Initial Assessment of

The Yale Swale

Yale Campus, New Haven, CT

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Executive Summary

"Urban jungles: Explore, in winter (when the thorn bushes are dormant) the jungle between Mansfield and Prospect Streets — paths, a small stream, a former apple orchard, a marsh,. Access behind any of the Yale Buildings on Prospect Street past Sachem Street."

-The Merry Life of the Beekeeper: a Guide for New Haven and Yale[1]

The "Yale Swale" is a largely forested area at the northern edge of Yale University's campus in New Haven, CT. The site is bounded by Prospect St. to the east, the Prospect-Sachem Parking Garage to the south, Mansfield St. to the west, and Hillside Place to the north. The site is just west of Yale's School of Forestry & Environmental Studies (F&ES) and to the north of Yale's iconic hockey arena (colloquially dubbed the "Yale Whale"). Earlier in the last century, the site comprised a mix of trees and backyards maintained by Mansfield and Prospect St. residents. A series of changes in ownership leading to Yale's acquisition of most of the properties within the project area has created an interest in managing the site collectively.

Based on a proposal[2] for ecological restoration of the site developed in 2011 by Yale F&ES students and faculty, funding was granted by the Hixon Center for an initial site assessment for Urban Ecology at Yale. Quoting the original proposal, the project's vision is as follows:

"We hope to transform the Swale from an underutilized and degraded site to one that is highly productive – where academic research can be conducted and community members can recreate."

Project Objectives:

- Primary: Develop the space into an on-campus outside laboratory for education and research purposes.
- Secondary: Establish demonstration sites of ongoing restoration activities to educate the broader Yale community and general public.
- Provide recreational opportunities (nature study etc.)

Fieldwork took place during the summer of 2012 to characterize the site and provide baseline vegetation data in anticipation of future management and research. The site was overgrown with thick, mostly invasive understory vegetation that made walking difficult, and many trees were either supporting massive vines (again, mostly invasive species) or had fallen, creating gaps in the forest which have yet to regenerate. There was abundant evidence of previous use of the site by neighborhood youth and transient individuals.

[1] http://www.yale.edu/beekeeper

[2] Miley, D., Ashton, M., Gentry, B. 2011. Memorandum (8/4/11): Ecological Restoration of the Yale Swale

All trees >4" in diameter were identified and mapped, and forty $4m^2$ permanent understory sampling plots were established on a study area of ~5.5 acres. Despite the significant presence of invasive species, many native wetland and forest species were also found. In terms of species, an impressive total of ~52 trees, ~22 woody shrubs, and ~62 herbaceous and climbing species were found.

With these data, we have developed a series of recommendations for initial management interventions:

- Collect further baseline data (i.e. birds, soils, hydrology, neighborhood use, etc.)
- Define the landscaping and mowing boundaries of each Yale-owned building
- Remove invasive vines to encourage survival and regeneration of existing native trees
- Remove some invasive trees.
- Extirpate invasive understory species in some portions of the site
- Plant some trees to fill in persistent canopy gaps
- Consider engagement with the Mansfield Community Garden
- Remove sections of deteriorated fence.

General Recommendations (Expanded)

Prior to defining prescriptions for site planning and management, a careful mapping of stakeholders and interests is necessary. While that work should be part of the next phase of this project, we have provided some general recommendations below to consider as the project develops. In doing so, we are explicitly assuming the following:

- The site should remain mostly forested
- Native vegetation, including trees, should be prioritized over non-native and invasive species
- Access to the site and ease of use should be improved

Based on these assumptions, we propose the following activities:

- Yale property managers should define the landscaping and mowing boundaries for non-forested areas; in other words, where backyards begin and end. Otherwise, the boundaries of the Swale as a forested, semi-natural site will continue to be in flux.
- The survival and regeneration of existing native trees is a significant challenge. A variety of factors appear to have contributed to the high number of tree falls in the area, and the gaps created by these falls have filled in with dense, largely invasive understory vegetation. The removal of vines from trees throughout the site may reduce the risk of falls as well as the continued propagation of the vines, most of which are invasive (with the notable exception of poison ivy and *Vitus* grape species. Seedling and sapling growth may also benefit from vine removal.
- Invasive trees and herbaceous vegetation is a problem throughout the site. Norway maples, Amur corktrees, Sycamore maples, and Trees of heaven are common in different densities throughout the site, and are likely to increase. Some removal may be warranted.
- Understory invasive species should be removed in some portions of the site, together with a longer term plan for continuous management. Japanese knotweed, multiflora rose, English ivy, and other species outcompete native vegetation and pose serious problems for regeneration of trees. Without a management intervention, the Swale as a whole runs the risk of becoming an invasive species botanical garden rather than a mixed native and non-native forest.
- Consideration should be given to potential management research opportunities (e.g. tree planting and removal) that address invasive species utilization of canopy gaps due to tree falls.
- The community garden located behind the New Haven Zen Center at 193 Mansfield St. partly extends into the Swale and its boundaries have shifted over time and appear to have been somewhat undefined. As it is non-Yale property and serves an important role in the Mansfield community, Yale should consider how its presence fits into the overall Swale site. Engagement with the Zen Center and the New Haven Land Trust may be productive to this end, and a joint effort to

expand its use (perhaps by Mansfield student tenants or Forestry School students) might bolster its presence as a community focal point and contribute to making the Swale a public green space.

- Create trails to allow access to the site's features. These should be unhardened, though allowing access by wheelchair, and providing dry footing over wet areas.
- Mark points of egress, probably located at the southern boundary near the parking garage, in the northeast corner (with suitable stairs), and at the community garden if desired by the users. Each should have a blue phone for security.
- Remove fencing that run through the site. These fences once served as property boundaries between adjacent parcels, but now only impede potential trail locations and support invasive vines.
- Continue data collection to evaluate site conditions. Priorities are collection of soil samples at pre-designated vegetation sample plots, and measurements of water flow or level throughout the study site.

Site Conditions

Initial site visits began in late June, 2012. Several informal trails or fragments were found to have been previously established throughout the project site; however, most have become overgrown with understory vegetation and show limited signs of current use.

The clearing of paths was required to access most parts of the site, given the abundance of Japanese knotweed, multiflora rose, jewelweed, and other vegetation. Thorns, poison ivy, climbing vines, and an abundance of downed tree trunks made for difficult and uncomfortable walking.

Though there was little evidence in August 2012 of recent presence of people, it was clear that a variety of activities had taken place there in the past. Sporadic trash and evidence of inhabitation suggest the variety of uses the site has served.

Among the items found across the site:

- a rotting tree house
- golf balls, a baseball, a lacrosse ball, and a hockey puck
- a dog toy
- shoes of all types
- small vials - perhaps drug paraphernalia, though not appearing to be recent
- trash heap at NW end - electronics, clothes, etc
- uninstalled ceramic drain pipes
- a glass window
- a door
- worn blankets/carpets suggesting sleeping spaces
- cleared grassy area among weeds, also suggesting it was used as a campsite of some sort
- human waste and toilet paper on a recently cleared path
- beer bottles and cans of many kinds and vintages, some relatively recent
- pruners loppers, yard tools, etc.

Methodology

Sampling Protocol for Trees

All woody vegetation at least 4¨ in diameter at breast height (DBH) was surveyed across the entire property (n=551 trees). Identification was carried out to the species level, and in some cases to genus where appropriate (i.e. *Prunus sp.*). DBH was recorded using a Biltmore stick, with few (<10) exceptions where visual estimates were made due to lack of easy access to the sampled tree. Height was visually estimated and corroborated between the two researchers. Locations of trees were also determined with GPS having a likely uncertainty of about # m.

Large gaps on the tree map (such as the narrow bottleneck in the middle of the site that is only ~20 m wide) indicate tree falls that have largely been replaced by invasive understory vegetation.

Based on calculations performed in ArcMap, the study area is 240,000 square feet, or 5.5 acres. The perimeter is 2800 feet.

Sampling Protocol for Understory Vegetation

A geometric grid was created in ArcMap with each plot location placed 80 feet from the next, in both an east-west and north-south orientation. 43 points were fit into the proposed sampling area, and of these, 3 were unused based on their location in residence backyards or non-Yale properties.

A handful (~5) of other points were repositioned in a systematic manner away from either residence backyards or non-Yale properties. The repositioning was generally ~10 feet away in the direction of the forest or Yale property. These deviations are recorded in the metadata.

A two foot section of 1" PVC pipe was hammered into the ground at these locations based on GIS coordinates from the proposed grid loaded onto the Trimble GPS device. The pipes generally extend ~5" above ground, and are labeled with permanent black marker and an aluminum tag affixed with red and green metal wire. The aluminum tag was generally pushed downwards to the soil surface to make it less likely to be removed. A penny was placed in the soil next to the pipe to make the point detectable by metal detector. In most cases, orange biodegradable flagging tape was affixed to the closest branch above the site to facilitate location for future sampling.

Plots were labeled S*XX*, with S standing for Swale and XX a number ranging from 1 to 43. As above, 3 plots were not sampled and lack a PVC marker due to their location. These plot numbers and their X and Y coordinates are recorded in the understory data entry Excel file.

Plot sample size was $4m^2$ in a circular fashion, using a string to extend a visual radius of 1.13 m (i.e. Area = $\pi(1.13m)^2$) from the PVC post.
The following data were recorded in each plot:

- All woody plants > 1.3 m (i.e., DBH height) within each plot, including species and DBH. Shrubs (i.e., multi-stem plants) were qualitatively recorded by frequency.
- All woody plants between 50 cm and 1.3 m were recorded by species and frequency.
- All woody plants less than 50 cm were likewise recorded by species and frequency and tabulated separately.
- Herbaceous and ground cover vegetation was recorded using visual estimates by percentage. The minimum percentage was 1%, and all other estimates at multiples of 5%. For instance, a given plot might be 1% garlic mustard, 10% pokeweed, and 25% English ivy, etc.

A plant´s inclusion in the plot was generally dependent on stem location, i.e. if a knotweed stem was located outside of the 1.13 m radius, but it´s leaves grew over the plot, it was not included.

Results

Key Figures

Based on the complete inventory of all trees greater than 4" DBH, the following figures were calculated:

Study area (acres)	5.507

Basal Area	*ft^2/acre*
Live Basal Area =	77
Snag Basal Area =	6.2
Major Invasive BA=	20.5
Other Species BA =	56.

Stem Density	
Total stems =	551
	per acre
Total stems =	100.
Live stems =	91
Snags =	9.4
Major Invasive Stems =	44.
Other Species Stems =	46.

Note:

- For the purpose of the charts below, tree species were divided into two categories: "major invasives" and "other species." Given the mix of planted, naturalized, native, and invasive trees, we elected to limit the "invasives" group to four species that have a disproportionate presence or impact on the forest: Norway maple, Tree of Heaven, Sycamore maple (both cultivars), and the Amur cork tree.
- In addition to the total herbaceous percent cover chart, sample coverage maps for the three dominant herbaceous species (English ivy, Japanese knotweed, and multiflora rose) are provided.

Basal Area

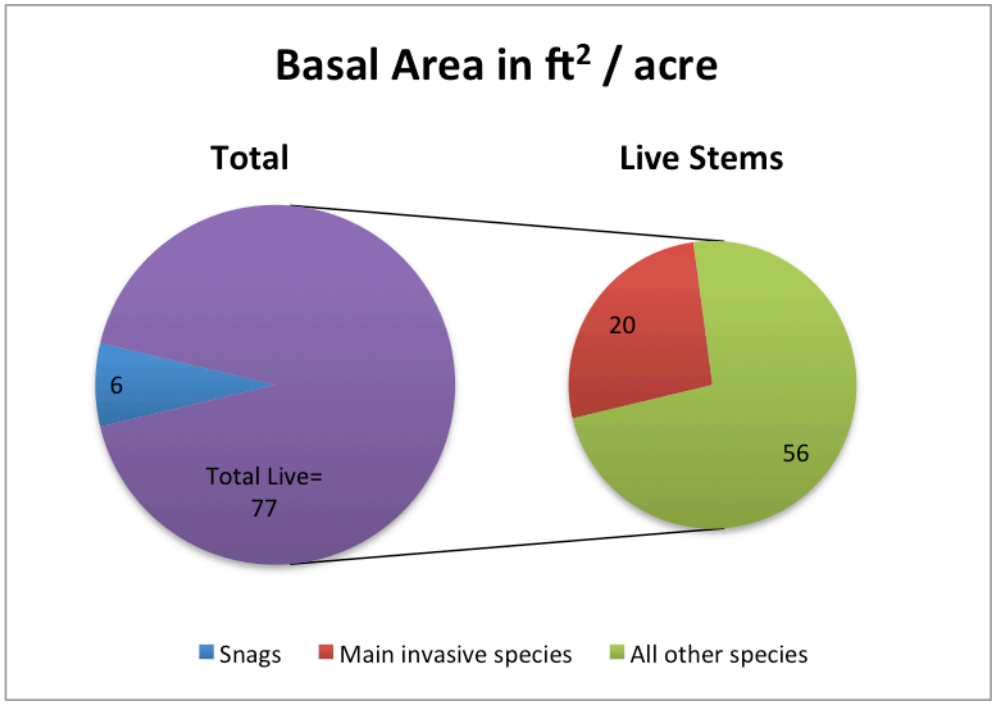

Figure 1: Basal Area in ft2 / acre

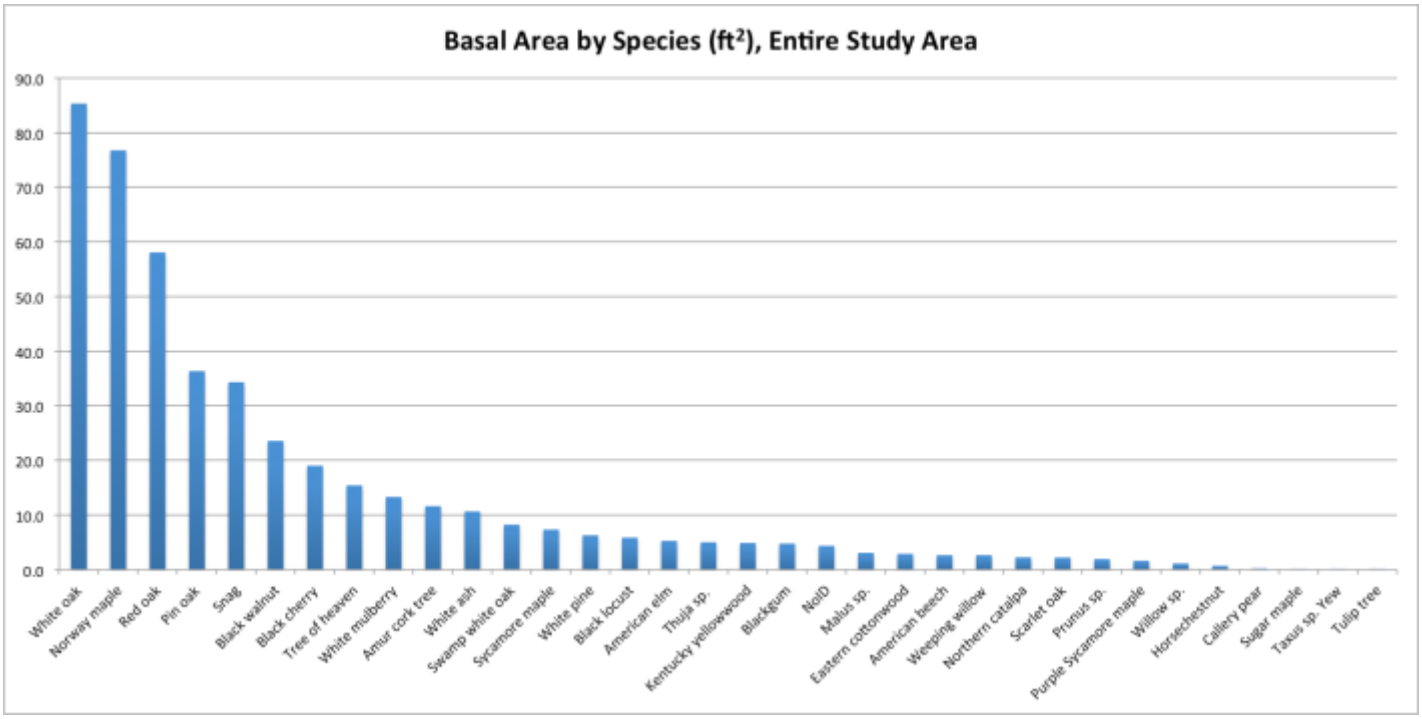

Figure 2: Basal Area by Species (ft2), Entire Study Area

Stem Density

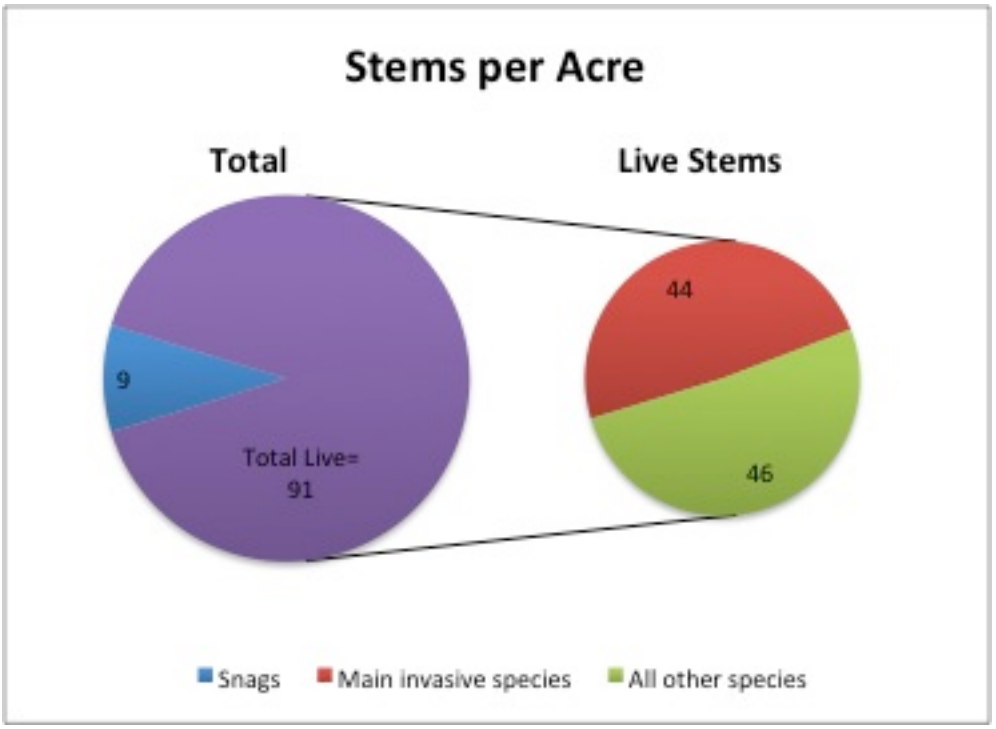

Figure 3: Stems per Acre

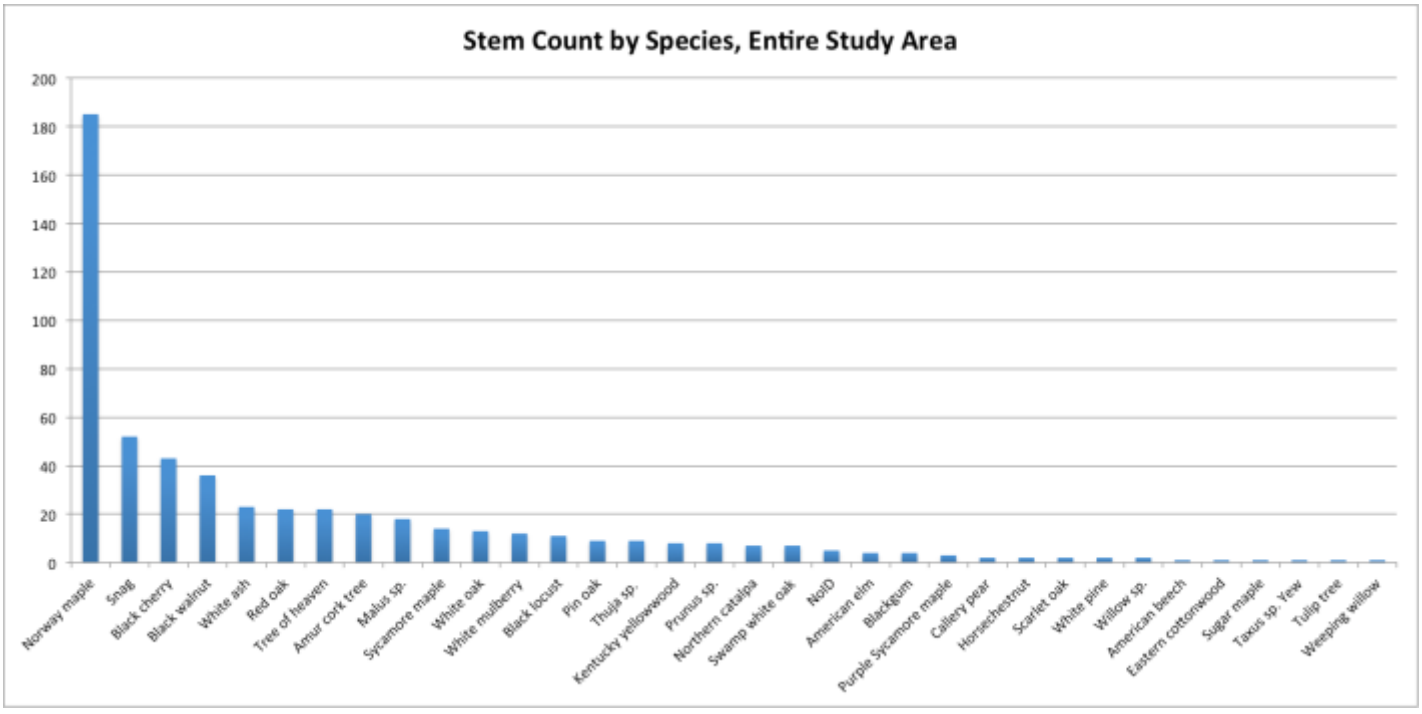

Figure 4: Stem Count by Species, Entire Study Area

Size Class Distribution

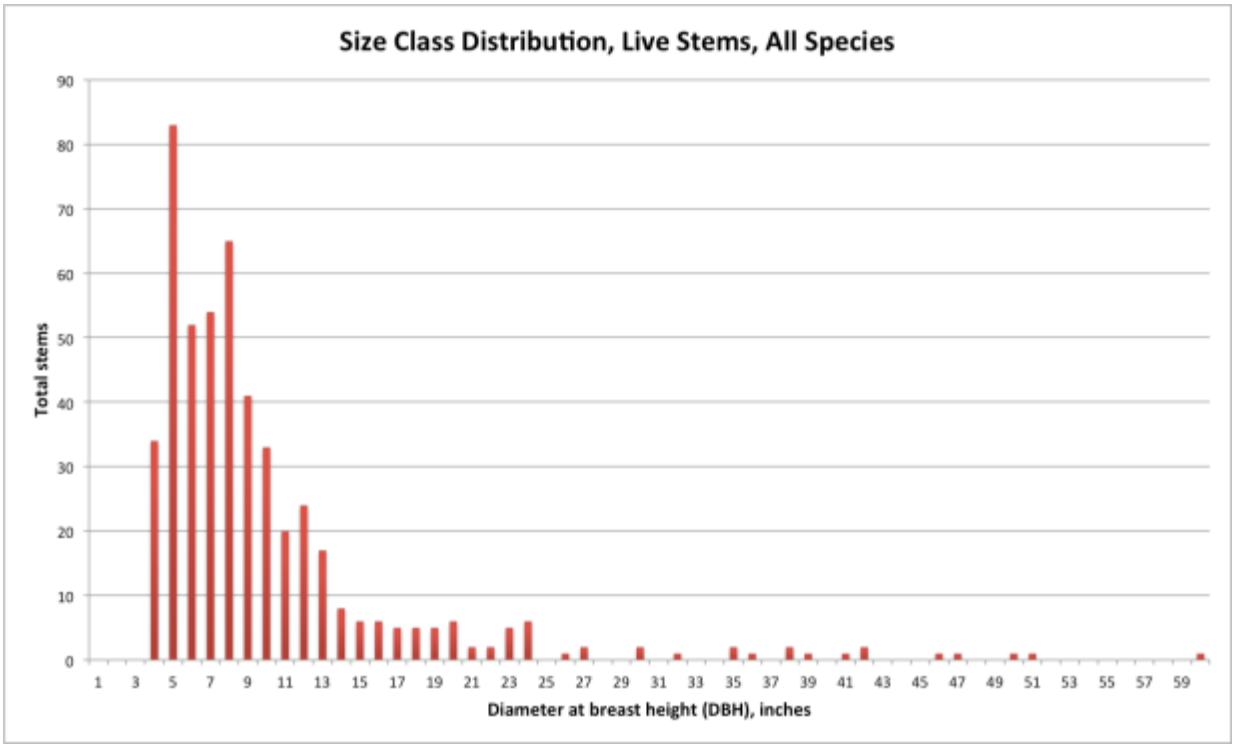

Figure 5: Size Class Distribution, Live Stems, All Species

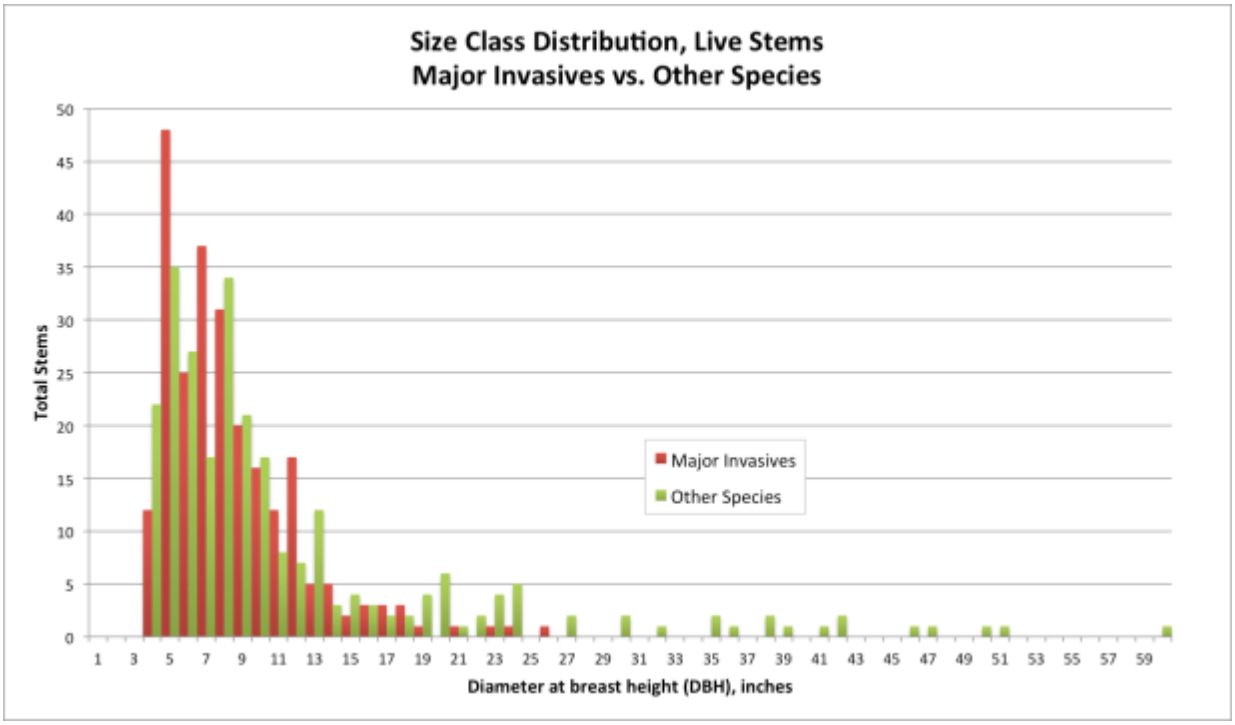

Figure 6: Size Class Distribution, Live Stems - Major Invasives vs. Other Species

Herbaceous Percent Cover

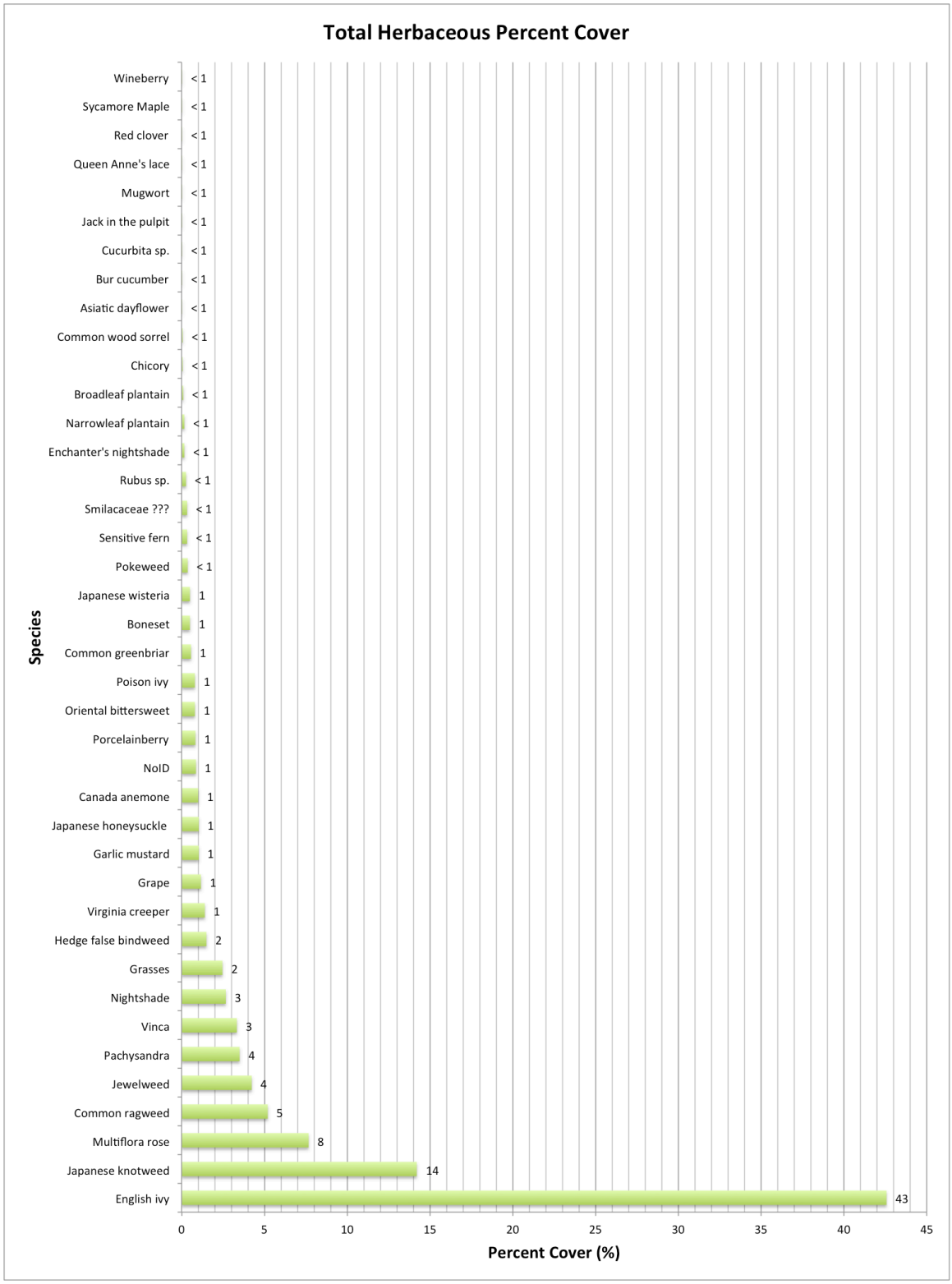

Figure 7: All species total percent cover

Figure 8: English ivy percent cover

Figure 9: Japanese knotweed percent cover

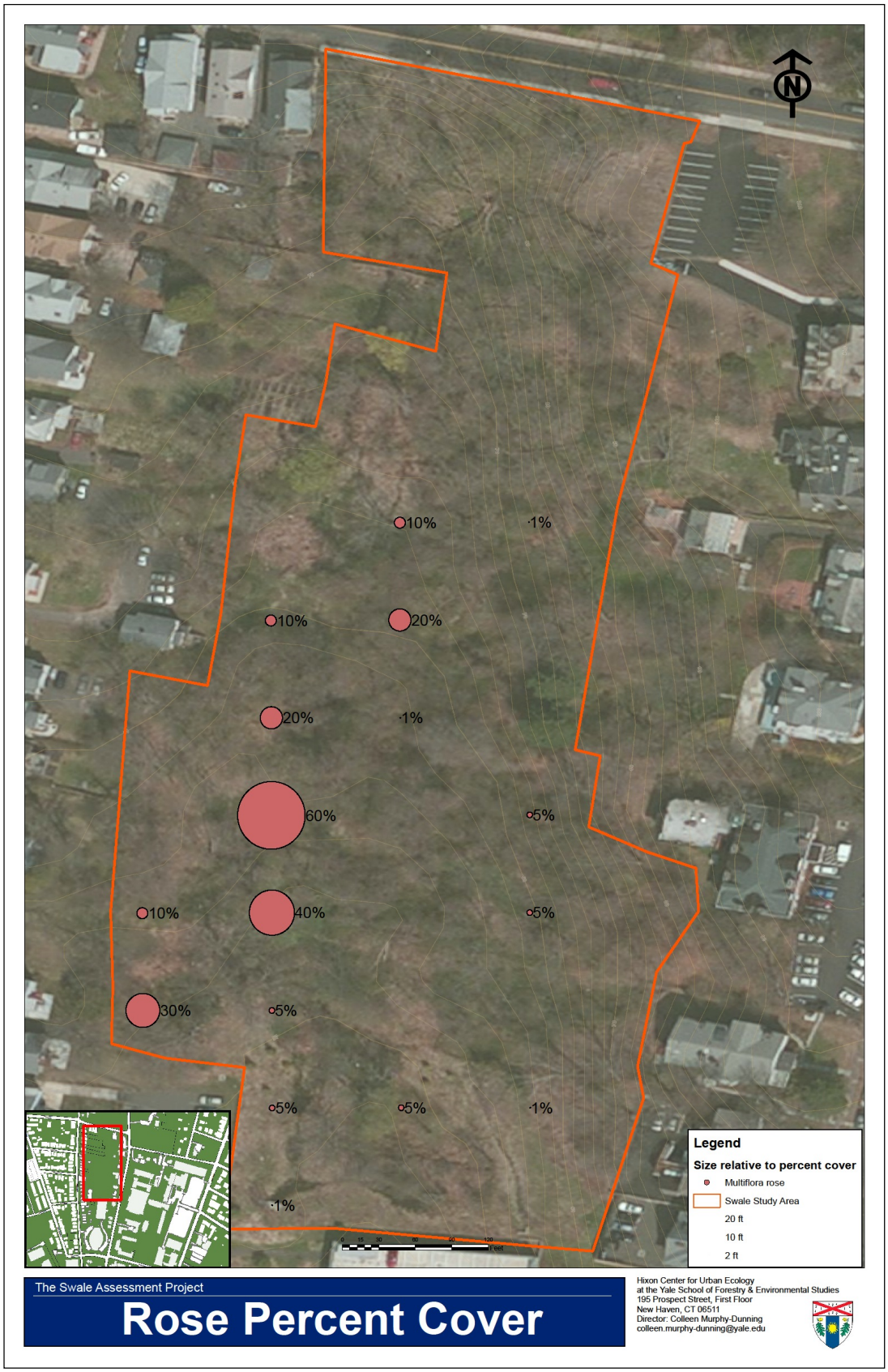

Figure 10: Multiflora rose percent cover

Contacts for Future Work

Among the individuals contacted during the course of this project were the following:

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Maps


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4
5
6
1
2
3
Legend
Veg Sample Plots
Swale Study Area
Thru Trail
20 ft
10 ft
2 ft
Feet
The Swale Assessment Project
Vegetation Sample Plots
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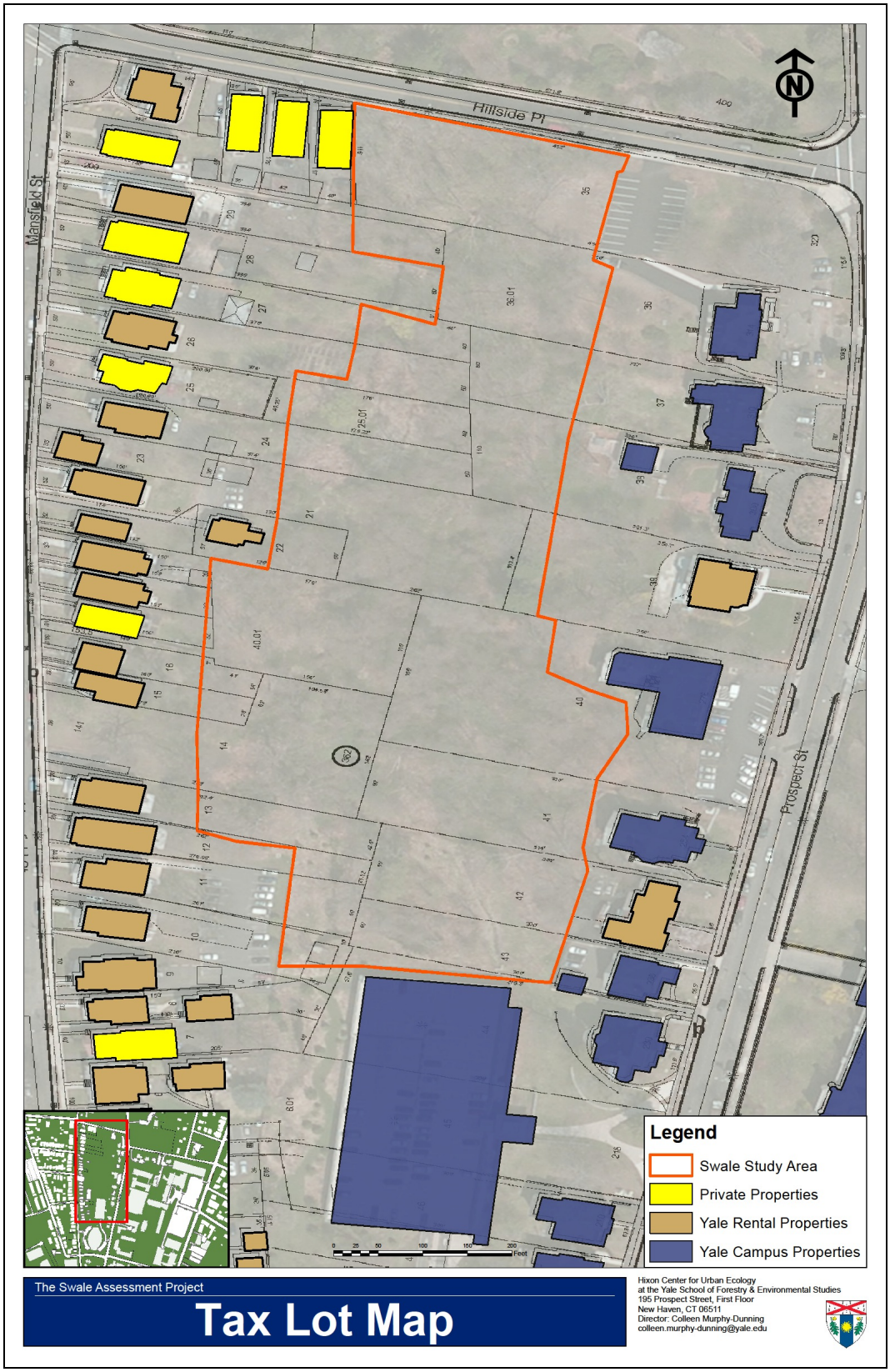
Hillside Pl
Mansfield St
Prospect St
Legend
Swale Study Area
Private Properties
Yale Rental Properties
Yale Campus Properties
The Swale Assessment Project
Tax Lot Map
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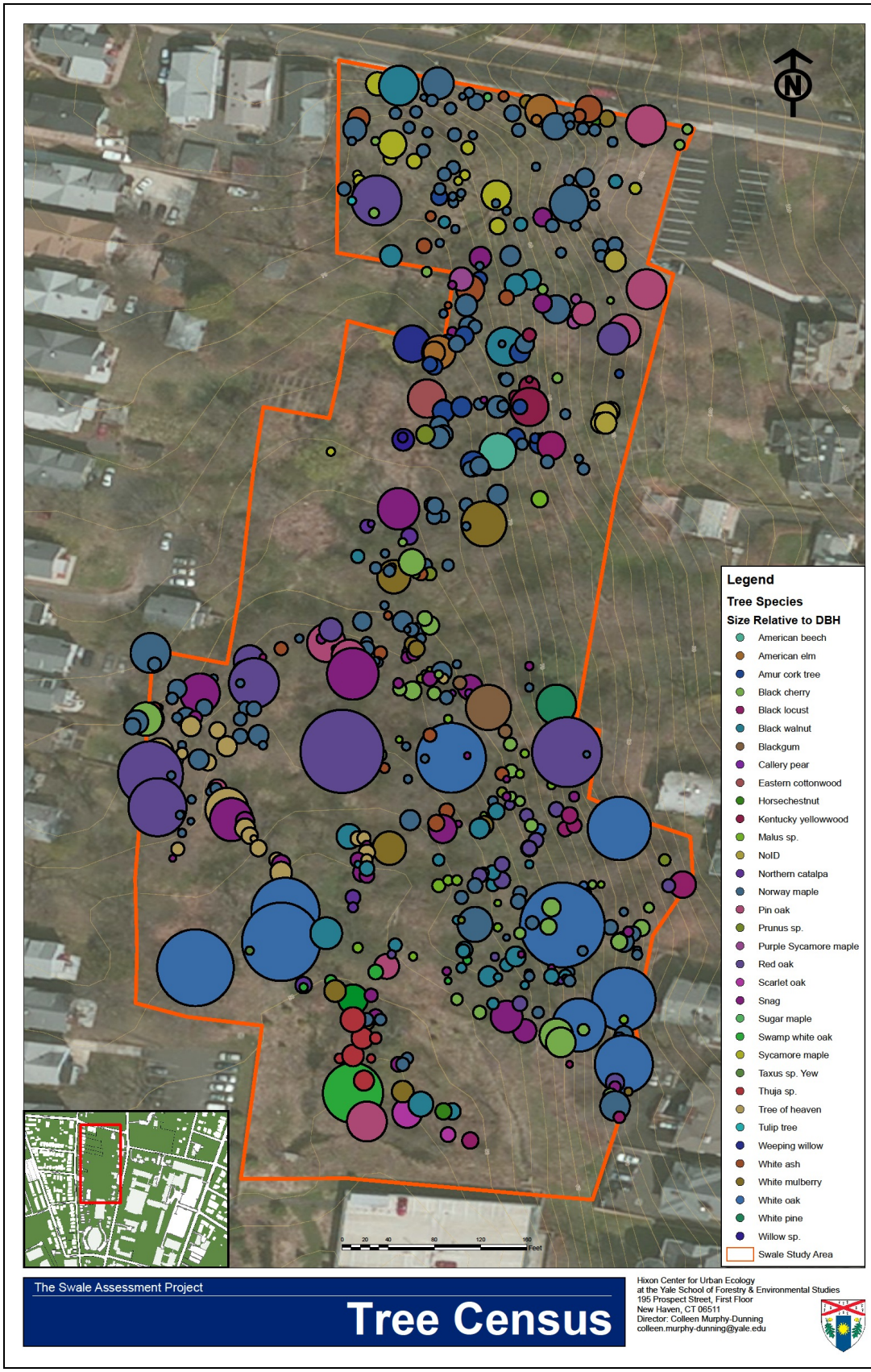
N
Legend
Tree Species
Size Relative to DBH
American beech
American elm
Amur cork tree
Black cherry
Black locust
Black walnut
Blackgum
Callery pear
Eastern cottonwood
Horsechestnut
Kentucky yellowwood
Malus sp.
NoID
Northern catalpa
Norway maple
Pin oak
Prunus sp.
Purple Sycamore maple
Red oak
Scarlet oak
Snag
Sugar maple
Swamp white oak
Sycamore maple
Taxus sp. Yew
Thuja sp.
Tree of heaven
Tulip tree
Weeping willow
White ash
White mulberry
White oak
White pine
Willow sp.
Swale Study Area
0 20 40 80 120 160
Feet
The Swale Assessment Project
Tree Census
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at the Yale School of Forestry & Environmental Studies
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HILLSIDE PLACE
MANSFIELD STREET
PROSPECT STREET
0800
0805
0808
0820
0905
0910
0924
Legend
Project Area
The Swale Assessment Project
1934 Aerial View
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Appendix I

Species lists: An approximate total of ~ 136 plant species were identified.

Note: The following lists are in draft form, as some species identifications are awaiting confirmation.

Trees			
Common Name	**Genus species**	**Origin**	**Family**
norway maple	*Acer platanoides*	invasive	Sapindaceae
sycamore maple	*Acer pseudoplatanus*	planted	Sapindaceae
purpleleaf sycamore maple	*Acer pseudoplatanus 'Atropurpureum'*	planted	Sapindaceae
red maple	*Acer rubrum*	native	Sapindaceae
silver maple	*Acer saccharinum*	native	Sapinadaceae
sugar maple*	*Acer saccharum*	native	Sapindaceae
horse chestnut	*Aesculus hippocastanum*	naturalized	Sapindaceae
tree of heaven	*Ailanthus altissima*	invasive	Simaroubaceae
serviceberry	*Amelanchier sp.*	native	Roseaceae
river birch	*Betula nigra*	planted	Betulaceae
hickory*	*Carya spp.*	native	Juglandaceae
northern catalpa	*Catalpa speciosa*	native	Bignoniaceae
kentucky yellowwood	*Cladrastis kentukea*	non-native	Fabaceae
Siberian dogwood	*Cornus alba 'variegata'*	non-native	Cornaceae
flowering dogwood	*Cornus florida*	native	Cornaceae
grey dogwood	*Cornus racemosa*	native	Cornaceae
American beech	*Fagus grandifolia*	native	Fagaceae
white ash	*Fraxinus americana*	native	Oleaceae
black ash*	*Fraxinus nigra*	native	Oleaceae
green ash*	*Fraxinus pennsylvanica*	native	Oleaceae
honey locust	*Gleditsia triacanthos*	non-native	Fabaceae
black walnut	*Juglans nigra*	native	Juglandaceae
tulip tree	*Liriodendron tulipifera*	native	Magnoliaceae
apple	*Malus domestica*	planted	Roseaceae
mulberry	*Morus alba*	naturalized	Moraceae
tupelo / blackgum	*Nyssa sylvatica*	native	Cornaceae
princess tree*	*Paulownia tomentosa*	invasive	Paulowniaceae
Amur cork tree	*Phellodendron amurense*	invasive	Rutaceae
Austrian pine*	*Pinus nigra*	planted	Pinaceae
white pine	*Pinus strobus*	native	Pinaceae
eastern cottonwood	*Populus deltoides*	native	Salicaceae
pin cherry	*Prunus pensylvanica*	native	Roseaceae
black cherry	*Prunus serotina*	native	Roseaceae
Prunus species	*Prunus sp.*	multiple	Roseaceae
callery pear	*Pyrus calleryana*	planted	Roseaceae

white oak	*Quercus alba*	native	Fagaceae
swamp white oak	*Quercus bicolor*	native	Fagaceae
scarlet oak*	*Quercus coccinea*	native	Fagaceae
pin oak	*Quercus palustris*	native	Fagaceae
red oak	*Quercus rubrum*	native	Fagaceae
black locust	*Robinia pseudoacacia*	planted	Fabaceae
weeping willow	*Salix spp.*	planted	Salicaceae
willow (multiple species)	*Salix spp.*	multiple	Salicaceae
sassafras	*Sassafras albidum*	native	Lauraceae
European yew	*Taxus baccata*	non-native	Taxaceae
unidentified #1	*TBD*	TBD	TBD
unidentified #2	*TBD*	TBD	TBD
white cedar	*Thuja occidentalis*	planted	Cupressaceae
Thuja sp.	*Thuja sp.*	multiple	Cupressaceae
American elm	*Ulmus americana*	native	Ulmaceae
Chinese elm	*Ulmus parvifolia*	non-native	Ulmaceae
slippery elm*	*Ulmus rubra*	native	Ulmaceae
** an asterisk denotes unconfirmed identification*			

Woody Shrubs			
Common Name	**Genus species**	**Origin**	**Family**
buttonbush	*Cephalanthus occidentalis*	native	Rubiaceae
red osier dogwood	*Cornus sericea*	native	Cornaceae
hawthorn	*Crataegus sp.*	native	Roseaceae
autumn olive	*Elaeagnus umbellata*	invasive	Elaeagnaceae
burning bush	*Euonymus alatus*	invasive	Celastraceae
Euonymus sp.	*Euonymus sp.*	non-native	Celastraceae
pearl bush	*Exochorda sp.*	non-native	Roseaceae
forsythia	*Forsythia sp.*	non-native	Oleaceae
japanese holly or inkberry	*Ilex crenata*	non-native	Aquifoliaceae
holly	*Ilex sp.*	planted	Aquifoliaceae
privet (multiple species)	*Ligustrum spp.*	planted	Oleaceae
Amur honeysuckle	*Lonicera maackii*	invasive	Caprifoliaceae
Morrow's honeysuckle	*Lonicera morrowii*	invasive	Caprifoliaceae
mock-orange	*Philadelphus sp.*	multiple	Hydrangeaceae
common buckthorn	*Rhamnus cathartica*	non-native	Rhamnaceae
black jetbead	*Rhodotypos scandens*	non-native	Roseaceae
staghorn sumac	*Rhus typhina*	native	Anacardiaceae
wingleaf soapberry	*Sapindus saponaria*	invasive	Sapindaceae
highbush blueberry	*Vaccinium corymbosum*	native	Ericaceae
arrowwood viburnum	*Viburnum dentatum*	native	Caprifoliaceae
European cranberrybush	*Viburnum opulus*	planted	Caprifoliaceae
cranberry leaved viburnum	*Viburnum trilobum*	native	Caprifoliaceae

Vines and Herbaceous Plants				
Common Name	**Genus species**	**Origin**	**Family**	**Habit**
five-leaf akebia	*Akebia quinata*	non-native	Lardizabalaceae	vine
garlic mustard	*Alliaria petiolata*	invasive	Brassicaceae	herbaceous
common ragweed	*Ambrosia artemisiifolia*	native	Asteraceae	herbaceous
porcelainberry	*Ampelopsis brevipedunculata*	non-native	Vitaceae	vine
Canada anemone	*Anemone canadensis*	native	Ranunculaceae	herbaceous
greater burdock	*Arctium lappa*	native	Asteraceae	herbaceous
jack in the pulpit	*Arisaema triphyllum*	native	Araceae	herbaceous
mugwort	*Artemisia vulgaris*	naturalized	Asteraceae	herbaceous
swamp milkweed	*Asclepias incarnata*	native	Apocynaceae	herbaceous
lady fern	*Athyrium filix-femina*	native	Dryopteridaceae	herbaceous
hedge false bindweed	*Calystegia sepium*	native	Convolvulaceae	vine
mace sedge	*Carex grayi*	native	Cyperaceae	herbaceous
oriental bittersweet	*Celastrus orbiculatus*	invasive	Celastraceae	vine
chicory	*Cichorium intybus*	naturalized	Asteraceae	herbaceous
enchanter's nightshade	*Circaea lutetiana*	native	Onagraceae	herbaceous
asiatic dayflower	*Commelina communis*	naturalized	Commelinaceae	herbaceous
squash	*Cucurbita sp.*	non-native	Cucurbitaceae	herbaceous
Queen Anne's lace	*Daucus carota*	naturalized	Apiaceae	herbaceous
fleabane	*Erigeron annuus*	native	Asteraceae	herbaceous
boneset	*Eupatorium perfoliatum*	native	Asteraceae	herbaceous
joe-pye weed	*Eupatorium purpureum*	native	Asteraceae	herbaceous
flat-top goldenrod	*Euthamia caroliniana*	native	Asteraceae	herbaceous
japanese knotweed	*Fallopia japonica*	invasive	Polygonaceae	herbaceous
english ivy	*Hedera helix*	planted	Araliaceae	vine
common day lily	*Hemerocallis fulva*	invasive	Xanthorrhoeaceae	herbaceous
hosta	*Hosta sp.*	non-native	Asparagaceae	herbaceous
jewelweed	*Impatiens capensis*	native	Balsaminaceae	herbaceous
blue flag iris	*Iris versicolor*	native	Iridaceae	herbaceous
oxeye daisy	*Leucanthemum vulgare*	naturalized	Asteraceae	herbaceous
cardinal flower	*Lobelia cardinalis*	native	Campanulaceae	herbaceous
japanese honeysuckle	*Lonicera japonica*	invasive	Caprifoliaceae	vine
bird's-foot trefoil	*Lotus corniculatus*	non-native	Fabaceae	herbaceous
false Solomon's seal	*Maianthemum racemosum*	native	Asparagaceae	herbaceous
sweetclover	*Melilotus alba*	native	Fabaceae	herbaceous
monkey flower	*Mimulus sp.*	multiple	Phrymaceae	herbaceous
sensitive fern	*Onoclea sensibilis*	native	Onocleaceae	herbaceous
royal fern	*Osmunda regalis*	native	Osmundaceae	herbaceous
common wood sorrel	*Oxalis acetosella*	native	Oxalidaceae	herbaceous
pachysandra	*Pachysandra sp.*	planted	Buxaceae	groundcover
virginia creeper	*Parthenocissus quinquefolia*	native	Vitaceae	vine
phragmites	*Phragmites australis australis*	invasive	Poaceae	herbaceous
pokeweed	*Phytolacca americana*	native	Phytolaccaceae	herbaceous
narrowleaf plantain	*Plantago lanceolata*	naturalized	Plantaginaceae	herbaceous
broadleaf plantain	*Plantago major*	naturalized	Plantaginaceae	herbaceous
Pennsylvania smartweed	*Polygonum pensylvanicum*	native	Polygonaceae	herbaceous
jumpseed	*Polygonum virginianum*	native	Polygonaceae	herbaceous
multiflora rose	*Rosa multiflora*	invasive	Rosaceae	shrub

blackberry	*Rubus fruticosus*	native	Rosaceae	herbaceous
raspberry	*Rubus idaeus*	non-native	Rosaceae	herbaceous
native black raspberry	*Rubus occidentalis*	native	Rosaceae	herbaceous
wineberry	*Rubus phoenicolasius*	invasive	Roseaceae	herbaceous
blackberry	*Rubus spp.*	multiple	Rosaceae	herbaceous
bur cucumber	*Sicyos angulatus*	native	Cucurbitaceae	vine
common greenbriar	*Smilax rotundifolia*	native	Smilacaceae	vine
nightshade	*Solanum dulcamara*	invasive	Solanaceae	vine
goldenrod	*Solidago sp.*	native	Asteraceae	herbaceous
poison ivy	*Toxicodendron radicans*	native	Anacardiaceae	vine
red clover	*Trifolium pratense*	non-native	Fabaceae	herbaceous
hairy vetch	*Vicia villosa*	non-native	Fabaceae	herbaceous
vinca	*Vinca sp.*	planted	Apocynaceae	groundcover
grape	*Vitus sp.*	native	Vitaceae	vine
Japanese wisteria	*Wisteria floribunda*	non-native	Fabaceae	vine