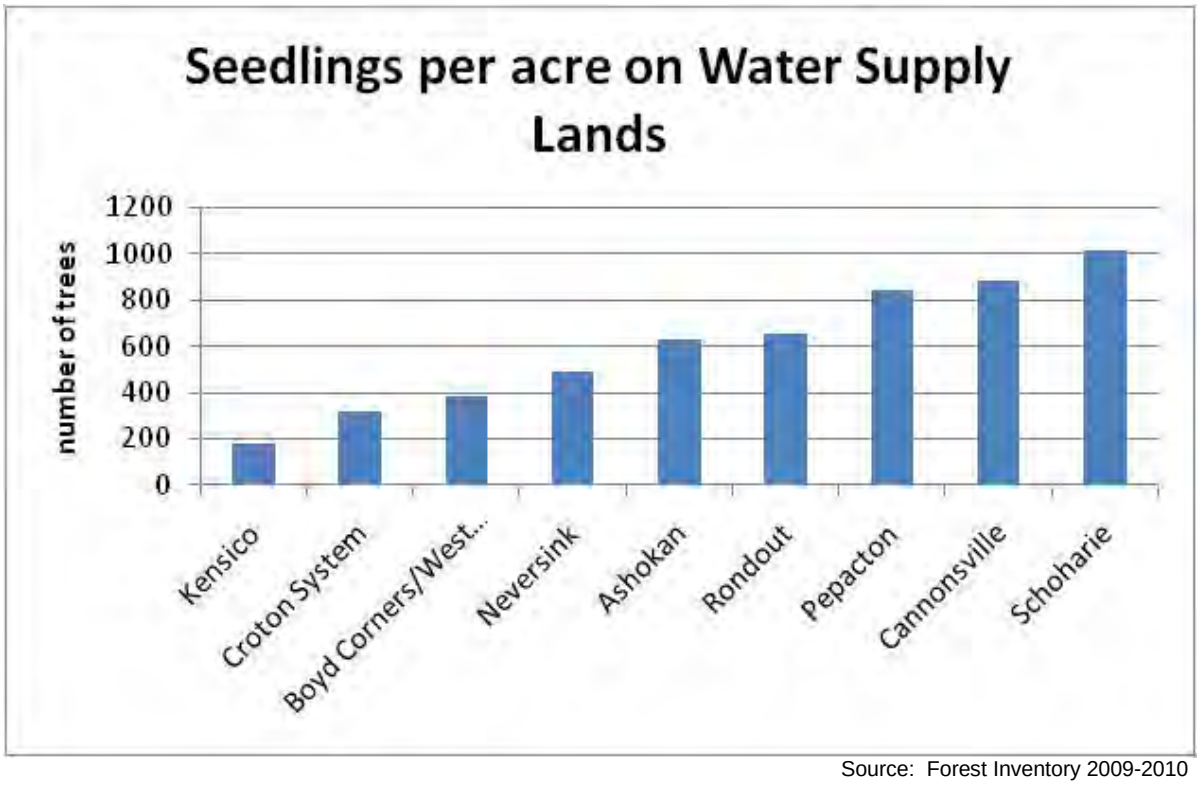
Figure 21. Effective age levels (percentage of basin) of stands on all inventoried City water supply lands

6.8 Forest Regeneration

Trees are genetically conditioned to grow until they can no longer support themselves and then new seedlings replace them (Nyland 2003). Different species have different strategies for survival and regeneration. Most species are better adapted to regenerate in one kind of disturbance over another (Hicks 1998). Silvicultural treatments are designed to mimic natural disturbance events, and can favor certain species or species groups. Under natural conditions this may occur as single trees, groups of trees, or over larger landscapes. However, under management, individual trees can be harvested and utilized before they decline and die.

Tree seedlings must be produced to naturally regenerate mature, over mature, declining, or disturbed stands (Brose et al. 2008). Risk of regeneration failure is reduced if seedlings can be produced before stand removal. When saplings and seedlings are part of the stand structure, they can act as an insurance policy against unpredictable natural disturbances like wind and ice storms (Leak and Smith 1997). While some tree species respond to stress events by producing a seed crop, it may drain the trees' resources to the point where pathogens become established and kill the tree. Healthy and vigorously growing trees are more likely to produce periodic quantities of viable seed over long periods. These seeds are more likely to germinate and produce seedlings that may be needed in the future.

Currently, tree seedlings can be found on City water supply lands on two-thirds of WOH and a third of EOH plots inventoried. Figure 22 shows the number of seedlings found per acre. This demonstrates the potential for the forest to produce tree seedlings. However, deer are still substantially controlling the growth and development of these seedlings. In addition, overall seedling numbers are below those typically desired to ensure successful regeneration.



Source: Forest Inventory 2009-2010

Figure 22. Seedlings per acre on all inventoried City water supply lands

In a balanced ecosystem, more seedlings are produced than are consumed by deer (Cote et al. 2004). When deer populations are not controlled and exceed the carrying capacity of the vegetation, then most, if not all, tree seedlings are controlled or consumed as fast as they are produced (Rawinski 2008). Under these conditions, natural regeneration and sometimes artificial regeneration cannot be successfully achieved. Protecting seedlings through the use of protective tubes or exclusion fences is expensive and also affects the future composition of the forest produced.

Continued, heavy deer browsing can also produce dense populations of deer-resistant vegetation, such as New York or hay-scented fern (Stout 2010). These ferns are native plants that, once established, interfere with growth and survival of hardwood seedlings. This vegetation will control the site even if deer are brought under control. It is often necessary to remove this vegetation or scarify the soil before being able to obtain natural regeneration. This adds considerable expense to achieve forest regeneration.

Desired conditions are to move toward seedling that are sufficient in number, quality (good root systems, woody stem, height development) and species diversity that will survive existing and future deer pressure to grow into a healthy diverse forest. Sufficient seedling numbers cannot be simply quantified but must be determined by professional foresters taking into consideration deer populations, forage availability, species diversity and seedling quality.

6.9 Volume

Merchantable value of the trees in the watershed can be assessed by quantifying the volume of potential products in the low-grade category, measured in cords (one thousand cords, MCords), and the higher value category (sawtimber) in board feet (million board feet,

MMBF) (Table 23). Low-grade or cord wood is generally used for pulp and paper, wood pellets fuel, chips for biomass fuel, flakes for oriented strand board, and firewood. Markets other than firewood are very limited in the watershed area. Sawtimber values can range from low with low-quality logs classified as "pallets and ties" to high values associated with veneer logs. In many cases, the most valuable trees were harvested from City water supply lands when they were still in private ownership.

Table 23. Volume of all inventoried City water supply lands stands

	MCords	MMBF
East of Hudson		
Boyd Corners/West Branch	135	54
Croton System	154	79
Kensico	39	21
East of Hudson Totals	**328**	**154**
West of Hudson		
Ashokan	262	110
Cannonsville	344	141
Neversink	116	46
Pepacton	286	111
Rondout	142	56
Schoharie	197	76
West of Hudson Totals	**1,347**	**540**
Grand Total	**1,675**	**695**

Source: Forest Inventory 2009-2010

6.10 Elements of Forest Change

Elements of forest change affect regeneration, or renewal of the forest or the conversion of the forest from one suite of species to another, as a result of adaptation toward new conditions, or impact the vigor, growth, resiliency, mortality and even presence of certain forest species within the forest community.

6.10.1 Forest Succession

Forests are dynamic, and human and natural forces constantly change the ecological balance (Roe and Ruesink 2001). The physiology of any tree requires periodic growth. Some trees grow faster than others and become more dominant on the site, making it difficult for neighboring trees to get the required water, nutrients, and sunlight to conduct photosynthesis. Without forest management actions, these trees will become stressed, decline, and eventually die. Dominant trees will eventually become too large to support themselves during periods of adversity like storm damage, drought, or defoliation. Because they are large, these trees usually leave a gap in the canopy when they die. This new source of light results in forest growth from seedlings that are in place and provides growing space to adjacent trees. In this type of forest succession, trees with less tolerance for shade tend to be replaced by trees that are genetically conditioned to survive in a shaded environment when the gaps are small (where full sunlight does not reach the ground for most of the day). Conversely, when weather events like a windstorm level a forested area or larger openings are created where sunlight reaches the ground for most of the day, light-seeded or wildlife-distributed seed

causes the site to revert to fast-growing, shade-intolerant species (Franklin et al. 2007). Change through larger size disturbance gaps is rapid, and favors more shade intolerant species, while change through species succession is slow, favoring shade tolerant species. A mix of disturbances, both natural and through active forest management will provide the diversity of species and age classes to promote forest recovery and resiliency. Today these regeneration processes are interrupted by overabundant deer. Few seedlings are growing beyond browse height to replace trees lost in a disturbance or through succession. In addition, newly germinated seedlings are eventually consumed and rarely become part of the stand structure. The long-term effect is a gradual depletion of the tree population and subsequent increase in non-forested cover.

6.10.2 Deer Impacts

Much of the forest land in City water supply lands was abandoned farmland around and following the turn of the 20th century. At that time, white-tailed deer were aggressively hunted (Severinghaus and Brown 1956). The combination of lower populations and abundant forage resulted in a forest of diverse species that is maturing today. Since then, forage supply has steadily diminished along with hunting pressure. By the 1960s, deer impacts began to change the landscape. Abandoned farmland began to reforest with lower tree densities and less species diversity. Deer populations that were above carrying capacity continued to reduce available forage and tree regeneration. Today, deer consume most desirable forage, including tree regeneration; new trees are not replacing old and declining trees; some once-common species are now rare; and open lands generally do not revert back to forest cover or do so very slowly with well-distributed, low-browse-preference vegetation.

Lack of natural predators and reduced popularity of hunting are resulting in higher deer densities than forest vegetation can sustain. Deer populations that exceed the carrying capacity of the habitat remove most or all of the tree regeneration (Rawinski 2008). Other less palatable plants develop from the available light and soil resources. These plants develop into a dense composition of low shade and competitive root systems that interfere with new tree regeneration. Even if deer populations are controlled, this dense ground vegetation will remain and limit future regeneration (Pennsylvania Forest Stewardship Program 2007). Removing this interfering vegetation, as well as controlling deer population, is often required to develop desirable tree regeneration. Exotic, invasive vegetation often becomes interfering as well, and there are usually no natural controls for invasive plants.

Currently, the vast majority of City water supply lands are experiencing moderate to high deer impacts (Table 24). Refer to the Wildlife Report and Deer Impact Report (Reitz 2011a, b) for more detailed information regarding these impacts (see Figure 23). The primary impact related to forest succession is the regeneration potential for successful forest regeneration. As deer impacts increase, the regeneration risk increases, and decreasing successful regeneration of a diversity of species. This risk rating is displayed in Table 25.

Table 24. Deer impact rating for all inventoried City water supply lands

Basin	Low Deer Impact		Moderate Deer Impact		High Deer Impact	
	acres	%	acres	%	acres	%
			Delaware			
Cannonsville	355	2	6,302	32	12,878	66
Neversink	516	9	2,039	37	2,909	53
Pepacton	61	<1	2,882	19	12,380	81
Rondout	254	4	1,402	20	5,222	76
			Ashokan/Schoharie			
Ashokan	205	2	3,582	27	9,378	71
Schoharie	516	5	3,121	30	6,700	65
			Boyd Corners/West Branch			
Boyd Corners	32	1	108	2	4,219	97
West Branch	0	0	172	5	3,320	95
			Kensico			
Kensico	0	0	308	15	1,745	85
			Croton System			
Amawalk	27	4	75	12	519	84
Bog Brook	0	0	0	0	167	100
Cross River	0	0	2	<1	458	100
Croton Falls	4	<1	89	7	1,195	93
Diverting	<1	<1	44	17	207	82
East Branch	0	0	28	5	513	95
Lake Gilead	0	0	1	1	71	99
Lake Gleneida	0	0	1	1	33	99
Middle Branch	5	10	8	16	37	74
Muscoot	84	4	172	8	2,010	89
New Croton	14	1	234	9	2,471	91
Titicus	0	0	0	0	244	100

Source: Forest Inventory 2009-2010, Wildlife Deer Transects 2010

The deer impact ratings serve as a key long-term monitoring tool for DEP to develop a baseline of deer impacts across the watersheds. The deer browse impacts explained (DEP 2010c):

- High impact − Preferred herbaceous species and regeneration absent. Moderately preferred species are essentially absent and few plots contain regeneration. Some low preference regeneration may exist, but is predominantly severely browsed and generally less than 1 foot in height. If canopy conditions permit, fern, grass, and invasive plants dominate the understory. Lowest likelihood of success with regeneration failure likely.

- Moderate impact − Preferred herbaceous species absent. Highly preferred species are present but are predominantly moderately to severely browsed (greater than 50

percent of stems browsed) and not becoming established, resulting in a loss of diversity. Moderately to less preferred regeneration is predominantly un-browsed to lightly browsed. If canopy conditions permit, fern, grass, and invasive plants may be present, but they do not dominate the understory.

- Low to moderate impact – Preferred herbaceous species present. All regeneration is predominantly unbrowsed to lightly browsed ((less than 50 percent of stems browsed), exists in a variety of sizes and is being established on the site. Little or no fern, grass, or invasive plants are present. More species diversity than moderate impact.

- Low impact − Lush understory with vigorous regeneration of a wide variety of species including preferred herbaceous and woody species. No deer browsing evident. Highest likelihood of regeneration species diversity.

The deer browse data collected during the 2009–2010 inventory was modified slightly using professional judgment to fall into three impact categories (combined low to moderate and moderate) to closer reflect the actual conditions on the ground. Minor differences in total acres between Table 24 and Table 25 are due to inconsistencies between the GIS coverage and inventory data summaries (242 acres). In addition, values displayed for Kensico and Ashokan basins under-represent the amount of high deer browse and impact ratings due to variation in data collection methodology.

(a) (b)

Figure 23. Deer browse impact on City water supply land: (a) deer browse, and (b) no deer browse

6.10.3 Regeneration Risk

One of the primary objectives of obtaining deer impact data is to identify a strategy that will help promote adequate forest regeneration to become established on water supply lands. Based on the deer density and impact data, stands that presently contain a larger component of preferred species for regeneration and also receive moderate to high levels of hunting provide the best opportunity to achieve successful regeneration. Also, more isolated stands that currently have lower deer impacts may be at greater risk than stands in landscapes that contain a larger component of lands with reduced deer impact (i.e., moderate to low). Consequently, to identify risks associated with regeneration of forested lands; the stand-level

deer impact data, the understory plot data (used to identify stands with a larger preferred species component), hunter access, and spatial considerations such as impacts on adjacent lands were collectively used to develop a Deer Regeneration Risk Rating. The following is a summary of the process used to identify stands by risk category.

Low Deer Impact (High likelihood of success) – Stands in this category were initially identified by reviewing the seedling data to identify stands that had a large number of preferred seedlings (e.g., more than 150 seedlings per plot) that are not dominated by beech/striped maple or birch. These stands were then combined with stands that had received a low deer rating to collectively identify stands with the lowest potential deer impacts. This group of stands was then looked at spatially, and stands that were surrounded by lands with a high deer browse rating were moved into high deer impact category. Finally, because hunting will be necessary to keep the deer herd reduced during management, all lands in this category must be open to hunting. If managed, these stands will have a high likelihood of successful regeneration that will contain a diversity of species.

Moderate Deer Impact (Moderate likelihood of success) – Lands in this category include lands with a moderate deer rating that are not surrounded by lands with a high deer impact rating. These lands are also open to hunting and if managed, would likely be regenerated, however, a reduction in preferred species would be expected to occur, especially if surrounding lands are also open to hunting.

High Deer Impact (Low likelihood of success) – Lands in this category include: (1) lands with a high deer browse rating, and (2) stands that were initially rated as low but surrounded by water supply lands with a high deer browse rating. These lands may or may not be open to hunting and, if managed, it is likely that these stands would either not be regenerated, or if regeneration did occur, it would consist largely of less preferred species.

Table 25. Regeneration risk (likelihood of regeneration success) acres

Likelihood of Success	Analysis Area			
	West of Hudson*	West Branch/ Boyd Corners	Kensico*	Croton System
	Acres	Acres	Acres	Acres
High	3,121	0	0	0
Moderate	10,774	0	308	175
Low	56,808	7,850	1,745	8,539
Total	70,703	7,850	2,053	8,714

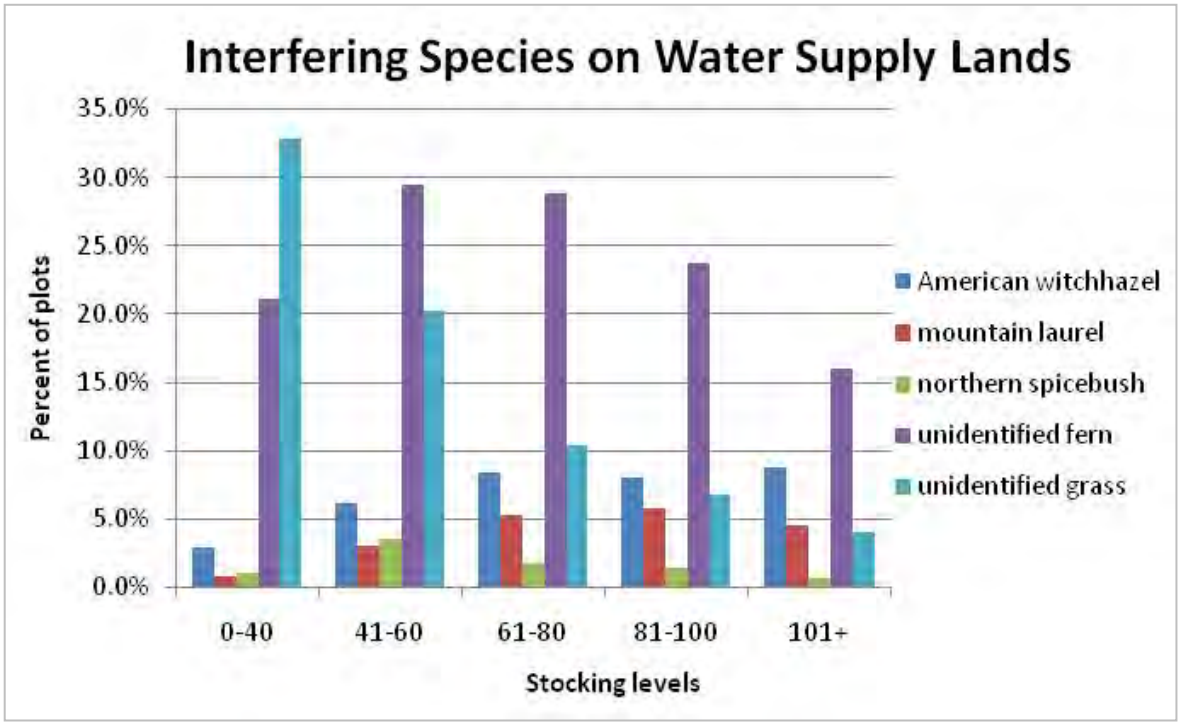
*-Browse data in the Kensico and Ashokan basins contain more lands in the low likelihood of success category and fewer lands in the moderate and high likelihood of success categories than is indicated in this table.

Source: Wildlife Report, Reitz 2011a

6.10.4 Interfering Species

Interfering vegetation (native shade-tolerant plants) interfere with normal tree regeneration. The catalyst for this problem is an overabundant deer population. Over time, plants that are low-deer-browse-preference become established and grow into dense ground cover, shading out tree regeneration or preventing germination. Once interfering species are established, reducing deer pressure will have little effect. Removing this vegetation is difficult and expensive. Ferns and grasses were collected without differentiation of species with known tree regeneration interference

capabilities. Figure 24 shows the percentage of interfering species by overstory stocking level on all inventoried City water supply lands.



Source: Forest Inventory 2009-2010

Figure 24. Percentage of interfering species by overstory stocking levels on total inventoried City water supply lands

6.10.5 Insect and Disease Threats

Human development and international trade introduce and spread exotic pathogens. These insects and diseases can easily grow exponentially as there are no established defenses to control these invaders (Mattson 1997). Native pathogens exist as well, typically at endemic (naturally low) levels. Forests that experience one or more inciting factors that weaken a tree's defenses are even more susceptible to decline due to these pathogens.

6.10.5.1 Hemlock Woolly Adelgid

The introduction of hemlock woolly adelgid (*Adelges tsugae*) from Asia has put the hemlock population in jeopardy (Figure 25). It has already decimated hemlock populations farther south. It became established in the 1980s in small pockets in the Catskills region (Kizlinski et al. 2002). Although aggressive harvesting during the tanning era reduced the amount of hemlock in the overall forest composition, this species is still a significant portion of the forest structure. Infection sites are generally located in concentrations of hemlock (Foster 1999). Mortality can be severe, but not all trees are dying across the landscape, and many isolated trees seem to be unaffected. Sometimes, the insect is controlled by sustained low temperatures during the winter season.

Figure 25. Hemlock woolly adelgid egg masses

Currently, there are many infestation sites with mortality occurring (Bridges et al. 2003). Approximately 16 percent of the hemlock inventoried is affected, in all size classes. This insect, however, can be difficult to spot in forest settings. Early populations can be difficult to see in crowns and the insect avoids lower shaded foliage.

DEP foresters report that they have observed a much larger affected population than indicated by the inventory results. If a control mechanism is not developed, it is likely that the majority of the hemlock population will be killed.

There is some hope of controlling the woolly adelgid. A natural predator from Japan, the lady bird beetle (*Pseudoscymnus tsugae*) has been introduced to control woolly adelgids. Another predator, the derodontid beetle (*Laricobius nigrinus*) was recently approved and will be released soon (USDA Forest Service Northeastern Area State and Private Forestry 2010a). In the interim, continued spread and mortality are likely.

The impacts of the woolly adelgid on the Watershed vary and have the potential to affect areas more sensitive for water quality since most of the hemlock (host species) inhabits riparian areas, many times being the primary species.

6.10.5.2 Elongate Scale

Elongate scale (*Fiorinia externa)* also called fiorina scale is another imported pest of hemlock and it can be confused with hemlock woolly adelgid. It has spread throughout the mid-Atlantic region including the City Watershed. While it is known to be in the area, there is no population survey data published. It is an armored scale that populates hemlock needles. It can kill the tree, but is more likely to weaken it so a secondary pathogen like root rot actually kills the tree. Two small wasp parasitoids, the lady beetle, *Chilocorus stigma*, and several species of lacewings are natural enemies of this scale insect, which provide some population reduction (Hoover 2009).

6.10.5.3 Emerald Ash Borer

The spread of the introduced emerald ash borer (*Agrilus planipennis*) threatens all ash trees. The insect had been identified in the Ashokan Basin, Ulster County in three locations. Additional sites were found recently and actions are being taken to address this in conjunction with the State. Previously, the favored method of control was to remove all ash trees from an extended area around the detected population. Currently, it is felt that this method forces the insect to spread rather than controlling it. A recently tested technology is to girdle a group of ash trees inside an infection zone. The

Figure 26. Emerald ash borer

female emerald ash borer can detect stressed ash trees and is attracted to them, where she lays her eggs in June. The girdled trees can then be harvested, chipped, and burned to destroy the eggs. This technique does not eliminate the population, but it tends to keep it controlled or spreading slowly (Siegert, personal communication). Canadian researchers are optimistic about the use of a fungi and nematode distributed from pheromone traps as a control mechanism (Canadian Forest Service 2010).

Michigan, one of the more heavily affected states, has published recommendations for landowners to help control the insect, protect forest values and productivity. They recommend thinning stands that have ash as a significant component and reducing the population to no more than 10 square feet of basal area as long as at least 70 percent of stocking can be retained. They also recommend removing stressed, suppressed or larger trees if the infestation is approaching (Michigan DNR Bulletin 2011). Table 26 shows acres by basins where significant amounts of ash are part of stands that may be practical to thin to achieve this objective.

Table 26. Stands with a significant component of ash in the composition, where thinning could be accomplished and retain 70 percent stocking

	20-30% BA of ash	30-40% BA of ash	41+% BA of ash	Grand Total
	acres	acres	acres	
		East of Hudson		
Boyd Corners/West Branch	32	1	15	48
Croton System	110	49	65	224
Kensico (No stands)[1]				
East of Hudson Totals	**143**	**49**	**80**	**272**
		West of Hudson		
Ashokan	140	68	62	271
Cannonsville	245	27	42	313
Neversink	0	34	15	49
Pepacton	348	71	13	432
Rondout	36	9	0	44
Schoharie	200	50	30	280
West of Hudson Totals	**969**	**259**	**162**	**1,390**
Grand Total	1,112	308	242	1,662
Total acres of stands with Ash	3,787	2,080	1,670	7,628

Source: Forest Inventory 2009-2010

[1] There are approximately 158 acres of stands with an ash component exceeding 20 percent BA, however these stands did not have sufficient stocking to meet the thinning requirement of removing the ash and retaining 70 percent stocking.

The total acres of stands with an ash component of at least 20 percent basal area is approximately 7,628 acres. The table above identifies those stands where there is sufficient density to reduce the ash component and still maintain a fully stocked stand condition. No stands in Kensico were identified as having a minimum of 20 percent basal area in ash that has sufficient density to thin out the ash and maintain a minimum of 70 percent stocking.

The effect of this insect on stands would be to reduce overall canopy cover by killing the ash trees within a stand. Where ash makes up a higher percentage of the canopy, the impacts would be greater. In addition, losing an entire species within the Watershed would result in less species diversity.

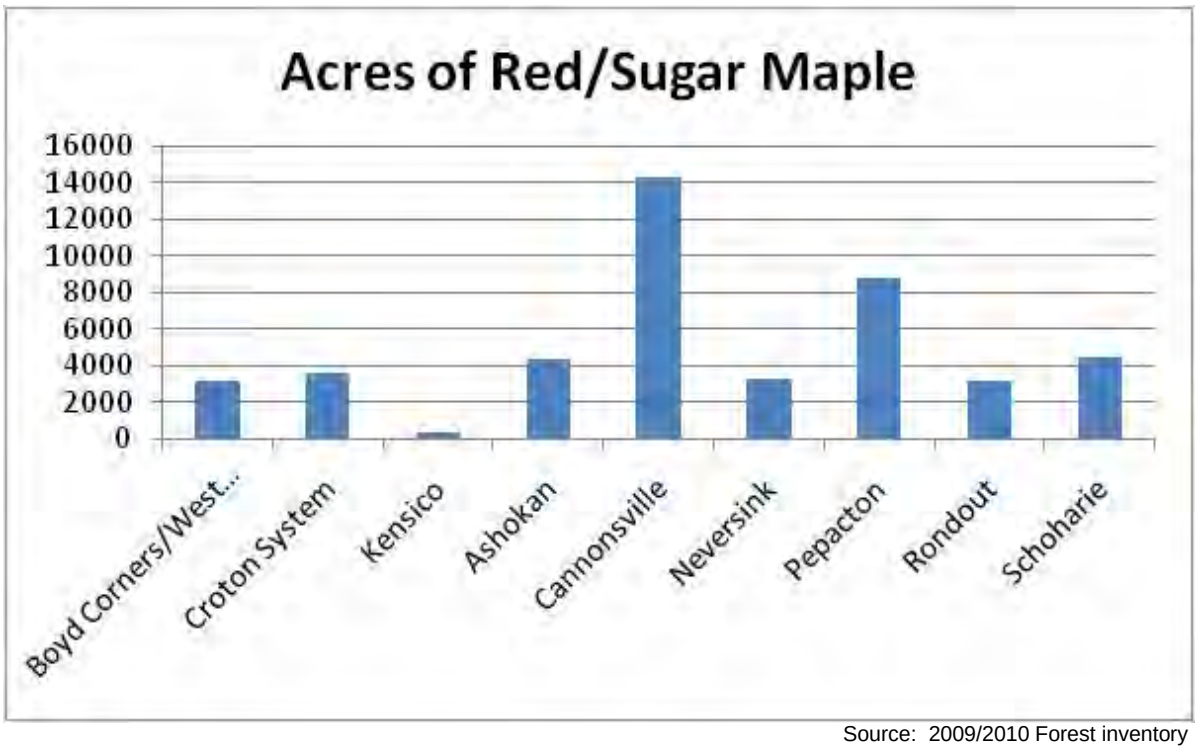
6.10.5.4 Asian Longhorned Beetle

Figure 27. Asian longhorned beetle

The Asian longhorned beetle, (*Anoplophora glabripennis*) (Figure 27), threatens many hardwood species in New York. This introduced insect has a preference for maples, but can attack a variety of hardwoods including ash and birch. It was discovered in New York City in 1996 and the Worcester area of Massachusetts in 2008. The only current control is to identify inhabited tress and destroy them, or treat the soil surrounding the base of preferred trees with Imidaclopid insecticide before they are attacked. The insect seems to be under control in the original affected areas, but continues to expand slowly outward from those areas (APHIS website 2011).

To date, all the studies of the insect's effects were conducted in urban and suburban settings. There was little information regarding the expectations if it were to spread into forested areas. An article in the *New England Society of American Foresters News Quarterly* written by Dodds, Orwig and Siegert (2011) discloses information gathered in forest stands surrounding Worcester, Massachusetts. It was determined that Asian longhorned beetle has been in these stands for 5 to 10 years. As of 2011, over 30,000 trees have been removed and chipped. Another 18,000 trees are still infested and planned for removal. There will be an effort to chemically treat over 100,000 trees to combat the spread of Asian longhorned beetle. In the forest setting, the insect seems to attack only maples. Other potential host species were present but not attacked. Where the Asian longhorned beetle was present, 32 to 62 percent of the maples present showed signs of attack. Red maple seemed to be preferred over sugar maple. Also the regeneration success of the insect was greater when red maple is the host. In this study, none of the infested trees counted had died from the insect attack. There were indications that there would be substantial crown mechanical failure and substantial bole defects (Dodds et al. 2011). It is also reasonable to assume that many of these trees will eventually succumb to secondary pathogens.

Currently, red maple and sugar maple are the first and second most common species on the City water supply lands. They are 16 and 13 percent, respectively, of the total volume which is closer to one-third of the entire ownership stocking (Wingate and Jaeschke, 2011). These percentages are higher in some basins. There are very few stands that don't include maple as part of their composition. Figure 28 displays the acres by basin with stands having red and/or sugar maple.



Source: 2009/2010 Forest inventory

Figure 28. Acres of red/sugar maple

The proximity of east of Hudson lands and the amount of human interaction between the current infected area and City water supply lands raises concerns about the spread of this insect to the watershed. The preferred hosts, sugar and red maple, plus other hosts, ash and birch, are common in the Watershed and represent over 40 percent of the overall trees by species. In addition, it appears that Asian longhorned beetle can attack oaks as well. Currently, this species seems to be focused in more metropolitan areas, and doesn't seem to spread as quickly as other beetles.

6.10.5.5 Sirex Woodwasp

Discovered in 2004, the Sirex woodwasp, (*Sirex noctilio*) (Figure 29), is another invasive insect established in New York State. It has been found in most western and many northern counties. It prefers to attack weakened or stressed trees, but can also attack healthy trees. It can decimate unthinned stands with high density (USDA Forest Service 2005). In New York State it has only caused serious damage in plantations, especially unthinned Scotch pine, but it has also attacked a few white and red pine plantations (Dodds et al. 2007). So far, it seems to be confined to conifer plantations, and there is a concern that it could spread to forest pines throughout the region (New York State DEC 2010b). Plantations within the Watershed are at higher risk partially due to this

Figure 29. Sirex woodwasp

insect. Currently there are approximately 2,046 acres of plantations that have the potential to be affected by this insect.

There is an effective biological control—a nematode, *Deladenus siricidicola,* can be introduced to an infected area. Prior to an infestation developing or while waiting to establish the nematode, it is important to reduce stocking in plantations to reduce crowding stress (Dodds et al. 2007).

6.10.5.6 Gypsy Moth

Figure 30. Adult gypsy moth

The gypsy moth (*Lymantriidae disambiguation*) (Figure 30) was accidentally introduced into the region in 1869, and its impact has been sporadic. An outbreak in Sullivan and Orange Counties collapsed in 2009 (New York State DEC 2009c). The outbreaks generally occur in oak-dominated forests and among preferable species such as aspen. Approximately 17 percent of the tree species in the Watershed are oak species, with 2 percent of the forest types dominated by oak species. Trees that are not under stress from another factor can deal with the gypsy moth defoliation and recover. However, trees predisposed from another factor, such as drought, are more likely to suffer mortality if gypsy moth outbreaks occur repeatedly (Gottschalk 1993). Currently, outbreaks appear to be controlled by a fungus (*Entomophaga maimaiga*) and by a virus called the "wilt," which seems to be responsible for population collapse in unusually wet spring weather or when populations are dense (Hoover 2000).

6.10.5.7 Forest Tent Caterpillar

Figure 31. Forest tent caterpillar

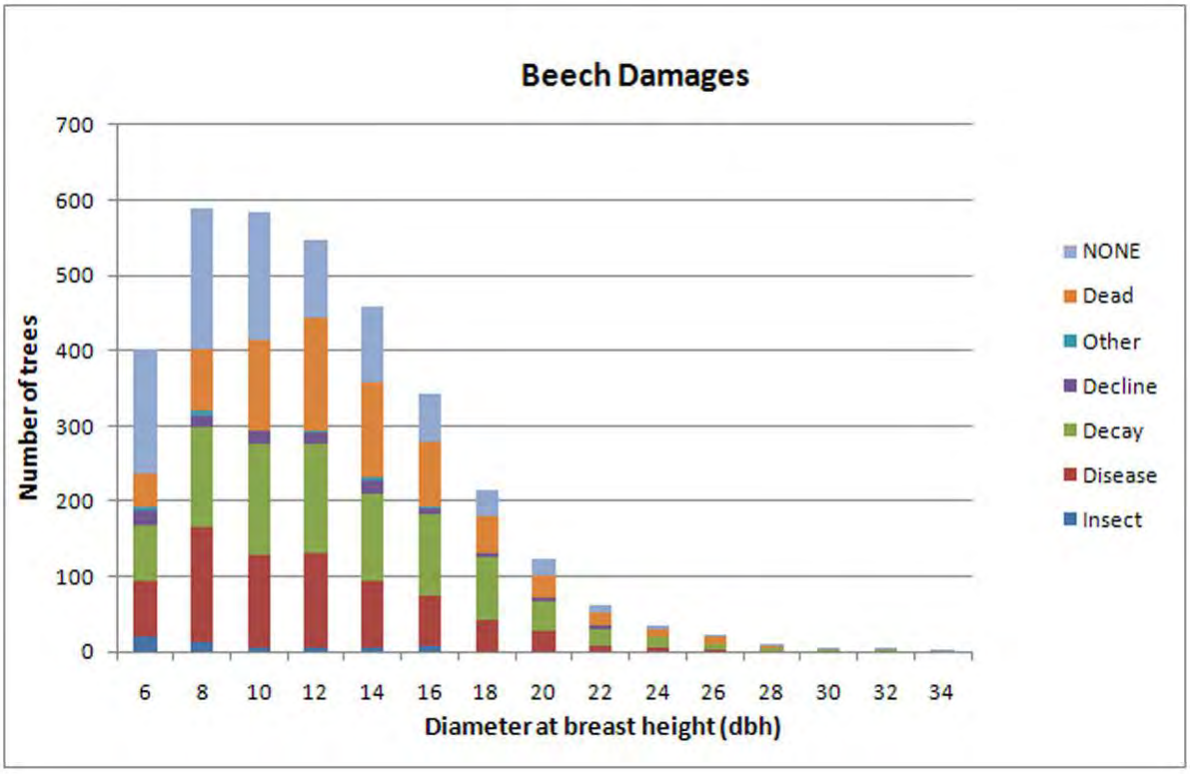
The forest tent caterpillar (*Malacosoma disstria*) (Figure 31) is a native species and a major defoliator of most hardwood species in New York State. Generally, infestations occur every 5 to 15 years, lasting 2 to 3 years. Cycles of population explosions have resulted in significant mortality in the past. Recently, repeated defoliations from forest tent caterpillar may have resulted in significant mortality in northern Ulster County (New York State DEC 2009a) and locally within the Watershed in Rondout, Neversink, and Ashokan basins. Within the Watershed, approximately 94 percent of the stands are hardwood stands. Native insect pest population expansions are often connected with predisposing stress events.

6.10.5.8 Beech Scale Complex

American beech was once one of the most common species in the Catskills Region (McIntosh 1962). Beech scale complex, initiated by the beech scale insect (*Cryptococcus*

fagisuga), was imported from Europe and has been present in the area since the 1950s (Griffin et al. 2003 and Leak 2006). The population and spread of the scale insect and subsequent fungal infections, usually (*Nectria coccine*) may be influenced by sustained cold winter temperatures (Smallidge and Nyland 2009). Beech populations have a range of genetic resistance to the scale insect. During the early stages of the infection, the most susceptible, larger, and more mature trees were killed. Since then, the disease complex has developed more slowly in trees with some degree of resistance. Mortality to beech scale complex is predictable over the long term, with trees increasing in risk as they increase in size (Houston 2005). The overall population of beech trees has been substantially affected in the City Watershed. Cankers that subsequently develop from fungal infection significantly reduce the value of most affected beech trees (Hancock et al. 2008).

Figure 32 displays health factors observed on beech trees during the inventory. While these could have many causes, it is very likely that they are directly related to beech scale. Trees with insect or disease observed still have value and function to protect water quality. Those with decline or decay are at immediate risk and will probably die within the next 10 years.



Source: Forest Inventory 2009-2010

Figure 32. Types of beech damage recorded (number of trees by diameter class)

A small part of the population is resistant to the scale insect and the remainder of the population has a range of resistance (Houston 2004). There is a viable population of unaffected beech trees and an additional population of living trees that have been affected on City water supply lands. Other researchers have shown that beech trees can live a long time and yield valuable material even if they are infected (Leak 2006). The surviving trees span the entire size range of beech. This figure also illustrates that the effects of beech scale

complex have not stabilized and that mortality and reduction in product quality will likely continue for some time.

It is reasonable to conclude that while beech will remain a part of stand structure, there will be reduced growth and continued mortality for the foreseeable future. When beech trees die, they tend to produce coppice reproduction through root suckers (Evans et al. 2005), which have the same genetic makeup of their parents and will be susceptible to the scale complex when they are larger (Bashant et al. 2005). These root suckers (commonly referred to as 'beech brush') can be prolific, dominating a site and reducing the potential for other forest species regeneration.

6.11 Fire Hazards

Large damaging forest fires are rare in the Northeast. It is very unlikely that a fire capable of affecting water quality will occur within the Watershed. A special combination of weather and fuel factors would be required to provide even a chance of a significant wildfire (USDA Forest Service 2010b). DEC gives credit for this rarity to its efforts to spread fire awareness information and organizing suppression efforts. As an example, DEC compares an extremely dry spring in 1903 when Adirondack and Catskill regions had 643 fires burning 464,000 acres with a similar dry period in 2002 when 324 wildfires in same area burned only 2,062 acres.

Since 1985, humans caused 96 percent of wildfires, while lightning caused only 4 percent. The State of New York analyzed fire danger ratings from 1985 through 2010. The main criteria DEC uses to determine fire danger rating areas are climate, topography, and similar vegetation (DEC website 2011a). On average, towns in City Watersheds east of the Hudson were rated in the moderate range with about 36 fires during this period, averaging one or two per year. Only two of these were over 100 acres and they were in remote areas (DEC website 2011a).

The highest ratings in basins west of the Hudson were in Schoharie in the Town of Windham, which was rated as high with over 31 fires reported in this period. The next highest area is in Pepacton Basin in the Towns of Middletown and Roxbury with 21 to 30 fires reported in each. The remainder of the area west of the Hudson rates in the low to medium range with 1 to 10 fires reported in this period. Three fires west of the Hudson were over 100 acres and all in remote areas (DEC website 2011a).

Small fires are routinely discovered and extinguished in the Catskill region. Frequency and intensity are strongly related to climate factors, and the risk of large and potentially dangerous fire is predictable. Aside from weather, which is routinely measured and reported, areas of intense fuel accumulation like blow downs, tree or shrub mortality, concentrated slash, conifer plantations, and ice damage are needed to support an intense fire in this region.

Forest management activities can affect fire risk. Loggers and equipment can be a source of ignition, which is why contractual requirements for operations on City water supply lands require firefighting equipment to be available to provide immediate response to these ignitions. In the short term, logging slash and landing debris can be an increase in fuel load; however, specific treatment requirements in forest management activities ensure that slash meets expected standards. Salvage logging in blow down areas, ice damage, or tree mortality reduces fuel composition in both the short and long run. In the long run, forest management activities reduce woody debris and fuels loading as stand densities are reduced, stand

structure is improved to mitigate adverse weather impacts and mortality, and fuel loads are reduced. Immediate risks can be reduced by limiting logging activity during periods of extreme fire danger.

Forest inventory data can be used to identify areas with concentrated fuel loadings, therefore actions can be taken to reduce these fuel loads, and locations of these areas can be identified and shared with local firefighting agencies.

7. FOREST MANAGEMENT

The need for active forest management is compelling when comparing the existing forest vegetation conditions to the desired conditions described in the Guiding Principles. A set of activities referred to as the management strategy (Section 7.7) was developed incorporating many concepts, scientific knowledge, professional experience, and integrated resource considerations to move forest conditions toward the desired conditions.

Developing specific forest management treatments incorporated in the management strategy to address the dissimilarities between the existing and desired conditions is based upon the vegetation conditions described earlier.

7.1 Management Needs and Opportunities

The opportunities for management are derived from the difference between the existing conditions (age distribution, stocking levels, reforestation need or opportunity, species composition) and how the desired conditions are described based on the Guiding Principles, Goals and Objectives (Map Packet Section 7.1 Management Needs). Of particular importance is the current condition related to age class distribution and stocking levels. The majority of the Watershed forests are within a mature or overmature age class (65 percent of the forest acres is 81 years old or older), and almost half (48 percent) of the Watershed forests are in an overstocked condition (Table 22 and Table 21, respectively). Many of the treatments will meet several different objectives. Treatment and implementation priorities are also based upon numerous factors, including staffing, resource availability, access, and economic feasibility to name a few.

Due to the relatively short time period over which farming was abandoned and forests began to regrow in the region, the forests on much of City water supply land are similar in age and density. Forests in this condition are known as even-aged, while those originating over longer time periods are known as uneven-aged. Age class diversity is lacking, and densities are generally at high enough levels that trees are experiencing significant effects of crowding stress, which may result in reduced tree vigor, higher susceptibility to insects and disease, or mortality. Ideally, stands would be evenly distributed across density and age classes, maximizing diversity and minimizing the risk of landscape-scale catastrophic disturbance.

Because trees grow continuously, distributions across the forest of stand density (basal area and relative density) and effective age are constantly changing. In general, in the absence of management or other disturbance, stands will become increasingly dense and old until they reach a point where the large overstory trees that have made up the stand for the majority of its life begin to die. This creates large canopy gaps that cannot be filled by expansion of existing overstory trees. These gaps are subsequently filled with new trees. This point in a stand's life cycle is often referred to as stand break up. Stand break up may result in a net export of nutrients, particularly nitrogen, as the amount of nutrients made available through

soil processes and released through decomposition exceeds the amount utilized. The stands also become increasingly susceptible to disturbance.

The majority of stands on City water supply land have not yet reached this point of break up. However, a large proportion are grouped into a few density and age classes, and can therefore be expected to approach the point of break up around the same time, probably in the next two decades. Because having all these stands approach break-up at the same time could degrade the water-quality protection benefits of forest canopy over a large area, it would be beneficial to move toward a more balanced distribution of age and density classes across the landscape.

While most forest management activities can be prioritized and scheduled, natural disturbance events like wind and ice storms or outbreaks of forest diseases or insect pests interrupt normal activities and require a rapid response. If trees are damaged and risk substantial loss of value, timely salvage activities will be desirable to recover value. At the same time, silvicultural solutions may be needed to replace tree stocking. In some cases, both of these objectives can be accomplished with the same treatment.

7.1.1 Age Class Diversity

Forests become mature when overall growth slows or stagnates. This is mostly associated with tree size. Biological maturity is more associated with tree health than actual age. Decline and subsequent tree death is preceded by one or several stress events. Stresses caused by drought, lack of required nutrients, or defoliation can weaken trees, making them susceptible to insect and or disease attack. These successive stress events can result in a fungal or insect attack that kills the tree. This process is described as “the spiral of decline” (Manion 1981). It is generally recognized that by the time stress is detected in a tree, it is often too late to save it. Stand maturity can be postponed through maintenance thinning that controls stocking levels and reduces competition. Trees susceptible to decline due to competition can be harvested, reducing stress levels in residual population and ensuring longer productive life for the remaining trees (Goodell and Faber-Langendoen 2007).

Age maturity can be closely associated with tree size. As trees become larger, they have more demand for light, water, and nutrients to survive. When one or more of these elements is limited, as in periodic drought or defoliation, the result is stress that can increase susceptibility to pathogens. In this way, tree age can be related to risk factors in forest health. Individual or stands of trees can be regenerated through silvicultural systems. The priority to regenerate stands is affected by species content and site factors. These variables need to be analyzed for each stand and compared with other stands to develop priorities for regeneration. Depending on species content, stand maturity can be postponed through careful stand maintenance treatments. By creating growing space and removing trees that mature early or are subject to risk, stress associated with maturity may be avoided for a limited amount of time.

Addressing the current age class distribution will require increasing the amount of younger age classes through forest regeneration. To ensure successful regeneration of forest stands to increase age class diversity, the greatest management need is to reduce deer populations below carrying capacity. Overabundance of deer and browsing effects prevent successful outcomes in nearly all silvicultural regeneration applications. The effect is cumulative and long lasting. Even if populations are brought under control, it will take years of deer population maintenance below carrying capacity to restore diversity and natural functions to the landscape.

It would be detrimental to water quality to regenerate too many stands at once (Douglass and Swank 1975, Baldigo et al. 2005, Siemion 2011). It is important to establish age regulation within basins so that a limited number of acres are in the process of regeneration at any one period of time. At the same time, the highest priority stands are regenerated, providing age class diversity and sustained yield across the landscape (Aplet 1993).

7.1.2 Stocking Levels

High stocking levels in stands result in competition, stress, and tree mortality. Growth can be anticipated and stocking reduction can be scheduled to produce an even but sustained flow of forest products while maintaining healthy stands within optimal stocking ranges. Tree age within uneven-age strategies and stand age within even-age systems can be regulated by scheduled regeneration harvests and follow-up treatments.

Forest stands that have 70 percent and greater stocking have the greater value toward maintaining water quality as they provide continuous forest cover. It is essential that stocking levels be maintained at the level of maximum stocking, while providing sufficient growing space to maintain vigorous growth. Stands that currently exhibit relative density of 100 percent and greater should be considered for silvicultural treatment, followed by stands that are between 80 and 100 percent and are likely to achieve full stocking and become overstocked from normal growth within the next 20 years.

7.1.3 Forest Cover at Risk

Numerous factors act in combination to influence priority of treatment for forested stands. Within each basin, it is important to carefully evaluate the risk factors for each stand and the overall landscape, along with the effects to water quality, when developing treatment priorities (see Table 27 and Figure 33). Two primary risk factors that affect forest cover are potential impacts from insects or disease and plantations. Plantations are at risk due to the lack of management to maintain vigorous growth, and from species planted that are not necessarily suited to the site.

7.1.3.1 Potential Insect and Disease Impacts

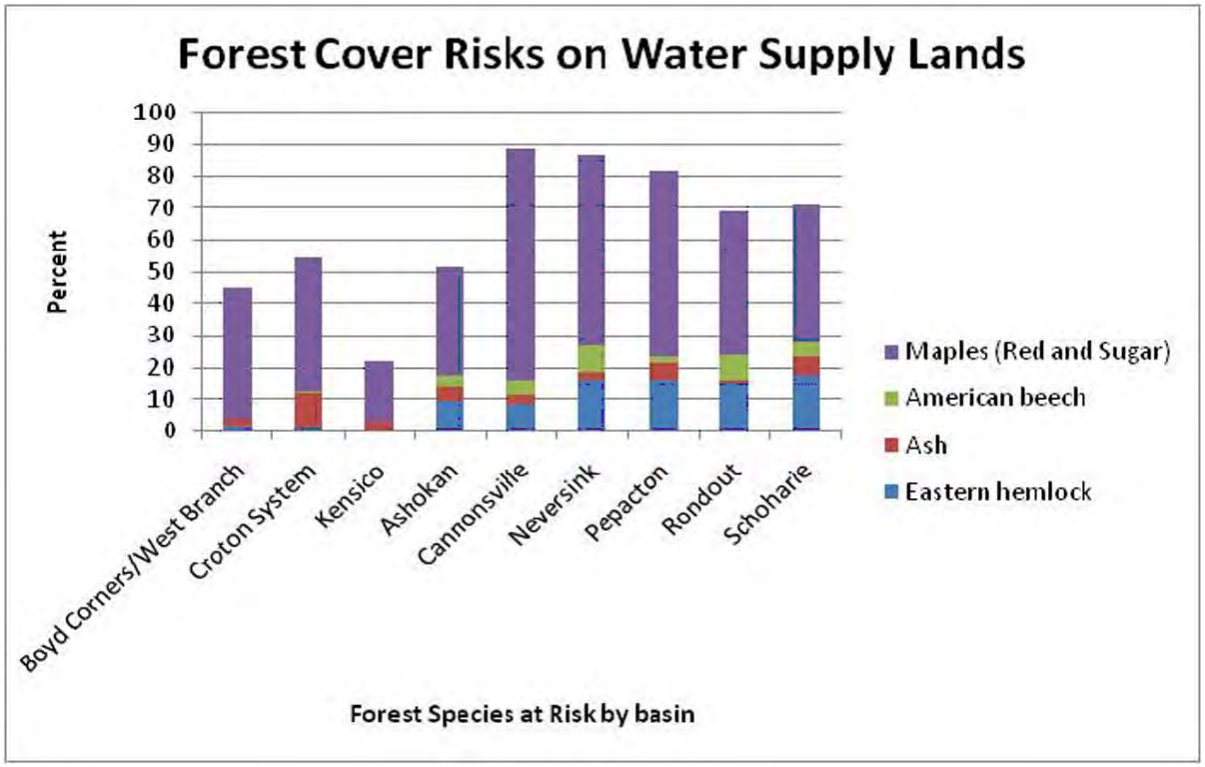
Several active or threatening pests could substantially alter some stands and affect water quality (Mattson 1997). Hemlock woolly adelgid affects the hemlock hardwood type that represents 22 percent of the forest cover on City water supply lands. Hemlock trees are 12 percent of the forest cover measured by basal area. It is often the principal tree species on many riparian sites. If this cover is lost, among many negative effects would be rising water temperature in feeder streams that hemlock currently shade. Emerald ash borer affects ash trees comprising about 7 percent of the basal area on City water supply lands. Beech scale complex affects beech, which makes up 4 percent of the cover basal area. Beech seedlings and saplings currently represent 25 percent of potential regeneration. Asian longhorned beetle has the potential to affect almost 40 percent of the tree species on the Watershed, as red and sugar maple are a primary species.

In many cases, these forest cover species are a significant part of stand composition. If these trees were lost, there is heightened potential for impacting water quality. Table 27 and Figure 33 show the amount of area where ash and beech occupy 30 percent or more of the stocking and 35 percent of hemlock. A higher percent was chosen for hemlock because it tends to occupy more of a site.

Table 27. Forest stands at risk in all City water supply lands (in acres and percent)

	Eastern hemlock		Ash		American beech		Red/Sugar maple		Grand Total
	acres	%	acres	%	acres	%	acres	%	
East of Hudson									
Boyd Corners/ West Branch	139	2	197	3	0	0	3,221	41	3,556
Croton System	99	1	907	11	48	1	3,633	42	4,687
Kensico	0	0	65	3	0	0	379	19	444
East of Hudson Totals	**238**	**1**	**1,169**	**6**	**48**	**0**	7,233	39	8,687
West of Hudson									
Ashokan	1,259	10	578	4	487	4	4,418	34	6,743
Cannonsville	1,689	9	527	3	894	5	14,331	73	17,442
Neversink	875	16	134	2	457	8	3,300	60	4,766
Pepacton	2,483	16	752	5	326	2	8,764	58	12,324
Rondout	1,057	15	70	1	521	8	3,143	45	4,791
Schoharie	1,816	18	611	6	441	4	4,467	43	7,334
West of Hudson Totals	**9,179**	**13**	**2,672**	**4**	**3,127**	**4**	**38,423**	**54**	**53,401**
Grand Total	**9,416**	**11**	**3,841**	**4**	**3,175**	**4**	**45,656**	**51**	**62,088**

Source: Forest Inventory 2009-2010



Source: Forest Inventory 2009-2010

Figure 33. Forest cover risks due to insects and disease

7.1.3.2 Plantations

Many plantations of tightly packed conifer trees have never been tended. These trees are in a weakened state and subject to damage by wind, weather, or pathogens (see Figure 34). Monocultures of trees are always a risk as one pathogen can wipe out the entire stand. All together, these species and plantations represent 2 percent of the forest cover. Management actions that improve the growing conditions, and diversify species composition will increase the resiliency of these stands. Plantation management opportunities to maintain, diversify, or replace will be dependent upon site-specific conditions.

Figure 34. Conifer plantation

7.2 Management Strategy Development Considerations

7.2.1 Harvesting

Harvesting trees (see Figure 35) produces a usable, renewable product, as well as providing a means to maintain stands of trees in a healthy state. Harvest operations also enable the regeneration of mature and declining forests to young healthy stands (Marquis 1990). Under natural conditions, trees die when resources are scarce and neighboring trees have a competitive advantage. In a managed forest, professional foresters can determine which trees are likely to die in the future and harvest them while they still have value. In addition, other trees can be harvested to prevent future crowding by creating growing space.

Figure 35. Harvesting

In a natural forest, trees or groups of trees periodically blow down in storms, are struck by lightning, are severely injured by ice formation or decline and die due to maturity. The professional forester can mimic this natural process by selecting certain older or declining stands that should be replaced and targeting them for regeneration. The principal difference between these natural

processes and a professionally managed forest is that the trees which normally die and decay in the natural regimen are harvested and processed into products in the managed area.

7.2.2 Growth and Nutrient Assimilation

Nutrients derived from human sources that become airborne can precipitate out of the atmosphere and enter water systems, degrading water quality and subsequent aquatic vegetative growth.

Trees grow by collecting water and nutrients from the soil. With greater growth comes greater nutrient assimilation. Trees also use sunlight to conduct photosynthesis to produce carbohydrates and other essential compounds to sustain existing cells and to grow new cells. Rates of photosynthesis and biomass accumulation reach a peak and begin to decline as individual trees and stands age (Ryan et al. 1997) If trees are harvested to promote rapid growth in the remainder of trees, some of the nutrients they absorbed are stored in products produced.

During the life of a tree, growth begins modestly and steadily increases as the tree becomes larger and occupies more space and soil (Marquis 1986). As trees mature, growth becomes more difficult due to their size and the effort needed to survive. In the managed forest, growth and nutrient assimilation can be maintained by regenerating trees when the overstory becomes mature and before growth rates begin to decline.

Harvesting can be used to change species composition and stand structure. When one species dominates a stand, the canopy tends to be flat on top as trees with similar growth potential compete for light. When there is good diversity in tree species, there will also be diversity in shade tolerance. This produces an uneven canopy surface and depth within and below, resulting in more leaf surface area absorbing more light, and therefore, supporting a larger stocking of trees and growth. Stands with greater species diversity are also more resilient and less susceptible to insect and disease outbreaks (Leak and Smith 1997). Diversity can be fostered by harvesting the more common trees and releasing the less common trees from competition.

7.2.3 Growing Stock Quality

The quality and economic value of stands of trees (growing stock) can be improved gradually over time by harvesting lower quality trees and retaining trees with quality potential (Nyland 2006a, Miller et al. 2001). This also improves resiliency of the stand as the lower quality trees are less likely to withstand disturbance. Improving overall tree quality within a stand increases the capacity for water quality protection through increased nutrient assimilation, increased resiliency, and higher quality tree crowns to provide site protection. When there are very few quality trees, economic value can be increased by regenerating the stand (Nyland 2006b). To finance harvesting operations, a certain amount of value must be removed to cover the costs of the harvest and provide some profit for the contractors implementing the management actions. This product value can be thought of as quality or quantity. The lower the quality of the timber, the more quantity per acre must be harvested to break even. Stands with high-quality trees can be treated lightly (removing less volume), while achieving the same silvicultural objectives.

Improving timber quality is greatly aided by well-developed, low-quality markets like pulp and paper, energy chips, firewood, and pellet manufacture. The Catskill region has limited opportunity for these products. Low-quality markets are often reduced to local firewood.

When quality trees are present, they often occur in groups where at least a few should be removed to provide growing space for the others. In this way, a few quality trees and some lower quality sawtimber can finance the removal of lower quality trees. Even where low-quality markets are well developed in the East, higher value sawtimber usually subsidizes the cost of harvesting low-quality wood.

If the worst quality stands can be regenerated and the better quality stands are prioritized for thinning, value will gradually improve across the Watershed (Ice and Stednick 2004). This is easier to achieve under even-age strategies or group selection rather than single-tree selection.

7.3 Carbon Storage and Sequestration

Trees are made up of primarily water and carbon. As trees grow, photosynthesis removes carbon from the atmosphere and manufactures carbohydrates that become the main ingredient for cellular structure. Standing forests store large quantities of carbon, both in the trees and in the organic components of the soil (Heath et al. 2011). When trees are harvested, a portion of the resulting tree fiber goes into durable wood products, another form of carbon storage (Evans et al. 2010). Trees that die and decay produce methane and other greenhouse gases that contribute toward overall emissions (Ryan et al. 2010). Harvested trees are replaced by new trees or growth in adjacent trees and the carbon removed is replaced. Harvesting requires burning some fossil fuels to operate equipment and transport products. The net carbon footprint of forest management varies, but produces products with less carbon emissions than competing, nonrenewable raw materials. Management strategies can be applied to maximize the amount of carbon stored in the forest, while providing growth to sustain future harvests.

7.4 Silvicultural Practices

Forest inventory data are used to categorize forest stands and suggest treatment needs or options. Some stand variables are difficult to quantify, but important to consider. A trained and experienced professional forester is needed to analyze data and observe site conditions. This experience and judgment is required to find the best solutions for providing the best water quality available. Accomplishing the goals of the management plan will be challenging. Deer populations, exotic pests, invasive plants, atmospheric depositions, and local regulations all influence silvicultural options or require substantial financial investments to overcome. Professional judgment made from onsite observations will be the key toward achieving quality management.

7.4.1 Silvicultural Systems

Two principal silvicultural systems used in forest management are even and uneven-age. These can be applied across the landscape or to individual stands. In even-age systems, nearly all trees are harvested and replaced by younger trees. The resulting stand will be populated with trees of nearly the same age. Prior to maturity, tree density and growing space is often regulated through thinning (Marquis 1969). Uneven-age systems set a maximum diameter for the most mature trees in a stand, and regulate size classes and structure. Mature trees are harvested when diameter objectives are reached and smaller trees are harvested to regulate an even distribution of size classes. Growth in all size classes provides for future harvest volumes. In the intervals between harvests, new trees become established in the understory. Each type of treatment will favor the physiology and regeneration process of a

limited number of species. Even-age tends to favor light-seeded, fast-growing shade-intolerants, while uneven-age favors slower growing shade-tolerant species (Section 6.10.1 explains this in more detail).

7.4.1.1 Even-age Management

7.4.1.1.1 Regeneration Methods

Even-age management systems result in a population of trees that are all relatively the same age. This strategy includes clearcutting, seedtree, and shelterwood treatments. These methods are used when the existing forest condition can no longer be maintained, or disturbances have impacted the majority of the stand where the objective is to initiate a new stand to replace the existing stand. Regeneration methods are typically the 'last resort' when the existing stand condition can no longer be maintained to provide resilient forest conditions that protect water quality.

Clearcut and patch clearcut methods

Where a clearcut is generally thought of as larger than 10 acres, a patch cut would be in a 5-acre size range (Leak 2005). Variations in both of these systems include leaving selected reserve trees distributed across the treatment area for other resource benefits (wildlife habitat, species and structural diversity, future coarse woody debris recruitment, etc.). Tree regeneration originates from dormant seed in the duff, seed blown in or transported by wildlife, and root and stump coppice (sprouts from the existing root system and stumps).

Seedtree method

Similar to a clearcut, but with a small residual density of trees retained to provide a seed source for natural regeneration. This method is distinguished from a shelterwood method by the fact that seed trees are not of sufficient density to provide shade or other site amelioration qualities.

Shelterwood method

This process includes harvesting 30 to 40 percent of the stocking to create filtered light. Often the harvest includes site preparation or removing small-diameter trees, which produce low shade that would impede germination and seedling development. Trees retained are selected specifically to supply high shade and superior seed stock (Marquis et al. 1990). Regeneration develops slowly from stored seed, seed from overstory seed production, and coppice. Once sufficient quantities of diverse regeneration are present and before it gets too large, the overstory is harvested, releasing the seedlings for rapid growth in full sunlight. Sometimes the removal is done in two stages to help the seedlings like shallow-rooted maples, adapt to full sunlight. The same modifications for tree retention may be applied as in clearcutting. Regeneration from shelterwood treatments tend to be more diverse with greater amounts of shade intolerants (Marquis et al. 1990). Shelterwood systems are more complicated to manage, more costly to apply, and may increase the impacts on soil if not carefully planned. An important advantage, however, is if regeneration fails to develop, the effort can be abandoned and there will be adequate forest cover to protect water quality. If a clearcut fails, artificial regeneration may be required and water quality would be affected for a much longer period of time.

Two-age method

A modified even-age strategy is called “two age” (Miller et al. 1995a). In this case, a portion of the original stand is retained during the clearcut or shelterwood removal cut (Smith and Miller 1991). When the regeneration has reached approximately half the recommended maximum age for that timber type, the older age class is harvested (Miller et al. 1997). In the space created by that harvest, a new age class develops. Consequently, at any given time the stand will have two age classes of trees. Generally, the older age class contains less than 50 percent of the original stocking. This condition is often found in older stands where a harvest occurred in the past, but a small unharvested portion of the stand was left. In this case, the older age class often lacks quality and occupies valuable growing space. In recent times, this variant was further developed, principally to mitigate the visual effects of even-age regeneration treatments (Pings and Hollenhorst 1993). Harvesting the older age group without excessively damaging the younger group can be challenging (Smith et al. 1994).

7.4.1.1.2 Sources of Regeneration

The two principal methods for obtaining tree regeneration on a site once a regeneration method is applied are artificial (planting) or natural regeneration.

Artificial regeneration

Artificial regeneration is generally accomplished by planting seedlings raised and transplanted from a nursery or vegetative cuttings. Generally applied to land lacking older trees to provide viable seed, artificial regeneration can result in stands that lack species and size diversity. Although expensive to apply, it may be the only practical means of restocking non-forested lands. It may also be used to restore desirable, individual species to the population. When considering artificial regeneration, ensure that the species being considered is suitable for the soils on the site and that the seed comes from local sources (Grier et al. 1989). Seed from local sources is important as these are genetically suited to the local conditions, however, other sources may be necessary where local sources are not available. The important consideration is to match as closely as possible the growing conditions of the source with the intended site locations.

Figure 36. Natural regeneration in a forest opening

Natural regeneration

Management activities can be designed to mimic natural processes or disturbance events, with natural regeneration as the objective. In this case, seeds stored in the soil, distributed from retained seed trees, blown in from adjacent stands, or deposited by wildlife are the basis for the future forest. These may be supplemented by coppice reproduction—stump and root sprouts originating from previously harvested trees (Shirer and Zimmerman 2010). Natural regeneration is

generally less expensive to achieve and will more closely represent a natural forest for the site. Natural regeneration can be assisted through site preparation treatments that provide a seedbed for seed to germinate. Often, minor soil disturbance from logging equipment is beneficial for producing a seedbed or may act as a stimulant for seed germination.

7.4.1.1.3 Thinning

Even-age strategies often include periodic thinning to maintain growth and vigor and increase quality. This includes commercial and noncommercial applications where trees are removed to promote growth on desirable stems and generally increase the value of the growing stock in each application (Miller et al. 2001). Thinning can be applied any time the stand approaches full stocking. Typically, the growing stock population is reduced to 60 to 70 percent of full stocking, and an average site will regrow to nearly full stocking in 20 years (Leak 2003).

Water quality is not dependent on tree quality Higher tree quality is directly related to resiliency of a stand to disturbance and ability to uptake nutrients which provides for increased water-quality protection. The sale of trees being removed can finance most beneficial forest treatments. The choice to improve stand quality pays off financially in the long run (Miller et al. 2001). Tree quality can be improved by identifying better quality, healthy trees, and releasing them from competition by removing trees of poorer quality or less vigor. In the short run, timber sales will have lower revenues and investments of capital may be needed to regenerate the lowest quality stands. In the long run, forest management will generate higher levels of income, providing income sources to fund forest management activities that do not generate income, such as tree planting, fencing, and timber stand improvement activities.

7.4.1.1.4 Even-age Options

For quantification of the management strategy, even-age stands are divided into two groups: immature—99 years old or less, and mature—100 years old or more. One hundred years is used because it is a midpoint in the range of mature ages for the forest types in the even-age management option.

For immature stands, if relative density is 85 percent or above, a thinning was identified following general management guidelines for hardwood management and stocking control. Eighty-five percent is used because stands at the lower end of this stocking will grow to 95 to 100 percent relative density by the end of the decade. Those with less than 85 percent relative density can be deferred until the next decade.

For mature stands, if relative density is between 41 and 80 percent, they are candidates for regeneration. These stands are currently at or nearly at desirable shelterwood level stocking. If stocking is closer to 80 percent relative density, site preparation may be desirable to reduce stocking and remove low shade. The understory must be assessed. If there is regeneration present or at least no interference, a fence may be all that is needed to develop and protect regeneration. If an undesirable understory is present, it must be removed. Fencing will probably be needed here as well.

If mature stands are over 81 percent relative density, a shelterwood harvest to lower stocking to approximately 65 percent relative density could be applied. A minimum of 81 percent stocking is used, assuming either stands receiving a shelterwood are currently merchantable or will grow to that level by the end of the decade. To achieve an even balance of age classes

over the long term, approximately 4,700 acres per decade would need to be treated. This is derived by estimating the amount of even-age types that have site limits, making regeneration an unrealistic goal and deducting this amount. The result is divided by 10 decades.

This age class balance target will be partially satisfied by regenerating low- and medium-stocked stands. The balance is drawn from the mature, 81+ percent, group. The remainder of that group is included in the maintenance thin category. Although some of these stands are at or near the lower stocking threshold of 81 percent and are not currently merchantable, they could be in the 90 to 95 percent stocking range by the end of the decade.

All forest types other than hemlock hardwood and northern hardwoods are typically managed with even-age systems. When even-age treatments are applied to northern hardwoods or hemlock hardwoods, there is typically a species shift toward less shade-tolerant species. This could appear to be discrimination against those species. On the other hand, the principal species in that group—sugar maple, beech, and hemlock—are most commonly under threat from exotic pests and atmospheric deposition. In many cases, more species diversity in both forest types would help ensure forest cover sustainability. Also, shelterwood systems can be modified to favor more shade-tolerant species. Overstory removal can be delayed to favor more shade-tolerant seedlings and the overstory can be removed in two stages to help shallow-rooted sugar maples to adapt (Leak 2005).

7.4.1.2 Uneven-age Management

There are two principal means of conducting uneven-age management; single-tree and group selection. In single-tree selection, mature trees are harvested, making room for a new regeneration and growth in younger or smaller trees (Donoso et al. 2000). Ideally, there will be a variety of ages and sizes in the composition (Leak 2003). Harvesting will target various size trees, based on calculations to achieve an ideal distribution of different sizes (Leak 2004). Generally, the most numerous trees will be the smallest going up to the lowest number being the largest. This can be modeled with a slope formula and a variable referred to in the literature as the “Q factor” (Leak 2002), where the quantity of the variable sets the ratio of smaller trees to larger trees. This silvicultural system tends to reduce the species present to the most shade tolerant.

In group selection, trees are harvested in “groups.” Group size can be anywhere from a cluster of trees to several acres. Typically, group sizes vary from one-quarter to one-half acre with irregular boundaries (Miller et al. 1995b. An area of harvest target is developed by dividing the target age of the oldest trees by the time interval between harvests, which is usually in the range of 10 to 20 years (Lamson and Leak 2000). For example if the target age is 100 years and you plan an entry every 20 years, the gross area of groups would be one-fifth of the total each entry. Managers select portions of the stand that contain higher concentrations of mature, high-risk, or shade-intolerant trees. Ideally, they are of variable size and shape, and are well distributed in the stand. Generally, no more than one-fifth of the stand area can be included in groups in one application without the groups becoming connected.

Variations of this technique include conducting maintenance treatments in the areas between groups currently being harvested. This would include ensuring growing space for desirable trees, salvaging declining trees, and other cleaning and weeding functions. Group selection generally produces more diverse regeneration than single-tree selection. Making groups larger will encourage more shade-intolerant regeneration. Group selection is often popular

with managers because there is commonly variation in stands of trees, which makes some selected silvicultural practices less desirable in portions of the stand. This system allows treatments to be customized for every part of the stand.

7.4.1.2.1 Uneven-age Options

Uneven-age management is identified as appropriate for hemlock hardwood and northern hardwood forest types, based on common management guidelines. This assumes that the current species composition is best suited for soil and site, and each management system proposed will maintain a similar species composition in the future. At a landscape scale, it is difficult to plan in any greater detail. As foresters collect additional data and observe site conditions, they are likely to draw different conclusions. They weigh many factors when making this decision. Often the best management approach in a northern hardwood type is a shelterwood system, while group selection could be the ideal treatment for a stand with a shade-intolerant population.

The presence of abundant deer complicates these decisions. The additional time needed to develop regeneration under shade; either in even- or uneven-age strategies, exposes seedlings to greater browsing pressure. By preferential browsing, deer can eliminate many tree species from the future stand, regardless of the silvicultural system applied.

Adaptive management is a relatively new concept that encourages managers to use current technology to manage resources relative to specific characteristics of that resource (Kennard 2008, Lessard 1998). When established management strategies do not seem to fit a given stand situation, thinking should be adapted to fit the situation in the stand (Larsen 1991).

7.5 Conservation Practices

Forests contain natural resources in addition to trees that are important not only for potential water quality protection, but also for their own intrinsic value. Some examples include wetlands, vernal pools, seeps and springs, riparian areas, and threatened and endangered species. Conservation practices provide the framework for conducting forest management projects while managing and/or protecting these co-existing resources.

The DEP formulated a specific process for planning, developing and reviewing individual forest management projects, as well as approved conservation practices to ensure the protection of water quality during project implementation (2010 DEP Forest Management Projects and Conservation Practices, Appendix 1). These conservation practices are in addition to recommended best management practices identified by the State, *New York State Forestry Best Management Practices for Water Quality (2007),* which will also be followed where applicable on forest management projects.

The planning process for designing and implementing forest management projects incorporates many of the Plan objectives outlined earlier. The Plan objectives that are specifically related to the design of projects include:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-4	Apply conservation practices to prevent adverse water quality impacts and reduce or eliminate soil erosion. Restore and reclaim detrimentally impacted areas for the control of point and nonpoint source pollution concurrent with forest projects where appropriate.
GPI-5	Designate special management zones around riparian, wetland and hydrologically sensitive areas (steep slopes, unstable geology, etc.) and establish specific management practices with objective standards to maintain and enhance ecological function to prevent sediment delivery.
GPII-1	Management activities will incorporate basin-specific opportunities to protect or promote desired habitat conditions.
GPII-2	Identify conservation recommendations to protect or enhance habitat components for Threatened, Endangered, and Special Concern species.
GPII-3	Design forest treatments to be visually sensitive around public access sites, highly visible areas, and adjacent landowners, dependent upon adjacent landowner use.
GPII-4	When appropriate, forest management may be used to develop, maintain, and enhance recreation sites.
GPII-5	Provide opportunities to utilize forest products and employment opportunities where compatible with other forest uses.
GPII-6	Maintain and enhance forest cover to promote carbon sequestration.
GPIII-1	Promote coordination and outreach activities with Watershed Agriculture Councils (WAC), local governments, and adjacent landowners and other interested parties and stakeholders.
GPIII-2	Conduct annual and five-year incremental monitoring to identify needs for adaptive management (change in specific management practices) and Forest Management Plan amendment needs to address changes to ensure Guiding Principles are achieved.

7.6 Operational Principles and Recommendations

Operational principles and recommendations are additional practices that can be used during project-level planning and implementation to further reduce potential adverse impacts from forest management activities and meet the Plan objectives. Operational principles will be integrated into all forest management projects, while Operational recommendations will be considered during project planning and implemented where they do not interfere with achieving management objectives and operational feasibility.

7.6.1 Operational Principles

These principles direct management actions specific to implementation of forest projects to ensure the protection of public safety and resources. These Principles are required for all forest management projects.

7.6.1.1 Public Safety

Forest management activities will incorporate plans to protect public safety, by identifying and mitigating potential hazards and incorporating DEP required safety practices.

7.6.1.1.1 Objectives

OP1 Identify and mitigate potential hazards to public safety through incorporation of DEP required practices.

7.6.1.2 Cultural and Historic Heritage Sites

Forest management activities will follow all legal requirements to ensure protection of these sites.

7.6.1.2.1 Objectives

OP2 Identify and protect cultural and historic heritage sites within proposed project areas where management activities may impact these resources.

7.6.2 Operational Recommendations

These practices will be considered during project design and planning to address other resource needs and concerns, and implemented where they do not interfere with the achievement of Guiding Principles.

7.6.2.1 Invasive Plant Species

7.6.2.1.1 Project planning

Before forest management activities commence, each site should be assessed for invasive species on or adjacent to the site.

Projects should be planned to minimize disturbance that may promote establishment of nonnative invasive species.

7.6.2.1.2 Preventing Introduction of Invasive Plants to Uninfested Sites:

Equipment should be visually inspected and clumps of dirt, vegetation and seeds removed prior to visiting the site.

Activities should begin in uninfested areas before infested areas to prevent moving seed and plant matter from infested areas into uninfested areas.

Native plants, weed-free seed, and mulch should be used.

Fill that has no invasive plant material (e.g., seeds, roots, etc.) should be used.

Invasive plant prevention should be incorporated into road work layout, design, and decisions as practicable. Uninfested areas should be used for staging, parking, and cleaning equipment. Any and all travel through infested areas should be avoided or restricted to periods when spread of seed and propagules is least likely.

7.6.2.1.3 Containing New Invasions of Invasive Plants:

Regular monitoring of work sites for new invasive plants should be conducted both during management activities and for several years after activities have ceased.

Invasive species should be addressed or treated immediately.

7.6.2.1.4 Minimizing Transport of Invasive Plants to Uninfested Areas:

Sites where equipment can be cleaned safely without risking introduction or spread of invasive plants should be identified.

Equipment should be cleaned thoroughly and carefully before moving it into a project area and before leaving the project site. Mud, dirt, and plant matter should be removed from equipment before moving to another project area. Seeds and plant parts should be collected for disposal (e.g., burn, bury, dry, or bag and landfill) in a manner appropriate for the invasive plants being handled.

Work in infested areas should be avoided whenever possible, or postpone work until invasive plants have been eradicated from the site, if possible.

7.6.2.1.5 Maintaining Desirable Species and Revegetating Disturbed Areas:

Revegetation should be actively managed in those areas where it is not likely to occur naturally or will happen at such a slow rate that the area will be vulnerable to invasive plants.

Disturbed soil (except surfaced roads or areas that will receive ongoing disturbance) should be revegetated in a manner that optimizes plant establishment for that specific site. Revegetation may include planting, seeding, fertilizing, and mulching. Because fertilizing can encourage growth of invasive plants, it should be done with caution and it is not suitable in all situations.

Local seeding guidelines and appropriate mixes should be used. Many species previously recommended for the purpose are now presenting invasive problems; therefore, careful selection is imperative.

Only native or non-invasive exotic material should be used.

Revegetation efforts should be monitored and evaluated for success.

7.6.2.2 Wildlife

7.6.2.2.1 "At Risk" Wildlife Species and Their Habitat

Wildlife species considered to be most "at risk" from management activities include rare or uncommon species such as federally listed threatened and endangered species and State-listed threatened and endangered or species of concern (TES species), as well as those species that prefer or require habitats that may be sensitive to forest management. These habitats include wetlands, vernal pools, springs and seeps, reservoirs, lakes and ponds, and their associated riparian habitat.

These species and habitats are largely protected by the project review process that is in place (Appendix 1). Each vegetation management project is reviewed by a number of resource specialists within DEP and, where necessary, a wildlife biologist conducts site assessments. Local knowledge of State rare, endangered, and threatened species and their habitats are

considered, as are landscape considerations, where applicable. After completion of fieldwork by the wildlife biologist, the foresters are alerted to any potential conflicts between the proposed work and important habitat features and site-specific recommendations are applied. Additional recommendations related to specific habitat components to be considered in project design are included in Appendix 4.

7.7 Forest Management Strategy

The forest management strategy was developed by analyzing the forest inventory data using various combinations of vegetation characteristics to determine the appropriate treatments to meet the Guiding Principles, Goals and Objectives. The decision flowchart (Figure 37) outlines the thought process and data filtering behind the management strategy tables, attempting to simplify key information to produce estimates of potential needs and opportunities based on meeting desired vegetation conditions. Actual stand-level decisions should be produced from additional stand-level data and on-site evaluation by a professional forester. An approximation of the amount of each treatment is portrayed in Table 28, Table 29, and Table 30 at the end of this section.

7.7.1 Forest Management Strategy Treatments

The following treatments are identified to focus management activities and establish a priority-setting process. These treatments are not ranked, nor should they be considered hierarchical, but rather considered holistically across an identified treatment area. From an organizational and financial perspective, it is likely to be more practical and efficient to manage lands in local clusters with common access routes, especially given the fragmented nature of City water supply land ownership patterns (as opposed to large contiguous ownership similar to State lands). This would provide the opportunity to accomplish a variety of treatments with a mix of investment requirements as well as possible profitable returns (Kenefic and Nyland 2006). This effort can be combined with measures to reduce deer populations in a treatment area. Neighboring landowners can also benefit and contribute to the effect by timing their harvest activities in the same cycle. Recommended prescriptions are provided that identify potential methods to accomplish these treatments; however, professional foresters will determine specific methods after site-specific evaluations.

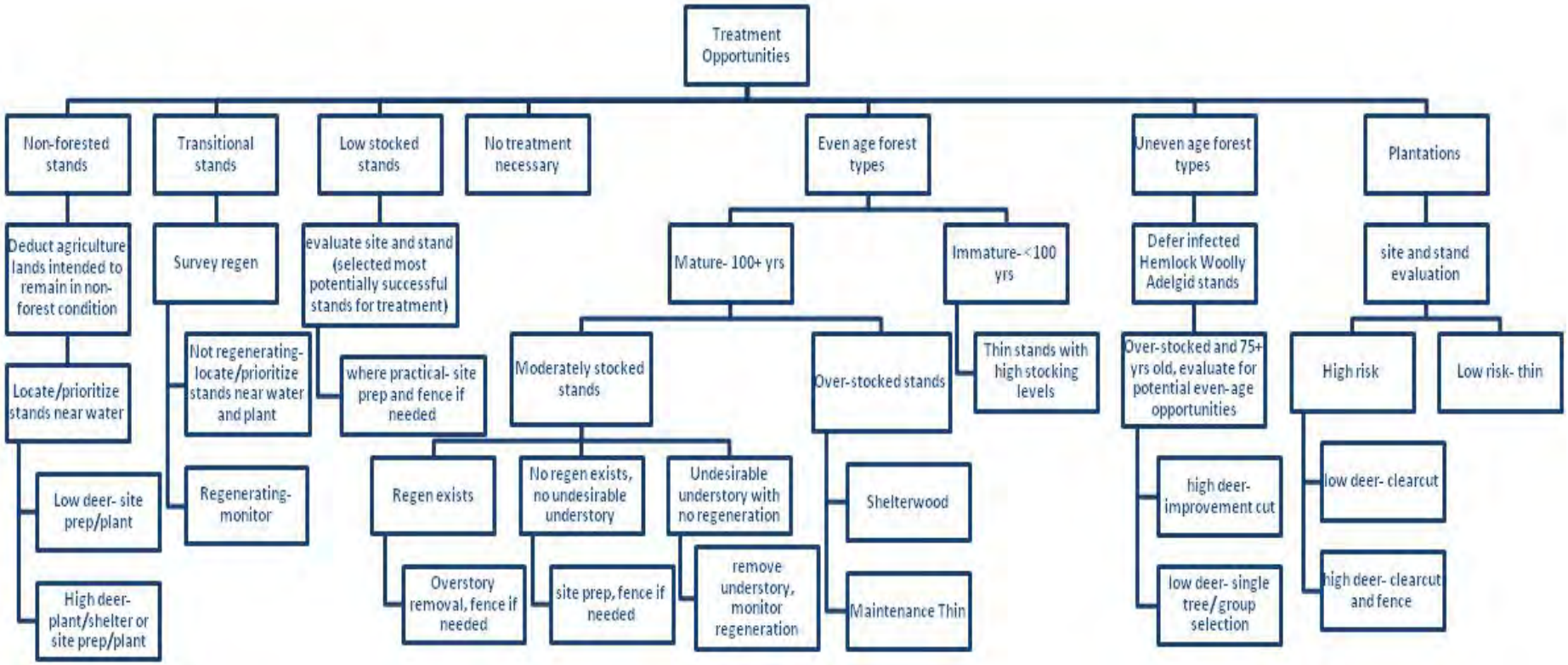


Figure 37. Management strategy treatment opportunity flowchart

7.7.2 Reforest Open Lands

Where forest cover is absent and there are no compelling reasons to maintain a non-forested condition, reforestation to promote forest cover in the future is desired. Those areas identified nearest water have the higher priority as they are directly associated with potential water quality impacts. These stands were identified through GIS, selecting all non-forested stands directly adjacent to streams and other delineated water bodies.

Within the inventory of land cover types, the category of "herbaceous" describes City water supply lands dominated by grassy or herbaceous vegetation. As a group, these sites offer the least effective forest vegetative protection for water quality. Although dense grass and herbaceous cover provides good filtration of stormwater (NYS Stormwater Design Manual 2010c), it generally lacks the protection and nutrient-uptake potential that forest cover provides. These are lands previously managed for agriculture and most likely located near streams and rivers with little forest area to act as a buffer. Some lands are dedicated to a specific use like preserving the farming heritage of the community. Most are abandoned and would eventually revert to forest cover if they were not controlled by deer browsing.

Prescription: These sites should be surveyed completely before deciding on a course of action. It is possible that natural regeneration could have developed, which would allow for monitoring its progress only. If deer impacts are low or if there is a concerted effort to control populations, natural regeneration could develop in the near term or the transition could be hastened by applying some more proactive work that could stimulate establishment of tree seedlings.

> *Artificial Regeneration:* Plant hardwoods, softwoods, or a mix raised in a nursery (Hargrave 2008), or cuttings of willow or poplar. To ensure that local genetic material is used, a seed or cutting collection program may be needed. Generally, hardwood planting stock has bulky root systems and planting holes are made with a hand-operated, power auger. Weed control around the planted stock is important. This can be done by removing the sod from the planting location, called scalping, or a mulch disk can be applied around the stem. If deer impacts are high and hardwoods are involved, it may be necessary to protect the planted hardwood material with tree shelters. When trees emerge from the tube and are above browsing height, the tubes should be removed. If not, the trees often rub against the top of the tube edge and damage the tree stem. Also, stems that are partially supported by tubes may not develop the caliper strength to resist wind, snow, or ice loading.
>
> *Natural Regeneration*: Prepare the site by scarification or disking, using agricultural disks with extra weights to break up the sod mat so that naturally falling, blown in, or applied seed has some access to soil. If deer impacts are high, resulting selected seedlings can be protected with tree shelters or the entire area can be enclosed in a fence.

In either case, where deer are a problem, area fencing may be the most efficient choice and no additional treatments are needed (McDonald and Hollingsworth 2009). Automated equipment is available to install either woven wire or electric fencing economically. This equipment works best in open areas with reasonable topography. The highest priority areas are often close to roads where electric power is available. These fenced areas are more accessible for maintenance and the fence condition can often be observed from a distance.

This treatment corresponds to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species-dominated areas.

GPI-4 Apply conservation practices to prevent adverse water quality impacts and reduce or eliminate soil erosion. Restore and reclaim detrimentally impacted areas for the control of point and nonpoint source pollution concurrent with forest projects where appropriate.

GPI-5 Designate special management zones around riparian, wetland and hydrologically sensitive areas (steep slopes, unstable geology, etc.) and establish specific management practices with objective standards to maintain and enhance ecological function to prevent sediment delivery.

GPI-7 Manage deer populations and other regeneration-limiting factors to restore the forest's ability to naturally regenerate.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.3 Transitional Stands

Another land cover type, "transitional," may be as important to treat as herbaceous. These acres are predominantly open, but inventoried as in transition to forest cover. During the inventory, areas were observed as having 10 percent or more of woody vegetation; however, the quality and quantity of the forest cover is unknown. Currently, these areas have the potential to develop forest cover in the future with potentially lesser investments than those without any forest cover. Many of these areas may be under intense deer browsing pressure which could substantially delay or prevent the transition from ever taking place.

Prescription: These areas need to be examined to determine if regeneration is adequate to produce forest cover. If regeneration is not occurring or deer are controlling regeneration, the site should be transferred to the reforestation group. If adequate regeneration is present, the site should be periodically monitored to ensure regeneration progresses. There is a risk that partial deer browsing will limit regeneration to the more deer-resistant species. When budgets are limiting, monitoring can be accomplished with a walk through of the area and notes of observations recorded. When time allows, it is better to take a statistical sample of 1/1,000-acre plots with all seedlings present recorded by species and the results totaled.

This treatment corresponds to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species-dominated areas.

GPI-3 Maintain forest stands through periodic treatment to maintain vigorous growing conditions and reduce forest competition.

GPI-6 Maintain and promote forest structural diversity while reducing competition to enhance resiliency.

GPI-7 Manage deer populations and other regeneration limiting factors to restore the forest's ability to naturally regenerate.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.4 Plantation Management

The most common plantation species is Norway spruce followed by Scotch pine and red pine. Other planted species include European larch, balsam fir, and white pine. Most of these plantations have a component of other species, with some having as much as 50 percent hardwoods. Generally, these are planted, nonnative conifers that have not been tended over the years. Some of these plantations are on the margins of reservoirs or adjacent to feeder streams. There is a short- and long-term risk that these plantations will be damaged by windstorm, creating considerable disturbance of the soils around them. If the trees are harvested or felled in place, that risk is averted, but the site is no longer forested. These stands could also be thinned to mitigate the risk, allowing the residual trees to increase root depth and structural integrity.

Prescription: Examine these stands to determine the best management strategy associated with maintaining water quality protection. Compare the risk of blowdown or decline to the risk of site disturbance that could degrade water quality protection. Consider factors like proximity to water, soil type, slope, species, age, and relative density. Analyzing these factors will yield the best course of action to protect water quality. For example, if the soil type causes trees to be shallow-rooted, the stand is tightly packed and exposed to high winds; it is a wind-throw risk. If the location is on the shore of the reservoir, it could be best to fell all the trees, but leave them in place to hold the soil until hardwood regeneration can be established. This retained material could also serve as a barrier to deer browsing. If the stands are more deeply rooted, thinning could be the best course of action. Variations include commercial harvests to remove or thin the stand and light, repeated thinning to reduce stocking gradually. In some cases, thinning around these hardwoods would allow them to develop larger tops and have a more secure position in the stand. Where there are other trees of several species, a group of plantation trees could be cut to provide space for natural regeneration. Control of deer populations and continued thinning could encourage hardwood colonization.

This treatment corresponds to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species-dominated areas.

GPI-3 Maintain forest stands through periodic treatment to maintain vigorous growing conditions and reduce forest competition.

GPI-6 Maintain and promote forest structural diversity while reducing competition to enhance resiliency.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.5 Regenerate Low-stocked Stands

Low-stocked stands provide minimal protection to the soil and water quality. Incomplete canopies or gaps reduce filtering and interception of precipitation. It is unlikely that these stands can re-grow to an adequate level of stocking in a reasonable amount of time. Also, resulting regeneration and residual trees will be of low quality and lack species diversity. Identifying specific treatment priorities in this category should consider the amount of existing forest regeneration, presence or absence of interfering vegetation, and deer impacts.

Prescription: The first step is to conduct a survey to identify the present condition, determine the most effective treatment method, and estimate cost and materials. There are a range of potential activities depending on site conditions and vegetation present. It may be possible to do nothing other than reduce deer population or install a fence to keep deer out. There may be some overstory trees that have value as high shade and seed source. There may be quality saplings or seedlings present that can be retained. These should be protected, while removing the remainder of the low-quality component, except to preserve species diversity. The best method of this site preparation depends on available equipment and the nature of the material to be removed. When there is a viable chip or energy market and the material is woody stems, site preparation can be accomplished by mechanical harvesters feeding a chipper (Devlin et al. 2007), or the work can be done by crews with chainsaws and the material left onsite. Mechanical harvesters can also be used to fell the same trees and leave them onsite. Other options include large brush hogs or flail devices that reduce the woody material to strips and chips. Rocks and slope make these methods more difficult and may eliminate the opportunity all together. It may be necessary to apply herbicides to grasses, forbs, invasive weeds, or other interference if it fully occupies the site and prevents regeneration from becoming established.

7.7.6 Regenerate Moderately Stocked Stands

Stands with moderate stocking may be able to grow back to full stocking if there is species diversity and the residual trees are vigorous and healthy. In this case, water quality might be compromised in the short run, but disturbance is avoided providing a net reduction in effects.

The long-term effects are the transition to a fully stocked situation with the benefits of protecting water quality over a shorter amount of time.

Prescription: A survey should be conducted to determine whether the stocking level is a product of an ongoing decline or a previous harvest. If the stand is not yet mature and has viable growth opportunity, it should be left to grow to a better level of stocking. If the stand is mature, take advantage of the current stocking level and treat it as an ongoing shelterwood. Site preparation may be needed to remove low shade and increase light availability as well as achieve 60 to 65 percent relative density. Monitor regeneration periodically. The overstory should be harvested and removed when established regeneration meets satisfactory levels. Area fencing may be needed to protect natural regeneration, and it may be necessary to apply herbicides to grasses, forbs, invasive weeds, or other interference if it fully occupies the site and prevents regeneration from becoming established.

7.7.7 Regenerate Mature Stands

When stands are mature, lack species diversity, and are subject to exotic pests regeneration is the best course of action. Using a shelterwood system provides interim forest cover while allowing for regeneration. It is likely that some site preparation would be required. If this is limited to cutting smaller trees to eliminate low shade, effects will be minimal. It may, however, be necessary to remove other understory plants by scarification, fire, or herbicide use. Once regeneration is established, the overstory is removed.

Shelterwood Prescription: Harvest trees so that 60 to 65 percent relative density remains, but not more than one-third of the overstory basal area. Retain a diverse species mix of trees that will provide high shade and filtered light. A site-preparation cut of smaller trees may be needed to remove low shade. If regeneration from oak and pine are desirable, conduct the harvest when the ground can be scarified by harvesting equipment (Brose et al. 2008, Dey and Fan 2009). It may be necessary to apply herbicides to grasses, forbs, invasive weeds, or other interfering vegetation if it fully occupies the site and prevents regeneration from becoming established. Monitor development of regeneration and remove the overstory when adequate levels of regeneration are established. If maples are a component of the regeneration and they are desirable, it may be best to remove the overstory in two stages to help establish the root systems and provide a gradual transition to full light. Area fencing may be needed to protect natural regeneration.

Two-Age Prescription: Some areas may be adjacent to or near a public road, exclusion zone, stream and wetland, or on slope above 33 percent where it may be necessary to apply a two-age management prescription. The object is to foster two age classes of trees. Two-age management can be used as a variant to the normal shelterwood system.

There are stands that already have a two-age structure. These are difficult to identify just from inventory data. They would have originated from a heavy harvest or other disturbance in the past, providing enough light for a new age class of trees. They can be detected through observation of diameter groups and character of the canopy. Generally, the larger trees in the stand will have broad tops with a mid or understory of pole and sapling size trees.

These regeneration treatments correspond to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species-dominated areas.

GPI-4 Apply conservation practices to prevent adverse water quality impacts and reduce or eliminate soil erosion. Restore and reclaim detrimentally impacted areas for the control of point and nonpoint source pollution concurrent with forest projects where appropriate.

GPI-5 Designate special management zones around riparian, wetland and hydrologically sensitive areas (steep slopes, unstable geology, etc.), and establish specific management practices with objective standards to maintain and enhance ecological function to prevent sediment delivery.

GPI-7 Manage deer populations and other regeneration limiting factors to restore the forest's ability to naturally regenerate.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.8 Maintenance Thin Mature Stands

During the period when not all mature stands can be regenerated at once and while solutions to deer populations are being developed, mature stands will continue to grow and competition between trees will increase. These can be thinned in the interim to preserve their health. Thinning under these conditions is different than thinning in an immature stand. Trees are larger and more difficult to harvest without damaging other trees or creating large gaps in the canopy. It is important to control the amount of light reaching the forest floor. If there is too much light and there are undesirable understory species present, those interfering or invasive plants could become dense ground cover and complicate regenerating the stand in the future.

Prescription: To reduce stress from crowding and provide growing space, thin stands to reduce relative density to 75 percent. This step is important to maintain viability and improve resistance to pathogens, but this treatment can also encourage interfering understory vegetation that will make regenerating the stand more difficult in the future. Select trees for cutting that are likely to die within the next two decades and thin between competing groups of trees. When deciding which trees to cut or leave, try to maintain species diversity in the stand. Avoid removing many of the shade-tolerant trees. These are better suited to crowded conditions and can provide important stocking for the future. Typically, in mature stands this treatment produces a greater proportion of sawtimber, and therefore, a light cut can be economically viable.

7.7.9 Thin Immature Stands

The physiology of trees requires continuous growth to maintain good health. The importance of this varies with different tree species and is expressed by the amount of shade tolerance a species has (Marquis 1969). It is important to maintain growing space within stands to reduce stress from competition for light, water, and soil nutrients. Crowding stress can act as an inciting factor in establishing other forest pathogens (Marquis et al. 1990). There may be some flexibility as to when crowding needs to be relieved, but generally once a stand reaches the stem exclusion stage or full stocking; the negative effects begin to increase. At the same time, the longer a stand remains fully stocked, the more difficult it is to correct.

Prescription: Thin to reduce crowding stress, provide room for growth, maintain species maturity, and improve growing stock quality. Remove up to 30 percent, but retain 70 percent relative density. Thin throughout the size classes, maintaining species diversity, and harvesting trees that are at-risk and low-quality, while providing evenly distributed growing space.

These thinning treatments correspond to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-3 Maintain forest stands through periodic treatment to maintain vigorous growing conditions and reduce forest competition.

GPI-6 Maintain and promote forest structural diversity while reducing competition to enhance resiliency.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.10 Uneven-age Management

Northern hardwoods and hemlock hardwood forest types were assumed for purposes of identifying treatment opportunities to have uneven-age management potential, due to the regeneration processes for these forest types and the higher amounts of shade-tolerant species in these groups. Other forest types and individual stands may well be candidates for this treatment, and would be considered by professional foresters during stand-level treatment identification. Stands where hemlock woolly adelgid is present should not be considered for this treatment as it might exacerbate the existing infection. Stands with at least 85 percent relative density and over 75 years old would be considered for this treatment. Data from the inventory are not sufficient to break out group selection or single-tree selection opportunities. Where deer impacts are high, these treatments would not be successful and fencing would be impractical, therefore a thinning could be applied to reduce stocking and improve stand structure.

Prescription: Generally, if there is good size distribution and stocking strongly favors shade-tolerant species, single-tree selection is a good approach. If there are irregular-sized populations and one-quarter or more shade-intolerant stocking, then group selection could be more appropriate. Desirable species regeneration in single-tree selection can be difficult to

achieve even when deer populations are under control. Often group selection provides a better chance for success.

For group selection, locate groups of mature or shade-intolerant trees in the field to cut as groups first. Include no more than one-fifth of the stand area in the groups. Groups with higher amounts of shade-tolerant trees should be in larger groups up to 2½ acres to encourage diversity in the future stand. Reduce stocking between groups if needed to reduce crowding stress and provide growing space.

This treatment corresponds to the following Objectives:

GPI-1 Prioritize treatments and measures to proactively address conditions such as invasive species outbreaks and other forest disturbance risks that have the potential to degrade forest cover or ecological health and diversity.

GPI-2 Restore, regenerate, and improve forest cover in areas that currently have less than desirable conditions. These areas include, but are not limited to forests that are poorly stocked or in declining health (from abiotic or biotic factors), former agriculture lands that currently do not have forested cover (those lands not under permit for other purposes), and invasive species-dominated areas.

GPI-3 Maintain forest stands through periodic treatment to maintain vigorous growing conditions and reduce forest competition.

GPI-6 Maintain and promote forest structural diversity while reducing competition to enhance resiliency.

GPI-7 Manage deer populations and other regeneration limiting factors to restore the forest's ability to naturally regenerate.

GPI-8 Promote and retain diverse species best suited to the site (soil and moisture) conditions.

7.7.11 No Treatment Necessary

Stands that are in good condition and are meeting the desired conditions do not require treatment at this time. Stand conditions are always evolving as the trees grow, tree recruitment and mortality occurs, and stand structure changes. These changes may occur gradually or may change rapidly from significant events such as insect outbreaks, weather events, etc. Therefore, though treatments are not prescribed at this time, the stands should be monitored for changes and will probably require treatment in the future as conditions change.

7.7.12 Management Strategy Treatment Acres

Table 28, Table 29, and Table 30 provide estimates of the potential acres of treatment, based on the inventory data analyzed. It is important to remember that this was a landscape-level inventory and statistical accuracy is low for individual stand data. There are many more factors and site conditions that require the judgment of a professional forester with local experience to evaluate and determine the best treatment for an individual stand. Product and volumes available in some of these treatments may not amount to a merchantable or saleable operation in some of the basins due to local market conditions.

The management strategy treatments were identified in areas designated in the conservation practices (section 7.5) as exclusion zones (EZ) and special management zones (SMZ) that require additional environmental review or treatment modifications; including steep slopes where operational equipment may not be currently available to implement treatments. The remaining forest area is the remaining City water supply land outside of EZs, SMZs, and steep slopes where these treatments would be applicable. Acres listed in EZ, SMZ, and steep slopes columns are estimates based on GIS analysis.

Table 28. Management strategy treatments for all City water supply lands

Management Strategy - All City water supply lands					
Treatment	**EZ**	**SMZ**	**Steep slopes**	**Remaining Forest Area**	**Total Proposed**
Reforest open lands	32	159	12	1,052	1,255
Reforest open lands nearest water	140	443	16	1,367	1,966
Transitional stands	112	229	24	1,094	1,459
Plantation management	111	453	40	1,442	2,046
Regenerate low-stocked stands	65	272	146	840	1,323
Regenerate moderate-stocked stands	94	401	123	987	1,605
Regenerate mature stands	108	465	144	1,052	1,769
Maintenance thin mature stands	193	827	262	1,866	3,148
Thin immature stands	435	1,798	2,800	9,741	14,774
Uneven-age management	338	1,938	3,942	6,973	13,191
No treatment necessary	1,964	7,033	9,537	32,687	51,221
Totals	3,592	14,018	17,046	59,101	93,757

Source: Forest Inventory 2009-2010

Table 29. Management strategy treatments for East of Hudson Watershed water supply lands

Management Strategy – East of Hudson					
Treatment	**EZ**	**SMZ**	**Steep slopes**	**Remaining Forest Area**	**Total Proposed**
Reforest open lands	5	23	1	57	86
Reforest open lands nearest water	14	18	1	17	50
Transitional stands	2	12	0	89	103
Plantation management	24	98	4	113	239
Regenerate low-stocked stands	17	48	5	96	166
Regenerate moderate -stocked stands	64	294	75	547	980
Regenerate mature stands	64	316	87	535	1,002
Maintenance thin mature stands	114	561	155	951	1,781
Thin immature stands	184	585	216	1,893	2,878
Uneven-age management	75	307	35	383	800
No treatment necessary	1,038	2,629	509	6,506	10,682
Totals	1,601	4,891	1,088	11,187	18,767

Source: Forest Inventory 2009-2010

Table 30. Management strategy treatments for West of Hudson Watershed water supply lands

Proposed Management Strategies – West of Hudson					
Activity	**EZ**	**SMZ**	**Steep slopes**	**Remaining Forest Area**	**Total Proposed**
Reforest open lands	27	136	11	995	1,169
Reforest open lands nearest water	126	425	15	1,350	1,916
Transitional stands	110	217	24	1,005	1,356
Plantation management	87	355	36	1,329	1,807
Regenerate low-stocked stands	48	224	141	744	1,157
Regenerate moderate -stocked stands	30	107	48	440	625
Regenerate mature stands	44	149	57	517	767
Maintenance thin mature stands	79	266	107	915	1,367
Thin immature stands	251	1,213	2,584	7,848	11,896
Uneven-age management	263	1,631	3,907	6,590	12,391
No treatment necessary	926	4,404	9,028	26,181	40,539
Totals	1,991	9,127	15,958	47,914	74,990

Source: Forest Inventory 2009-2010

7.8 Harvesting Equipment

Implementing harvest practices requires the use of a wide variety of mechanical equipment from chainsaws to boom-mounted processing equipment that can cut, limb and buck a tree; skidding or forwarding equipment (typically either rubber-tired or tracks) to take the logs from the woods to the landing, and processing equipment at the landing to buck and process logs for shipment. Logging trucks transport logs from the landing to the sawmill or other production facility.

Harvest activities and associated traffic typically are short-term in duration, and localized to a specific forest management project, with harvest and transportation activities occurring over 3 to 6 months. Logging truck traffic typically ranges from two to six trucks per day, depending on operational production. Existing contract requirements limit operations during high recreational traffic periods and adjacent to noise receptors to minimize impacts from noise and traffic.

The types of skidding equipment commonly used have either rubber tires or metal tracks, and either a winch and cable or grapple system to gather logs for skidding to the landing. Many variables (availability of equipment, period of operations, skidding distance, soil and water characteristics, and topography) influence the site-specific decisions on type of logging systems to be used.

Forwarders and cut-to-length systems utilize equipment that can harvest and process the tree in the woods and then transport the processed logs to the landing.

Other types of logging equipment (cable and skyline systems) exist that may be used in future projects, but are uncommon in the local area. Cable and skyline systems utilize cables and carriages to bring logs uphill to a landing, without the use of mechanical equipment within the treatment unit. These systems are typically used on very steep slopes where ground-based mechanical equipment cannot operate.

There are no restrictions on equipment type that can be used to implement projects that are designed under the Plan; however, during site-specific evaluation and project planning certain restrictions on equipment may be identified to address site-specific concerns. Additionally, certain types of equipment may be required for projects with site conditions, such as aquic soils, that require specialized equipment.

7.9 Economic Effects of the Management Strategy

7.9.1 Employment and Labor

Economic effects resulting from treatments identified in the management strategy use an annual average of the treatment levels and timber volumes corresponding to the East and West of Hudson management strategies over the initial 10-year timeframe (starting in year 2012 and ending in 2021). Treatment activities and volume harvested would have direct, indirect, and induced effects on local jobs and labor income.

Table 31 displays both direct and total (direct, indirect, and induced) effects for employment (part- and full-time) and labor income that may be contributed from the management strategy. Treatment actions without cost recovery (reforestation and evaluation) would result

in less than one part- and full-time job on an average annual basis in the East of Hudson watershed economy.

Table 31. Average annual employment and labor income

	East of Hudson Watershed Economy				West of Hudson Watershed Economy			
	Employment (full and part-time)		Labor Income (2011 dollars)		Employment (full and part-time)		Labor Income (2011 dollars)	
	Direct	Total	Direct	Total	Direct	Total	Direct	Total
Treatment costs	0.03	0.03	$857	$1,059	4.6	5.4	$103,768	$132,241
				Sawtimber				
removal	2.2	3.0	$68,570	$108,497	8.5	12.7	$262,092	$424,973
processing	1.8	2.8	$74,055	$135,664	6.9	12.6	$283,060	$533,253
Total	**4.0**	**5.9**	**$142,625**	**$244,162**	**15.4**	**25.3**	**$545,152**	**$958,226**
				Potential Low-grade wood products				
removal	3.3	4.5	$101,639	$160,822	11.8	17.7	$364,765	$591,451
processing	3.7	5.8	$152,458	$279,293	13.3	24.3	$547,147	$1,030,764
Total	**7.0**	**10.3**	**$254,097**	**$440,115**	**25.1**	**42.0**	**$911,911**	**$1,622,215**

Source: IMPLAN 2009

In the West of Hudson Watershed economy, these treatments could contribute 4.6 direct part- and full-time jobs in the Support Activities for Agriculture and Forestry sector, in addition, about 1 indirect and induced part- and full-time job (for a total of 5.4 part- and full-time jobs) on an average annual basis.

Potential sale of sawtimber could contribute 4 direct part- and full-time logging and timber processing job, in addition to about 2 indirect and induced part- and full-time jobs (for a total of 5.9 part- and full-time jobs) on an average annual basis in the East of Hudson watershed economy. In the West of Hudson watershed economy, the potential sale of sawtimber could contribute about 15 direct part- and full-time logging and timber processing jobs, in addition to 10 indirect and induced part- and full-time jobs (for a total of 25 part- and full-time jobs) on an average annual basis.

In addition to the potential sale of sawtimber, treatments under the management strategy would make low-grade material available. The opportunities presented in the Forest Management Plan suggest the sale of this material may be possible. If utilized, this low-grade material would provide about 10 total part- and full-time jobs in the East of Hudson watershed economy, and about 12 part- and full-time jobs in the West of Hudson watershed economy on an average annual basis (see Table 32).

Combining all effects from the treatments that occur without cost recovery, the sale and removal of sawtimber, and the potential sale of low-grade material; the direct contributions to the logging, timber processing and forestry support sectors would constitute about 1 percent of current employment and income in the East of Hudson watershed economy and less than 2 percent of current employment and income in the West of Hudson watershed economy.

In addition, volume estimates over a second 10-year timeframe are used to measure the economic effects resulting from shelterwood overstory removal treatments that do not occur in the first decade. It is anticipated that these treatments would start in year 2022 and end in 2031. The potential sale of sawtimber from these shelterwood overstory removals in the second decade could contribute 19 direct part- and full-time logging and timber processing jobs, in addition to 11 indirect and induced part- and full-time jobs (for a total of 29 part- and full-time jobs) on an average annual basis in the East and West of Hudson watershed economy.

7.9.2 Costs and Revenues from Management Strategy Treatments

Using an annual average of the treatment levels corresponding to the East and West of Hudson management strategies and the cost of these treatments, the annual cost of treatment under the management strategy would be $325,072 in the East of Hudson watershed and $585,869 in the West of Hudson watershed. In addition, the discounted present value of these annual costs (for first decade treatments) would be $2.85 and $5.14 million in the East and West of Hudson watersheds, respectively (Table 32). Annual revenues from sawtimber would be $237,267 and $906,899 from the East and West of Hudson watersheds, respectively. These revenues (estimated at average annual current prices) would cover costs of treatment in West of Hudson basins however, would not cover costs in East of Hudson sub-basins combined. Consequently, the net present value for first decade treatments would be negative $769,940 in the East of Hudson and a positive $2.8 million in the West of Hudson watersheds. The negative net present value for the East of Hudson watershed is largely due to the high cost of fencing and installation and the extent of acreage needing fencing. The minimum price required for sawtimber to cover the cost of treatment under the management strategy would be $342 and $161 per MBF in the East and West of Hudson watersheds, respectively.

Table 32. Discounted costs of treatments, revenues from forest products, and net present values

	East of Hudson 1st Decade Treatments	West of Hudson 1st Decade Treatments	East of Hudson 2nd Decade treatments	West of Hudson 2nd Decade treatments
Cost of treatments	$2,850,488	$5,137,363	$730,662	$2,138,905
Sawtimber revenues	$2,080,548	$7,952,416	$3,554,789	$5,154,303
Net-present value	$(769,940)	$2,815,054	$2,824,127	$3,015,399
Benefit-to-cost ratio	0.7	1.5	4.9	2.4
Potential low-grade revenues	$140,896	$505,651	$136,751	$234,188

Incorporating costs and revenues from second decade treatments yields far different results than in the first decade. By considering the cost and revenues from additional volume with shelterwood overstory removal during the second decade, the net present value over both decades increases substantially to $2.82 million and $3.02 million in East and West of Hudson watersheds, respectively. Thus, under current price and cost assumptions, benefits exceed costs when sawtimber revenues from shelterwood overstory removal in the second decade are considered. In order for costs to justify treatments in the second decade, the price of sawtimber would need to be $50 and $89 per MBF for revenues to cover costs in East and West of Hudson watersheds, respectively.

7.9.3 Ecosystem Services (benefits of forest management for water quality and cost avoidance related to filtration)

Incorporating the value of ecosystem services provides for consideration of water quantity and quality contributions from City forests. The cost of treatment would be same as presented above, and the potential for sale of sawtimber would also be the same. However, assuming no sawtimber is sold, the cost of treatments can be justified solely on an estimate of value communities in the area and in New York City could place on water from forest management (of $190 for 100,000 gallons of water; Romm et al. 1987). Using this value, only 459 and 828 million gallons would need to be produced annually from City forests in the East and West of Hudson watersheds to justify the discounted costs of treatment in the first decade (Table 32). In 2009, New York City water consumption was 1,007 millions of gallons per day (City of New York 2011), thus, the value of daily consumption in the City (in terms of the value of water from forest management) would cover the annual cost of treatment.

The value of water filtration can also be evaluated in terms of household value for groundwater protection. Over 3.3 million households in New York City and upstate New York depend upon water supplied in part from City forests. Estimates of community value for groundwater protection ($77.50 per household; Schultz and Lindsay 1990) suggest these communities conservatively value groundwater protection at $260 million dollars annually. The cost of treatment under the management strategy represents only 1 percent of this value.

8. FOREST MANAGEMENT IMPLEMENTATION

The management strategy provides the impetus to increase projects executed by the Forest Management Program by several magnitudes compared to the current management levels. DEP will develop an implementation strategy that considers the recommendations outlined below, staff and financial resources, agency and program priorities, other recommendations in this Plan and on the ground realities (access, local ordinances, deer impacts, etc.). It is expected this implementation strategy be in a form so that this Plan can be implemented beginning in 2012, and follow the schedule outlined below.

8.1 Implementation Recommendations

The following recommendations can be used to leverage existing resources or expand capacity without significant investments or increased staffing levels.

8.1.1 Increasing Efficiencies

Identifying processes that support project planning will increase productivity and incorporating recommendations for inventory and data refinements will allow for increased efficiencies in prioritizing projects and scheduling resources. Increasing staffing opportunities through contracts with professional foresters, temporary or permanent hiring may improve program capacity.

8.1.2 Stewardship Contracts

This method could utilize outside entities, such as foresters, forestry consultants, loggers, arborists, etc., that are responsible for many aspects of forest management. The stewardship contractor is responsible for all forest management activities within the contract area

(invasive species control, inventory, road improvements, infrastructure development, etc.) as specified in the contract. Stewardship contracts could be managed by the DEP Forestry Program.

8.1.3 In-house Harvest Crews

Developing additional capacity within DEP utilizing Operations staff during down periods and off-season can also be used to increase productivity and fully utilize existing staff and personnel. This may be especially useful for small-scale timber stand improvement projects in which staff could be mobilized for shorter periods of time such as during the winter.

8.2 Implementation Schedule

8.2.1 2012

By May 31, 2012, DEP will strive to initiate at least eight[2] forest management/forest stewardship projects. Planning would begin for following years, and DEP will develop a Forest Project Timeline for forest management/forest stewardship projects to be initiated in 2013, 2014, 2015 and 2016.

8.2.2 2013, 2014, 2015 and 2016

During 2013, 2014, 2015, and 2016, DEP will revise the Forest Project Timeline as needed and continue to initiate/implement projects and present projects at semi-annual FITT meetings. DEP will also strive to continue to initiate at least eight forest management/forest stewardship projects per year.

8.2.3 2015 and early 2016

In 2015 and early 2016, DEP will begin planning for updating the Forest Management Plan.

8.2.4 2016 (late) and 2017

In late 2016 and 2017, DEP will update the Forest Management Plan, with a target completion date of December 24, 2017.

9. FOREST MANAGEMENT PLAN MONITORING RECOMMENDATIONS

Effective, efficient and repeatable monitoring provides valuable information on adapting the Forest Management Plan to best meet the Guiding Principles, Goals and Objectives. Measurable Criteria identify metrics to gauge how well the implementation of the Forest Management Plan is meeting the defined objectives. These metrics will be further defined and timeframes for monitoring will be established after the Forest Plan Implementation strategy is developed. Monitoring of these criteria will occur with the intent of adapting

[2] This figure reflects "average" forest management projects of around 100 acres. Number may vary depending on the size of projects, for example-to address deer regeneration issues and take advantage of economies of scale, DEP may initiate larger-acreage projects (i.e., 400 to 800 acres).

management practices to better address the goals and objectives, and to identify needs for amending the Forest Management Plan to improve directions guiding management practices.

9.1 Forest Management Plan Monitoring

9.1.1 Guiding Principle I – Forest cover promotes high water quality

Objective[3]	Measurable Criteria
GPI-1	Develop and update action plan by basin
GPI-2	Forested acres restored
GPI-3	Acres treated with maintenance treatments
GPI-4	Implementation and Effectiveness monitoring
GPI-5	Acres treated within special management zones
GPI-6	Acres treated to promote structural diversity
GPI-7	Regeneration success (acres successfully regenerated)
GPI-8	Acres treated where species mix is modified

9.1.2 Guiding Principle II – Watershed forests provide multiple benefits

Objective	Measurable Criteria
GPII-1	Change in specific habitat components by basin
GPII-2	Change in key habitat components by basin.
GPII-3	Acres treated incorporating aesthetic and recreational considerations
GPII-4	Amount of forest products provided, employment measure (contracts awarded, forest jobs provided)
GPII-5	Acres treated maintaining or enhancing forest cover

9.1.3 Guiding Principle III – Knowledge and information sharing

Objective	Measurable Criteria
GPIII-1	Number of opportunities for public information provided
GPIII-2	Reporting of monitoring items identified

10. Conservation Practices Effectiveness Monitoring

Following the recommendations provided in U.S. Forest Service Handbook 2509.22 R-1/R4 Amendment No. 1 (USDA Forest Service 1988), monitoring should be conducted in the following steps. New York State best management practices review process is another example that can be followed.

[3] Objectives are described in Section 3.1.

The primary intent of this monitoring is to evaluate the effectiveness of the Conservation Practices in meeting the intent of the Practice, and to provide a feedback mechanism to modify the Practice if necessary to meet the protection intent of the Practice.

10.1.1 Monitoring

Monitoring is the first step of the feedback mechanism. It is designed to answer questions about site-specific Conservation Practice development, application, and effectiveness. Specific questions may be:

- Were the appropriate conservation practices included in the project?
- Did the project follow the plan?
- Are the Conservation Practices technically sound and appropriate for the specific site conditions?
- Is there a better Conservation Practice to apply, which is technically sound, economically feasible, within institutional authority, and that protects the resources?
- Were the Conservation Practices applied in total concept or only partially employed?
- Were personnel, equipment, funds, or training lacking, which resulted in incomplete or inadequate application?
- How effective were the site-specific Conservation Practices in meeting the evaluation criteria?

Monitoring also is designed to provide answers about the appropriateness of practices in maintaining or protecting soil and water resources and water-related beneficial uses. Some questions may be:

- Are the practices protecting the soil and water resources and beneficial uses?
- Do the parameters that are monitored establish the right indices to indicate protection of resources or uses?
- Do the Conservation Practices protect water quality and promote beneficial uses?

To monitor all aspects of site-specific Conservation Practices, an appropriate mix of both extensive and intensive monitoring is needed and performed at established intervals. Extensive monitoring is the primary means that the DEP will use to evaluate the development, application, and effectiveness of Conservation Practices. It can be characterized by use of project reviews and collection of both quantitative and qualitative information on nearly all project activities. Intensive monitoring tends to be more costly than extensive monitoring, and will be restricted to the determination of cause-and-effect relationships and specific Conservation Practice effectiveness both on a representative sample basis. This type of monitoring obtains mostly quantitative information.

10.1.2 Evaluation

- Evaluation is the second step in the feedback mechanism. To evaluate monitoring information and judge the effectiveness of site-specific Conservation Practices, evaluation criteria must be defined. These criteria should be defined in quantitative terms, whenever possible. These criteria should recognize and consider the attributes and characteristics of the particular resource or use, natural variability and background, limits of acceptable change in magnitude and duration, transport mechanisms and pathways, time-delayed effects, and risk.

- In design of monitoring and during evaluation, certain elements in the application of Conservation Practices must be recognized and acknowledged. The first of these is that a certain risk of failure is inherent in each site-specific Conservation Practice utilized. The magnitude of risk is a balance between the value of the resource(s) to be protected, cost of the impact of Conservation Practice failure, and the cost of additional units of protection. Monitoring and evaluation must not only measure effects, but must determine when a design failure point has been exceeded.
- Another consideration is recognition that the link between land management activities and the resulting impacts on soil and water resources and water-related beneficial uses is not always well understood. Monitoring and evaluation must be designed to improve knowledge of this link and to provide an early warning system where little research information exists for guidance. Where adequate research information exists for similar conditions, the use of site-specific Conservation Practices that are designed and based on this information can be reasonably expected to protect the soil and water resources and beneficial uses. In this case, monitoring and evaluation need not be so intensive.
- The use of sometimes inappropriate State Water Quality Standard Criteria in evaluation is another element to recognize. With existing technology, it is extremely difficult to determine the background levels and variability to a level of precision and accuracy necessary for direct control by numeric State Water Quality Standards. This difficulty is particularly evident when considering the tremendous temporal and spatial variability of soil and water resources and water-related beneficial uses. Because many existing water quality standards do not recognize this variability, they may be of limited value as evaluation criteria for nonpoint source activities. For this very reason, State Water Quality Standards for nonpoint sources in conjunction with Conservation Practices are also monitored, evaluated, and adjusted, if necessary. Without any adjustment, there is a danger that site-specific Conservation Practices will be required that are technically sound and feasible, but are of little or no value in protecting soil and water resources and beneficial uses.

10.1.3 Adjustment

- The last step of the feedback mechanism is adjustment. If monitoring and evaluation indicate evaluation criteria not being met, an adjustment of the site-specific Conservation Practices is needed. This adjustment will vary depending upon the type and severity of the impact to the soil and water resource or beneficial use. For minor or moderate impacts, the conservation practice will be redesigned or upgraded to assure the criteria are not exceeded. When the impact is major, the project activity will be reevaluated, redesigned, or may be stopped until appropriate measures are taken to correct. Corrective actions to prevent or minimize the impact will be initiated immediately. Additionally, the appropriate evaluation criteria are reviewed for adjustment.

This feedback mechanism is an iterative type process. Through the continuous cycle of monitoring, evaluation, and adjustment of Conservation Practices and/or evaluation criteria, the site-specific Conservation Practices will lead to achievement of evaluation criteria (that is, State Water Quality Standards and Forest Management Plan Guiding Principles) and protection of soil and water resources and beneficial uses.

11. FUTURE FOREST MANAGEMENT PLAN RECOMMENDATIONS

11.1 Components of Future Forest Management Plans

11.1.1 Land Acquisition Policy

Appraisers under contract to the City since 1997 have stated that with the exception of certain large and well-stocked properties, watershed land being appraised should not include value for standing timber because in the case of fee simple, the market does not appear to place measurable additional value on the resource, and in the case of conservation easements the landowner retains the right to timber. As a result of this approach, many landowners cut their timber prior to selling in fee simple to the City. The investment required to restore forest cover on those properties acquired by the City where poor forestry practices have occurred can be high and take decades. The City should investigate mechanisms to incentivize the conveyance of standing timber resources to the City. Continue to work with the Land Acquisition Program to identify properties to purchase which will help keep large tracts of forested land protected.

11.1.2 Implementation Schedule

Annually develop an implementation schedule and action plan with a 5-year planning horizon to identify treatment areas in manageable blocks or areas where best opportunities lie. Provide direction on outyear infrastructure, access and regeneration needs (seed plans, nursery stock production, contractors, etc.), as well as budget estimates to support program needs.

11.2 Future Data Needs

This inaugural Plan utilized existing information from many sources within DEP that DEP personnel collected, mostly for other purposes. These included DEC wetland and National Wetland Inventory data, FLIR deer surveys, hydrology and soils data, as well as other data sets. The forest inventory collected during 2009–2010, was the primary dataset collected primarily for Plan development. Many additional data needs will be necessary to support forest management activities and for future analysis and Plan revisions.

Many of these mapping and data collection needs can be accomplished in a methodical manner by using the Implementation Schedule to identify manageable portions of the Watershed to be inventoried and mapped on an annual basis.

11.2.1 Stand-level Inventories

To be able to plan forest management activities to implement the management strategy, stand-level information is critical. Professional foresters and other resource specialists need site-level information to support management decisions at the stand level.

11.2.1.1 Stand Delineation Revision

The stand delineation process used for the Forest Management Plan was based on two data sources (lands before 2003 used a landscape remote sensing to define stand boundaries), and

for lands acquired since then, aerial photo interpretation with some ground-truthing was completed.

To be efficient in implementing the Management Strategy, and identify site-specific treatment opportunities, the existing Stand GIS database should be revised, updating all stand polygons to reflect both ground-level vegetation characteristics, but also incorporating additional protocol for GIS and data accuracy. This revision should be completed prior to large-scale forest inventory, so that the most accurate data collection can be completed.

11.2.1.1.1 Non-forested Lands

Land cover typing was completed at a coarse scale, and requires refinement of the classification definitions and delineation protocols to provide consistently defined stand polygons for the watershed. Land cover typing was defined at two levels—stand delineation aerial photo interpretation and previously defined general categories (shrub, herb, non-forest). Data collection for these stands was qualitative; therefore, additional site information is necessary to support this refinement.

11.2.1.1.2 Activities and Accomplishment Tracking

A planning and activities tracking system integrated into Watershed Lands Information System (WaLIS) will be useful to support monitoring, activity tracking and reporting, and outyear planning for data collection and project development. This system could support all data needs for future project planning to be coordinated during the Forestry Interdisciplinary Technical Team (FITT) meetings.

11.2.1.2 Invasive Species Inventories

More site-specific, forest project-focused inventories should be planned to support outyear planning of actions. The Invasive Species Working Group will be providing assistance during FITT meetings to prioritize needs.

11.2.1.3 Deer Impact Assessments

Implementation of deer impact mitigation measures, either fencing, deer management assistance program (DMAP), or other deer reduction programs will be necessary to fully implement the Management Strategy. Assessing the effectiveness of the measures, and the success in regeneration establishment will be important for adapting the measures to be more successful in future applications.

11.2.2 Stream Mapping

The existing stream maps available are of various origins and intensities. DEP is currently mapping all larger order streams in the Watershed. Additional mapping of smaller order streams, and especially headwater streams will provide better site-specific information for forest project planning.

11.2.3 Wetland Mapping

More detailed wetland mapping will provide better site-specific information for forest project planning. DEP is currently collecting wetland location information on each of its forestry projects.

12. APPENDICES

Appendix 1– DEP Forest Management Projects and Conservation Practices

INTERNAL GUIDANCE DOCUMENT

DEP Forest Management Projects And Conservation Practices

October 29, 2010

Table of Contents

LIST OF ACRONYMS

ACOE	Army Corps of Engineers
BEPA	DEP Bureau of Environmental Planning and Analysis
BMPs	Best Management Practices
BWS	DEP Bureau of Water Supply
CEQR	City Environmental Quality Review
CFR	Code of Federal Regulations
CRW	Critical Resource Water
DEC	New York State Department of Environmental Conservation
DEP	New York City Department of Environmental Protection
EHS	Environmental Health and Safety
ECL	New York State Environmental Conservation Law
ERA	Ecological Research and Assessment Group
FITT	Forestry Interdisciplinary Technical Team
GIS	Geographic Information System
GPS	Global Positioning System
MSDS	Material Safety Data Sheets
NRCS	National Resource Conservation Service
NRM	Natural Resources Management Section
NWP	Nationwide Permit
NYCRR	Codes, Rules and Regulations of the State of New York
NHP	New York National Heritage Program
RRE	Division of Regulatory Review and Engineering
SEQRA	State Environmental Quality Review Act
SHPO	State Historic Preservation Office
SOP	Standard Operating Procedure
SWP	Safe Work Plan
WaLIS	Watershed Lands Information System
WLCP	Division of Watershed Lands and Community Planning
WQ	Directorate of Water Quality
WWQO	Division of Watershed Water Quality Operations

USFS	United States Forest Service
USFWS	United State Fish and Wildlife Service

1. INTRODUCTION

The New York City Department of Environmental Protection (DEP), along with many other water suppliers, has recognized that forest cover is the best land use for large-scale watershed protection. Since maintaining forest cover has significant, demonstrated benefits for water quality protection, typically at reduced expenditure when compared to more conventional options like filtration, many major public water supply managers, including DEP, have committed to acquiring and managing forested land within their watersheds to aid in the production of high-quality drinking water.

Forests contain natural resources in addition to trees that are important not only for potential water quality protection, but also for their own intrinsic value. Some examples include wetlands, vernal pools, springs, riparian areas, and threatened and endangered species. This document contains a framework for conducting forest management projects while managing and/or protecting these co-existing resources.

2. PROCESS

2.1 Introduction

- The process of developing individual DEP forest management projects and when and how other DEP staff are involved is critical to the highest level of protection for the water supply and the watershed.
- This document outlines the internal process for developing a Forest Management Project including coordination with other DEP groups, compliance with regulatory requirements and protection of other natural resources. The project review flowchart and associated time frames are included in Appendix A.

2.2 Forestry Interdisciplinary Technical Team

- The Forestry Interdisciplinary Technical Team (FITT) is modeled after the DEP SEQRA Tech Team and the Interdisciplinary Review teams that the USFS promotes. The FITT will review projects, participate in field assessments and provide a broad array of in-house technical expertise.
- The following groups will be invited to participate in the FITT:
    - Bureau of Water Supply: Natural Resources Management (Forest Management Group, Ecological Research and Assessment Group, and Recreation Group), Stream Management Group, Wildlife Studies Section, Regulatory and Engineering Programs, and Operations.
    - Bureau of Environmental Planning and Analysis

2.3 Semi-Annual Forestry Meeting

- On a semi-annual basis Forest Management staff and other FITT members will meet to review ongoing and proposed projects. Other DEP staff will be

invited as appropriate. These meetings will provide a brief summary and tentative schedule for each proposed project and a status update for active projects. These meetings will serve as a forum in which to resolve any issues with existing project implementation, project review protocols, and conservation practices, and to provide an introduction to potential upcoming projects. Additional meetings will be arranged as necessary if project-specific issues arise.

2.4 Expedited Procedures

- If forest management is needed on an urgent basis, the process and conservation measures detailed in this document will be followed to the maximum extent possible. Forest management situations that warrant expedited procedures include but are not limited to: responses to forest pest infestations, storm damage events (i.e. blowdowns, tornados, ice storms, etc.) that may threaten public health and safety, or instances where failure to expedite silvicultural treatment could lead to negative water quality impacts. All FITT members will expedite reviews and field participation for these cases. Review time frames will be determined on a case-by-case basis depending on the type and severity of the situation. The determination of whether a particular project warrants expedited procedures shall be made by the Director of Watershed Protection and Planning.

2.5 Project Phases

2.5.1 Initiation Phase

The Initiation Phase is the first project phase of a forest management project. During the Initiation Phase, the Project Forester will select the site, develop a Conceptual Project Plan and Maps, and hold a field meeting(s) with the FITT to get initial input on any concerns or fatal flaws with the proposed project. At the end of the Initiation Phase the Project Forester will recommend whether to pursue, modify, postpone or abandon the proposed project. Details of the Initiation Phase include:

- Site Selection: Project site selection will be governed by the priorities set forth in the Forest Management Plan. Once a site has been selected, the Project Forester will develop a Conceptual Project Plan, Concept and Vicinity Maps.
- Conceptual Project Plan: The Conceptual Project Plan will include a brief description of the proposed project, a statement of purpose, and the Concept and Vicinity Maps.
- Concept and Vicinity Maps: Concept and Vicinity Maps will be based on available GIS data. Information to be included in the Concept and Vicinity Maps can be found in Appendix B. Ideally, Conceptual Project Plans and initial Maps will be provided to the FITT during or immediately prior to the semi-annual meeting.

- Field Visits: One or more field visits will be conducted during the initiation phase. At least one field visit will be conducted with all available members of the FITT. The Project Forester will provide a written summary of identified issues or concerns following the field visit(s). FITT members are encouraged to submit comments to the Project Forester within 2 weeks of the field visit so that concerns can be addressed early in the project planning phase.
- Site-specific Issues: Site-specific concerns for endangered, threatened species or species of special concern as well as natural, historic and archaeological sensitive areas will be identified through the internet or other resources. Project Forester will submit a request to the NY Natural Heritage Program and the State Historic Preservation Office for project review and referral to other groups within DEC as appropriate.
- The State classification of any stream on site will be identified. Any stream classified with the T (trout) or TS (trout spawning) modifiers will be highlighted in the project plan and special protections may be required to sustain those fisheries.
- At the end of the Initiation Phase the Project Forester will recommend whether to pursue, modify, postpone or abandon the proposed project. This recommendation will consider factors such as the priority of the silvicultural work as identified in the Forest Management Plan, site-specific concerns for other resources in the project area (e.g. wetlands, endangered species or historic resources) and impacts on operational needs. The Chief of Watershed Lands and Community Planning will review all recommendations and make a final decision.

2.5.2 Planning Phase

The Planning Phase is the second project phase of a forest management project. During the Planning Phase, the Project Forester will work with the FITT to develop the Draft Project Plan and the Draft Project Map, incorporating FITT comments, and will submit the project to BEPA for SEQRA/CEQR review. Federal, state, or local permitting processes will be initiated as appropriate. Tree marking may occur during the latter stages of the Planning Phase. Details of the Planning Phase include:

- Draft Project Plan: The Draft Project Plan will be a refinement of the Conceptual Project Plan based on FITT feedback, field reconnaissance and project-specific details on applicable regulations and restrictions as well as any unusual potential impacts. It will also include detailed information on current and desired forest conditions, silvicultural prescription(s), information on project closure, road development and/or improvement, and project-specific notification contacts.
- Draft Project Map: The Draft Project Map will be a refinement of the Concept Map, and will include field-delineated features and site-specific information on soils, skid trails, landings, stormwater controls, SHPO sites, threatened or endangered species or species of special concern, and any other

details pertinent to execution of the project. Water features, such as wetlands, within 100 feet of the project area boundaries will also be included to ensure all appropriate Special Management Zones are included. Information to be included in the Draft Project Map can be found in Appendix B.

- Project Closure Plan: A Project Closure Plan will be developed for each forest management project. Items in the Project Closure Plan will be included in the bid documents and will be clearly explained during the contractor orientation. At a minimum it will include the following:
    - Removal of all temporary structures, such as skidder bridges.
    - Restoration, to the extent practicable, of pre-existing drainage patterns.
    - Restoration of disturbed areas such as landings and skid trails including regrading if deeply rutted (> 6 in. depth) and seeding and mulching as necessary to prevent erosion.
    - Restoration of any forest road or skid trail that had to be relocated because of interception of groundwater or seeps. The abandoned section will be regraded, seeded and mulched as necessary to prevent erosion.
    - Restoration of any wetland impacts, including regrading as necessary and revegetation with appropriate native, non-invasive wetland species if required.
- Internal Review: The Draft Project Plan and Draft Project Map will be reviewed by the FITT. FITT members will submit written comments to the Project Forester and the Draft Project Plan and/or Map will be updated as appropriate. The FITT members will make every effort to adhere to target timeframes for review (Appendix A). Additional field visits will be scheduled and additional drafts of the Plan and Map will be circulated as necessary. The Project Forester will prepare a single, unified response to comments and circulate this to the FITT.

  FITT members will provide provisional and final approval, for their respective areas of expertise, in writing, by email or memo. Provisional approval implies agreement with all major components of the plan. Final approval will be provided once the tree marking is completed.
- Tree Marking: Tree marking will be initiated once the FITT members provide provisional approval of the Draft Project Plan. If sections of the Draft Project Plan are approved but there are some outstanding issues preventing sign-off, then tree marking may commence in areas where agreement has been reached. Final approval will be provided in writing once the FITT has had the opportunity to review the tree marking.
- SEQRA/CEQR: BEPA will issue a determination that the Project meets the requirements to be covered under the general environmental review for the Forest Management Plan or that it requires an individual review.

- Permitting: The Project Forester will commence any necessary permitting procedures or document that none are required.

2.5.3 Implementation Phase

The Implementation Phase is the third project phase of a forest management project. During the Implementation Phase, the Project Forester will finalize the Project Plan and Map, complete the SEQRA/CEQR process, secure all necessary permits, put the project out to bid, and oversee the selected contractor's compliance with all aspects of the Project Plan. The Project Forester will also implement any necessary Plan Modifications during the Implementation Phase with input from the FITT as required. Details of the Implementation Phase include:

- Final Project Plan and Map: The Final Project Plan and Map will be used as the basis for the bid documents. There will be further refinements of the Draft Project Plan and Map, updated with FITT comments and any additional field data, including GPS data, collected by the Project Forester or members of the FITT.
- Preparation for Project Commencement: The name of the selected contractor and the start date of the project will be provided to the FITT not less than 10 business days before project commencement. Prior to commencement of work, the Project Forester will confirm that key project features such as exclusion zones, landing areas, and road and skid trail layout are clearly marked in the field. This can involve a combination of tape, flagging, and/or different tree marks.
- Plan Modifications: Plan modifications may be advisable during project implementation and can be made in the following manner:
    - Minor modifications to the Project Plan can be approved onsite by the Project Forester. Minor modifications include but are not limited to: expansions of Special Management and/or Exclusion Zones and relocation of skid trails and haul roads that remain outside of Special Management Zones. Minor modifications should provide a positive or at least neutral benefit to water quality and the environment, and adhere to applicable conservation practices.
    - Major modifications to the Project Plan require a review by the FITT. Major modifications include but are not limited to: any work conducted outside of seasonal restrictions; any modification to a Special Management Zone other than an expansion; modification of treatment within a Special Management Zone; and relocation of landing area(s) or access road(s). Review of major plan modifications by the FITT will completed in a timely manner, within 2 weeks, so as not to delay the project unnecessarily (Appendix A).

  The process for making plan modifications will be clearly explained in the bid documents and during the contractor orientation.

- DEP Inspections: The Project Forester is responsible for regular site inspections during the Implementation Phase. Three types of inspections will be utilized:
    - Comprehensive Inspections: Comprehensive Inspections will cover all aspects of the project including all active project areas, conservation practices, and contractual obligations.
    - Focused Inspections: Focused Inspections may include an assessment of conservation practices related to stormwater management, general inspection of condition of landing area, haul roads, and skid trails, compliance with contractual obligations, and any other items the Project Forester deems necessary to inspect (e.g. areas of concern). Focused Inspections will be conducted as soon as practicable following significant storm events, prior to such storm events when feasible, and at any other time deemed necessary by the Project Forester.
    - A Final Inspection will be conducted at least 1 week prior to the removal of equipment by the contractor. This inspection will include Regulatory Review staff and will assess the entire project site to determine if site stabilization measures in the Project Plan were correctly implemented, if any additional stabilization measures are necessary, and the efficacy of the BMPs utilized on the project. The Project Forester shall notify Regulatory Review staff at least 2 weeks in advance of the expected project closure to schedule the Final Inspection.
- Regulatory Review staff will be invited to inspect stormwater-related conservation practices as they are installed so that concerns can be addressed early.
- All inspections will be documented on Timber Harvest Inspection Forms (Appendix C). Inspections will occur at least once a week during active implementation, with a Comprehensive Inspection occurring at least once every two weeks. During times when implementation is temporarily suspended, the Project Forester will conduct Focused Inspections as necessary to ensure all BMPs remain in good working order, at minimum once per month.

2.5.4 Completion Phase

The Completion Phase is the fourth and final project phase of a forest management project. During the Completion Phase, the Project Closure Plan will be implemented and the Final Inspection will take place. Items requiring remedy per the Final Inspection will be addressed, and the FITT will be notified. Details of the Completion Phase include:

- The Project Forester will prepare an As-Built Project Map, showing any changes in the plan that occurred during implementation. The As-Built Project Map will be distributed to the FITT and kept in the project file.

- Final Inspection: The Final Inspection will be conducted as described above. Contractor will not be released until final stabilization is approved.
- An inspection of the project site may be conducted a year after completion to evaluate the effectiveness of the conservation practices. The FITT will be invited and the results discussed during the semi-annual forestry meetings.

2.6 Notification Plan

- Effective and timely communication both within DEP and with local stakeholders is critical to a successful Project. See Appendix D for Notification Guidelines. Draft Project Plans will include project-specific contacts.

2.7 Record Keeping

- Each project will be assigned a unique Project Identification Number by WaLIS. All records pertaining to forest management projects will be kept in a single project file referencing the Project Identification Number housed in the Project Forester's office. Records that lend themselves to electronic filing will be promptly added by the Project Forester to WaLIS.
- All records will be kept for 5 years, after which all paper records other than the Project Plan, the As-Built Project Map, the bid package, and any other information the Project Forester deems important to retain will be destroyed. These paper records and all electronic records will be maintained in perpetuity.

3. REGULATORY COMPLIANCE

DEP is committed to complying with all applicable regulations for forest management projects. Below is a summary of the expected regulatory requirements related to permitting that must be complied with by DEP as well as each DEP contractor. References to such compliance will be included in bid documents.

Other regulatory requirements, concerning waste management or worker safety, are covered separately in the bid documents according to Agency protocols for contractors.

3.1 Federal

3.1.1 ACOE 404 Wetland Permit

- May be required for forest management projects if the project causes any discharge of dredged or fill material into Waters of the United States. Examples of fill include side casting from forest road construction and discard of wood chips.
- Forest management projects will be designed to keep stormwater discharges, fill and roads away from any wetlands. If site conditions require a wetland crossing or potential discharge of material then the project will be sent to ACOE for a jurisdictional determination.

- If a 404 Wetland Permit is required, this also triggers the need for federal review (i.e. USFWS) of the project (Section 4.4).

3.1.2 Exempt activities

- Incidental discharges due to normal silvicultural activities are exempt from 404 Wetland Permits. Practices covered by the exemption include planting, seeding, cultivating, minor drainage and harvesting. Minor drainage does not include the conversion of wetlands to a non-wetland or the construction of any structure that drains or significantly modifies Waters of the United States.
- Construction or maintenance of forest roads (permanent roads, temporary roads and skid trails) where such roads are constructed and maintained in accordance with BMPs (33 CFR 323.4.a.6) to assure that flow and circulation patterns and chemical and biological characteristics of waters of the United States are not impaired. The forest roads must only be used for forestry activities even after the project is completed and no other silviculture activities occur at the site.
- Requirements for the exemption:
    - Activities must be part of an "established silviculture operation". Activities which bring an area into silviculture use are not part of an established operation.
    - Incidental discharges associated with silvicultural projects must have a permit if the activity converts a water of the United States to a use to which it was not previously subject, where the flow or circulation of waters of the United States may be impaired or the reach of such waters reduced.

3.1.3 Nationwide Permits (NWP)

- While much work proposed on forest roads would likely fall under the 404 forest road exemption, NWPs for other activities may apply. NWPs that may be relevant to forest management projects include but are not limited to:
    - NWP 3 Maintenance,
    - NWP 13 Bank Stabilization,
    - NWP 14 Linear Transportation Projects,
    - NWP 18 Minor Discharges,
    - NWP 33 Temporary Construction, Access, and Dewatering,
    - NWP 41 Reshaping Existing Drainage Ditches,
    - NWP 45 Repair of Uplands Damaged by Discrete Events, and
    - NWP 46 Discharge in Ditches.
- The text of the current NWPs should be consulted to determine covered activities, acreage limits, and pre-construction notification thresholds.

Regional conditions established by the New York District of the ACOE must also be followed.

- As per the regional conditions of the New York District of the ACOE, Waters in the East of Hudson Watershed have been designated as Critical Resource Waters (CRWs). Some NWPs are unavailable in CRWs, thereby requiring an individual permit, while other NWPs may require a preconstruction notification.
- Waters in the West of Hudson Watersheds have not been designated as CRWs. NWPs, as conditioned by the NY District, may apply.

3.2 State

3.2.1 Stormwater SPDES Permit

- Stormwater SPDES permits are unlikely to be required for forest management projects as long as any forestry roads constructed are only used for forestry purposes in the future. Forestry is not listed under CFR 122.26(b)(14) and is therefore not subject to NPDES permitting.

3.2.2 Protection of Waters Permit (ECL Article 15)

- Applies to most activities impacting the bed or banks of streams classified C(T) or higher including stream crossings, culvert replacement and harvesting.
- Prohibits work in trout streams between October 1st and April 30th.
- Exemption: removal of fallen tree limbs or trunks where material can be cabled and pulled from the stream without disruption of the stream bed or banks, using equipment placed on or above the stream bank.

3.2.3 Freshwater Wetland Permit (ECL Article 24)

- Applies to State mapped wetlands and a 100 ft. adjacent area. Exempt activities include selective cutting of trees or constructing winter truck roads less than 5 meters in width.
- Non-exempt activities that require a permit include: clear-cutting; constructing roads that require moving earth or other aggregate or that alter water flow; filling, grading, and dredging. Filling, according to 6 NYCRR 663.2, means depositing any soil, stones, sand, gravel, mud, rubbish, or fill of any kind, including spoil resulting from dredging or draining activities. A permit is required for wetland crossings.

3.2.4 Other

- No soil should be removed or imported during the course of a forest management project. If fill is needed it must meet the requirements of the Unrestricted Use Soil Cleanup Objectives (6 NYCRR 375-6.8) and specifications are available upon request. For the purposes of this subsection, fill includes soil and compost materials.

3.3 New York City Watershed Rules and Regulations

- Silvicultural activities have a general exemption from the Stormwater Pollution Prevention Plan requirements.
- Silvicultural activities are not exempt from the crossing, piping, and diversion permit (CPDP) approval although there are several conditions that must be met in order to trigger the need for a CPDP approval. A stream crossing:
    - Must not be permitted by any other regulatory agency.
    - Must involve an impervious component, such as a concrete abutment for a stream crossing or a culvert for a watercourse diversion. A wooden slatted bridge is not considered impervious.
    - Must be permanent in nature.

  Therefore, if a stream crossing requires a permit from some other agency like DEC, or is temporary, or is pervious – it does not require a CPDP.
- Piping or diversion of a watercourse must also include an impervious component, such as a culvert, in order to require a CPDP approval.

3.4 Local

- Municipalities may have ordinances and regulations that govern some aspects of forest management projects such as hours of operation, wetland ordinances and notification requirements. During development of the draft plan, the Project Forester will contact the municipality to discuss any specific requirements.

3.5 Environmental Review

- The Forest Management Plan will be evaluated under SEQRA/CEQR and individual forest management projects undertaken in conformance with the Forest Management Plan will be covered by that generic environmental review. The conservation practices and guidelines specified in this document will be incorporated into the Forest Management Plan and will form the basis for that environmental review.
- Some projects may require deviations from the guidelines due to site-specific conditions or the need for greater management in specific areas. In that case the FITT will work together to determine the minimum disturbance necessary to meet the management objective while protecting the other resources. Whenever changes from the conservation practices and guidelines are required for a project BEPA will assess whether the deviations require an individual review under SEQRA/CEQR.

4. PROTECTION OF NATURAL RESOURCES

4.1 Introduction

Protection of certain natural resources such as reservoirs and wetlands largely relies on setting up Exclusion Zones, where no treatment or disturbance will be permitted under normal circumstances, and Special Management Zones, where silvicultural treatments will be modified and equipment use will be minimized. These areas will be clearly marked on the Final Project Map as well as in the field and the restrictions clearly discussed in the Final Project Plan. These restrictions are guidance for DEP projects on City lands – they are not regulatory—and in some instances are more protective than regulatory controls.

The following areas will be designated as Exclusion Zones:

- Reservoirs and Controlled Lakes: reservoirs/lakes and a 50 ft. buffer along shoreline;
- Streams: area between stream banks as measured from top of bank, on either side of channel;
- Wetlands: wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools; and
- Areas with extremely steep slopes (greater than 1:1).

The following areas will be designated as Special Management Zones:

- Reservoirs and Controlled Lakes: 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft. is an Exclusion Zone);
- Streams: 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is an Exclusion Zone); and
- Wetlands: 100 ft. wide area around wetlands and lakes, and a 150 ft. wide area around vernal pools (first 50 ft. around a vernal pool is an Exclusion Zone).

No skid trails will be located in Special Management Zones. If operations in Special Management Zones create ruts deeper than 6 inches, equipment use will be suspended and the area will be restored to grade prior to project closure. Equipment will not be allowed back into the Special Management Zone.

Conservation practices and modifications for the Special Management Zones are discussed below. Unless otherwise noted, forest management projects conducted by DEP or its contractors will follow the *New York State Forestry Best Management Practices for Water Quality*.

4.2 Special Management Zones for Reservoirs and Streams

4.2.1 Conservation Practices

- No tops or slash will be left in stream channels.

- Basal area reduction will be limited to 50% or less, with minimal disturbance to vegetation.
- Presence of trout or trout-spawning waters may require additional protections. These additional protections will take into account water temperatures, shade retention, season of activity and the need for more extensive sediment control.
- No work will take place within the bed or banks of streams or reservoirs except as necessary to install crossings approved in the Final Project Plan.

4.3 Special Management Zones for Wetlands and Vernal Pools

4.3.1 Guidelines

- Wetlands including vernal pools will either be delineated in the field by ERA or delineated by the Project Forester and confirmed by ERA. The wetland boundaries will be mapped using GPS after field confirmation. Wetlands and vernal pools are Exclusion Zones.
- For wetlands that were created by historic site alterations and/or that fall beneath the federal regulatory size threshold the width of the Special Management Zone may be adjusted at the discretion of the DEP wetland scientist. The type of management zone for linear features that include streams with pockets of wetland vegetation will be based on the extent and connectivity of wetland vegetation at the discretion of the DEP wetland scientist.

4.3.2 Wetland Special Management Zones Conservation Practices

- At least 75% of pre-harvest basal area evenly distributed throughout the managed area will be maintained.
- Harvesting will occur only during dry or frozen conditions.
- Trees will be removed by cable and winch whenever possible. Heavy equipment will only be utilized when necessary.
- Tops and slash that accidentally fall into wetlands may remain as long as they do not cause hydrologic modification.
- Snags and slash will be retained whenever possible to provide habitat value and ground cover.

4.3.3 Vernal Pool Special Management Zones Conservation Practices

- At least 75% of pre-harvest basal area evenly distributed throughout the managed area will be maintained. Tree selection will be designed to maintain a high level of crown cover.
- Trees or slash that accidentally lands in vernal pools shall not be removed during the amphibian breeding season (March 15 through June 30).
- Harvesting will occur only during dry or frozen conditions.

- Felled trees will be removed by cable and winch whenever possible. Heavy equipment will only be utilized when necessary.
- Snags and slash will be retained whenever possible to provide habitat value and ground cover.

4.4 Stormwater Management

4.4.1 Guidelines

- Best management practices for stormwater control will consist of temporary and permanent measures to ensure that silvicultural activities do not adversely impact water quality during or after implementation. Existing water quality risks such as undersized culverts or unstable roads on City property will be identified and referred to the appropriate contact in Operations, and will be addressed prior to or during the project if practicable.
- Areas with slopes between 1:3 (20 degree slope) and 1:1 (45 degree slope) will be limited to the single-tree selection method or thinning only and in no case will remove more than 50% of the pre-project basal area.

4.4.2 Landing Area Best Management Practices

- Landings will be located on flat or gently sloping, well-drained soils greater than 250 ft. from adjacent dwellings, wetlands, and vernal pools where feasible unless otherwise authorized by ERA and noted in the Project Plan. Where not possible, additional soil protection measures will be implemented as necessary.
- Existing landing sites are preferred over creation of new sites.
- Silt fence may be necessary downslope of landing areas to avoid sediment impacts. The need for silt fence will be determined based on adjacent slopes, soil types and distance to sensitive habitats (e.g. wetlands, trout streams).
- Spoil, stumps and any other material removed for landing construction will be located away from runoff paths.

4.4.3 Haul Road Best Management Practices

- Well drained, usable or repairable, existing roads are preferred over new roads. Roads in poor condition will be repaired prior to use.
- Total length of all roads will be the minimum necessary for the project. The design will minimize the amount of cut and fill.
- New roads will be located at least 250 feet from wetlands and vernal pools where feasible unless otherwise authorized by ERA and noted in the Project Plan. Where not possible, additional soil protection measures will be implemented as necessary.
- Silt fence may be necessary downslope of roads to avoid sediment impacts. The need for silt fence will be determined based on adjacent slopes, soil types and distance to sensitive habitats (e.g. wetlands, trout streams).

- Road grades of greater than 10% will be avoided. On soils defined as highly erodible by NRCS, road grades of greater than 5% will be avoided.
- Coarse stone will be located a minimum of 50 feet from intersections with public roads to reduce or eliminate the tracking of sediment onto public highways.
- Roads will be outfitted with water bars or broad-based dips as determined necessary during the Planning, Implementation or Completion Phases.
- In general, roads will be permanent forest features that will be stabilized, but not decommissioned. The roads will provide access for future silvicultural activity. In the event that DEP desires to decommission a road, ground cover will be reestablished as necessary by seeding with native seed and mulching, or the road will be stabilized by covering with wood chips or packing with brush/branches. Compacted soils will be loosened prior to seeding if necessary for vegetation establishment.

4.4.4 Skid Trail Best Management Practices

- Existing trails are preferred over new trails when possible as long as their use does not pose unacceptable ecological risk.
- Total length and density of skid trails will be kept to the minimum necessary to provide appropriate site access while minimizing impact to resources.
- Trails will cover less than 10% of total harvest unit area in hilly terrain and less than 5% of total area in flat terrain.
- Trails will be located to maximize distance from water bodies, minimize the number of water crossings and minimize trail slope. Trails will be located outside of special management zones.
- If repeated use of a trail results in the interception of seeps or channelized surface runoff, it may be necessary to relocate it and remediate.
- Water bars will be located on trails at appropriate locations throughout the harvest area. During the Completion Phase, trails will be stabilized as necessary by seeding with native seed and mulching, covering with wood chips, or packing with brush/branches.

4.4.5 Stream Crossings

- Stream crossings that disturb the stream bed (e.g. culverts) will be installed during low flow or dry conditions, preferably from May-September. DEC-permitted crossings will be installed according to the permit conditions.
- Stream crossings that do not disturb the stream bed (e.g. temporary bridges) will be installed during low-flow conditions whenever possible.
- Existing crossings are preferred over new crossings. Existing crossings that are contributing to water quality impairments will be remediated prior to use. All necessary reviews and permits will be completed prior to remediation.
- Temporary structures are preferred over permanent structures.

- Crossing structures will avoid direct impact to water or channel whenever possible (i.e. bridge or arch preferred to culvert).
- Stream crossings will be installed at right angles to banks, where banks are low and stable, and crossed in riffle areas whenever possible.
- Stream crossings will be designed to avoid obstructing flows up to and including bankfull flows to the extent practicable.
- Fords will only be used during low-water periods. Fords will be located where the stream bottom is made of bedrock or large stone. Average water depth in a ford location will be no more than 1 foot. Fords will not be used on protected or trout streams.
- Stream crossings may trigger additional regulatory requirements such as a Protection of Waters permit (Article 15 Permit).

4.4.6 Wetland Crossings

- Wetland crossings will be avoided to the extent possible. For unavoidable crossings:
    - Skidding will only occur during frozen or dry conditions. Crossing springs, seeps, and areas of water that do not freeze well will be avoided.
    - Crossings will be installed at the narrowest point possible.
    - Temporary crossings such as corduroy, mats, culverts, and skidder bridges will be used to minimize compaction and hydrologic modifications and to maintain hydrologic connectivity. Crossings will be removed and the impacted area returned to original grade and restored at project completion.
- Wetland crossings will trigger additional regulatory requirements such as wetland permits and an individual SEQRA review.

4.5 Protected Species

4.5.1 Guidelines

- During the Planning Phase, the likely presence of any endangered species, threatened species or species of special concern will be ascertained and species-specific measures will be taken to ensure the Project complies with all applicable regulations and is conducted in a manner that minimizes the potential for adverse impacts.
- The areas displayed in the New York State Environmental Resource Mapper show the vicinity around known locations for rare species. The New York State Natural Heritage Program (NHP) guidance says NHP should be contacted "If a project or action is within a location displayed in the rare plant or animal data layer, or close enough to a location that off-site effects are possible, and if the project or action requires a review under SEQRA."

- NHP guidance also states that all species, listed and unlisted by DEC, that appear on the data layer should be addressed in project planning and the environmental review. The NHP lists all rare plants and animals in the state and is more comprehensive than the DEC Protected Plant List and DEC list of Endangered, Threatened and Special Concerns Species. For the purposes of the environmental review for the forest management projects, species that will have to be addressed in the environmental review and project planning are those listed in the DEC Fish and Wildlife Endangered, Threatened and Special Concern Species (ECL § 11-0535; 6 NYCRR Part 182.6) and in the DEC Protected Native Plant List (ECL § 9-1503; 6 NYCRR 193.3). These lists are the official lists of regulated species and are inclusive of all federally listed species in the state.
- The DEC list of Endangered, Threatened and Special Concern Species is inclusive of all federally listed species in the state, therefore consultation with USFWS is not required in most cases. In addition, for projects that are not authorized (i.e. no federal permit required), funded or carried out by a Federal agency, consultation with the USFWS is not required.
- The Endangered Species Act requires federal agencies to consult with the USFWS if those agencies are permitting a project that may impact a federally listed species (e.g. ACOE issuing a permit for fill in a Water of the US). The USFWS will need to be consulted if a forest management project requires any federal permit (such as ACOE) and/or a federally listed species is located in the county in which the project is located. County lists of federally listed species can be found at www.fws.gov/northeast/nyfo/es/section7.htm

4.5.2 Investigative Procedure

- During the Initiation Phase, consult with the NHP and the Environmental Resource Mapper to see if the Project may impact a listed species. A positive result is when the project area falls within the data layer and/or the NHP letter states there are rare species (as defined in section 4.5.1 above) in the vicinity.
- If a forest management project requires a federal permit, check the website above and work with WWQO for the procedure if listed species in the county has habitat within the project site.
- Additional information can be gathered from local and regional experts/environmental organizations regarding the presence of rare or listed species that may not yet have been reported or included in the State's databases.
- If a positive result is returned for a wildlife species, WWQO Wildlife Studies section will be consulted regarding surveys and appropriate survey methodology. An appropriate and thorough survey of the project area will be done if recommended by DEC, USFWS or the Wildlife Studies Section to see if the listed species exists in or near in the project area. DEC or the USFWS will be consulted for guidance.

- If the on-site survey finds listed wildlife species being in or near the project area, DEC's Endangered Species Unit, DEC Regional Office endangered species biologist or USFWS will be contacted, through the Section Chief of Wildlife Studies, and the project will be redesigned as necessary based on DEC's, USFWS's and/or Wildlife Studies' stipulations to avoid impacting the species and/or its habitat. If impacts are unavoidable due to the critical need for a project, appropriate permits and/or mitigation will be incorporated into the Project Plan and approved by DEC or USFWS.
- If a positive result is returned for a plant species, ERA will be consulted to help determine whether appropriate habitat exists on site to support the listed species. This determination may require an on-site survey of habitat. If, based on the survey, habitat for the listed plant species is found on-site, an intensive survey for that species will be conducted by ERA at the appropriate time of year.
- If the listed plant(s) are found on the project site, the project will be redesigned as necessary based on ERA's recommendations to avoid impacting the species. If impacts are unavoidable, mitigation measures, including but not limited to transplanting, will be incorporated into the Project Plan.
- The reviews conducted by Wildlife Studies and ERA will follow any applicable regulatory process established by DEC or USFWS.

4.5.3 Animal Species Special Management Zones

- If a State or Federal listed animal species is found on site of the forest management project, DEC and/or USFWS will be contacted through WWQO's Wildlife Studies Section. Restrictions and guidelines set forth by DEC, USFWS or Wildlife Studies Section, as well as any permit conditions (if applicable), will be followed.

4.5.4 Plant Species Special Management Zones

- Habitat Only: Restrictions and alterations to forest management will be made on a case-by-case basis through consultation between the Forestry Program, ERA and BEPA.
- Occurrence of Listed Plant Species: Special Management Zones around listed plant species will be determined by ERA based on the species and type of plant material found. Practices to reduce or prevent impact will be determined on a case-by-case basis through consultation between the Forestry Program, ERA and BEPA.

5. PROTECTION OF HUMAN RESOURCES

5.1 Introduction

- As a large landowner with many neighbors, and as a provider of recreational opportunities, the City must consider the potential social considerations related to activities conducted on its lands.

5.2 Recreation Resources

- The WALIS database will be queried for existing public uses of the project area and any adjacent parcels. Public access to the project area will be temporarily restricted to protect public safety. Signs will be posted at all major points of access to the project area at least two weeks prior to commencement of the project to warn the public that silvicultural work is taking place and that the area is closed to recreation.
- Forest management projects will be suspended and project areas re-opened to recreation during NYS big game gun season in units open to hunting (http://www.dec.ny.gov/outdoor/10002.html) for contractor safety and to promote management of the deer herd to improve forest regeneration.
- If access to boat storage areas will be impacted or if boats will need to be temporarily relocated, boat owners will be notified directly. Boat owners will be given at least 30 days to move their boats, and will be given an estimated time when their boats may be returned. An alternate means of access will be provided to recreational boaters when necessary. Notification of impacts to boat storage areas will be provided to the local DEP Boating Office.

5.3 Historic and Archeological Resources

5.3.1 Guidelines

- The State Historic Preservation Office (SHPO) will be contacted to identify general areas of (1) listed historical sites on State/National Registers, and (2) suspected or known archeological sensitivity areas. (http://www.oprhp.state.ny.us/nr/main.asp)
- The general information contained in the State and National Registers of Historic Places web page can provide an early indication of the presence or absence of listed historic properties in or near a project area. The likely need for an archeological survey of a project area can be ascertained by determining if the project is within a sensitive area on the Archeological Sensitivity Maps (available from the SHPO Archeological Sensitivity GIS database).
- If, in the course of the Planning or Implementation Phases, a potentially historic or archeological resource is discovered, all effort will be made to avoid adverse impacts.

5.3.2 Cultural Special Management Zone

- If any culturally significant areas are identified by SHPO or DEP in the project area a Special Management Zone may be delineated to avoid or minimize disturbance.

5.4 Visual and Aesthetic Resources

5.4.1 Aesthetic Special Management Zone

- Public roads: Within 100 ft. of public highways, tree removal will be limited to 50% of the pre-project basal area and slash height will be limited to 4 ft. or less.
- Neighboring residences: Within portions of the project area visible to a neighboring residence, slash height will be limited to 4 ft. or less.

5.5 Traffic and Noise Resources

- Landings and skid trails will be located to maximize the distance to sensitive receptors to the maximum extent possible while still meeting resource protection requirements and silvicultural objectives.
- Hours of operation will be limited to 7am - 7pm, Monday to Saturday when working within 500ft. of a residence or other sensitive receptor, unless town ordinances further restrict operating hours.

6. CONTRACTOR GUIDELINES

6.1 Introduction

- Many of the conservation practices rely on proper implementation by the contractors conducting the work.

6.2 Safe Work Plan

A Safe Work Plan (SWP) is required for all projects and is reviewed by DEP EH&S staff. It is utilized for site specific tasks that are considered non-routine or hazardous. SWP would incorporate any Safe Entry Plans and Standard Operating Procedures (SOP) as well as reference any applicable facility specific documents such as an EAP. The plan must contain the following:

1. General Site Information
2. List of site contacts (i.e. project management information)
3. Detailed scope of work and work plan (or reference SOP to be used). Pertinent information to be included:
    a. Detailed description of task or operation to be performed
    b. General requirements not covered elsewhere in the SWP including task or operation specific training requirements.
    c. Materials and Equipment needed for task or operation
    d. Step by step procedure for task or operation.
4. Site specific hazard analysis of work (physical, biological, chemical and radiological)
5. Site specific work practices to address hazards (i.e. equipment and PPE, procedures, action levels/alarms, emergency procedures, engineering and administrative controls).
6. Site specific training needed, *if applicable.*

7. Environmental information (i.e. chemical and petroleum transport, storage and containment, waste management, permits, and *spill procedures*).
8. Emergency planning information (emergency contact numbers, what to do in case of a spill, hospital map, etc).
9. Applicable documents. Attach or list documents referenced in the SWP such as:
    a. Safe Entry Plan (SEP) for the site. *(Generally not applicable for these projects.)*
    b. Standard Operating Procedures for tasks to be performed
    c. MSDSs. *(i.e., gasoline, hydraulic oil, etc.)*
    d. DEP EHS Policy and Procedure documentation (attachments or procedures developed or to be used in accordance with DEP policy such as LOTO procedures, confined space evaluations and permit, hotwork permits, etc.). *If applicable*.

6.3 Contract Requirements

There are specific requirements for all contractors performing silvicultural treatments on City lands. Required contract language is provided in Appendix E. The topics covered include but are not limited to: hazardous materials, spills, safe work plan, emergency action plan, communication plan, training, identification of personnel, DEP inspections, and pollution prevention guidelines.

REFERENCES

2010 CEQR Technical Manual.

Cowardin, L.W., V. Carter, F.C. Golet, and E.T.LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.9

Forested Wetlands: Functions, Benefits and the Use of Best Management Practices. U.S.Forest Service, Natural Resource Conservation Service, Army Corps of Engineers, Environmental Protection Agency, and Dept. of the Interior – Fish and Wildlife Service. NA-PR-01-05

National Management Measures to Control Nonpoint Pollution from Forestry. U.S. Environmental Protection Agency - Non Point Source Control Branch – Office of Wetlands, Oceans and Watersheds, 2005.

New York State Forestry Best Management Practices for Water Quality – BMP Field Guide. New York State Dept. of Environmental Conservation, Watershed Agricultural Council – Forestry Program, and the Empire State Forest Products Association.

Nonpoint Source Management Program. New York State Dept. of Environmental Conservation - Division of Water - Bureau of Watershed Management, 2000.

Water Quality Protection Guidelines for Forest Harvesting. New York City Dept. of Environmental Protection. 1999.

Watershed Forest Ad Hoc Task Force: Policy Recommendations for the Watersheds of New York City's Water Supply. New York State Water Resources Institute, 1996.

GLOSSARY

Basal Area – The cross-sectional area of all trees in a stand as measured at breast height (4.5 feet from the ground) and expressed per unit of land area.

Clearcut – A forest treatment that removes virtually all vegetation in one entry, freeing up all growing space for the establishment of new plants.

Crown Cover – The ground area covered by the crowns of trees or woody vegetation as delimited by the vertical projection of crown perimeters and commonly expressed as a percent of total ground area.

Fill material – materials placed in waters of the United States where the material has the effect of 1) replacing any portion of a water of the United States with dry land or 2) changing the bottom elevation of any portion of a water of the United States (ACOE, 33 CFR 323)

Haul Road – A roadway used by on-road equipment (i.e. trucks) to haul materials to and from the project site that connects to a public road.

Landing Area – A cleared area in or near the forest to which logs are yarded or skidded for further processing, sorting, or transport.

Listed Animal Species – All animal species listed by DEC as Endangered, Threatened or Special Concern under ECL § 11- 0535

Listed Plant Species – All plant species listed in the DEC Protected Plant List under ECL § 9-1503

Native Seed – seed from species listed as native in the New York Flora Atlas

Project Forester – DEP staff with project manager responsibilities for a specific forest management project.

Protected Stream – a stream with a classification and standard of C(T) or higher.

Sensitive Receptor – A defined area where human activity may be adversely affected when noise levels exceed predefined thresholds of acceptability or when levels increase by predefined thresholds of change, used for noise analyses. Examples include, but are not limited to, residences, hotels, motels, health care facilities, nursing homes, schools, houses of worship, court houses, public meeting facilities, museums, libraries, parks, outdoor theaters, golf courses, zoos, campgrounds, beaches, etc.

Significant Storm Events – Significant storms are defined as greater than 2 inches of rainfall within a 24 hour period during the growing season or greater than 1 inch of rainfall during saturated or frozen conditions. Forecasts can be obtained from the National Weather Service website (http://www.nws.noaa.gov/).

Silviculture – The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis.

Skid Trail – A temporary, nonstructural pathway over forest soil used to drag or carry felled trees or logs to the landing. Skid trails may be constructed or simply developed due to use depending on the terrain.

Snag – A standing dead tree from which the leaves and most of the branches have fallen.

Slash – The residue, e.g. treetops and branches, left on the ground after logging, or accumulating as a result of storm, fire, girdling or delimbing.

Spring – A permanent feature where water emerges from the ground and flows across the soil surface without defined bed and banks. The limits of the spring are demarked by the extent of surface water. For the purposes of DEP Forest Management Projects, springs will be treated as watercourses.

Stream – A visible path through which surface water travels on a regular basis, including an intermittent stream. A drainage ditch, swale or surface feature that contains water only during and immediately after a rainstorm or a snowmelt is not considered a stream for the purposes of DEP Forest Management Projects.

Stream bank – land area immediately adjacent to and which slopes toward the bed of a watercourse and which is necessary to maintain the integrity of the watercourse. A bank will not be considered to extend more than 50 feet horizontally from the mean high water line; with the following exception: Where a generally uniform slope of 45 degrees (100%) or greater adjoins the bed of a watercourse, the bank is extended to the crest of the slope or the first definable break in slope, either a natural or constructed (road, or railroad grade) feature lying generally parallel to the watercourse (DEC).

Trout stream – A trout stream means any stream with a DEC classification of AA, A, B and C with a trout waters (T) or suitable for trout spawning (TS) suffix. Stream classifications can be found in the stream coverage (GIS library) and through the Environmental Mapper website.

Vernal Pool – Shallow, seasonally inundated wetlands that occur in depressions and receive water from precipitation, snowmelt, and other runoff. Vernal pools lack perennial inlets and outlets, are inundated in the spring and are typically dry during the summer months. They are normally free of fish and can provide important habitat for aquatic invertebrate species and for many terrestrial or semi-aquatic species such as frogs, salamanders, and turtles.

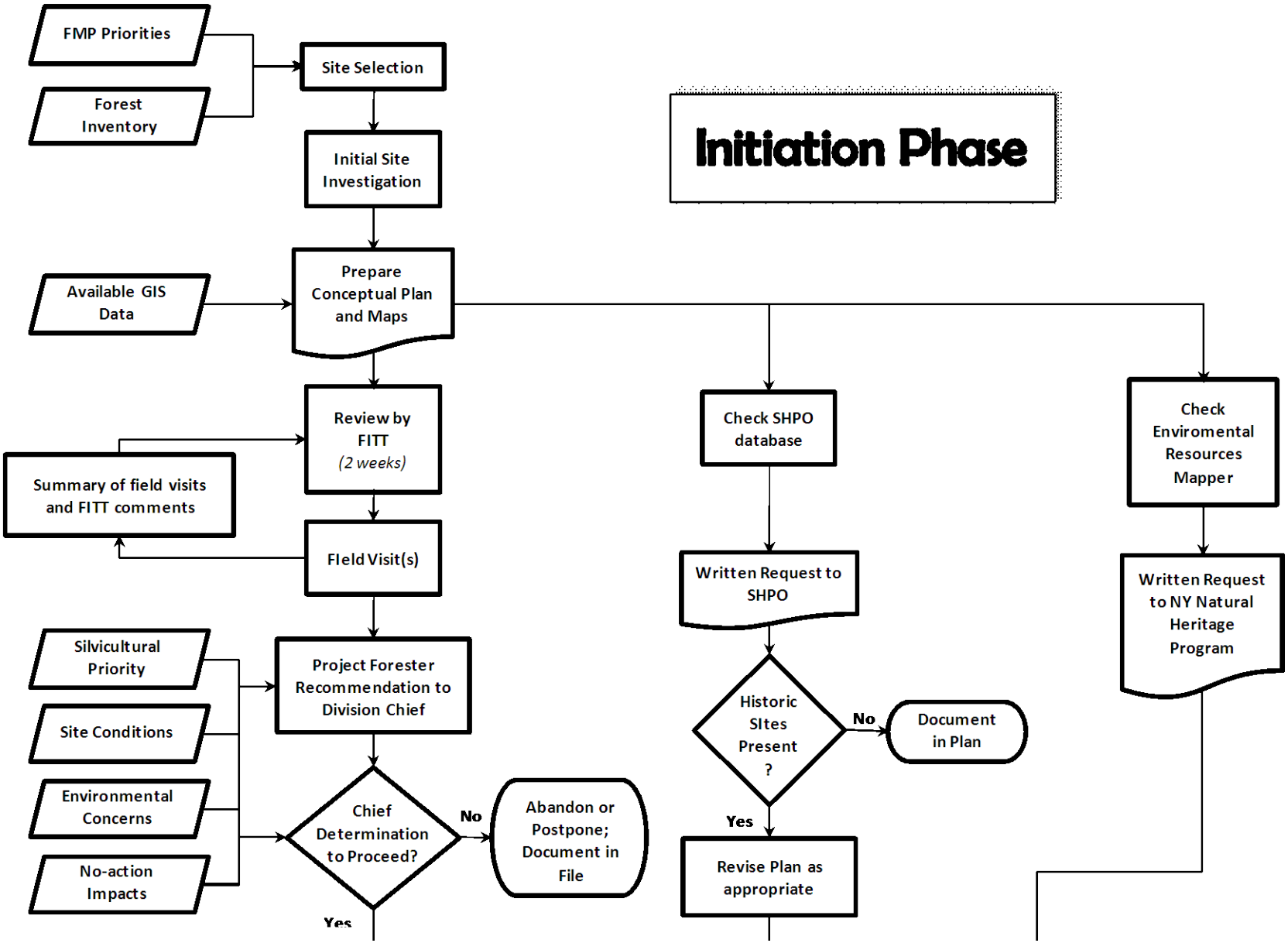
Water Bars – A drainage structure used to manage stormwater on haul roads or skid trails. Water bars can be shallow (height ≈ 8 – 12 inches; width perpendicular to the road or trail surface ≈ 6 to 12 feet) or deep (height ≈ 24 – 30 inches; width ≈ 6 to 10 feet). Spacing of water bars depends on slope. Specifications from the USFS can be found at http://www.na.fs.fed.us/spfo/pubs/stewardship/accessroads/construction.htm.

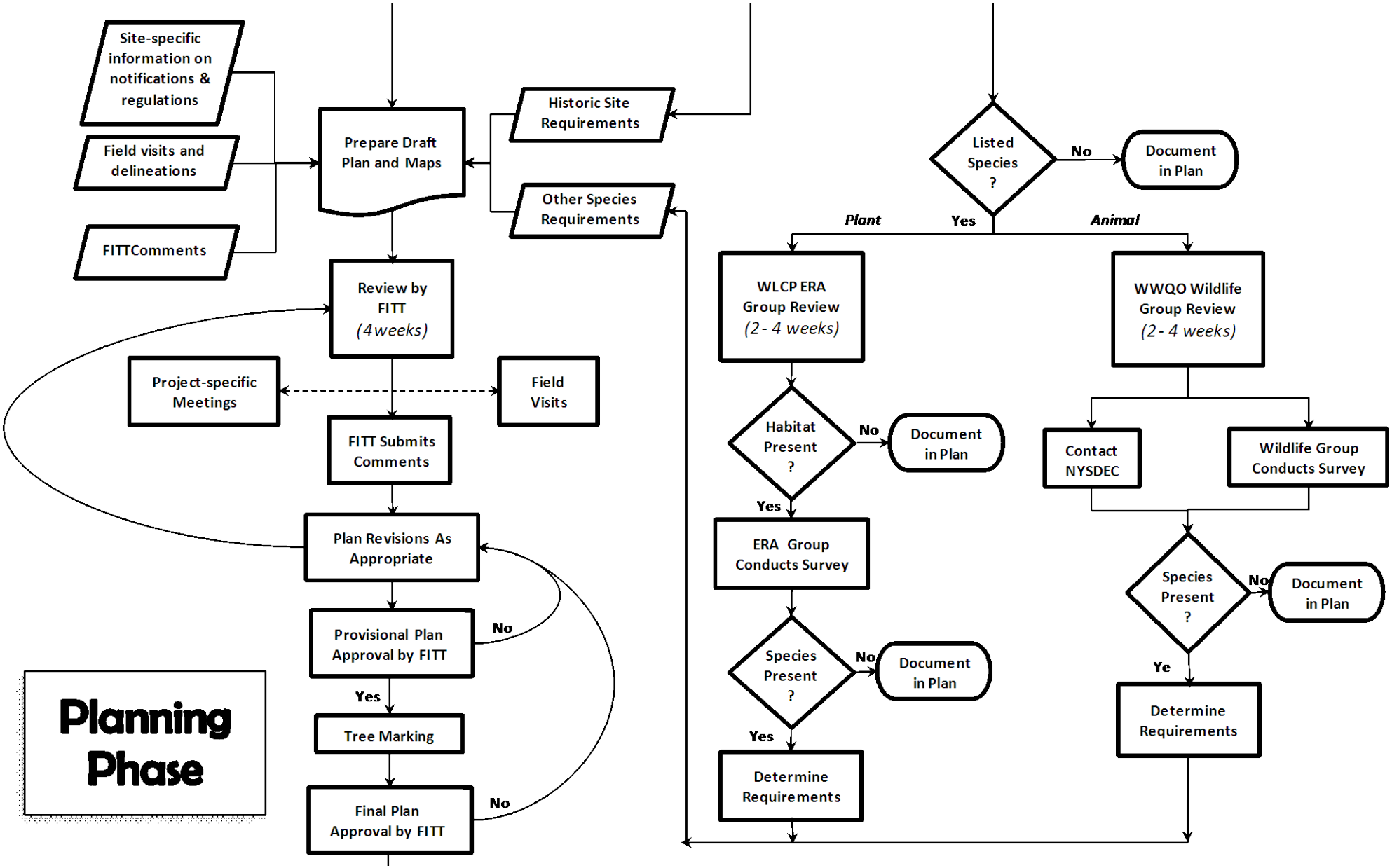
Wetlands – "Lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports

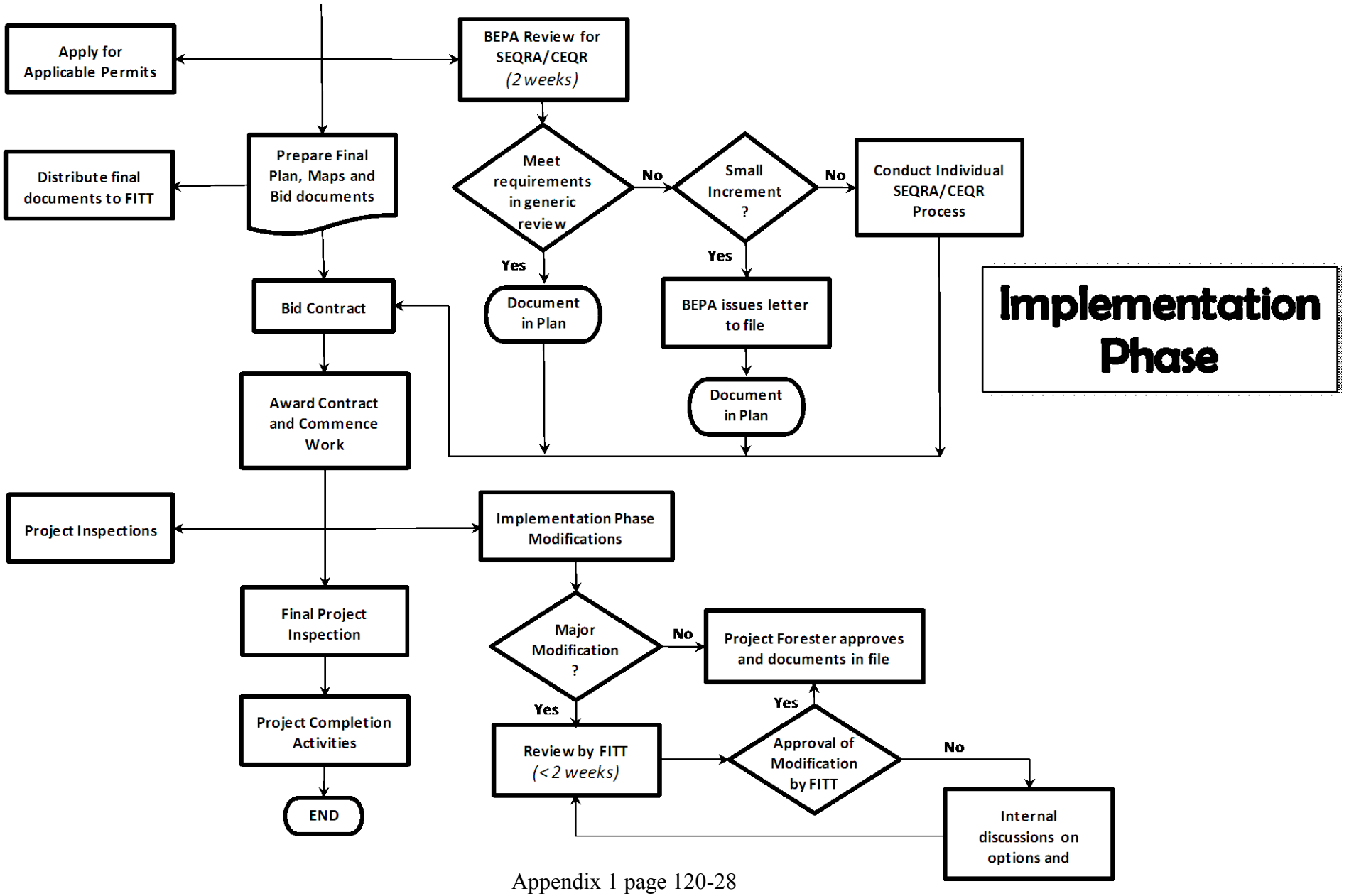
predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year." (Cowardin et al. 1979). Common wetland types include forested wetlands such as red maple and hemlock swamps, scrub-shrub wetlands, emergent marshes, wet meadows, fens, bogs, seeps, vernal pools, and ponds.

APPENDICES

Appendix A: Project Review Flowchart and Timeframes


Initiation Phase
FMP Priorities
Forest Inventory
Site Selection
Initial Site Investigation
Available GIS Data
Prepare Conceptual Plan and Maps
Review by FITT
(2 weeks)
Summary of field visits and FITT comments
FIeld Visit(s)
Silvicultural Priority
Site Conditions
Environmental Concerns
No-action Impacts
Project Forester Recommendation to Division Chief
Chief Determination to Proceed?
No
Abandon or Postpone; Document in File
Yes
Check SHPO database
Written Request to SHPO
Historic SItes Present ?
No
Document in Plan
Yes
Revise Plan as appropriate
Check Enviromental Resources Mapper
Written Request to NY Natural Heritage Program


Site-specific information on notifications & regulations
Field visits and delineations
FITTComments
Prepare Draft Plan and Maps
Historic Site Requirements
Other Species Requirements
Review by FITT (4weeks)
Project-specific Meetings
Field Visits
FITT Submits Comments
Plan Revisions As Appropriate
Provisional Plan Approval by FITT
No
Yes
Tree Marking
Final Plan Approval by FITT
No
Planning Phase
Listed Species ?
No
Document in Plan
Plant
Yes
Animal
WLCP ERA Group Review (2 - 4 weeks)
Habitat Present ?
No
Document in Plan
Yes
ERA Group Conducts Survey
Species Present ?
No
Document in Plan
Yes
Determine Requirements
WWQO Wildlife Group Review (2 - 4 weeks)
Contact NYSDEC
Wildlife Group Conducts Survey
Species Present ?
No
Document in Plan
Ye
Determine Requirements


Apply for Applicable Permits
BEPA Review for SEQRA/CEQR (2 weeks)
Distribute final documents to FITT
Prepare Final Plan, Maps and Bid documents
Meet requirements in generic review
No
Small Increment ?
No
Conduct Individual SEQRA/CEQR Process
Yes
Yes
Bid Contract
Document in Plan
BEPA issues letter to file
Document in Plan
Implementation Phase
Award Contract and Commence Work
Project Inspections
Implementation Phase Modifications
Final Project Inspection
Major Modification ?
No
Project Forester approves and documents in file
Yes
Yes
Project Completion Activities
Review by FITT (< 2 weeks)
Approval of Modification by FITT
No
END
Internal discussions on options and

Appendix B: Project Maps

Accurate mapping of Forest Management Projects is essential for environmental review, successful project implementation, and project tracking. Maps will be of a scale that allows all displayed information to be easily reviewed on standard-sized paper. Sample maps can be found at the end of this appendix. Sample maps are for representational purposes only and do not depict actual features on any past or future Forest Management Project.

Concept and Vicinity Maps

The concept and vicinity maps will be created and distributed to the FITT for review during the Initiation Phase after the Project Forester has determined through evaluation of available data regarding forest characteristics, interpretation of any additional forest inventory performed, and preliminary field site assessment that treatment of the site is consistent with bureau goals. The maps will be created with information available in DEP's GIS data library, and will include the following:

Concept Map

- City-owned land
- Water bodies, including reservoirs
- Proposed project area
- Existing forest access roads, if any
- Rivers and streams (with T or TS classification labels as appropriate)
- NRCS soil types with labels
- 20' topographic lines with labels
- Text box reporting any potential Natural Heritage species
- NWI-mapped wetlands
- DEC-mapped wetlands
- Public roads
- Legend
- Locus map
- Scale bar
- North arrow

Vicinity Map

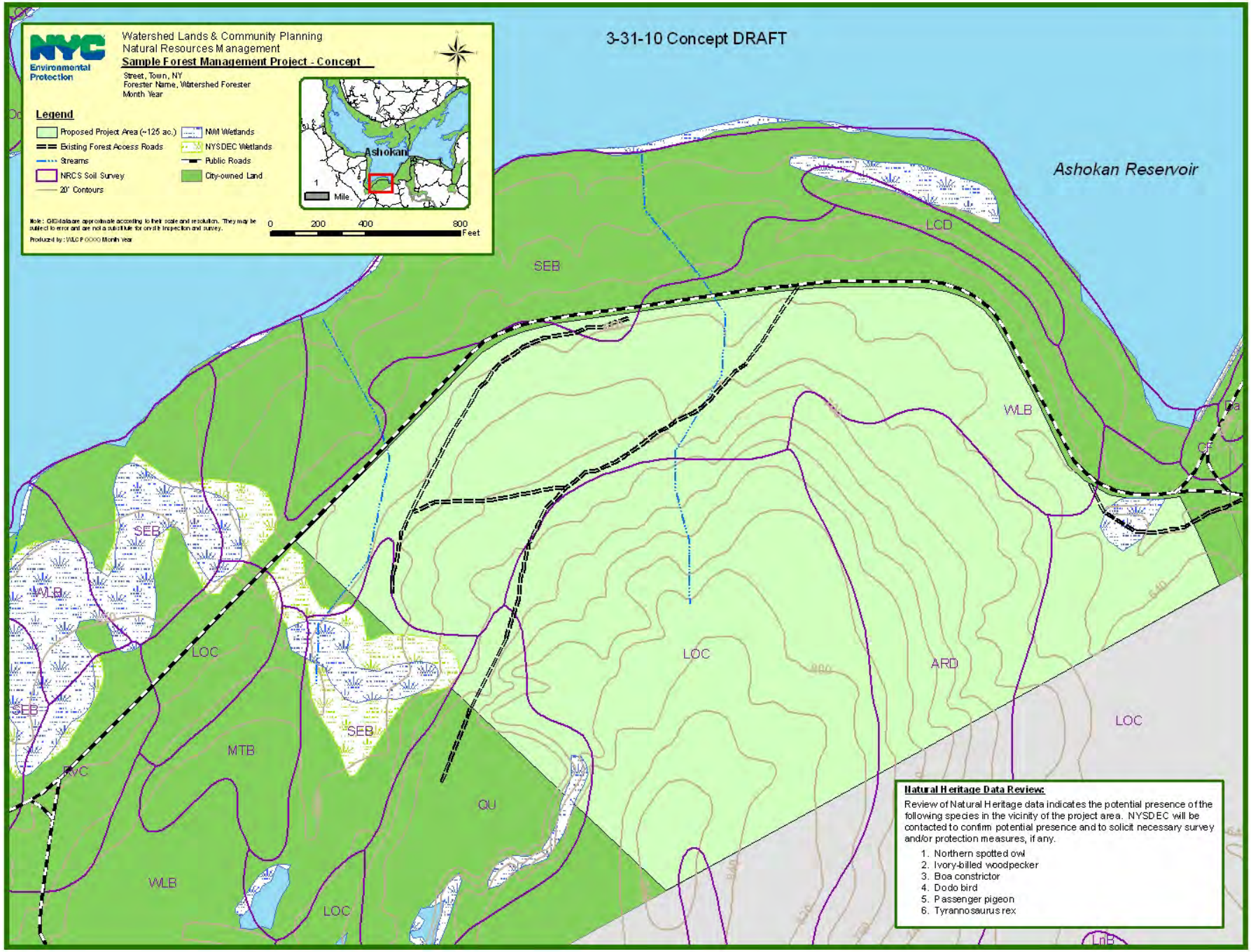
- City-owned land
- Water bodies, including reservoirs
- Proposed project area
- Identification of access points
- 20' topographic lines with labels
- NWI-mapped wetlands
- DEC-mapped wetlands
- Line indicating ½ mile radius around project area
- Planimetrics
- Legend
- Locus map
- Scale bar
- North arrow

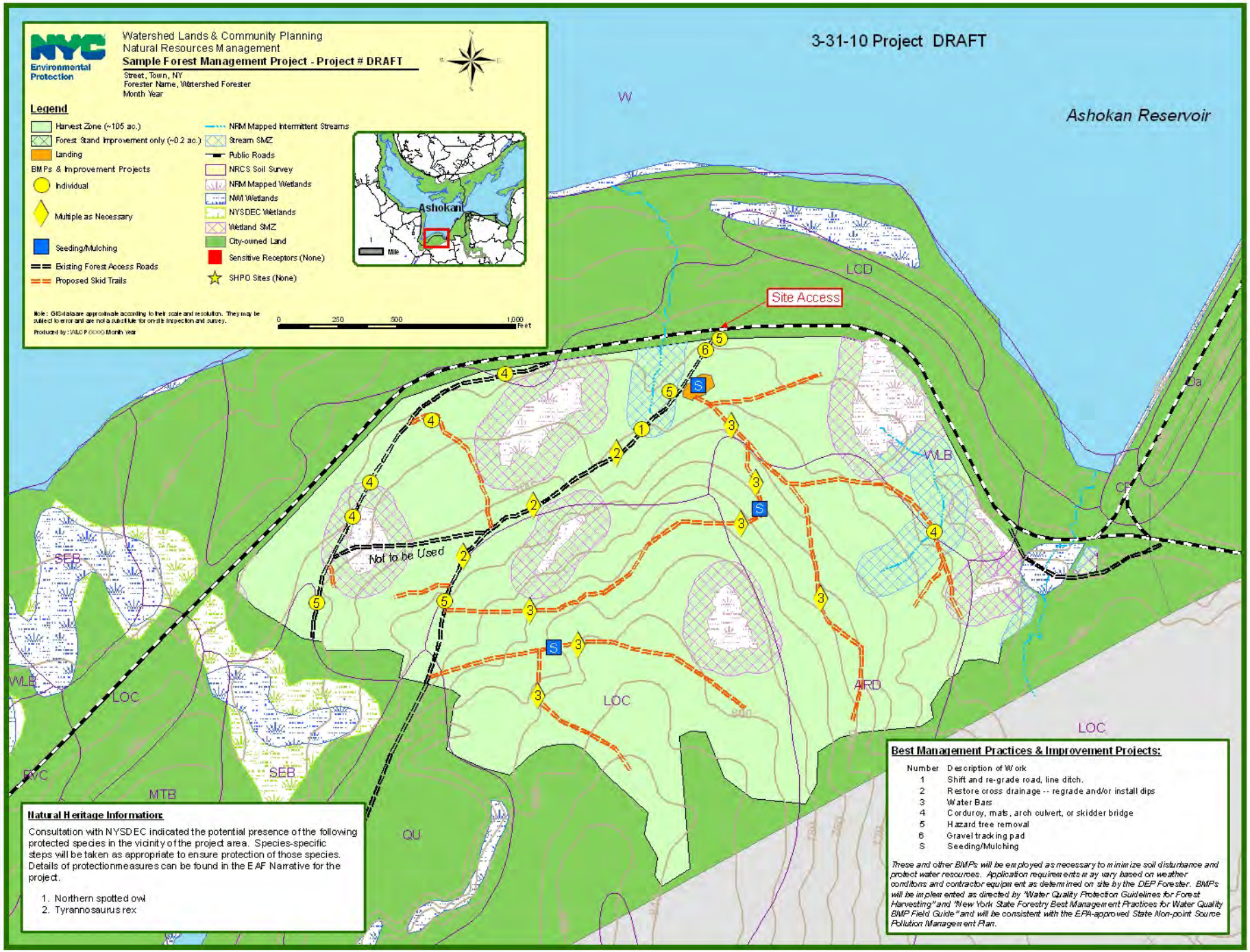
If requested by the FITT, the Project Forester will provide an additional Concept Map for field use that includes aerial photography and enough of the layers listed above to allow for location of relevant features in the field.

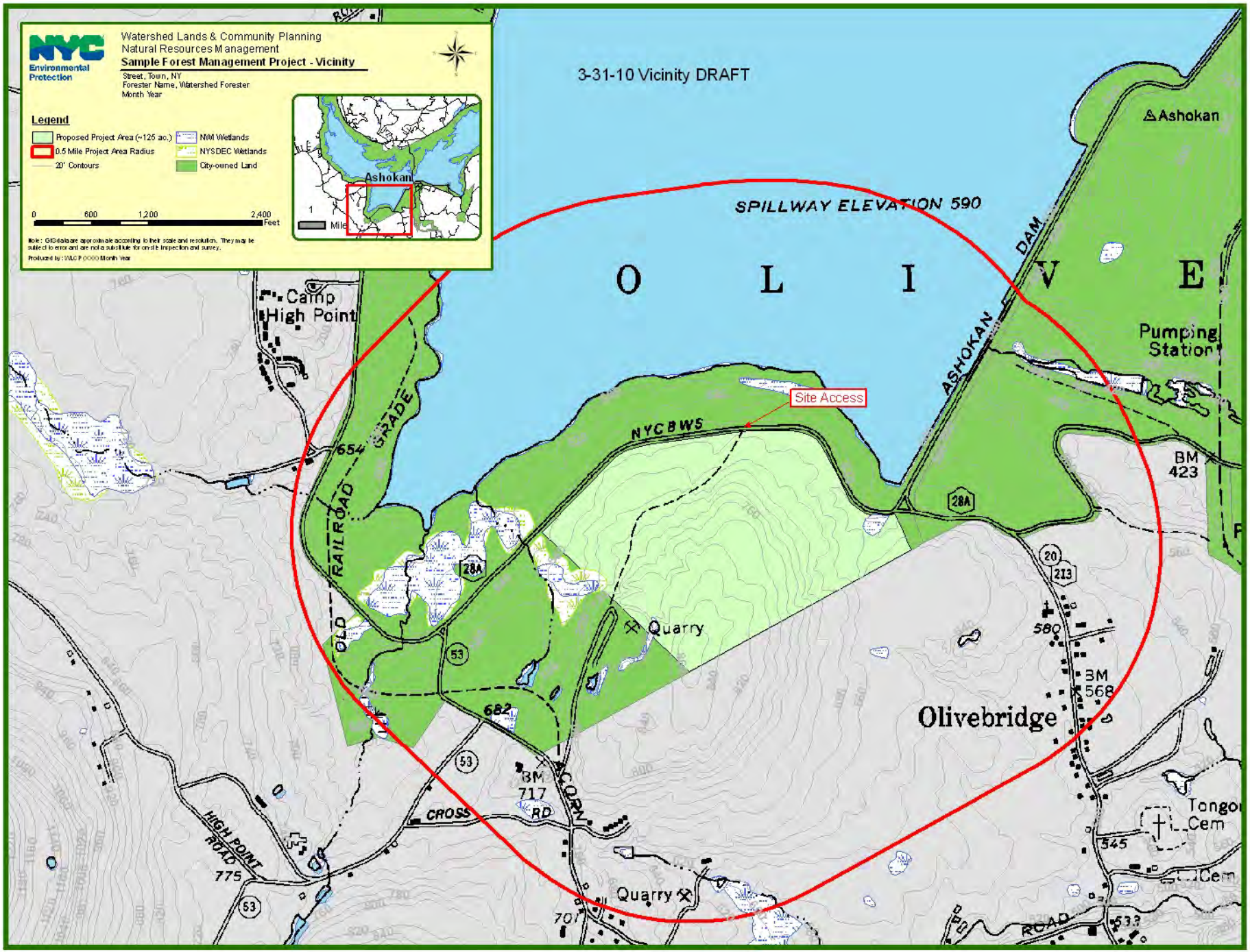
Project Map – Draft and Final

The draft project map will be created and distributed to the FITT for review during the Planning Phase. It will be created both with information available in DEP's GIS library and information gathered by the Project Forester during field-based project planning, and will be of a scale that displays at least 100 feet of area outside the project boundaries. The final project map will be a refinement of the draft project map based on comments received and additional field data collected, including GPS work as appropriate, and will be distributed to the FITT for review prior to completion of the Planning Phase. The project map will include the following:

- City-owned land
- Field-delineated project area or harvest zone
- Existing forest access roads, if any
- Landing areas
- DEC-mapped wetlands
- Rivers and streams, field delineated if necessary (with T or TS classification labels as appropriate)
- 20' topographic lines with labels
- NRCS soil types with labels (draft map only if project is phased)
- SHPO sites
- Text box reporting DEC-confirmed Natural Heritage species
- Legend
- Scale bar
- Water bodies, including reservoirs
- Special management and exclusion zones, if applicable
- Skid trail and haul road layout
- NWI-mapped wetlands
- NRM field-delineated wetlands
- Best Management Practices and improvement projects
- Identification of access points
- Project phasing, if applicable (final map only)
- Sensitive receptors, if applicable
- Any other information relevant to project implementation
- Locus map
- North arrow


NYC Environmental Protection
Watershed Lands & Community Planning
Natural Resources Management
Sample Forest Management Project - Concept
Street, Town, NY
Forester Name, Watershed Forester
Month Year
Legend
Proposed Project Area (~125 ac.)
Existing Forest Access Roads
Streams
NRCS Soil Survey
20' Contours
NWI Wetlands
NYSDEC Wetlands
Public Roads
City-owned Land
Ashokan
1
Mile
Note: GIS data are approximate according to their scale and resolution. They may be subject to error and are not a substitute for on-site inspection and survey.
Produced by: WLG P 0000 Month Year
0
200
400
800
Feet
3-31-10 Concept DRAFT
Ashokan Reservoir
LCD
SEB
WLB
LOC
ARD
MTB
RVC
QU
LnB
Natural Heritage Data Review:
Review of Natural Heritage data indicates the potential presence of the following species in the vicinity of the project area. NYSDEC will be contacted to confirm potential presence and to solicit necessary survey and/or protection measures, if any.
1. Northern spotted owl
2. Ivory-billed woodpecker
3. Boa constrictor
4. Dodo bird
5. Passenger pigeon
6. Tyrannosaurus rex


NYC Environmental Protection
Watershed Lands & Community Planning
Natural Resources Management
Sample Forest Management Project - Project # DRAFT
Street, Town, NY
Forester Name, Watershed Forester
Month Year
3-31-10 Project DRAFT
Ashokan Reservoir
Legend
Harvest Zone (~105 ac.)
Forest Stand Improvement only (~0.2 ac.)
Landing
BMPs & Improvement Projects
Individual
Multiple as Necessary
Seeding/Mulching
Existing Forest Access Roads
Proposed Skid Trails
NRM Mapped Intermittent Streams
Stream SMZ
Public Roads
NRCS Soil Survey
NRM Mapped Wetlands
NWI Wetlands
NYSDEC Wetlands
Wetland SMZ
City-owned Land
Sensitive Receptors (None)
SHPO Sites (None)
Ashokan
1 Mile
Note: GIS database approximate according to their scale and resolution. They may be subject to error and are not a substitute for on-site inspection and survey.
Produced by: WLC P.0000 Month Year
0 250 500 1,000 Feet
Site Access
Not to be Used
W
LCD
VLB
SEB
LOC
MTB
RVC
QU
ARD
Natural Heritage Information
Consultation with NYSDEC indicated the potential presence of the following protected species in the vicinity of the project area. Species-specific steps will be taken as appropriate to ensure protection of those species. Details of protectionmeasures can be found in the EAF Narrative for the project.
1. Northern spotted owl
2. Tyrannosaurus rex
Best Management Practices & Improvement Projects:
Number Description of Work
1 Shift and re-grade road, line ditch.
2 Restore cross drainage -- regrade and/or install dips
3 Water Bars
4 Corduroy, mats, arch culvert, or skidder bridge
5 Hazard tree removal
6 Gravel tracking pad
S Seeding/Mulching
These and other BMPs will be employed as necessary to minimize soil disturbance and protect water resources. Application requirements may vary based on weather conditions and contractor equipment as determined on site by the DEP Forester. BMPs will be implemented as directed by "Water Quality Protection Guidelines for Forest Harvesting" and "New York State Forestry Best Management Practices for Water Quality BMP Field Guide" and will be consistent with the EPA-approved State Non-point Source Pollution Management Plan.


NYC Environmental Protection
Watershed Lands & Community Planning
Natural Resources Management
Sample Forest Management Project - Vicinity
Street, Town, NY
Forester Name, Watershed Forester
Month Year
Legend
Proposed Project Area (~125 ac.)
0.5 Mile Project Area Radius
20' Contours
NWI Wetlands
NYSDEC Wetlands
City-owned Land
0
600
1,200
2,400
Feet
Ashokan
1
Mile
3-31-10 Vicinity DRAFT
SPILLWAY ELEVATION 590
DAM
ASHOKAN
Ashokan
Pumping Station
Site Access
NYCBWS
Camp High Point
654
SPADE
RAILROAD
OLD
28A
53
Quarry
682
BM 717
CORAL
CROSS
RD
HIGH POINT ROAD
775
701
BM 423
20
213
580
BM 568
Olivebridge
Tongo Cem
545
ROAD
533

Appendix C: Project Inspection Form

TIMBER HARVEST INSPECTION FORM

Project Name / #: _____

Date of Inspection: _____ Weather conditions: _____

Forester: _____ Logger: _____

Type of inspection: ☐ Focused ☐ Comprehensive ☐ Final

Purpose if focused: ☐ BMPs ☐ Skid Trails/landing ☐ Water Features ☐ Status

☐ Other (specify) _____

Issues noted previously? ☐ No ☐ Yes, Explain: _____

Previous issues resolved? ☐ NA ☐ Yes ☐ No, Explain: _____

Issue(s) Observation(s) ☐ None

Suggested resolution(s) for issues above (if applicable) ☐ None

Suggestions for next inspection: ☐ None

Appendix D: Notification Plan

Organization/Group	Contact	Method	Milestones
DEP			
Operations	See Note 1	internal email or memo	when contract is awarded; 2 weeks prior to commencement
DEP Police	Chief Fusco		
RRE	See Note 2		
WQ	See Note 3		
FITT	all members		
BWS Management			
WLCP EH&S	EH&S Liaison		
Municipalities			
Town Supervisor	determine during planning phase	letter	when project plan is final and when contract is awarded
Town Highway Superintendent			
Code Enforcement Officer			
Conservation Board	*if applicable*		
Recreational Stakeholders			
Fisherman	depends on access category	signs at major access points	at least 2 weeks prior to commencement
Hunters			
Hikers			

Note 1:

For West-of-Hudson:

- Chief of Western Operations (J.Vickers)
- Regional Manager and Regional Supervisor

For East-of-Hudson:

- Chief of Eastern Operations (M.Donecker)
- Regional Manager and Regional Supervisor

Note 2:

- Chief of Regulatory Engineering Programs (B. Drake)
- Stormwater Manager (M. Giannetta)

Note 3:

- Water Quality Compliance Advisor (T. Lawrence)
- Section Chief of Wildlife Studies (C. Nadareski)

Appendix E: Contract Language

Health and Safety Guidelines

5.1 Scope

The intent of this section is to advise the Contractor of the environmental, health and safety and training requirements for performing work at NYCDEP facilities and lands as well as special procedures applicable to locations where hazardous materials are stored and used. See ATTACHMENTS I and J for further details.

5.2 Notification of Hazardous Materials in Work Area

Hazardous materials may be present in large quantities at NYCDEP facilities or on NYCDEP lands. The Contractor shall, at all times, when working at these facilities or on City-lands, exercise all necessary precautions to avoid interaction with the hazardous materials feeds and/or storage systems and conform to all directions and instructions provided by the NYCDEP.

5.3 Pre-Award Requirements

Within five (5) business days of NYCDEP's request, the successful Bidder shall provide the information specified herein; failure to provide the requested information may result in a rejection of the bid.

5.3.1 The Contractor shall provide a written description of its environmental, health and worker safety (safe work practices) program (and associated training) which will clearly specify the contractor's understanding of all OSHA, EPA, NYSDEC and DEP requirements as well as its commitment to comply with these requirements. An NYCDEP form may be provided to the Contractor for this purpose.

5.3.2 The Contractor shall provide its Worker's Compensation Rating (i.e., Experience Modification Rating or EMR) and a list of all its workers' job related accidents, over the past five (5) years; worker's compensation claims shall be included. In addition, the Contractor shall provide a listing of all regulatory agency (e.g., OSHA, DEC, EPA, DEP, etc.) notices of violations, fines and reportable releases of chemical or petroleum products associated with the contractor's operations over the last 5 years. If the Contractor's EMR exceeds 1.2, the bid shall be rejected. If the environmental, health and safety and training program descriptions indicate that the contractor understands its regulatory requirements; the EMR is below 1.2; there is not a pattern of violations or releases; and the contractor has represented that its programs and training comply with all regulatory requirements; it may be awarded the contract.

5.4 Pre-Construction Orientation

5.4.1 Prior to commencing any work at the facilities indicated in subsection 2, the Contractor shall be required to attend a two-hour orientation. After attending the initial two hour orientation, the Contractor shall, in turn, provide a two hour orientation to any of the contractor's employees assigned to work at the facility. This training must also be provided to subcontractors and lower tier contractors as well as any suppliers, contractor visitors, and field consultants who will work without being accompanied by a trained employee.

5.4.2 The Contractor shall receive and distribute to all workers who are to attend the orientation a hazardous material and safe work practices information package. If possible, it will be distributed at least two days prior to the orientation. The workers shall sign for the packages and indicate that they have reviewed the contents prior to their attending the orientation.

5.4.3 Prior to commencing any work at the facilities indicated in subsection 5.2 above, the Contractor shall provide a written procedure to indicate that the Contractor's supervisor shall ensure that the facility's environmental, health and safety provisions are followed by the Contractor's workers while working at the facilities.

5.4.4 If the Contractor or subcontractor needs to add additional or replacement worker(s) to its crews, the new worker(s) must receive the hazardous materials information package and attend the two-hour orientation for the facilities as described above.

5.5 Requirements During Work

5.5.1 The Contractor, its workers and the subcontractors and all their workers shall, at all times when working at the facilities, be required to wear and/or maintain photo-identification badges. The badges shall be provided by the Contractor and shall only be provided to workers who have received and reviewed the hazardous material and safe work practices information package and have attended the orientation. Personal protective equipment including steel-toed work shoes, hardhat, etc. must be worn or carried by each on-site person at all times.

5.5.2 The Contractor shall, at all times when working at the facilities, exercise all necessary precautions to avoid interaction with the hazardous material feeds and/or storage systems and conform to all directions and instructions provided by the NYCDEP.

5.5.3 Any worker who fails to abide by the safety requirements presented in the hazardous material and safe work practices information package and/or at the orientation shall, at the sole discretion of the NYCDEP, be denied access to the NYCDEP

facilities and/or lands and shall be replaced by the Contractor, as directed by the NYCDEP.

5.5.4 The Contractor shall immediately inform the NYCDEP Contracting Supervisor of all chemical or petroleum product spills or releases, of any contract employee OSHA-reportable work place injuries or illnesses, and of any notices of violation resulting from work performed.

5.5.5 NYCDEP will perform periodic evaluations of the contractor's performance to ensure compliance with all NYCDEP and facility environmental and safe work practices. The Contractor must promptly correct problems communicated by NYCDEP concerning non-compliance with any applicable regulations and NYCDEP and facility environmental and safe work practices. Failure to correct the problems in a timely manner or repeated violation of regulations or NYCDEP/facility environmental and safe work practices is *grounds for termination*. Such failures will also be considered when evaluating the contractor's submittals for future work proposals.

Under General Guidelines:

SUCCESSFUL BIDDER will have in place prior to the start of work and maintain throughout the term of this agreement, a communication plan and emergency action plan including a daily "check in/check out" contact and emergency contact chain. Such plans shall be required to be reviewed and accepted by the Agency's Office of Environmental Health and Safety as part of their required review of this project.

Contractor Pollution Prevention Guidelines

6.0 POLLUTION PREVENTION

6.1 Extreme caution must be taken at all times, to prevent environmental pollution. All equipment (e.g., bulldozers, skidders, forwarders, trucks) must not have any leakage of fluid (e.g., lubricating, fuel, hydraulic, coolant) of any amount, onto bare ground or into hydric sites (e.g., wetlands, springs, streams, pools) while on DEP property. If leakage or a spill does occur, it is to be contained immediately by using absorbent pads and / or a filter berm. Simultaneously, a telephone call is to be made by the SUCCESSFUL BIDDER or an employee thereof, to the NYCDEP BWS Police Command Center ("CC") at (914) 245-6694 or 888-H20-SHED and the information on the Emergency Spill Form (ATTACHMENT H) given to the BWS Police. Also, the DEP FORESTER is to be called when a spill is reported to the BWS Police.

6.2 All work areas must be kept clean of oil containers, snapped cable, sandwich wrappers, garbage, and other litter or debris. Equipment lubricants and fuel (e.g., diesel, gasoline, motor oil, hydraulic and transmission fluid, radiator coolant, chainsaw oil) are not to be stored on DEP property. There is to be no leakage of these fluids onto DEP property while they are being transported in containers (e.g., drums, barrels, tanks, cans) and transferred into the SUCCESSFUL BIDDERS equipment. Absorbent pads must be placed underneath equipment when fluids (e.g., diesel, gasoline, motor oil, coolant,

hydraulic, transmission) are being added, to catch any spillage that might occur. The "used" absorbent pads are then to be properly disposed of, off-site.

6.3 The SUCCESSFUL BIDDER will at his sole expense provide sanitary facilities necessary for the use of those on the work site to assure that all human waste will be disposed of off site. SUCCESSFUL BIDDER shall make such facilities available when the first employee arrives on site of the project area, shall properly seclude them from public observation, shall maintained them in a satisfactory and sanitary condition at all times during the progress of the work and shall enforce their use. Said sanitary facilities shall be located a minimum of one hundred feet from surface waters or wetlands adequate to prevent contamination of such waters should failure of facility occur. A violation of this sale condition will result in a $250 per day penalty, payable to DEP, and shall entitle DEP, in its discretion, to order the suspension of all work as specified in this bid package.

6.4 All vehicle and equipment fueling and maintenance will be conducted by the SUCCESSFUL BIDDER in designated areas as determined by the DEP FORESTER. These locations will generally be located in the landing areas. No maintenance vehicles will be allowed beyond the landing areas unless specifically approved by the DEP FORESTER. The SUCCESSFUL BIDDER is required to keep the following spill prevention and clean-up materials on-site, at all times: an oil pan; one package (100 count) of eighteen-by-eighteen inch (18"x18") absorbent oil pads, sixteen pounds (16 lbs.); thirty feet of an approved absorbent tube; and two shovels. When fluids are being changed on-site, absorbent pads must be used beneath the equipment and the container being used as a catchment, to capture any spillage. The "used" fluid and absorbent pads are then to be properly transported and disposed of, off-site. Non-compliance with any of the pollution prevention measures in the HARVEST CONDITIONS will result in a penalty of $250 per day, payable to DEP, and shall entitle DEP, in its discretion, to order the suspension of all work until acceptable, corrective action has been taken by the SUCCESSFUL BIDDER.

Appendix 2 – Forest Species, Forest Types by Basin

Table 33.Species by percent basal area for all inventoried City water supply lands

Species	Percent
Red maple	16
Sugar maple	13
Northern red oak	13
Eastern hemlock	12
Eastern white pine	10
Ash	7
Sweet birch	4
American beech	4
Black cherry	2
Chestnut oak	2
White oak	2
Other (90 species)	14

Source: Forest Inventory 2009-2010

Table 34. Forest types for all inventoried City water supply lands

Forest type	Acres	Percent
Oak northern hardwoods	24,084	27
Hemlock hardwoods	19,706	22
Northern hardwoods	16,965	19
Other mixed woods	6,559	7
Pine hardwoods	6,316	7
Allegheny hardwoods	5,874	7
Other hardwoods	4,039	5
Oak	2,042	2
Oak northern pine	1,913	2
Other softwoods	1,581	2
Total	89,078	

Source: Forest Inventory 2009-2010

Table 35. East of the Hudson species by percent basal area

Species	Percent
Northern red oak	16
Sugar maple	11
Red maple	11
Eastern white pine	8
Sweet birch	8
Ash	8
Tuliptree	6
White oak	4
Black oak	4
Chestnut oak	3
Norway spruce	3
Hickory	2
Other	17

Source: Forest Inventory 2009-2010

Table 36. East of Hudson forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	10,803	58
Northern hardwoods	1,774	10
Other hardwoods	1,753	9
Allegheny hardwoods	1,403	8
Oak	1,001	5
Pine hardwoods	759	4
Hemlock hardwoods	472	3
Other softwoods	226	1
Other mixed woods	183	1
Oak northern pine	153	1
Total	18,528	

Source: Forest Inventory 2009-2010

Table 37. Boyd Corners/West Branch species by percent basal area

Species	Percent
Northern red oak	20
Red maple	13
Sugar maple	11
Sweet birch	10
Chestnut oak	8
White oak	5
Ash	5
Tuliptree	4
Eastern white pine	4
Scarlet oak	3
Eastern hemlock	3
Hickory	2
Other	10

Source: Forest Inventory 2009-2010

Table 38. Boyd Corners/West Branch forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	5,719	73
Northern hardwoods	556	7
Oak	506	6
Allegheny hardwoods	439	6
Other hardwoods	285	4
Hemlock hardwoods	166	2
Other mixed woods	77	1
Pine hardwoods	54	1
Other softwoods	40	1
Oak northern pine	17	0
Total	7,860	

Source: Forest Inventory 2009-2010

Table 39. Croton System species by percent basal area

Species	Percent
Northern red oak	12
Sugar maple	12
Red maple	11
Ash	9
Eastern white pine	9
Sweet birch	7
Black oak	6
Tuliptree	5
White oak	4
Norway spruce	4
Black locust	3
Hickory	2
Eastern hemlock	2
Other	16

Source: Forest Inventory 2009-2010

Table 40. Croton System forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	3,930	46
Other hardwoods	1,374	16
Northern hardwoods	1,175	14
Allegheny hardwoods	741	9
Pine hardwoods	474	5
Oak	339	4
Hemlock hardwoods	288	3
Other softwoods	143	2
Other mixed woods	96	1
Oak northern pine	67	1
Total	8,628	

Source: Forest Inventory 2009-2010

Table 41. Kensico species by percent basal area

Species	Percent
Northern red oak	20
Tuliptree	15
Eastern white pine	14
Sweet birch	7
Ash	7
Sugar maple	6
Red maple	5
Norway spruce	4
Black oak	3
White oak	3
Hickory	2
Chestnut oak	2
Norway maple	2
Scarlet oak	2
Other	7

Source: Forest Inventory 2009-2010

Table 42. Kensico forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	1,154	57
Pine hardwoods	231	11
Allegheny hardwoods	222	11
Oak	156	8
Other hardwoods	94	5
Oak northern pine	69	3
Other softwoods	43	2
Northern hardwoods	43	2
Hemlock hardwoods	19	1
Other mixed woods	10	0
Total	2,040	

Source: Forest Inventory 2009-2010

Table 43. West of the Hudson species by percent basal area

Species	Percent
Red maple	18
Eastern hemlock	16
Sugar maple	14
Northern red oak	12
Eastern white pine	11
Ash	6
American beech	4
Sweet birch	3
Black cherry	3
Yellow birch	2
Chestnut oak	2
Other	9

Source: Forest Inventory 2009-2010

Table 44. West of the Hudson forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	19,233	27
Northern hardwoods	15,191	22
Oak northern hardwoods	13,281	19
Other mixed woods	6,375	9
Pine hardwoods	5,557	8
Allegheny hardwoods	4,471	6
Other hardwoods	2,286	3
Oak northern pine	1,760	2
Other softwoods	1,354	2
Oak	1,041	1
Total	70,550	

Source: Forest Inventory 2009-2010

Table 45. Ashokan Basin species by percent basal area

Species	Percent
Northern red oak	20
Eastern white pine	16
Eastern hemlock	11
Red maple	11
Sugar maple	8
Chestnut oak	7
Ash	7
American beech	3
White oak	3
Sweet birch	3
Hickory	2
Norway spruce	1
Other	10

Source: Forest Inventory 2009-2010

Table 46. Ashokan Basin forest types by acres and percent

Forest type	Acres	Percent
Oak northern hardwoods	4,162	32
Hemlock hardwoods	2,512	19
Pine hardwoods	1,601	12
Oak northern pine	1,260	10
Northern hardwoods	1,173	9
Oak	878	7
Other mixed woods	837	6
Other hardwoods	483	4
Other softwoods	173	1
Allegheny hardwoods	82	1
Total	13,161	

Source: Forest Inventory 2009-2010

Table 47. Cannonsville Basin species by percent basal area

Species	Percent
Red maple	25
Sugar maple	16
Eastern hemlock	14
Northern red oak	10
Ash	8
American beech	6
Black cherry	5
Eastern white pine	4
Sweet birch	3
Yellow birch	2
American basswood	2
Other	6

Source: Forest Inventory 2009-2010

Table 48. Cannonsville Basin forest types by acres and percent

Forest type	Acres	Percent
Northern hardwoods	6,093	31
Hemlock hardwoods	4,827	25
Oak northern hardwoods	3,821	20
Allegheny hardwoods	1,972	10
Other mixed woods	1,511	8
Other hardwoods	620	3
Pine hardwoods	519	3
Other softwoods	159	1
Total	19,523	

Source: Forest Inventory 2009-2010

Table 49. Neversink Basin species by percent basal area

Species	Percent
Red maple	25
Eastern hemlock	19
Sugar maple	11
Eastern white pine	10
Black cherry	7
American beech	6
Sweet birch	5
Northern red oak	5
Yellow birch	4
Ash	3
Red pine	2
Other	4

Source: Forest Inventory 2009-2010

Table 50. Neversink Basin forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	2,204	40
Northern hardwoods	1,106	20
Allegheny hardwoods	733	13
Pine hardwoods	596	11
Other mixed woods	387	7
Oak northern hardwoods	233	4
Other softwoods	118	2
Other hardwoods	87	2
Total	5,465	

Source: Forest Inventory 2009-2010

Table 51. Pepacton Basin species by percent basal area

Species	Percent
Eastern hemlock	22
Sugar maple	18
Red maple	17
Northern red oak	13
Ash	6
Eastern white pine	5
Sweet birch	3
Black cherry	3
American beech	3
Yellow birch	3
American basswood	1
Other	6

Source: Forest Inventory 2009-2010

Table 52. Pepacton Basin forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	4,641	31
Northern hardwoods	3,586	24
Oak northern hardwoods	2,619	17
Allegheny hardwoods	1,349	9
Other mixed woods	1,272	8
Other softwoods	734	5
Pine hardwoods	464	3
Other hardwoods	438	3
Oak	58	0
Oak northern pine	6	0

Source: Forest Inventory 2009-2010

Table 53. Rondout species by percent basal area

Species	Percent
Eastern white pine	25
Red maple	17
Eastern hemlock	16
Northern red oak	9
Sugar maple	6
American beech	6
Sweet birch	5
Ash	3
Chestnut oak	3
Yellow birch	3
Other	8

Source: Forest Inventory 2009-2010

Table 54. Rondout forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	1,818	26
Oak northern hardwoods	1,448	21
Northern hardwoods	1,414	20
Other mixed woods	806	12
Pine hardwoods	661	10
Oak northern pine	363	5
Other hardwoods	167	2
Allegheny hardwoods	131	2
Oak	96	1
Other softwoods	19	0
Total	6,924	

Source: Forest Inventory 2009-2010

Table 55. Schoharie Basin species by percent basal area

Species	Percent
Eastern white pine	21
Eastern hemlock	17
Sugar maple	17
Red maple	11
Northern red oak	9
Ash	7
American beech	4
Yellow birch	2
Other	12

Source: Forest Inventory 2009-2010

Table 56. Schoharie Basin forest types by acres and percent

Forest type	Acres	Percent
Hemlock hardwoods	3,231	31
Northern hardwoods	1,818	18
Pine hardwoods	1,715	17
Other mixed woods	1,563	15
Oak northern hardwoods	997	10
Other hardwoods	491	5
Allegheny hardwoods	204	2
Other softwoods	150	1
Oak northern pine	131	1
Oak	9	0
Total	10,307	

Source: Forest Inventory 2009-2010

Appendix 3 – Species of Greatest Conservation Need

Table 57. Species of greatest conservation need and status

Habitat	Common Name	Scientific Name	State Status* (Federal Status)*	Heritage Rank*	NE Species of Concern
Birds					
Wetland/Marsh	American bittern	*Botaurus lentiginosus*	SC	S4	YES
Wetland/Marsh	American black duck	*Anas rubipes*		S2	
Early-Successional/ Shrub	American woodcock	*Scolopax minor*		S5	
Reservoir/ Stream	Bald eagle	*Haliaeetus leucocephalus*	T (delisted)	S2B, S2N	
Opening/ Savannah	Barn owl	*Tyto alba*		S3	
High-Elevation Conifer	Bicknell's thrush	*Catharus bicknelli*	SC	S2B	YES
Early-Successional/ Shrub	Black-billed cuckoo	*Coccyzus erythropthalmus*		NR	
Mature Forest	Black-throated blue warbler	*Dendroica caerulescens*		NR	
Wetland/Marsh	Blue-winged teal	*Anas discors*		NR	
Early-Successional/ Shrub	Blue-winged warbler	*Vermivora pinus*		S5	
Grassland	Bobolink	*Dolichonyx oryzivorus*		S5	
Early-Successional/ Shrub	Brown thrasher	*Toxotoma rufum*		NR	
Early-Successional/ Shrub	Canada warbler	*Wilsonia canadensis*		S5	YES
Mature Forest	Cerulean warbler	*Dendroica cerulea*	SC	S4B	YES
Wetland/Marsh	Common loon	*Gavia immer*	SC	S3	
Opening/ Savannah	Common nighthawk	*Chordeiles minor*	SC	S4	
Mature Forest	Coopers hawk	*Accipiter cooperii*	SC	S4	
Grassland	Eastern meadowlark	*Sturnella magna*		NR	
Early-Successional/ Shrub	Golden-winged warbler	*Vermivora chrysoptera*	SC	S4	YES
Grassland	Grasshopper sparrow	*Ammodramus savannarum*	SC	S4	
Wetland/Marsh	Great egret	*Ardea alba*		S2	
Grassland	Henslow's sparrow	*Ammodramus henslowii*	T	S3B, SAN	YES
Grassland	Horned lark	*Eremophila alpestris*	SC	S5	
Reservoir	Hudsonian godwit	*Limosa haemastica*		NR	
Mature Forest	Kentucky warbler	*Oporornis formosus*		S2	
Wetland/Marsh	Least bittern	*Ixobrychus exilis*	T	S3B, S1N	

Table 57. Species of greatest conservation need and status

Habitat	Common Name	Scientific Name	State Status* (Federal Status)*	Heritage Rank*	NE Species of Concern
Mature Forest	Louisiana waterthrush	*Seiurus motacilla*		NR	YES
Early-Successional/ Shrub	Northern bobwhite	*Colinus virginianus*		NR	
Mature Forest	Northern goshawk	*Accipiter gentilus*	SC	S4B, S3N	
Opening/ Savannah	Northern harrier	*Circus cyaneus*	T	S3B, S3N	YES
Mature Forest	Olive-sided flycatcher	*Contopus borealis*		S4	
Reservoir/Stream	Osprey	*Pandion haliaetus*	SC	S4B, SZN	
Wetland/Marsh	Pied-billed grebe	*Podilymbus podiceps*	T	S3B, S1N	YES
Early-Successional/ Shrub	Prairie warbler	*Dendroica discolor*		S5	
Mature Forest	Red-headed woodpecker	*Malanerpes erythrocephalus*	SC	S4	
Mature Forest	Red-shouldered hawk	*Buteo lineatus*	SC	S4B, SZN	
Early-Successional/ Shrub	Ruffed grouse	*Bonasa umbellus*		NR	
Mature Forest	Scarlet tanager	*Piranga olivacea*		NR	
Grassland	Sedge wren	*Cistothorus platensis*	T	S3B, SAN	YES
Reservoir	Semi-palmated sandpiper	*Calidris pusilla*		NR	
Mature Forest	Sharp-shinned hawk	*Accipiter striatus*	SC	S4	
Opening/ Savannah	Short-eared owl	*Asio flammeus*	E	S2	YES
Grassland	Vesper sparrow	*Pooecetes gramineus*	SC	S5	
Early-Successional/ Shrub	Whip-poor-will	*Caprimulgus vociferus*	SC	S4	YES
Early-Successional/ Shrub	Willow flycatcher	*Empidonax traillii*		S5	
Mature Forest	Wood thrush	*Hylocichla mustelina*		S5	
Mature Forest	Worm-eating warbler	*Helmitheros vermivorus*		S4	
Early-Successional/ Shrub	Yellow-breasted chat	*Icteria virens*	SC	S3	
Reptiles and Amphibians					
Forest/Openings	Black rat snake	*Elaphe obsoleta*		NR	
Wetland	Blanding's turtle	*Emydoidea blandingii*	T	S2	YES
Vernal Pool	Blue-spotted salamander	*Ambystoma laterale*	SC	S3	YES
Wetland	Bog turtle	*Clemmys muhlenbergii*	E (T)	S2	
Forest/Opening	Eastern box turtle	*Terrapene carolina*	SC	S3	YES

Table 57. Species of greatest conservation need and status

Habitat	Common Name	Scientific Name	State Status* (Federal Status)*	Heritage Rank*	NE Species of Concern
Forest/Openings	Eastern hognose snake	*Heterodon platirhinos*	SC	S3	YES
Lake/River	Eastern ribbon snake	*Thamnophis sauritus sauritus*		S5	YES
Forest/Opening	Eastern spadefoot	*Scaphiopus holbrookii*	SC	S3	YES
Forest/Openings	Eastern worm snake	*Carphophis amoenus*	SC	S2	
Wetland	Four-toed salamander	*Hemidactylium scutatum*		NR	
Forest/Openings	Fence lizard	*Sceloporus undulates*	T	S1	
Wetland	Fowler's toad	*Bufo fowleri*		NR	
Stream/River	Hellbender	*Cryptobranchus alleganiensis*	SC	S2	YES
Stream/River	Jefferson salamander	*Ambystoma jeffersonianum*	SC	S3	YES
Stream/River	Long-tailed salamander	*Eurycea longicauds*	SC	S2	YES
Vernal Pool	Marbled salamander	*Ambystoma opacum*	SC	S3	
Forest/Openings	Northern black racer	*Coluber constrictor*		NR	
Forest/Openings	Northern copperhead	*Agkistrodon contortrix mokasen*		NR	
Stream/River	Northern cricket frog	*Acris crepitans*	E	S1	
Lake/River	Northern map turtle	*Graptemys geographica*		NR	
Stream/River	Northern red salamander	*Pseudotriton ruber*		NR	
Forest/Openings	Smooth green snake	*Opheodrys vernalis*		NR	
Lake/Pond/ Stream	Snapping turtle	*Chelyda serpentina*		NR	
Wetland	Southern leopard frog	*Rana sphenocephals*	SC	S1	
Wetland	Spotted turtle	*Clemmys guttata*	SC	S3	YES
Vernal Pool	Tiger salamander	*Ambystoma tigrinum*	E	S1	YES
Forest/Openings	Timber rattlesnake	*Crotalus horridus*	T	S3	
Wetland	Western chorus frog	*Pseudacris triseriata*		NR	
Lake/River/Forest	Wood turtle	*Clemmys insculpta*	SC	S3	YES
Mammals					
Mature Forest	Allegheny woodrat	*Neotoma magister*	E (E)	S1	YES
Mature Forest	Indiana bat	*Myotis sodalis*	E (E)	S1	

Table 57. Species of greatest conservation need and status

Habitat	Common Name	Scientific Name	State Status* (Federal Status)*	Heritage Rank*	NE Species of Concern
Early-Successional/ Shrub	New England cottontail	*Sylvivagus transitionalis*	SC (Candidate)	SH	
Mature Forest	Small-footed Bat	*Myotis leibii*	SC	S2	YES
Invertebrates					
Stream/River/ Riparian	Appalachian Tiger Beetle	*Cicindela ancocisconensis*		S1	
Openings	Dusted Skipper**	*Atrytonopsis hianna*		NR	
Openings	Northern Metalmark	*Calephelis borealis*		SH	
Forest	Northern Oak Hairstreak	*(Fixsenia favonius ontario)*		S3	
Mollusks					
Stream/River	Alewife Floater	*Anodonta implicata*		S1	
Mayflies, Damselflies and Dragonflies					
Streams/Seep	Arrowhead Spiketail	*Cordulegaster obliqua)*		S2	
Stream	Mocha Emerald	*Somatochlora linearis*		S2	
Ponds/Lake/ Riparian	New England Bluet	*Enallagma laterale*		S2	
Ponds/Lake	Spatterdock Darner	*Aeshna mutata*		S2	
Streams/River	Spine Crowned Clubtail	*Gomphus abbreviatus*		S2	
Streams/Spring/ Seep	Tiger Spiketail	*Cordulegaster erronea*		S1	

*-E—Endangered, T—Threatened, SC—Special Concern, S1—fewer than 5 occurrences, S2—6 to 20 occurrences, S3—21 to 100 occurrences, S4—apparently secure, S5—demonstrably secure, SH—historically known from New York State, but not seen in the past 15 years, NR—not rated, SAN—accidental species non-breeding, SZ-species occurs in New York State, but not in specific locations, B-breeds in New York State, N-does not breed in New York State.

** - Although not an SGCN, the dusted skipper was documented in the heritage data base and is included because it is considered a locally rare species.

Because the only source of documentation for some groups (e.g., invertebrates) was the State CWCS plan that identifies species by different delineations of watershed than used for the Forest Management Plan, Table 58 displays West of Hudson as the Delaware River (Cannonsville, Pepacton, Neversink basins), Upper Hudson (Ashokan, Rondout, Schoharie basins), and Lower Hudson (all EOH basins).

Table 58. Species of greatest conservation need documented on City water supply lands

Common Name	Scientific Name	CWCS plan Watersheds		
		Delaware River	Upper Hudson	Lower Hudson
Birds				
American bittern	*Botaurus lentiginosus*	X	X	X[1]
American black duck	*Anas rubipes*	X	X	X
American woodcock	*Scolopax minor*	X	X	X
Bald eagle	*Haliaeetus leucocephalus*	X	X	X
Barn owl	*Tyto alba*			X
Bicknell's thrush	*Catharus bicknelli*	X	X	X[1]
Black-billed cuckoo	*Coccyzus erythropthalmus*	X	X	X
Black-throated blue warbler	*Dendroica caerulescens*	X	X	X
Blue-winged teal	*Anas discors*			X
Blue-winged warbler	*Vermivora pinus*	X	X	X
Bobolink	*Dolichonyx oryzivorus*	X	X	X
Brown thrasher	*Toxotoma rufum*	X	X	X
Canada warbler	*Wilsonia canadensis*	X	X	X
Cerulean warbler	*Dendroica cerulean*	X	X	X
Common loon	*Gavia immer*	X	X[1]	X[1]
Common nighthawk	*Chordeiles minor*	X	X[1]	X[1]
Coopers hawk	*Accipiter cooperii*	X	X	X
Eastern meadowlark	*Sturnella magna*	X	X	X
Golden-winged warbler	*Vermivora chrysoptera*		X	
Grasshopper sparrow	*Ammodramus savannarum*	X	X	X
Great egret	*Ardea alba*			X
Henslow's sparrow	*Ammodramus henslowii*	X	X	
Horned lark	*Eremophila alpestris*		X	X[1]
Hudsonian godwit	*Limosa haemastica*			X
Kentucky warbler	*Oporornis formosus*	X	X	X
Least bittern	*Ixobrychus exilis*	X		
Louisiana waterthrush	*Seiurus motacilla*	X	X	X
Northern bobwhite	*Colinus virginianus*	X	X	X
Northern goshawk	*Accipiter gentilus*	X	X	X
Northern harrier	*Circus cyaneus*	X		X
Olive-sided flycatcher	*Contopus borealis*		X	
Osprey	*Pandion haliaetus*	X	X	X
Pied-billed grebe	*Podilymbus podiceps*		X	X
Prairie warbler	*Dendroica discolor*	X	X	X
Red-headed woodpecker	*Malanerpes erythrocephalus*	X		X
Red-shouldered hawk	*Buteo lineatus*	X	X	X
Ruffed grouse	*Bonasa umbellus*	X	X	X
Scarlet tanager	*Piranga olivacea*	X	X	X

Table 58. Species of greatest conservation need documented on City water supply lands

Common Name	Scientific Name	CWCS plan Watersheds		
		Delaware River	Upper Hudson	Lower Hudson
Sedge wren	*Cistothorus platensis*			X
Semipalmated sandpiper	*Calidris pusilla*			X
Sharp-shinned hawk	*Accipiter striatus*	X	X	X
Short-eared owl	*Asio flammeus*			X
Vesper sparrow	*Pooecetes gramineus*	X		X[1]
Whip-poor-will	*Caprimulgus vociferus*		X	X[1]
Willow flycatcher	*Empidonax traillii*	X	X	X
Wood thrush	*Hylocichla mustelina*	X	X	X
Worm-eating warbler	*Helmitheros vermivorum*	X	X	X
Yellow-breasted chat	*Icteria virens*			X
Total (48)		35	36	44
Reptiles and Amphibians				
Black ratsnake	*Elaphe obsoleta*		X	X
Blanding's turtle	*Emydoidea blandingii*			X
Blue-spotted salamander	*Ambystoma laterale*	X	X	X
Bog turtle	*Clemmys muhlenbergii*	X	X	X
Eastern box turtle	*Terrapene carolina*	X	X	X
Eastern hognose snake	*Heterodon platirhinos*	X	X	X
Eastern ribbon snake	*Thamnophis sauritus sauritus*	X	X	X
Eastern spadefoot	*Scaphiopus holbrookii*			X
Eastern worm snake	*Carphophis amoenus*			X
Four-toed salamander	*Hemidactylium scutatum*	X	X	X
Fowler's toad	*Bufo fowleri*		X	X
Hellbender	*Cryptobranchus alleganiensis*	X		
Fence Lizard	*Sceloporus undulates*			X
Jefferson salamander	*Ambystoma jeffersonianum*	X	X	X
Long-tailed salamander	*Eurycea longicauds*		X	
Marbled salamander	*Ambystoma opacum*	X	X	X
Northern black racer	*Coluber constrictor*		X	X
Northern copperhead	*Agkistrodon contortrix mokasen*		X	X
Northern cricket frog	*Acris crepitans*			X
Northern map turtle	*Graptemys geographica*			X
Northern red salamander	*Pseudotriton ruber*	X	X	X
Smooth green snake	*Opheodrys vernalis*	X	X	
Snapping turtle	*Chelyda serpentina*	X	X	X
Southern leopard frog	*Rana sphenocephals*	X		X
Spotted turtle	*Clemmys guttata*	X	X	X
Tiger salamander	*Ambystoma tigrinum*		X	
Timber rattlesnake	*Crotalus horridus*	X	X	X

Table 58. Species of greatest conservation need documented on City water supply lands

Common Name	Scientific Name	CWCS plan Watersheds		
		Delaware River	Upper Hudson	Lower Hudson
Western chorus frog	*Pseudacris triseriata*	X		X
Wood turtle	*Clemmys insculpta*	X	X	X
Total (29)		17	20	25
Mammals				
Allegheny woodrat	*Neotoma magister*			X
Indiana bat	*Myotis sodalis*		X	X
New England cottontail	*Sylvivagus transitionalis*			X
Small-footed bat	*Myotis leibii*	X	X[1]	X
Total (4)		1	2	4
Invertebrates				
Appalachian tiger beetle	*Cicindela ancocisconensis*	X	X	
Dusted skipper (not SGCN)	*Atrytonopsis hianna*			X
Northern metalmark	*Calephelis borealis*		X	
Northern oak hairstreak	*(Fixsenia favonius ontario)*		X	X
Alewife floater	*Anodonta implicata*	X	X	
Arrowhead spiketail	*Cordulegaster obliqua)*		X	X
Mocha emerald	*Somatochlora linearis*		X	X
New England bluet	*Enallagma laterale*		X	X
Spatterdock darner	*Aeshna mutata*		X	X
Spine-crowned clubtail	*Gomphus abbreviatus*	X		X
Tiger spiketail	*Cordulegaster erronea*		X	X
Total (11)		3	9	8
Grand Total (92)		56	67	81

1 – Documentation was added following confirmation by NYC DEP personnel

Appendix 4 – Wildlife Operational Recommendations

Table 59. Wildlife operational guideline summary

Federally Listed Species Guidelines		
Bog turtle	Occupied and potential bog turtle habitat	If a project occurs in a county listed by the USFWS as having potential for bog turtle occurrence, a Phase I (USFWS 2001) survey will be completed. The USFWS will make the final suitable habitat determination and specific project level guidelines will be determined on a case by case basis by the USFWS and DEC, following submission of the Phase I survey.
Indiana bat	City lands less than 900 feet above sea level in all but Delaware County	Less than 10 miles from known hibernaculum - unless project work has been reviewed and approved by NYS DEC or USFWS biologists, potential roost trees greater than or equal to 4 inches d.b.h. should only be cut from November 15 through March 31, while bats are in hibernation (USFWS 2010b). Proximity to hibernacula will be determined by the Wildlife Studies Section.
		Greater than 10 miles from known hibernaculum - unless project work has been reviewed and approved by DEC or USFWS biologists, potential roost trees greater than or equal to 4 inches d.b.h. should only be cut between October 1 to March 31, while bats are in hibernation (USFWS 2010b). Proximity Information on proximity to hibernacula will be acquired by the DEP Wildlife Studies Section from USFWS and DEC.
	All City-owned lands	All known roost trees* will be protected until such a time as they no longer serve as a roost (e.g., loss of exfoliating bark or cavities, blown down). In the event that it is absolutely necessary to remove a known Indiana bat roost tree, such removal will be done in consultation with the USFWS, during the time period when bats are likely to be in hibernation (October 15 to March 31) (USDA FS 2007b).
		Maintain a component of trees with characteristics of suitable roosts (i.e., dead or dying with exfoliating bark or large living trees with flaking bark), wherever possible with regard to public safety and accomplishment of overall resource goals and objectives (USFWS 2007b).
		If occupied Indiana bat maternity roost trees* are discovered, work should be ceased until contact is made with USFWS and DEC to determine how to proceed. Trees will be protected from physical disturbance until they naturally fall to the ground. Designate an area of use based on site conditions, radio-tracking or other survey information, and best available information regarding maternity habitat needs. Within this area, no ground-disturbing activity or timber harvest should occur until the colony has left the maternity area for hibernation. The character of the site should be maintained or enhanced year round by: (1) maintaining an adequate number of snags, including known roost trees; (2) maintaining large live trees to provide future roosting opportunities; and (3) maintaining optimal roosting and foraging habitat (USDA FS 2007b).
		If occupied Indiana bat male roost trees* are discovered during the summer season, work should be ceased until contact is made with USFWS and DEC to determine how to proceed. Trees should be protected from physical disturbance by designating a 75-foot radius buffer zone around the tree(s). Within the buffer zone, no ground-disturbing activity or timber harvest should occur. The buffer zone should remain in place until the roost tree naturally falls to the ground (USDA FS 2007b).
		Remove hazard trees that provide suitable roost habitat between October 15 and April 1, whenever possible (USDA FS 2007b).

Table 59. Wildlife operational guideline summary

Federally Listed Species Guidelines		
Bald eagle	Any nest site	To maintain the integrity of the nest site, activities that modify the landscape or alter nest site conditions such as final harvest treatments, landing construction or road construction shall not occur within 660 feet of a nest (exceeds USFWS 2007a). This distance may be increased or decreased (to a minimum of 330 feet) on a case-by-case basis as determined by the DEC and USFWS and reported to the DEP Wildlife Studies Section. The National Bald Eagle Management Guidelines (USFWS, May 2007) should be used as a guideline for the establishment of bald eagle buffer zones. The designated nest buffer will remain in place for five years after a nest has been declared abandoned.
		To maintain nest habitat on sites where nests are blown from trees or otherwise destroyed, continue to protect the site in the absence of the nest for up to three complete breeding seasons, using the 660-foot no landscape modification buffer (USFWS 2007a).
	Active nest site	Management activities that could result in disturbance to nesting birds will not occur during the breeding season (December 1 to August 31) within approximately 1,320 feet of an active nest. Examples of management activities that should be restricted include timber cutting and hauling, and road and skid trail construction and maintenance (exceeds USFWS 2007a). This buffer can be decreased (to a minimum of 660 feet) or increased on a case-by-case basis by the DEC and USFWS and reported to the DEP Wildlife Studies Section.
	DEP Reservoirs	In an effort to maintain suitable unoccupied habitat, harvest within ½ mile of a lake or reservoir should retain a component of large live or dead trees that are above the adjacent forest canopy (USFWS 2007a), including scattered white pine and other trees with potential for use as nesting or roosting trees.
Bald eagle	DEP Reservoirs with known use	To maintain suitable unoccupied habitat, silvicultural activities and associated road, landing and trail construction that may result in degradation or loss of roosting or nesting habitat (i.e., loss of suitable nest/roost habitat or increased access to the site) shall be avoided within 330 feet (USDA FS 2007a) of NYC DEP reservoirs with known eagle use. This buffer may be increased on a case-by-case basis as determined by the DEC and USFWS and reported to the DEP Wildlife Studies Section.
	Roosting and foraging habitat	To minimize disturbance to bald eagle roosting and foraging, activities that may result in harm or harassment (timber harvest and road, trail or landing construction) to roosting or foraging eagles or degradation of habitat, shall be avoided within 1,320 feet of known roost sites or important foraging areas (USFWS 2007a). Frequently used roost sites or important foraging areas will be identified during project planning by the DEC and USFWS and reported to the DEP Wildlife Studies Section.
New England cottontail	Basins with documented use	Within basins with documented New England cottontail use, whenever possible maintain suitable corridors between patches of shrub and early-successional habitat. Corridors can be narrow strips of shrubs or early-successional vegetation along stream edges, fields or roads (Arbuthnot 2008). Potential areas will be identified during project planning by the by the DEC and USFWS and reported to the DEP Wildlife Studies Section.

* -Roost trees include trees where Indiana bats have been documented. Maternity roost trees include roosts where a lactating female has been documented, whereas male roost trees are roosts where only male bats have been found.

**-Active nests include nests where an adult bird has been observed during the nesting season, or a nest that contains greenery or other signs of activity. Nests will be considered active for five years following the last year of documented activity. An active territory is an area that contains one or more documented goshawk nests and includes nesting, foraging and post-fledgling habitat. Territories will be considered active for five years following the last year of documented activity. Also all nest buffers may be increased or decreased depending on site specific review by the wildlife studies section.

Table 60. Summary of limited operating periods and management restrictions

Species	Season	Buffer Distance	Restricted Activity
Indiana bat	April 1 to November 14	Not Applicable	Removal of known roost tree
Bald eagle	January 15 to July 31	1,320 ft from nest	Timber harvest and road construction
Bald eagle	Year-around	330 ft from nest	Clear cutting or removal of overstory trees (USFWS, May 2007 – National Bald Eagle Management Guidelines)

Table 61. Wildlife operational guidelines

Habitat or Species Targeted	Area/Site	Operational Guidelines
Habitat Guidelines		
Wetland	Any mapped wetland	Within 250 ft of any mapped wetland, avoid routing skid trails through areas with concentrations of physical structure such as dead logs, hollow stumps, upturned rocks, rock outcrops, and other debris (USDA FS 1995).
		To avoid mortality to turtles and salamanders, within 660 ft of any mapped wetland close logging roads and skid trails to vehicle use after cutting (USFS 1995).
		Where final harvest is necessary to achieve a watershed objective, whenever possible cuts within 250 ft of a mapped wetland should be less than 10 acres in size, narrow and irregular in shape (USDA FS 1995).
Vernal pool	Vernal pool	When harvesting between 150 and 200 ft of a vernal pool, maintain 50 percent canopy cover (USDA FS 2007a).
		Silt fences are formidable barriers to salamander migration; do not use silt fences within 250 ft of a vernal pool and remove them as soon as practicable outside the buffer (USDA FS 1995).
Rocky areas	All City-owned lands	New roads and skid trails should be managed to mitigate impacts to SGCN by avoiding the following (USDA FS 1986). Rock ledges, caves or rock outcrop areas Talus areas and any rocky site on southern or southeastern exposures suitable for snake dens
Hard mast	All City-owned lands	To maintain hard mast following treatment, retain a component of large-diameter oak and beech on all partial and final harvest treatments.
Shrub-dependent birds	Large utility right-of-way	Work with utility companies and where possible, coordinate efforts to maintain or increase the shrub structure within the right-of-way (USDA FS 2007b).
	Old field habitat	Where it is consistent with water quality objectives, existing old field habitat should be maintained and upland shrub/forb communities should be developed to meet the needs of declining shrub nesting species (USDA FS 2007b).
Snags, Legacy Tree and Dead Wood Guidelines		
Snags	All City-owned lands	Within all units retain existing snags with the exception of those removed for safety or to meet silvicultural objectives. Retain an average of at least four snags per acre with a goal of two between 11 to 17 inches d.b.h. and two 18 inches d.b.h. or larger (DEC 2011c).
		To minimize impacts to nesting and roosting wildlife, removal of snags between April 15 and August 15 should be avoided to the extent possible (USDA FS 2007a, DEC 2011c).

Table 61. Wildlife operational guidelines

Habitat or Species Targeted	Area/Site	Operational Guidelines
		In stands with a deficiency of snags, live trees should be selected as additional recruitment trees to become snags (DEC 2011c).
		Dead trees with cavities may satisfy both the snag retention requirement in addition to the cavity tree retention goal (DEC 2011c).
Legacy trees	All City-owned lands	Retain an average of at least one live tree per acre in the largest pre-harvest diameter class (DEC 2011c).
		In even-aged stands, recruitment trees should be identified at the time of the final harvest (DEC 2011c).
		In uneven-aged stands recruitment trees should be identified during intermediate treatments (DEC 2011c).
Coarse woody debris	All City-owned lands	Retain at least three logs greater than 10 inches in diameter at the small end and 16 ft in length or an equivalent volume in longer or shorter lengths per acre (DEC 2011c).
		Retain at least 20 percent of the fine woody material less than 6 inches in diameter of harvested trees when conducting regeneration harvest on even-aged stands (DEC 2011c).
Habitat Structure Guidelines		
Reserve trees	All City-owned lands	In even-aged stands 5 acres or larger, at the time of regeneration harvest retain 5 percent or more of the stand area in reserve patches that are 0.1 to 2 acres in size or 5 percent or more of the pre-harvest basal area in dispersed individual trees (DEC 2011c).
Hardwood/ conifer inclusions	All City-owned lands	During intermediate treatments in conifer plantations, retain at least 10 percent of the overall pre-harvest basal area in hardwoods (DEC 2011c).
		In natural stands (i.e., other than plantations), retain conifer in hardwood stands and retain hardwoods in conifer stands so that they compose at least 5 percent of the overall pre-harvest basal area (DEC 2011c).
		Hardwood/conifer inclusions may contribute toward retention standards for reserve trees, legacy trees, and cavity trees (DEC 2011c).
Songbirds	All City-owned lands	To reduce impacts to breeding migratory birds, hand cutting or mechanical treatments that remove saplings from forested stands should occur outside the songbird nesting season (April 1 to June 30) (USDA FS 2007b).
Transportation Guidelines		
Species sensitive to motorized vehicle use	All City-owned lands	Logging roads and skid trails should avoid patches of native shrubs. Also avoid inclusions of conifer or hardwoods, when they are a minor component of the stand (USDA FS 2007a).
		New logging roads should be minimized and whenever possible, utilize existing road corridors (Univ of Mass 2007b and 2007c).
		Abandoned logging roads and landing sites should be seeded with native herbaceous species (USDA FS 2007a).
		Where it can be done safely, road intersections and approaches to paved roads should be angled to limit the line of sight into the forest (Bennett 2010).
		To minimize impacts to wildlife dispersal, landings and roads should not be located between wetlands or vernal pools when more than one occurs on a site (Univ. of Mass 2007c).

Table 61. Wildlife operational guidelines

Habitat or Species Targeted	Area/Site	Operational Guidelines
		To minimize potential impacts to breeding and migrating wildlife, new roads constructed should be closed to public access (Univ. of Mass 2007b and 2007c).
Forest Raptors Guidelines		
Northern goshawk	Active nest**	Timber harvest should not be permitted within 660 ft of an active nest (USDA FS 2007a).
		Timber harvest activities should not occur during the nesting season between 660 ft and 1,320 ft of an active nest (USDA FS 2007a).
		Within 1,320 ft of an active nest, 70 percent of the area should be maintained as mid- to late-successional habitat (USDA FS 2007a).
		No new road construction should be permitted within 1,320 ft of an active nest (USDA FS 2007a).
		Between 660 ft and 2,640 ft from an active nest, no new road construction should be permitted during the nesting season. Seasonally restrict or close existing roads (USDA FS 2007a).
Red-shouldered hawk	Active nest**	Timber harvest should not occur within 330 ft of an active nest (USDA FS 2007a).
		No new road construction should occur within 660 ft of an active nest (USDA FS 2007a).
		Between 330 ft and 1,320 ft of an active nest, all timber harvest should occur outside the nesting season (USDA FS 2007a).
		Within 1,320 ft of an active nest, activities that could result in disturbance to nesting birds should be restricted during the nesting season (USDA FS 2007a).
Coopers and sharp-shinned hawks	Active nest**	No road construction or timber harvest should occur within 330 ft of an active nest (USDA FS 2007a).
		Within 1,320 ft of an active nest, activities that could result in disturbance to nesting birds should be restricted during the nesting season (USDA FS 2007a).
Reptile and Amphibian Guidelines		
Wood turtle	Perennial streams	To reduce mortality to dispersing individuals, local roads should be closed to public access within 600 ft of preferred perennial streams (i.e., clear flowing streams with a sandy or gravel bottom) during the breeding season (May 15 to October 15) (Univ. Of Mass 2007b).
	Occupied habitat	Where this species has been documented, minimize motorized access to the hibernation period within 2,000 ft of the documented site and associated breeding (stream) habitat (Univ. Of Mass 2007b).
Spotted turtle	Occupied habitat	Where this species has been documented, minimize motorized access to the hibernation period within 300 ft of the documented site and associated breeding (vernal pool and wetlands) habitat (Univ of Mass 2007e).
Blandings turtle	Occupied habitat	Where this species has been documented, minimize motorized access to the hibernation period within 1,000 ft of the documented site and associated breeding (wetlands and vernal pools) habitat (Univ. of Mass 2007d).

Table 61. Wildlife operational guidelines

Habitat or Species Targeted	Area/Site	Operational Guidelines
Timber rattlesnake	Known den and basking sites	New roads and landings should not be permitted within 450 ft of known den sites or basking areas. Protect the integrity of the den site by not moving rocks larger than 2 ft in diameter and by not creating excessive soil compaction (USDA FS 2007b).
		Within 450 ft of known den sites, timber harvest should be restricted to the denning season (November 1 and March 31) (USDA FS 2007a).
Vernal pool salamanders	Vernal Pool	To reduce potential impacts to breeding individuals, public access should be restricted and motorized use minimized within 600 ft of vernal pools during the peak breeding season (March 1 to May 15, August 15 to October 15) (Univ. Of Mass 2007c).
	Vernal pool clusters	When more than one vernal pool occurs at a site, landings should not be located between vernal pools. If a final harvest is to be completed, a forested corridor should be maintained between pools (Univ. of Mass 2007e).
	Occupied habitat	Whenever possible, avoid surface-disturbance activities within 600 ft of documented sighting of a SGCN (Univ. of Mass 2007e).

Table 62. Summary of limited operating periods and management restrictions

Species	Season	Buffer Distance	Restricted Activity
Northern goshawk	Year-round	660 ft from nest	Timber harvest
	April 1 to July 31	660 to 1,320 ft from nest	Timber harvest
	Year-round	1,320 ft from nest	New road construction and final harvest activities
	April 1 to July 31	660 ft to 2,640 ft from nest	New road construction restrict or close roads
Red-shouldered hawk	Year-round	330 ft from nest	Timber harvest and new road construction
	Year-round	330 to 660 ft from nest	New road construction
	March 1 to August 31	660 to 1,320 ft from nest	Timber harvest and road construction, restrict/close roads
Coopers hawk	Year-long	330 ft from nest	Timber harvest and road construction
		330 to 660 ft from nest	New road construction
	March 1 to July 31	660 to1,320 ft from nest	Timber harvest and road construction, restrict/ close roads
Sharp-shinned hawk	Year-long	330 ft from nest	Timber harvest and road construction
		330 and 660 ft from nest	New road construction
	April 15 to August 15	660 to1,320 ft from nest	Timber harvest and road construction, restrict/ close roads
Neo-tropical migrant songbirds	April 1 to June 30	Within the stand	Site preparation
Timber	Year-round	450 ft from den	Road and landing construction

Table 62. Summary of limited operating periods and management restrictions

Species	Season	Buffer Distance	Restricted Activity
rattlesnake	April 1 to October 31		Timber harvest
Wood turtle	May 15-October 15	2,000 ft from documented site	Minimize motorized access
		600 ft from perennial stream	Public access of local NYC DEP roads
Spotted turtle	March 16-October 31	300 ft from documented site	Minimize motorized access
Blandings turtle	March 16-October 31	1,000 ft from documented site	Minimize motorized access

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14. GLOSSARY

Aquic conditions – Soils are saturated either periodically or continuously.

Argillic – Soils with clay-rich deposits and advanced development that are commonly found on stream terraces adjacent to higher order stream drainages.

Basal area – The area in square feet of the cross section at breast height of a single tree, a group of trees, or all of the trees in a stand, usually expressed in square feet per acre.

Biodiversity – Biological diversity in an environment as indicated by numbers of different species of plants and animals.

Broadleaf forest – Forest cover type that is predominantly deciduous or hardwood species.

Buffering capacity – Ability to resist change in pH.

Carrying capacity –The carrying capacity of a biological species in an environment is the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in the environment.

Cation exchange capacity – Measure of the ability of a soil to retain cations, some of which are plant nutrients.

Conifer forest – Forest cover type that is predominantly conifers or softwoods.

Crystalline rock – Rock entirely composed of crystallized minerals without glass matter.

Ephemeral streams – Streams that flow only after rain or snowmelt and have no baseflow component.

Evapotranspiration – Water loss from the soil, including that by direct evaporation and that by transpiration from plant surfaces.

Even-age management – timber management methods that result in the creation of forest stands in which all trees are essentially the same age.

Forested wetlands – Forest cover type which is likely to be hardwoods. This type is difficult to accurately quantify based on data collection methodology so it is only used for comparison purposes.

Fragipan – Soils with dense layers in the subsoil that restrict rooting and water drainage.

Glacial till – Unsorted material deposited by glacial processes, ranging in size from clay to boulders.

Goals – Concise statements that describe ways to achieve the guiding principles. These statements are normally expressed in broad general terms without a distinct timeframe for achievement. Goal statements form the basis from which objectives are developed with more specific timeframes.

Guiding Principles – An integrated vision of a properly functioning forest that supports a broad range of biodiversity-maintaining ecological functions and services.

Humic – Non-living litter layer over forest soil. Consists of undecayed to mostly decayed organic matter, which contains many nutrients that are recycled in the soil when it's broken down.

Hydrology – The study of water in the natural or disturbed environment.

Inceptic – Soils lacking substantial subsurface organic matter accumulation and clay fines that occur over a lengthy time.

Infiltration – To pass into or through forest soils by filtering or permeating.

Interception – Net loss of precipitation by evaporation between the top of the forest canopy and the forest floor. This water returns to the atmosphere and does not enter the soil or increase runoff.

Invasive species – A species that is (1) nonnative (or alien) to the ecosystem under consideration, and (2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health (Executive Order 13112). Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

Keystone herbivore – Species that disproportionately affects the environment relative to its abundance.

Mixed forest – Forest cover type that contains at least 25 percent stocking of one other forest cover type as well as mixed.

Muck soils – Soils made up primarily of humus from drained swampland, used for growing specialty crops such as onions, carrots, celery, and potatoes.

Objectives – Form the basis for project-level actions or proposals to achieve the goals within the existing planning timeframe, generally considered to be the next 10 to 15 years.

Peneplain – Gently undulating, almost featureless plain that, in principle, would be produced by fluvial erosion that would, in the course of geologic time, reduce the land almost to baselevel (sea level), leaving so little gradient that essentially no more erosion could occur. The peneplain concept was named in 1889 by William M. Davis, who believed it to be the final stage of his geomorphic cycle of landform evolution.

pH – Concentration of hydrogen ions. Low pH corresponds to high hydrogen ion concentration and vice versa. A substance that when added to water increases the concentration of hydrogen ions(lowers the pH) is called an acid. A substance that reduces the concentration of hydrogen ions(raises the pH) is called a base.

Photosynthate – Product of photosynthesis.

Relative density – Amount of tree occupation relative to maximum site occupation.

Residuum – Non-transported material that has weathered in place out of baserock or bedrock (may be igneous, metamorphic, or sedimentary). Usually not sorted by particle size beyond any sorting present in the parent rock.

Resilience – Ability of an organism to recover from or adjust easily to distress or change.

Resistance – The inherent ability of an organism to resist harmful influences (such as disease, pests, toxic agents, or infection).

Riparian areas – Transition zones between terrestrial and aquatic ecosystems, such as streams, lakes, and wetlands.

Stocking – The degree of occupancy of land by trees, measured by basal area or the number of trees in a stand and spacing in the stand, compared with a minimum standard, depending on tree size, required to fully utilize the growth potential of the land.

Till – Unsorted glacial sediment mostly derived from the subglacial erosion and entrainment by the moving ice of glaciers of previously available unconsolidated sediments.

Turbidity – Opaque, deficient in clarity or purity.

Uneven-age management – timber management method that results in forest stands characterized by trees of many ages or sizes intermingled singly or in groups.

Vernal pools – Temporary pools of water, which are usually devoid of fish, allowing safe development of amphibian and insect species. Many pools are dry for part of the year and fill with winter rains or snowmelt. Vernal means relating to spring when many of the pools fill with water and teem with life (often frogs, toads, and salamanders).

Watershed – Croton, Delaware, and Catskill water supply systems.

Watershed management – The planned manipulation of one or more factors of the natural or disturbed drainage to effect a desired change in or maintain a desired condition of the water resource.

15. MAP PACKET

Attached separately, the map packet includes 9 maps for each section, based on the basin or combination of basins suitable for printing at a scale to display on 11-inch by 17-inch paper.

Section 2 - Protected Lands

Section 4.5 – Conservation Practices

Section 6.1 - Land Cover Types

Section 6.3 - Forest Types

Section 7.1 – Management Needs

16. INDEX

New York City Watershed Forest Management Plan

CAT-374

Map Packet

Ashokan Reservoir

Prepared by:

USDA Forest Service TEAMS Enterprise Unit

For:

New York City Department of Environmental Protection

November 10, 2011

MAP PACKET

This map packet includes 9 maps for each section, based on the basin or combination of basins suitable for printing at a scale to display on 11 inch by 17 inch paper. The sections correspond to the Forest Management Plan section.

Section 2 - Protected Lands

Section 4.5 – Conservation Practices

Section 6.1 - Land Cover Types

Section 6.3 - Forest Types

Section 7.1 – Management Needs

Section 2 - Protected Lands

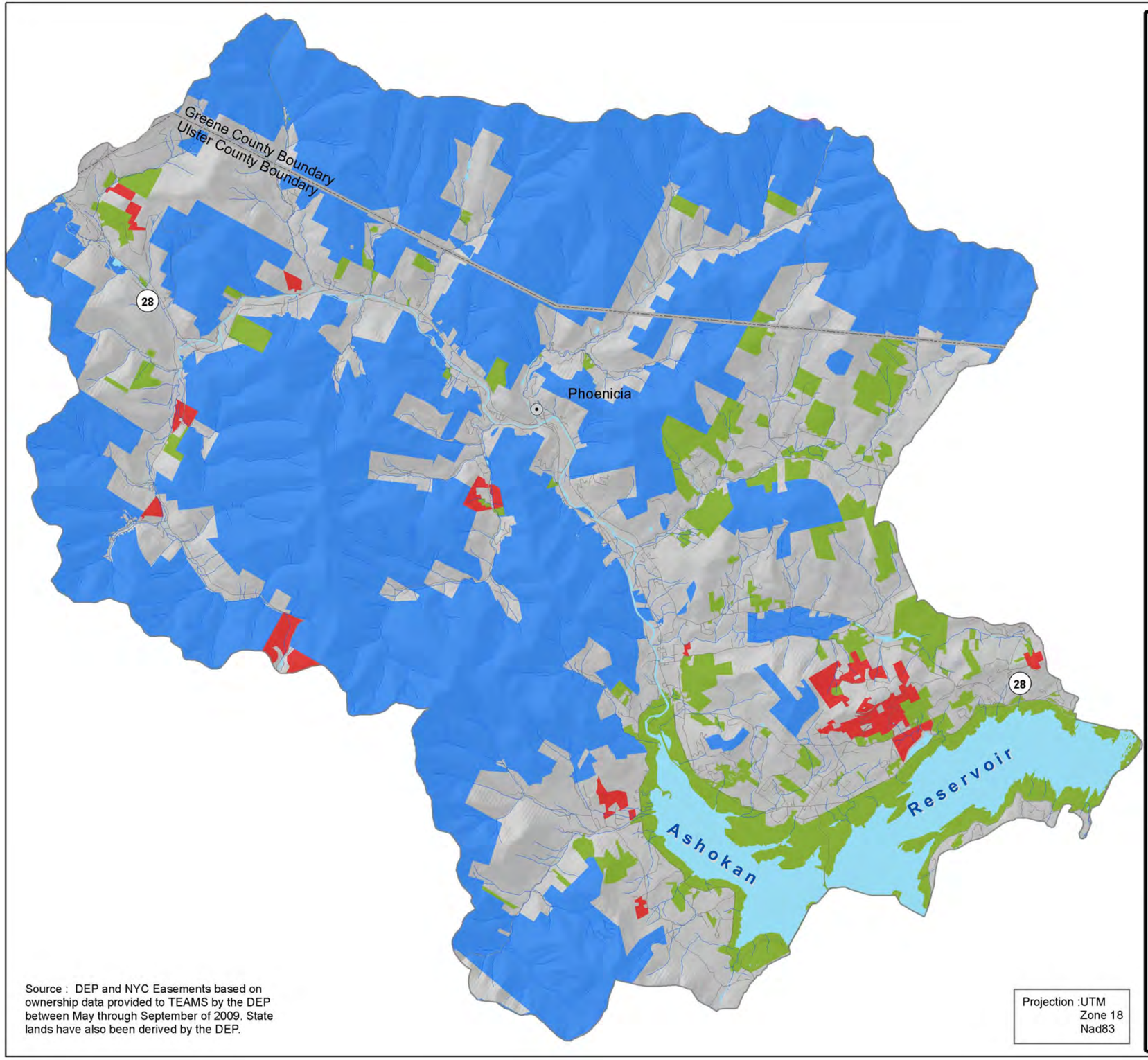
New York City
Watershed Forest Management Plan

NYC Environmental Protection

West of Hudson
Ashokan Basin

TEAMS

Protected Lands



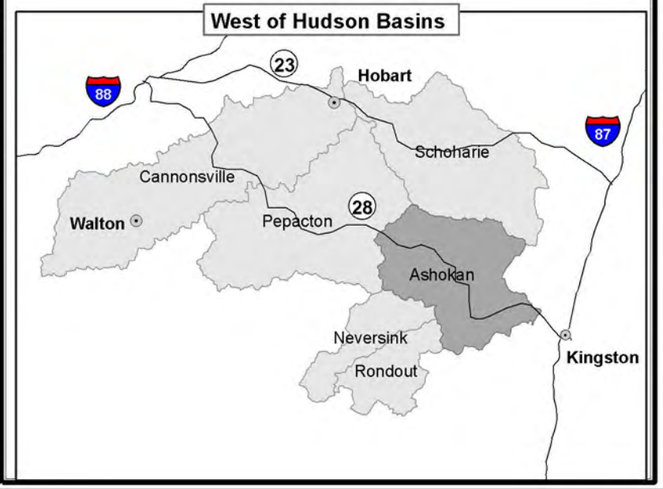
- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

N
W E
S

0 1.25 2.5 5
Miles

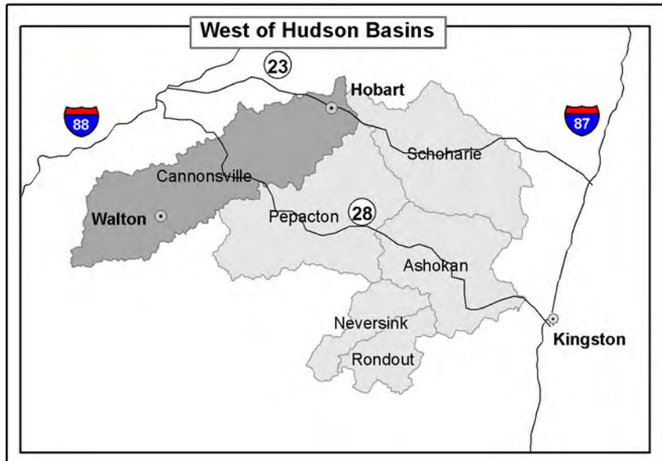
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

West of Hudson Basins



Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

Projection :UTM
Zone 18
Nad83


West of Hudson Basins
23
Hobart
88
87
Schoharie
Cannonsville
Walton
Pepacton
28
Ashokan
Neversink
Kingston
Rondout

Schoharie County Boundary
Delaware County Boundary
23
Hobart
Delhi
28
N
W
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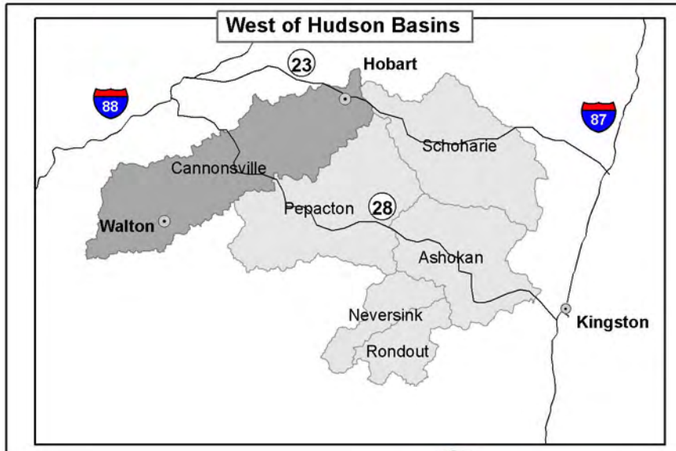
S
0
1.5
3
6
Miles
Projection :UTM
Zone 18
Nad83
Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.
New York City
Watershed Forest Management Plan
NYC Environmental Protection
West of Hudson
Cannonsville Basin
(East Half)
TEAMS
Protected Lands
DEP
NYC Easements
State
Private and Other
Public Roads
Streams
County Boundaries
Basin Boundaries
Water



New York City Watershed Forest Management Plan

West of Hudson Cannonsville Basin (West Half)

Protected Lands

Delhi

28

Walton

10

Reservoir

Cannonsville

N

W

E

S

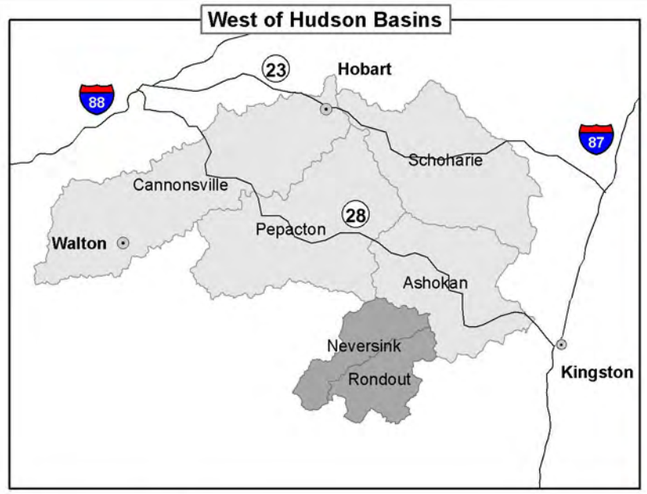
Projection :UTM
Zone 18
Nad83

0 1.5 3 6 Miles

Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



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Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Neversink

Rondout

Ulster County Boundary
Sullivan County Boundary
County Boundary

55

Neversink

Rondout Reservoir

Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

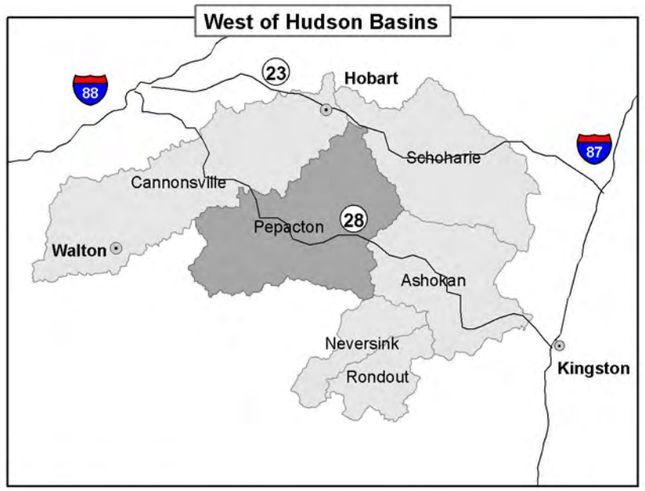
NYC Environmental Protection

TEAMS

West of Hudson Neversink & Rondout Basin

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

0 1.25 2.5 5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

West of Hudson
Pepacton Basin

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

New York City
Watershed Forest Management Plan

NYC Environmental Protection

TEAMS

West of Hudson
Schoharie Basin

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Delaware County Boundary

Schoharie

Schoharie County Boundary

Greene County Boundary

Prattsville

23

Hunter

Tannersville

23A

N
W E
S

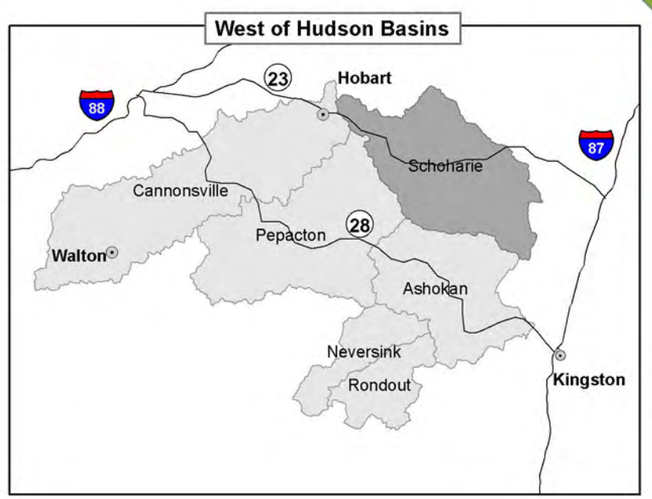
0 1.25 2.5 5 Miles

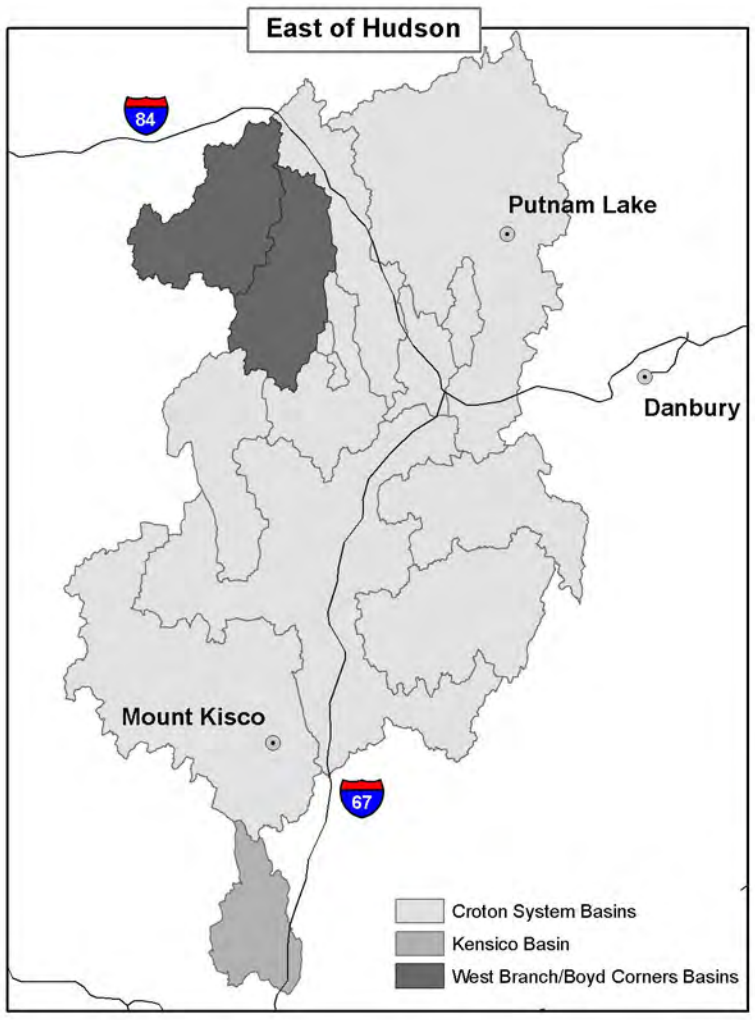
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

Projection :UTM
Zone 18
Nad83

West of Hudson Basins





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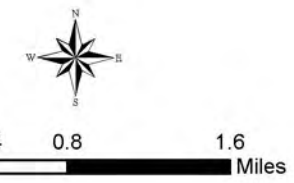

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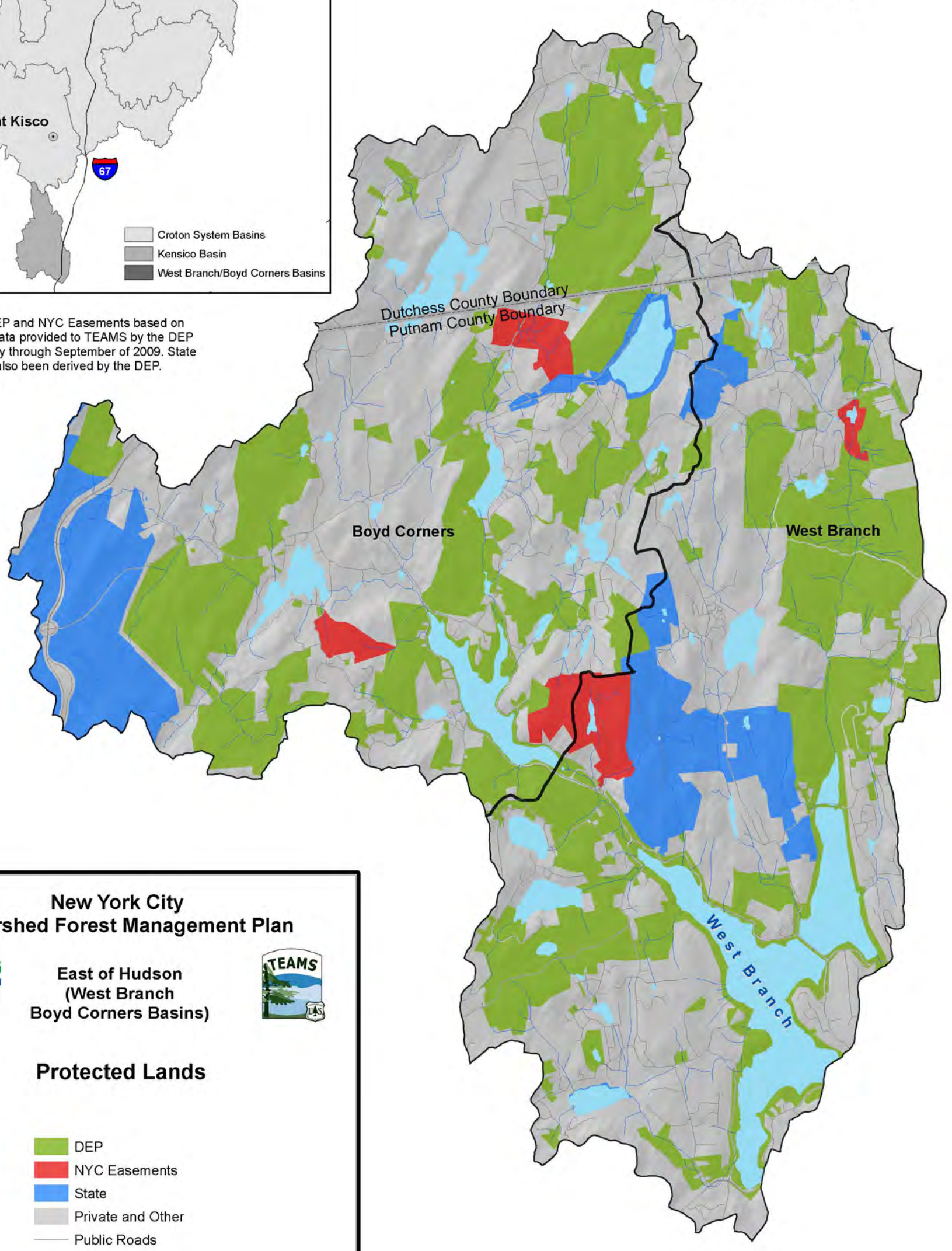


New York City Watershed Forest Management Plan

Environmental Protection

East of Hudson (West Branch Boyd Corners Basins)

TEAMS

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Projection :UTM
Zone 18
Nad83

New York City
Watershed Forest Management Plan

Environmental Protection

East of Hudson
(Croton System Basins)

TEAMS

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.

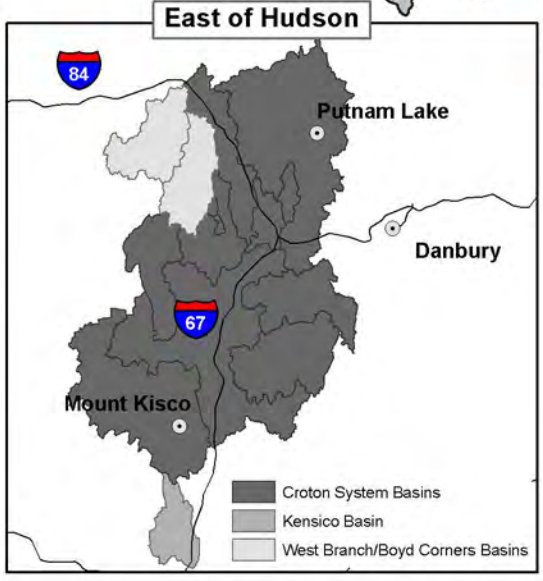
Middle Branch
Dutchess County Boundary
East Branch
Putnam Lake
Bog Brook
Lake Gleneida
Diverting
Lake Gilead
Croton Falls
Amawalk
Putnam County Boundary
Westchester County Boundary
Titicus
Titicus
Yorktown
Cross River
Muscoot
Cross River
New Croton
New Croton
Mount Kisco
84
684

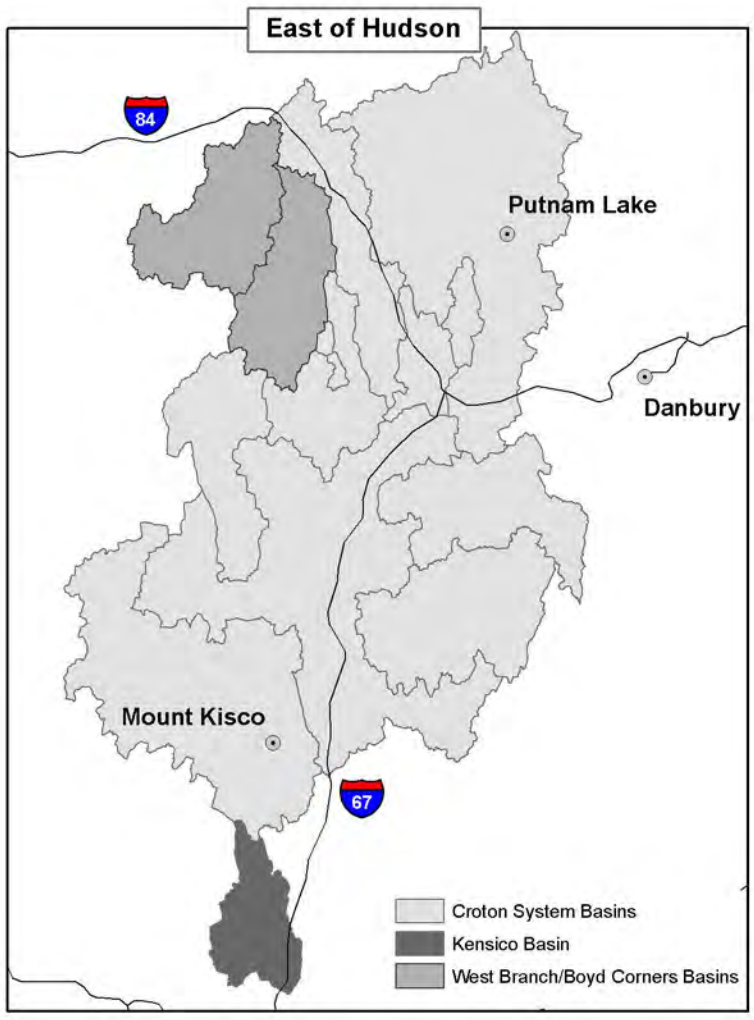
Projection :UTM
Zone 18
Nad83

0 1.25 2.5 5 Miles

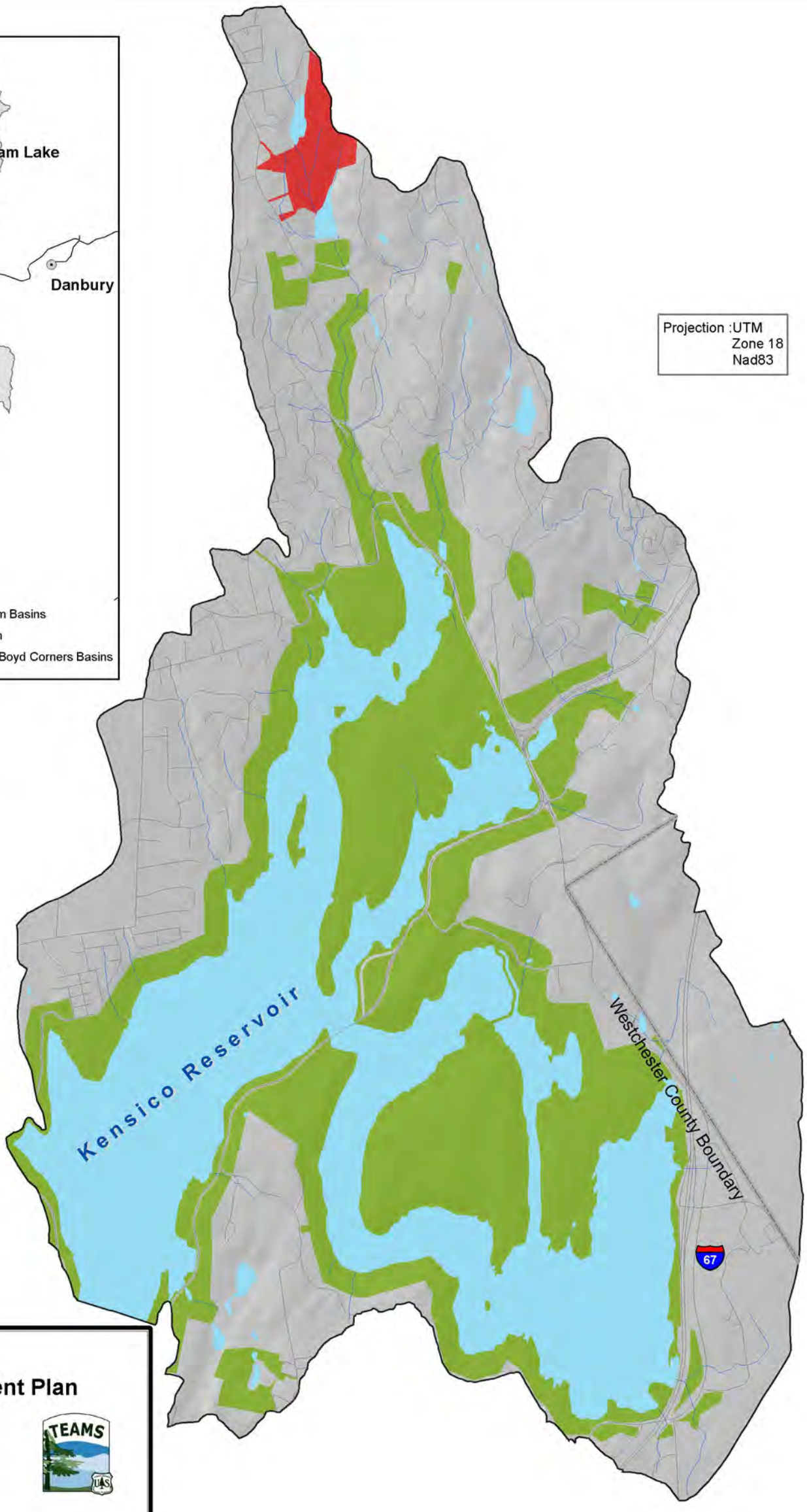
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

East of Hudson





Source : DEP and NYC Easements based on ownership data provided to TEAMS by the DEP between May through September of 2009. State lands have also been derived by the DEP.



New York City Watershed Forest Management Plan

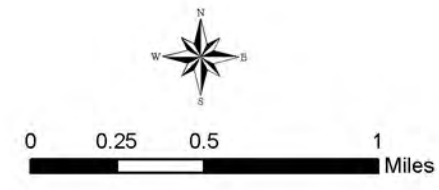
NYC Environmental Protection

TEAMS

East of Hudson (Kensico Basin)

Protected Lands

- DEP
- NYC Easements
- State
- Private and Other
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Section 4.5 - Conservation Practices

New York City
Watershed Forest Management Plan

West of Hudson
Ashokan Basin

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

Projection :UTM
Zone 18
Nad83

Source: DEP Forest Management Projects and Conservation Practices, 2010.

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Scale 1:125,000

Scale 1:125,000

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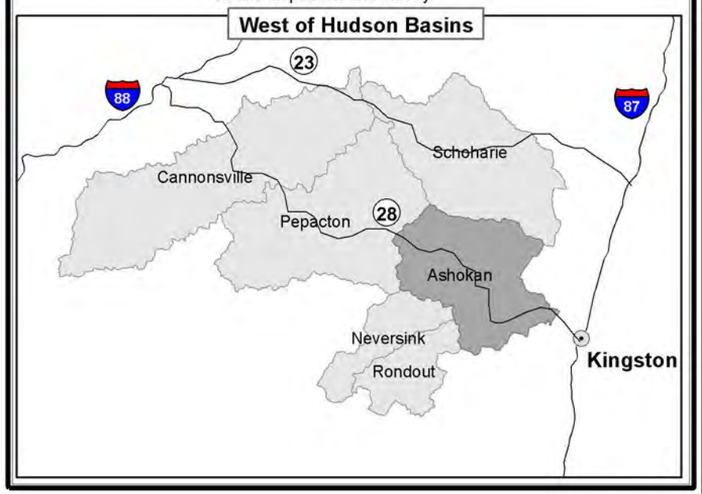
Scale 1:95,000

Scale 1:95,000

Scale 1:95,000

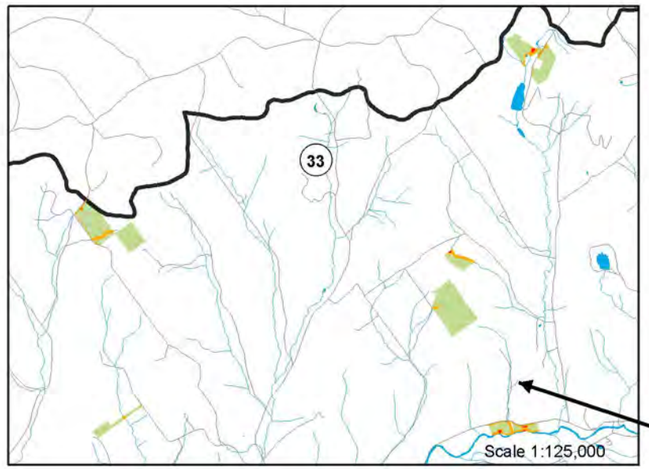
West of Hudson Basins

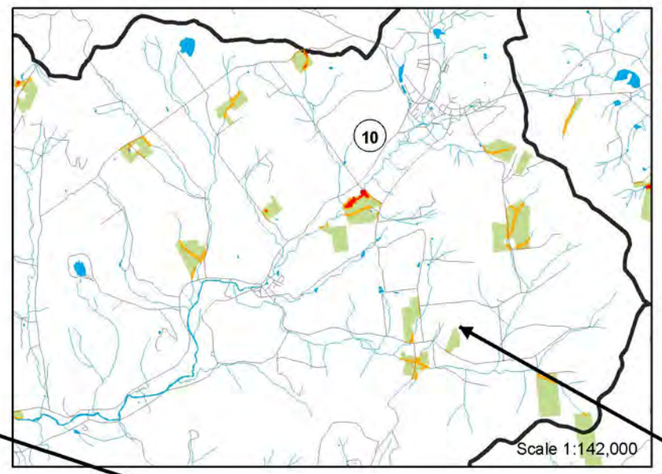


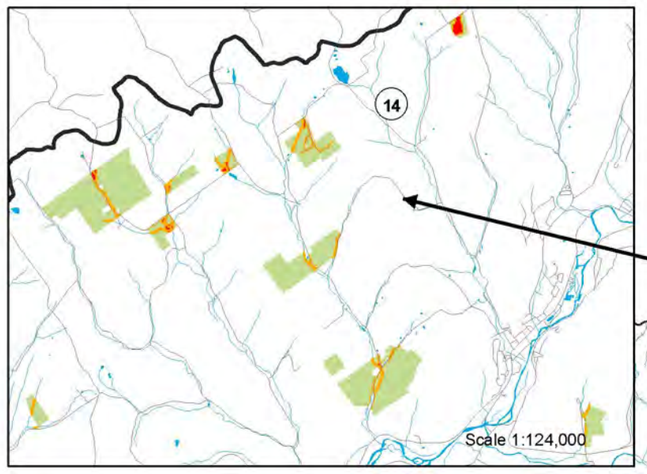
New York City
Watershed Forest Management Plan

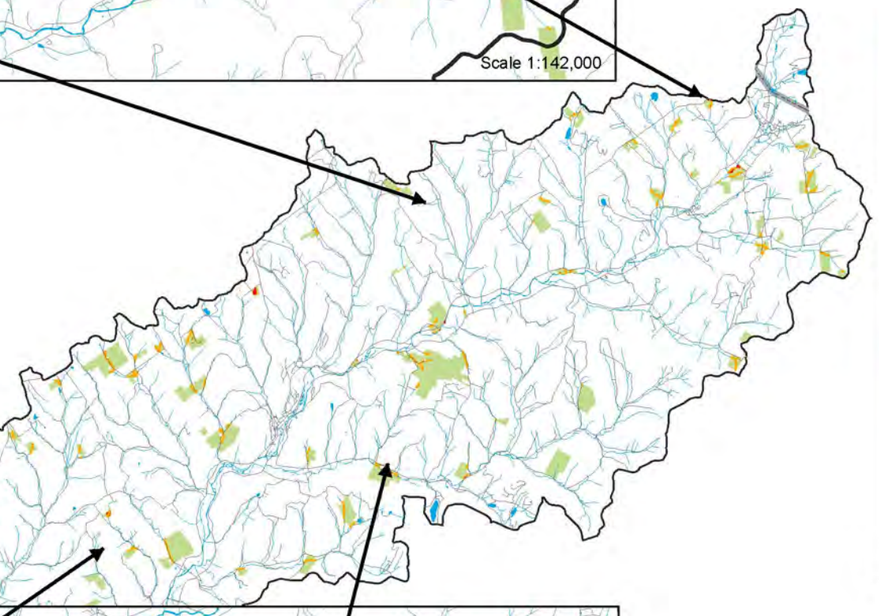
West of Hudson
Cannonsville Basin (East)

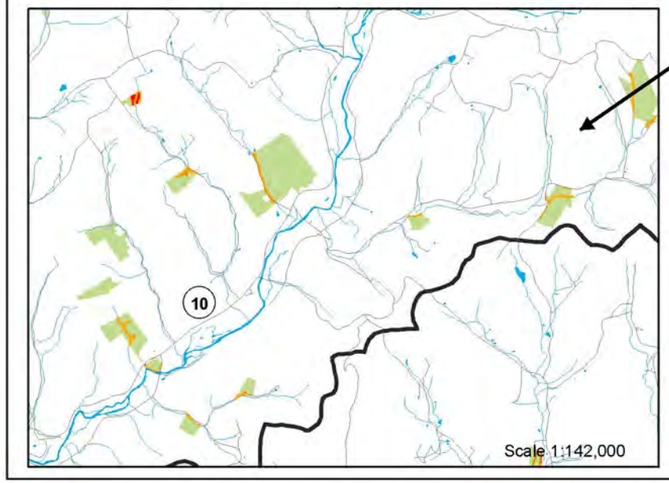
Conservation Practices

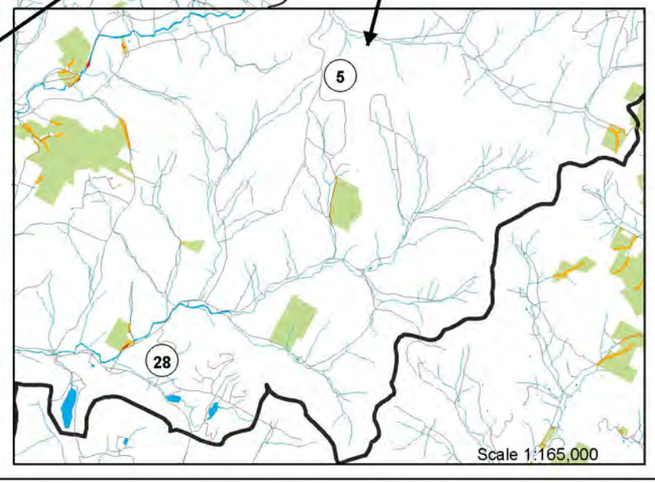












Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

Projection :UTM
Zone 18
Nad83

Source: DEP Forest Management Projects and Conservation Practices, 2010.

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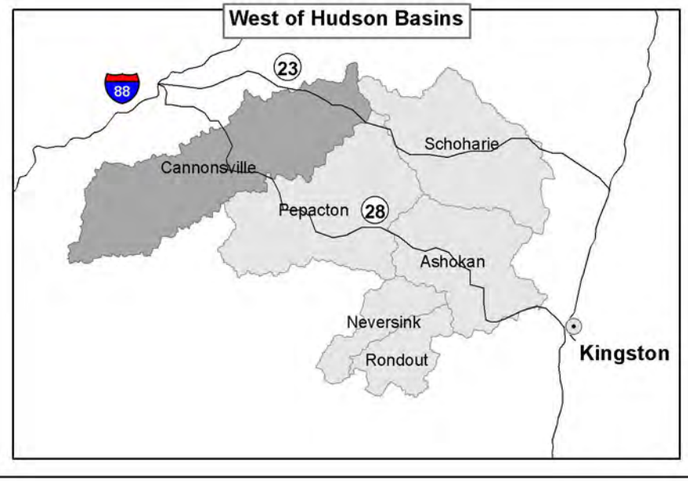
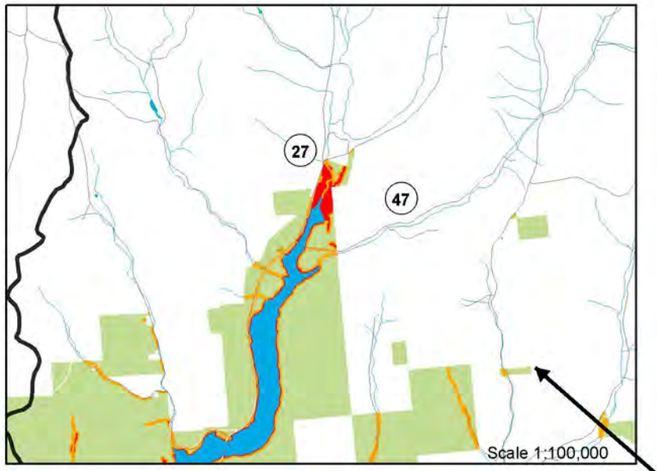
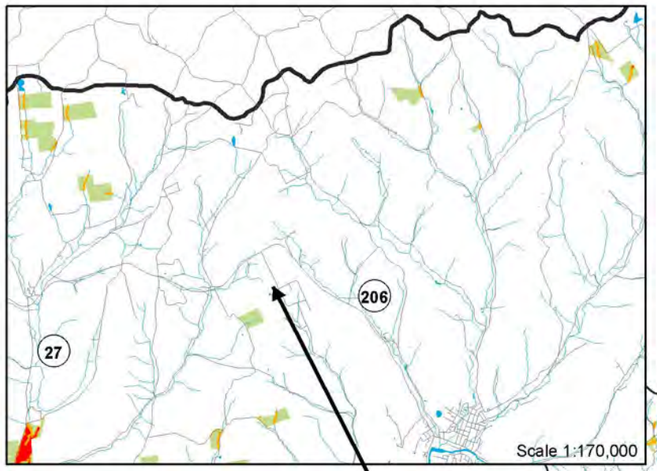
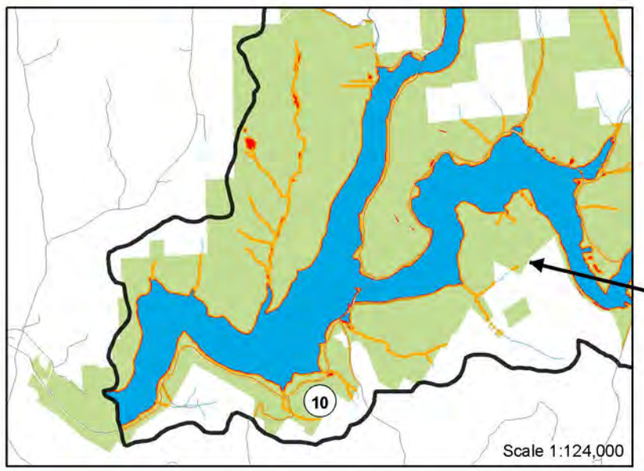
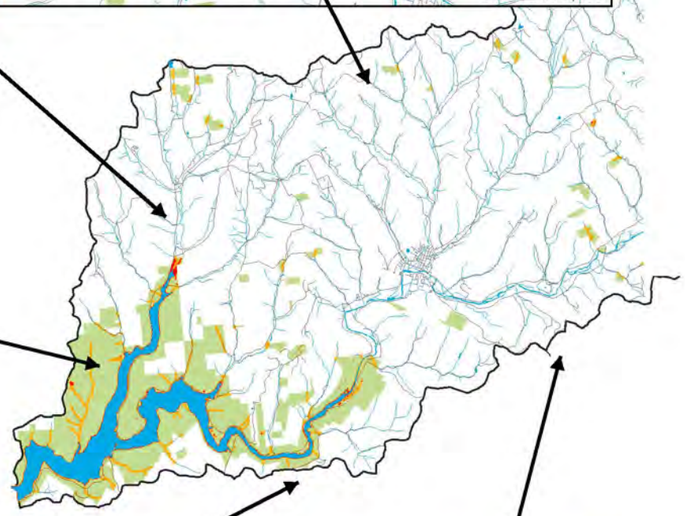
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

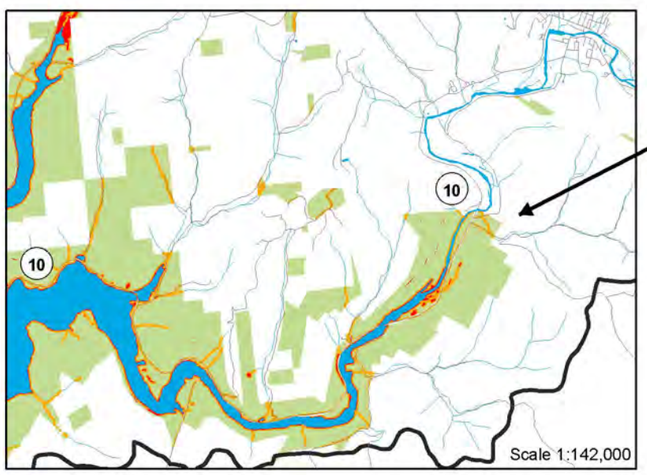


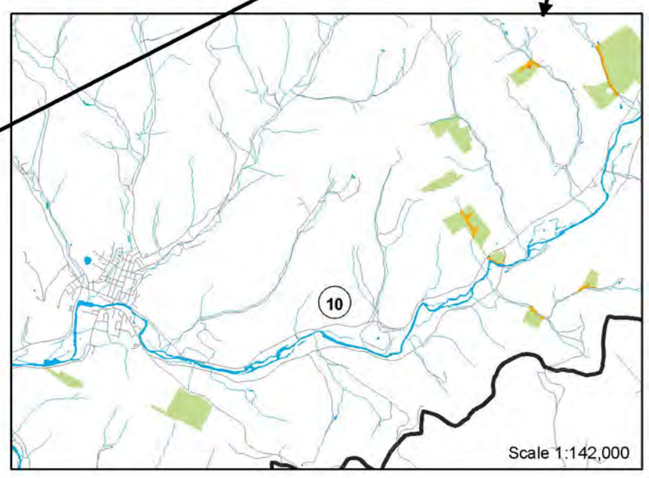












New York City Watershed Forest Management Plan

West of Hudson
Cannonsville Basin (West)

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

Projection :UTM
Zone 18
Nad83

Source: DEP Forest Management Projects and Conservation Practices, 2010.

N
W E
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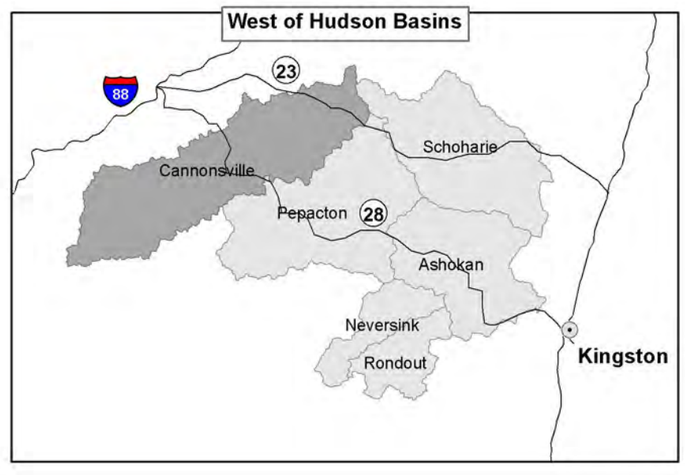
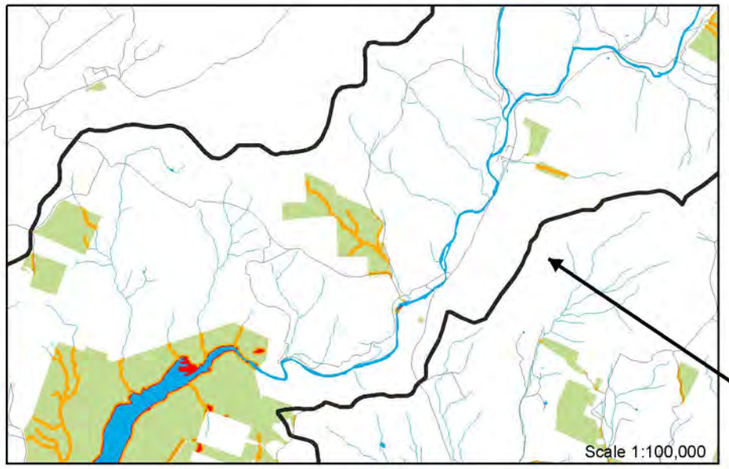
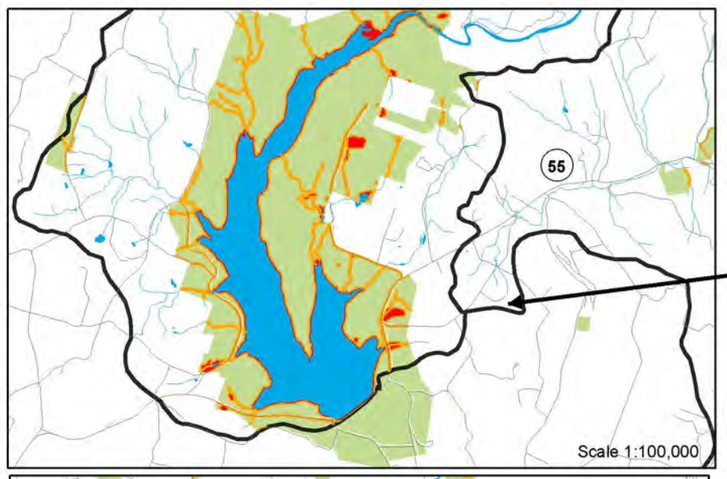


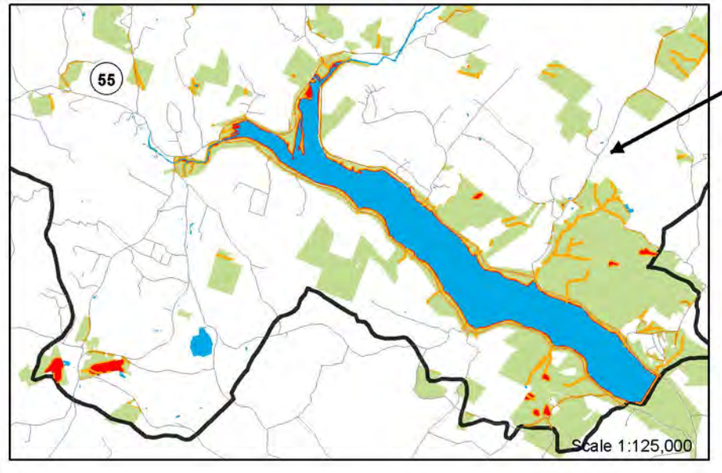
New York City
Watershed Forest Management Plan

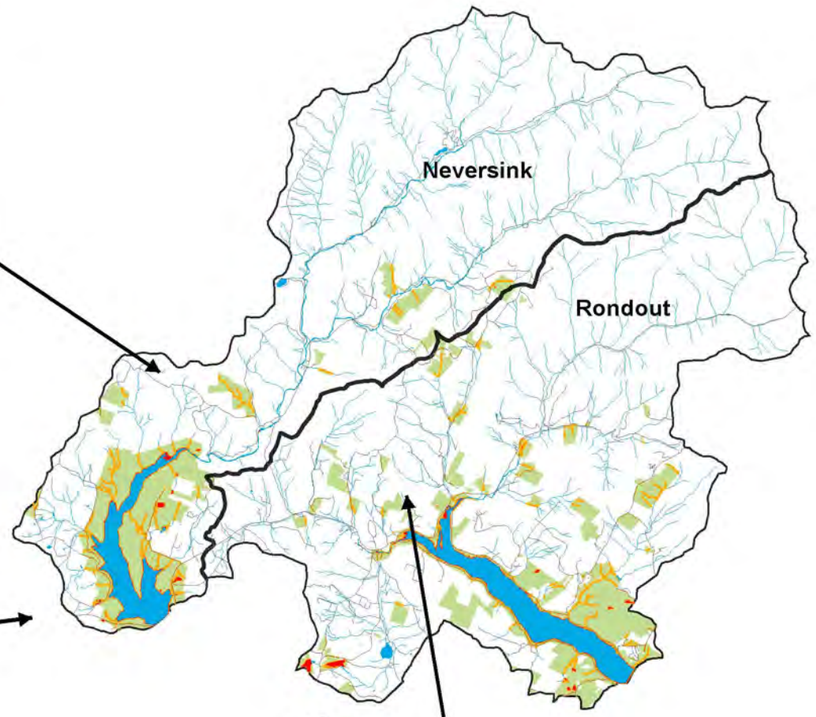
West of Hudson
Neversink & Rondout Basin

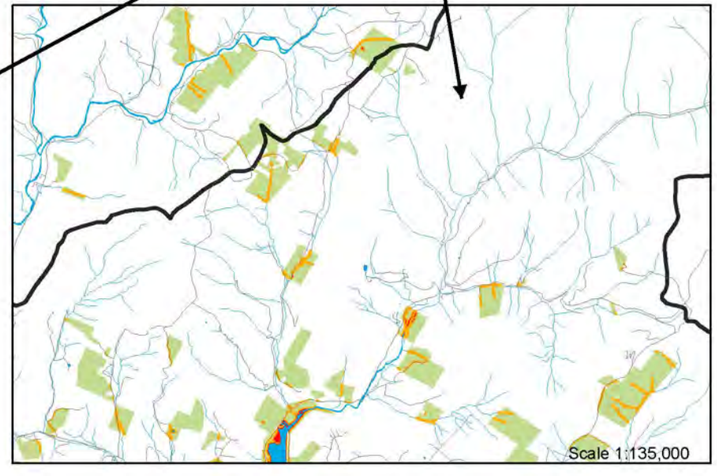
Conservation Practices











Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

Projection :UTM
Zone 18
Nad83

Source: DEP Forest Management Projects and Conservation Practices, 2010.

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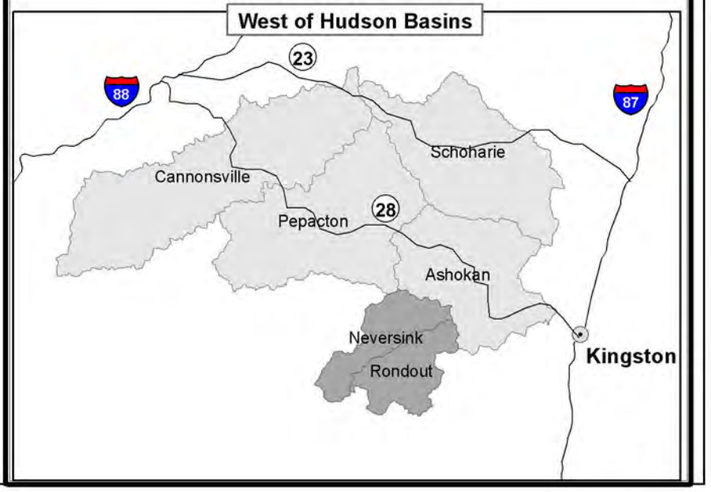

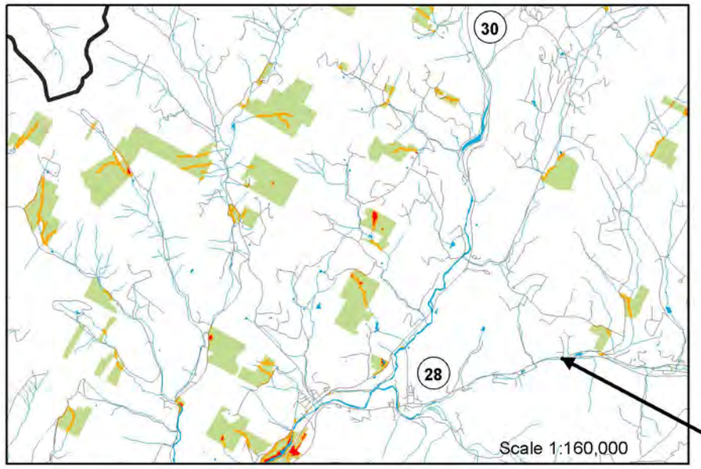

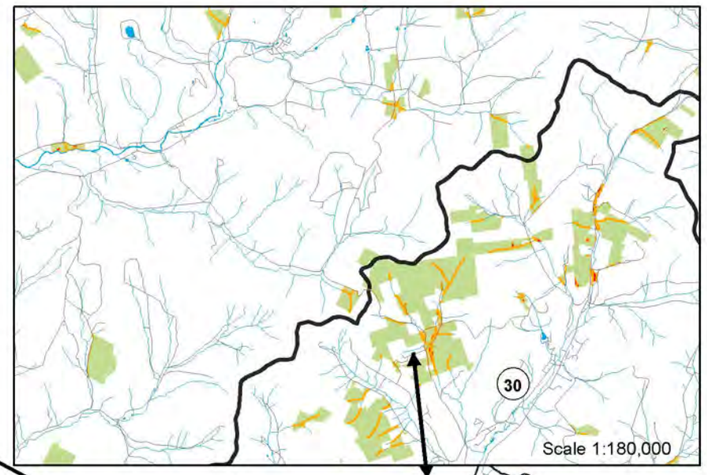

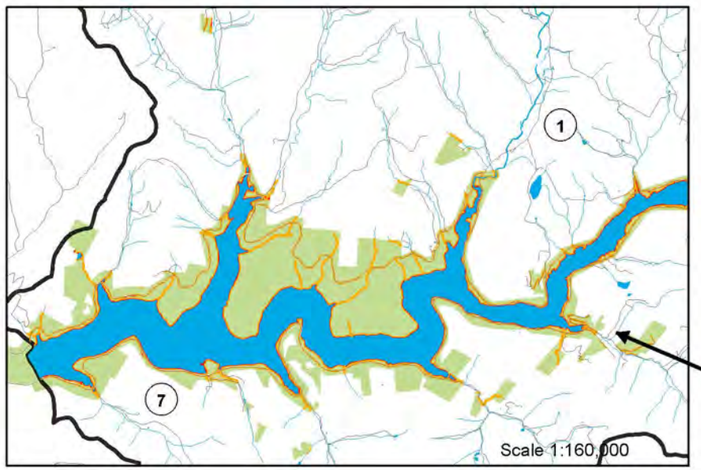

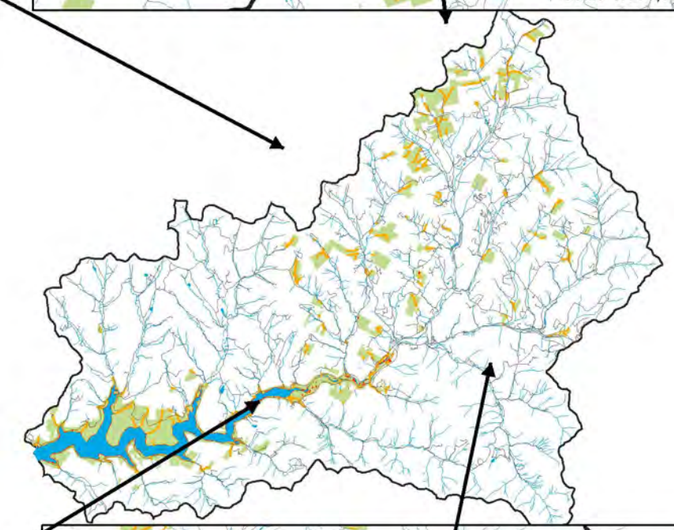

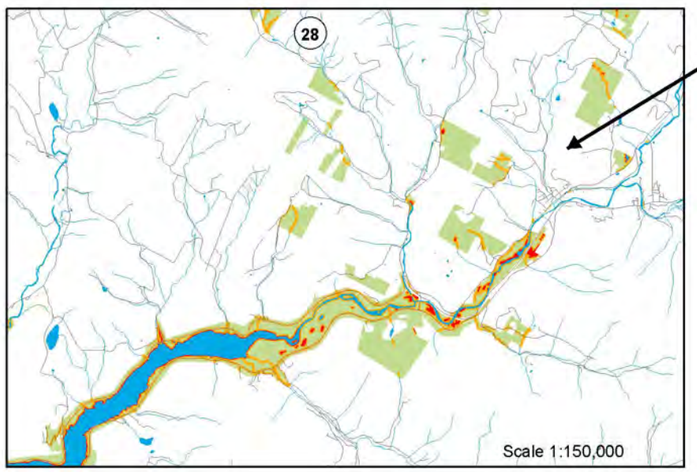

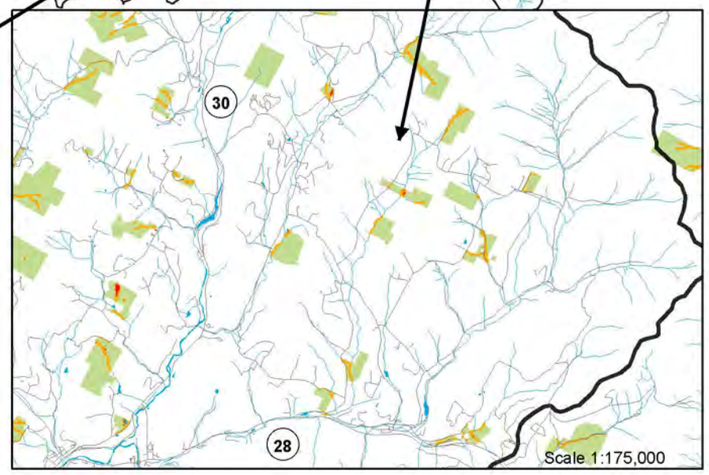

New York City Watershed Forest Management Plan

West of Hudson Pepacton Basin

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

N W E S

Projection :UTM Zone 18 Nad83

Source: DEP Forest Management Projects and Conservation Practices, 2010.

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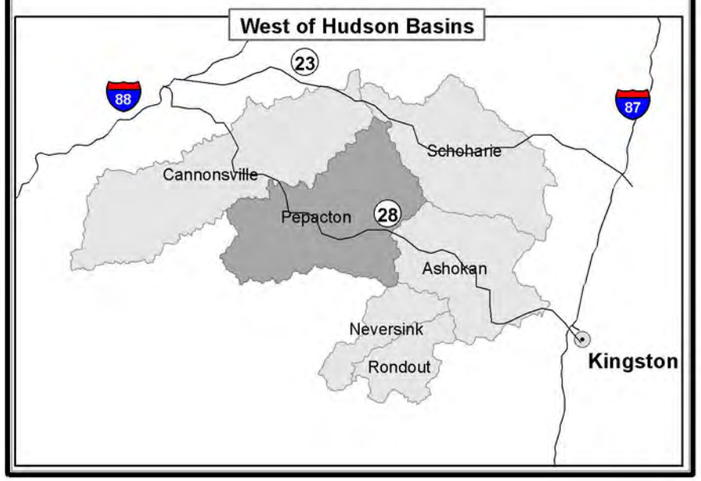

New York City
Watershed Forest Management Plan

West of Hudson
Schoharie Basin

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline

EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.

EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools

EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)

SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)

SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)

SM4- 100 ft wide area around public roads

DEP Lands

Public Roads

Streams

Basin Boundaries

Water

Projection :UTM Zone 18 Nad83

Source: Species at risk based on GIS stand data and field inventory.

N W E S

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Scale 1:150,000

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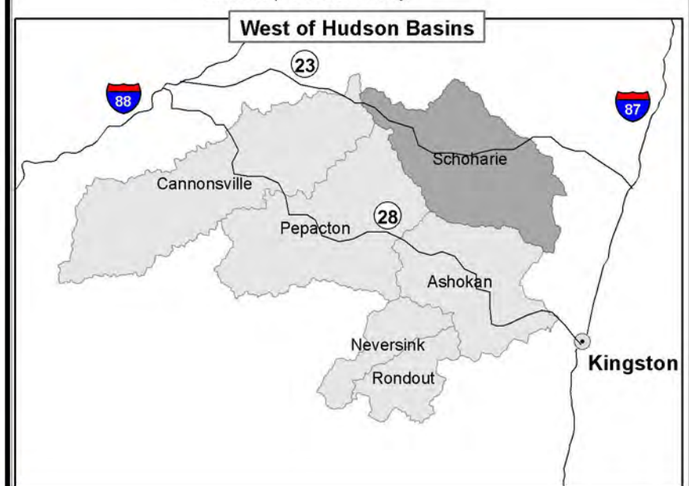

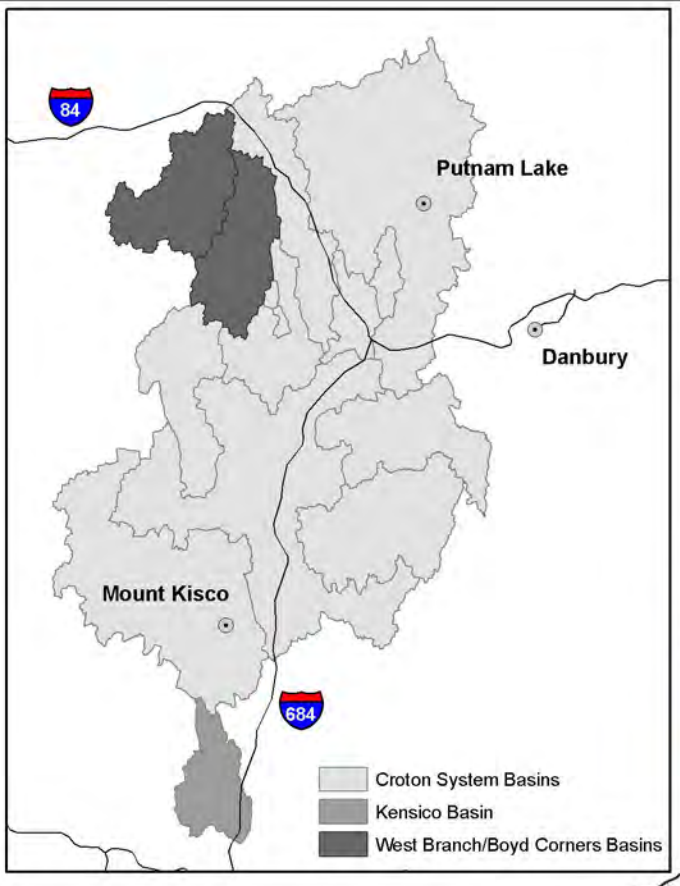

Boyd Corners

West Branch

Source: DEP Forest Management Projects and Conservation Practices, 2010.

New York City Watershed Forest Management Plan

East of Hudson
West Branch/Boyd Corners Basins

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
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- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

Projection :UTM Zone 18 Nad83

N
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1 0.5 0 1 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

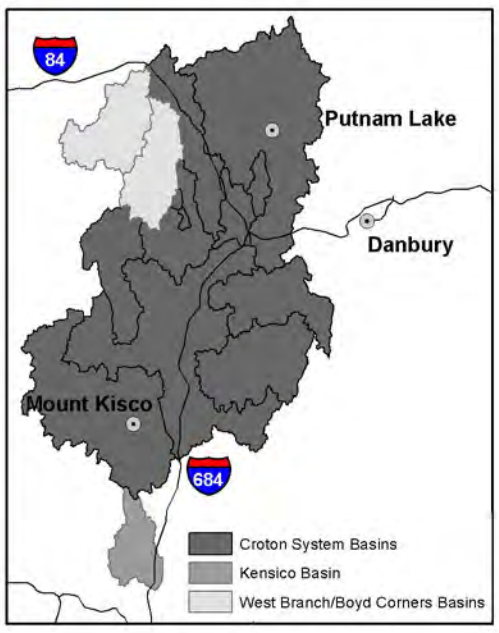
N
W E
S

0 1 2 4
Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Middle Branch
Bog Brook
East Branch
Lake Gleneida
Diverting
Lake Gilead
Croton Falls
Amawalk
Titicus
Cross River
Muscoot
New Croton

Projection :UTM
Zone 18
Nad83



Source: DEP Forest Management Projects and Conservation Practices, 2010.

New York City Watershed Forest Management Plan

NYC Environmental Protection

TEAMS

East of Hudson Croton System Basins

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
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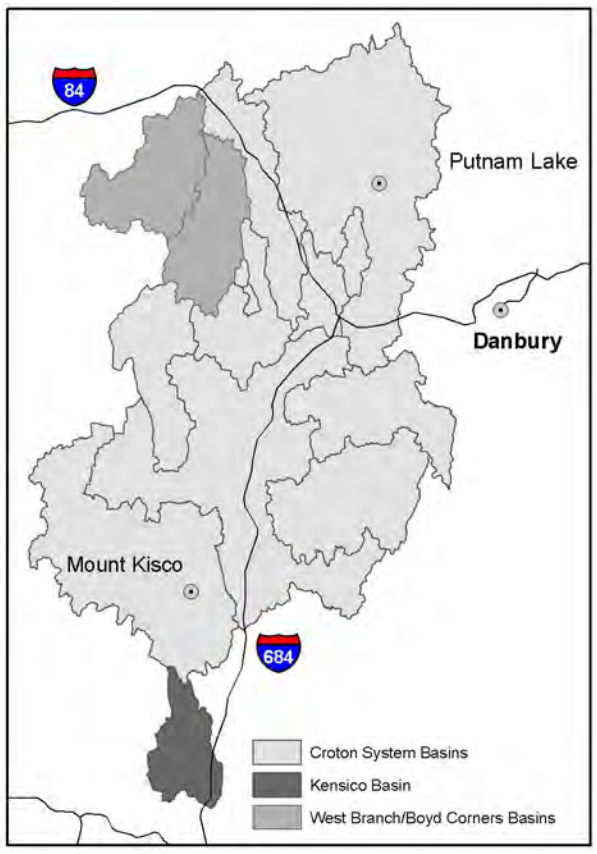
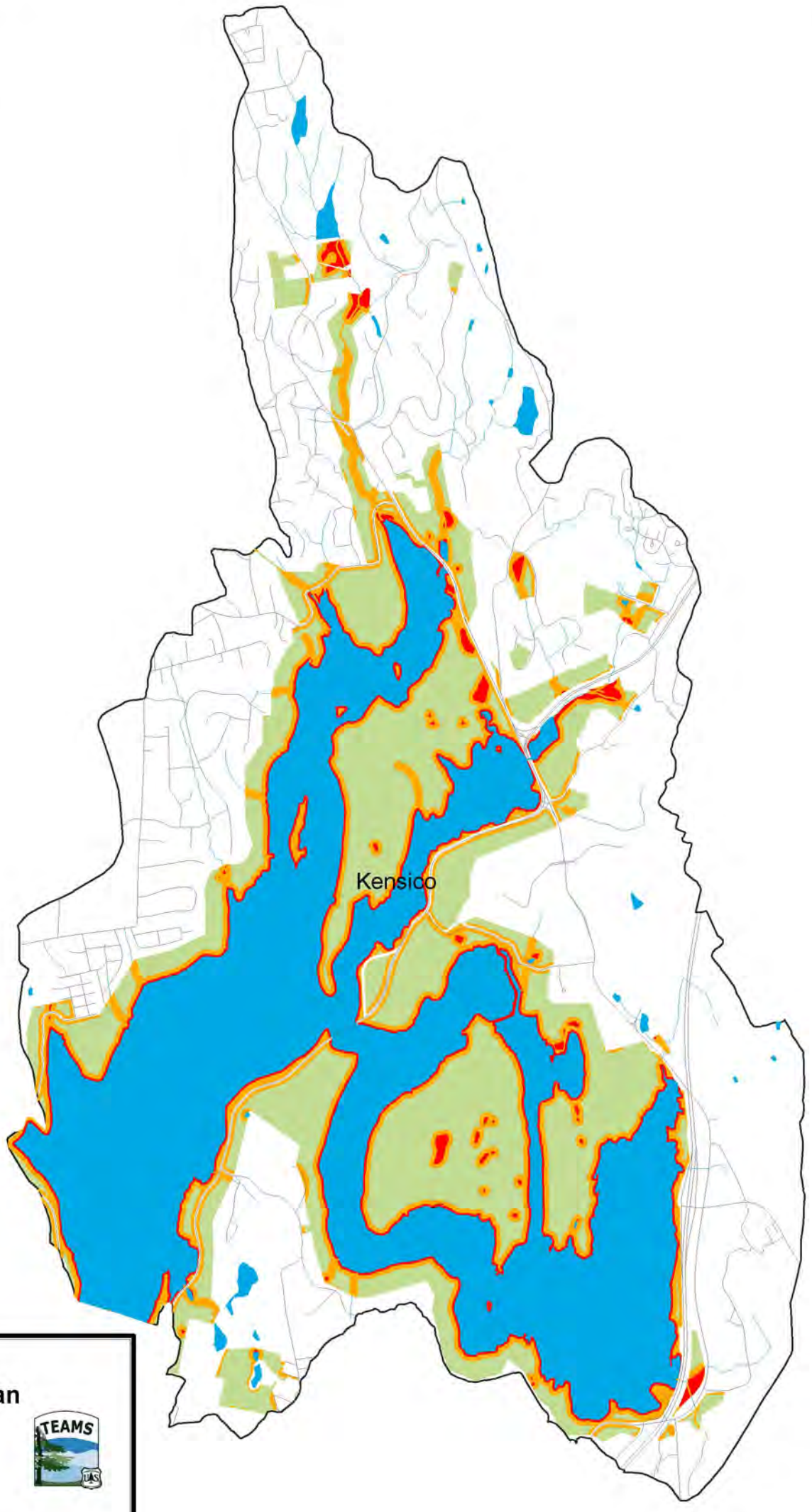
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water



Source: DEP Forest Management Projects and Conservation Practices, 2010.



Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

NYC Environmental Protection

East of Hudson
Kensico Basin

TEAMS

Conservation Practices

Exclusion Zones

The following areas will be designated as Exclusion Zones:

- EZ1 - Reservoirs/lakes and a 50 ft. buffer along shoreline
- EZ2 - Streams, area between stream banks as measured from top of bank on either side of channel.
- EZ3 - Wetlands, lakes, vernal pools and 50 ft. buffer around vernal pools
- EZ4 - Areas with extremely steep slopes (greater than 1:1)

Special Management Zones

The following areas will be designated as Special Management Zones:

- SM1 - 150 ft. wide area from the reservoir or controlled lake edge as measured from the spillway elevation (first 50 ft is an exclusion zone)
- SM2 - 100 ft. wide area as measured from top of bank on either side of channel (area between the stream banks is and exclusion zone)
- SM3 - 100 ft. wide area around wetlands, lakes and a 150 ft. wide area around vernal pools (first 50 ft. around vernal is an exclusion zone)
- SM4- 100 ft wide area around public roads

DEP Lands
Public Roads
Streams
Basin Boundaries
Water

N
W E
S

0 0.375 0.75 1.5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Section 6.1 - Land Cover Types

New York City
Watershed Forest Management Plan

NYC Environmental Protection

West of Hudson
Ashokan Basin

TEAMS

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

N
W E
S

0 1.25 2.5 5
Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Greene County Boundary
Ulster County Boundary

28

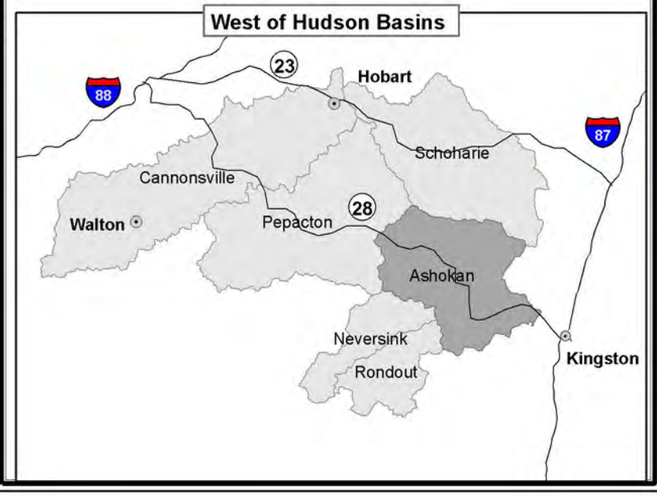
Phoenicia

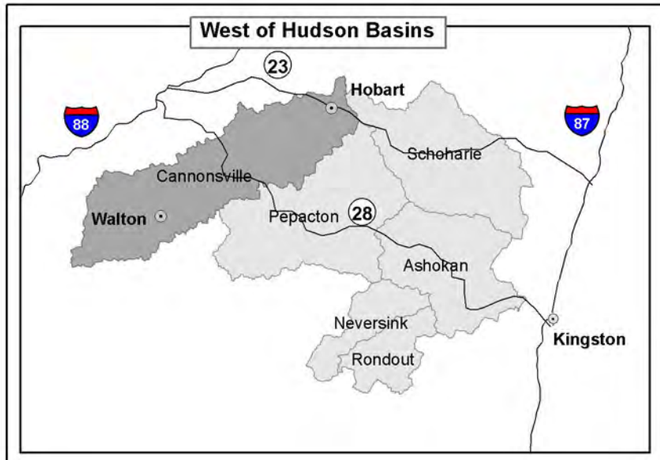
Ashokan Reservoir

Projection :UTM
Zone 18
Nad83

Source: Cover types based on GIS stand data and forest inventory 2009-2010.

West of Hudson Basins





Schoharie County Boundary

Delaware County Boundary

23

Hobart

Delhi

28

N

W

E

S

0 1.5 3 6 Miles

Projection :UTM
Zone 18
Nad83

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Source: Cover types based on GIS stand data and forest inventory 2009-2010.

New York City
Watershed Forest Management Plan

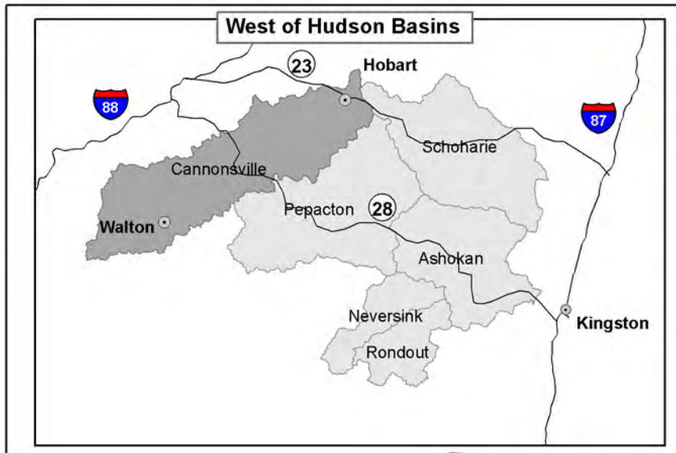
NYC Environmental Protection

TEAMS

West of Hudson
Cannonsville Basin
(East Half)

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries



Delhi

28

Walton

10

Reservoir

Cannonsville

Source: Cover types based on GIS stand data and forest inventory 2009-2010.

N
W
E
S

Projection :UTM
Zone 18
Nad83

0 1.5 3 6 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

New York City Watershed Forest Management Plan

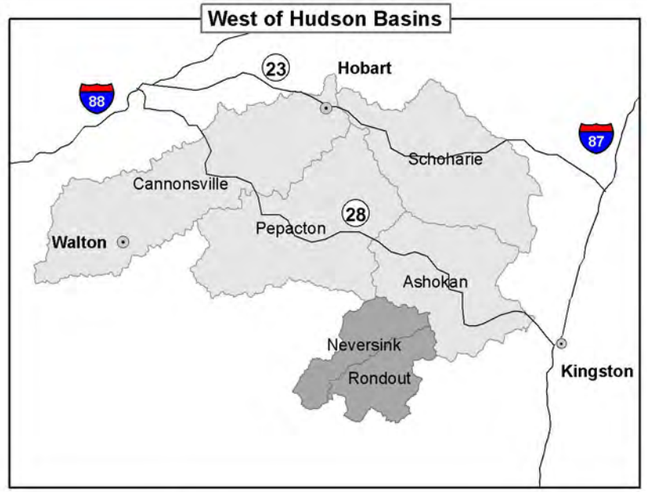
NYC Environmental Protection

TEAMS

West of Hudson Cannonsville Basin (West Half)

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries



N
W E
S

0 0.5 1 2
Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Neversink

Rondout

Ulster County Boundary
Sullivan County Boundary

55

Neversink

Rondout Reservoir

Source: Cover types based on GIS stand data and forest inventory 2009-2010.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

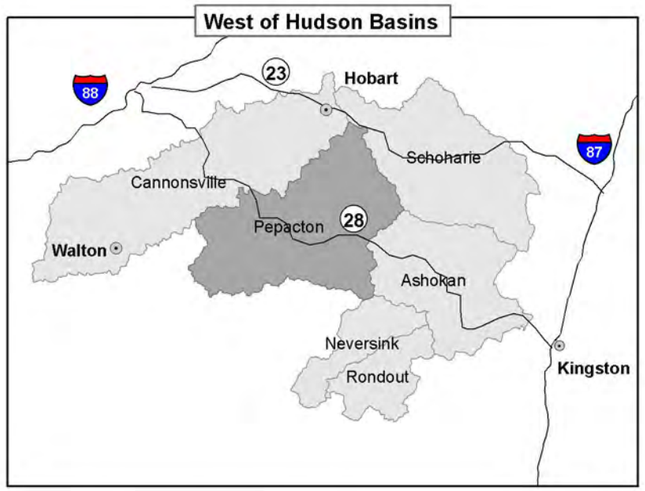
NYC Environmental Protection

TEAMS

West of Hudson
Neversink
&
Rondout Basin

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries



Source: Cover types based on GIS stand data and forest inventory 2009-2010.

0 1.25 2.5 5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

West of Hudson
Pepacton Basin

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

New York City
Watershed Forest Management Plan

NYC Environmental Protection

TEAMS

West of Hudson
Schoharie Basin

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Delaware County Boundary

Schoharie County Boundary

Greene County Boundary

Schoharie

Prattsville

23

Hunter

Tannersville

23A

N
W E
S

0 1.25 2.5 5 Miles

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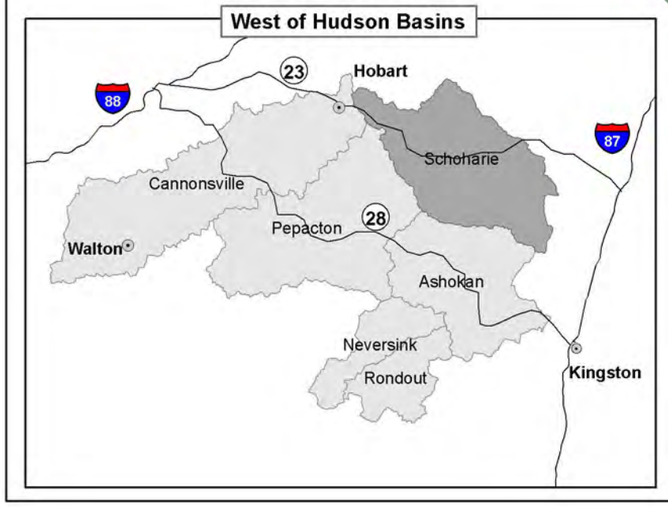
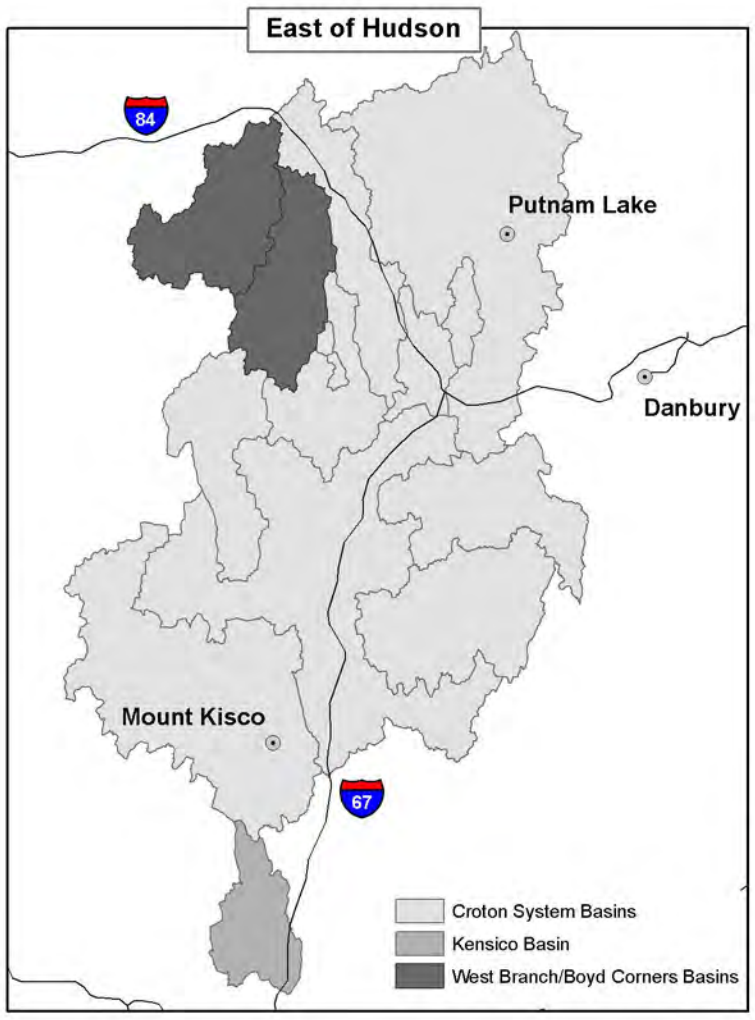
West of Hudson Basins

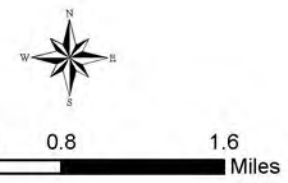


Source: Cover types based on GIS stand data and forest inventory 2009-2010.

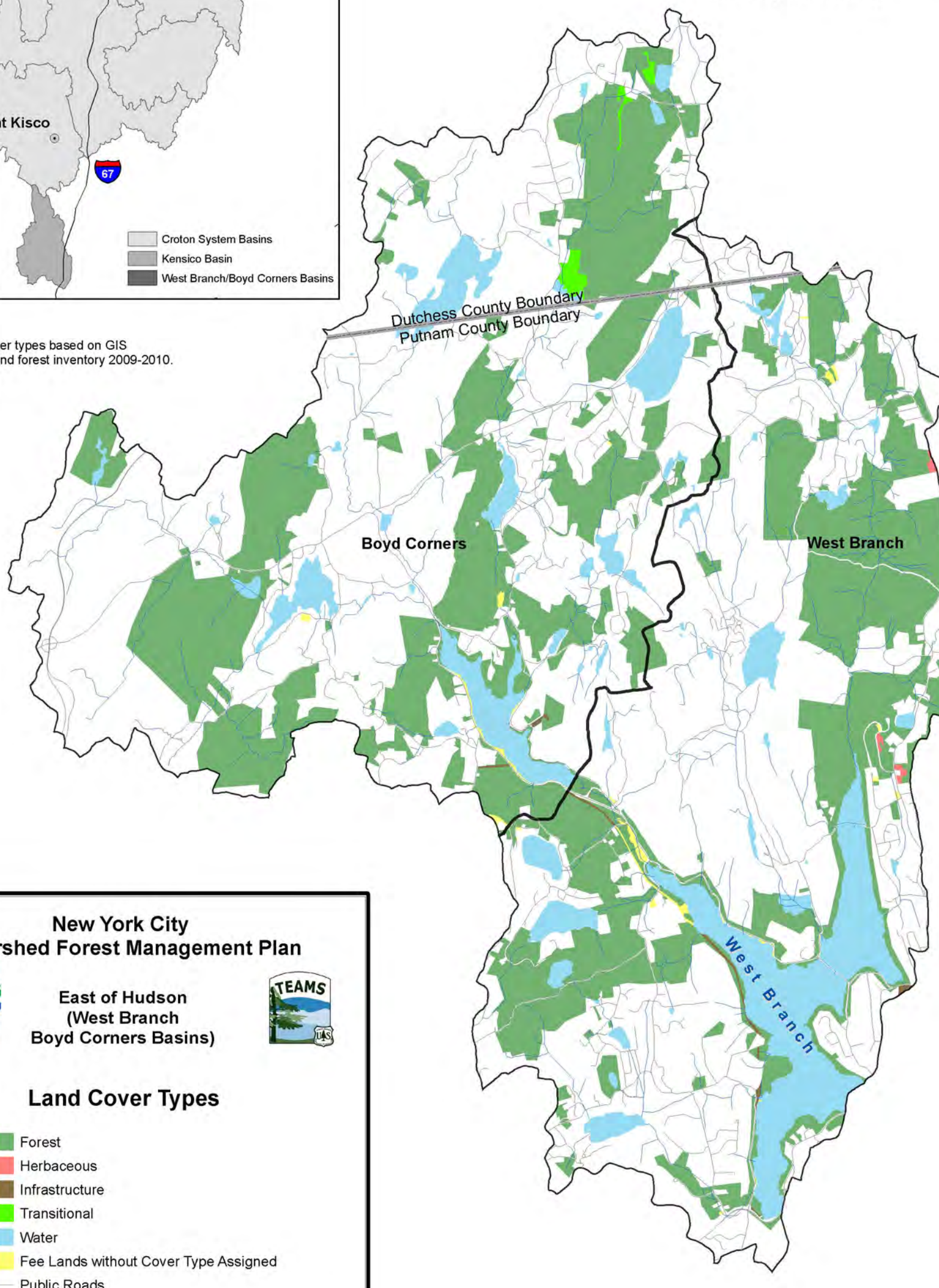
Projection :UTM
Zone 18
Nad83



Source: Cover types based on GIS stand data and forest inventory 2009-2010.



GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.



New York City Watershed Forest Management Plan

NYC Environmental Protection

East of Hudson (West Branch Boyd Corners Basins)

TEAMS

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Projection :UTM
Zone 18
Nad83

New York City
Watershed Forest Management Plan

Environmental Protection

East of Hudson
(Croton System Basins)

TEAMS

Land Cover Types

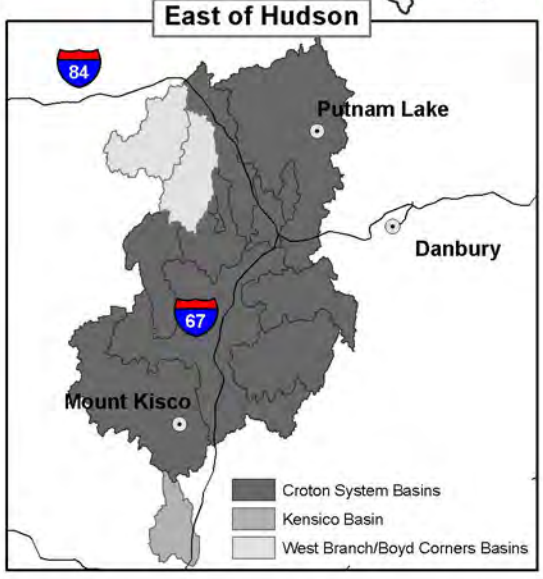
- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Source: Cover types based on GIS stand data and forest inventory 2009-2010.

Middle Branch
Dutchess County Boundary
East Branch
Putnam Lake
Bog Brook
Lake Gleneida
Diverting
Lake Gilead
Croton Falls
Amawalk
Putnam County Boundary
Westchester County Boundary
Titicus
Titicus
Yorktown
Cross River
Muscoot
Cross River
New Croton
New Croton
Mount Kisco
84
684

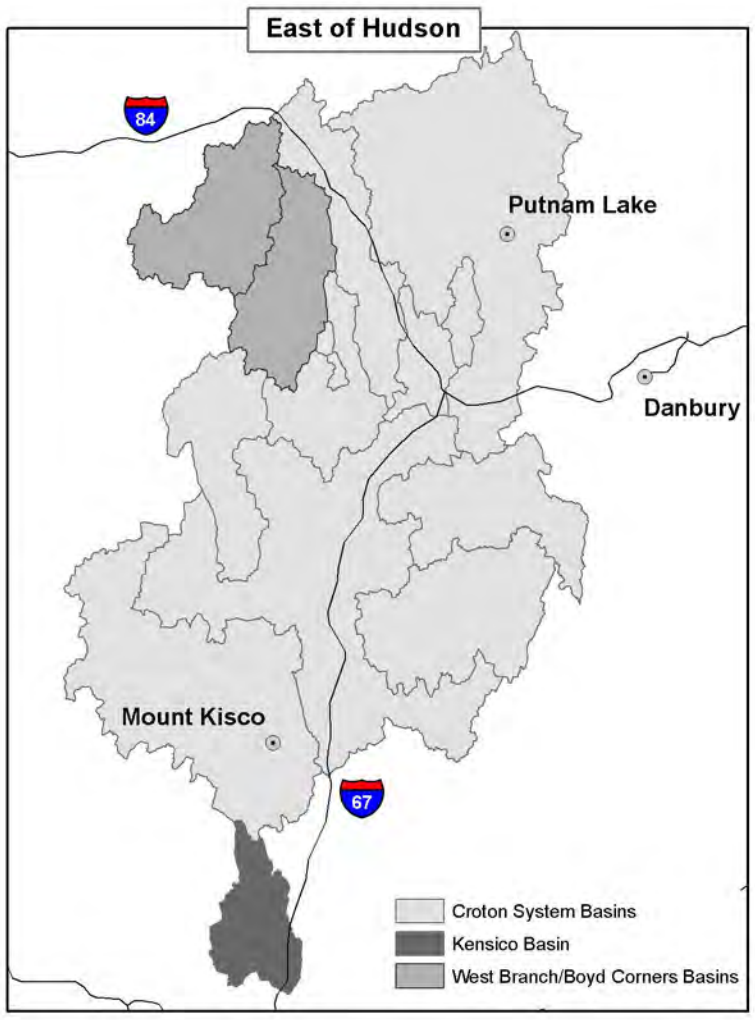
Projection :UTM
Zone 18
Nad83

East of Hudson

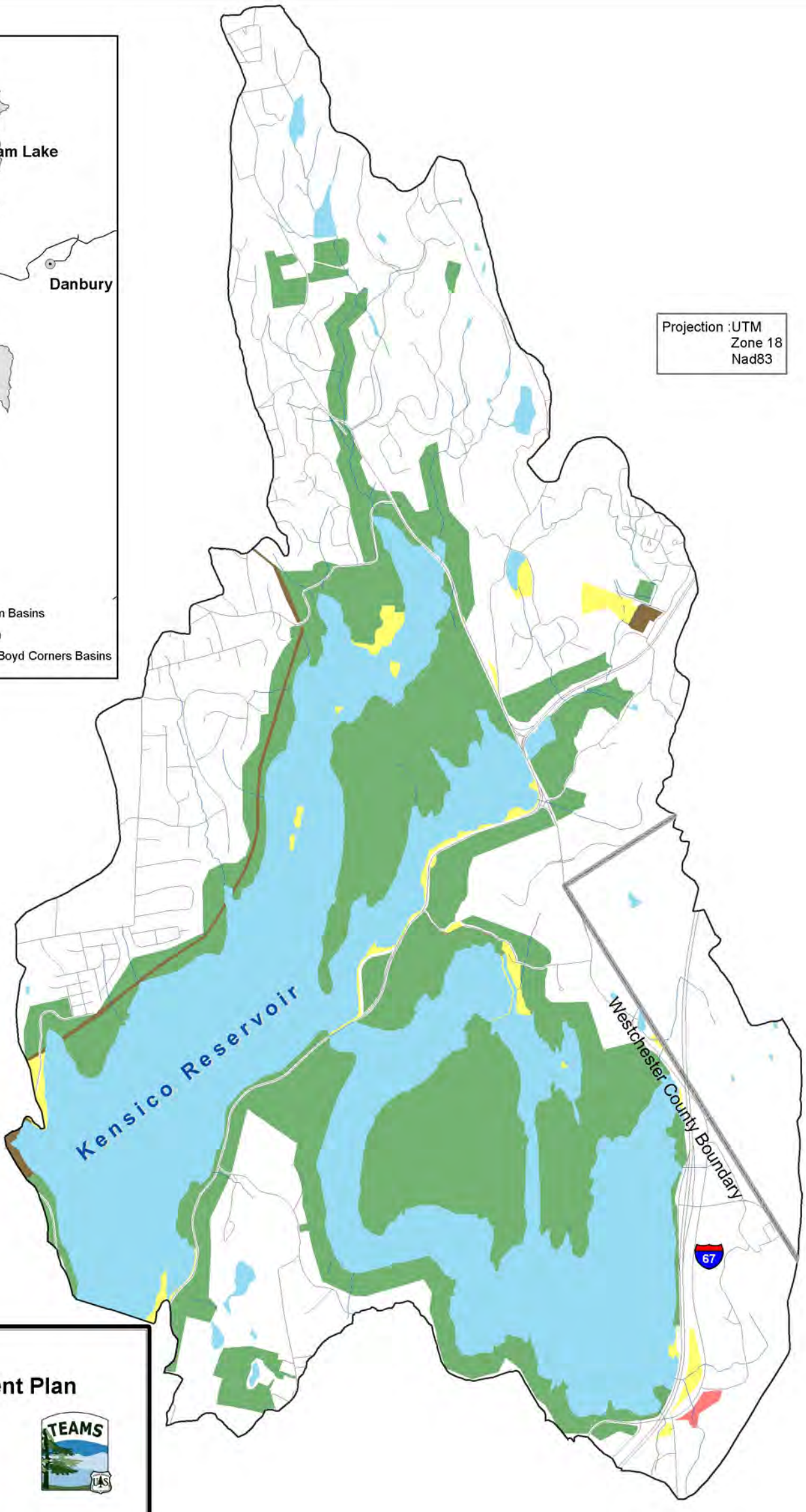


0 1.25 2.5 5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.



Source: Cover types based on GIS
stand data and forest inventory 2009-2010.



New York City
Watershed Forest Management Plan

NYC Environmental Protection

TEAMS

East of Hudson
(Kensico Basin)

Land Cover Types

- Forest
- Herbaceous
- Infrastructure
- Transitional
- Water
- Fee Lands without Cover Type Assigned
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Section 6.3 - Forest Types

New York City
Watershed Forest Management Plan

NYC Environmental Protection

West of Hudson
Ashokan Basin

TEAMS

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

N
W E
S

0 1.25 2.5 5
Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Greene County Boundary
Ulster County Boundary

28

Phoenicia

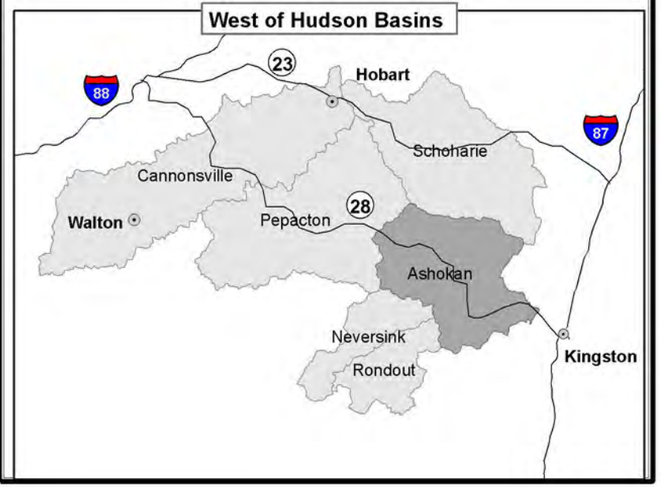
Ashokan Reservoir

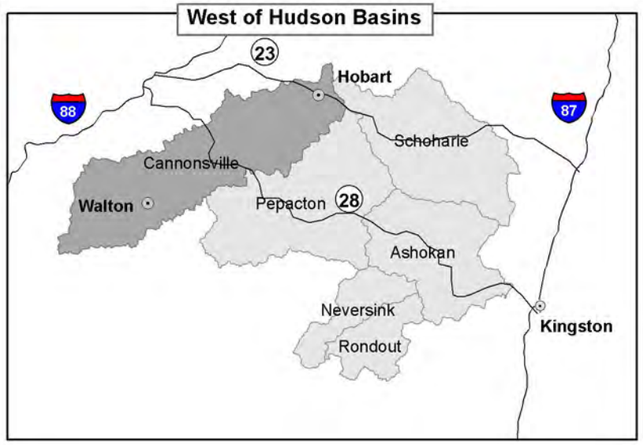
28

Source: Forest types groups based on forest inventory 2009-2010.

Projection :UTM
Zone 18
Nad83

West of Hudson Basins





Schoharie County Boundary

Delaware County Boundary

23

Hobart

Delhi

28

Projection :UTM
Zone 18
Nad83

N
W
E
S

0 1.5 3 6 Miles

Source: Forest types groups based on forest inventory 2009-2010.

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

New York City Watershed Forest Management Plan

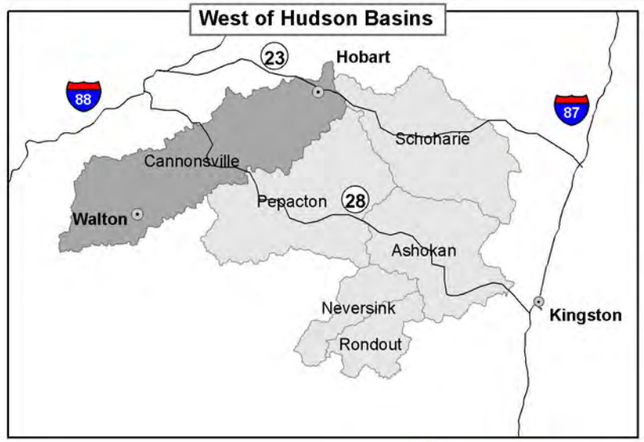
NYC Environmental Protection

TEAMS

West of Hudson Cannonsville Basin (East Half)

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries



Delhi

28

Walton

10

Reservoir

Cannonsville

Source: Forest types groups based on forest inventory 2009-2010.

N
W
E
S

Projection :UTM
Zone 18
Nad83

0 1.5 3 6
Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

New York City Watershed Forest Management Plan

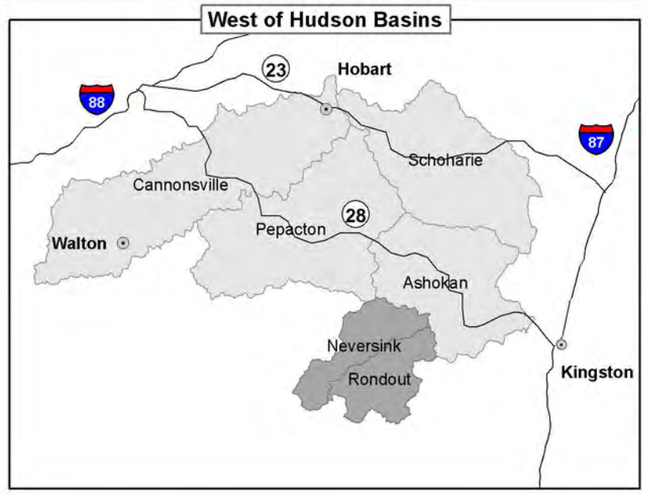
NYC Environmental Protection

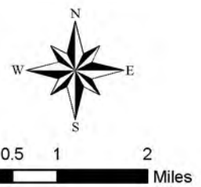
West of Hudson
Cannonsville Basin
(West Half)

TEAMS

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries





0 0.5 1 2 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Source: Forest types groups based on forest inventory 2009-2010.

Neversink

Rondout

Ulster County Boundary
Sullivan County Boundary

55

Neversink

Rondout Reservoir

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

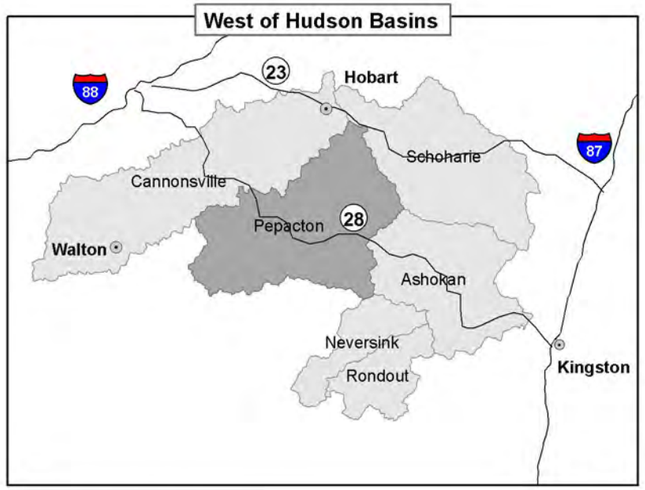
West of Hudson Neversink & Rondout Basin

NYC Environmental Protection

TEAMS

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries



Source: Forest types groups based on forest inventory 2009-2010.

0 1.25 2.5 5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

NYC Environmental Protection

TEAMS

West of Hudson Pepacton Basin

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

New York City
Watershed Forest Management Plan

West of Hudson
Schoharie Basin

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Delaware County Boundary

Schoharie

Schoharie County Boundary

Greene County Boundary

Prattsville

23

Hunter

23A

Tannersville

N

W

E

S

0 1.25 2.5 5 Miles

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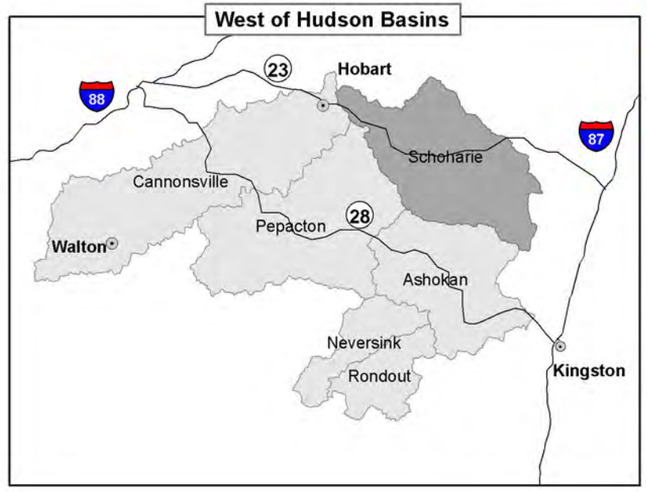
West of Hudson Basins

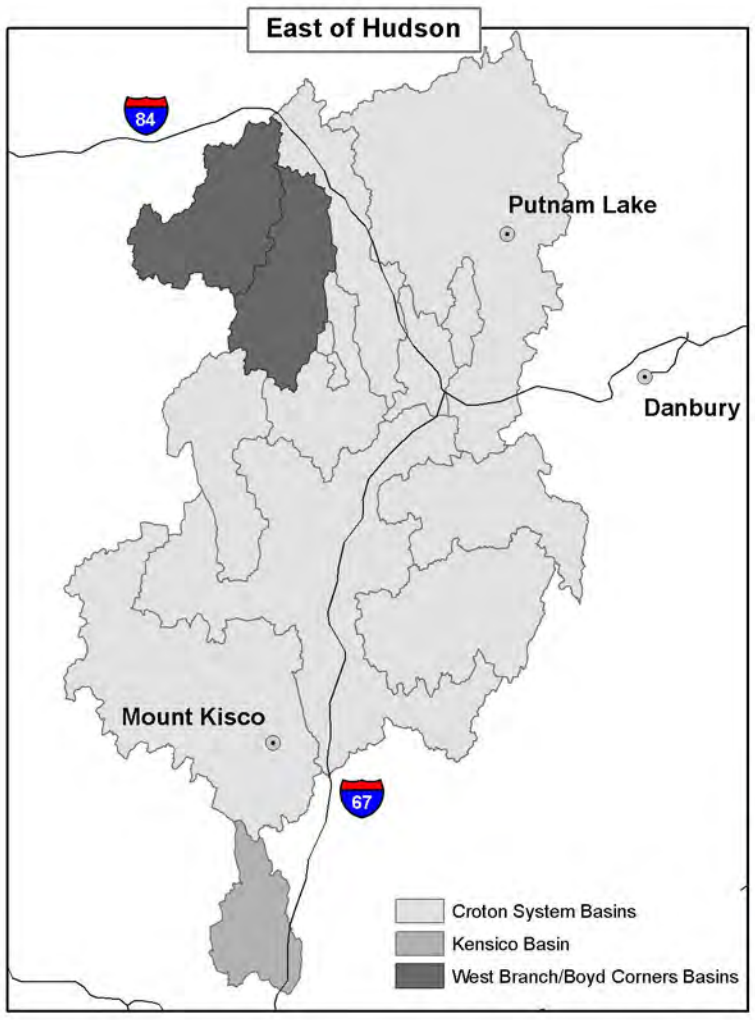


Source: Forest types groups based on forest inventory 2009-2010.

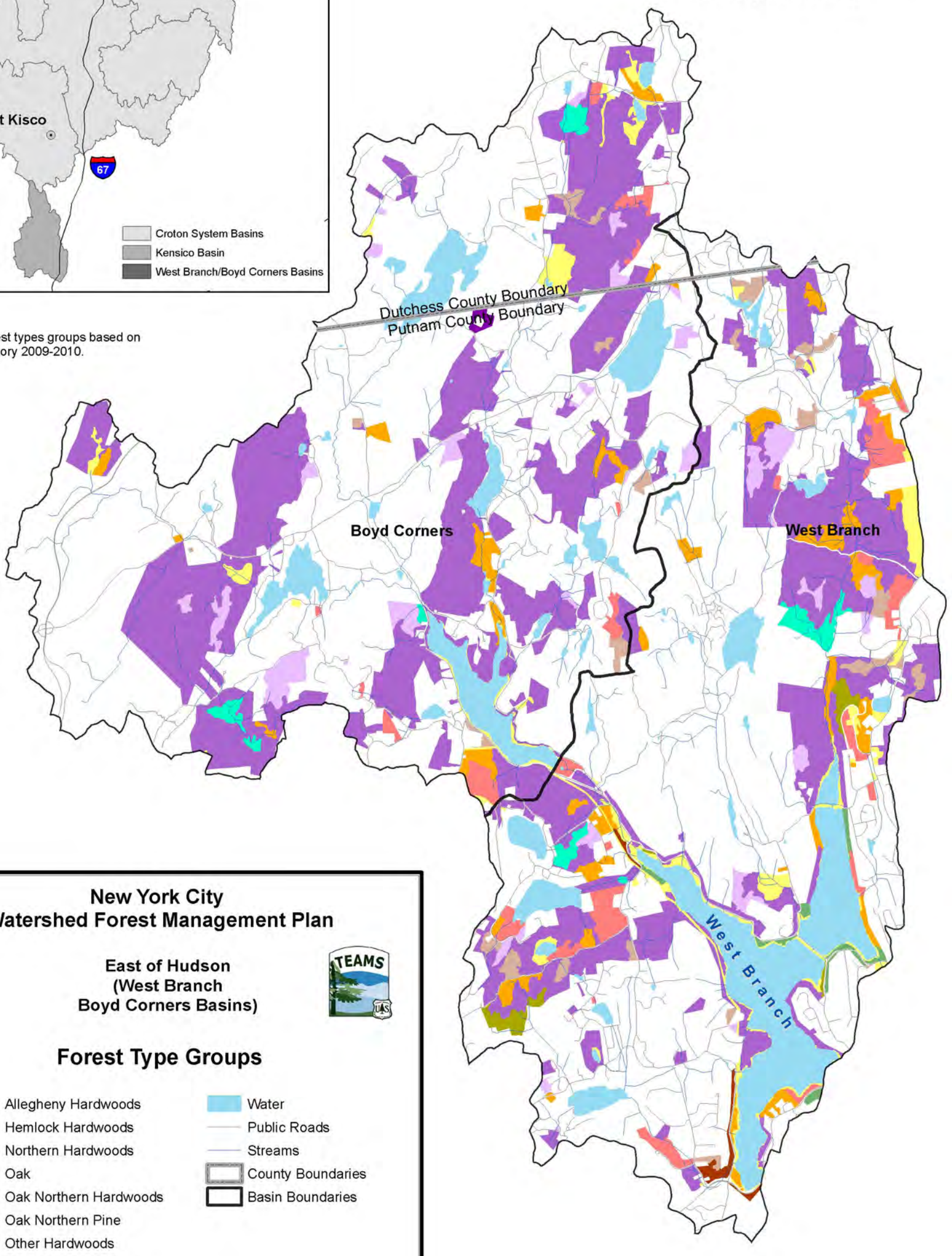
Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

East of Hudson (West Branch Boyd Corners Basins)



Source: Forest types groups based on forest inventory 2009-2010.



GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Projection :UTM
Zone 18
Nad83

New York City
Watershed Forest Management Plan

NYC Environmental Protection

East of Hudson
(Croton System Basins)

TEAMS

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

Source: Forest types groups based on forest inventory 2009-2010.

Middle Branch
Dutchess County Boundary
East Branch
Putnam Lake
Bog Brook
Lake Gleneida
Diverting
Lake Gilead
Croton Falls
Amawalk
Putnam County Boundary
Westchester County Boundary
Titicus
Titicus
Yorktown
Cross River
Muscoot
Cross River
New Croton
New Croton
Mount Kisco

Projection :UTM
Zone 18
Nad83

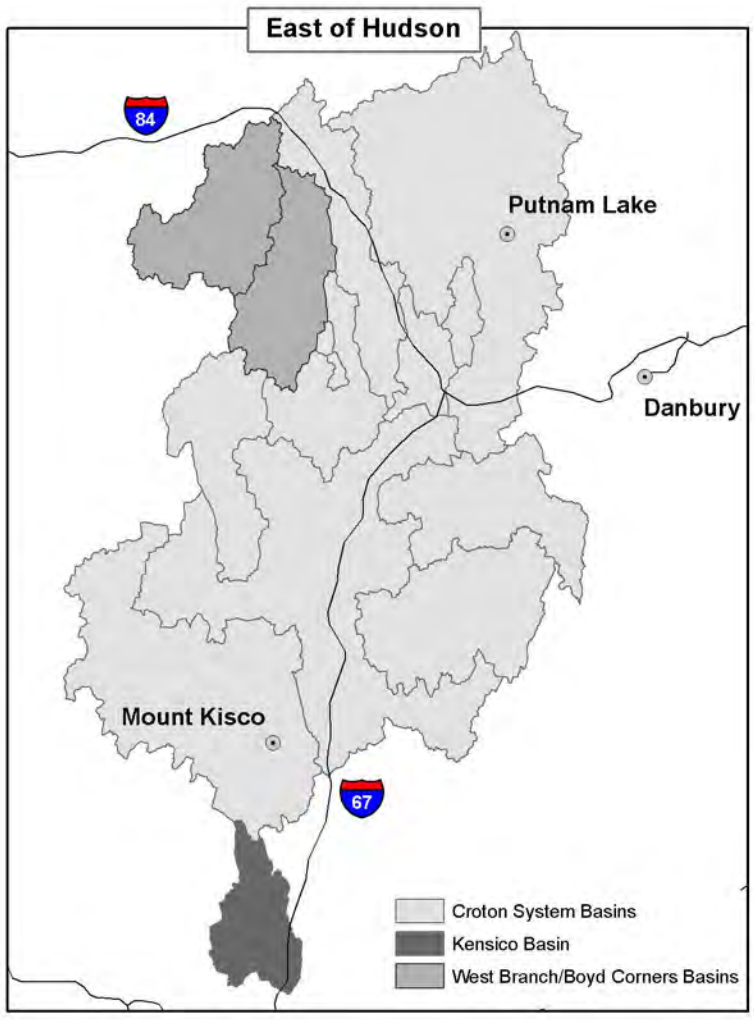
East of Hudson

Putnam Lake
Danbury
Mount Kisco

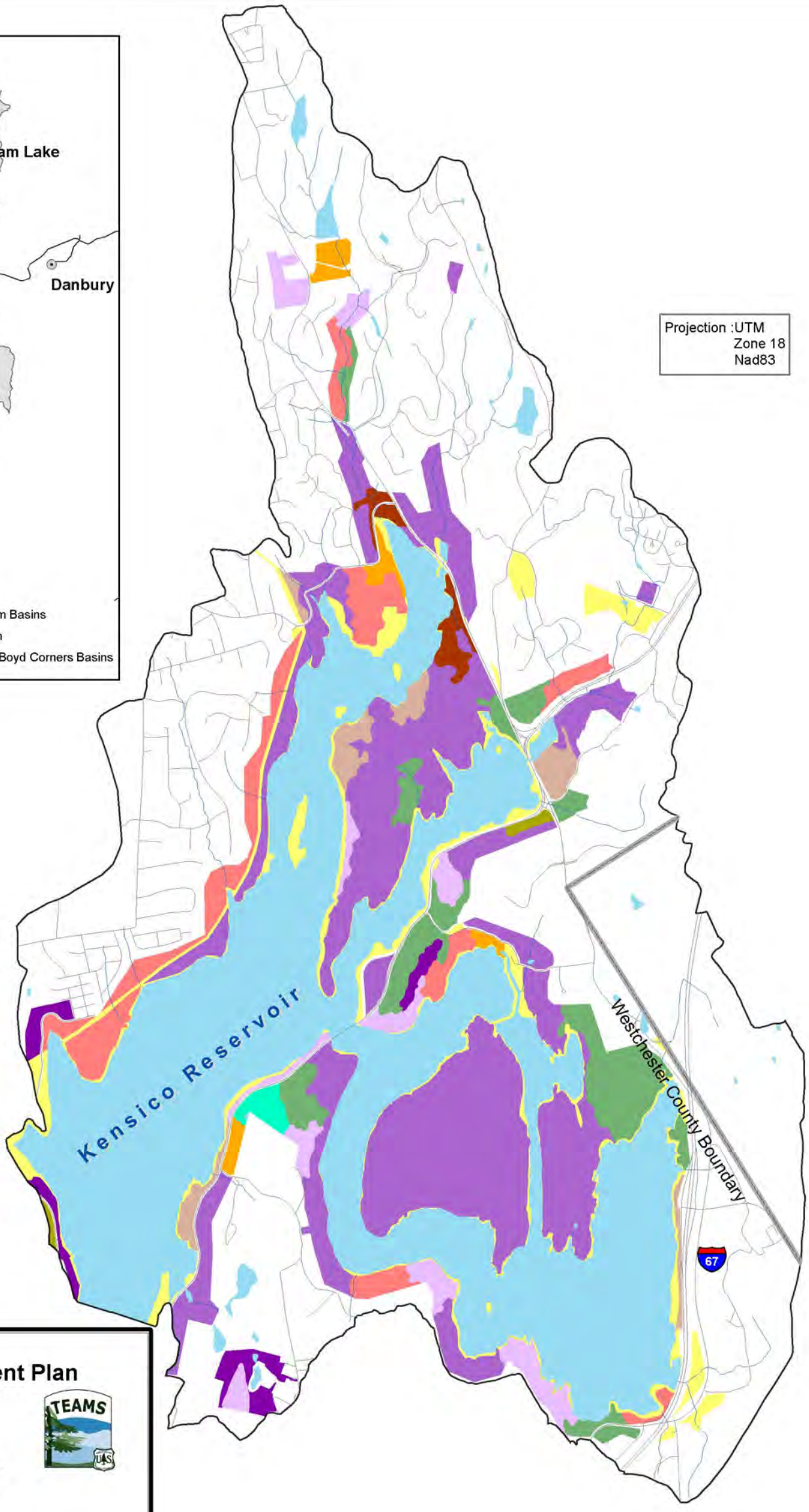
Croton System Basins
Kensico Basin
West Branch/Boyd Corners Basins

0 1.25 2.5 5 Miles

GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.



Source: Forest types groups based on forest inventory 2009-2010.



New York City
Watershed Forest Management Plan

Environmental Protection

East of Hudson
(Kensico Basin)

TEAMS

Forest Type Groups

- Allegheny Hardwoods
- Hemlock Hardwoods
- Northern Hardwoods
- Oak
- Oak Northern Hardwoods
- Oak Northern Pine
- Other Hardwoods
- Other Mixedwoods
- Other Softwoods
- Pine Hardwoods
- Fee Lands without Forest Type Groups Assigned
- Water
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries

N
W E
S

0 0.25 0.5 1 Miles

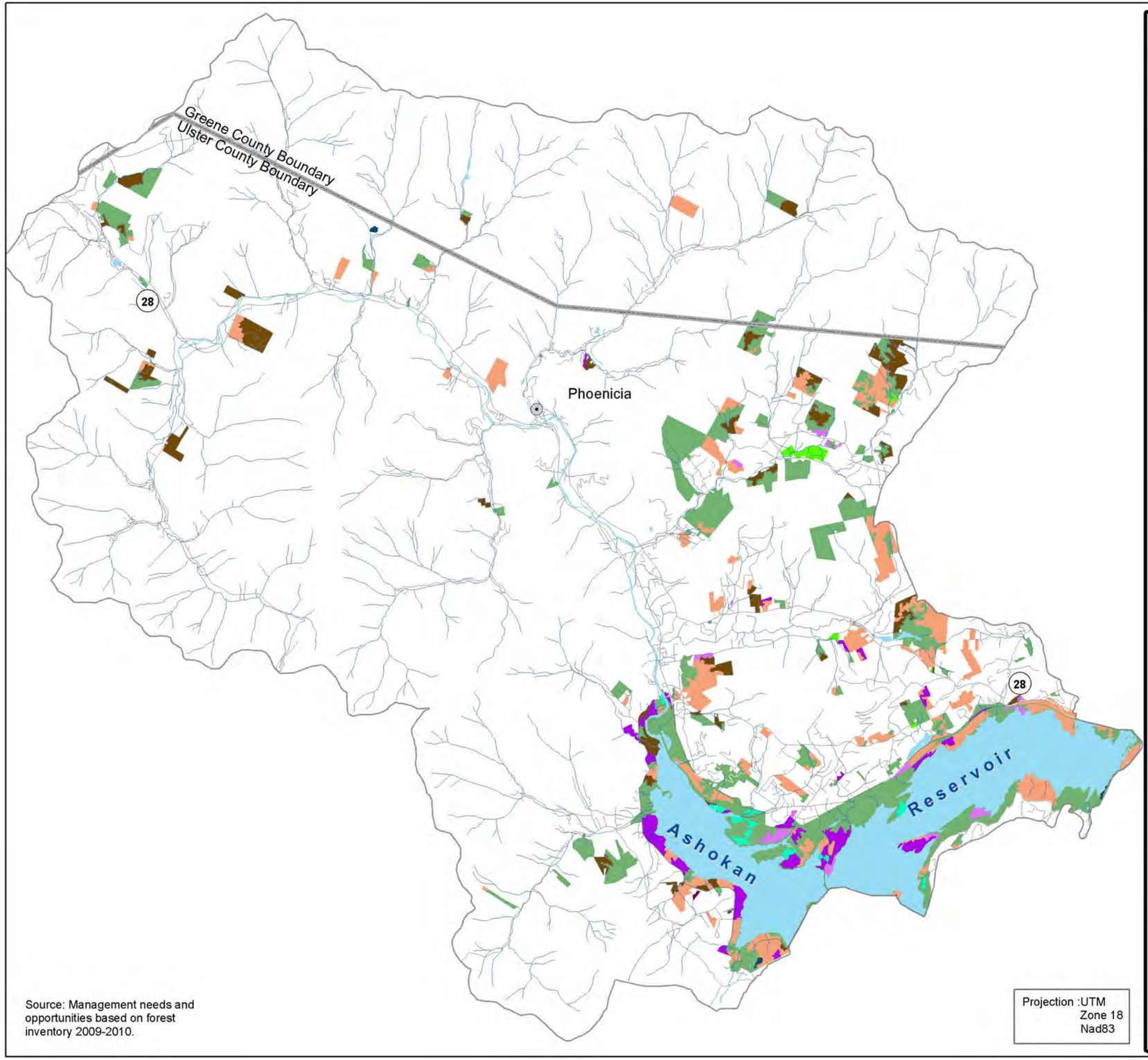
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

Section 7.1 - Management Needs

New York City Watershed Forest Management Plan

West of Hudson
Ashokan Basin

Management Needs and Opportunities



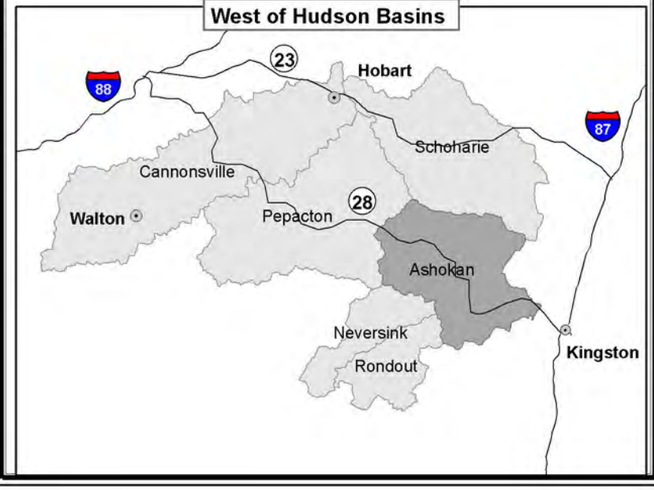
- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

N
W E

0 1.25 2.5 5 Miles

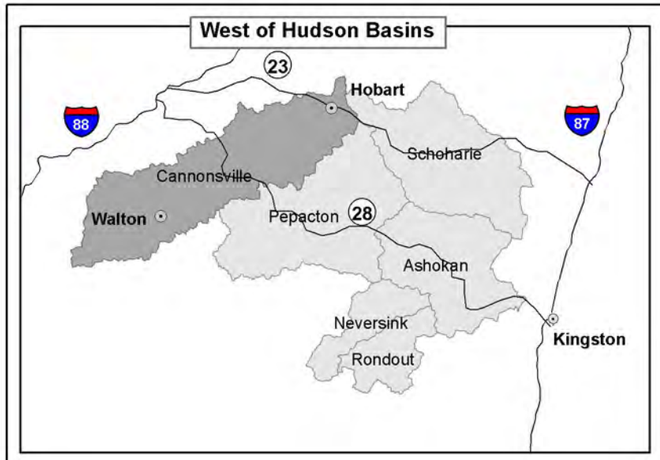
GIS data and product accuracy may vary according to their scale and resolution. GIS products may be subject to error and is not intended as a substitute for on-site inspection and survey.

West of Hudson Basins



Source: Management needs and opportunities based on forest inventory 2009-2010.

Projection :UTM
Zone 18
Nad83



Schoharie County Boundary

Delaware County Boundary

23

Hobart

Delhi

28

Projection :UTM
Zone 18
Nad83

N
W
E
S

0 1.5 3 6 Miles

Source: Management needs and opportunities based on forest inventory 2009-2010.

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New York City Watershed Forest Management Plan

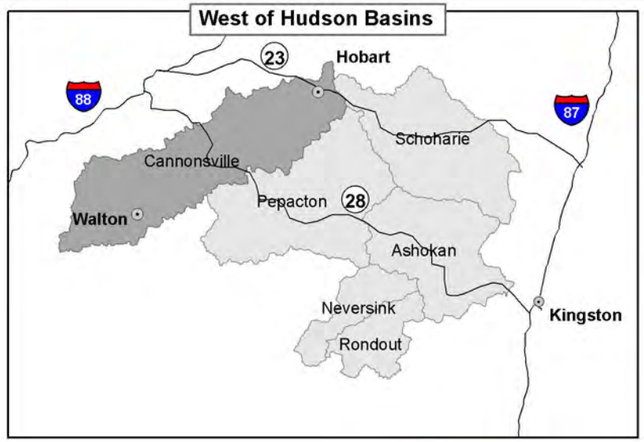
NYC Environmental Protection

TEAMS

West of Hudson Cannonsville Basin (East Half)

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



Delhi

28

Walton

10

Reservoir

Cannonsville

Source: Management needs and opportunities based on forest inventory 2009-2010.

N
W
E
S

Projection :UTM
Zone 18
Nad83

0 1.5 3 6
Miles

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New York City Watershed Forest Management Plan

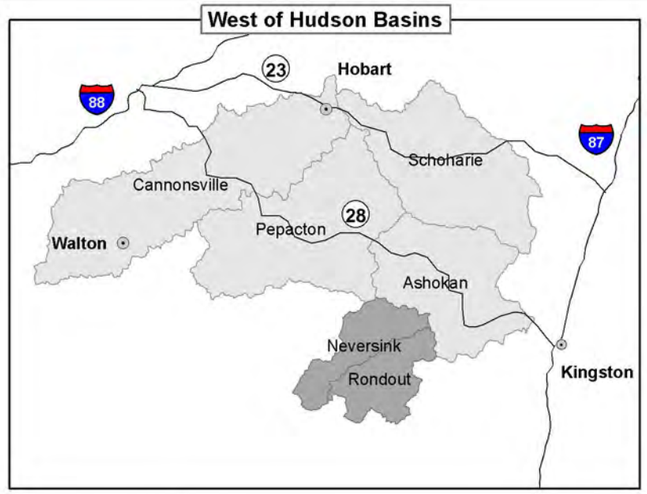
NYC Environmental Protection

TEAMS

West of Hudson Cannonsville Basin (West Half)

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



N
W E
S

0 0.5 1 2
Miles

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Neversink

Rondout

Ulster County Boundary
Sullivan County Boundary

55

Neversink

Rondout Reservoir

Source: Management needs and opportunities based on forest inventory 2009-2010.

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

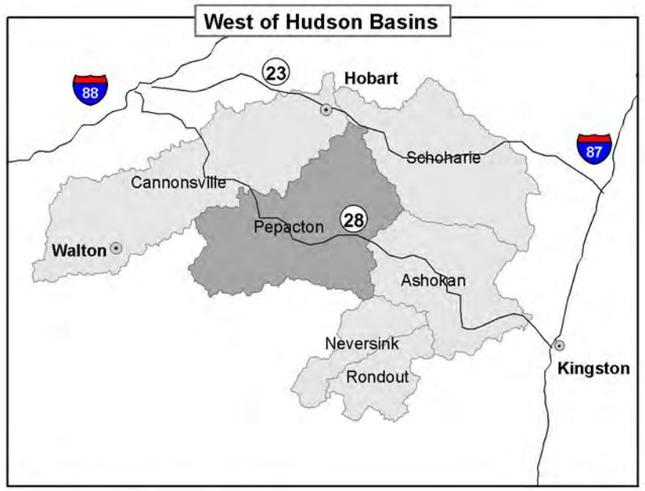
NYC Environmental Protection

TEAMS

West of Hudson
Neversink
&
Rondout Basin

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water



Source: Management needs and opportunities based on forest inventory 2009-2010.

0 1.25 2.5 5 Miles

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Roxbury

30

Andes

28

Greene County Boundary

Delaware County Boundary

28

Margaretville

Ulster County Boundary

Pepacton Reservoir

Projection :UTM
Zone 18
Nad83

New York City Watershed Forest Management Plan

West of Hudson
Pepacton Basin

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

New York City
Watershed Forest Management Plan

NYC Environmental Protection

West of Hudson
Schoharie Basin

TEAMS

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Delaware County Boundary

Schoharie County Boundary

Greene County Boundary

Schoharie

Prattsville

23

Hunter

23A

Tannersville

N
W E
S

0 1.25 2.5 5 Miles

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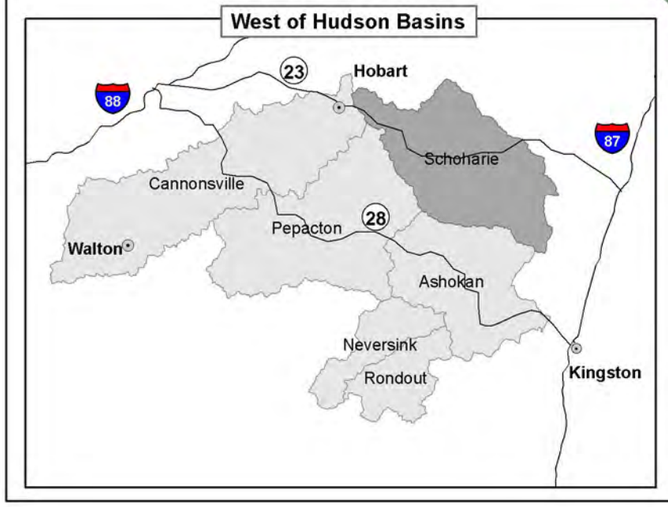
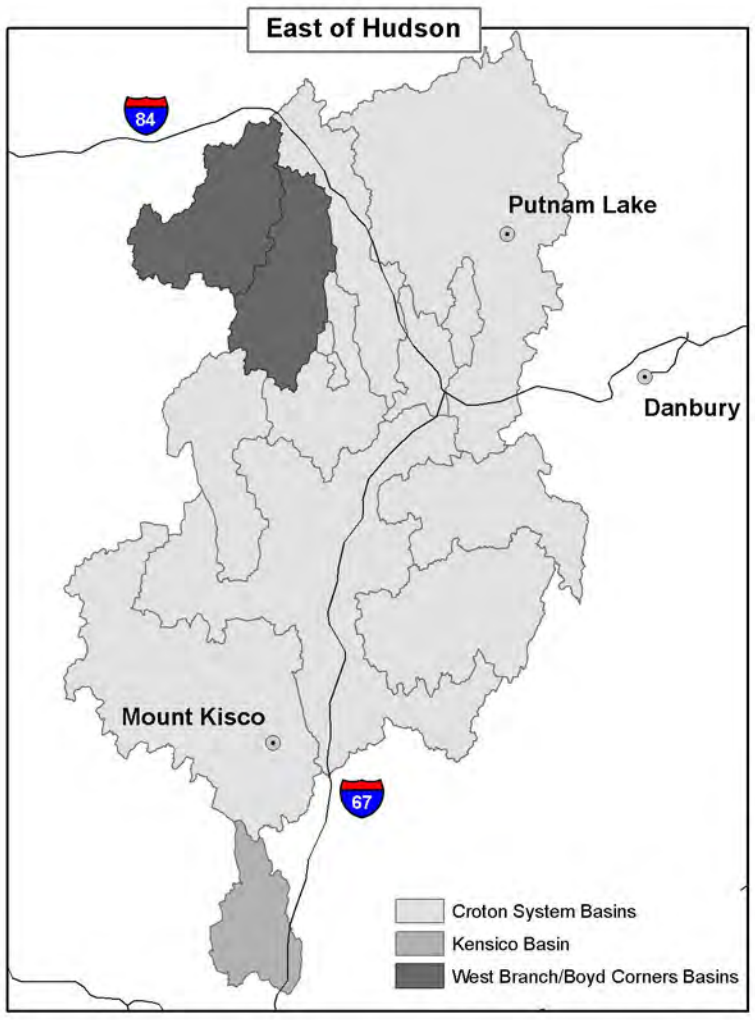
West of Hudson Basins

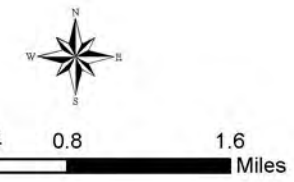


Source: Management needs and opportunities based on forest inventory 2009-2010.

Projection :UTM
Zone 18
Nad83



Source: Management needs and opportunities based on forest inventory 2009-2010.



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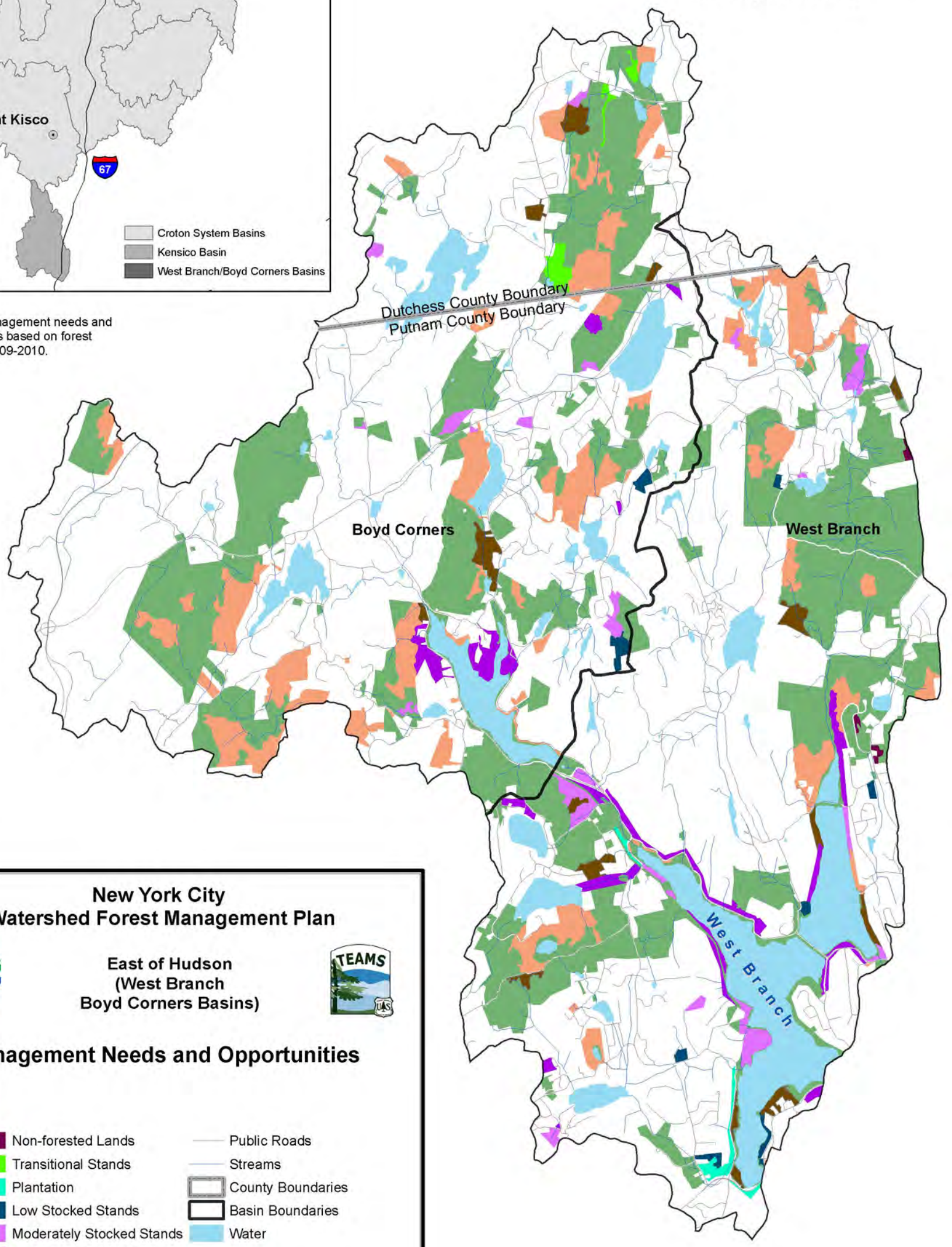


New York City Watershed Forest Management Plan

East of Hudson
(West Branch
Boyd Corners Basins)

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Projection :UTM
Zone 18
Nad83

New York City
Watershed Forest Management Plan

NYC Environmental Protection

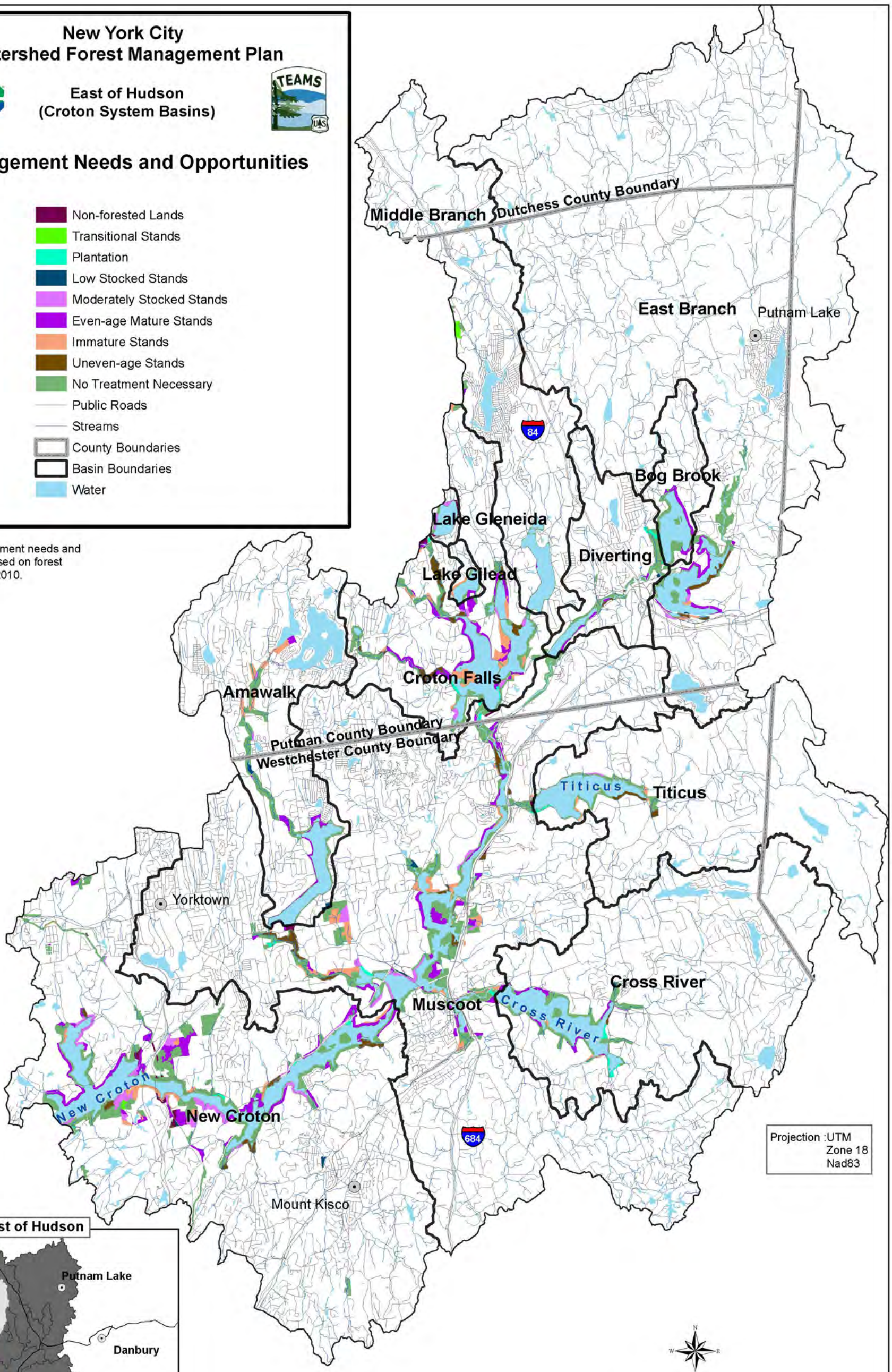
East of Hudson
(Croton System Basins)

TEAMS

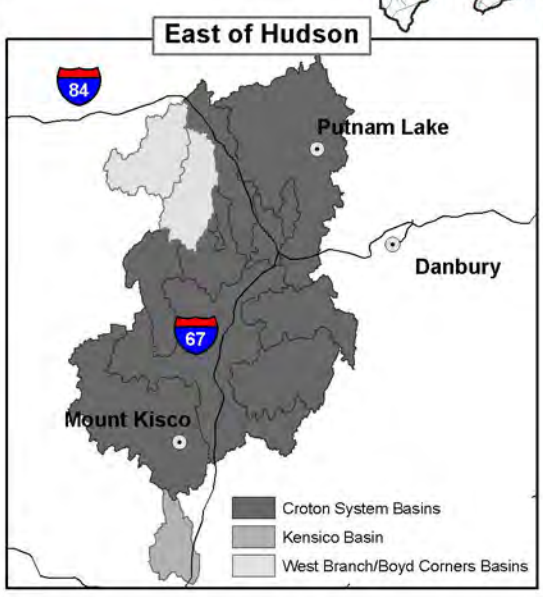
Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

Source: Management needs and opportunities based on forest inventory 2009-2010.



Projection :UTM
Zone 18
Nad83



0 1.25 2.5 5 Miles

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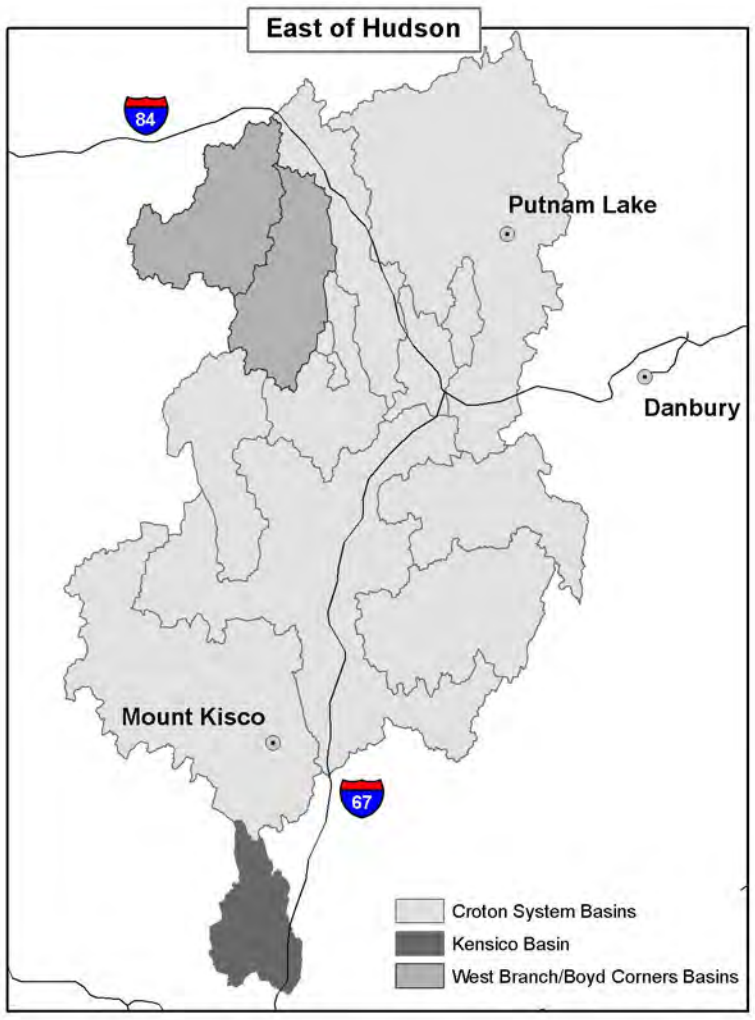
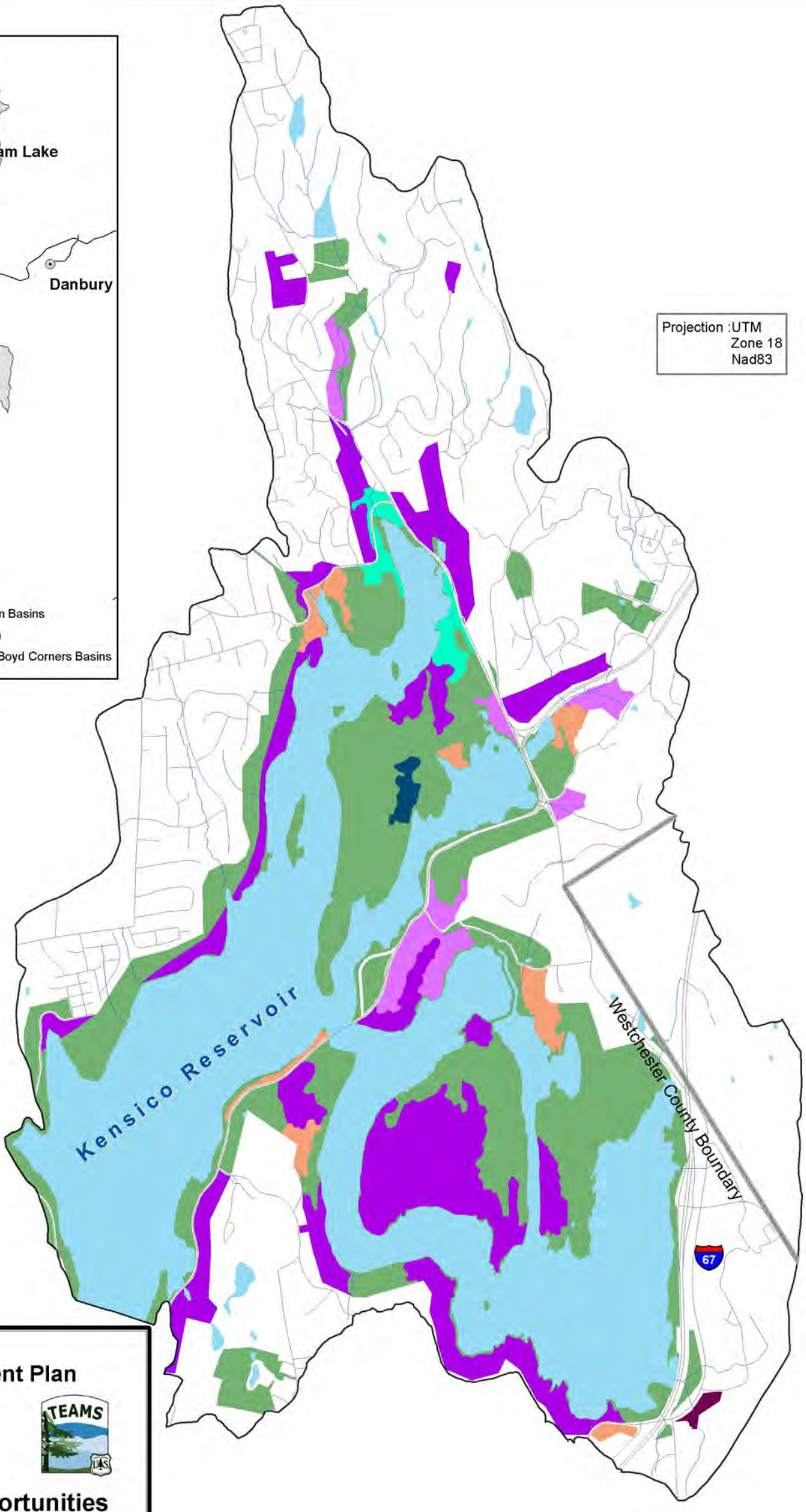


Source: Management needs and opportunities based on forest inventory 2009-2010.



New York City Watershed Forest Management Plan

NYC Environmental Protection

East of Hudson (Kensico Basin)

TEAMS

Management Needs and Opportunities

- Non-forested Lands
- Transitional Stands
- Plantation
- Low Stocked Stands
- Moderately Stocked Stands
- Even-age Mature Stands
- Immature Stands
- Uneven-age Stands
- No Treatment Necessary
- Public Roads
- Streams
- County Boundaries
- Basin Boundaries
- Water

N W E S

0 0.25 0.5 1 Miles

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