The Value of Preserving Native Forest Remnants in Urban Areas: Fairfield County, Connecticut

Submitted in partial fulfillment of the Graduate Certificate in Urban Forestry, Oregon State University

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TABLE OF CONTENTS

ABSTRACT

The purpose of this study was to evaluate a native remnant forest in Westport, Connecticut. The study site is a fragmented woodland located near a highly urbanized area of roadways and development. Preliminary descriptive information was collected for a partial sampling of tree stands in an attempt to obtain baseline data about the urban forest location and its value with respect to providing ecological services. iTree Canopy was used to quantify tree canopy, carbon sequestration, air pollution, and hydrological benefits at the study site. A reference site, the National Park Service (NPS) site at Weir Farm in Wilton, CT, a regenerated forest site, was also assessed for the same biophysical parameters and values using the iTree Canopy tool. Both sites are located within Fairfield County, Connecticut. The native remnant study site had a tree canopy coverage estimated at 70% across 77 acres while the regenerated NPS farm site had an estimated canopy of 60% across 89 acres. iTree Canopy values for the ecological services data showed that estimated benefits and value for carbon sequestration and storage, air pollution containment, and hydrological metrics at the NPS regenerated farm site were larger compared with the native remnant forest study site.

Keywords:

Native Remnant Forest, Connecticut, Ecological Services, Biophysical Habitat, Urban Forestry, Urban Ecology

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INTRODUCTION

In the State of Connecticut, old growth forests are not common, however, in some areas there are patches and tracts of native remnant forest areas that have been historically documented and preserved. In the early 1900's a survey of a 'virgin' or 'primeval' forest in Colebrook, CT was conducted (Nichols, 1913). Tree species, diameters, circumference, height, age from stumps tree rings, and understory plants were documented. The most common tree species found at the Colebrook site were: Eastern Hemlock (*Tsuga canadensis*) and American Beech (*Fagus grandifolia*) which comprised an estimated 55% of the forest survey site. Tree age for these species ranged from 250 to 350 years. Other tree species, although in smaller percentages, documented in the area were Sugar Maple (*Acer saccharum*), Yellow Birch (*Betula alleghaniensis*), Red Oak (*Quercus rubra*), American Chestnut (*Castanea dentata*), Basswood (*Tilia americana),* Sweet Birch (*Betula lenta*), Eastern Red Maple (*Acer rubrum*), White Ash (*Fraxinus americana*), and Black Cherry (*Prunus serotina*). Approximately 5 other sites in Connecticut were surveyed at that time and there was some tree species variation between sites in north central Connecticut and north eastern Connecticut. Eastern White Pine (*Pinus strobus*) and Eastern Hemlock were predominant species at another site. Notes were made in the report regarding the towering height of the predominant tree species, especially the Eastern Hemlock and White Pine. According to the report, extensive logging in this area began in 1912.

A report was published which identified 19 old growth sites (ancient sites) in Western and Northwestern, CT (Ruddat, 2020). There were no sites documented for Eastern, CT in the publication. Old growth forest remnants were mapped in areas near Colebrook, CT and Norfolk, CT which were locations from the survey conducted by Nichols in the early 1900's. The native remnant forest in Westport, CT which is the proposed site for this study was not included in the 2020 report published by Ruddat.

An awareness of the history of these types of forest patches in Connecticut and what tree species are represented in these forests is a significant pathway to defining the methods and data to be collected in this study proposal. Forests in the wilderness and urban forests have distinct features and represent different types or variations of ecosystems. The latter are intricately connected to management and common use by people. Native remnant forests which exist near urban areas may have or share ecosystem features of each of these forest types. Native remnant forests harbor some of the older and larger native tree species that exist in undisturbed wilderness areas and can provide similar dense canopies, although the effects of insect pests, plant diseases, and climate change can shift the composition of tree species. One example of the deleterious effects of plant diseases is the disappearance of the American Chestnut tree from eastern forests (Hancock, 2018). A fungal blight, *Cryphonectria parasitica,* in the early 1900's which was introduced by the importation of the Asian Chestnut was the cause of the destruction of the native American Chestnut (Horton, 2011).

BACKGROUND

In general, the study topic was designed based upon information and research data which was available for 'native remnant forests' and urban woodland habitats in the United States. Current research information was used to define the parameters of the study proposal. The goal for this urban forestry project was to study a local native remnant forest in Westport, Connecticut (Fairfield County) and obtain descriptive forest information. A secondary goal was to determine whether any of the forest trees represented old growth.

Fairfield County borders New York State and is the closest Connecticut county to New York City. Westport, CT is located between a major Interstate (I-95) and the Merritt Parkway (CT 15). The total acreage of the urban forest study area is approximately 70 acres. The remnant forest is located in the northwestern section of Westport which, although it is forested, is relatively close to Route 1 which is a major road through the municipality with excessive traffic and businesses (Appendix 1). The study site is on the edge of an urban area and is also connected to other fragmented woodland areas in residential neighborhoods creating potential wildlife corridors. The native remnant forest, itself, is relatively undisturbed and hosts conifer and deciduous tree species. Additionally, the understory, meadow and forest edge areas flourish with native wildflowers in the Spring and Summer.

PROBLEM STATEMENT

The study proposal is based upon the concept that undisturbed native remnant forests in urban areas provide a habitat that enhances the biodiversity of the area and can provide a sustainable environment for native plant communities and wildlife (Forman, 1995). The importance of native tree species and the understory vegetation to sustaining a healthy and diverse habitat is the basis for the problem statement. Consideration of climate effects, the presence of insect pests, tree diseases, and seasonal variations in the biodiversity of the habitat are factors that need to be considered for this study proposal and any effects upon the native forest remnant habitat.

OBJECTIVES

Objectives for the study proposal are:

a) To conduct a partial sampling inventory of remnant forest trees in the habitat and collect baseline data about forest composition, structure, and characteristics
b) To assess the ecological services provided by the native remnant forest
c) To compare the ecological services of the 70 acre native remnant study site with a second 89 acre regenerated forest, around the Weir Farm National Historic farm site in nearby Wilton, CT. In the past, the National Park Service conducted a vegetation survey at the second site (Metzler et al., 2009).

LITERATURE REVIEW

Overview

The literature review initially addresses the history of native remnant and old growth forests in Connecticut and provides a summary of the types of old growth trees that have been found in these types of forest patches. The characteristics of this type of forest ecosystem were reviewed. The urban forestry area for this native remnant study proposal is not well known by people from outside the local area in Westport, Connecticut. There is not a plethora of public information about the site except that its preservation began in the 1950's by a devoted group of citizens and local landowners. There is no specific information from the town or the historical society about the estimated age of the old growth trees or previous land use.

Between 1950 to 1960 there was a 44% increase in the town population which reflected increased residential development post World War II. One can only surmise that with the increasing population density after 1950 and rising residential and commercial development in this area of Connecticut during the mid 1900's, that the preservation of this tract of native remnant forest became important to those specific philanthropic citizens and land owners of the Town of Westport, CT which is why it still exists today.

In the years during and after the 1950's, a youth education center was created, followed by the development of a nature education center. The native remnant forest around the nature education center, now called Earthplace (http://earthplace.org/about/our-history/) has been undisturbed and remains under the management of the Town of Westport, Connecticut. Basically, there is no land use at the project site except for the discrete

area of the Earthplace nature center, the Wadsworth Arboretum in an adjacent area, and a limited number of nature trails. The arboretum is not included in the study since it has been actively managed by the town tree warden. There are smaller patches of fragmented woodland corridors in the developed residential areas around the study site. These patches consist of both remnant and regenerated trees.

The study habitat consists of urban forest woodlands and meadows which represent a unique example of a native remnant forest habitat in the State of Connecticut. The biome is mesic in this temperate climate area which averages 3-4 inches of rain per month. There are small pond and brook watersheds within the area, but Nash's Pond and the Saugatuck River are outside the study area. Westport's town boundary area is approximately 33 square miles. Land represents 60% while water represents the remaining area in the form of rivers, streams, and ponds.

Urban Forest Ecosystem

This study project is designed to assess biophysical and ecosystem aspects of the forested area. The project title implies that there is a social, economic, and cultural framework built into the study proposal, i. e., 'the value of preserving….' It is well established that urban forests offer environmental, social, health, cultural, and economic benefits often termed ecological services.

The Food and Agricultural Organization of the United Nations (FAO) defines urban and peri-urban forestry as: "...networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners.

Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint...." (FAO, 2011). The implication is that urban forestry is cross cultural. The 'many' in social and cultural terms can benefit from the ecological services of trees. It is well established that urban forests offer environmental, social, health, cultural, and economic benefits often termed ecological services.

Ecological Services of the Urban Forest

Urban forestry is unique with respect to the relationship between nature, trees, and people. Nowak (2017) identified four steps to quantify ecosystem services and values from the forests:

1) Quantify the forest structural attributes that provide the service for the area of interest (e.g. number of trees, tree cover). These structural data are essential as they quantify the resource attributes that provide the services.
2) Quantify how the structure influences the ecosystem service (e.g. tree density, tree sizes, and forest species composition are significant drivers for estimating carbon storage).
3) Quantify the impact of the ecosystem service. In many cases, it is not the service itself that is important, rather the impact that the service has on human health or other attributes of the environment that provide value to society.
4) Quantify the economic value of the impact provided by the ecosystem service.

The third item on the list points to the "...impact that the service has on human health...." Thus, the urban forest has 'value' in many respects which are social and cultural.

Economic value is provided for example by the ability of trees to sequester carbon, provide shade, and remove pollutants from air, soil, and stormwater.

Brockerhoff, et al. (2017) provided a summary of research that supports the beneficial role of biodiversity has in the provision of ecological services and health of the ecosystem, Dawson and Hostetler (2010) found that diversity of bird species in a study in Florida was related to specific characteristics of native remnant forest areas: remnant size, habitat diversity of trees and other plants, connectivity, and shape. The presence of older and larger trees and extent of the canopy was also an important factor.

Lastly, the native remnant forest identified for the project is located near a nature education center which offers children and adults opportunities to engage with nature. Van den Bosch (2017) provides a brief summary of the benefits of natural environments to children's behavior, cognitive skill development, and learning, in addition to the exercise and physical activity. The forests, including urban forests, therefore have educational and cultural 'value' in that respect.

From the perspective of conservation, the study proposal is directed towards the biophysical aspects of the urban forest which engage and provide the link to social, economic, health and cultural benefits to those who enjoy, learn, and recreate.

Scope of Urban Forest Parameters

The scope of the project includes a survey of dominant conifer and deciduous tree species and the understory trees. In order to study a sustainable urban forest, which involves both environmental science and sociological aspects, measurable parameters

for the proposed study were proactively established. These parameters are based on observation, hypotheses, and delineation of specific objectives in advance of the collection of data for the research project. There are no scientific publications related to the forested site. Therefore, the study proposal represents a preliminary assessment of the characteristics of this native remnant forest.

For the purposes of this project proposal in the field of urban forestry, a major observation is that the native remnant forest provides significant environmental benefits, as well as, social and health benefits to the community. The total acreage of the urban forest study area is approximately 70 acres and is a hub of education and outdoor activity for citizens and the youth.

Barron, et al. (2016) conducted a Delphi survey of urban forest indicators. The features that were most relevant to the experts surveyed were: *Urban Tree Diversity; Stormwater Management; Physical Access to Nature; Habitat Provision; Canopy Cover; Air Quality Improvement; Visual Access to Nature; Greenhouse Gas Sequestration and Storage Availability; and Growing Space.* For this study proposal of the native remnant forest, the features of 'urban tree diversity, habitat provision, and canopy cover may be the most relevant considerations.

Town of Westport and State of Connecticut Forest Data

In 2018 a consulting group Western Council of Connecticut Governments (West Cog) prepared a summary of the Western Connecticut region tree canopy and cost benefit analysis for municipalities in the region. The study found that the town of Westport, CT had a 47.1% canopy coverage in the year 2015 (WestCog, 2018). However, the

downtown and peripheral area to downtown consist primarily of limited street tree plantings. The study site is a community greenspace and citizens have access to the area for hiking and wildlife observation, In 2000, the average community green space in Connecticut had tree coverage which averaged 45.3% (Nowak and Greenfield, 2008).

Ecological Integrity

One of the considerations for this study is the concept of ecological integrity of the native remnant forest: "The ability of an ecological system to support and maintain a community of organisms that has species composition, diversity, and functional organization comparable to those of natural habitats within a region. An ecological system has integrity when its dominant ecological characteristics (e.g., elements of composition, structure, function, and ecological processes) occur within their natural ranges of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human disruptions." (Parrish et al. 2003).

It is hypothesized that the urban study site and its habitat biodiversity mirror that of a similar forested area in the wilderness. Measurement and indicators for ecological integrity are summarized by Wurtzeback and Schultz (2016).

METHODS AND MATERIALS

On-site methodological techniques and use of GIS Apps were used to collect data in order to study the biophysical parameters of the native remnant trees including forest structure and composition. The data collection timeframe was in the Winter of 2021.

Data Collection for Study Site

1. Dendrometrics for sampled trees in the study area included: circumference at breast height (CBH), diameter at breast height (DBH); tree height, and an estimate of tree age using growth factor calculations for specific tree species where growth factor data was available.

2. Tree canopy coverage for the study area and ecological service data were quantified using iTree Canopy software for both the native remnant forest study site and the regenerated forest area at Weir Farm National Historic Site.

3. Forest Survey - Intact stands of Conifer and Deciduous trees were partially sampled for data collection.

Materials:

Used for on-site data collection were:

a) tree tape to measure circumference

b) NASA Globe Observer GIS Phone App to measure tree height (https://www.nasa.gov/feature/goddard/2019/help-nasa-measure-trees-with-new-app)

Research Plan Timeline and Limitations

Access to the proposed study site is not limited during the year. The timeline for the project was the Winter, 2021. A limitation of the project was that the understory native herbaceous vegetation could not be feasibly studied during the winter months.

Native Remnant Forest Criteria Matrix

Socio-ecological systems (SES) is a framework term that has been used in both ecology and urban forestry to broadly define the relationship and interactions between people

and nature (Colding and Barthel, 2019) This study proposal is primarily based upon biophysical criteria of urban forestry, but indirectly involves sociological criteria. An interdisciplinary and integrative approach is required for the methodology. The dynamic drivers of the study proposal are neither divergent nor conflicting. Criteria are generally parallel with both direct and indirect relationships. The ecological system drivers are the forest tracts, species of flora and fauna, and habitat diversity,

Table 1: Native Forest Remnant Study Proposal - Biophysical and Sociological/Economic Criteria

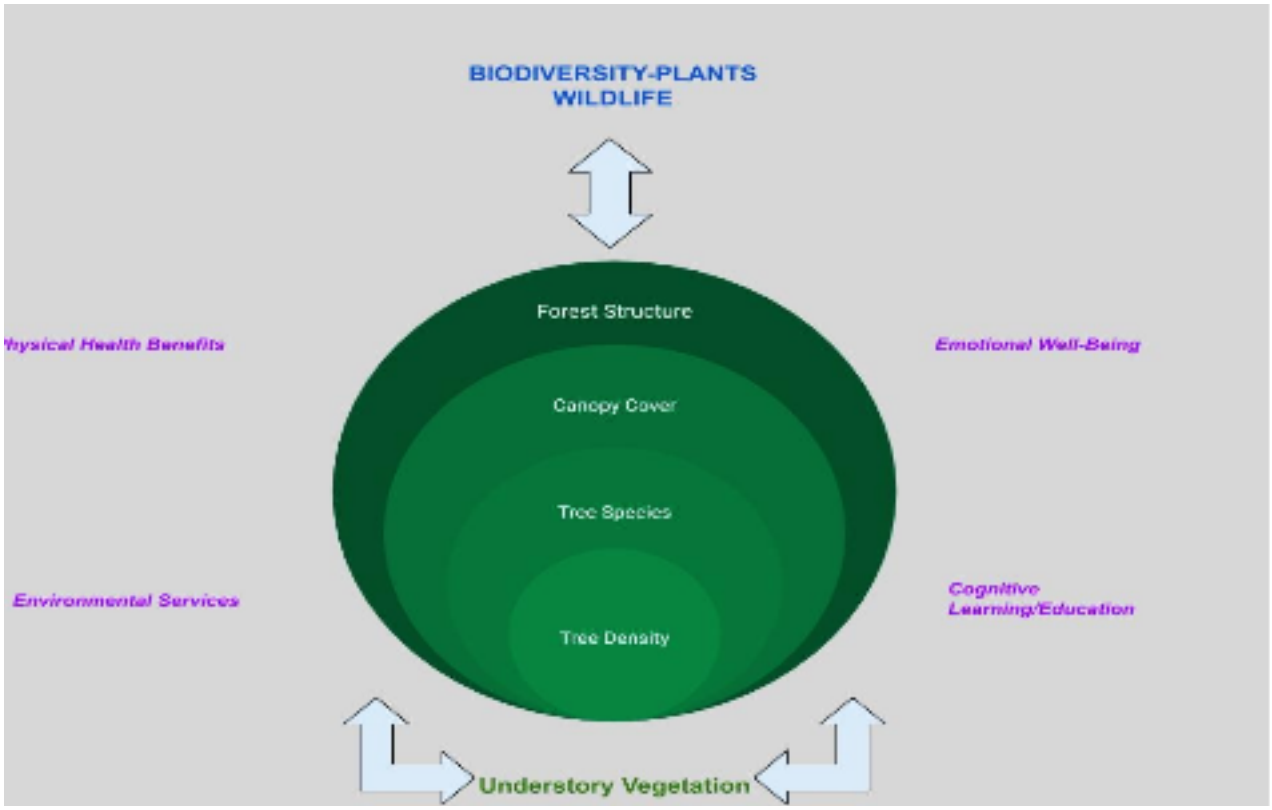
CRITERIA	Physical Health Benefits	Emotional Well-Being Benefits	Learning/Educational Value	Environmental Value/Carbon Storage/ Reduced Air Pollution/Water and Soil Quality
Forest Structure	Indirect	Indirect	Indirect	Direct
Canopy Cover	Indirect	Indirect	Indirect	Direct
Tree Species	Indirect	Indirect	Indirect	Direct
Tree Density	Indirect	Indirect	Indirect	Direct
Understory Vegetation	Indirect	Indirect	Indirect	Direct
Wildlife Species Use	Indirect	Indirect	Indirect	Direct
Biodiversity	Indirect	Indirect	Indirect	Direct

Biophysical System Parameters and Benefits

The following diagram (Figure 1) illustrates that the biophysical system of the native remnant forest is the foundation and primary goal of the study proposal, and that any

derived benefits are reliant on this biological system. This aspect was the rationale for a partial sampling of tree stand data in the field at the native remnant site which was conducted for this project.

Figure 1 - Biophysical Forest System Parameters



RESULTS

Dendrometrics

Field data for the study site (Site A) was collected from three different stands of trees. Table 2 summaries the dendrometrics and estimated tree age based upon tree species growth factors. Stand 1 consisted of Eastern White Pine in an upland area. The pine

canopy was open with no understory. Stand 2 consisted of a northerly transition from Stand 1 to a deciduous hardwood upland and meadow area. Stand 3 consisted of deciduous hardwood trees and a few conifers in an upland area. This stand was in a location isolated by the entry road. An old partial stone boundary was near the south end of the stand. No trees from the site wetland area were surveyed.

Table 2: Native Remnant Forest Composition

Survey Area	Tree Species	CBH (in)	DBH (in)	*Tree Height (ft)	**Estimated Tree Age (years)
Stand 1	White Pine (*Pinus strobus*)	83	26.4	35.9	132
	White Pine (*Pinus strobus*)	95	30.3	35.3	152
	White Pine (*Pinus strobus*)	110	35.0	55.0	175
	White Pine (*Pinus strobus*)	80	25.5	29.8	128
	White Pine (*Pinus strobus*)	97	30.9	73.0	154
Stand 2	Sugar Maple *(Acer sacch*)	58	18.5	43.5	93
	Sugar Maple *(Acer sacch*)	80	25.5	34.3	128
	White Oak *(Quercus alba)*	39	12,4	20.1	62
	Red Oak *(Quercus rubra)*	47	15.0	77.0	60
	White Oak *(Quercus alba)*	30	9.6	32.1	48
Stand 3	Sugar Maple *(Acer sacch*)	73	23.2	51.0	116

	White Oak *(Quercus alba)*	56	17.8	30.4	89
	White Pine (*Pinus strobus)*	235	74.8	51.3	374
	White Cedar (Thuja Occidentalis)	82	26.1	26.5	----------
	White Pine (*Pinus strobus)*	15	4.8	22.2	24

*(NASA Globe Observer)
**(White Pine Growth Factor=5, Sugar Maple Growth Factor=5, White Oak Growth Factor=5, Red Oak Growth Factor=4)

Variability in early growth rate for white pine can account for some of the age-related differences in growth factor estimates found in Table 2, Stand 1, in addition to climate-related factors. However, non invasive estimates of tree age using growth factor calculators based upon tree circumference and height is a technique that is used where dendrocore extractions are not possible. This geospatial tree height assessment technique using NASA Globe Observer presents some variability with respect to over- or underestimation of tree height based upon the angle of the phone camera. A sample data set for NASA Globe Observer is found in Appendix 3. Appendix 4 displays two photos of Eastern White Pine tree stumps that had been cut down from Stand 1. The tree rings in both photos can be compared to the estimates in Table 2. An on site visual inspection of the tree rings on the stumps indicated that there were more than 100 rings which suggested that the growth factor estimates of tree age based on CBH and tree height are plausible.

iTree Canopy Data

Data generated using iTree Canopy software showed that estimated tree canopy coverage for the remnant study site (Site A) was 70.9% across the discrete parcel of the calculated 77 acres, while that for the comparison site of regenerated farmland at the National Park Service location was 60.6% across the parcel totaling 90 acres (Site B). iTree Canopy specifications for each site, with respect to land cover classification, were set-up in advance of establishing the geospatial analysis polygons which are used by the software algorithms to estimate tree canopy and ecological services data and values. .

The land cover distribution by type for each site is illustrated in Figure 2 and Figure 3. In addition to the increased tree canopy at Site A, there was more grass/herbaceous land cover than at Site B which had increased soil/bare ground land cover area, as well as, an increased amount of impervious road surface and other impervious surfaces.

Figure 2: iTree Canopy Chart - Remnant Forest Study Site, Westport, CT

(Site A)

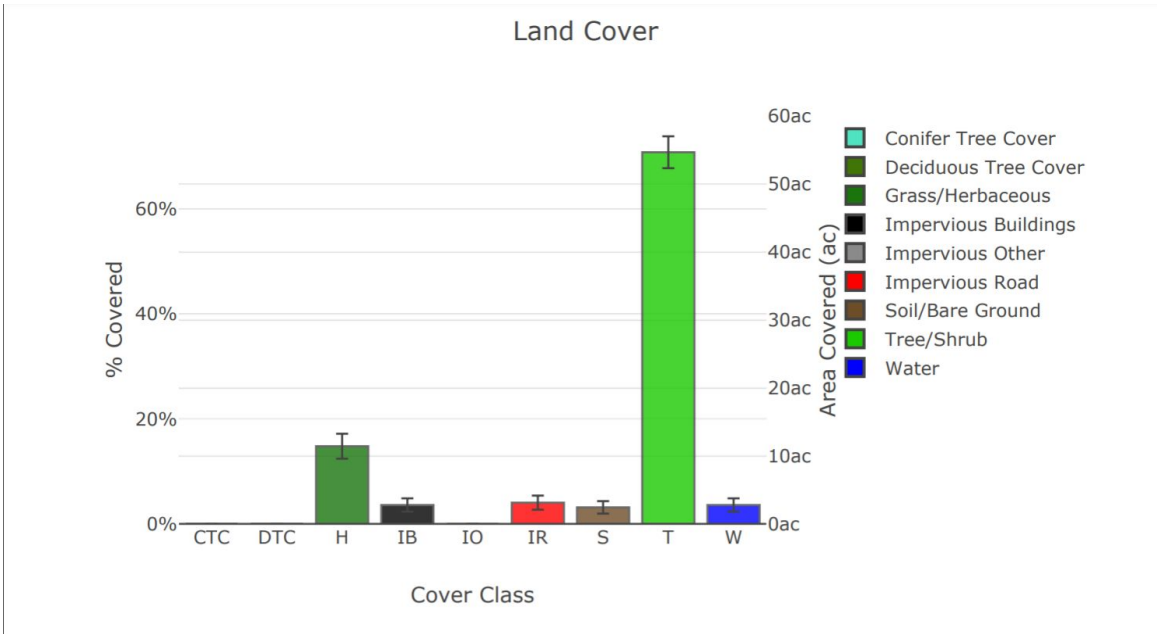
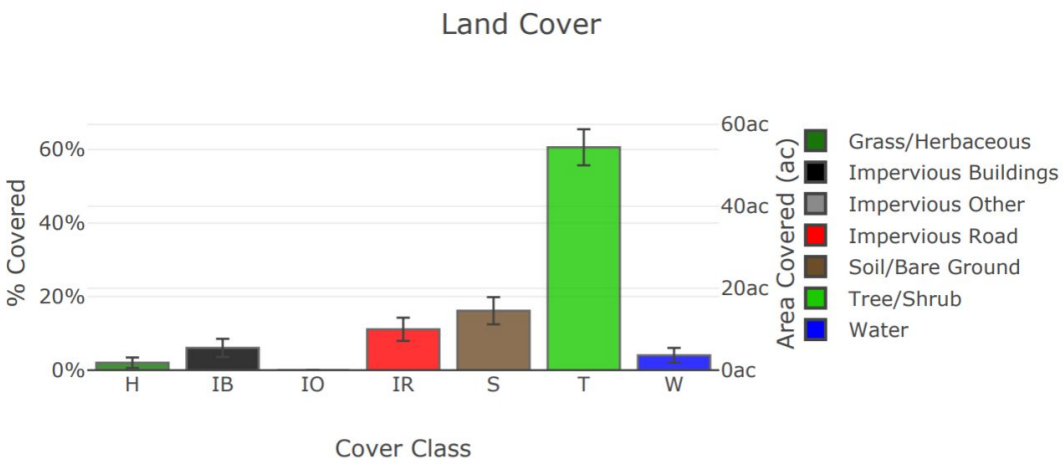


Figure 3: iTree Canopy Chart - Regenerated Forest Site Weir Farm NPS, Wilton, CT (Site B)



iTree Ecological Services Data

A review of the data for carbon sequestration, air pollution, and hydrological benefits provided by the sites revealed that the regenerated farmland site, Site B, appeared to provide more ecological services than the remnant study site, Site A. There was basically no variability in the data for Site B as indicated by the standard error values. This can possibly be attributed to the distribution of land cover classes (iTree Technical Support communication, 2021) or the difference in total acreage at each site. However, the difference in the acreage between the two sites was only 13 acres. The large difference in iTree Ecological Services Data seen in Table 3 between Site A and Site B

represents a confounding factor when viewed from the perspective of increased percent canopy cover for the study site (Site A) versus the reference site (Site B). Zipperer (2003) found that both remnant and regenerated forest areas contributed substantially to carbon sequestration in a study in Syracuse, NY. It was suggested that the benefit is amplified when compared with parkland and street trees because management requires more financial resources.

Table 3: iTree - Ecological Service Data - Tree Benefit

	*Site A / B	Site A / B	Site A / B	Site A / B	Site A / B	Site A / B
Carbon (Tons)	Amount	(+-) SE	CO2 Equiv	(+-) SE	Value (USD)	(+-) SE
**Sequest Annually	74.6 / 122.51	3.21 / 0.00	273.64 / 449.22	11.75 / 0.00	12,728 / 20, 895	547 / 0
Stored in Trees	1,874.24 / 3,076.80	80.50 / 0.00	6,872.20 / 11,281.59	295.17 / 0.00	319,652 / 524,750	13,729 / 0
**Air Pollution	Amount (lb)	(+-) SE			Value (USD)	(+-) SE
CO	49.30 / 80.93	2.12 / 0.00			2 / 3	0 / 0
NO2	268.81 / 441.28	11.55 / 0.00			4 / 6	0 / 0
O3	2,677.22 / 4,395.00	114.99 / 0.00			188 / 309	8 / 0
SO2	169.40 / 278.09	7.28 / 0.00			1 / 0	0 / 0
PM10	896.77 / 1,472.16	38.52 / 0.00			137 / 224	6 / 0
PM2.5	130.09 / 213.56	5.59 / 0.00			389 / 638	17 / 0

Total	**4,191.59 / 6,881.03**	**180.03 0.00**			**720 / 1,181**	**31 / 0**
****Hydrological**	**Amount (gal)**	**(+-) SE**			**Value (USD)**	**(+-) SE**
Avoided Runoff	**28.27 / 46.41**	**1.21 / 0.00**			**0 / 0**	**0 / 0**
Evaporation	**2,334.17 / 3,831.84**	**100.26 / 0.00**			**N/A**	**N/A**
Interception	**2,347.24 / 3,853.29**	**100.82 / 0.00**			**N/A**	**N/A**
Transpiration	**3,158.50 / 5,185.07**	**136.66 / 0.00**			**N/A**	**N/A**
Potential Evaporation	**17,687.06 / 29,035.56**	**759.68 / 0.00**			**N/A**	**N/A**
Potential Evapotranspiration	**14,431.16 / 23,690.59**	**619.84 / 0.00**	`		**N/A**	**N/A**

(* Site A = Remnant Study Site; Site B = Regenerated Weir NPS)

(Value per acre/year)**

DISCUSSION

Forest Composition

The study site (Site A) consists of a variety of tree species which are native to the northeastern United States. In an area of fragmented woodlands which are near major roadways, highways, and both residential and commercial development, the site represents a habitat with vegetation diversity. There was an absence of Eastern Hemlock trees at the location which could indicate that there had possibly been early

harvesting of these trees. Similarly, at the Weir Farm NPS site (Site B), Eastern Hemlock was not a common tree species, contrary to the old growth forests of northwestern Connecticut, where Eastern Hemlock is one of the dominant tree species. The Eastern Hemlock does exist as isolated specimens in areas and towns around Westport. The tree was valuable in earlier centuries for its lumber and tannins found in the bark (United States Forest Service, 1970) which may explain its absence at both sites. Tannins were used to cure leather for saddlery. There is a history of saddlery in the region.

As shown in Appendix 5, extensive urban development along coastal Connecticut including the Town of Westport left woodlands fragmented and isolated The pattern of less fragmented and larger core forest areas transitions from southwestern Connecticut in Fairfield County through the study site (Westport, CT) and reference site (Wilton, CT) up to the northwestern section of the State where Old Growth forests still exist.

Although the study site cannot be classified as an old growth forest, there is a sampling of Eastern White Pine trees from Stand 1 that are estimated to be older than 100 years. One White Pine tree with a triple codominant stem from Stand 3 was aged by a growth factor calculation as being more than 300 years old. This is an estimate only and this tree does not represent the average age by growth factor estimation of trees across the three sampled stands which varied in age group classifications. The White Pine at the study site were the oldest trees averaging greater than 100 years in age. Without specific historical land use information about the native remnant forest study site, it is

difficult to speculate about the forest composition and whether, when, and how successional tree growth may have occurred at the site during the last 100 to 200 years. The reference site, Weir Farm/NPS, has been historically documented as abandoned farmland during that same period of time.

The current state of Connecticut forests by tree age classes is that: 3% are in the 0-20 year range; 4% are in the 21-40 year range; 7% in the 41-60 year range; 30% are 61-80 year range, 32% in the 81-100 year range, 14% in the 101-120 year range, 1% in the 121-140 year range, <1% in the 141-160 year range (Peracchio, 2020). The largest combined percentage of tree age classes in Connecticut forests are in the 61-80 years and 81-100 years groups which represents a total between 60-65%. Thus, there is a trend toward reduction in tree age class diversity in Connecticut forests. It has been suggested the largest percentage of tree age classes exists as a result of a 1930's Connecticut tree planting campaign conducted by the Civilian Conservation Corps (Wharton, et al., 2004).

The trees sampled in this study varied in estimated age via growth factor calculations between 24 and 364 years. The age class numbers were: 1 (21-40 year range); 2 (41-60 year range); 1 (61-80 year range); 2 (81-100 year range); 1 (101-120); 3 (121-140 year range); 2 (141-160 year range); 1 (161-180 year range); 1 (> 200 years).

A visual comparison of the site satellite images in Appendix A and Appendix B illustrate the extent of development, highways, and traffic in the area surrounding the study site

(Site A). The National Park reference site at Weir Farm (Site B), although Route 7 which is a major transit route is nearby, is more isolated from other major roadways and the surrounding area is more suburban with less traffic and transit use than the study site.

The trees surveyed at the study site (Site A) were represented by Maple, Oak, and White Pine. Northern white cedar and Sweet Birch were observed although minimally represented. In contrast, tree upland groupings were identified in detail at Site B by the National Park Service were: Semi-rich Northern Hardwood Forest Acer saccharum - (Fraxinus americana); Northeastern Dry Oak - Hickory Forest Quercus (alba, rubra, velutina) / Cornus florida / Viburnum acerifolium Forest; Lower New England Slope Chestnut Oak Forest Quercus prinus - Quercus (rubra, velutina) / Vaccinium angustifolium Forest; Mesic Sugar Maple - Ash - Oak - Hickory Forest Acer saccharum - Quercus rubra / Hepatica nobilis var. obtusa Forest; Northeastern Modified Successional Forest Prunus serotina - Liriodendron tulipifera - Acer rubrum - Fraxinus americana. These groupings were dominated by deciduous hardwoods with minimal representation by conifer species including White Pine and Eastern Hemlock (Metzler et al., 2009). The Oak-Hickory is the predominant forest type in Connecticut and is a result of succession from abandoned farmlands (Wharton, et al., 2004).

iTree Canopy and Ecological Services

The average canopy coverage in the Town of Westport is 47.1% (WestCog, 2018). The iTree Canopy data revealed an estimated 70% tree canopy coverage at the study site along with estimates for carbon sequestration, air pollution, and hydrological data in

conjunction with economic values. The remnant forest study site provides clear value in terms of ecological services. The biophysical parameters of the site are the framework and foundation for a diverse habitat in a fragmented urban forest setting. The social, cultural, and aesthetic values of the outdoor space and nature education center are derived from the preservation of this native remnant forest.

In contrast, the average canopy coverage in the Town of Wilton, CT (Site B) and the bordering Town of Ridgefield, CT are 70.7% and 68.5%, respectively. These canopy values are higher than the 47.1% in the Town of Westport where the study site is located (WestCog, 2018). The Towns of Wilton and Ridgefield are less dense with respect to residential and commercial development and have less proximity to highway and high volume roadway traffic. These differences are apparent when comparing the satellite images of Appendix 1 and Appendix 2 The iTree Canopy from NPS Weir Farm in Wilton, CT was approximately 60% which is lower than the overall town canopy coverage noted previously. The NPS reference site also serves as a social, cultural, and educational center and benefits from the ecological services as estimated by iTree Canopy.

RECOMMENDATIONS

Future Research

The native remnant study site offers an opportunity for future research:

- Expand the scope of the native remnant forest survey to include larger areas and the wetland area

- Compare ecological benefits of a native remnant forest and a representative wilderness area.
- Conduct a seasonal wildlife survey with trail cameras to study the wildlife that utilize this native remnant forest habitat and evaluate the biodiversity of the habitat
- Conduct an understory and edge Floristic Survey - Quality and Biodiversity/Pollinators
- Assess the status of the understory vegetation and determine the extent of invasive plant species. A consideration for this is to determine whether a native remnant forest can preserve native vegetation (grasses, flowers, shrubs) and protect against invasive plant species.

CONCLUSIONS

The primary goal of the study was to obtain basic descriptive information and ecological service data about the native remnant forest site in Westport, CT. A secondary goal was to determine if the site contained any old growth trees. General forest stand composition and dendrometric data were collected at the site as part of this study. Ecological services data obtained using iTree Canopy were compared with a reference site in Wilton, CT which is a National Park Historic site, the Weir Farm. Weir Farm was originally abandoned farmland from the 1800's and early 1900's, thus the area contains regenerated and successional tree growth. Both sites are used for social, cultural and educational purposes.

The native remnant forest study site in a more urbanized area provided tree canopy coverage of 70% while the regenerated NPS Weir Farm site had a canopy coverage of 60%. The value of the native remnant forest study site in Westport, CT is represented by biophysical parameters such as increased canopy coverage and direct ecological services benefits of carbon sequestration and storage, containment and mitigation of air

pollution, as well as, hydrologic effects which improve microclimates and control stormwater in the area. The importance and value of this native remnant forest located in a fragmented urban ecosystem can be further defined at this location by future urban forestry research which encompasses ecological aspects of the habitat both flora and fauna.

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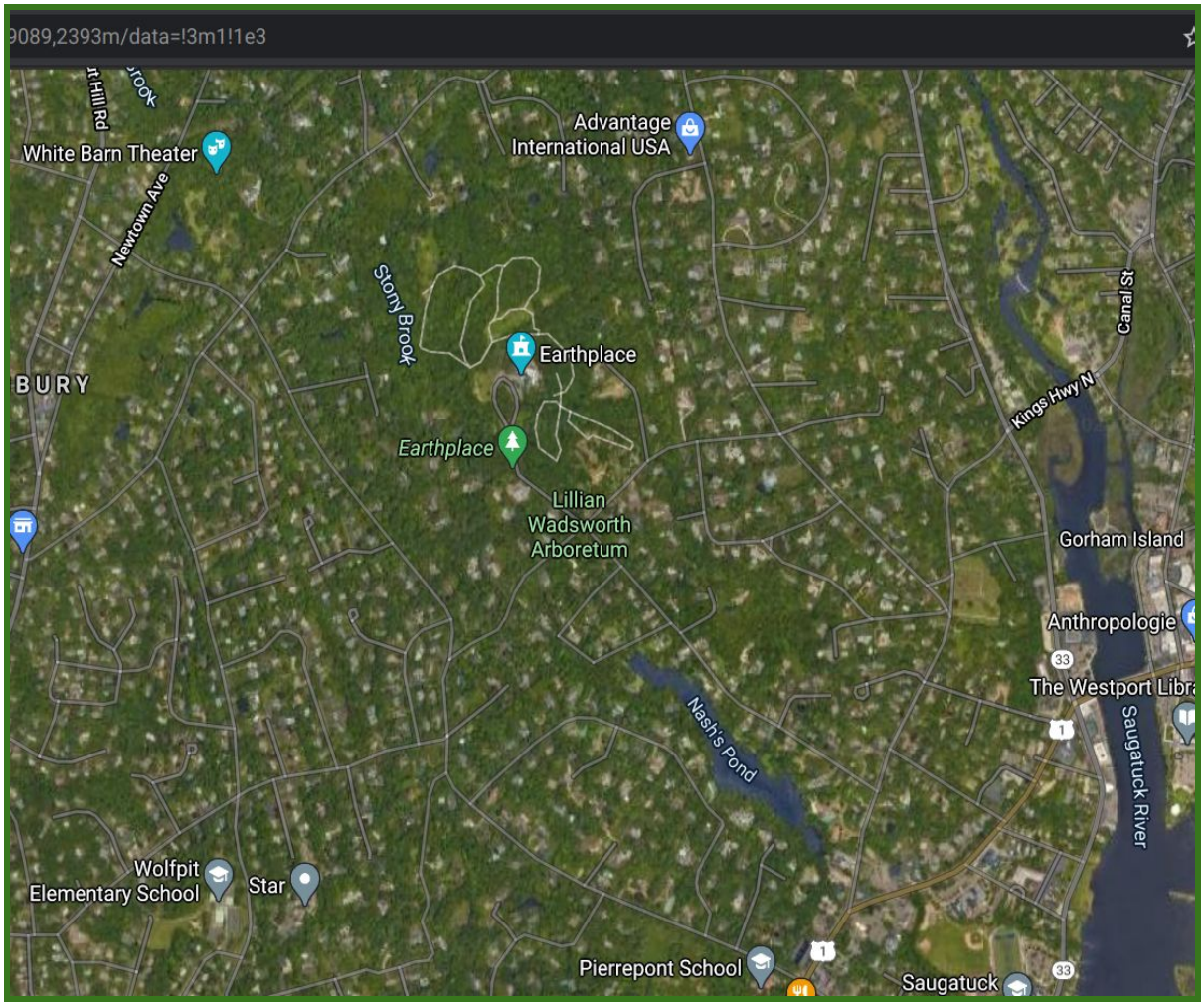
APPENDIX 1

Native Remnant Forest Study Site - Satellite Map Location, Westport, CT

The study site is the wooded area surrounding the Earthplace marker in the center of the photo. Thin white lines represent trails within native remnant forest study area:

West **North** **East**

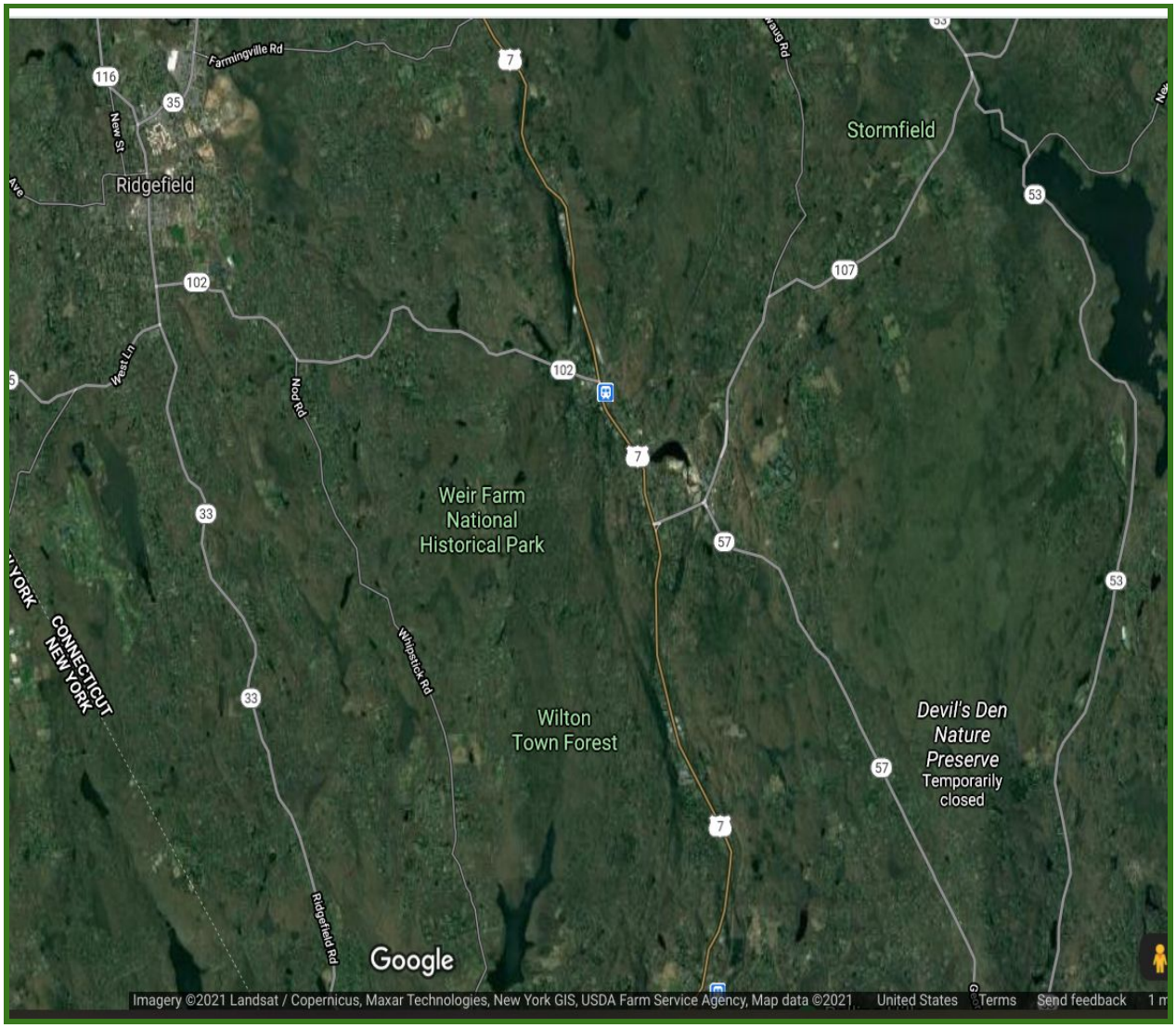


West **South** **East**

APPENDIX 2

Regenerated Forest Site Weir Farm National HIstoric Site - Satellite Map Location, Ridgefield/Wilton, CT

West North East



West South East

APPENDIX 3

NASA Globe Observer Sample Data - Geospatial Tree Height Calculations, Study Site (Site A) - Native Remnant Forest, Westport, CT

Tree Photo

Date/Time (UTC): **02/24/2021 16:52:00**

Data Source: **GLOBE Observer App**

Latitude/Longitude: **41.1471, -73.381 (41° 8' 49.56", -73° 22' 51.6")**

Organization: **United States of America Citizen Science**

Site Name: **18TXL358563**

Height (m): **10.95**

Circumference (cm): **210.8**

Surface Conditions: **Snow/Ice: No; Standing Water: No; Muddy: No; Dry Ground: No; Leaves on Trees: No; Raining/Snowing: No**

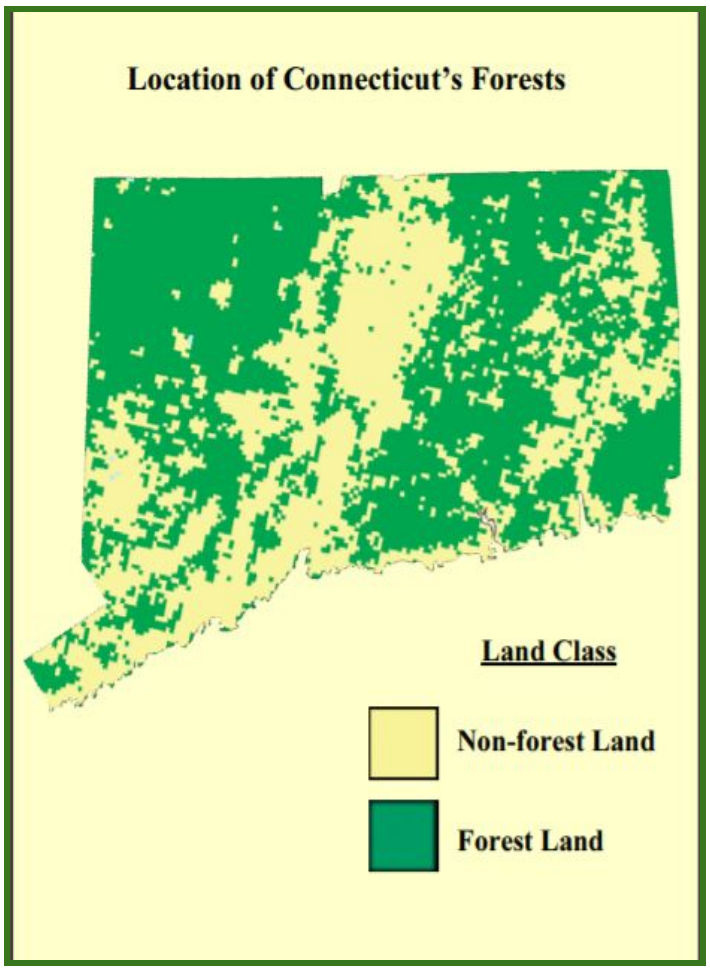
APPENDIX 4

Stand 1
White Pine Stumps and Tree Rings
Right photo shows damaged trunk probably from a tree disease in basal area


(Image credit: E. George, February 2021)

APPENDIX 5

Illustration of transition from non-forest land and fragmented areas along coastal Connecticut northward through western Connecticut. Old Growth forest areas exist in the northwestern section of the State



(Wharton, et al., 2004)

Conifer Stand at the Study Site, Westport, CT
Bears Sculpture by Anna Hyatt Huntington
(Image credit: E. George, May, 2020)