Biophysical Characteristics of the Olin Powder Farm Property

View of the tree canopy facing northwest from Whitney Center, fall 2003

Introduction

Biophysical characteristics of the Olin Powder Farm are divided into sections on Climate, Geology, Soils, Hydrology, Forest Resources, and Wildlife. Together these sections present a complete ecological picture of the property in its current state. In addition to the scientific information presented in narrative form, maps developed using Geographic Information Systems provide an added visual interpretation of the property. Complete plant and wildlife species lists are included as **Appendix I** and **Appendix L**.

Climate

The Olin Powder Farm is located in southern New Haven County, about five miles inland from Long Island Sound. Climate of the site is generally moderate due to its proximity to the Sound and the Atlantic Ocean. Unless otherwise mentioned, climatological data presented below are summarized from data collected at Mount Carmel, Connecticut used in the 1979 Soil Survey of New Haven County, Connecticut.[1] This weather station is six miles farther inland than the Olin Powder Farm.

In New Haven County summers are warm and humid, and winters are cold and wet. Average temperature is 70 degrees Fahrenheit in the summer months, with average maximum temperatures of 81 degrees. The highest temperatures recorded for the area are 100 degrees at Mount Carmel in July 1957, and 101 degrees at New Haven airport in July 1926.[2] Winter has average temperatures of 29 degrees, and average lows of 20 degrees. The lowest temperatures on record are 17 degrees below zero at Mount Carmel, January 1961, and 15 degrees below zero at New Haven airport, February 1934. Generally the time from the start of May to the start of October is freeze-free, yielding an average growing season of 150 days.[3]

[1] Reynolds, C.A. 1979. **Soil Survey of New Haven County, Connecticut. Washington** : National Cooperative Soil Survey. 197 p.
[2] Data for New Haven Airport are from Ludlum, D. 1976. **The New Country Journal New England Weather Book**. Boston: Houghton Mifflin Company.
[3] South Central Connecticut Regional Water Authority. 1989. **Forest Management Plan**. 133 p.

Average annual precipitation is 47 inches. Extremes recorded at New Haven are 60 inches in 1888 and 28 inches in 1965. Snowfall averages 32 inches per year, with an extreme high of 76 inches in New Haven in the winter of 1915-16. Depths of snow persisting on the ground for more than two weeks are rarely greater than 5 inches.

Seasonal storms move up along the coast of the northeastern United States, bringing cold weather, rain, and snow in winter. Winds coming off the water in summer months moderate the temperature and increase relative humidity. Wind speed averages 7.6 miles per hour over the year, with speeds slightly higher in winter and slower in summer.

Occasional dramatic weather events have affected the region in the past. Major hurricanes in late summer of 1788 and early fall of 1815 and 1938 touched down on Long Island before heading into central Connecticut and points north.[4] Evidence remains on the Olin Powder Farm of a summer 1989 tornado that broke and uprooted many large white pine trees. Periodicity of rare and extreme weather events such as hurricanes and tornados is difficult to determine, and the margins of error for such estimates are often quite large, but such storms typically exceed 100-year returns.

[4] Smith, D.M. 1946. **Storm Damage in New England Forests**. New Haven: unpublished thesis. 173 p.

Geology

The Olin Powder Farm is located in the Central Valley[5] of Connecticut. The Central Valley runs north-south through the center of the state and is a rift valley,[6] formed approximately 250 million years ago when the super-continent Pangaea separated, forming the Atlantic Ocean. New Haven Arkose is the bedrock geology found at the Olin Powder Farm site but does not determine the topography of the site. The bedrock has been greatly reduced by the eroding forces of rivers and glaciers over the past 200 million years since its formation. The most recent glacial ice sheet retreated from Connecticut 18,000 years ago. Glaciers acted like a harsh sandpaper on the arkose bedrock, grinding it into gravel, sand and silt, which were then laid down by meltwater and largely make up the surficial geology of the OPF today.

As the glaciers retreated, their meltwaters formed giant rivers which carried suspended materials, such as gravels, sands, silts and clays, and deposited them across the valley in a stratified manner. The rivers and streams of meltwater cut channels into the stratified drift. Huge isolated blocks of ice left by the retreating, irregularly melting glaciers became wedged in the midst of the melt water, and outwash was laid down around them to form kames. When the blocks of ice finally melted they left depressions known as kettles and ridges, called 'kames,' in the stratified drift (see **Figure 4**).

Surficial Geology and Topography

The Olin Powder farm has a surficial geology of ice-contact stratified drift. Ice-contact stratified drift is formed when edges of glacial drift are held up by standing ice; when the ice melts, drift falls inward, re-mixing the stratified layers laid down by the meltwater, as shown in **Figure 4**.

Ice-contact stratified drift[7] commonly possess one or more of these characteristics: great internal variability; poor sorting; large and abrupt changes in grain size both vertically and horizontally; inclusion of small bodies of till, erratic boulders, or flowtill (a till-like sediment deposited by landsliding off adjacent ice); deformation of sedimentary layers by subsidence or other displacement activated by melting of underlying or adjacent glacier ice. The features on the OPF site, such as the Southeast Kettle, reflect the presence of irregular bodies of melting ice during accumulation of the drift.

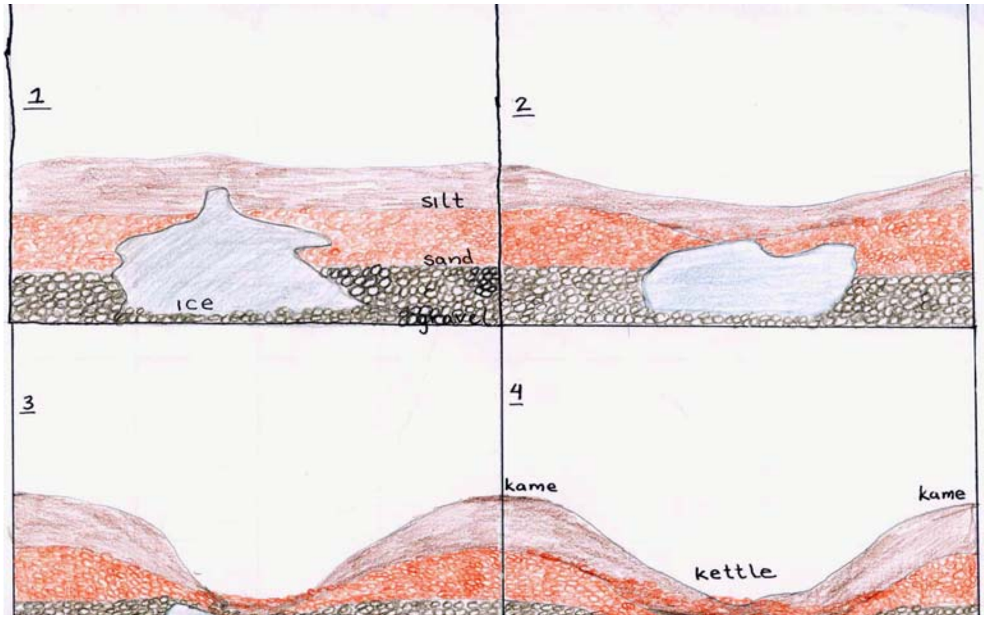
Over time, water erodes the drift and forms stream and river channels. As erosion continues, sediments are deposited from the

[5] Also referred to as the "Connecticut Valley", "Central Lowlands", "Hartford Basin" or "Mesozoic Valley" (Bell, 1985); The geology summation in this paper is a summary of the glacial history of Connecticut from Bell. Michael. (1985). *The Face of Connecticut*. Hartford, Connecticut. State Geological and Natural History Survey of Connecticut.

[6] A rift valley is a tensional valley bounded by normal faults. Rift valleys are found at diverging plate boundaries on continents and along the crest of the mid-oceanic ridge. From : http://geotech.fce.vutbr.cz/wwwroot/scripta/geologie/Glossary_of_basic_geological_terms/Glossary

[7] The information on ice-contact stratified drift given here is from Flint, R.F. 1965. **The Surficial Geology of the New Haven and Woodmont Quadrangles with Map.** Quadrangle Report No. 18. Connecticut Department of Agriculture and Natural Resources.

Figure 4: Formation of Ice-Contact Stratified Drift and Wet and Dry Kettle Holes



surrounding hills of glacial outwash into the water channels. Wetland species also begin to inhabit the channel, depositing organic material and making the water increasingly shallow as it fills with this mixture of sediments and undecomposed organic material to form peat. Eventually, succession and erosion will fill the channel with sediment and organic material, turning it into a peat swamp.

Pond Creation

Initially, the ponds on the OPF site were peat swamps, rather than the present-day ponds. A brook depicted as "Pine Marsh Brook" in **Figure M12**, **Map A** ran through the swamps and into the Mill River. When a dam was built on the Mill River to create the Lake Whitney reservoir in 1860, it raised water levels by 30 feet and caused the brook to back up and flood the swamp, as shown in **Figure M12, Map B**.[8] When the swamps were flooded, mats of peat in the basin of the swamps floated to the surface, creating the three floating bog islands in the present-day ponds. This was confirmed when we stepped on the islands and the ground was not solid. The peat is at least eight feet deep and contains trapped methane created through anaerobic decomposition of the peat over time. This trapped methane probably contributes to the buoyancy of the bog islands. The only other bog area in Connecticut may be Beckley Bog near Norfolk.[9]

Since the ponds are currently located on what was once a brook running through a swamp, the ponds are also very shallow, ranging from only one to eight feet deep.

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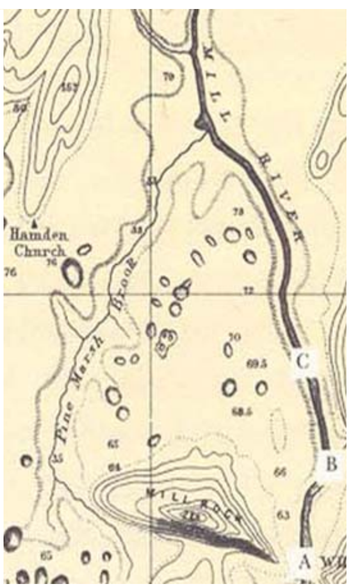
[8] Cooper, C. and K.L. Kibler Hall. Undated. **Windows on the Works: Industry on the Eli Whitney Site, 1798-1979**. Hamden, CT: Eli Whitney Museum.
Otto E. Schaefer Consulting for the South Central Connecticut Regional Water Authority. Memo to Tom Chaplik regarding the Outlet of Water from Pine Swamp into Lake Whitney. October 22, 2002.

[9] Connecticut Botanical Society Web site, http://www.ct-botanical-society.org/trip.html.

When the Treadwell Street dam was installed, this tributary grew even larger, spreading primarily south and west. Large stumps, preserved in the ponds by standing water, specifically in Pond E, remain as indicators that the land was previously forested. When the bunkers were constructed in the early 1900s, Winchester needed an access road and therefore linked the pond shores by laying down artificial fill. These man-made isthmuses and the surficial geology of OPF are depicted in **Figure M12**, **Map C.** In addition to building the bridges, Winchester changed the topography of the site when constructing the bunkers. Outwash sand and gravel were scooped from the sloping edges of the terraces to form level-bottomed, horseshoe-shaped bunkers. The road was built to connect the bunkers, and excess sand and gravel piled to form a berm on the side of the road opposite to the bunkers. The shapes of the bunkers are depicted by the topographic lines in **Figure M12, Map C**.

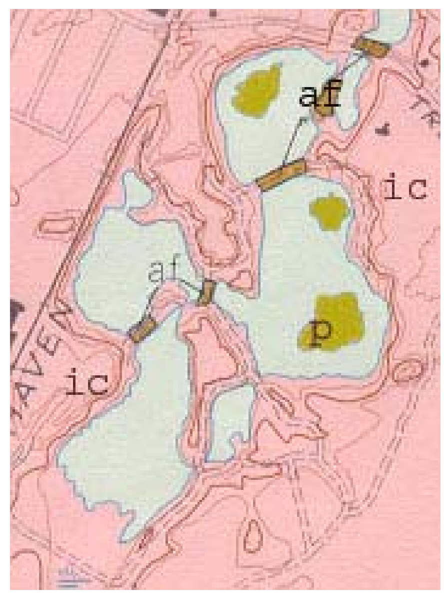
Figure M12: Pond Creation[10]

Map A is from the Eli Whitney Museum and shows the Pine Marsh Brook, which was a tributary into the Mill River before the damming of the Mill River in 1860. Map B is from the 1890's and depicts the flooding of the Mill River due to the Lake Whitney Reservoir dam. You can see that the Pine Marsh Brook flooded its channel at this point. Map C is the Surficial Geology of the Olin Powder Farm Site after Winchester created the bunkers and road on the site. Sections in pink labeled 'ic' are ice-contact stratified drift, the green labeled 'p' is for peat and brown labeled 'af' is for artificial fill.



Map A : Pre-1860; before the creation of Lake Whitney Dam

Map B: 1892 USGS Map



Map C: Post 1914, after bunker and road construction

[10] Map A was adapted from Hall, Karl Lee Kibler and Carolyn Cooper. 1984. ***Windows on the Works: Industry on the Eli Whitney Site 1798-1979.*** Eli Whitney Museum; Hamden, CT. Map B was cut from http://docs.unh.edu/CT/nhav92ne.jpg . Map C was adapted from Flint, Richard Foster. 1965. ***The Surficial Geology of the New Haven and Woodmont Quadrangles with Map***. Quadrangle Report No. 18. Connecticut Deparment of Agriculture and Natural Resources. Peat and one segment of artificial fill were added to correct the original map.

Soils

Due to the request of the landowner, soils were not verified by field inspection and all classifications are based on the mapping of the New Haven County, CT Soil Survey.[11]

The soils of Olin Powder Farm are classified as Manchester Gravelly Sandy Loam, and Penwood Loamy Sand, with a linear section of Urban Land, and small patches of Udorthents-Urban Land Complex, and Carlisle Muck (**Figure M13**). The islands are floating mats of peat, an organic material comprising undecomposed and slightly decomposed plant fibers.

Soils of the Manchester series consist of sandy-skeletal, mixed, mesic Typic Udorthents. These are recently formed soils with little to no soil profile development. They are reddish-colored soils formed in glacial outwash on terraces of stream valleys, are excessively drained, and are made up of deposits of sand and gravel derived primarily from Triassic sandstone and conglomerate. Trees favored by this soil type include white pine and red oak.

Soils on the eastern portion of the property are comprised mostly of Manchester Gravelly Sandy Loam on moderate slopes. These soils are excessively drained and runoff is moderate. Permeability is rapid in the surface layer to very rapid in the subsurface layers. Acidity in the soil ranges from strongly to moderately acidic. Soils on the ridges of the northern portion of the property are also classified as Manchester Gravelly Sandy Loam. Soils adjacent to developed trails are highly erodable. These soils are moderately steep to very steep, excessively drained, have a rapid permeability in the surface and very rapid permeability in the subsurface layers. Runoff is rapid and acidity is medium to strong.

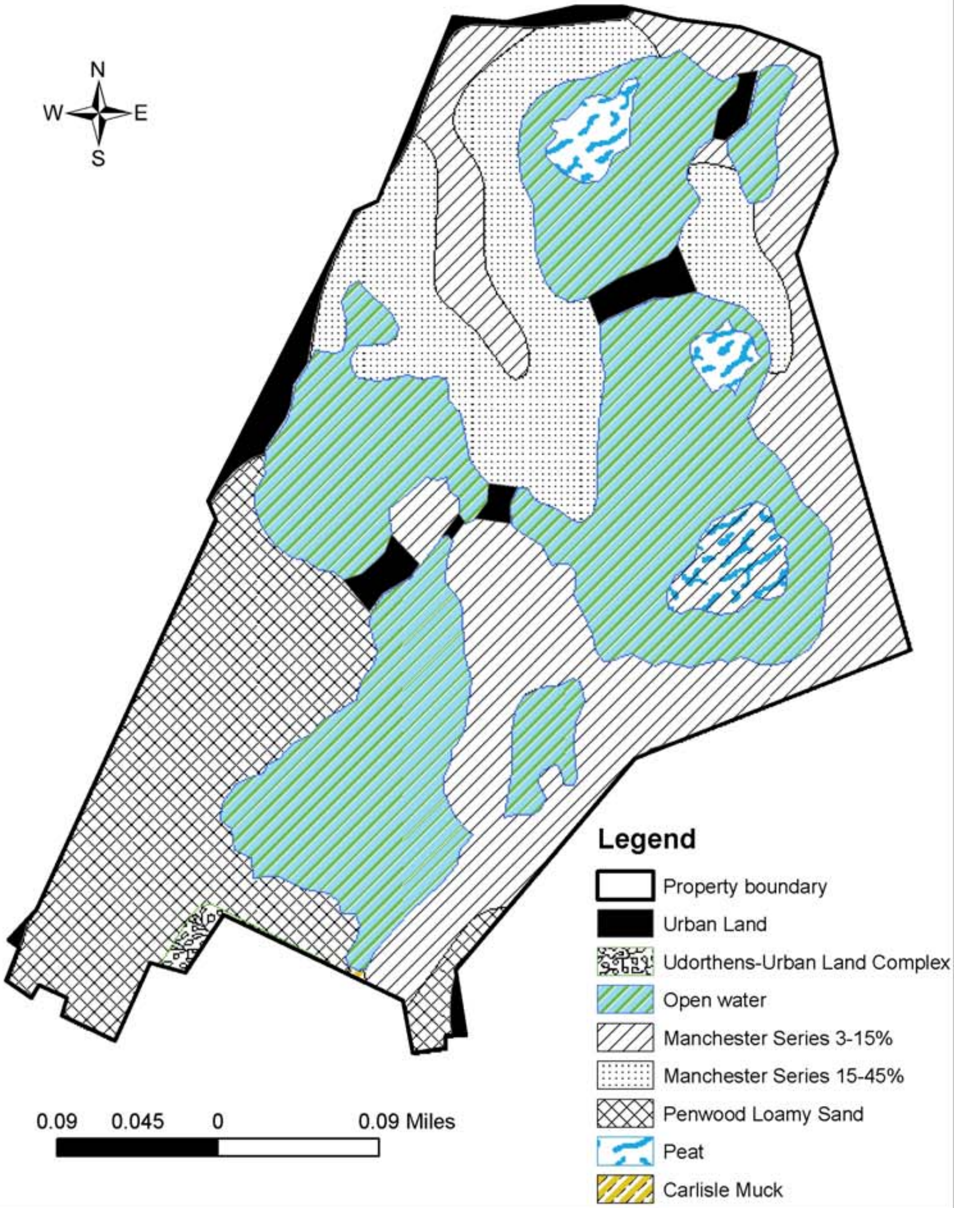
The southwestern portion of the property is comprised of Penwood Loamy Sand. Soils of this series consist of mixed, mesic Typic Udipsamments and are found on broad outwash terraces. Penwood series soils are deep, excessively drained and are derived mainly from sandstone, shale, conglomerate, and basalt. These gently sloping soils have a rapid permeability, medium runoff potential, and are slightly to strongly acidic. Trees favored in this soil series include eastern white pine, pitch pine (*Pinus rigida*), and northern red oak.

A linear section along the western portion, northwestern corner, and between the ponds of the property is classified as Urban Land, a designation afforded in this case to soil that abuts paved development and buildings and has been recently altered by humans. Given the miscellaneous nature of this series, land use decisions in this soil classification require on-site investigation and evaluation.

A small portion of the property in the southwest corner is classified as Udorthents-Urban Land Complex. Soils

[11] Reynolds, C.A. 1979. **Soil Survey of New Haven County, Connecticut**. Washington : National Cooperative Soil Survey. 197 p.

Figure M13: Soils on the Olin Powder Farm Property



Hydrology

Watershed Context
Water

Three rivers, the Mill, Quinnipiac, and West, run through Hamden, Connecticut, making watershed management a primary environmental concern for the Town. The Olin Powder Farm property is part of the Pine Swamp basin, which lies within the southern reaches of the Mill River watershed and is one of six subregional basins in Hamden. The Mill River originates in Cheshire and moves south through Hamden towards Lake Whitney and the Long Island Sound. The entire Mill River watershed has a total drainage area of 36.4 square miles (see **Figure M14**). Pine Swamp basin comprises less than five percent of this drainage, or approximately 1.5 square miles, but is a key component of Hamden's water resource management plan, as it is the largest basin in Hamden, draining approximately 48 percent

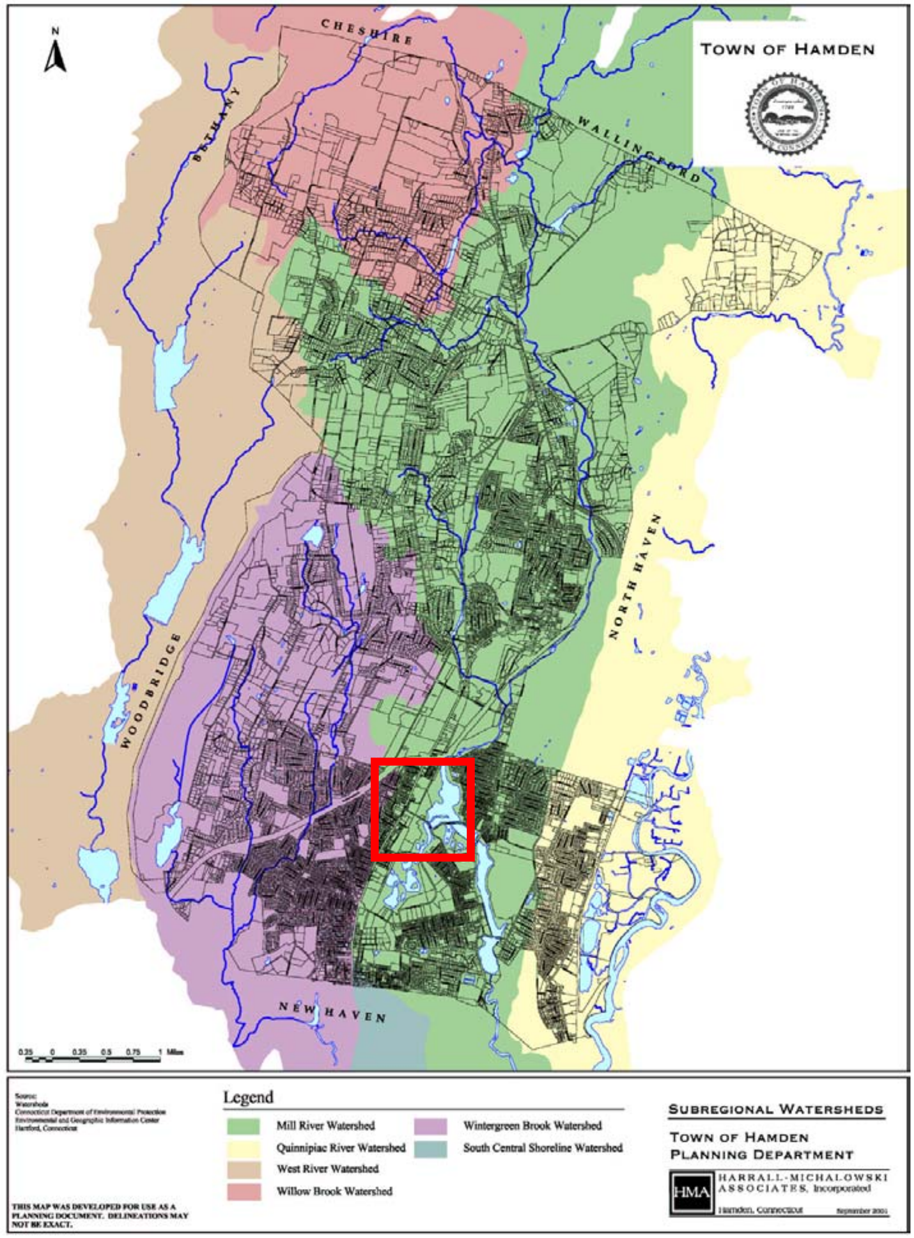


Figure M14: Hamden Watersheds

of the Town's total land area.[12]

The Significance of Water Resources on the OPF Site

The significance of the Olin Powder Farm site is enhanced by the fact that the six interconnected ponds on site will be reincorporated into the public drinking water supply system in 2004, serving as pretreatment basins for water flowing towards Lake Whitney and the new Lake Whitney water treatment facility. The ponds were previously part of the public water supply from 1860 until the old Lake Whitney treatment plant went offline in 1991.[13] Plus, the OPF is one of the only large undeveloped parcels of land remaining within the Pine Swamp basin.[14] Development in Hamden is the densest around the Olin Powder Farm and in the south end of the Town in general (refer to **Figure M6**).

Surface Water

The six shallow ponds and associated wetland areas on the 102.5-acre Olin Powder Farm site take up approximately 50 percent of the property's surface area and are generally two to six feet deep, becoming more shallow around the edges of the ponds. Surface water on site slowly flows north towards the Mill River and Lake Whitney (see **Figure M15**).

The Dam on Treadwell Street

The drainage area feeding into the site from the Pine Swamp basin has its main outlet on the OPF property through a dam on Treadwell Street.[15] This dam is responsible for maintaining the surface water elevation of the ponds,[16] which are approximately one to two feet higher than the Mill River and Lake Whitney. The dam at the north end of Pond F, approximately six feet wide and three feet deep, was first installed in 1871 and then again in 1914 when Treadwell Street was relocated by the New Haven Water Company. Its primary purpose is to hold water in the Olin Powder Farm ponds, preventing them from converting to mudflats when Lake Whitney is drawn down to levels that affect the hydrology of the ponds.

Low water levels and mudflats occurred frequently during the 1860s and early 1870s.[17] According to a consultant, i 1869, the elevation of the Lake Whitney dam was increased from 30 to 34 feet above the base of the dam and new areas were flooded for long enough periods to kill trees and shrubs. Later, Treadwell Street was moved at the request of the Winchester Repeating Arms Company, which stored ammunition on the Powder Farm site during this time. Winchester was concerned that high water levels in Lake Whitney would result in the flooding of the ponds and the ammunition storage bunkers, and the new dam served to

[12] Malcolm Pirnie, 1988.
[13] Harrall-Michalowski Associates, Inc., 2003.
[14] Malcolm Pirnie, 1988.
[15] Malcolm Pirnie, 1988.
[16] Malcolm Pirnie, 1988.
[17] Otto E. Schaefer Consulting. 2002.

Figure M15: Olin Powder Farm Site Hydrology

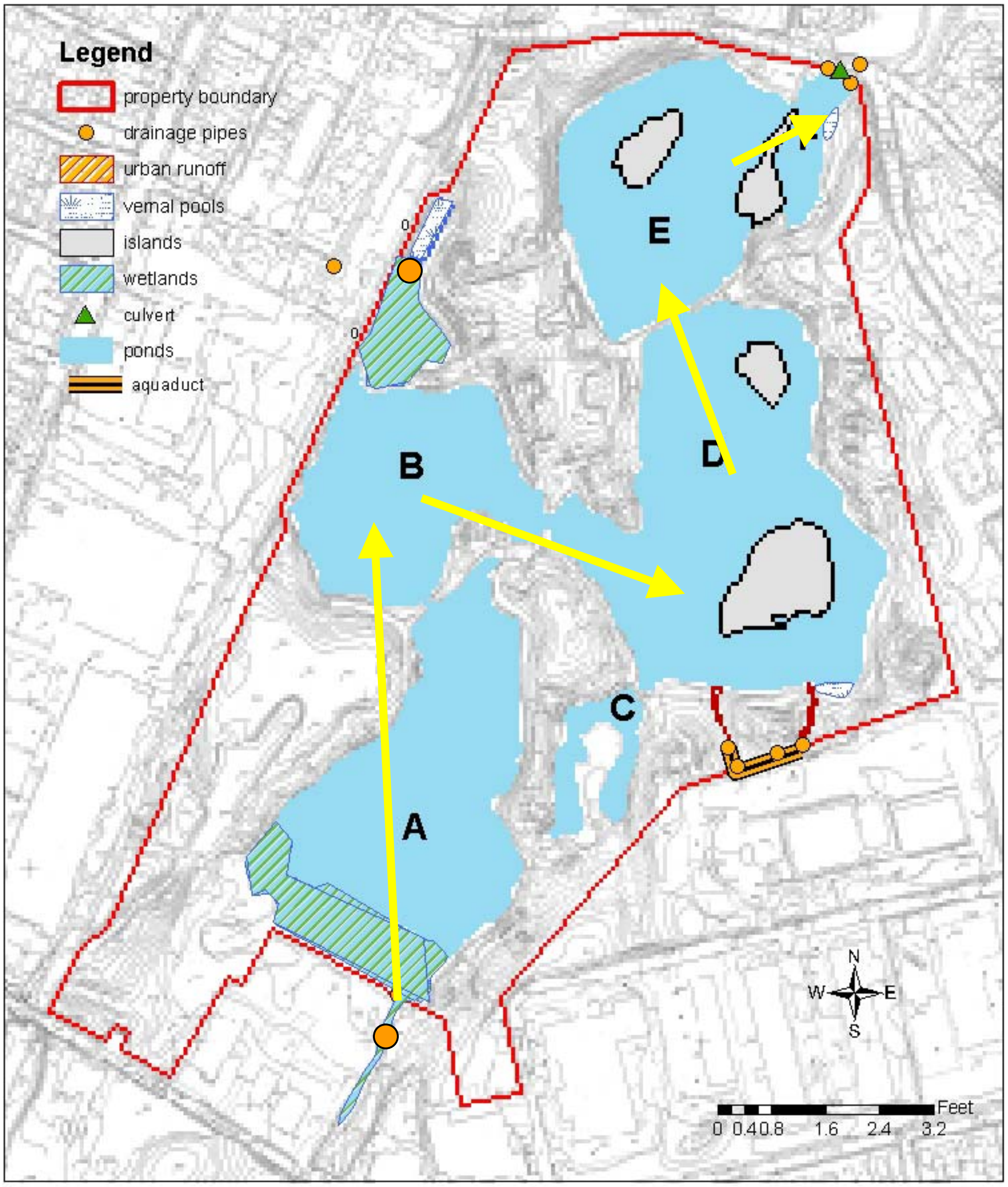


Figure M15: Olin Powder Farm Site Hydrology
Stormwater, the only surface water input to the site, enters the ponds at the orange points on the east, west, and north sides of the property, as well as at the wetland at the southeastern corner. Surface water flows in the direction of the yellow arrows and eventually flows north toward the Mill River. The direction of groundwater flow is undetermined, but suspected to flow slowly toward the southwest.

prevent flooding. Overall, the dam simply maintains water levels in the ponds, during storm events and reservoir spillovers and drawdowns.

With the new road came a causeway and the new dam that provided flood protection to the site. Winchester built a pumping station south of the new Treadwell dam as added insurance. A consultant hired by the RWA believes that Olin, the current property owner, would have had no reason to operate the pump after the bunker use was discontinued in the 1970s.[18] The dam, in combination with the existing road, raises water levels in the ponds by approximately two feet and retards the flow of surface water from the ponds and into the ponds.[19] Tom Chaplik, vice president of water quality at the Regional Water Authority, suspects that because of the restriction caused by the dam, water levels of the ponds would not be affected by water level changes at Lake Whitney. Water running through the dam from the ponds on the Powder Farm site to the Mill River tributary north of Treadwell Street was documented in 2002 as being an inch deep and flowing at a rate of six to eight inches per second.[20]

Pond Creation

Refer to the Geology section for details on pond formation.

Floodplain

Because most of the Olin Powder Farm sits within the Mill River's 100-year flood plain overlay district, regulations prevent it from being developed, despite its zoning as a residential area.[21] The only area that does not fall within this overlay district is in the southwest corner of the property.

Stormwater

Natural drainage to the ponds has been modified by development and storm water drainage systems in the surrounding urban area (see **Figure M16)**. There are currently no natural surface water inflows to the site; all inflow in the form of urban runoff. There is a large stormwater outflow pipe here that feeds into a wetland north of Pond B. Another outflow pipe discharges directly onto the site in a wetland south of Pond A. On the eastern border of the property, at least three outflow pipes discharge stormwater just

Stormwater outflow pipe that drains onto the Olin Powder Farm property.

[18] Otto E. Schaefer Consulting. 2002.
[19] Tom Chaplik. Personal communication. September 2003.
[20] Otto E. Schaefer Consulting 2002.

[21] Harrall-Michalowski Associates, Inc. 2003.

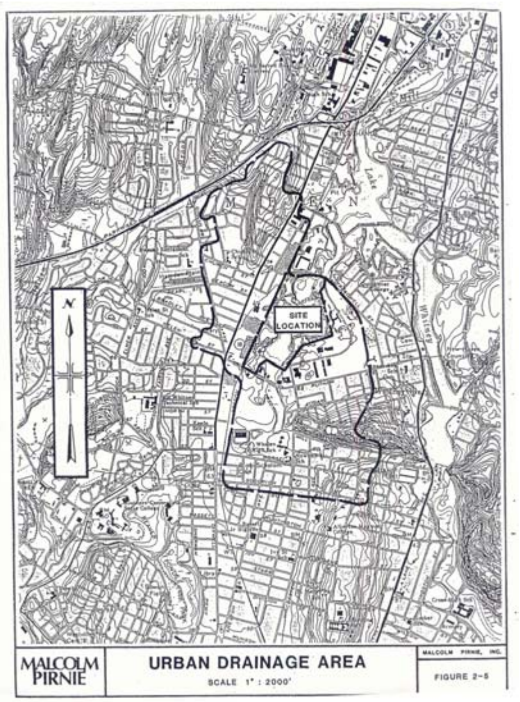


Figure M16: Urban Drainage

east of the property boundary. This channeled runoff flows on site towards Pond D. See **Figure M17** for intended stormwater drainage, as planned by Town of Hamden engineers.

Groundwater

The saturated thickness of the stratified drift on site varies from approximately 150 feet at the north end of the property to more than 200 feet at the south, and the depth to groundwater varies from zero to approximately 35 feet, reflecting topographic relief above the relatively flat groundwater table. The stratified drift in the area creates a high-yield, unconfined water table aquifer,[22] which should fluctuate with the water levels in the ponds.

Monitoring wells were installed on site by Olin after 1970 to monitor groundwater quality. Because of high hydraulic conductivities, individual well yields can exceed 1,000 gpm. Well completion depths are generally less than 100 feet, because of such high yields. Bedrock and glacial till have not been tapped by wells and are not a significant aquifer. Groundwater gradients are generally low, experiencing highs in April, when they can reach up to 5.4 feet per day. There is no apparent hydraulic gradient for groundwater movement in an off-site direction, and groundwater on site tends to discharge to the nearest surface water body.[23]

Local groundwater movement and water table levels are influenced by well pumping at H.A. Leed Corporation across Leeder Hill Drive to the East and the Whitney Center, adjacent to the property to the east. The water table here slopes toward the Leed property, in the direction of its well, indicating a small hydraulic gradient toward the east.[24]

Hydrology and water quality

Groundwater contamination on site has not been identified as a serious problem by the RWA. Urban runoff, however, seems to contribute a significant concentration of semi-volatiles and heavy metals to the sediment load and surface water on the Olin Powder Farm. The surface waters on the Olin Powder Farm property have been deemed clean by the RWA, with no detectable

[22] Malcolm Pirnie, 1988.

[23] Malcolm Pirnie, 1988.

[24] Asea, Brown and Boveri Environmental Services, Inc. for Olin Corporation. Site Investigation and Exposure Assessment, Olin Anixter Site: Hamden, Connecticut. September 1992.

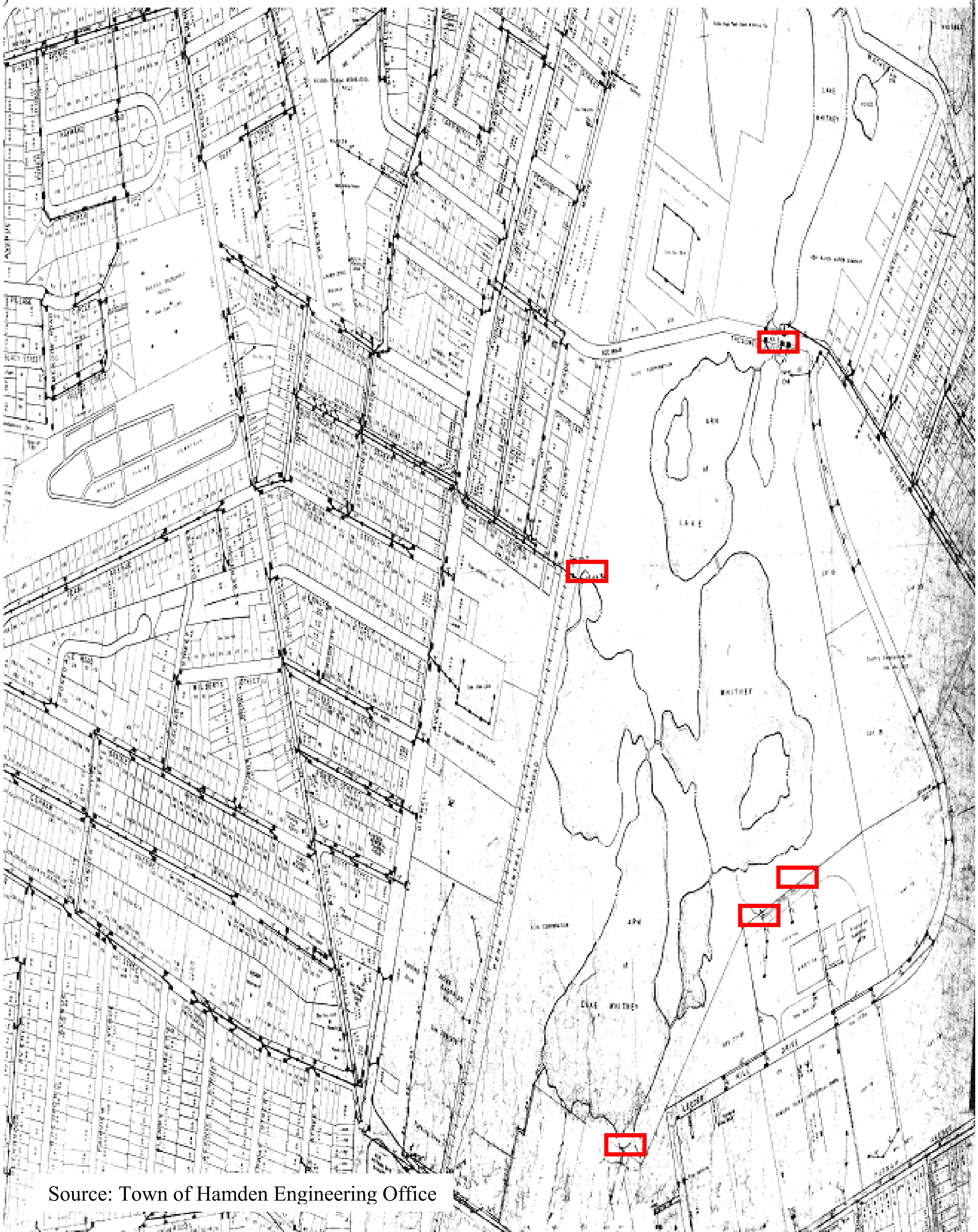
contamination from remaining OPF waste sites.

Olin monitors groundwater primarily for the burning grounds and Anixter site (see **Figure M4**).

Overall, the ponds serve as valuable water pretreatment basins for the Lake Whitney water supply system because runoff and groundwater are cleansed as they flow north through the Olin Powder Farm pond system.

Figure M17: Stormwater Drainage into the Olin Powder Farm Property

Area highlighted in red are where stormwater enters the property via drainage pipes.



Source: Town of Hamden Engineering Office

Forest Resources

Introduction

The Olin Powder Farm has two main forest types: an oak-pine association, and white pine remnant of plantations. For the purposes of this plan a third type was delineated that is called “disturbed.” Although it has substantial oak overstory, its understory and groundstory have significant incursions of invasive plant species[25] and it lies entirely on disturbed, excavated, or bulldozed soils. Descriptions of the vegetative cover types are based on sampling of overstory, understory, and groundstory layers of the forest in fixed-area plots.[26] See **Figure M18** for a map of these cover types.

Because of the difficulty in distinguishing red and black oaks (*Quercus rubra* and *Q. velutina*, respectively) morphologically on the site, they have been lumped in analysis and will be referred to simply as “the red oak group” here. Because of the late season sampling, herbaceous layer data is limited. Spring or summer sampling would yield more diverse species compositions; certainly it would enable identification to the species level, whereas the plants in winter could only be identified to the genus level.

This section provides general stand descriptions based on sampling; expanded results are included in **Appendix I**.

Disturbed Stand

Most of the property falls into the category of “disturbed,” having been influenced by bulldozing associated with bunker construction and industrial uses of the site. The entire southern portion of the site, hazardous waste areas, roads and bunkers are all areas affected by industrial uses. Our sampling fell within the uncontaminated forested areas of this disturbed type, in bunkers and in the disturbed area concentrated in the southern section of the property. There we found oak dominance and patchy colonization by invasive species and species adapted to waste places, edges, and disturbed landscapes in general (see **Figure 5** for a diagram of the stand structure). The native vine poison ivy (*Toxicodendron radicans*) abounds both in the groundstory and climbs the tree canopy in the south portion of the property. Invasive species Japanese knotweed (*Polygonum cuspidatum*) lines the paved road, especially in the southern section. Winged burningbush (*Euonymus alatus*), Amur corktree (*Phellodendron amurense*), tree-of-heaven (*Ailanthus altissima*) and Asiatic bittersweet (*Celastrus orbiculatus*) are all invasive plant species with distributions concentrated in bunkers, though some populations exist in degraded portions of other cover types.

[25] Invasive plant species are defined by the Connecticut Invasive Plants Working Group as those species that are “nonindigeneous to Connecticut, naturalized, and have potential for widespread dispersal and establishment…[and] able to out-compete other species in the same natural plant community.” Full discussion at http://www.hort.uconn.edu/cipwg.
[26] Full sampling design is provided in **Appendix A.**

Figure M18: Vegetative Covertypes

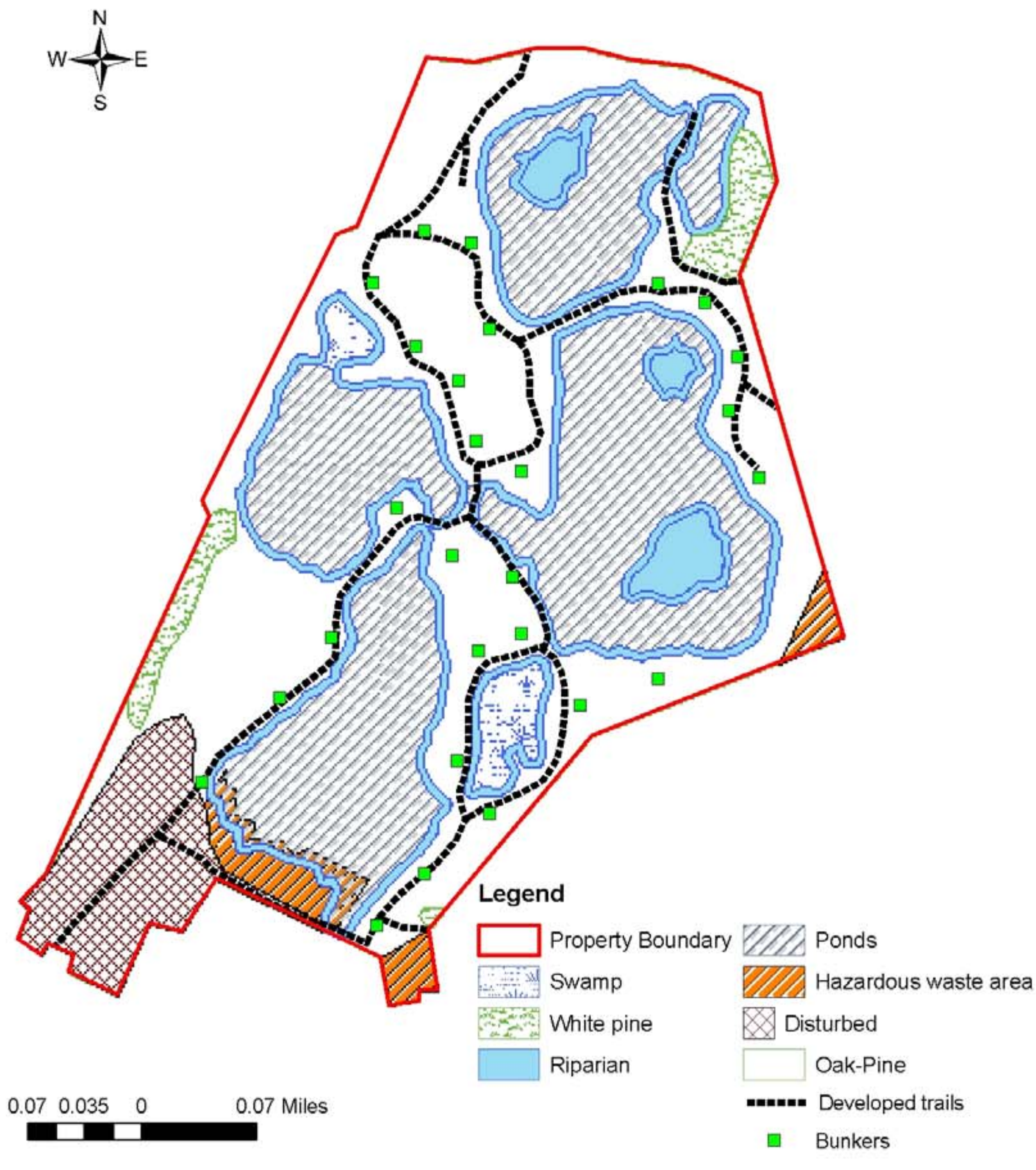
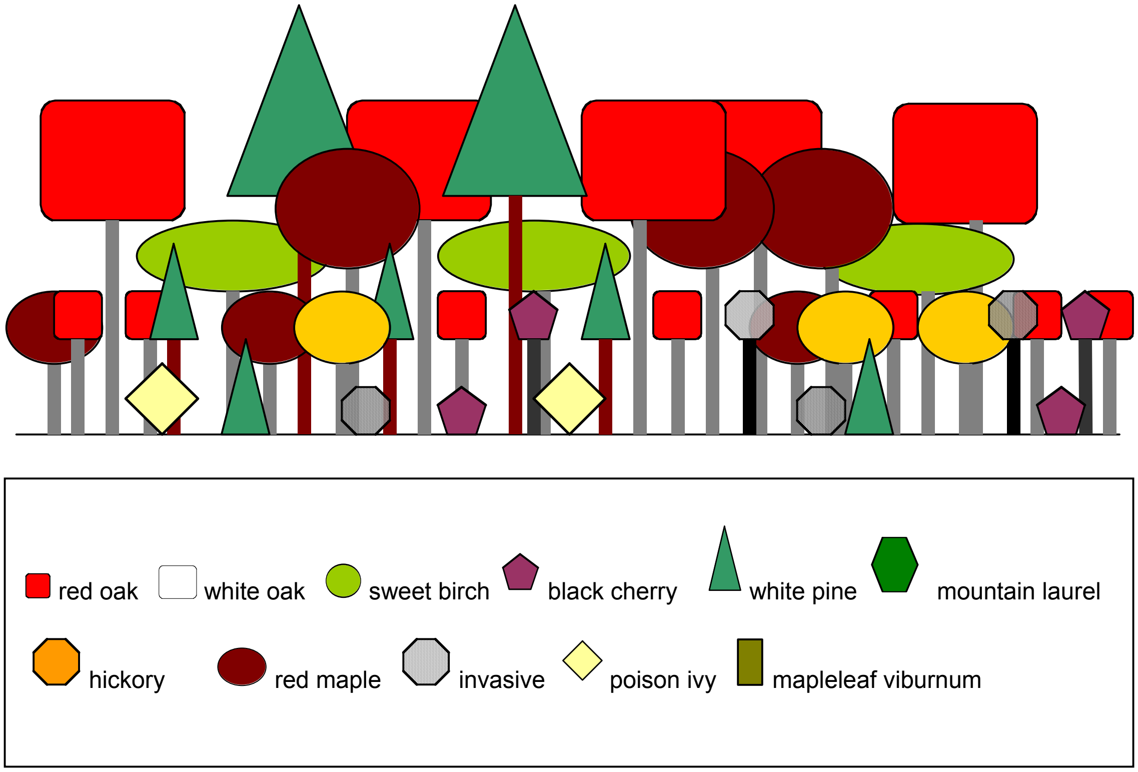


Figure 5: Disturbed Stand Diagram



Forest structure is patchy and varied across the disturbed type. Along the railroad spur (see **Figure M19**) young saplings are establishing, still in the stand initiation stage. The western burning ground (see **Figure M4**) is an opening of herbaceous vegetation within the forested matrix. Closed canopy and a well-developed vertical structure are present in areas to the east and south of the paved road.

Oak-Pine Stand

Nearly all of the forested lands on site that are located on intact soils on site are in the Oak-Pine type. Especially well-developed on the less-disturbed high ground, kame terraces, and plateaus of the site, it is dominated by red and black oaks. White pine is the next most important species in the overstory. Though oaks are most important in understory and groundstory, many other species are found there as well (see **Appendix K)**; indeed, this type has the greatest species richness. More shade tolerant species, such as sugar, red, and Norway maples are present and may emerge to be the next overstory dominants – the forest of the future -- as the oak canopy breaks up and growing space becomes available. Shrubs such as mapleleaf viburnum (*Viburnum acerifolium*) and mountain laurel (*Kalmia latifolia*) are abundant and provide important habitat features for wildlife; viburnum has berries into the fall months, and the winter-green mountain laurel provides thermal cover (see **Figure 6**). Herbaceous layer was difficult to assess during fall.

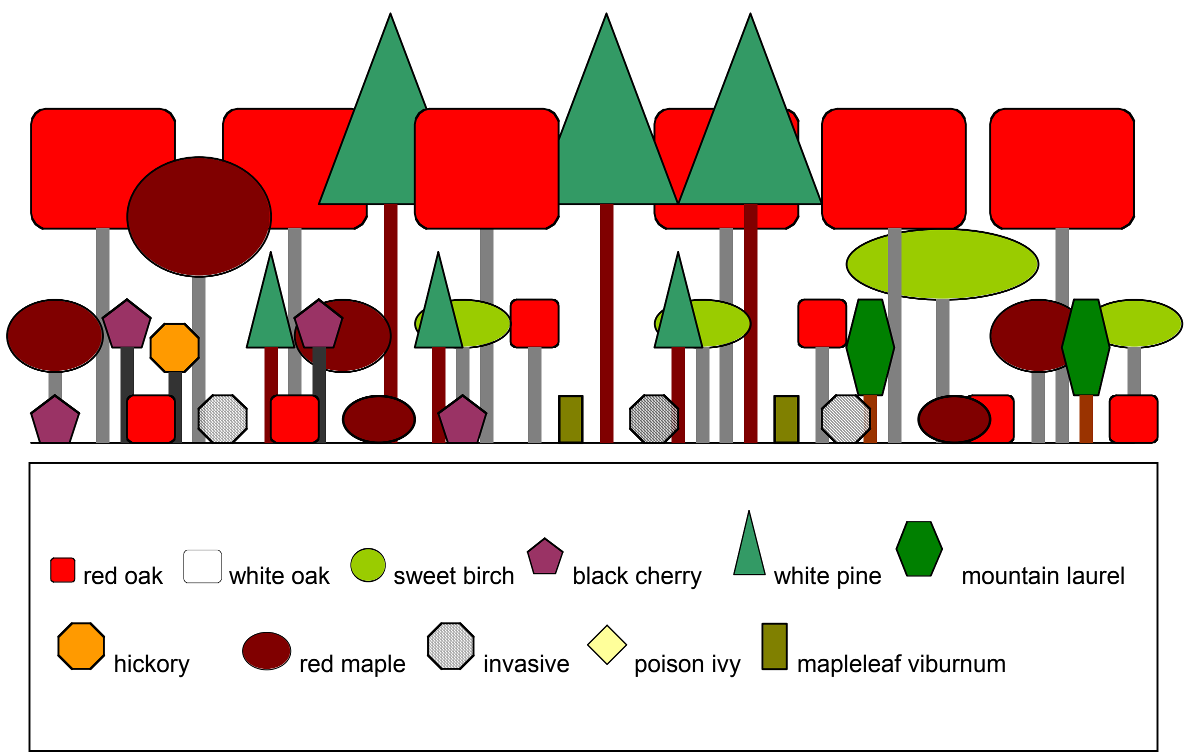
As would be expected, there is some variability within the oak pine, in the importance of oak relative to white pine and in whether oak or pine is most important in the understory layer.

Speaking generally and anecdotally, the eastern portion of the oak pine type has slightly more pine in the canopy, and slightly more pine regeneration in the understory than the western side of the property. This might indicate divergent future compositions and cover types for different portions of the oak pine. Much of the understory pine is browsed by insect larvae, however, so it is unclear what exactly the future forest will look like. Several acres on a plateau south of pond A were burned in a fire 10-20 years ago, and are regenerating in black cherry (*Prunus serotina*), sweet birch (*Betula lenta*), and red oak group species; just north, immediately along the lake edge, is a grove of American beech (*Fagus* grandifolia). Though not as pronouncedly as in the disturbed type, age, species, and structure vary across the oak pine type, which makes the stand resilient in the face of disturbance and unlikely to be decimated in one storm or pest outbreak.

Pine Stand

Though white pines (*Pinus strobus*) exist on much of the property, in several areas they do so in planted near-monoculture. Remnants of plantations established in the early 1930s[27] persist scattered along the property edge. These pine stands are almost exclusively white pine, with few, large, open-grown oak wolf trees.[28] Pine regeneration is strong in places, but along the eastern edge of the property needles of young pine saplings are

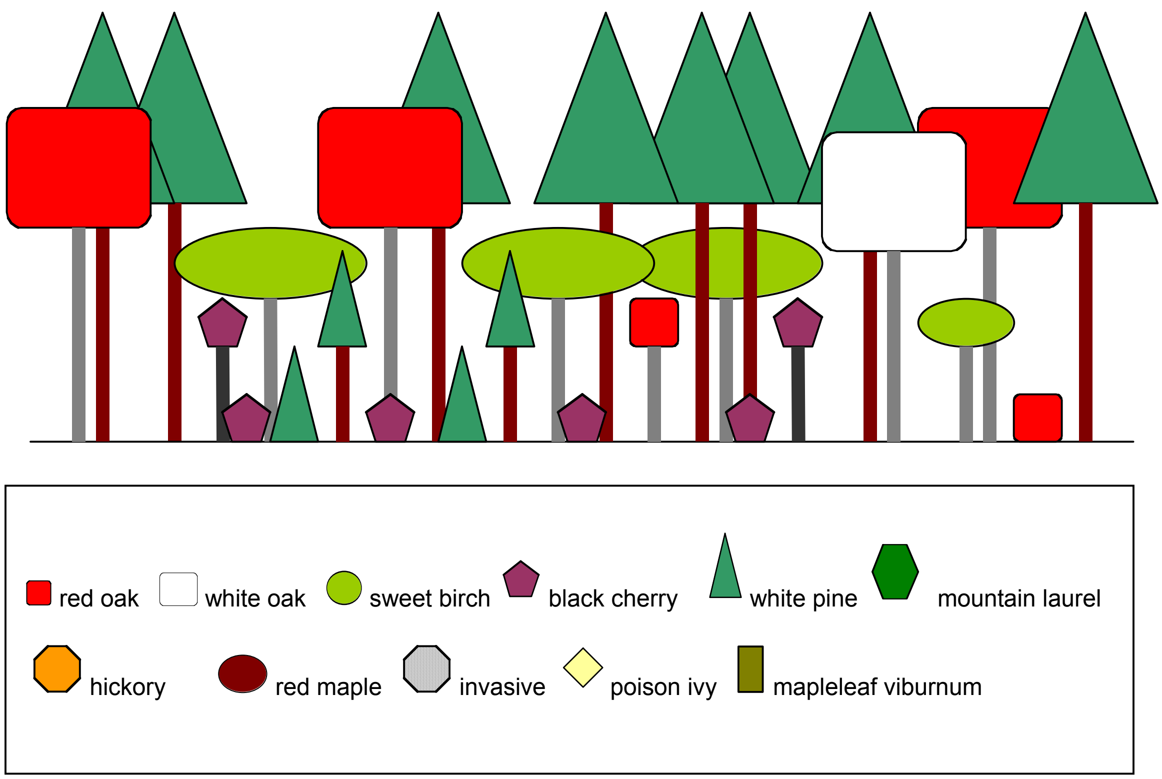
Figure 6: Oak-Pine Stand Diagram



[27] Orderly spacing indicates that the pines were planted, and several cores taken at DBH were aged to the early 1930s.

damaged by larval insect feeding, and deer browse was evident in the western pine stand. More common within the pine type are areas of only minimal pine regeneration, with young trees and seedlings including primarily black cherry, red oak group, and sweet birch. Shrubs in the acid-loving family Ericaceae are common in the groundstory layer, with huckleberry (*Gaylussacia bacatta*) more important than blueberry (*Vaccinium* sp.) (see **Figure 7**). Very little invasive incursion was observed.

Figure 7: Pine Stand Diagram



Pond Edges and Islands

Slopes quickly rise from the water's edge to upland soils and vegetation types. Characteristic swamp and water-associated vegetation rings each pond to a depth of one row of trees but not much more than 5 feet from the shoreline. Species observed at pond edges but not elsewhere include willow (*Salix* sp.), sassafras (*Sassafras albidum)* speckled alder (*Alnus incana*), musclewood (*Carpinus caroliniana*), nannyberry (*Viburnum lentago*), buttonbush (*Cephelanthus occidentalis*), sweet pepperbush (*Clethra alnifolia*), and hop tree (*Ptlea trifoliata*). Red maple (*Acer rubrum*), winterberry (*Ilex verticillata*), and highbush blueberry (*Vaccinium corymbosum*) are also common along pond edges.

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[28] "Wolf" trees are trees that grew in open forest conditions and have spreading branches.

Duckweed in Pond A, early fall, 2003

Contrasting with the woody edge around most ponds, some pond edges grade from open water to upland more gradually, with marsh grasses and emergent vegetation such as common

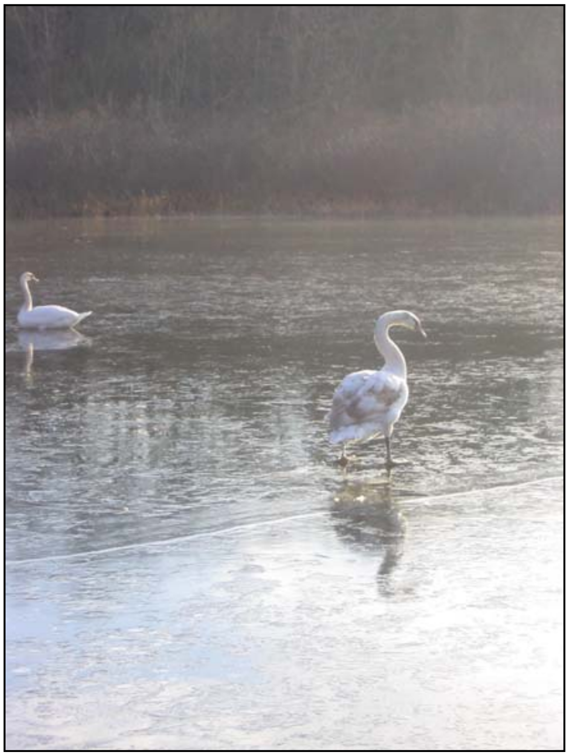
Several of the ponds on the property contain islands, and these islands have typical wetland vegetation, most of which is rooted in decaying logs on a floating bog mat substrate of peat. From the edge to the center, species present are water-willow (*Decodon verticillatus*), swamp rose (*Rosa palustris*), swamp azalea (*Rhododendron viscosum*), highbush blueberry, winterberry, silky dogwood (*Cornus amomum*), sweet pepperbush, speckled alder, blackgum (*Nyssa sylvatica*), and red maple. No island is sufficiently large or elevated from the water to support upland species.

Bog island in Pond E, fall 2003

reed (*Phragmites australis*) and arrow-arum (*Sagittaria* sp.)

The surfaces of all the ponds were covered with the floating plants duckweed (*Lemna minor*) and water meal (*Wolffia* sp.) in early fall, but by mid- October, open water was mostly free of floating vegetation.

Wildlife



Adult and juvenile Mute Swans on Pond A, winter 2003

The multitude of habitats on the Olin Powder Farm property harbor a diverse array of mammalian, avian, reptilian, and amphibian wildlife species that utilize the various niches present. Ponds, wetlands, and forested uplands, all in close proximity, provide complex structures necessary to support multiple species.[29] All this is bordered by an urban matrix; the site provides a refuge to various wildlife species that is uncommon in the Town of Hamden and New Haven County.

Overstory inclusions of white pine within the oak-pine stands provide foraging, nesting, and winter shelter that the oak-pine stands could not provide independently. The prevalence of nut-producing (mast) trees including hickory (*Carya sp.)*, various oaks, and beech, provides ample nutritional forage to a diverse array of wildlife species. Dead and downed woody debris, as well as standing dead trees (snags) provide foraging and shelter sites to primary and secondary cavity nesting species. Forest litter and moss on the groundstory within shaded canopies of moist and well-drained forested areas provide an additional niche to amphibian, subterranean and burrowing species.

Perhaps the greatest attributes of the property are the six ponds that make up approximately 50 percent of the property's total area. These ponds provide high quality open water habitat to a diverse array of ducks, swans, wading birds, and waterfowl. The presence of these six open water habitats within the forested uplands and at a landscape scale within the urban matrix, make the property a valuable asset to migratory waterfowl. Additionally, the large amount of open water habitat and wetland features likely provides necessary habitats for many amphibian species, some reptiles, and fish.

Overall, the Olin Powder Farm property provides a great opportunity to manage the diverse habitats for quality wildlife habitat, particularly for those species

[29] Hunter, Jr., M.L. 1990. **Wildlife, Forests, and Forestry: Principles of Managing Forests for Biological Diversity**. Prentice Hall. 370 p.

with small home ranges and migratory species with seasonal habitat requirements. A complete list of wildlife species observed during our study or likely to be present based on habitat, yet not observed, are listed in **Appendix L**. Next are outlined specific characteristics of the property that provide unique wildlife habitat features.

Snags

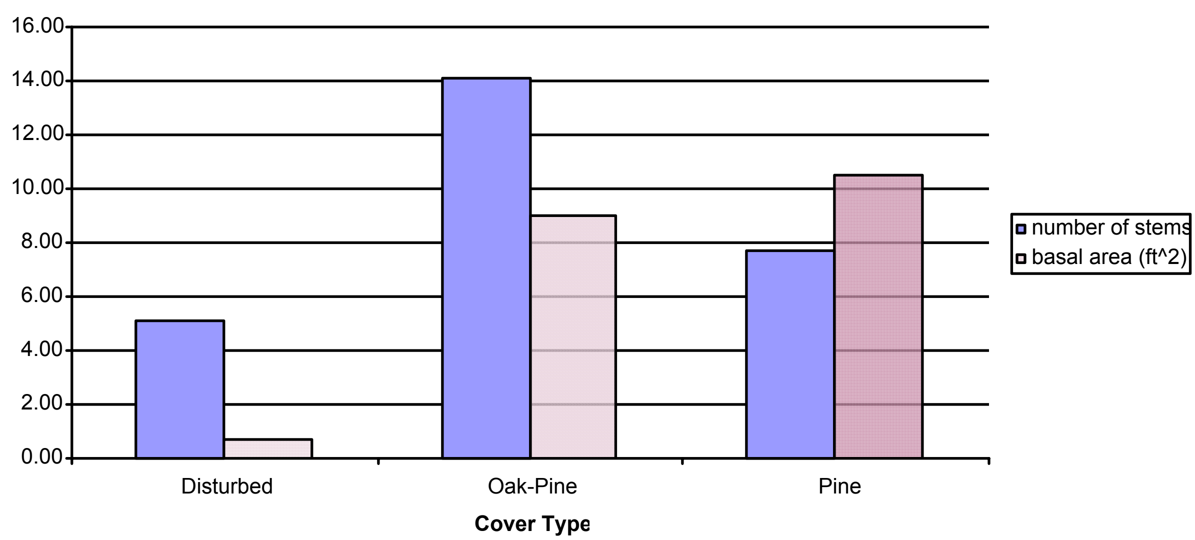
Snags are standing dead trees that provide habitat for many primary and secondary cavity nesters. Primary cavity nesters include such species as woodpeckers, sapsuckers and flickers that drill holes in the dead, hollow wood of snag trees. Secondary cavity nesters are those avian species such as chickadees that will utilize a nest created by a primary cavity species. Both primary and secondary cavity nesters use snags for nesting and feeding. Owls often nest in snags that have broken tops. Many other raptor species such as osprey prefer to use snags as perch trees while hunting prey. Snags are often utilized as den trees by small mammals that use the lower hollow portions for protection. Insects also greatly depend on standing dead trees for food, and they increase the rate of decomposition of the snags.

Our biophysical assessment showed the

White pine snag on site, fall 2003

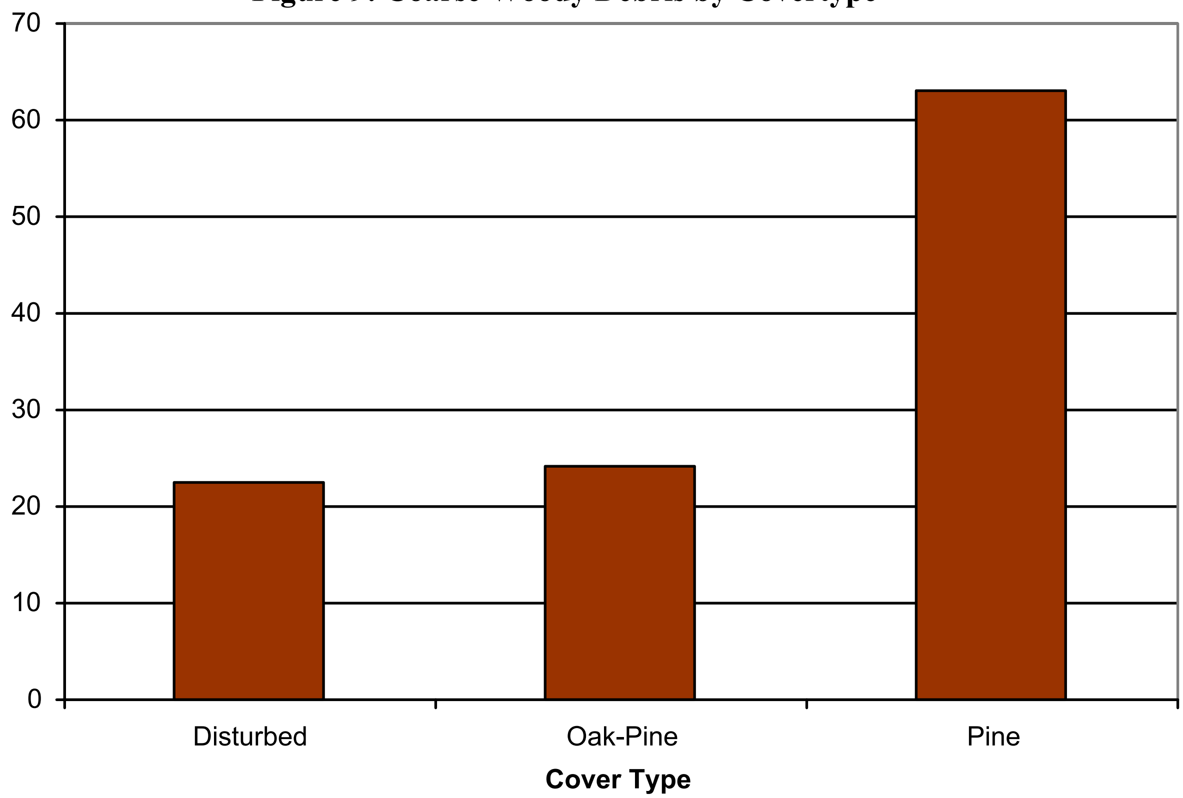
presence of numerous snags throughout the property of varying diameters and

Figure 8: Snags per Acre by Covertype



species. The oak-pine habitat had the greatest number of snags per acre, followed by the white pine and disturbed covertypes, respectively. The basal area of snags was greatest in the white pine stands, followed by the oak-pine and then the disturbed. Snag densities are presented in **Figure 8**. Many pileated woodpecker (*Dryocopus pileatus)* excavations (holes) were observed on snags throughout the property and downy woodpeckers (*Picoides pubescens*) were observed on snags in the property.

Figure 9: Coarse Woody Debris by Covertype



Coarse Woody Debris

Coarse woody debris (CWD) refers to trees, branches, and stumps that are left to decompose on the forest floor. CWD provides a moist, protective habitat for amphibian species and food and shelter for invertebrate species. Amphibians like salamanders, newts, frogs, and toads spend portions of their life cycle in both aquatic and terrestrial habitats. Some amphibian species breed or hibernate within these decomposing logs left on the forest floor.[30] The Olin Powder Farm is unique in that much of its upland terrestrial habitat borders open water and wetlands. The property likely harbors numerous amphibian species that depend on CWD for nesting habitat and protective habitat from predators. Two

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[30] Blanchard F.N. 1933. "Late autumn collections and hibernating situations of the salamander, *Hemicactylium scutatum* (Schlegel), in southern Michigan." **Copeia** 1933:216-217 Cited in Degraaf, R.M. and M. Yamasaki. 2001. **New England Wildlife: Habitat, Natural**

frog species were observed during the course of our biophysical assessment. The most CWD was observed within the white pine stands followed by relatively equal amounts in the oak-pine and disturbed stands. Volume of Coarse Woody Debris by Covertype is presented in **Figure 9**.

Overstory Forest Structure

The overstory forest composition of the Olin Powder Farm is dominated by nut and berry producing tree species which provide food for various bird and mammal species. Mast is a term that refers to the seeds and fruits produced by trees and shrubs; mast production varies from year to year. A distinction is drawn between a hard mast species and a soft mast species.[31] Hard mast includes nuts and seeds produced by oaks, beech, chestnut, and hickory that are consumed by such species as deer, rodents, turkeys, squirrels, jays, and crows. Soft mast includes fleshy fruits and berries produced by maple and ash species and consumed by berry-eating birds and omnivorous mammals. Often the supply of hard mast is a limiting factor for winter survivorship.[32] The year in which this study was conducted seemed to be a high hard mast production year with many acorns littering the forest floor, although our study lacks comparative data. Wildlife observations in oak-dominated stands included turkeys, gray squirrels, and jays. Deer tracks were also observed throughout the property, although no deer were observed.

On the property native white pines, as well as the non-native species red pine, Scotch pine, and Norway spruce provide winter shelter and habitat for resident bird species including the black-capped chickadee (*Poecile atricapillus).*

Understory Forest Structure

Similar to the overstory forest structure, understory trees and shrubs also produce soft mast berries and fleshy fruits. Black cherry, blueberry, and mapleleaf viburnum all produce edible fruits for bird and mammal species. An additional attribute of a dense understory is protective cover for small mammals and, in turn, forage opportunities for accipiter (forest dwelling) raptor species. Understory vegetation on the Olin Powder Farm varies from none in parts of the pure white pine stands to extremely dense in areas dominated by oak.

Leaf Litter Layer

The leaf litter layer, similar to coarse woody debris, provides protective cover and foraging opportunities for reptiles, amphibians, and for many invertebrates. Leaf litter characteristics depend on the overstory vegetation. Litter is made up of either coniferous needles, deciduous leaves of northern hardwoods, or some combination of the two. Because pine needles create an acidic soil habitat, earthworms are more common in leaf litter dominated by deciduous leaves. However, earthworms were observed in one pine needle-dominated leaf litter area. An undisturbed layer of leaf litter contributes to quality wildlife habitat for ground dwelling wildlife species and

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History, and Distribution. Hanover: University Press of New England. 482 p.

[31] Smith D.M., B.C. Larson, M.J. Kelty, and P.M.S. Ashton. 1997. **The Practice of Silviculture: Applied Forest Ecology**. 9th Ed. New York: John Wiley & Sons, Inc. 537 p.

[32] Smith, D.M., et. al. 1997

efforts should be made to limit disturbance.

Open Water and Wetland Features

Proximity to open water is perhaps the greatest wildlife habitat attribute of the Olin Powder Farm. The property attracts a myriad of water-dependent bird species. Mute swans, osprey, great blue heron, Canada geese, mallard, gadwall, wood duck, green winged teal, and widgeons have all been observed on the property. Aquatic turtles were also observed. In addition to the numerous waterfowl and water-dependent species, the proximity to water likely attracts deer, fox, and other small mammals and reptiles to the property. The ribbon snake (*Thamnophis sauritus),* generally uncommon and localized in southern New England,[33] was observed on the property

[33] Blanchard, F.N. 1933.